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Blowout preventer with multiple application ram blades

Abstract

A blowout preventer incudes a body having a bore and first and second guideways; a first ram movably positioned relative to the first guideway and movable toward the bore, the first ram including a first blade including at least one flat side; a first blunt leading contour running parallel to a plane of the flat side along a distal end of the first blade; at least one upper inclined surface above the first blunt leading contour; and at least one lower declined surface below the first blunt leading contour, wherein the first blade is positioned and is movable above a first plane; a second ram movably positioned relative to the second guideway and movable toward the bore, the second ram including a second blade including a second blunt leading contour; and at least one lower declined surface, wherein the second blade is positioned and is movable below the first plane.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application is a continuation of U.S. application Ser. No. 17/604,513, filed Oct. 18, 2021, which is a National Stage entry of International Application No. PCT/US2020/015787, filed Jan. 30, 2020, which claims benefit of and priority to U.S. Provisional Application Ser. No. 62/836,699, filed Apr. 21, 2019. Each of these applications is incorporated by reference herein in its entirety.

TECHNICAL FIELD

(1) The present disclosure relates generally to the field of drilling wells. More particularly, the invention concerns blowout preventers (BOPs) for shearing tubing string or tools and sealing wellbores.

BACKGROUND

(2) This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the presently described embodiments. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present embodiments. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

(3) Blowout preventers (BOPs) are used extensively throughout the oil and gas industry. Typical blowout preventers are used as a large specialized valve or similar mechanical device that seal, control, and monitor oil and gas wells. The two categories of blowout preventers that are most prevalent are ram blowout preventers and annular blowout preventers. Blowout preventer stacks frequently utilize both types, typically with at least one annular blowout preventer stacked above several ram blowout preventers. The ram units in ram blowout preventers allow for both the shearing of the drill pipe and the sealing of the blowout preventer. Typically, a blowout preventer stack may be secured to a wellhead and may provide a safe means for sealing the well in the event of a system failure.

(4) In order to meet consumer and industrial demand for natural resources, companies invest significant amounts of time and money in finding and extracting oil, natural gas, and other subterranean resources from the earth. Particularly, once a desired subterranean resource such as oil or natural gas is discovered, drilling and production systems are employed to access and extract the resource. These systems may be located onshore or offshore depending on the location of a desired resource. Further, such systems generally include a wellhead assembly through which the resource is extracted. These wellhead assemblies may include a wide variety of components, such as various casings, valves, fluid conduits, and the like, that control drilling or extraction operations.

(5) More particularly, wellhead assemblies often include a blowout preventer to control pressure at the top of a well and prevent flow of formation fluids through the blowout preventer. Among the various types of blowout preventers, a shear ram blowout preventer achieves pressure control through the operation of rams (operated hydraulically or electrically) capable of shearing a tubular contained within a main bore of the blowout preventer (e.g., drill pipe, a liner, or a casing string). The rams are grouped in opposing pairs and are forced together as a result of the hydraulic or electric operation. Often, the rams are driven into and out of a main bore of a blowout preventer by operating pistons coupled to the ram blocks by connecting rods.

(6) In a typical blowout preventer, a ram bonnet assembly may be bolted to the main body using a number of high tensile bolts or studs. These bolts are required to hold the bonnet in position to enable the sealing arrangements to work effectively. Typically an elastomeric sealing element is used between the ram bonnet and the main body. There are several configurations, but essentially they are all directed to preventing a leakage bypass between the mating faces of the ram bonnet and the main body.

(7) During normal operation, the blowout preventers may be subject to pressures up to 20,000 psi, or even higher. To be able to operate against and to contain fluids at such pressures, blowout preventers are becoming larger and stronger. Blowout preventer stacks, including related devices, 30 feet or more in height are increasingly common.

(8) As noted above, ram-type blowout preventers may be designed and constructed for use with drill pipe or other tubulars of specified diameter. A blowout preventer stack including rams for one size of pipe may be used with pipe of a different size by changing the pipe engaging rams or parts of the rams. Also, the ram operating mechanisms in a blowout preventer are comparatively

complex and require inspection and servicing before the blowout preventer is put into service at a wellhead. Such activities, when performed in a large modern blowout preventer stack, may require the presence of personnel at locations that can be hazardous, if not impractical.

(9) A blowout preventer may be used for shearing a tubular positioned in a bore extending through the blowout preventer, as disclosed in US2016/0258238, incorporated herein by reference in its entirety. The blowout preventer includes a first shear ram movable towards the tubular, the first shear ram including a first blade, and the first blade including an outer cutting profile and an inner cutting profile. The blowout preventer further includes a second shear ram positioned opposite the first shear ram with respect to the tubular and movable towards the tubular, the second shear ram including a second blade, and the second blade including the outer cutting profile and the inner cutting profile. The outer cutting profile includes blade portions on opposite sides of the inner cutting profile, and positioned between an angle of about 120 degrees and an angle of about 140 degrees from each other.

(10) U.S. Pat. No. 4,537,250 discloses a ram-type shearing apparatus for a wellhead having a body with a vertical bore therethrough and aligned, opposed ram guideways extending outward in the body from the bore, a ram assembly in each of the guideways, each of the ram assemblies having a ram body with a shearing blade on the face of the ram and means for moving the ram inward and outward in the guideway, the cutting edge of the upper shear blade and the face of the ram assembly below the upper shear blade being concave to support the string during shearing sufficiently to constrain the string below the upper shear blade as it is sheared to a shape suitable for receiving an overshot type of retrieving tool and to allow flow therein, the lower shear blade having at least one node extending toward the upper shear blade so that when a pipe is being sheared the node engages and penetrates the pipe prior to other shearing of the pipe to thereby reduce the force used for such shearing.

