

July 18, 1967

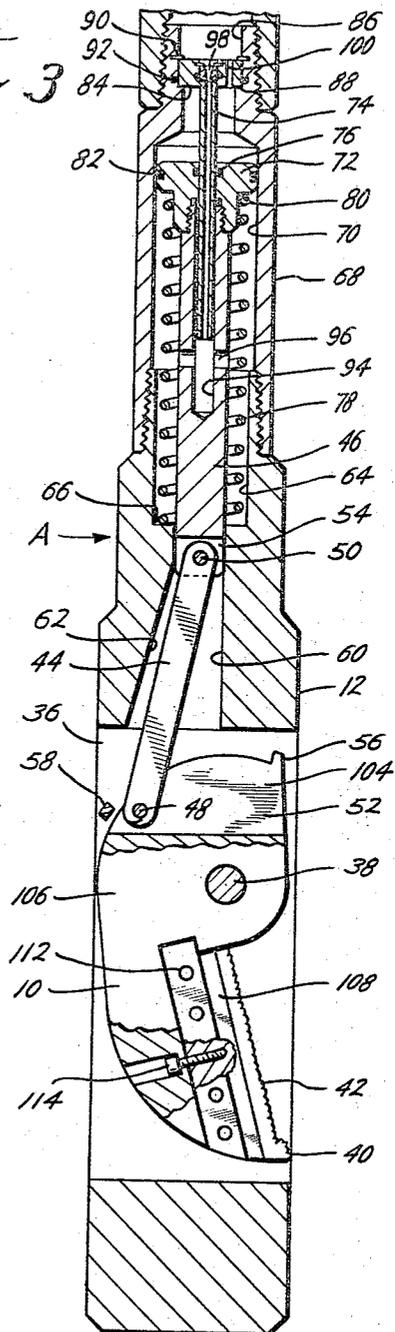
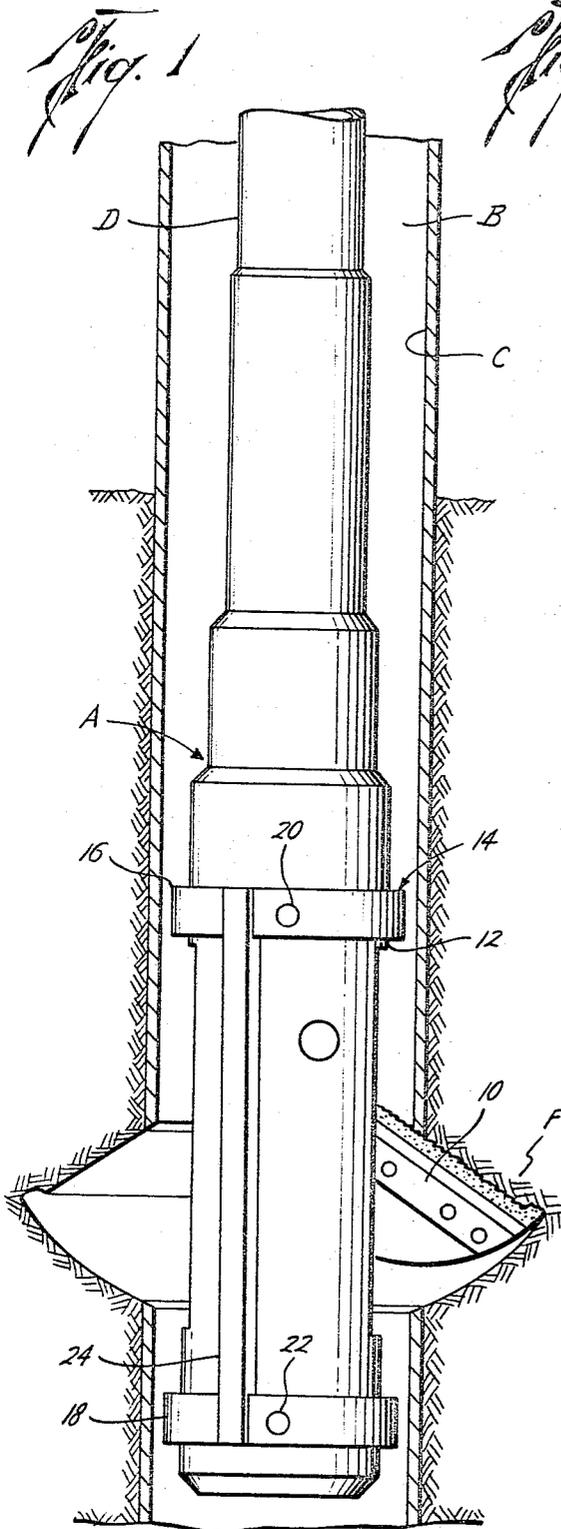
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3,331,439

