June 3, 1952 E. J. ROBISHAW 2,599,069

CASING MILL

Filed July 29, 1948 2 SHEETS—SHEET 1

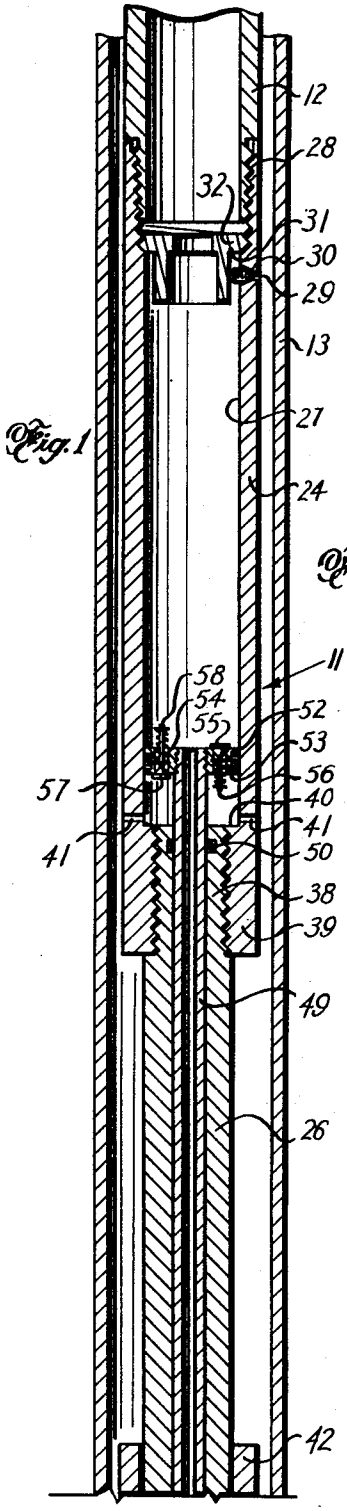


Fig. 1

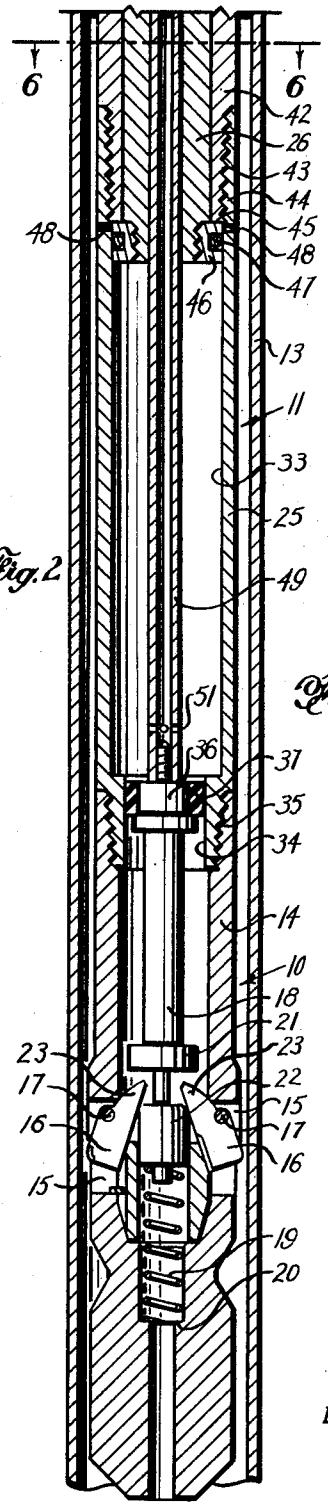


Fig. 2

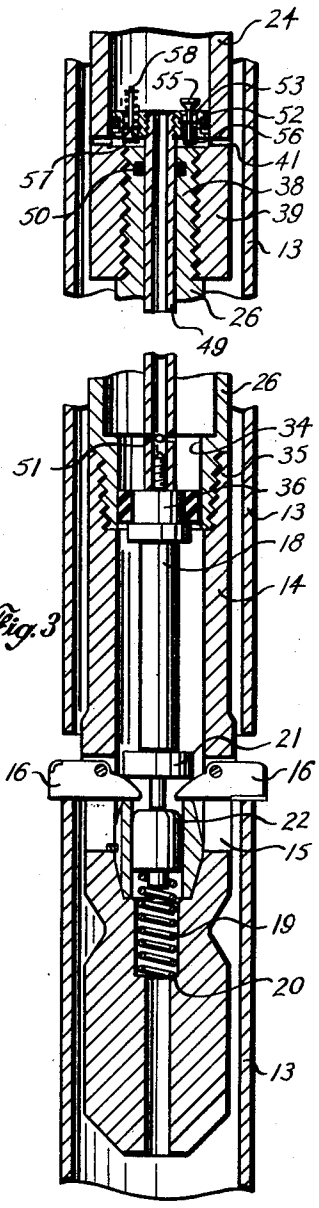