(11) A unitary blade seal for a shearing blind ram of a ram-type blowout preventer is disclosed in U.S. Pat. No. 7,354,026. The blade seal includes an elongate member having a generally semi-circular cross section with a curved upper surface and a lower surface. The lower surface has a pair of laterally extending sides that taper outwardly and have a metal outer cap bonded thereto. The metal outer caps form an acute angle that engages a complementary groove formed in the upper ram of the shearing blind ram assembly.

(12) Over the past decade the drilling market has experienced an increase in governmental regulation and operational challenges that have impacted the requirements of drilling safety equipment. To meet these requirements operators and contractors have placed an increased focus on pressure controlling equipment and the enhancement of its capabilities. One such desired enhancement is the increased shear and seal capacity of shear rams.

(13) During drilling activities contractors are limited in what they can shear based on the shear capacity of their deployed shear rams. This requires drillers to keep track of what is in front of their shear ram blades to successfully ensure a shear in the event of an emergency disconnect situation.

(14) The increased competitive nature of the energy industry has driven the need for more efficient and capable blowout preventer designs within the drilling and completions industry.

SUMMARY

(15) In accordance with the teachings of the present disclosure, the invention greatly enhances the shear capability of the shearing pressure control equipment (shear ram) utilized inside of drilling blow out preventers. The invention enhances the shear effectiveness of a shear ram's leading edge by reducing its contact area with an opposing pipe. The design incorporates a rounded edge terminating in two symmetric angles above and below the rounded point of contact with the pipe. This “bull nose” design allows the leading contour to dig into the pipe and impart a ripping action throughout the contact plane by placing the tubular into tension at the point of contact. Further, the symmetric angles ensure no bending is incorporated onto the blade edge as the vertical component of the reaction force of the pipe is equalized with the other symmetric angle.

(16) According to one or more embodiments of the present disclosure, a blowout preventer for shearing, cutting, ripping, or tearing a structure positioned in a bore extending through the blowout preventer includes: a body having a bore, a first guideway, and a second guideway; a first ram movably positioned relative to the first guideway and movable toward the bore, the first ram including a first blade, the first blade including: at least one flat side; a first blunt leading contour running parallel to a plane of the at least one flat side along a distal end of the first blade; at least one upper inclined surface above the first blunt leading contour; and at least one lower declined surface below the first blunt leading contour, wherein the first blade is positioned and is movable above a first plane; a second ram movably positioned relative to the second guideway and movable toward the bore, the second ram including a second blade, the second blade including: a second blunt leading contour; and at least one lower declined surface, wherein the second blade is positioned and is movable below the first plane.
(17) According to one or more embodiments of the present disclosure, a blowout preventer for shearing, cutting, ripping, or tearing a structure positioned in a bore extending through the blowout preventer includes: a body having a bore, a first guideway, and a second guideway; a first ram movably positioned relative to the first guideway and movable toward the bore, the first ram including a first blade, the first blade including: at least one flat side; a first blunt leading contour running parallel to a plan of the at least one flat side along a distal end of the first blade; at least one upper inclined surface above the first blunt leading contour, wherein the at least one upper inclined surface forms an angle between about 120 and 160 degrees with the at least one flat side, and at least one lower declined surface below the first blunt leading contour, wherein the at least one lower declined surface forms an angle between about 60 and 100 degrees with the at least one upper inclined surface; a second ram movably positioned relative to the second guideway and movable toward the bore, the second ram including a second blade, the second blade including: at least one flat side; a second blunt leading contour; and at least one lower declined surface, wherein the first blunt leading contour and the second blunt leading contour are vertically offset from each other by an offset distance.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) A more complete understanding of the present embodiments may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features.
(2) FIG. **1**A illustrates a cross-sectional side view of a blowout preventer, wherein the rams are in an open position.
(3) FIG. **1**B shows a cross-sectional top view of the blowout preventer shown in FIG. **1**A.
(4) FIG. **1**C illustrates a cross-sectional side view of the blowout preventer shown in FIGS. **1**A-**1**B, wherein the rams are in a shearing or ripping position.
(5) FIG. **1**D shows a perspective view of a blowout preventer body.
(6) FIG. **2**A illustrates perspective views of first and second rams.
(7) FIG. **2**B shows top views of the first and second rams of FIG. **2**A.
(8) FIG. **3**A shows a top perspective view of a first ram.
(9) FIG. **3**B illustrates a bottom perspective view of the first ram shown in FIG. **3**A.
(10) FIG. **3**C shows a front view of the first ram shown in FIGS. **3**A-**3**B.
(11) FIG. **3**D illustrates a top view of the first ram shown in FIGS. **3**A-**3**C.
(12) FIG. **3**E shows a bottom view of the first ram shown in FIGS. **3**A-**3**D.
(13) FIG. **3**F shows a side view of the first ram shown in FIGS. **3**A-**3**E.
(14) FIG. **4**A shows a top perspective view of a second ram.

