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(54) SYSTEMS AND METHODS FOR CUTTING A TUBULAR MEMBER

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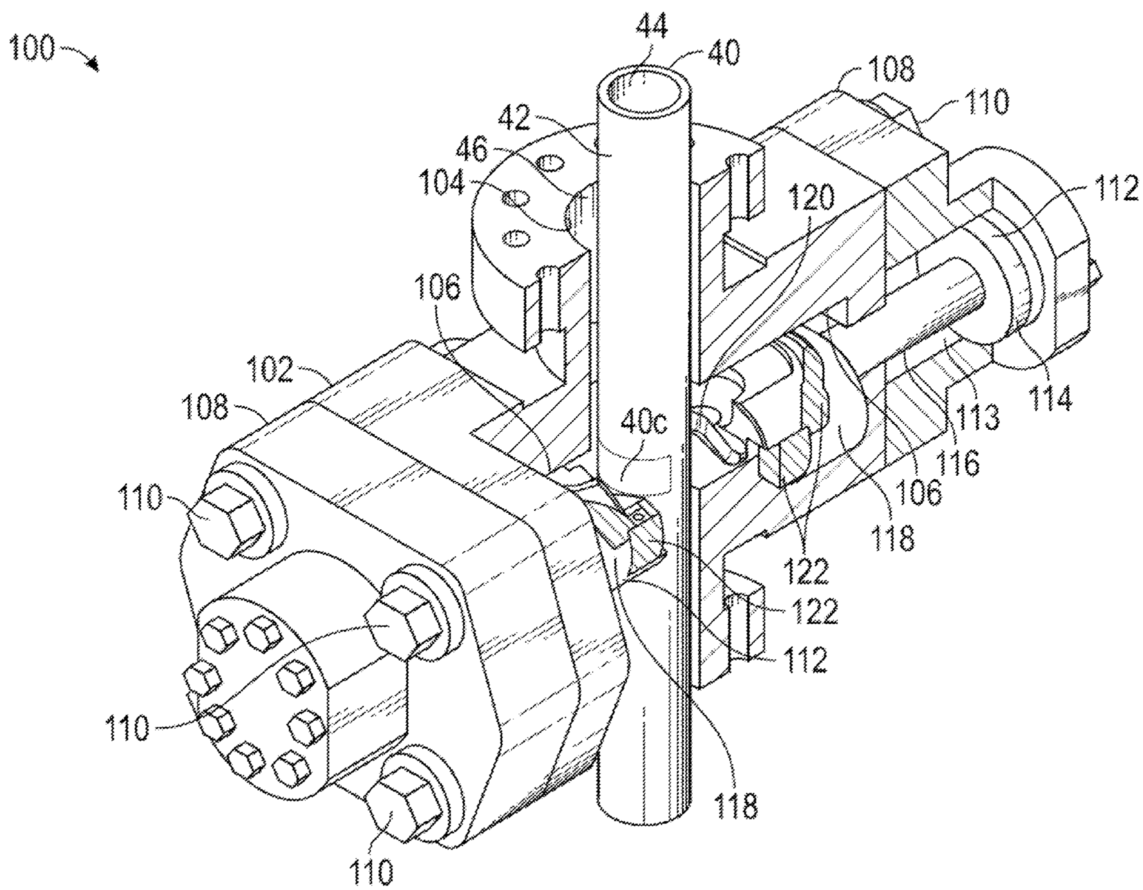
(57) **ABSTRACT**

A closure device for cutting a tubular member includes a housing, and a cutting member disposed in the housing, wherein the cutting member is coupled to a heating element, wherein the cutting member is configured to transfer heat to a tubular member from the heating element to cause a loss of mechanical integrity of the tubular member as the cutting member physically engages the tubular member.



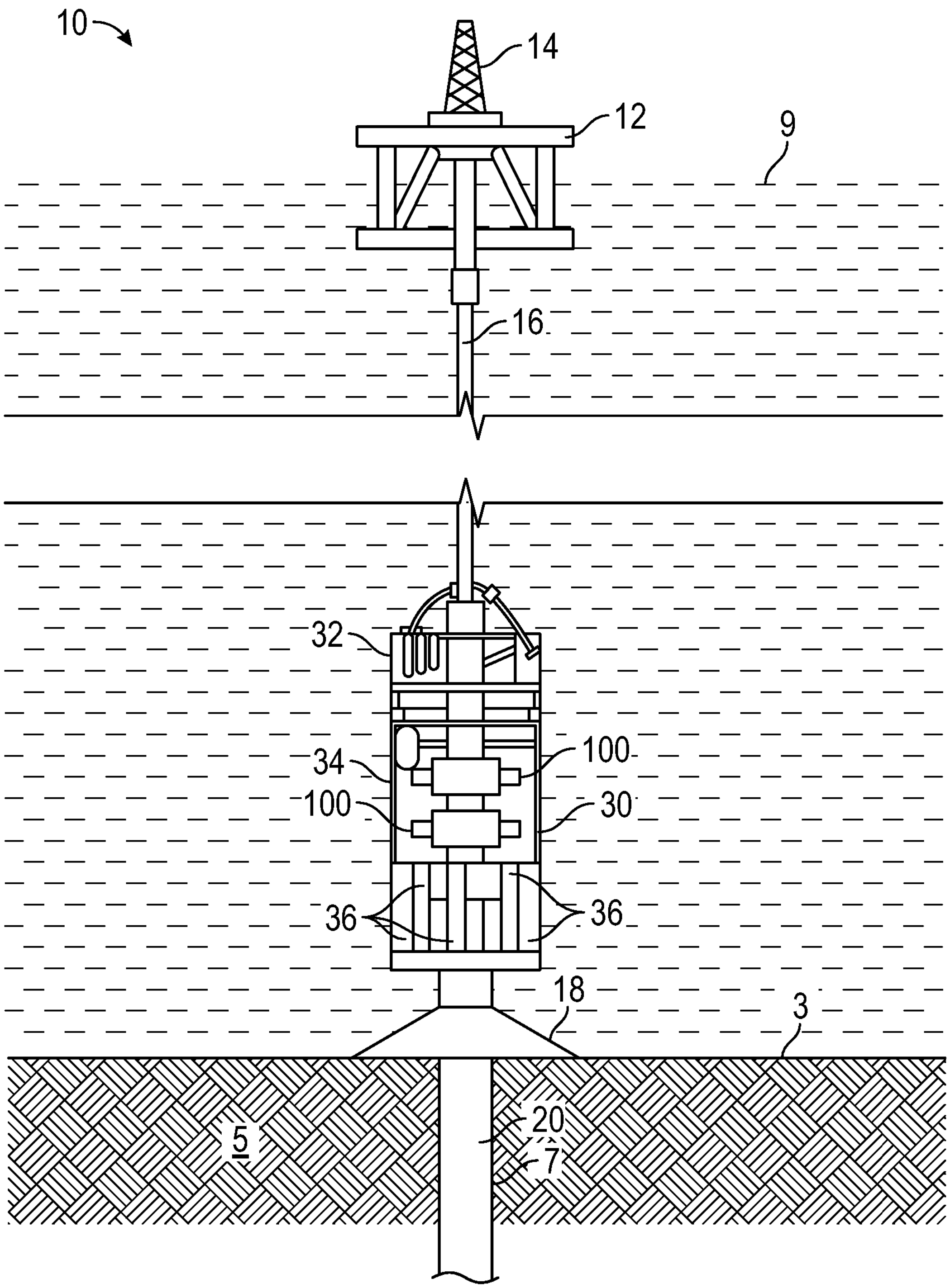
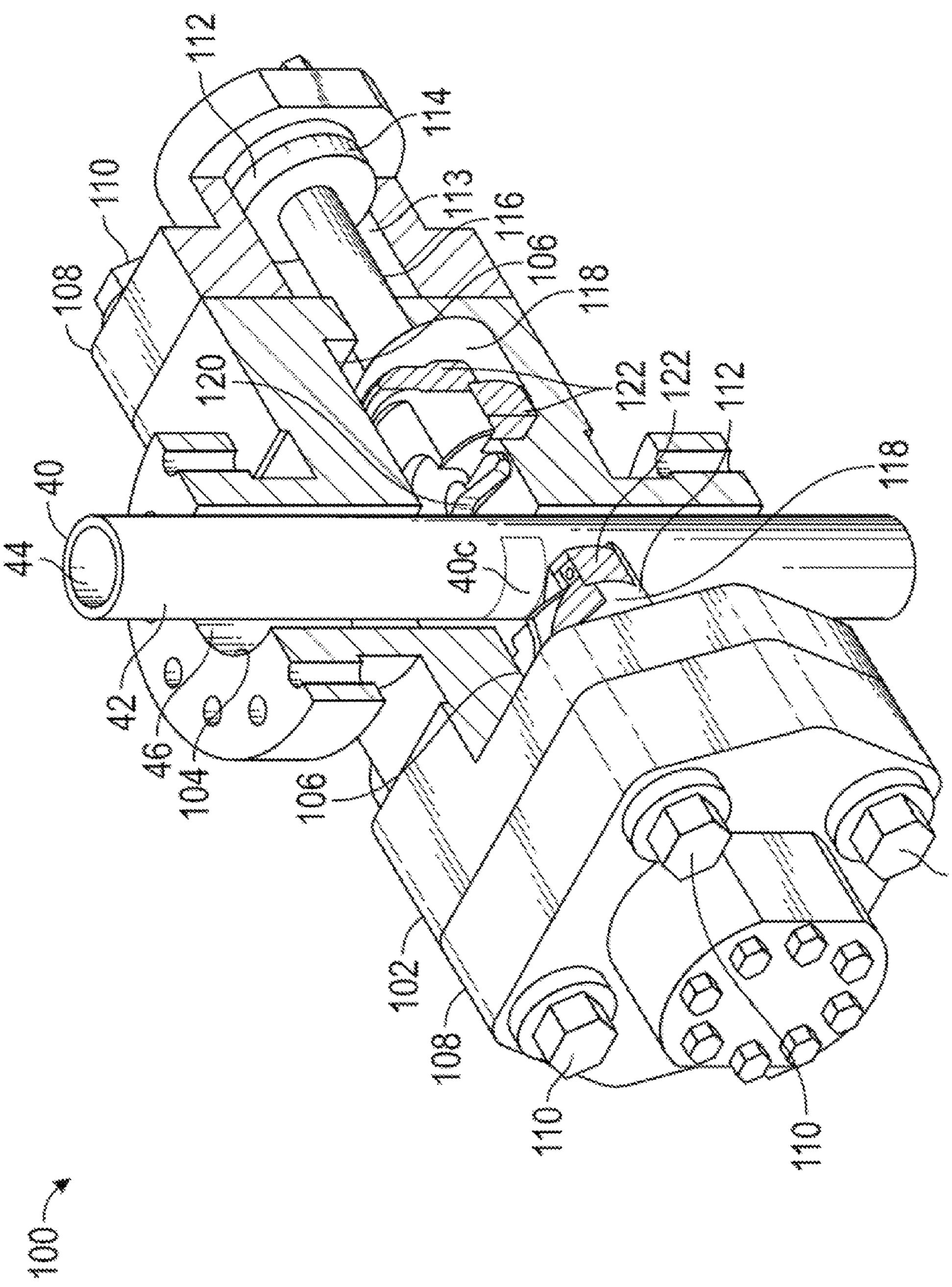