Fig. 3

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Fig. 4

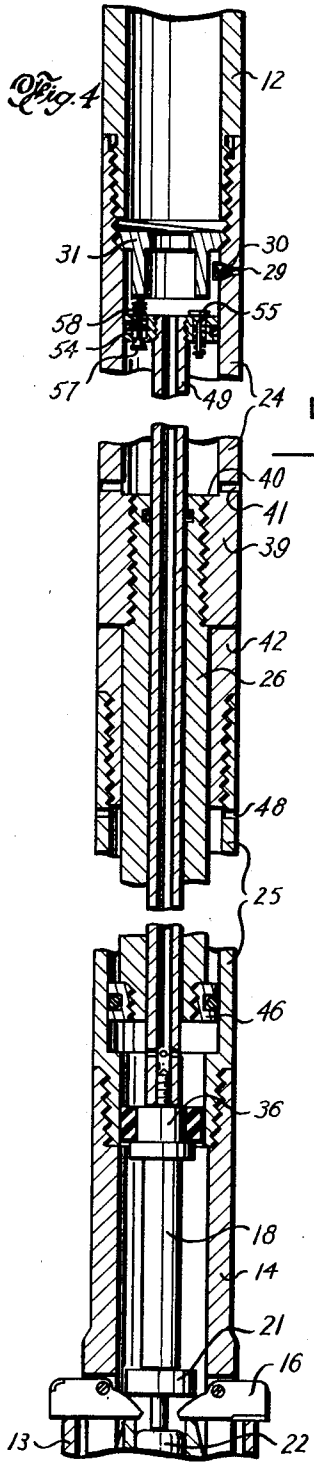


Fig. 5

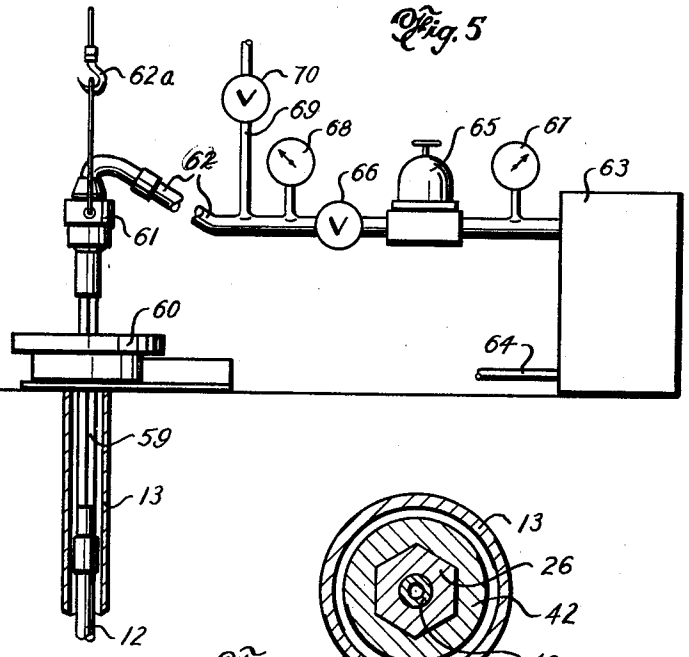
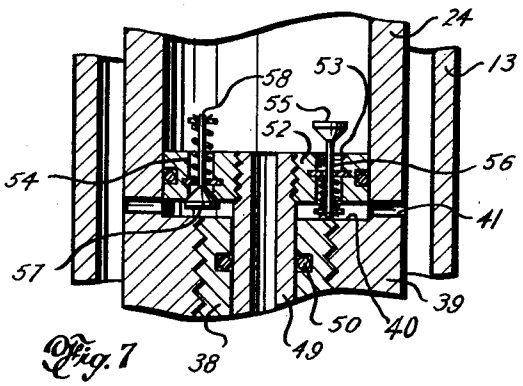