MULTIPLE CUTTING TOOL

Filed Aug. 14, 1964

4 Sheets-Sheet 1



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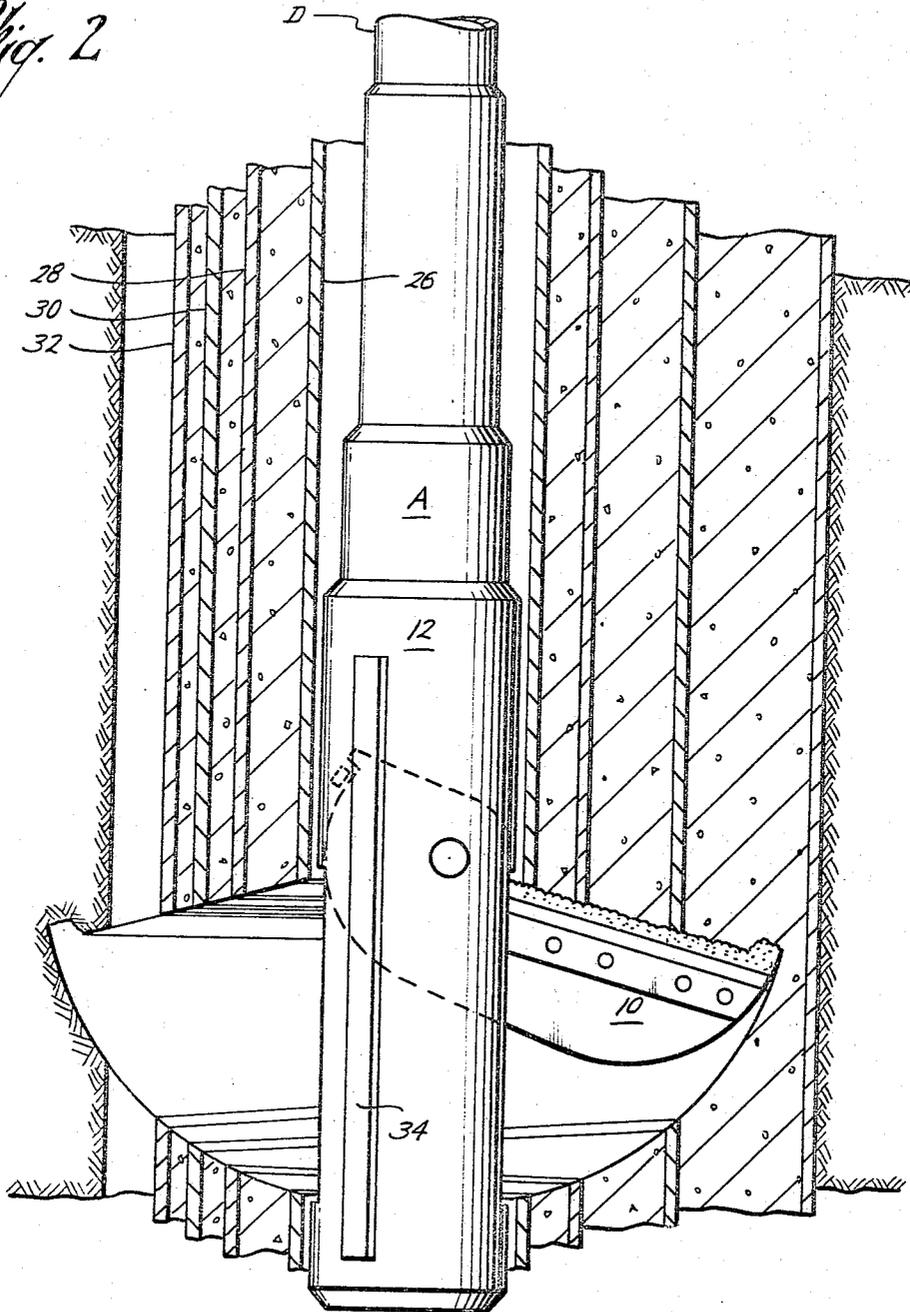
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Fig. 2