FIG. 1


112
114
110
113
116
108
106
118
120
122
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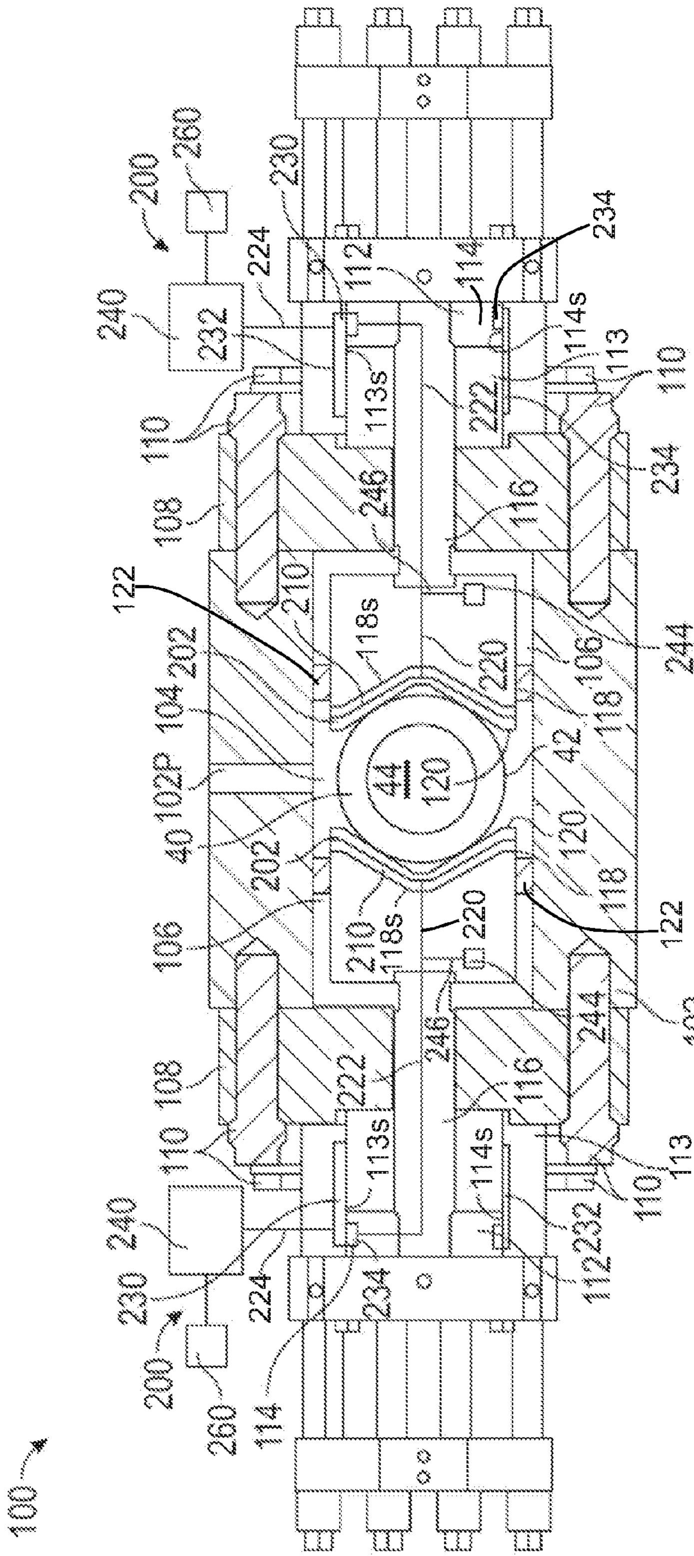
44
118
40c
42
46
104
106
102
108
110
110
110
100

FIG. 2



260
200
230
240
232
224
112
114
234
114s
113
110
113s
222
108
246
116
122
210
118s
202
104
102P
40
44
120
42
118
106
220
244
102
100