Fig. 6

Fig. 7



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CASING MILL

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4 Claims. (Cl. 164—0.8)

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This invention relates to a pipe cutter such as a casing mill which is particularly adapted to be used in a well bore for cutting out a section of the well casing or pipe.

It is frequently desirable in connection with well operations to cut out or remove a section of the casing lining the well bore in order to provide access to the formations along the well bore for purposes of conducting various types of operations with respect to such formations. Heretofore various cutting tools have been designed for cutting out sections of the pipe in a well bore. These tools consist essentially of a head, carrying laterally expandable cutting blades, which are attached to the lower end of a string of pipe by means of which the cutting head is lowered to the desired depth in the well. The blades are then expanded into contact with the casing wall and the operating pipe string is rotated from the top of the well to cause the blades to first sever the pipe and then to engage in a milling operation on the upper edge of the lower portion of the severed pipe in order to cut out as long a section of this pipe as may be desired to provide access to the surrounding formations.

Such existing tools may employ hydraulic means for expanding cutting blades but ordinarily employ the weight of the operating pipe string for applying pressure to the knives to effect the desired milling operation of the upper end of the severed pipe. Such conventional tools suffer from several disadvantages arising primarily from the employment of the weight of the operating pipe string to apply pressure to the cutting blades. Particularly when used in deep wells, the natural flexibility of the long operating pipe strings make it very difficult to control from the top of the well the weight applied to the cutting blades. Also the torsional forces resulting from rotation of long operating pipe strings will result in a substantial degree of twisting of the operating string which again makes it difficult to maintain the proper pressure on the cutting blades. Excessive pressure will result in destruction of the blades while insufficient pressure will prevent the blades from properly carrying out their cutting function.

The present invention has for its principal object the provision of a cutting tool in which the pressure on the cutting blades is applied through a fluid medium controlled from the surface to permit uniform and accurate control of the applied pressure.

An important object is the provision of a cutting tool wherein the pressure applied to the cutting blades is independent of the weight or longitudinal movement of the operating string.

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A further object is the provision of a cutting tool in which fluid pressure is employed both for expanding the cutting blades and for maintaining predetermined pressure on the cutting blades during the milling operation.

A more specific object is the provision of a cutting tool employing air as the pressure fluid medium for operation of the tool.

A further object is provision of means for signaling to the operator at the surface when the cutting blades are fully extended laterally and when a predetermined interval of longitudinal cutting has been completed.

Other and more specific advantages of this invention will become apparent when read in conjunction with the accompanying drawings which illustrate a useful embodiment in accordance with this invention.

In the drawings:

Figs. 1 and 2 together constitute a longitudinal sectional view through the cutting tool in accordance with this invention, showing the tool in position in a well casing prior to engaging in cutting operations thereon;

Fig. 3 is a view similar to Fig. 2 showing parts of the tool with the cutters engaging the casing;

Fig. 4 is a view showing the parts of the tool in another position during operations;

Fig. 5 is a schematic view of the well head connections employed in operating the tool;

Fig. 6 is a cross-sectional view along line 6—6 of Fig. 2; and

Fig. 7 is an enlarged view of a detail of the tool.

