Jan. 6, 1953 F. E. O'NEILL 2,624,409

CUTTING APPARATUS FOR WELL CONDUITS

Filed Oct. 26, 1946 2 SHEETS—SHEET 1

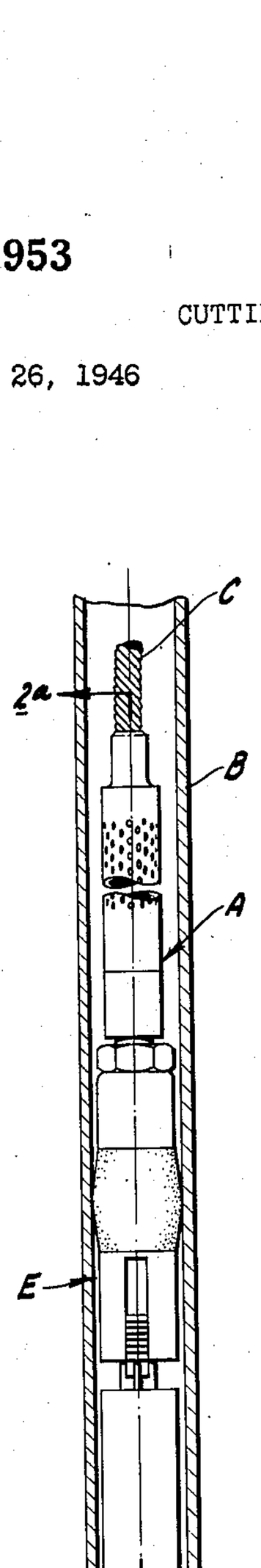

FIG. 1