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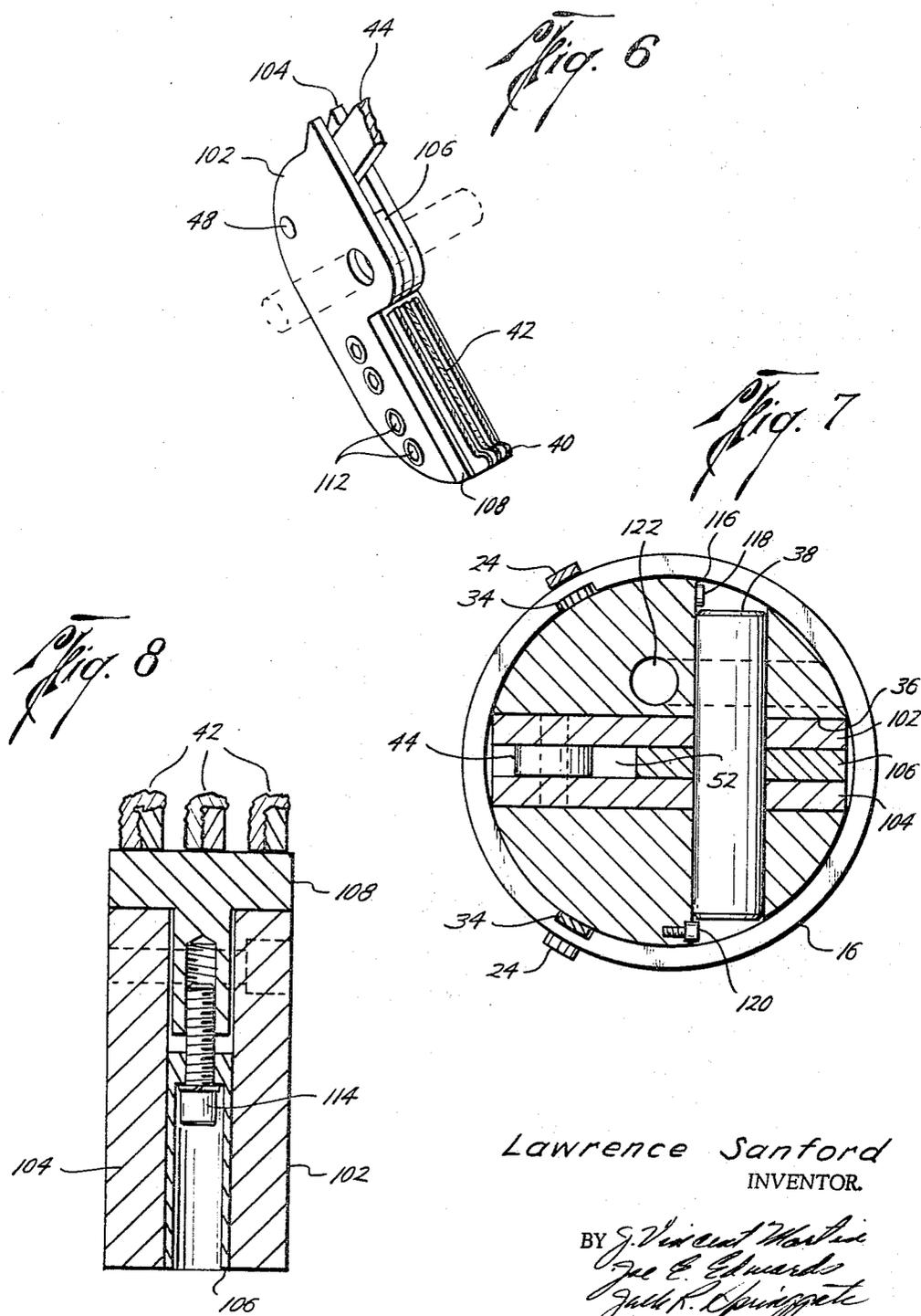
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4 Sheets-Sheet 4



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MULTIPLE CUTTING TOOL
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The present invention relates to a cutting tool for use in well bores. More particularly the cutting tool of the present invention may be used for cutting a plurality of well strings within a well bore regardless of the downhole alignment of the well strings.