FIG. 3

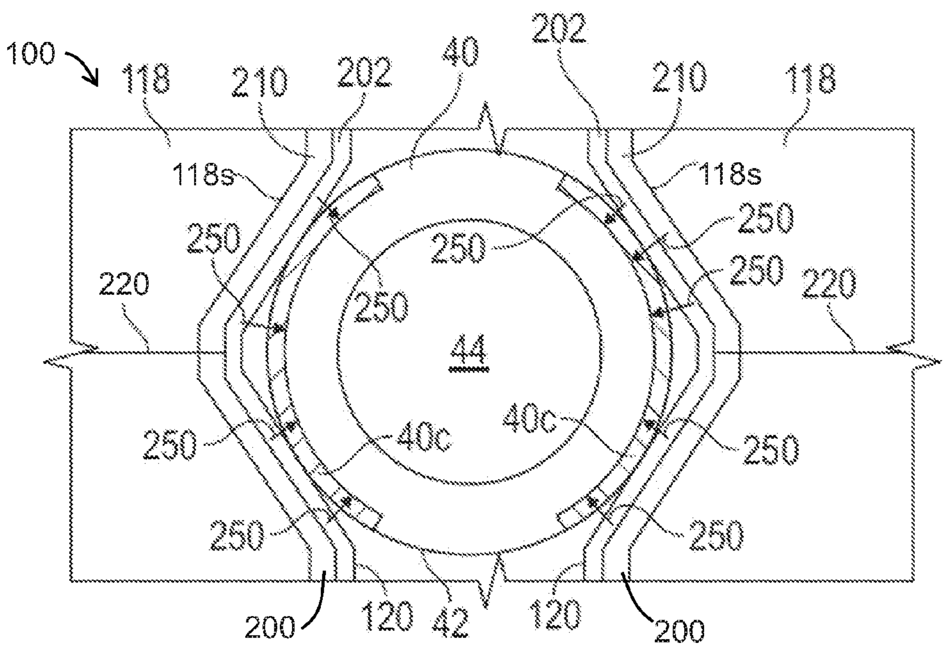

100
118
210
202
40
202
210
118
118s
118s
250
250
250
250
250
250
220
220
44
250
40c
40c
250
250
250
250
200
120
42
120
200

FIG. 4

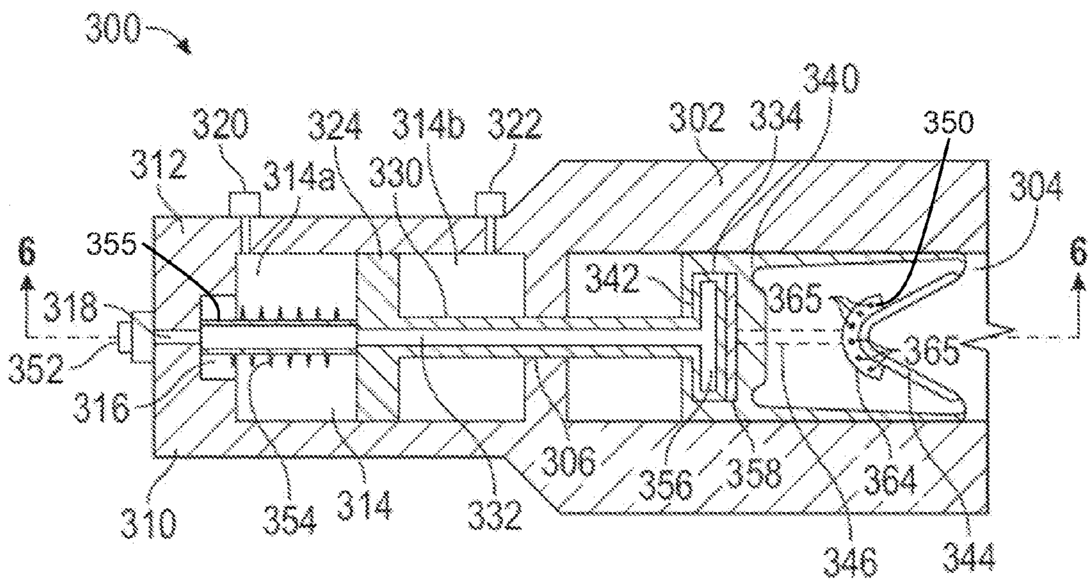

300
320
324
314b
322
302
334
340
350
304
312
314a
330
6
355
342
365
6
318
365
352
316
306
356
358
364
310
354
314
332
346
344