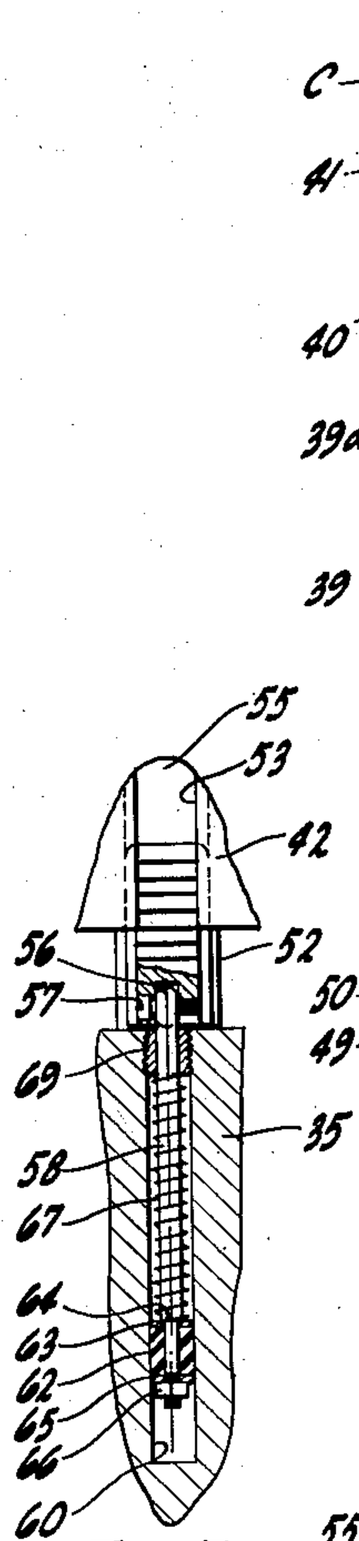

FIG. 7

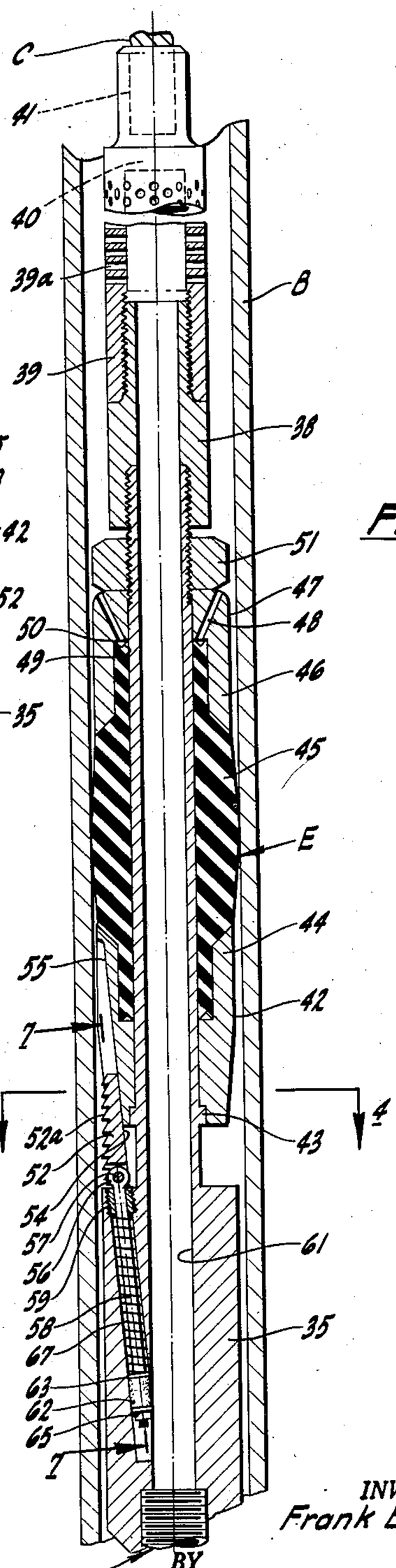

FIG. 2a

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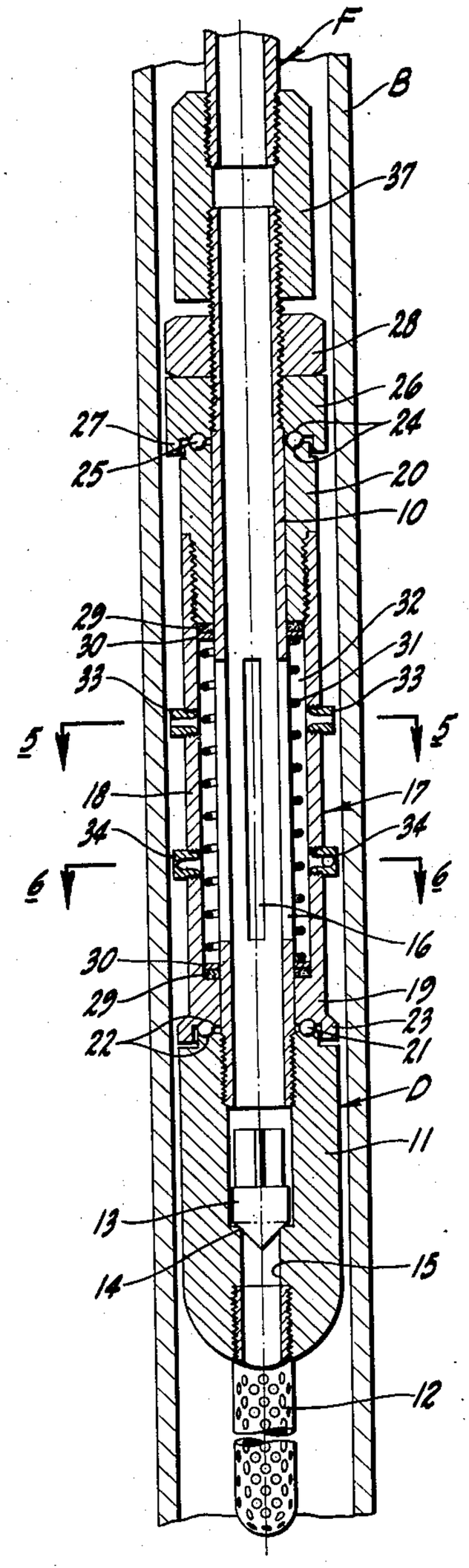