(15) FIG. **4**B illustrates a bottom perspective view of the second ram shown in FIG. **4**A.
(16) FIG. **4**C shows a front view of the second ram shown in FIGS. **4**A-**4**B.
(17) FIG. **4**D illustrates a bottom view of the second ram shown in FIGS. **4**A-**4**C.
(18) FIG. **4**E shows a top view of the second ram shown in FIGS. **4**A-**4**D.
(19) FIG. **4**F shows a side view of the second ram shown in FIGS. **4**A-**4**E.
(20) FIG. **4**G shows a side view of a portion of a blade of the second ram shown in FIGS. **4**A-**4**F.
(21) FIG. **5**A illustrates a side view of first and second blades initially engaging a tubular in a blowout preventer.
(22) FIG. **5**B shows a side view of the first and second blades of FIG. **5**A fully engaging to shear or rip the tubular.
(23) FIG. **6**A illustrates a side view of first and second blades initially engaging a wire in a blowout preventer.
(24) FIG. **6**B shows a side view of the first and second blades of FIG. **5**A fully engaging to cut the wireline.
(25) FIG. **7**A illustrates perspective views of first and second rams.
(26) FIG. **7**B shows top views of the first and second rams of FIG. **7**A.
(27) FIG. **8**A shows a top perspective view of a first ram.
(28) FIG. **8**B illustrates a bottom perspective view of the first ram shown in FIG. **8**A.
(29) FIG. **8**C shows a front view of the first ram shown in FIGS. **8**A-**8**B.
(30) FIG. **8**D illustrates a top view of the first ram shown in FIGS. **8**A-**8**C.
(31) FIG. **8**E shows a bottom view of the first ram shown in FIGS. **8**A-**8**D.
(32) FIG. **8**F shows a side view of the first ram shown in FIGS. **8**A-**8**E.
(33) FIG. **9**A shows a top perspective view of a second ram.
(34) FIG. **9**B illustrates a bottom perspective view of the second ram shown in FIG. **9**A.
(35) FIG. **9**C shows a front view of the second ram shown in FIGS. **9**A-**9**B.
(36) FIG. **9**D illustrates a bottom view of the second ram shown in FIGS. **9**A-**9**C.
(37) FIG. **9**E shows a top view of the second ram shown in FIGS. **9**A-**9**D.
(38) FIG. **9**F shows a side view of the second ram shown in FIGS. **9**A-**9**E.
(39) FIGS. **10**A-**10**E are top views of first and second rams with a tubular in various positions between the ram blades.

DETAILED DESCRIPTION

(40) The following discussion is directed to various embodiments of the present disclosure. The drawing figures are not necessarily to scale. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. Although one or more of these embodiments may be preferred, the embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. It is to be fully recognized that the different teachings of the embodiments discussed below may be employed separately or in any suitable combination to produce desired results. In addition, one skilled in the art will understand that the following description has broad application, and the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to intimate that the scope of the disclosure, including the claims, is limited to that embodiment.
(41) Certain terms are used throughout the following description and claims to refer to particular features or components. As one skilled in the art will appreciate, different persons may refer to the same feature or component by different names. This document does not intend to distinguish between components or features that differ in name but are the same structure or function. The drawing figures are not necessarily to scale. Certain features and components herein may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in interest of clarity and conciseness.
(42) In the following discussion and in the claims, the terms “including” and “comprising” are used

in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . " Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. In addition, the terms "axial" and "axially" generally mean along or parallel to a central axis (e.g., central axis of a body or a port), while the terms "radial" and "radially" generally mean perpendicular to the central axis. For instance, an axial distance refers to a distance measured along or parallel to the central axis, and a radial distance means a distance measured perpendicular to the central axis. The use of "top," "bottom," "above," "below," and variations of these terms is made for convenience, but does not require any particular orientation of the components.

(43) Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present disclosure. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

(44) Preferred embodiments are best understood by reference to FIGS. **1**A-**10**E below in view of the following general discussion. The present disclosure may be more easily understood in the context of a high level description of certain embodiments. Specific details are given in the following description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that embodiments may be practiced without these specific details. For example, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

(45) Referring now to FIGS. **1**A-IC, multiple views of a blowout preventer **10** for shearing a tubular D in accordance with one or more embodiments of the present disclosure are shown. The blowout preventer **10**, which may be referred to as a ram blowout preventer, includes a body **12** with a vertical bore **14** formed and/or extending through the body **12**. As shown, the body **12** may include a lower flange **16** and/or an upper flange **18**, such as to facilitate connecting the blowout preventer **10** to other blowout preventers and/or other components. Cavities and/or guideways **20** and **22** may be formed within the body **12** of the blowout preventer **10**, in which the guideways **20** and **22** may extend outwardly from the bore **14** and/or be formed on opposite sides of the bore **14**.

(46) The blowout preventer **10** may then include one or more ram assemblies, such as a first ram **24** and a second ram **26**. The first ram **24** may be positioned and movable within the first guideway **20** and a second ram **26** positioned and movable within the second guideway **22**, such as by having the first ram **24** and/or the second ram **26** movable towards and away from the tubular D. One or more actuators **28** may be provided to move the first ram **24** and/or the second ram **26**, such as for moving the first ram **24** and/or the second ram **26** into the bore **14** to shear the portion of the tubular D extending through the bore **14** of the blowout preventer **10**. In this embodiment, a hydraulic actuator is shown, though any type of actuator (e.g., pneumatic, electrical, mechanical) may be used in accordance with the present disclosure. As such, the actuators **28** shown in this embodiment may include a piston **30** positioned within a cylinder **32** and a rod **34** connecting the piston **30** to each respective ram **24** and **26**. Further, pressurized fluid may be introduced and fluidly communicated on opposite sides of the piston **30** through ports **35**, thereby enabling the actuator **28** to move the rams **24** and **26** in response to fluid pressure.

(47) A first (e.g., upper) blade **36** (any blade according to the present disclosure) may be included with or connected to the first ram **24**, and a second (e.g., lower) blade **38** (any blade according to the present disclosure) may be included with or connected to the second ram **26**. The first and second blades **36** and **38** may be formed and positioned such that the second blade **38** passes below the first blade **36** in shearing of a section of a tubular D. The shearing action of first and second blades **36** and **38** may shear the tubular D. The lower portion of the tubular D may then drop into the well bore (not shown) below the blowout preventer **10**, or the tubular D may hung off a lower set of rams (not shown).