Referring to the drawings, the tool in accordance with this invention comprises a cutting head, indicated generally by the numeral 10, and a telescoping connection, indicated generally by the numeral 11, for connecting the cutting head to an operating string of pipe 12 which is employed for lowering and raising the tool in a well casing 13 and for operating it in the manner to be hereinafter described. Cutting head 10 is of more or less conventional construction and comprises a hollow cylindrical body 14 having a plurality of angularly spaced slots 15 in the wall thereof in which are mounted a corresponding number of cutting blades 16. The latter are rockably mounted on pivot pins 17 for radial movement toward and away from casing 13. For actuating the blades, a plunger 18 is slidably mounted in the bore of body 14 and is normally urged up-

wardly by means of a coil spring 19 engaged against a shoulder 20 arranged in the lower end of the bore of body 14. Plunger 18 carries a pair of vertically spaced abutments 21 and 22 which are adapted to engage the heel portions 23 of the blades for expanding or retracting them, as the case may be, depending upon the direction of movement of the plunger. Under the upwardly applied pressure of spring 19, the blades will normally be held in the retracted position, illustrated in Fig. 2.

Telescoping connection 11 comprises an upper cylinder 24, a lower cylinder 25 and a hollow externally splined rod 26 telescopically connecting the two cylinders for relative longitudinal movement, while maintaining rotative connection between the cylinders. Upper cylinder 24 has a hollow bore 27 and is provided at its upper end with an internally threaded socket 28 for attachment to a conventional threaded pin member on the lower end of operating pipe 12. A port 29 opens through the wall of cylinder 24 at a point just below socket 28 and is closed by an inwardly opening check valve 30. A tubular bushing 31 is concentrically arranged in the upper end of cylinder 24 and locked in position between the base of socket 28 and the inserted end of pipe 12 by means of a radial flange 32. Bushing 31 extends somewhat below the level of port 29 into bore 27. Lower cylinder 25 has a hollow bore 33 which is reduced in diameter at its lower end to provide a cylinder 34 of smaller diameter than bore 33. The exterior of cylinder 34 is threaded for connection to a threaded socket 35 on the upper end of body 14. Plunger 18 is adapted to extend into cylinder 34 and has mounted on its upper end a piston 36 which carries a resilient packing ring 37 slidably engageable with the wall of cylinder 34.

Splined rod 26, the exterior of which is preferably hexagonal in cross section, but which may be of any other irregular configuration, has an externally threaded pin 38 which is adapted to be screwed into a socket 39 provided in the lower end of upper cylinder 24. The bore of socket 39 is reduced in diameter relative to bore 27, thereby providing an internal annular shoulder 40 at the lower end of cylinder 24. A plurality of radially extending ports 41 open through the wall of cylinder 24 immediately above shoulder 40. The lower end of splined rod 26 is slidably engaged in the bore of spline collar 42 which has an internal configuration complementing the external configuration of splined rod 26, whereby rotational connection between these members is maintained, while permitting relative longitudinal movement between these parts. The lower end of collar 42 is provided with an externally threaded pin 43 for engagement in a threaded socket 44 provided at the upper end of lower cylinder 25. The lower end of pin 43 forms an inwardly extending shoulder 45 at the upper end of bore 33 of cylinder 25. The lower end of splined rod 26 carries a bushing 46 having a packing ring 47 mounted in the exterior thereof to thereby form a fluid-tight slidable seal between the inner wall of cylinder 25 and the lower end of splined rod 26. A plurality of radially extending ports 48 open through the wall of cylinder 25 immediately below the shoulder 45. A hollow stem 49 forming an extension of plunger 18, extends axially through the bore of splined rod 26 and is slidable therein. A packing ring 50 is arranged in the bore of pin 38 to form a fluid-tight seal between the bore of splined rod 26 and stem 49. The lower end of stem 49 is rigidly connected to plunger 18 and is provided with a plurality of ports 51 adjacent the point of connection to plunger 18 to provide communication between the bore of stem 49 and bore 33 of the lower cylinder 25. The upper end of stem 49, which extends into bore 27 of upper cylinder 24, has mounted thereon a piston 52 (see Fig. 7) through which extend a pair of spaced passageways 53 and 54. Passageway 53 is closed by an upwardly opening spring-loaded check valve 55 having a stem 56 which extends below the lower face of piston 52. Passageway 54 is closed by a spring-loaded downwardly opening check valve 57 having a stem 58 which extends above the upper surface of piston 52. Stem 49 is of such a length that when the telescoping connection 11 is in its fully extended position and blades 16 are in their retracted position, as illustrated in Figs. 1 and 2, the lower end of valve stem 56 will be spaced from shoulder 40 by a distance corresponding to the length of travel of plunger stem 49 required to force blades 16 into their fully extended position, so that when that condition is attained, lower end of valve stem 56 will strike shoulder 40 and open check valve 55 (see Figs. 3 and 7).