FIG. 2b

FIG. 4

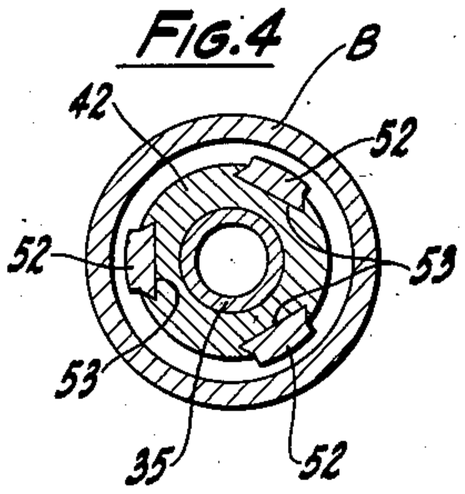


FIG. 5

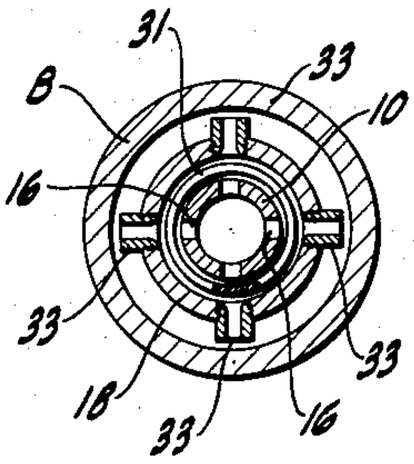


FIG. 6

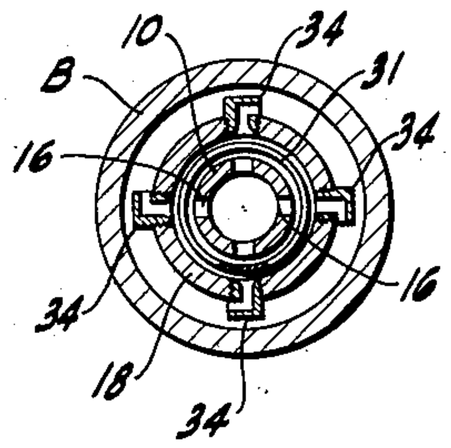
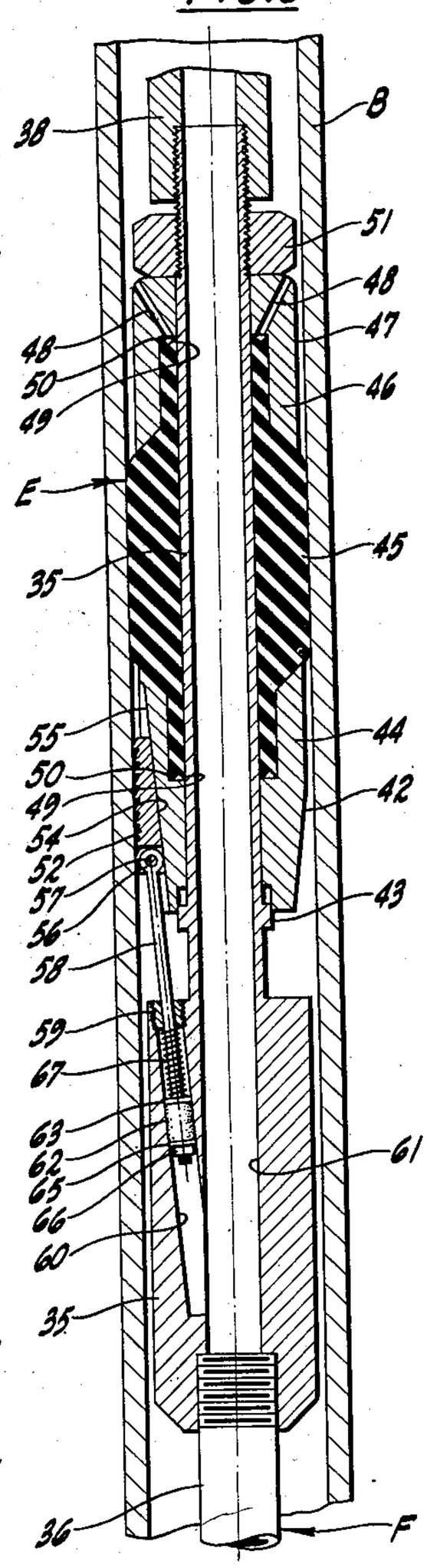


FIG. 3



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CUTTING APPARATUS FOR WELL CONDUITS

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4 Claims. (Cl. 166—1)

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The present invention relates to pipe cutting apparatus, and more particularly to apparatus capable of cutting well casings, liners, drill pipe, and similar conduits while positioned in well bores.

An object of the present invention resides in the provision of improved apparatus for severing a conduit in a well bore transversely of its longitudinal axis by the action of cutting fluid impinging directly on the conduit.

Another object of the invention is to provide apparatus for severing a conduit in a well bore through the direct impinging action of fluid on the conduit, fluid under pressure for performing the severing operation being supplied directly through the conduit itself.