(48) Accordingly, disclosed herein are a system, blowout preventer, and/or a blade for a blowout

preventer for shearing a tubular. The tubular may be positioned within the bore extending through the blowout preventer, in which the blowout preventer may be actuated to move one or more blades to engage and shear the tubular. A blade of a blowout preventer in accordance with the present disclosure may be used for shearing one or more different types of tubulars that may have different shapes, sizes, thicknesses, and other dimensions and properties. For example, a tubular may include a drill pipe joint, a casing joint, and/or a tool joint, in which a blowout preventer in accordance with the present disclosure may be used to shear each of these different types of tubulars. These tubulars may be sheared with or without replacement of any blade of the blowout preventer.
(49) FIG. **1**D shows a perspective view of an embodiment of the body **12** of the blowout preventer **10** shown in FIGS. **1**A-**1**C. Rather, than an upper flange **18**, this embodiment has studs **19** to make up a studded connection. The guideway **22** has a cross-sectional shape that is linear on the top and the bottom and semi-circular on the left and the right sides.
(50) Referring to FIG. **2**A, a perspective view of an embodiment of a first ram **24** and a second ram **26** are shown. The rams are positioned opposite each other as they would be if positioned within the guideways **20** and **22** of the body **12** of the blowout preventer **10**. The first ram **24** has a first seal **37** extending from a right side, over the top, and to the left side. The first ram **24** also has first side seals **40**, one on each side. The second ram **26** similarly has a second seal **39** extending from a right side, over the top, and to the left side. The second ram **26** also has second side seals **41**, one on each side. The seals engage with the sides and tops of the guideways **20** and **22** to seal the vertical bore **14** when the rams are fully extended to the closed position by the actuators **28**. A ram seal is positioned in a seal channel **42** in the bottom side of the first ram **24** so as to seal between the rams when they are in a closed position. (See FIG. **3**B). The first ram **24** has upper guides **44** and lower guides **46** for guiding the first ram **24** in guideway **20** (see FIG. **1**A). As shown, one upper guide **44** and one lower guide **46** are on the left side of the ram and another upper guide **44** and another lower guide **46** are on the right side of the first ram **24**. The upper and lower guides **44** and **46** define guide channels **48** of the first ram **24** for receiving and guiding the second lower blade **38** and the second side seals **41** of the second ram **26**.
(51) FIG. **2**B is a top view of the embodiment of the first ram **24** and the second ram **26** shown in FIG. **2**A, except that the seals are removed from the rams. The first ram **24** has a first upper blade **36**, which has a blunt leading contour **58**. The second ram **26** has a second lower blade **38**, which has a blunt leading contour **88**.
(52) Referring to FIGS. **3**A and **3**B, top and bottom perspective views of an embodiment of a first ram **24** are shown. The first ram **24** comprises a first upper blade **36** having a blunt leading contour **58** that extends between the upper guides **44** at the front of the blade **36**. The first upper blade **36** has upper inclined surfaces **60** extending from the blunt leading contour **58** to the top side **52**. At the leading most portions of the bottom side **50**, the blade **36** has a cutting edge **64**. The first upper blade **36** also has lower inclined surfaces **62** extending from the blunt leading contour **58** to the cutting edge **64**. The cutting edge **64** is a very short substantially vertical front side of the blade **36** that meets the bottom side **50**. The first upper blade **36** also has lower declined surfaces **62** extending from the blunt leading contour **58** to the cutting edge **64**. In the middle of the blunt leading contour **58**, the first upper blade **36** has a point **66**.
(53) FIG. **3**C shows a front view of the first ram **24**. As clearly shown in this view, the first upper blade **36** is flat and horizontal on its bottom side **50**. The top side **52** of the first upper blade **36** is also flat and horizontal, except that in the mid-section of the blade the top side is pitched to a ridge **54**. Ridge planes **56** extend from the flat and horizontal portions of the top side **52** to the ridge **54**. The blunt leading contour **58** extends between the upper guides **44** at the front of the blade **36**.
(54) FIG. **3**D shows a top view of the first ram **24**. In this view, the profile of the blunt leading contour **58** is shown extending between the upper guides **44**. The point **66** extends from the mid-section of the blunt leading contour **58**, with flanks **68** on opposite sides. The flanks **68** merge into concave arcs **70**. Each of the concave arcs **70** in the blunt leading contour **58** merge into forward

angled sections **72**. Each of the forward angled sections **72** merge into convex arcs **74** located adjacent the upper guides **44**. Relative to the forward advancing direction of the first ram **24**, which is upward in FIG. **3**D, the convex arcs **74** are more forward than the point **66**. The ridge **54** is on the centerline **76** of the first ram **24**. The flanks **68** sweep backwardly from the point **66** at an angle of about 65 degrees from the centerline **76**. Said another way, the flanks **68** form an angle of about 130 degrees at the point **66**. In some embodiments, the flanks **68** form an angle between about 110 to 150 degrees at the point **66**. The forward angled sections **72** sweep forwardly at an angle of about 52 degrees from the centerline **76**. The concave arcs **70** have radii about 8% the width of the first upper blade **36** between the upper guides **44**.

(55) Referring to FIG. **3**E, a bottom view is shown of the embodiment of the first ram **24** of FIGS. **3**A-**3**D. In this view, the bottom side of the first upper blade **36** is visible between the lower guides **46**. A seal channel **42** is located in the bottom side **50**. A seal may be positioned in the seal channel **42** for sealing engagement between the first upper blade **36** and the second lower blade **38** (see FIG. **2**) when the rams are closed. The profile of the blunt leading contour **58** is also visible in FIG. **3**E. Further, from this perspective, the cutting edge **64** is also visible. The cutting edge **64** has a profile similar to the blunt leading contour **58**. Lower decline surfaces **62** extend between the blunt leading contour **58** and the cutting edge **64**.