Many times in the operation of a well, it is desired and sometimes required that the casing strings be cut at a point below the surface within the well bore. It is a requirement in marine operations that the well casing be removed at least fifteen feet below the mudline if the well is to be abandoned so that such well strings will not present a hazard.

Cutting tools have been used for cutting well strings in well bores. Such devices generally provide a single tool for a single size of well string. Such prior devices generally require running and pulling the cutting tool for as many times as there are well strings to be cut. It is further requirement of such prior devices that the cutting tool be mounted during cutting so as to be substantially centered with the well string being cut.

Many times oil wells have been completed with the plurality of well casings which are theoretically concentrically mounted but which will very seldom, if ever, be concentric one within another at a substantial distance down into the well bore. A single cutting device has been needed which will cut such multiple strings and which will have a substantial cutting diameter as compared to its tool diameter. Further, a device has been needed which can be run into a well bore to cut multiple well strings in which the device need not be removed from the well bore during cutting. A need also has been felt for a single cutting tool which can be adapted to be used in a variety of well string sizes and which will cut multiple well strings or will cut through a single well string and into the producing formation.

During the life of a well it has been found that production may, in many instances, be increased through well-known formation fracturing processes. Such processes generally require that the casing be cut at the level of the producing formation and that substantial cuts be made into said formation from the casing so that the effectiveness of the formation fracturing process will be assured.

Therefore, it is an object of the present invention to provide a cutting tool for cutting through a plurality of concentric well strings at any position within a well bore and regardless of the downhole concentric alignment of such well strings.

Another object of the present invention is to provide a well cutting tool which is readily adaptable to a plurality of well string sizes.

A further object of the present invention is to provide a cutting tool which will cut through a plurality of well strings positioned one within another, and such cutting will proceed smoothly and evenly regardless of the downhole alignment.

Another object of the present invention is to provide a cutting tool for cutting a well string within a well bore; the maximum diameter of cut of which the tool is capable being many times the diameter of the body of the cutting tool.

A still further object of the present invention is to provide a cutting tool for use in well bores which provides an upwardly facing cutting surface which moves upwardly and outwardly during cutting of a well string within the well bore.

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A still further object of the present invention is to provide a cutting tool for use in cutting a well string within a well bore having cutters which progressively present a different cutting surface to the well casing being cut as the cutting progresses, whereby cutting efficiency is increased.

Still another object of the present invention is to provide a cutting tool for use in well bores in which the cutting elements may be changed without disconnecting or removing the cutting tool from the drill string with which it is being used.

Another object of the present invention is to provide a cutting tool for use in a well bore which will cut through a well string and the cement surrounding said string and additionally will cut a substantial distance radially outwardly into the well formation.

This invention will be readily understood from reading of the following detailed description with reference to the drawings wherein:

FIGURE 1 is a view illustrating a well cutting tool constructed in accordance with the invention, performing the cutting operation within a well bore;

FIGURE 2 is a view illustrating a well cutting tool constructed in accordance with the invention, performing the cutting operation of multiple well strings within a well bore;

FIGURE 3 is a detailed longitudinal sectional view of a well cutting tool constructed in accordance with the present invention illustrating the cutting element in retracted position;

FIGURE 4 is a longitudinal sectional view of a well cutting tool constructed in accordance with the present invention illustrating the cutting element in extended position;

FIGURE 5 is an exploded perspective view of the components of the cutter block assembly constructed in accordance with the present invention;

FIGURE 6 is a perspective view of the components illustrated in FIGURE 5 assembled;

FIGURE 7 is a detailed cross-sectional view taken along lines 7-7 in FIGURE 4; and

FIGURE 8 is a detailed cross-sectional view taken along lines 8-8 in FIGURE 4.

In the drawings, the cutting tool of the present invention is designated A. As shown in FIGURE 1, cutting tool A is positioned within the well bore B and is shown attached to the drill string D. The cutting tool A has been rotated in position by rotation of the drill string D and the pivotable cutting block assembly 10 has been pivoted outwardly with respect to the main body 12 of the cutting tool to cut through the casing C and into the formation F.

Since the inner diameter of the casing C, as illustrated in FIGURE 1, is substantially larger than the outer diameter of main body 12, stabilizer means 14 has been secured to main body 12 to hold cutting tool A substantially centered with respect to the interior of casing C. Stabilizer means 14 includes upper ring 16 and lower ring 18 suitably secured to main body 12 by screws 20 and 22 and stabilizer pads 24. While not shown in FIGURE 1, two stabilizer pads 24 are provided extending from upper ring 16 to lower ring 18, each being oriented approximately 120° from pivotable cutter block assembly 10.