A further object of the invention is to provide a cutter apparatus adapted to be lowered in a well conduit on a wire or smiliar flexible line, in which the apparatus is capable of receiving cutting fluid under pressure directly through the conduit and impinging it directly against the conduit.

Still a further object of the invention is to provide a casing cutter apparatus of the hydraulic jet type which can be used effectively to cut internal upset pipe positioned in a well bore.

Another object of the invention is to provide a jet type of casing cutter which can be anchored to and within a well conduit on which a cutting operation is to be performed, without the necessity for manipulation of the running-in string employed in lowering the cutter in the well conduit, offering greater assurance of anchoring the cutter at the actual location desired and of cutting the conduit at the place intended.

One form which the invention may assume is exemplified in the following description and illustrated by way of example in the accompanying drawings, in which:

Fig. 1 is a side elevation of the cutting apparatus positioned within a well conduit, such as a drill pipe.

Figs. 2*a* and 2*b* are collectively longitudinal sections on an enlarged scale, taken along the line 2*a*—2*a* and 2*b*—2*b*, respectively, on Fig. 1.

Fig. 3 is a view similar to 2*a*, showing the apparatus anchored to the drill pipe.

Fig. 4 is a cross-section taken generally along the line 4—4 on Fig. 2*a*.

Fig. 5 is a cross-section taken along the line 5—5 on Fig. 2*b*.

Fig. 6 is a cross-section taken along the line 6—6 on Fig. 2*b*.

Fig. 7 is a partial longitudinal section taken along the line 7—7 on Fig. 2*a*.

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In the form of the invention disclosed in the drawings the cutting apparatus A is adapted to be lowered through a well conduit, such as drill pipe B, which is to be cut or severed, on the end of a suitable wire rope C or other flexible line. The cutting apparatus includes a lower nozzle cutting portion D and an upper packer portion E adapted to anchor the entire apparatus in packed-off condition at a desired location within the drill pipe.

The apparatus includes a tubular mandrel or body F formed of several tubular sections. The nozzle or jet cutting portion D of the apparatus comprises a lower, elongate tubular mandrel or body section 10, having a housing 11 threaded on its lower end. This housing has a tubular perforated strainer 12 threaded in its lower end, and also contains a check valve in the form of a valve head 13 movable downwardly into engagement with a valve seat 14 in the housing, to prevent downward flow of fluid through the housing axial passage 15, while permitting upward flow of fluid therethrough and into the tubular body.

The lower body section 10 is provided with circumferentially spaced, elongate fluid ports or outlets 16 to permit fluid to pass from the interior of the mandrel F into a fluid chamber or nozzle housing 17 rotatable on the mandrel. The nozzle housing comprises a sleeve 18 and a lower head 19 slidably engaging the exterior of the lower body section 10, and its upper end includes a follower nut or upper head 20 threaded into the housing sleeve 18 and slidably engageable with the lower body section 10.

Suitable anti-friction bearings are provided at the head ends 19, 20 of the fluid chamber 17 to facilitate its rotation on the body F. As disclosed in the drawings, such bearings are constituted by a plurality of bearing balls 21 riding in opposed races 22 in the valve housing 11 and end of the lower head 19. The latter may have a depending shield 23 extending around the bearing balls 21 and the upper end of the valve housing 11 to protect the balls and races from sand and other harmful materials that might be present in the well conduit. Similar opposed bearing races 24 and bearing balls 25 are provided between the follower nut 20 and an adjusting nut 26 threaded on the upper end of the lower mandrel section 10, the nut 26 having a depending shield 27 extending over the ball bearings 25 and end of the upper head 20 to protect the upper bearing from sand and harmful materials in the well conduit.

The adjusting nut 26 is threaded on the body section 10 until the desired adjustment has been

made between the sets of bearing balls and their cooperable races, to permit free turning of the fluid chamber of housing 17 on the mandrel or body F, with a minimum amount of longitudinal movement along the mandrel. Following proper adjustment of the amount of play between the bearings, a lock nut 28 is threaded on the upper end of the mandrel section 10 and tightened against the adjusting nut 26 to hold it in proper position.

Leakage in a longitudinal direction between the fluid chamber heads 19, 20 and the lower mandrel section 10 is prevented by providing a gasket 29 in engagement with each head and the exterior of the mandrel. A metal ring 30 engages each gasket, and a suitable helical spring 31 is disposed in the annular chamber space 32 between the mandrel F and the chamber sleeve 17, with its ends engaging the steel rings 30. The spring exerts its compressive force against the seals or gaskets 29 to hold them in proper sealing engagement with the heads 19, 20 and mandrel 10, preventing leakage of fluids longitudinally from the annular chamber space 32.