(56) FIG. **3**F shows a right side view of the first ram **24**. An upper guide **44** is at the top of the first ram **24** and a lower guide **46** is at the bottom of the first ram **24**. A guide channel **48** is bounded between the upper and lower guides **44** and **46**. The blunt leading contour **58** extends slightly beyond the distal end of the upper guide **44**. In this view, the depth and width of the seal channel **42** are clearly visible. In one embodiment, the inclination angle of the upper inclined surfaces **60** and the declination angle of the lower declined surfaces **62** of the first upper blade **36** may be about 40 degrees from horizontal. (See FIG. **3**C).

(57) Referring to FIGS. **4**A and **4**B, top and bottom perspective views of an embodiment of a second ram **26** are shown. The second ram **26** comprises a second lower blade **38** having a top side **92**, a bottom side **90**, and a blunt leading contour **88** at the front of the blade **38**. At the leading most portions of the top side **92**, the blade **38** has a cutting edge **94**. The cutting edge **94** is a very short substantially vertical front side of the blade **38** that meets the top side **92** at a substantially 90 degree corner. The second lower blade **38** has upper inclined surfaces **80** extending from the blunt leading contour **88** to the cutting edge **94** at the leading boundary of the top side **92**. The second lower blade **38** also has lower declined surfaces **82** extending from the blunt leading contour **88** to the bottom side **90**. The blunt leading contour **88** of the second lower blade **38** has two points **96**.

(58) FIG. **4**C shows a front view of the second ram **26**. As clearly shown in this view, the second lower blade **38** is flat and horizontal on its top side **92**. The bottom side **90** of the second lower blade **38** is also flat and horizontal, except that first and second thirds of the width of the blade **38** the bottom side **90** is pitched to two ridges **84**. Ridge planes **86** extend from the flat and horizontal portions of the bottom side **90** to the ridges **84**. The blunt leading contour **88** extends across front of the blade **39** between the upper inclined surfaces **80** and the lower declined surfaces **82**. Two pointes **96** are at about the first and second thirds of the width of the blade **38**.

(59) FIG. **4**D shows a bottom view of the second ram **26**. In this view, the profile of the blunt leading contour **88** is shown at the leading portion of the second lower blade **38**. The blunt leading contour **88** is symmetrical about the centerline **76**. Two points **96** extend from the first and second thirds of the width of the blunt leading contour **88**, with flanks **98** on opposite sides of each point **96**. The flanks **98** merge into concave arcs **100** toward the ends of the blade **38** and merge into a common concave arc **101** at the mid-section. Each of the concave arcs **100** in the blunt leading contour **88** merge into forward sections **102**, which are substantially parallel to the centerline **76**. Each of the forward sections **102** merge into forward angled sections **104**. The forward angled sections **104** finally merge into transverse sections **106**, which are substantially transverse to the centerline **76**. Relative to the forward advancing direction of the first ram **24**, which is upward in

FIG. **4**D, the transverse sections **106** are more forward than the points **96**. The ridges **84** are colinear with the points **96**. The flanks **98** sweep backwardly from the points **96** at angle of about 60 degrees from the centerline **76**. The forward angled sections **104** sweep forwardly at an angle of about 75 degrees from the centerline **76**. The concave arcs **100** have radii about 3% the width of the second lower blade **38**. The common concave arc **101** has a radius about 10% the width of the second lower blade **38**.

(60) Referring to FIG. **4**E, a top view is shown of the embodiment of the second ram **26** of FIGS. **4**A-**4**D. In this view, the top side **92** of the second lower blade **38** is visible. The profile of the blunt leading contour **88** is also visible in FIG. **4**E. Further, from this perspective, the cutting edge **94** is also visible. The cutting edge **94** has a profile similar to the blunt leading contour **88**. Upper incline surfaces **80** extend between the blunt leading contour **88** and the cutting edge **94**.

(61) FIG. **4**F shows a left side view of the second ram **26**. The blunt leading contour **88** is located at the distal end of the second lower blade **38**. The top side **92** is opposite the bottom side **90**. A ridge **84** is at the bottom most portion of the blade **38**. A ridge plane **86** extends between the ridge **84** and the bottom side **90** of the blade **38**. An upper inclined surface **80** extends between the blunt leading contour **88** and the cutting edge **94**. In this embodiment, the top side **92** is flat. A reference horizontal plane **116** cuts through the middle of the blunt leading contour **88** and is parallel to the top side **92**. The upper inclined surface **80** has an inclination angle **112** of about 40 degrees relative to the reference horizontal plane **11**. Said another way, the upper inclined surface forms an angle of about 140 degrees with the top side **92**. In some embodiments, the upper inclined surface forms an angle between about 120 and 160 degrees with the top side **92**. A lower decline surface **82** extends between the blunt leading contour **88** and the bottom side **90** of the blade **38**. In this embodiment, the lower decline surface **82** has a declination angle **114** of about 40 degrees from reference horizontal plane **116**. Said another way, the lower declined surface **82** forms an angle of about 80 degrees with the upper inclined surface **80**. In some embodiments, the lower declined surface **82** forms an angle between about 60 and 100 degrees with the upper inclined surface **80**. Further, lower decline surfaces **82** extend from various portions of the blunt leading contour **88** to the ridge plane **86**.