FIG. 5

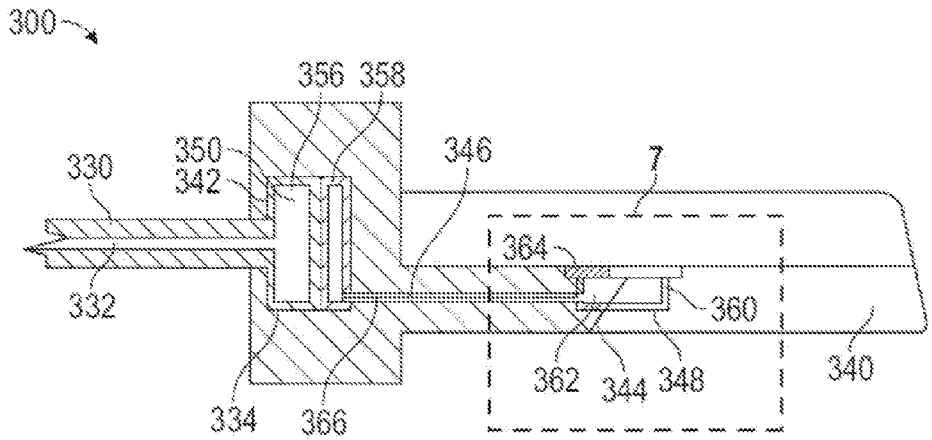


FIG. 6

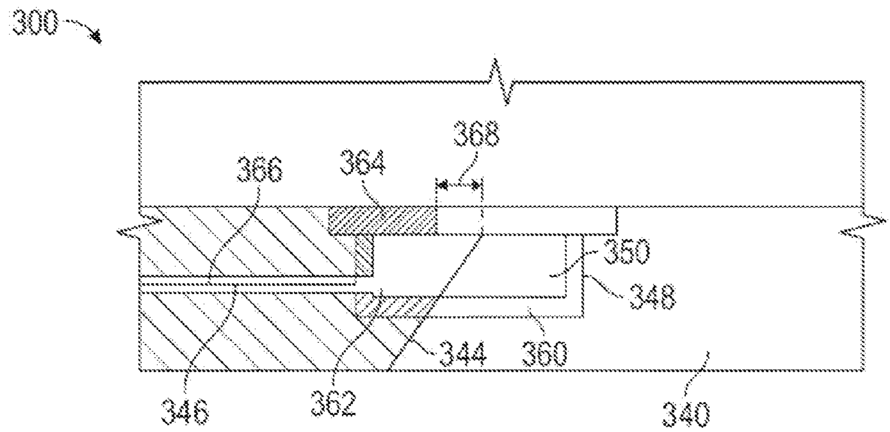


FIG. 7

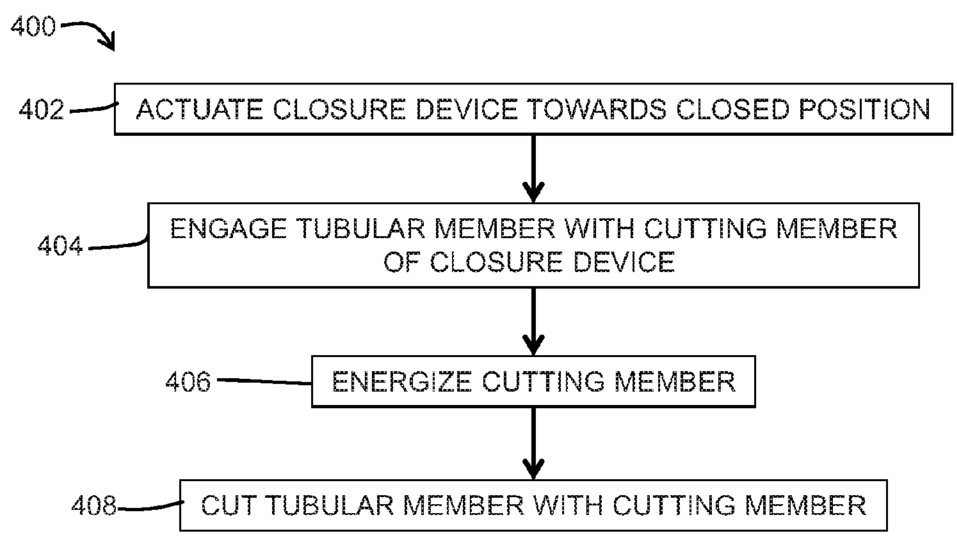


FIG. 8

SYSTEMS AND METHODS FOR CUTTING A TUBULAR MEMBER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND

[0003] Hydrocarbon drilling systems utilize drilling fluid or mud for drilling a wellbore in a subterranean earthen formation. Drilling systems often utilize a blowout preventer (BOP) stack or system to seal, control, and monitor the wellbore to prevent an uncontrolled release of wellbore fluids to the surrounding environment, such as in the event of an uncontrolled influx of fluid from the formation into the wellbore. BOP stacks may comprise one or more actuatable valves or mechanical devices, such as ram and annular BOPs. In offshore applications, the BOP stack may further include electrical and hydraulic lines, control pods, hydraulic accumulators, kill and choke lines, and a support frame. Ram BOPs of the BOP stack typically comprise a pair of opposed rams that are actuated rectilinearly towards a central throughbore or chamber of the ram BOP, where the rams of the ram BOP may comprise, among others, pipe rams for closing around a drill pipe extending through the central throughbore, shear rams for shearing a drill pipe extending through the central throughbore, and blind shear rams for both shearing the drill pipe and sealing the wellbore. Drilling systems employing relatively longer and deeper wellbores, including deviated wellbores, may employ higher-strength drill pipe comprising a larger size and/or wall thickness. These systems may necessitate the use of larger, more powerful shear rams configured for shearing larger, higher-strength drill pipe. Moreover, the use of higher-strength drill pipe may increase the time required by the shear rams to successfully shear the drill pipe in response to the actuation of the ram BOP.

SUMMARY

[0004] An embodiment of a closure device for cutting a tubular member comprises a housing, and a cutting member disposed in the housing, wherein the cutting member is coupled to a heating element, wherein the cutting member is configured to transfer heat to a tubular member from the heating element to cause a loss of mechanical integrity of the tubular member as the cutting member physically engages the tubular member. In some embodiments, the cutting member is configured to unequally distribute a thermal flux from the heating element to the tubular member along a partial circumference of the tubular member. In some embodiments, the cutting member is configured to transfer heat to a tubular member from the heating element using thermal conduction when the cutting member physically engages the tubular member. In certain embodiments, the closure device further comprises a retaining member frangibly coupling the heating element to the cutting member. In certain embodiments, the heating element comprises an induction heating element. In some embodiments, the heating element forms a cutting edge of the cutting member. In some embodiments, the closure device further comprises a thermal insulator disposed between the heating element and the cutting member. In certain embodiments, the closure device further comprises a power supply connected to the heating element and configured to store and selectably transfer energy to the heating element.

[0005] An embodiment of a closure device for cutting a tubular member comprises a housing, a heating element disposed in the housing, and a cutting member slidably disposed in the housing, wherein the heating element is configured to unequally distribute a thermal flux along a circumference of the tubular member when the cutting member physically engages the tubular member. In some embodiments, the cutting member is configured to transfer heat to a tubular member from the heating element using thermal conduction when the cutting member physically engages the tubular member. In some embodiments, the closure device comprises a ram blowout preventer and the cutting member comprises a ram block. In certain embodiments, the closure device further comprises a telescoping member extending between a bonnet and a slidable piston of the blowout preventer, wherein the telescoping member is configured to extend and retract as the piston is displaced through the blowout preventer, and a power cable electrically connected with the heating element, wherein the power cable is disposed about the telescoping member. In certain embodiments, the bonnet comprises a recess extending therein, and the telescoping member extends between the recess and the slidable piston. In some embodiments, the closure device further comprises a power supply connected to the heating element and configured to store and selectably transfer energy to the heating element. In some embodiments, the power supply comprises a capacitor array. In certain embodiments, the closure device further comprises a sensor disposed in the housing and configured to detect physical engagement between the cutting member and the tubular member, and a controller connected to the sensor and power supply, wherein the controller is configured to cause the power supply to transfer energy to the heating element in response to receiving a signal from the sensor indicating physical engagement between the cutting member and the tubular member. In certain embodiments, the heating element comprises an inductive heating element.

[0006] An embodiment of a method for cutting a tubular member comprises engaging an engagement portion of a tubular member with a cutting member, energizing a heating element, transferring heat from the heating element to the engagement portion of the tubular member via thermal conduction between the cutting member and the tubular member, and physically cutting the tubular member with the cutting member. In some embodiments, the engagement portion extends along only a portion of the circumference of the tubular member. In some embodiments, the method further comprises unequally distributing a thermal flux along a circumference of the tubular member. In certain embodiments, the method further comprises physically engaging the tubular member with the heating element, wherein the heating element is coupled to the cutting member. In certain embodiments, the method further comprises frangibly decoupling the heating element from the cutting member in response to the heating element fusing to the tubular member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a detailed description of exemplary embodiments, reference will now be made to the accompanying drawings in which:

[0008] FIG. **1** is a schematic view of an embodiment of a drilling system including an embodiment of a BOP stack in accordance with principles disclosed herein;

[0009] FIG. **2** is a cross-sectional perspective view of an embodiment of a ram BOP of the BOP stack of FIG. **1** in accordance with principles disclosed herein;

[0010] FIG. **3** is a cross-sectional, schematic top view of the ram BOP of FIG. **2**;

[0011] FIG. **4** is an enlarged view of the cross-sectional view of FIG. **3**;

[0012] FIG. **5** is a cross-sectional top view of another embodiment of a ram BOP in accordance with principles disclosed herein;

[0013] FIG. **6** is a cross-sectional side view along lines **6-6** of FIG. **5** of the ram BOP of BOP of FIG. **5**;

[0014] FIG. **7** is an enlarged view of the cross-sectional view of FIG. **6** of the ram BOP of FIG. **5**; and

[0015] FIG. **8** is a flowchart showing an embodiment of a method for inductively cutting a tubular member in accordance with principles disclosed herein.

DETAILED DESCRIPTION

[0016] In the drawings and description that follow, like parts are typically marked throughout the specification and drawings with the same reference numerals. The drawing figures are not necessarily to scale. Certain features of the disclosed 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. The present disclosure is susceptible to embodiments of different forms. Specific embodiments are described in detail and are shown in the drawings, with the understanding that the present disclosure is to be considered an exemplification of the principles of the disclosure, and is not intended to limit the disclosure to that illustrated and described herein. 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.

[0017] Unless otherwise specified, 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 . . . ". Any use of any form of the terms "connect", "engage", "couple", "attach", or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the elements and may also include indirect interaction between the elements described. The various characteristics mentioned above, as well as other features and characteristics described in more detail below, will be readily apparent to those skilled in the art upon reading the following detailed description of the embodiments, and by referring to the accompanying drawings.

[0018] FIG. **1** is a schematic diagram illustrating an embodiment of a drilling system **10**. In an embodiment, drilling system **10** comprises a system for cutting a tubular member, such as a drill pipe, by reducing the mechanical integrity of the tubular member through inductive heating. The drilling system **10** can be configured to extract various minerals and natural resources, including hydrocarbons (e.g., oil and/or natural gas), or configured to inject substances into a sea floor **3** and a subterranean earthen formation **5** via a well or wellbore **7**. In this embodiment, drilling system **10** generally includes a drilling vessel **12** disposed at a surface or waterline **9**, a wellhead **18** secured to the sea floor **3** via a casing conductor **20** that extends into the formation **5**, a marine riser **16** extending towards the sea floor **3** from the drilling vessel **12**, and a blowout preventer (BOP) assembly **30** disposed beneath the waterline **9** and connected to a lower end of the riser **16**. In this embodiment, vessel **12** is a floating platform, and thus, may also be referred to as platform **12**, and includes a drilling derrick **14**. In other embodiments, the vessel (e.g., vessel **12**) can be a drill ship or any other vessel disposed at the sea surface for conducting offshore drilling and/or production operations.