The chamber skirt 17 is provided with a set of radially disposed cutting nozzles or jets 33, threaded or otherwise secured in the skirt, and with a set of turning nozzles or jets 34 similarly secured in the skirt. These nozzles establish fluid communication between the interior of the fluid chamber 17 and the exterior of the tool, the outlets of the cutting jets being so disposed as to be adjacent the wall of the well conduit B on which the cutting or severing action is to take place. The turning jets 34 have their outlets out of alignment with the longitudinal axis of the tool, in order that the reactive force of fluid issuing through these jets will rotate the fluid chamber 17 on the mandrel or body F.

The upper portion of the tool includes an upper tubular mandrel or body section 35, which may be threaded directly into the upper end of the lower section 10. However, for some applications of the apparatus, it is preferred to increase the longitudinal distance between the upper and lower sections 35, 10 by threading the upper section onto an intermediate mandrel or body section 36, which is threaded into an intermediate sub 37 screwed on the upper end of the lower mandrel 10. The upper end of the upper mandrel or body section 35 is threadedly secured to a sub 38, which, in turn, is screwed into a top perforated strainer 39, having an intermediate imperforate end wall 40 and an upper threaded box 41 for reception of a rope socket (not shown) suitably secured to the lower end of the flexible wire line or rope C.

A slip expander 42 surrounds the upper tubular mandrel 35, resting on an external flange or shoulder 43 on the mandrel. This slip expander has an upwardly extending skirt 44 forming an annular pocket with the upper mandrel section 35 receiving the lower end of the packing element or sleeve 45 surrounding the mandrel. The upper end of the packing element is positioned within a similar annular pocket formed between the depending skirt 46 of a cup retainer 47, slidably mountd on the mandrel 35 and having a plurality of longitudinally extending ports 48 for directing fluid from the exterior of the cup to its interior. Inner and outer annular lips 49, 50 are formed on the ends of the packing elements 45 for sealing engagement against the upper mandrel section 35 and expander and retainer skirts 44, 46. A lock nut 51 is threaded on the upper

end of the upper mandrel section 35, and is adapted to engage the upper packing retainer 47 to compress the packing sleeve 45 between the retainer and the expander 42, expanding it initially outward to a diameter substantially equal to the inside diameter of the pipe B in which the cutting apparatus is to be used.

A plurality of circumferentially spaced slips 52 are slidably mounted in dovetailed slots 53 on the external portion of the expander. The slips have internal tapered surfaces 54 inclined downwardly toward the longitudinal tool axis in slidable engagement with cooperable tapered surfaces 55 on the expander, in order that upward movement of the slips 52 along the expander 42 shifts the former outwardly into engagement with the wall of the conduit B to hold the apparatus against downward movement therewithin.

The slips are shifted hydraulically in an upward direction from an initial inward retracted position. As disclosed in the drawings, such hydraulic shifting is provided by pivotally securing the eye 56 of a bolt to the lower end of each slip by means of a suitable pin or screw 57. The shank 58 of the bolt extends downwardly through a bushing 59 threaded in the upper end of an inclined cylinder 60 in the lower portion of the upper mandrel section 35, whose lower end communicates with the central passage 61 through the upper section. A suitable piston is secured on the lower end of the shank within this inclined cylinder. Such piston may be constituted by a packing sleeve 62 on the shank 58 confined between a washer 63 engaging a shank shoulder 64 and another washer 65 held against the sleeve by a clamp nut 66 threaded on the lower end of the bolt shank. Each piston sleeve 62 is in slidable sealing engagement with the cylinder wall, being urged in a downward direction by a compressed helical spring 67 contained within the cylinder 60, with its upper and lower ends engaging the bushing 59 and piston, respectively.

The cutter apparatus is run in a drill pipe, or other well conduit, through and around which circulation can be obtained, with the slips 52 in retracted position, and with the adjusting nut 51 threaded on the upper end of the upper mandrel section 35 to such an extent as to move the upper packing retainer 47 toward the lower expander 42 and expand the packing element 45 outwardly until its diameter is such that the packing is in slidable sealing engagement with the wall of the drill pipe B. The tool is lowered on the wire line C through the drill pipe, any fluid that might be present in the pipe passing upwardly through the tool to by-pass the packing 45, entering the bottom strainer 12, unseating the valve head 13 and flowing upwardly through the lower, intermediate and upper mandrel sections 10, 36, 35 for outward passage through the perforated top strainer 39 into the drill pipe above the packing element 45.