(62) A further aspect of the invention is that the first upper blade **36** functions to rip tubular, tools, or whatever else is located in the vertical bore of the blowout preventer body **12**. The first and second blades **36** and **38** may be formed and positioned such that the second blade **38** passes below the first blade **36** in shearing of a section of a tubular D. (See FIG. **1**C). The shearing action of first and second blades **36** and **38** may shear whatever structures are located in the vertical bore **14** of the blowout preventer **10**. The blades may shear; (1) tubulars D of any diameter that may be inserted into the vertical bore **14**; (2) tool joint; (3) drill collar; (4) production tubular; (5) hard banded tubular; (6) casing tubular; (7) tubular pin/box connections of any diameter; (8) coil tubing of any diameter; (9) tools, such as wireline tools, perforating guns, drill bits, fishing tools, etc.; (10) wireline; and (11) any other objects that may find their way into the vertical bore **14** of the blowout preventer **10**. Referring again to FIG. **2**B, relatively larger diameter tubular may become positioned at the centerline **76** where it may be initially engaged by the point **66** of the first upper blade **36** and the common concave are **101** of the second lower blade **38**. Relatively smaller diameter tubular may similarly become positioned at the centerline **76**, or it may become position away from the centerline **76** wherein it may be initially engaged by one of the points **96** of the second lower blade **38** and a concave arc **70** of the first upper blade **36**. Still smaller diameter tubulars may be positioned in either of these locations, or may be positioned still further away from the centerline **76** and be initially engaged by a forward angled section **72** of the first upper blade **36** and an outside flank **98** of the second lower blade **38**.

(63) The rams **24** and **26** may consists of blunt leading contours **58** and **88** running horizontally across the blades **36** and **38**. The rounded blunt leading contours **58** and **88** may terminate in two symmetric angled surfaces (upper inclined surface **60** and **80** and lower declined surface **62** and

82), where the angle between the surfaces is less than 90 degrees (inclination angle **112**+declination angle **114** shown in FIG. **4**F). Once contact is initiated with the pipe tubular D, the rounded blunt leading contour **58** will indent the pipe tubular D at which time the upper inclined surface **60** and **80** and lower declined surface **62** and **82** will begin to force the contact region open as the ram **24** and **26** continues its forward motion, thereby imparting a tensile load at the point of contact. The blade **36** and **38** may cause the pipe tubular D to fail in a ripping manner, rather than a traditional shear manner.
(64) For example, FIG. **4**G shows a cross-sectional side view of a second lower blade **38**, the upper inclined surface **80** and lower declined surface **82** surrounding the bull nose or rounded blunt leading contour **88** reduce the propensity of the blade **38** to bend during emergency disconnect operations. The rounded blunt leading contour **88** is substantially symmetric causing reaction forces in the vertical direction RF1Y and RF2Y to be balanced during closing operations. Thus, the "bull nose design" enhances the structural integrity of the blade during well control operations.
(65) FIG. **5**A shows cross-sectional side views of the first upper blade **36** and the second lower blade **38** at positions of initial engagement with a tubular D. Because the blades have inclined and declined surfaces, the blunt leading contour **58** of the first upper blade **36** and the blunt leading contour **88** of the second lower blade **38** are vertically offset from each other by an offset distance **110**. Rather than a sharp leading edge, the blades **36** and **38** present blunt leading contours **58** and **88**.
(66) FIG. **5**B shows cross-sectional side views of the first upper blade **36** and the second lower blade **38** of FIG. **5**A at positions of full engagement with the tubular D. The blades engage the tubular D in opposite horizontal inward directions to induce horizontal shear forces in the tubular D. Further, the offset distance **110** between the leading contours enables the blades to induce vertical tensile and shear forces in the tubular D. These forces combine to rip and tear the tubular D, rather than slice or cut.
(67) FIG. **6**A shows cross-sectional side views of the first upper blade **36** and the second lower blade **38** at positions of initial engagement with a wireline **120**. Because the blades have inclined and declined surfaces, the blunt leading contour **58** of the first upper blade **36** and the blunt leading contour **88** of the second lower blade **38** are vertically offset from each other by an offset distance **110**. Rather than a sharp leading edge, the blades **36** and **38** present blunt leading contours **58** and **88**. Cutting edge **64** and cutting edge **94** present sharper edges capable of cutting wireline **120**.
(68) FIG. **6**B shows cross-sectional side views of the first upper blade **36** and the second lower blade **38** of FIG. **6**A at positions of full engagement with the wireline **120**. The blades engage the tubular D in opposite horizontal inward directions so that the wireline **120** simply deforms around the blunt leading contours **58** and **88** in an S-shape. Further inward movement of the blades **36** and **38** causes the cutting edges **64** and **94** to engage and cut the wireline **120**.
(69) Referring to FIG. **7**A, a perspective view of an embodiment of a first ram **124** and a second ram **126** are shown. The rams are positioned opposite each other as they would be if positioned within the guideways **20** and **22** of the body **12** of the blowout preventer **10** (see FIGS. **1**A-**1**D). The rams also have seals similar to the embodiment shown in FIGS. **2**A-**2**B. The first ram **124** has upper guides **144** and lower guides **146** for guiding the first ram **124** in guideway **20** (see FIG. **1**A). As shown, one upper guide **144** and one lower guide **146** are on the left side of the ram and another upper guide **144** and another lower guide **146** are on the right side of the first ram **124**. The upper and lower guides **144** and **146** define guide channels **148** of the first ram **124** for receiving and guiding the second lower blade **138** of the second ram **26**.
(70) FIG. **7**B is a top view of the embodiment of the first ram **124** and the second ram **126** shown in FIG. **7**A. The first ram **124** has a first upper blade **136**, which has a blunt leading contour **158**. The second ram **126** has a second lower blade **138**, which has a cutting edge **194**.
(71) Referring to FIGS. **8**A and **8**B, top and bottom perspective views of an embodiment of a first ram **124** are shown. The first ram **124** comprises a first upper blade **136** having a blunt leading

contour **158** that extends between the upper guides **144** at the front of the blade **136**. The first upper blade **136** has upper primary inclined surfaces **160** extending from the blunt leading contour **158** to upper secondary inclined surfaces **161**. At the leading most portions of the bottom side **150**, the blade **136** has a cutting edge **164**. The first upper blade **136** also has lower inclined surfaces **162** extending from the blunt leading contour **158** to the cutting edge **164**. The cutting edge **164** is a very short substantially vertical front side of the blade **136** that meets the bottom side **150**. The first upper blade **136** also has lower declined surfaces **162** extending from the blunt leading contour **158** to the cutting edge **164**. In the middle of the blunt leading contour **158**, the first upper blade **136** has a concave arc **170** and the left and right sides have forward angled sections **172**.