[0019] In this embodiment, BOP assembly **30** includes a pair of closure devices or ram BOPs **100** coupled to the upper end of wellhead **18** and a lower marine riser package (LMRP) **32** connected to the lower end of marine riser **16**. During drilling operations, riser **16** takes drilling/formation fluid returns to platform **12**. Further, riser **16** is coupled to electrical and hydraulic lines (not shown) for powering and controlling the actuation of components of BOP assembly **30**, including ram BOPs **100**. BOP assembly **30** is generally configured to provide emergency pressure control of drilling/formation fluid in the wellbore **7** should a sudden pressure surge escape the formation **5** into the wellbore **7**. BOP assembly **30** may thereby prevent damage to the drilling vessel **12** and the marine riser **16** from fluid pressure exiting wellhead **18**. In this embodiment, BOP assembly **30** also includes a frame **34** for physically supporting components of BOP assembly **30**, including ram BOPs **100**, and a plurality of accumulators **36** configured to provide backup hydraulic fluid pressure for actuating components of BOP assembly **30**, such as ram BOPs **100**. Although ram BOPs **100** are shown in FIG. **1** as forming a part of offshore drilling system **10**, in other embodiments, ram BOPs **100** may be utilized in other applications, such as conventional, land based drilling systems.

[0020] Referring to FIGS. **2-4**, a cross-sectional perspective view of one of the ram BOPs **100** of BOP assembly **30** is shown. In this embodiment, ram BOP **100** generally includes a body or housing **102** and a pair of bonnet assemblies **108**. Housing **102** of ram BOP **100** includes a longitudinally extending throughbore **104** and laterally extending ram guideways **106**. Each bonnet assembly **108** is coupled or mounted to the housing **102** with fasteners **110** and aligned with ram guideways **106**. Housing **102** includes a laterally extending fluid passage **102**P in fluid communication with the throughbore **104** of housing **102**. Each bonnet assembly **18** includes an actuation assembly **112** configured to actuate ram BOP **100** between an open position (shown in FIG. **2**) allowing for the continuous passage of a tubular member or drill pipe **40** through throughbore **104**, and a closed position restricting the continuous passage of drill pipe **40** through throughbore **104**. Further, in this embodiment, in the open position of ram BOP **100** the passage of a fluid flow through throughbore **104** is permitted, while in the closed position, the passage of fluid flow through throughbore **104** is restricted. In this embodiment, each actuation assembly **112** generally includes an operating cylinder **113**, a piston **114**, a connecting rod **116**, and a cutting member or ram block **118**. While only one ram guideway **106** and actuation assembly **112** are completely shown in FIG. **2**, it is understood by those of ordinary skill in the art that there is a pair of ram guideways **106** and actuation assembly **112**. The connecting rod **116** of each actuation assembly **112** extends between and couples with a corresponding piston **114** and ram block **118**. In this arrangement, hydraulic pressure may be inputted to the cylinders **113** to apply fluid pressure against the pistons **114** disposed therein to displace the pistons **114** through cylinders **113**, thereby displacing the coupled ram blocks **118** into or out of the throughbore **104** of housing **102** to actuate ram BOP **100** between the open and closed positions.

[0021] Referring to FIGS. **2-4**, in this embodiment, ram BOP **100** comprises a blind shear ram BOP, and thus, ram blocks **118** are configured to physically engage and shear drill pipe **40** extending through throughbore **104** of housing **102** until drill pipe **40** is sheared into two separate pieces. Particularly, each ram block **118** includes a cutting edge **120** for physically engaging an outer surface **42** of the drill pipe **40**, where drill pipe **40** extends through the marine riser **16**, BOP assembly **30**, and wellhead **18** of drilling system **10** shown in FIG. **1**. Further, in this embodiment, ram blocks **118** include seals **122** for sealing against an inner surface of ram guideways **106**. In this manner, when ram BOP **100** is actuated into the closed position cutting or shearing drill pipe **40**, flow is restricted through an inner throughbore **44** of drill pipe **40** and an annulus **46** formed between the outer surface **42** of drill pipe **40** and the inner surface of the throughbore **104** of housing **102**.

[0022] As shown particularly in FIGS. **3** and **4**, in this embodiment, each actuation assembly includes an inductive heating assembly **200** generally configured to heat an engagement portion or interface **40***c* (shown in FIG. **4**) of drill pipe **40** when ram BOP **100** is actuated into the closed position and the cutting edge **120** of each ram block **118** shears the drill pipe **40**. Although FIG. **3** illustrates each actuation assembly **112** of ram BOP **100** as including an inductive heating assembly **200**, in other embodiments, only one of the actuation assemblies **112** of ram BOP **100** may include an inductive heating assembly **200**. Further, although in this embodiment inductive heating assembly **200** is utilized with blind shear ram BOP **100**, in other embodiments, inductive heating assembly **200** may be utilized in shear ram BOPs that are not configured to seal a throughbore extending therethrough (i.e., are not "blind" shear ram BOPs), or in other components of drilling systems actuatable to shear, cut, or sever a member, such as a tubular member or drill pipe.

[0023] Particularly, each inductive heating assembly **200** is configured to heat the engagement portion **40***c* of drill pipe **40** to be cut by ram blocks **118** to a temperature sufficient to cause a loss of mechanical integrity in drill pipe **40**, such as by weakening or decreasing the yield strength the engagement portion **40***c* of drill pipe **40**, thereby reducing the necessary pressure force applied against piston **114** and/or the necessary time required to completely cut engagement portion **40***c* of drill pipe **40** by ram block **118**. In this manner, given that the force required to cut drill pipe **40** is reduced via the reduction of mechanical integrity of drill pipe **40**, the hydraulic pressure necessary to cut drill pipe **40** via ram blocks **118** is also reduced. Thus, the necessary hydraulic pressure supplied to cylinders **113** of ram BOP **100** (i.e., the operating pressure of ram BOP **100**) for cutting drill pipe **40** is thereby minimized. In certain embodiments, the inductive heating assembly **200** of each actuation assembly **112** is configured to heat the engagement portion **40***c* of drill pipe **40** to an annealing temperature of the material (e.g., steel) comprising drill pipe **40**. In certain embodiments, the inductive heating assembly **200** of each actuation assembly **112** is configured to heat the engagement portion **40***c* of drill pipe **40** to a high temperature austenite phase of the material (e.g., steel) comprising drill pipe **40**.

[0024] In this embodiment, the inductive heating assembly **200** of each actuation assembly **112** generally includes a heating element **202**, a thermal insulator, **210**, conductors **220**, **222**, and **224**, an inductive coupler **230**, a power supply **240**, a sensor **244**, and a controller **260**. The heating element **202** of each inductive heating assembly **200** is configured to rapidly heat engagement portion **40***c* of drill pipe **40** in response to receiving energy from the power supply **240**, where the power is transferred from the power supply **240** to the heating element **202** via conductors **220**, **222**, **224**, and inductive coupler **230**. In this embodiment, conductors **220**, **222**, and **224** comprise insulated electric cables; however, in other embodiments, conductors **220**, **222**, and **224** may comprise other electrical conductors known in the art, such as busbars, etc. In this arrangement, heating element **202** comprises the cutting edge **120** of each ram block **118**. In this embodiment, the heating element **202** of each inductive heating assembly **200** comprises an induction heating element configured to rapidly heat engagement portion **40***c* of drill pipe **40** in response to receiving electrical power from power supply **240** and generally includes a conductor, an electromagnet, and an electronic oscillator (not shown) for passing a high-frequency alternating current through the electromagnet and generating eddy currents in the conductor that produce heat through ohmic heating; however, in other embodiments, heating element **202** may comprise other heating elements known in the art.