Fig. 5 illustrates the arrangement of connections at the well head employed in the operation of the tool in accordance with this invention. It will be seen that operating pipe 12 is connected at its upper end to the usual Kelly joint 59 which extends through rotary table 60 and is connected to a conventional rotary swivel 61 suspended from a hook 62a of the usual traveling block (not shown) of a drilling rig. A fluid supply pipe 62 connects the interior of the rotary swivel to a pressure fluid reservoir tank 63, which is supplied with suitable pressure fluid through a pipe 64 from any suitable source of supply by means of a pump or compressor (not shown), as the case may be. A pressure regulator 65 of any conventional or suitable type is interposed in pipe 62, which is also provided with a valve 66 on the down-stream side of the regulator. A pressure gage 67 is connected to pipe 62 between regulator 65 and tank 63, and a second pressure gage 68 is connected to pipe 62 on the downstream side of valve 66.

The operation of the tool will now be described. Operating pipe 12 carrying the cutting tool connected to its lower end, will be lowered into the well and connected for rotation by rotary table 60 in the usual manner, as illustrated in Fig. 5. When entering casing 13, the parts of the tool will be in the positions illustrated in Figs. 1 and 2 particularly, that is, blades 16 will be retracted and telescoping connection 11 will be in its extended position, the weight of the cutter head being sufficient normally to fully extend the connection. Piston 52 at the upper end of the plunger stem 49 will be held in the upper position illustrated in Fig. 1 by the upward thrust of coil spring 19. It will be assumed in this example that no extraneous fluid, such as drilling mud or well fluid, is present in casing 13. When the cutters have been lowered to the point at which cutting of the casing is to begin, the rotation of the operating pipe will be started and fluid pressure, which in this example may be air pressure, will be supplied through the surface connections to the interior of the operating pipe string. The pressure fluid, which will be supplied from pipe 64 by way of reservoir 63, under the control of reg-

ulator 65, will enter cylinder 24, and flow into the bore of extension rod 49 and thence through ports 51 into the interior of cylinder 25. The loading of check valve 57 will have been preset to hold this valve closed against the predetermined operating pressure. The pressure will thus be applied to the upper faces of pistons 52 and 36, forcing plunger 18 and its extension rod 49 downwardly against the resistance of spring 19, causing expansion of blades 16 into cutting position against the casing. Rotation of pipe string 12 will rotate the cutter body by reason of the splined connection formed between spline collar 42 and splined rod 26. As the operating string rotates, blades 16 will cut into the wall of casing 13, being forced outwardly under the pressure applied to pistons 36 and 52, which move downwardly as the blades continue to expand. When the blades have severed the casing, they will attain the horizontal position illustrated in Fig. 3 and, as noted previously, by reason of predetermined dimensional relationship, the lower end of valve stem 56 will, at that instant, come into contact with shoulder 40 forcing check valve 55 to open, relieving the pressure from inside bore 27 through passageway 53 and ports 41 into the annular space between the tool and casing 13. This produces an instantaneous drop in pressure in the interior of the tool string which will be indicated at the surface on gage 68 and will constitute a signal to the operator that the casing has been severed.