It should be noted that by use of different sizes of the stabilizer means that one size cutting tool A may be readily used within a plurality of sizes of casing C. Stabilizer means 14 are required to be attached to cutting tool A where the inner diameter of the casing to be cut is substantially larger than main body 12 of cutting tool A. With the cutting tool A of the present invention it is only necessary to center cutting tool A within the casing C for the initial cutting, as may be clearly seen from FIGURE 2.

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Cutting tool A, as shown in FIGURE 2, is also suitably secured to the drill string D and is positioned within the inner string 26 of a plurality of strings 28, 30 and 32 which are positioned one within another, as shown. Since the diameter of main body 12 is substantially the inner diameter of inner string 26, the stabilizer means includes only the longitudinally extending stabilizer pads 34. Two of the stabilizer pads 34 are used and are suitably secured to a main body 12, as by welding or other suitable means, and are oriented approximately 120° from pivotable cutter block assembly 10.

With cutting tool A, as shown in FIGURE 2, concentrically mounted for rotation within inner string 26, cutting may be commenced by rotating drilling string D and by pivoting cutter block assembly 10 with respect to main body 12. Sufficient force should be supplied to cutter block assembly 10 to force the cutting surfaces into the string 26 so that cutting may proceed. As cutter block assembly 10 cuts through inner string 26 it will pivot further and cut through the cement between strings 26 and 28.

As shown in FIGURE 2, strings 26, 28, 30 and 32 are not concentrically mounted; therefore, cutter block assembly 10 will initially come into engagement with one side of string 28 and commence cutting thereon, that is, the side closest to the exterior of inner string 26, before coming into engagement with the other side of string 28. It should be noted that as the cutting of inner string 26 progresses, different positions on the cutting edge of cutter block assembly 10 are used for cutting. This not only provides a continuously new cutting surface for the cutting of inner string 26 but also provides a governing action whereby cutter block assembly 10 is pivoted outwardly in a controlled motion. Without this continued cutting on inner string 26, the lack of concentricity of the strings 26 and 28 could allow cutter block assembly 10 to move outwardly into the area between strings 26, 28 at the point of maximum separation of the strings and become locked in such position. As the cutting progresses through the additional strings 28, 30 and 32, such governing action and the progression of cutting on the cutting surface of cutter block assembly 10 provides a smooth continuous cutting through the strings.

As best shown in FIGURES 3 and 4, cutter block assembly 10 is mounted within the slot 36 in the lower portion of main body 12. Pin 38 provides the pivotal mounting for cutter block assembly 10 with respect to main body 12. Pin 38, as hereinafter more fully described, extends through cutter block assembly 10 and is secured in the opposite portions of main body 12 at either side of the slot 36. Pin 38 should extend through main body 12 substantially perpendicular to the slot 36 to allow cutter block assembly 10 to be freely pivoted within slot 36.

FIGURES 3 and 4 are substantially the same except that FIGURE 3 illustrates the cutter block assembly 10 in retracted position, and FIGURE 4 illustrates the cutter block assembly in extended or cutting position. As can be seen from FIGURE 3, the width of cutter block assembly 10 is slightly less than the outer diameter of main body 12, and in retracted position of cutter block assembly 10 within the slot 36 the cutting tool A may be easily run into a well bore and readily removed therefrom. The length of cutter block assembly 10, however, that is, from pin 38 to the extremity 40 of cutting surface 42, will be substantially greater than the diameter of main body 12 whereby cutting tool A may be used for cutting within a well bore and have a cutting diameter many times the outer diameter of main body 12. It should be noted that pin 38 is mounted in offset position with respect to the center line of main body 12 which further increases the cutting diameter of the cutter block assembly 10. As hereinafter more completely explained, the limit of the ratio of cutting diameter to the diameter of main body 12 appears to be approximately five or six. Factors, such as the force required for cutting, will determine the maximum cutting diameter which may be achieved with the cutting tool A.