[0025] The thermal insulator **210** of each inductive heating assembly **200** is generally configured to limit or decrease the amount of flux of thermal energy from the heating element **202** to the material composing ram block **118**, where the thermal energy produced by heating element **202** could potentially jeopardize the mechanical properties of ram block **118**. Thus, thermal insulator **210** is configured to restrict the passage of thermal energy from heating element **202** to ram block **118** such that the material (e.g., steel) comprising ram block **118** is not damaged nor the mechanical properties of the material comprising ram block **118** materially degraded so as to jeopardize the operation of ram block **118** when ram BOP **100** is actuated into the closed position. The thermal insulator **210** of each inductive heating assembly **200** is coupled or attached to an attachment surface **118***s* of ram block **118**, thereby interposing thermal insulator **210** between heating element **202** and ram block **118** such that heating element **202** does not directly contact ram block **118**.

[0026] In this embodiment, thermal insulator **210** comprises a composite ceramic material; however, in other embodiments, thermal insulator **210** may comprise other materials known in the art suitable for restricting or limiting heat transfer between the heating element **202** and ram block **118**. In still further embodiments, the inductive heating assembly **200** of each actuation assembly **112** may not include a thermal insulator, and instead, the ram block **118**

of each actuation assembly **112** may comprise a material (e.g., temperature resistant steel, etc.) configured for operation at high temperatures.

[0027] The inductive coupler **230** is configured to pass the electrical power provided by power supply **240** from external conductor **224**, which is disposed exterior of housing **102** and connects with power supply **240**, to internal conductor **222**, which is disposed within housing **102** of ram BOP **100**, and connects with heating element **202**. In this embodiment, inductive coupler **230** comprises a first or outer annular inductive coupler **232**, and a second or inner annular inductive coupler **234**. The outer inductive coupler **232** is disposed along an inner surface **113***s* of cylinder **113**. The inner inductive coupler **234** is disposed along an outer surface **114***s* of piston **114**, and thereby is disposed directly adjacent with, or physically contacts, the outer inductive coupler **232**. Also, the outer inductive coupler **232** extends longitudinally along the inner surface **108***s* of bonnet **108** a sufficient distance such that outer coupler **232** and inner coupler **234** remain positioned directly adjacent in both the open and closed positions of ram BOP **100**. In this manner, electrical power may be communicated across inductive coupler **230** as ram BOP **100** is actuated from the open position into the closed position.

[0028] In this embodiment, each inductive coupler **232** and **234** of inductive coupler **230** generally includes an electrical conductor coiled about a magnetic member such that an electrical current applied to the conductor of one inductive coupler (**232** or **234**) is induced in the corresponding inductive coupler (**232** and **234**) via the physical proximity of the inductive couplers **232** and **234**, obviating the need of passing an electrical conductor between the piston **114** and bonnet **108**. However, in other embodiments, inductive coupler **230** may comprise other couplers known in the art that are configured for passing electrical power without requiring the passage of an electrical conductor. Moreover, in still further embodiments, the inductive heating assembly **200** of each actuation assembly **112** may include a single electrical conductor extending between the power supply **240** and heating element **202**.

[0029] The power supply **240** of each inductive heating assembly **200** is configured to rapidly provide electrical power to the corresponding heating element **202** sufficient to heat the engagement portion **40***c* of drill pipe **40** to a degree sufficient to reduce the mechanical integrity of the material comprising drill pipe **40** at the engagement portion **40***c*. Particularly, in certain embodiments, power supply **240** of each inductive heating assembly **200** is configured to rapidly provide electrical power to the corresponding heating element **202** sufficient to heat the engagement portion **40***c* of drill pipe **40** to the annealing temperature of the material comprising drill pipe **40**. In certain embodiments, the power supply **240** of each inductive heating assembly **200** is coupled to the BOP assembly **30**. In other embodiments, each power supply **240** is located on a separate subsea skid disposed proximal to BOP assembly **30**. In still further embodiments, each power supply **240** is disposed on the drilling platform **12**. In this embodiment, each power supply **240** comprises a capacitor array configured to store and selectably rapidly discharge or release electrical power. In other embodiments, each power supply **240** comprises other mechanisms for storing and rapidly releasing energy, which may be electrical energy or other forms of energy convertible to electrical energy. For instance, in certain embodiments, each power supply **240** may comprise one or more accumulators driving an electrical generator, a fuel cell powered by solid state Hydrogen, and other power storage and discharge mechanisms known in the art.

[0030] As will be explained further herein, the sensor **244** of each inductive heating assembly **200** is configured to detect physical contact or engagement between a corresponding ram block **118** and the outer surface **42** of drill pipe **40**. Each sensor **244** is coupled to a corresponding ram block **118** and is connected to a power supply **240** via a cable **246**. In this embodiment, each sensor **244** comprises a strain gauge configured to detect strain in the corresponding ram block **118**; however, in other embodiments, sensors **244** may comprise other sensors or detectors known in the art for detecting engagement between ram blocks **118** and drill pipe **40**. For instance, in other embodiments sensors **244** may comprise optical detectors mounted to the housing **102** of ram BOP **100** and configured to optically detect physical engagement between ram blocks **118** and drill pipe **40**. Each inductive heating assembly **200** includes a controller **260** comprising a processor and memory, where controller **260** is connected with power supply **240** and sensor **244** and is configured for controlling the transfer of energy from power supply **240** to heating element **202** in response to a signal transmitted from sensor **244**, as will be discussed further herein. Further, although in this embodiment each inductive heating assembly **200** includes a sensor **244** and a controller **260**, in other embodiments, inductive heating assembly **200** may not include sensor **244** and controller **260**.

[0031] Referring to FIGS. **5-7**, another embodiment of a ram BOP **300** including an inductive heating assembly **350** is shown. In this embodiment, ram BOP **300** generally includes a BOP body **302**, a bonnet **310**, a piston **324** connected to a connecting rod **330**, and a ram block **340** coupled to connecting rod **330**. BOP body **302** has a central bore **304** in which ram block **340** is slidably disposed and a central passage **306** through which connecting rod **330** extends. In this embodiment, bonnet **310** is coupled to body **302** and includes a head **312** disposed at a terminal end thereof and a chamber **314** in which piston **324** is slidably disposed. Bonnet **310** also includes a recess **316** extending into head **312** from chamber **314** and a cable passage **318** extending through head **312**. Bonnet **310** further includes a first or piston close port **320** and a second or piston open port **322**, where ports **320** and **322** are each in fluid communication with chamber **314**.

[0032] Piston **324** is coupled to a first or outer terminal end of connecting rod **330**, and in certain embodiments, includes an annular seal disposed on an outer surface thereof for sealingly engaging an inner surface of chamber **314**. In this arrangement, the sealing engagement between piston **324** and the inner surface of chamber **314** divides chamber **314** into a first chamber **314***a* and a second chamber **314***b*, where piston close port **320** provides fluid communication to first chamber **314***a* while piston open port **322** provides fluid communication to second chamber **314***b*. Thus, flowing pressurized fluid into first chamber **314***a* via piston close port **320** causes piston **324** to shift or be displaced into a closed position where piston **324** is disposed proximal BOP body **302**, while following pressurized fluid into second chamber **314***b* via piston open port **322** causes piston **324** to shift into an open position where piston **324** is disposed directly adjacent head **312** of bonnet **310**.

[0033] Connecting rod **330** couples piston **324** with ram block **340** and includes a central passage **332** extending longitudinally therethrough and a connector **334** disposed at a terminal end thereof for coupling connecting rod **330** with ram block **340**. In this embodiment, connector **334** comprises a radially expanded button or disc that is received within a corresponding recess of ram block **340**. In certain embodiments, an inner surface of passage **306** of body **302** includes an annular seal disposed therein for sealingly engaging an outer surface of connecting rod **330** to restrict fluid communication between chamber **314** of bonnet **310** and bore **304** of body **302**. In this embodiment, ram block **340** comprises a shear ram block for cutting a tubular member, such as a drill pipe, extending through ram BOP **300**, and generally includes a first receptacle **342**, a cutting edge **344** that is configured to physically engage and cut the aforementioned tubular member, a cable passage **346** extending from first receptacle **342**, and a second receptacle **348** extending along cutting edge **344**. While in this embodiment ram block **340** comprises single cable passage **346**, in other embodiments, ram block **340** may comprise multiple passages for the disposal of multiple independent cables. In this arrangement, the connector **334** of connecting rod **330** is received within first receptacle **342** of ram block **340** to releasably couple connecting rod **330** with ram block **340**.