The operations for milling the severed casing may now be begun. The operating string will be lowered by lowering hook 62*a* in the usual manner for a distance sufficient to collapse telescoping joint 11. This may occur because body 14, lower cylinder 25 and splined collar 42 will be supported against downward movement by the residence of the now extended blades 16 on the upper edge of the lower portion of the severed casing (see Fig. 3), thereby allowing upper cylinder 24 and splined rod 26 to move downwardly relative thereto. As upper cylinder 24 and splined rod 26 move downwardly, piston 52 will, of course, remain stationary and shoulder 40 will move downwardly relative thereto and release valve stem 56 allowing check valve 55 to close. This permits the pressure above pistons 52 and 36 to again build up to the operating level. The parts of the telescoping connection 11 will be so dimensioned, that when the connection is fully collapsed, the upper end of valve stem 58 will strike against the lower end of bushing 31, opening check valve 57 and again venting the pressure fluid through ports 41 (see Fig. 4). This will again be indicated by a drop in the pressure on gage 68 and will be a signal to the operator that the splined connection is fully collapsed. This is important because it will enable the operator to know instantly when to stop the lowering movement of the operating pipe so as to avoid the application of its weight to the blades, and thereby avoid the damaging effect thereon of excess weight. The operator will then immediately lift the operating string just sufficiently to permit valve 57 to close by the action of its loading spring, whereupon the pressure will again be allowed to build up to the desired operating level from tank 63 through regulator 65. With the pressure now built up, rotation of the operating string is continued while the upper end of the operating string is held stationary against longitudinal movement.

With the pressure thus applied to pistons 52 and 36, the blades will proceed to mill off the upper end of the severed portion of the casing. With operating pressure being maintained at the desired level during this operation, as the upper end of the lower casing section is thus milled off, the cutter head and cylinder 25 of the telescoping connection will descend, extension 49 carrying piston 52 descending correspondingly as the telescoping connection becomes extended. The movement of these parts relative to upper cylinder 24 and pipe 12 will continue until piston 52 has descended in cylinder 24 to a point at which stem 56 again strikes shoulder 40 whereupon valve 55 will be opened and the pressure relieved through ports 41. This will immediately apprise the operator at the surface, through the deflection of the indicator on gage 68, that the telescoping connection has become fully extended. Since the length of movement of the telescoping connection is known, the operator will be apprised that a corresponding length of the severed section of the casing has been milled off. If an additional increment of the casing is to be milled off, the operator will immediately lower the operating string until valve stem 58 strikes bushing 31, again signaling the full retraction of the telescoping connection and apprising the operator that the tool is ready for a repetition of the previously described operation for continuing the milling of the casing. This operation may be repeated as often as necessary to cut out a section of the casing of the desired length. When the milling operation has thus been completed, the fluid pressure is relieved at the surface by opening valve 70. The operating string is lifted at the surface raising blade 16 above the upper edge of the severed portion of the casing, thereby allowing coil spring 19 to force piston 18 upwardly and retract blades 16, whereby the entire string may be withdrawn from the well.

It will be understood that instead of air as the pressure fluid employed in the above operation, hydraulic fluids may be employed for the same purpose, as well as other pneumatic fluids, such as natural gas and the like. The fluid pressures employed may be varied to suit particular conditions which may be encountered. Ordinarily pressures of about 200–300 pounds per square inch will be sufficient for most purposes. Likewise the length of travel of telescoping connection 11 may be varied as desired, with one to three feet being convenient lengths for most purposes.

Where liquid is present in the well, such as ordinary drilling mud or well fluids, ports 29, 41 and 48 provide means for transference of such fluids between the interior and exterior of the tool string to permit suitable equalization of the pressures, while air pressure is supplied from the surface for operation of the tool. The operation will be substantially the same, the air acting on the liquid inside the tool string in the manner, as previously described to control the cutting operations.