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Actuation to pivot cutter block assembly 10 is achieved by connection of actuating link 44 to cutter block assembly 10 and to piston rod 46. Pin 48 provides a pivotal connection between actuating link 44 and cutter block assembly 10 and pin 50 provides a pivotal connection between actuating link 44 and piston rod 46. Actuating rod 44 is thereby pivotally mounted within the slot 52 of cutter block assembly 10 and within the lower slot 54 of piston rod 46 to allow freedom of movement of actuating link 44 responsive to movement of piston rod 46.

Cutter block assembly 10 includes the projection 56 which cooperates with the stop block 58 secured to main body 12 within the slot 36 to act as a limit to the pivoting of cutter block assembly 10 as it approaches the limit of its cutting diameter.

The upper interior of main body 12 is provided with the bore 60 into which the lower end of piston rod 46 extends. The bore 60 is suitably offset or tapered at 62 to accommodate the position of actuating link 44. The upper end of main body 12 is counterbored at 64 to a larger diameter than the bore 60 and to provide shoulder 66. Upper body 68 is threaded onto the upper end of main body 12 and is provided with a bore 70 within which piston 72 is positioned. Piston rod 46 is suitably secured to the piston 72 as by threads or other suitable means. Piston 72 and piston rod 46 are both suitably bored to receive fluid circulating tube 74. Suitable seal 76, such as an O-ring, is provided to seal between the interior bore on piston 72 and the exterior of fluid circulating tube 74.

Spring 78 is positioned within counterbore 64 of main body 12 and within bore 70 and upper body 68 and engages shoulder 66 at one end and shoulder 80 on piston 72 at its other end. Thus, spring 80 will urge piston 72 in an upward direction within bore 70. Suitable packing 82 is provided in the exterior of piston 72 to provide a reciprocating seal against the interior of bore 70.

The upper end of fluid circulating tube 74 is provided with an enlarged block 84. Block 84 is positioned within the upper bore 86 of upper body 68. Block 84 seats on the shoulder 88 and is held in position by the snap ring 90. Suitable sealing means 92, such as an O ring, is provided to seal between bore 86 of upper body 68 and the exterior of block 84.

The bore 94 in piston rod 46 into which fluid circulating tube 74 extends is provided with the ports 96 whereby communication is established from the interior of piston rod 46 to the interior of bore 64. Choke 98 is positioned in block 84 of fluid circulating tube 74 to provide a restriction to the flow of drilling fluid through fluid circulating tube 74. Restricted passageway 100 extends through block 84 to provide communication between the portion of bore 86 above block 84 and the interior of upper body 68 above piston 72.

As clearly shown in FIGURES 5 through 8, portable cutter block assembly 10 is a laminated structure including outer block sections 102 and 104, inner block section 106 and cutter block 108. Cutter block 108 is T-shaped with the depending portion thereof adapted to be positioned between outer block sections 102 and 104 and in engagement with the recess 110 in inner block section 106. Suitable fastening means, such as screws, 112 extends through section 102, the depending portion of cutter block 108, and engages block section 104, and fastening means 114 extends through block 106 to engage cutter block 108 whereby cutter block 108 is secured in cutter block assembly 10. Cutting surface 42 is provided by a matrix with suitable cutting material imbedded therein.

Body 12, FIGURE 7, is provided with a bore 116 to receive pin 38 for the mounting of cutter block assembly 10. With pin 38 inserted in the bore 116, one end of pin 38 will engage stop block 118 and the other end of pin 38 will be secured in position in engagement with the head of screw 120. Also in FIGURE 7, it should be noted that the positioning of stabilizer pads 34 and 24 are approximately 120° from the slot 36 through which cutting surface 42 of cutter block assembly 10 extends during

cutting. Stabilizer ring 18 is provided with recess to accommodate stabilizer pads 34.

Referring to FIGURES 5 and 6, pin 48 extends through outer block sections 102 and 104 and through actuating link 44. Inner block section 106 is suitably formed to allow actuating link 44 to freely pivot between block sections 102 and 104. Suitable means, such as set screws (not shown) are provided to retain pin 48 in position extending through outer block section 102, actuating link 44 and outer block section 104.

Pivotable cutter block assembly 10 is assembled with block sections 102, 104 and 106 in proper alignment, and thereafter the outer peripheries of such block sections are suitably welded to form a unitary structure.