[0034] Similar to the inductive heating assembly **200** discussed above, inductive heating assembly **350** is configured to heat an engagement portion or interface of the tubular member to be cut, such as engagement portion **40***c* discussed above. In this embodiment, inductive heating assembly **350** generally includes a power connector **352**, a coiled power cable **354**, a telescoping member **355**, a first or transmitting inductive coupler **356**, a second or receiving inductive coupler **358**, an insulator **360**, a heating element **362**, and a retaining plate or member **364**. Power connector **352** is configured to receive power for heating the heating element **362** from a power supply, such as power supply **240** discussed above. Power received by power connector **352** is transmitted to heating element **362** via coiled power cable **354**, inductive couplers **356** and **358**, and a cable **366** (shown in FIGS. **6** and **7**) extending between receiving coupler **358** and heating element **362**. While in this embodiment an inductive coupling provided by couplers **356** and **358** transmits power between cable **354** and cable **366**, in other embodiments, a hardwired connection may couple cable **354** with cable **366** in lieu of an inductive coupling. In still further embodiments, power may be transferred between heating element **362** and power connector **352** via one or more cables that extend through passages (not shown) in BOP body **302** instead of connecting rod **330**.

[0035] In this embodiment, cable **354** comprises a coiled power cable to allow for slidable displacement of piston **324** within chamber **314** of bonnet **310**. Further, when piston **324** is disposed in the open position directly adjacent head **312** of bonnet **310**, coiled power cable **354** is received within recess **316** of bonnet **310** to prevent damaging cable **354** or restricting the displacement of piston **324**. In this embodiment, coiled power cable **354** is disposed or coiled about telescoping member **355**, which extends between head **312** and piston **324**. Telescoping member **355** is configured to support power cable **354** and thereby prevent cable **354** from collapsing. Telescoping member **355** is also configured to expand and retract telescopically to allow piston **324** to be displaced through chamber **314**. In this embodiment, telescoping member **355** is hollow and perforated, and thus, is fully immersed by fluid disposed in chamber **314**. However, in other embodiments, inductive heating assembly **350** may not include a telescoping member for supporting coiled power cable **354**.

[0036] Transmitting coupler **356** of inductive heating assembly **300** is disposed within a receptacle of the connector **334** of connecting rod **330** while receiving coupler **358** is disposed within first receptacle **342** of ram block **340**. In this arrangement, inductive couplers **356** and **358** are disposed directly adjacent each other and are configured similarly to inductive coupler **230** discussed above. Thus, inductive couplers **356** and **358** are configured to inductively conduct power received from power connector **352** and transmit the power received therefrom to heating element **362** via cable **366**. While in this embodiment power connector **352** provides a hardwired connection, in other embodiments, power connector **352** may comprise an inductive coupler for inductively coupling with an external power supply.

[0037] In this embodiment, insulator **360** and heating element **362** are received within the second receptacle **348** of ram block **340** that extends along the cutting edge **344** thereof. Similar to insulator **210** discussed above, insulator **360** is configured to restrict or decrease the amount of heat transferred from heating element **362** to the material comprising ram block **340**. As with heating element **202** discussed above, heating element **360** is configured to transform electrical energy (such as the power received from power connector **352**) into heat, which may be transferred to the engagement portion of a tubular member to be cut. In this embodiment, insulator **360** and heating element **362** are received within the second receptacle **348** of ram block **340** and releasably coupled or secured to ram block **340** via retaining plate **364**. In certain embodiments, retaining plate **364** is releasably secured to ram block **340** via one or more fasteners **365** extending through retaining plate **364** and secured within ram block **340**.

[0038] Further, in this embodiment, there is an offset **368** between cutting edge **344** of ram block **340** and an outer edge (e.g., the edge closest cutting edge **344**) of retaining plate **364** to provide space for the fasteners **365** and to decrease the amount of heat transferred from heating element **362** to retaining plate **364**, thereby maximizing the amount of heat transferred from heating element **362** to the engagement portion (e.g., engagement portion **40***c*) of the tubular member to be cut. Further, in certain embodiments, retaining plate **364** is configured to provide a frangible connection between heating element **362** and ram block **340** such that heating element **362** may be released from ram block **340** in the event of heating element **362** fusing to the tubular member to be cut. Particularly, upon cutting the tubular member, the heat provided by heating element **362** may cause heating element **362** to fuse with the material comprising the cut tubular member. Thus, a frangible connection may be provided between heating element **362** and ram block **340** to allow heating element **362** to be released in the event of fusion or other coupling formed between heating element **362** and the tubular member to prevent damage from incurring to other components of ram BOP **300** and inductive heating assembly **350**. In this manner, the heating element **362** may comprise a sacrificial component for protecting other components of inductive heating assembly **350**.

[0039] Referring to FIGS. **1-3** and **7**, FIG. **7** illustrates a method **400** of inductively shearing a tubular member. At block **402** of method **400**, a closure device is actuated towards a closed position. In certain embodiments, block **402** comprises actuating ram BOP **100** from the open position (shown in FIG. **2**), where continuous passage of drill pipe **40** through throughbore **104** of ram BOP **100** is permitted, and the closed position where continuous passage of drill pipe **40** through throughbore **104** of ram BOP **100** is restricted. Particularly, in this embodiment, block **402** comprises providing hydraulic pressure within the cylinder **113** against an outer face of the piston **114** of each actuation assembly **112**, and thereby displacing the piston **114** and ram block **118** laterally towards the drill pipe **40** extending through the throughbore **104**. In this embodiment, hydraulic pressure may be applied to the cylinder **113** of each actuation assembly **112** via one or more pumps disposed on the drilling platform **12**, or via the accumulators **36** of BOP assembly **30**. Although hydraulic pressure is utilized in the embodiment above to actuate piston **114**, in other embodiments, piston **114** may be actuated through other mechanisms, such as an electrical motor for displacing piston **114**.

[0040] At block **404** of method **400** a tubular member is physically engaged or contacted with a cutting member of the closure device. In certain embodiments, block **404** comprises physically engaging the outer surface **42** of drill pipe **40** with the cutting edge **120** of the ram block **118** of each actuation assembly **112**. The engagement of the outer surface **42** of drill pipe **40** by the cutting edge **120** of each ram block **118** occurs during the process of actuating ram BOP **100** from the open position towards the closed position, as discussed above with respect to block **402**. As the cutting edge **120** of each ram block **118** physically engages the outer surface **42** of drill pipe **40**, each cutting edge **120** physically engages the engagement portion **40*c*** of drill pipe **40**, where the engagement portion **40*c*** of drill pipe **40** comprises a pair of opposed semi-circular sections of drill pipe **40** contacted and physically engaged by the corresponding pair of cutting edges **120**, as shown particularly in FIGS. **3** and **4**. Thus, in this embodiment, engagement portion **40*c*** does not cover the entire circumference of drill pipe **40**.

[0041] At block **406** of method **400**, the cutting member of the closure device is energized or provided with energy from an energy or power source. In certain embodiments, block **406** comprises transferring energy stored in each power supply **240** to the corresponding heating element **202** so as to rapidly heat a tubular member to be cut, such as engagement portion **40*c*** of drill pipe **40**. In this embodiment, electrical energy is not supplied to each heating element **202** until the cutting edge **120** of each ram block **118** physically engages or contacts the engagement portion **40*c*** of drill pipe **40**; however, in other embodiments, energy may be transferred from each power supply **240** to the corresponding heating element **202** prior to physical engagement of the cutting edge **120** of each ram block **118** against the engagement portion **40*c*** of drill pipe **40**. In this embodiment, sensors **244** are utilized to synchronize the energization of heating elements **202** with the engagement between ram blocks **118** and drill pipe **40**. Particularly, in response to receiving a signal from sensor **244** indicating physical engagement between ram block **118** and drill pipe **40**, controller **260** transmits a signal to power supply **240** to thereby transfer energy stored therein to heating element **202**, which rapidly converts the electrical energy supplied thereto into heat. As each heating element **202** is heated, thermal energy is transferred from heating elements **202** to the engagement portion **40*c*** of drill pipe **40**.