From the foregoing it will be seen that with a cutting tool constructed in accordance with this invention, fluid pressure is employed not only to expand the cutting blades for severing the casing but also to control the milling pressure applied to the blades. The pressure fluids thus afford very convenient and accurate means for maintaining very close control of the pressures to be applied and thereby permit very accurate control of the cutting operations with minimum danger of dam-

age to the parts of the tool, since the cutting head is advanced relative to the operating pipe during each cutting interval solely by fluid pressure and independently of the operating pipe. Moreover, the novel construction of the tool, including the described signalling arrangement, enables the operator to determine with a high degree of exactitude the length of casing or other well pipe which is removed by the tool.

It will be understood that various changes and alterations may be made in the details of the embodiment herein described without departing from the scope of the appended claims but within the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A casing mill, comprising, a head carrying radially expandible cutting blades, a hollow telescoping coupling member for connecting said head member with an operating pipe, said coupling member including a pair of end-aligned cylinders arranged for relative longitudinal movement and a hollow spline member connecting said cylinders for said relative longitudinal movement while maintaining rotative connections therebetween, a hollow plunger having a bore affording communication for movement of pressure fluid between said cylinders slidable axially of said spline member, pistons mounted on the plunger and located in said cylinders, said plunger being connected to said blades and said head member and actuable solely by fluid pressure transmitted through said pipe to expand said blades and to advance said head member relative to said operating pipe, spaced openings in said plunger communicating with the respective cylinders, and valve means carried by said plunger for controlling the movement of pressure fluid therethrough.

2. A casing mill, comprising, a head member carrying radially expandible cutting blades, a hollow telescoping coupling member for connecting said head member to an operating pipe, said coupling member including a pair of end-aligned cylinders and a hollow spline member connecting said cylinders for relative longitudinal movement while maintaining rotative connection therebetween, hollow plunger means slidable axially of said coupling member and affording pressure fluid communication between said cylinders, said plunger means being connected to said blades and actuable solely by fluid pressure to expand said blades and to advance said head member relative to said operating pipe, cooperating stop means arranged between said plunger means and said coupling member to limit relative longitudinal movement therebetween in both directions and valve means carried by said plunger actuable by engagement thereof with either of said stop means to produce a drop in the fluid pressure applied to said plunger means.

3. A casing mill, comprising, a head member carrying radially expandible cutting blades, a hollow telescoping coupling member for connecting said head member to an operating pipe, said coupling member including a pair of end-aligned cylinders and a hollow spline member connecting said cylinders for relative longitudinal movement while maintaining rotative connection therebetween, hollow plunger means slidable axially of said coupling member and affording pressure fluid communication between said cylinders, said plunger means being connected to said blades and said head and actuable solely by fluid pressure to expand said blades and to advance said head member relative to said operating pipe, a sealing piston mounted on said plunger means for sliding movement therewith in the upper one of said cylinders, spaced stop members in said upper cylinder on opposite sides of said piston, passageways through the wall of said upper cylinder below the point of maximum descent of said piston, normally closed valve means carried by said piston and actuable by engagement with either of said stop members to be opened for the discharge of pressure fluid from above said piston through said passageway.

4. A casing mill, comprising, a head member carrying radially expandible cutting blades, a hollow telescoping coupling member for connecting said head member to an operating pipe, said coupling member including a pair of end-aligned cylinders and a hollow spline member connecting said cylinders for relative longitudinal movement while maintaining rotative connection therebetween, plunger means slidable axially of said spline member and connected at its lower end to said blades for expanding said blades and for advancing said head member relative to said operating pipe, a bore in said plunger affording pressure fluid communication between said cylinders, pistons mounted on said plunger in each of said cylinders forming slidable seals therewith, and valve means carried by said plunger means for controlling the movement of pressure fluid therethrough.

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