When the desired point in the well conduit is reached at which it is to be cut or severed, the pumps at the top of the well bore are started and fluid pumped directly into the drill pipe B. Such fluid cannot pass downwardly around the exterior of the cutter apparatus A, in view of the sealing engagement of the packing element 45 with the wall of the drill pipe. Accordingly, it is directed through the tubular inlet ports 39*a* in the top strainer 39, into the upper mandrel section 35, passing through the intermediate mandrel section 36, sub 37, and lower section 10, and through the elongated ports 16 into the annular

fluid chamber 17 from where it exhausts through the cutting and turning nozzles 33, 34. Since the valve head 13 moves downwardly into engagement with its seat 14 to prevent downward flow of fluid through the valve housing passage 15, a back pressure is built up in the mandrel F, because of the restricted area through the nozzles, acting against the pistons 62 and shifting them upwardly to slide the slips 52 along the expander 42 into engagement with the drill pipe B. The fluid under pressure also enters the annular pocket within the upper packing retainer 47 through the longitudinal ports 48 and acts upon the upper end of the packing element 45 to foreshorten it and expand it more firmly and over a greater area into sealing engagement with the wall of the drill pipe.

The reactive force of the fluid leaving the turning nozzles 34 rotates the housing 17 around the mandrel F to revolve the cutting nozzles 33, which are all preferably positioned in a single transverse plane. Fluid issuing at a comparatively high velocity from the cutting nozzles 33 acts upon a relatively short longitudinal length of the drill pipe B, eroding the drill pipe around its entire circumference until it is completely severed into two parts. The fluid exhausting from all nozzles flows downwardly through the drill pipe and thence upwardly around its exterior to the top of the well bore.

Any suitable fluid may be pumped down the drill pipe to exhaust through the nozzles and perform the cutting operation. If desired, the fluid, which may be various types of drilling mud, may be charged with abrasive particles, such as sand, to expedite the cutting action, or suitable chemicals may be employed.

By being anchored against the conduit B, the slips 52 and their cooperable expander 42 relieve the flexible line C of the downward force of the fluid under pressure, since such force is transmitted from the upper mandrel section 35, lock nut 51 and packing sleeve 45 to the expander 42, which is wedged into the slips, whose wickers 52*a* are anchored in the wall of the drill pipe. Accordingly, any required pressure may be imposed on the fluid in the drill pipe to produce sufficient velocity in the fluid exhausting from the cutting nozzles 33 and effectively sever the conduit opposite the location of the nozzles 33, without fear of overstressing the rope C.

Following the severing of the conduit B, the pump pressure is relieved, which permits the springs 67 to shift the pistons 62, bolts 56, 58 and slips 52 downwardly, moving the latter along the expander 42 back to retracted position. The relieving of the pressure also relieves the hydraulic foreshortening force on the packing element 45 and allows it to move back to a position in which only a relatively small margin on its periphery engages the drill pipe B, so as to offer a minimum of resistance to elevating of the wire line C and the entire cutting tool A from the drill pipe.

If desired, the holding slip and expander arrangement 45, 52 need not be employed at all. In that event, the entire downward force exerted by the fluid under pressure would be withstood by the running-in string C, the packing element 45 still forming a proper seal with the wall of the drill pipe causing fluid under pressure to be directed through the upper strainer 39 to the interior of the tool. The provision of the slips, however, is preferred, since it permits the tool to be anchored in place at the desired point, without fear of subsequent shifting of the cutting nozzles

33 as a result of elongation or shortening of the running-in string C due to variations in pressure. Once the slips 52 are anchored to the drill pipe B, the cutting nozzles remain in a single plane and direct the high velocity cutting fluid at the same circumferential portion of the drill pipe during their revolution about the longitudinal axis of the tool.

By virtue of the hydraulic arrangement disclosed for setting the slips, it is unnecessary to manipulate the running-in string for the purpose of anchoring the tool at the desired location in the well bore. Careful measurement can be made of the length of wire line lowered in the well bore, in order to accurately position the cutting nozzle at the location where the severing operation is to occur.