(72) FIG. **8**C shows a front view of the first ram **124**. As clearly shown in this view, the first upper blade **136** is flat and horizontal on its bottom side **150**. The top side **152** of the first upper blade **136** is also flat and horizontal so as to fit within a guideway **20**. The blunt leading contour **158** extends between the upper guides **144** at the front of the blade **136**.

(73) FIG. **8**D shows a top view of the first ram **124**. In this view, the profile of the blunt leading contour **158** is shown extending between the upper guides **44**. In the middle of the blunt leading contour **158**, the first upper blade **136** has a concave arc **170** and the left and right sides have forward angled sections **172**. The first upper blade **136** has upper primary inclined surfaces **160** extending from the blunt leading contour **158** to upper secondary inclined surfaces **161**. In one embodiment, the inclination angle of the upper primary inclined surfaces **160** of the first upper blade **136** may be about 75 degrees from horizontal and the inclination angle of the upper secondary inclined surfaces **161** of the first upper blade **136** may be about 60 degrees from horizontal. (See FIG. **8**C).

(74) Referring to FIG. **8**E, a bottom view is shown of the embodiment of the first ram **124** of FIGS. **8**A-**8**D. In this view, the bottom side of the first upper blade **136** is visible between the lower guides **146**. A seal channel **142** is located in the bottom side **150**. A seal may be positioned in the seal channel **142** for sealing engagement between the first upper blade **136** and the second lower blade **138** (see FIG. **2**) when the rams are closed. The profile of the blunt leading contour **158** is also visible in FIG. **8**E. Further, from this perspective, the cutting edge **164** is also visible. The cutting edge **164** has a profile similar to the blunt leading contour **158**. Lower decline surfaces **162** extend between the blunt leading contour **158** and the cutting edge **164**.

(75) FIG. **8**F shows a right side view of the first ram **124**. An upper guide **144** is at the top of the first ram **124** and a lower guide **146** is at the bottom of the first ram **124**. A guide channel **148** is bounded between the upper and lower guides **144** and **146**. In this view, the depth and width of the seal channel **142** are clearly visible. In one embodiment, the declination angle of the lower declined surfaces **162** of the first upper blade **136** may be about 45 degrees from horizontal. (See FIG. **8**C).

(76) Referring to FIGS. **9**A and **9**B, top and bottom perspective views of an embodiment of a second ram **126** are shown. The second ram **126** comprises a second lower blade **138** having a top side **192**, and a bottom side **190**. At the leading most portions of the top side **192**, the blade **138** has a cutting edge **194**. The cutting edge **194** is a very short substantially vertical front side of the blade **138** that meets the top side **192** at a substantially 90 degree corner. The second lower blade **138** has lower primary declined surfaces **182** extending from the cutting edge **194** to lower secondary declined surfaces **183**, which extend to the bottom side **190**.

(77) FIG. **9**C shows a front view of the second ram **126**. The top side **192** is substantially flat and horizontal. The bottom side **190** is also substantially flat, but it is slightly declined from its leading end toward its trailing end.

(78) FIG. **9**D shows a bottom view of the second ram **126**. In this view, the profile of the cutting edge **194** is shown at the leading portion of the second lower blade **138**. The cutting edge **194** is symmetrical about the centerline **176**. A concave arc **200** is at the mid-section and a forward angled section **172** is on each side. The concave arc **200** merges into the forward angled sections **172**. The concave arc **200** has a radius about 50% the width of the second lower blade **138**. The forward

angled sections **172** sweep forwardly at an angle of about 80 degrees from the centerline **76**.
(79) Referring to FIG. **9**E, a top view is shown of the embodiment of the second ram **126** of FIGS. **9**A-**9**D. In this view, the top side **192** of the second lower blade **138** is visible. The profile of the cutting edge **194** is also visible in FIG. **9**E.
(80) FIG. **9**F shows a left side view of the second ram **126**. The cutting edge **194** is located at the distal end of the second lower blade **138**. The top side **192** is opposite the bottom side **190**. A lower primary declined surface **182** extends between the cutting edge **194** and a secondary declined surface **183**, which extends to a bottom side **190** of the blade **138**. In this embodiment, the lower primary declined surface **182** has a declination angle **214** of about 83 degrees from horizontal **216**. In this embodiment, the lower secondary declined surface **183** has a declination angle **215** of about 60 degrees from horizontal **216**.
(81) As represented on FIGS. **10**A through **10**E, in embodiments of the disclosure, the forward angled sections **72** of the first upper blade **36** and the forward angled sections **104** of the second lower blade **38** are such that the resulting blade geometries can induce or drive motion on the drill pipe or tubular D, pushing it into a position designed to impart maximum force onto such tubular. The design of the rams are not intended to centralize the pipe or tubular D with the rams' central axis, but rather induce motion of the pipe or tubular D into one of a plurality (here shown are three different) of locations designed to impart maximum load onto the tubular in order to successfully shear or rip it. In embodiments, the forward angled sections and other portions of the profiles are designed in such a manner that the pipe or tubular D will be pushed into one of these locations regardless of its original starting position. In embodiments as shown on FIGS. **10**A and **10**B, the pipe is excentered on a far side of the rams (FIG. **10**A) and the profiles of the leading contours of the blades enables, when the rams are moved towards a closed position, the pipe or tubular D to be driven to the preferred immediately following location (FIG. **10**B) where optimum shearing or ripping can occur. Similarly, as shown on FIG. **10**D, the pipe is excentered on the other far side of the ram (FIG. **10**D) and the profiles of the leading contours of the blades of the rams enable, when the rams are moved towards a closed position, the pipe or tubular D to be driven to the preferred immediately following location (FIG. **10**E) where optimum shearing or ripping can occur. In FIG. **10**C, the pipe or tubular D is shown in a location appropriate for optimum shearing or ripping, and thus, the profiles of the leading contours of the blades do not induce movement of the pipe or tubular D when rams are closing.
(82) Although the disclosed embodiments are described in detail in the present disclosure, it should be understood that various changes, substitutions and alterations can be made to the embodiments without departing from their spirit and scope.
INDUSTRIAL APPLICABILITY
(83) Blowout preventer systems and methods of the present invention have many industrial applications including but not limited to preventing blowouts in drilled well bores for the oil and gas industry.