[0042] In embodiments where each heating element **202** comprises or forms the cutting edge **120** of a respective ram block **118**, thermal energy or heat is transferred (indicated by arrows **250** in FIG. **4**) from heating elements **202** to engagement portion **40*c*** via thermal conduction resulting from the physical contact between cutting edges **120** and the engagement portion **40*c*** of drill pipe **40**. In this manner, energy is efficiently transferred between engagement portion **40*c*** of drill pipe **40** and heating elements **202** by minimizing heat loss to fluids disposed within throughbore **108**. Moreover, contact between heating elements **202** and engagement portion **40*c*** of drill pipe **40** focuses the thermal energy transferred from heating elements **202** into the engagement portion **40*c*** of drill pipe **40**. In other words, the thermal energy transferred from heating elements **202** is unequally distributed along the circumference of drill pipe **40**, with the maximum thermal or heat flux **250** occurring along engagement portion **40*c***. In certain embodiments, block **406** also comprises flowing an inert fluid or gas into throughbore **108** of housing **102** via passage **102**P such that the inert gas is disposed about the drill pipe **40** and cutting edges **120** of ram blocks **118**. In this manner, the cutting of drill pipe **40** by ram blocks **118** may occur in an inert environment, reducing the possibility of combustion taking place within throughbore **108**. In other embodiments, other mechanisms may be employed to produce an inert environment within throughbore **108**, such as by depleting oxygen within throughbore **108**.

[0043] At block **408** of method **400**, the tubular member is cut with the cutting member of the closure device. In certain embodiments, block **408** comprises cutting or shearing drill pipe **40** via the cutting edges **120** of ram blocks **118** until drill pipe **40** is completely severed and ram BOP **100** is disposed in the closed position. Particularly, in some embodiments, block **408** comprises initiating a cut or shear in engagement portion **40*c*** via the cutting edges **120** of ram blocks **118**. Given that engagement portion **40*c*** comprises the portion of the circumference of drill pipe **40** that is physically engaged by and initially cut by cutting edges **120**, focusing the thermal energy transfer in engagement portion **40*c*** efficiently utilizes the heat provided by heating elements **202** by maximizing the reduction in mechanical integrity in the portion (e.g., engagement portion **40*c***) of drill pipe **40** initially cut by cutting edges **120**. In some embodiments, block **408** comprises frangibly decoupling the heating element (e.g., heating element **362**) from the cutting member (e.g., ram block **340**) via a frangible connection therebetween (e.g., retaining plate **364**) in response to fusion between the heating element and the tubular member.

[0044] By maximizing thermal flux **250** into engagement portion **40*c***, a relatively lesser amount of energy may be transferred to heating elements **202** from power supplies **240** while still providing a sufficient degree of thermal energy to engagement portion **40*c*** to allow cutting edges **120** of ram blocks **118** to initiate a cut or shear in engagement portion **40*c*** of drill pipe **40**. Once a cut has been initiated in engagement portion **40*c***, the mechanical integrity of drill pipe **40** along the circumference of which engagement portion **40*c*** is disposed will be decreased due to the stress risers provided by the initial physical cuts made by ram blocks **118**, decreasing the amount of cutting force required to complete the shearing of drill pipe **40**. Thus, concentrating the thermal flux **250** into engagement portion **40***c* such that the thermal flux **250** into drill pipe **40** is not equally distributed about the circumference of drill pipe **40** may reduce the amount of energy required to be transferred to heating elements **202** to successfully cut or shear drill pipe **40**. Further, although method **400** is described above in the context of ram BOP **100**, the steps of method **400** may also be performed utilizing ram BOP **300** illustrated in FIGS. **5-7** and described above.

[0045] The above discussion is meant to be illustrative of the principles and various embodiments of the present disclosure. While certain embodiments have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the disclosure. The embodiments described herein are exemplary only, and are not limiting. Accordingly, the scope of protection is not limited by the description set out above, but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims.

What is claimed is:

1. A closure device for cutting a tubular member, comprising:
- a housing; and
- a cutting member disposed in the housing, wherein the cutting member is coupled to a heating element;
- wherein the cutting member is configured to transfer heat to a tubular member from the heating element to cause a loss of mechanical integrity of the tubular member as the cutting member physically engages the tubular member.

2. The closure device of claim **1**, wherein the cutting member is configured to unequally distribute a thermal flux from the heating element to the tubular member along a partial circumference of the tubular member.

3. The closure device of claim **1**, wherein the cutting member is configured to transfer heat to a tubular member from the heating element using thermal conduction when the cutting member physically engages the tubular member.

4. The closure device of claim **1**, further comprising a retaining member frangibly coupling the heating element to the cutting member.

5. The closure device of claim **1**, wherein the heating element comprises an induction heating element.

6. The closure device of claim **1**, wherein the heating element forms a cutting edge of the cutting member.

7. The closure device of claim **6**, further comprising a thermal insulator disposed between the heating element and the cutting member.

8. The closure device of claim **1**, further comprising a power supply connected to the heating element and configured to store and selectably transfer energy to the heating element.

9. A closure device for cutting a tubular member, comprising:
- a housing;
- a heating element disposed in the housing; and
- a cutting member slidably disposed in the housing;
- wherein the heating element is configured to unequally distribute a thermal flux along a circumference of the tubular member when the cutting member physically engages the tubular member.

10. The closure device of claim **9**, wherein the cutting member is configured to transfer heat to a tubular member from the heating element using thermal conduction when the cutting member physically engages the tubular member.

11. The closure device of claim **9**, wherein the closure device comprises a ram blowout preventer and the cutting member comprises a ram block.

12. The closure device of claim **11**, further comprising:
- a telescoping member extending between a bonnet and a slidable piston of the blowout preventer, wherein the telescoping member is configured to extend and retract as the piston is displaced through the blowout preventer; and
- a power cable electrically connected with the heating element, wherein the power cable is disposed about the telescoping member.

13. The closure device of claim **12**, wherein the bonnet comprises a recess extending therein, and the telescoping member extends between the recess and the slidable piston.

14. The closure device of claim **9**, further comprising a power supply connected to the heating element and configured to store and selectably transfer energy to the heating element.

15. The closure device of claim **14**, wherein the power supply comprises a capacitor array.

16. The closure device of claim **14**, further comprising:
- a sensor disposed in the housing and configured to detect physical engagement between the cutting member and the tubular member; and
- a controller connected to the sensor and power supply, wherein the controller is configured to cause the power supply to transfer energy to the heating element in response to receiving a signal from the sensor indicating physical engagement between the cutting member and the tubular member.

17. The closure device of claim **9**, wherein the heating element comprises an inductive heating element.

18. A method for cutting a tubular member, comprising:
- engaging an engagement portion of a tubular member with a cutting member;
- energizing a heating element;
- transferring heat from the heating element to the engagement portion of the tubular member via thermal conduction between the cutting member and the tubular member; and
- physically cutting the tubular member with the cutting member.

19. The method of claim **18**, wherein the engagement portion extends along only a portion of the circumference of the tubular member.

20. The method of claim **18**, further comprising unequally distributing a thermal flux along a circumference of the tubular member.

21. The method of claim **18**, further comprising physically engaging the tubular member with the heating element, wherein the heating element is coupled to the cutting member.

22. The method of claim **18**, further comprising frangibly decoupling the heating element from the cutting member in response to the heating element fusing to the tubular member.

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