Although the slips need not be employed, the packing element 45 enables fluid to be pumped directly into the drill pipe B or other well conduit to be severed, without the need for providing a separate fluid conductor. As pointed out above, this packing element is adjusted to seal initially with the drill pipe and prevent downward passage of fluid between the packing element and drill pipe. This arrangement permits a wire or other flexible line to be used in running the cutting tool rapidly in and out of the drill pipe.

The tool lends itself for use in connection with internal upset pipe. It is to be noted that the intermediate mandrel section 36 spaces the packing element 45 a relatively long distance from the cutting and turning nozzles 33, 34. When used in internal upset pipe, the adjusting nut 51 and upper packing retainer 47 are moved toward the lower expander 42 a sufficient distance to provide an initial external diameter of the packing sleeve 45 substantially equal to, and preferably slightly greater than, the internal diameter at the pipe upsets. The tool is lowered through such pipe until the packing sleeve is located in an upset, which prevents fluid from passing downwardly around the exterior of the tool beyond the packing sleeve. The application of pressure to the fluid in the drill pipe then causes the slips 52 to be shifted outwardly to anchoring position with the drill pipe, which may occur within the upset itself or along the drill pipe surface immediately below the upset. In any event, the cutting nozzles 33 are positioned a sufficient distance below the upset as to insure that the abrading action on the pipe takes place at a relatively thin wall section. The mandrel extension 36 is selected of appropriate length to assure placing of the cutting nozzles below the internal upset portion of the pipe against which the packing sleeve 45 is sealed.

While I have shown the preferred form of my invention, it is to be understood that various changes may be made in its construction by those skilled in the art without departing from the spirit of the invention as defined by the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. An apparatus for severing a well conduit, comprising a tubular member and a rotary cutting member rotatably supported by said tubular member, said cutting member having at least one transversely disposed radial jet nozzle and at least one transversely disposed jet nozzle disposed at an angle to the axis of rotation of the cutting member and being directed generally in a circumferential direction, and means for delivering fluids from said tubular member to said rotary cutting member for delivery from said jets

whereby delivery of such fluid from said radial jets will impinge upon a well conduit to abrasively cut the same while fluid ejected from said angularly disposed jet will rotate the cutting member.

2. An apparatus for severing a well conduit comprising a tubular member and a rotating cutting member rotatably supported by said tubular member, said cutting member having a plurality of transversely disposed radial jet nozzles at one level and a plurality of transversely disposed jet nozzles disposed at an angle to the axis of rotation of the cutting member at another level, said transversely disposed jet nozzles being directed generally in a circumferential direction, means for delivering fluid from said tubular member to said rotating cutting member to be ejected from said nozzles whereby said radial nozzles will deliver fluid to a surrounding well conduit to abrasively cut the same while fluid delivered from said angularly disposed jet will rotate said cutting member.

3. An apparatus for cutting a well conduit comprising a tubular member having a plurality of longitudinally extending peripheral openings, a bottom closure releasably secured thereto and having an inwardly opening valve, a rotary cutting member concentrically mounted upon said tubular member above said bottom closure, a plurality of radially disposed jets carried by said rotary cutting member registering and in communication with a portion of the longitudinal openings of said tubular member, and a plurality of jets carried by said cutting member, angularly disposed with respect to the axis of rotation of said cutting member, registering with and in communication with the longitudinal openings of said tubular member, the latter-named jets being directed generally in a circumferential direction, whereby said radial jets will direct fluid therefrom to abrasively cut a surrounding casing while said angularly disposed jets will deliver fluid, the reaction of which will rotate said rotary member.

4. An apparatus for severing a well conduit comprising a tubular mandrel having elongated,

longitudinally extending peripheral openings, upper and lower bearing members in threaded engagement therewith, a rotary cutting member concentrically mounted with respect to said mandrel and engaged by said bearings, a plurality of radial jets in said cutting member in alignment with and in communication with the upper portion of said longitudinally extending openings in said mandrel, a plurality of jets in said cutting member disposed at an angle to the axis of rotation of said cutting member registering with and in communication with a lower portion of said longitudinally extending openings of said mandrel, the latter-named jets being directed generally in a circumferential direction, upper and lower sealing members disposed above and below said peripheral openings of said mandrel comprising gaskets disposed concentrically of said mandrel above and below said peripheral openings, and a coil spring concentrically disposed with respect to said mandrel and bearing against said gasket.

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