Claims

1. A blowout preventer for shearing, cutting, ripping, or tearing a structure positioned in a bore extending through the blowout preventer, the blowout preventer comprising: a body having a bore, a first guideway, and a second guideway; a first ram movably positioned relative to the first guideway and movable toward the bore, the first ram comprising a first blade, the first blade comprising: at least one flat side; a first blunt leading contour running parallel to a plane of the at least one flat side along a distal end of the first blade; at least one upper inclined surface above the first blunt leading contour; and at least one lower declined surface below the first blunt leading contour, wherein the first blade is positioned and is movable above a first plane; a second ram movably positioned relative to the second guideway and movable toward the bore, the second ram

comprising a second blade, the second blade comprising: a second blunt leading contour; and at least one lower declined surface, wherein the second blade is positioned and is movable below the first plane.
2. The blowout preventer as claimed in claim 1, wherein the first blunt leading contour and the second blunt leading contour are vertically offset from each other by an offset distance.
3. The blowout preventer as claimed in claim 1, wherein the first blunt leading contour is disposed on and movable in a second plane, wherein the first plane, the second plane, and the plane of the at least one flat side of the first blade are parallel, and wherein the at least one lower declined surface of the first blade is between the first and second planes.
4. The blowout preventer as claimed in claim 3, wherein the second blunt leading contour comprises at least one upper inclined surface above the second blunt leading contour, wherein the second blunt leading contour is movable in a third plane, the first and third planes are parallel, and the at least one upper inclined surface of the second blade is between the first and third planes.
5. The blowout preventer as claimed in claim 1, wherein the first blade further comprises a first cutting edge below the at least one lower declined surface, and wherein the second blade further comprises a second cutting edge.
6. The blowout preventer as claimed in claim 1, wherein the first blunt leading contour comprises a profile having at least one point.
7. The blowout preventer as claimed in claim 1, wherein the second blunt leading contour comprises a profile having at least two points.
8. The blowout preventer as claimed in claim 1, wherein the first blunt leading contour comprises a profile having at least one point, wherein the second blunt leading contour comprises a profile having at least two points.
9. The blowout preventer as claimed in claim 1, wherein the first blunt leading contour comprises a profile having at least two concave arcs, and wherein the second blunt leading contour comprises a profile having at least one concave arc.
10. The blowout preventer as claimed in claim 9, wherein each of the at least two concave arcs of the first blunt leading contour merges into a first forward angled section, and wherein the at least one concave arc of the second blunt leading contour merges into a second forward angled section.
11. The blowout preventer as claimed in claim 2, wherein the first blade further comprises a first cutting edge below the at least one lower declined surface, wherein the second blade further comprises a second cutting edge, and wherein the structure is a wireline.
12. A blowout preventer for shearing, cutting, ripping, or tearing a structure positioned in a bore extending through the blowout preventer, the blowout preventer comprising: a body having a bore, a first guideway, and a second guideway; a first ram movably positioned relative to the first guideway and movable toward the bore, the first ram comprising a first blade, the first blade comprising: at least one flat side; a first blunt leading contour running parallel to a plane of the at least one flat side along a distal end of the first blade; at least one upper inclined surface above the first blunt leading contour, wherein the at least one upper inclined surface forms an angle between about 120 and 160 degrees with the at least one flat side, and at least one lower declined surface below the first blunt leading contour, wherein the at least one lower declined surface forms an angle between about 60 and 100 degrees with the at least one upper inclined surface; a second ram movably positioned relative to the second guideway and movable toward the bore, the second ram comprising a second blade, the second blade comprising: at least one flat side; a second blunt leading contour; and at least one lower declined surface, wherein the first blunt leading contour and the second blunt leading contour are vertically offset from each other by an offset distance.
13. The blowout preventer as claimed in claim 12, wherein the second blade further comprises at least one upper inclined surface above the second blunt leading contour, wherein the at least one upper inclined surface forms an angle between about 120 and 160 degrees with the flat side, and wherein the at least one lower declined surface of the second blade forms an angle between about

60 and 100 degrees with the at least one upper inclined surface of the second blade.

14. The blowout preventer as claimed in claim 12, wherein the first blade further comprises a first cutting edge below the at least one lower declined surface, and wherein the second blade further comprises a second cutting edge.

15. The blowout preventer as claimed in claim 12, wherein the first blunt leading contour comprises a profile having at least one point and flanks on opposite sides of the at least one point, wherein the flanks form an angle of about 110 to 150 degrees at the at least one point, wherein the second blunt leading contour comprises a profile having at least two points.