The cutting tool A of the present invention is lowered into a well bore with its components positioned as illustrated in FIGURE 3. When cutting tool A has been lowered to the position in the well bore at which cutting is desired, circulation of drilling fluid downwardly through drill string D should be commenced and rotation of drill string D should also be commenced. The circulation of drilling fluid will flow through choke 98, through the interior of fluid circulating tube 74 into the bore 94 of piston rod 46, out through ports 96 into counterbore 64 of main body 12 and downwardly through the passageway 122 to be discharged out from main body 12 at a position near cutter block assembly 10. The restriction to such flow of drilling fluid, provided by the choke 98, will cause the pressure above the choke 98 to build up, and such pressure will be transmitted through the restricted passageway 100 and be exerted against the upper surface of piston 72. As the pressure above piston 72 increases, piston 72 will move downwardly against the upward force of spring 78. The downward movement of piston 72 and piston rod 46 will force actuating link 44 to pivot cutter block assembly 10 about the pin 38 whereby the outer extremity of cutting surface 42 will be forced into engagement with the interior of the casing or well string to be cut. As cutting proceeds, the pressure of the drilling fluid will be maintained against the upper surface of piston 72 which will cause cutter block assembly 10 to be pivoted about pin 38 allowing cutting to continue until the desired cut has been completed. With the completion of the cut, it is only necessary to relieve the pressure of drilling fluid on the tool and to lift the drilling string and tool from the well. Engagement of the cutting surface 42 with the cut in the well string and the spring 78 will cause cutter block assembly 10 to move back into the position illustrated in FIGURE 3 wherein it is wholly contained within slot 36 in main body 12.

Without considering how much force could be transmitted through cutter block assembly 10 to cutting surface 42, the tool may be made any length and thereby any diameter of cut could be made. Practical limitations, such as the required force which must be exerted on cutting surface 42 to make a cut with tool A, the strength of the cutter block assembly 10 and the available pressure for forcing piston 72 downwardly to provide such force, are therefore the limiting factors in the diameter of cut that may be made with any size tool. The pressure which may be developed above piston 72 will be dependent upon the drilling fluid circulating system. The mechanical disadvantage of having the distance from pin 38 to pin 48 smaller than the distance from pin 38 to extremity 40 of cutting surface 42 is somewhat overcome by the offset position of pin 38. This offset will increase the effective lever arm between pin 38 and pin 48 and will further allow cutter block assembly 10 to extend farther from the center line of body 12 than it would if pin 38 were located in a position extending transversely through the center line of body 12.

In practice it has been found desirable that the extended cutting diameter should be limited normally to not more than five or six times the diameter of main body 12. Even with such limitation, the cutting diameter for

most tools has been found to be more sufficient for most cutting operations. The width of cutter block assembly 10 should be less than the diameter of body 12 so that it may be wholly contained within slot 36 during the running and the removal of cutting tool A from the well bore.

From the foregoing it can be seen that the present invention provides a cutting tool for cutting in well bores in which a well string and a substantial portion of the surrounding of the well string may be cut without having to remove the cutting tool from the well bore. Further, a cutting tool has been provided which may be used in different size well strings by providing the stabilizing assembly which will center the cutting tool within the innermost well string. The structure of the cutting tool of the present invention provides a governing action to restrict its outward movement by progressing cutting inwardly on the cutting surface so that the cutting surface is always in contact with the innermost well string being cut. This governing action will prevent the cutting surface from moving outwardly into a void or recess and will thereby prevent the tool from becoming jammed at an outwardly extended position which may be caused by the misalignment of more than one well string, one within the other. The cutting of the innermost well string will progress from the extremity 40 of cutting surface 42 in a direction toward pin 38, so that as cutting progresses a different portion of cutting surface 42 will be cutting the innermost string.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A cutting tool for use in well bores comprising:
 - a body,
 - a slot extending transversely across said body,
 - a cutter blade assembly pivotally mounted within said slot,
 - a drilling fluid passageway extending through said body,
 - a restriction in said drilling fluid passageway,
 - a piston positioned for reciprocating within said body,
 - means conducting drilling fluid ahead of said restriction to one side of said piston,
 - means connecting said piston to said cutter blade assembly whereby said cutter blade assembly may be pivoted to cutting position with respect to said body responsive to the movement of said piston.
2. A cutting tool according to claim 1, including resilient means urging said piston in a direction to retract said cutter blade.
3. A cutting tool according to claim 1, including means conducting drilling fluid downstream of said restriction to the opposite side of said piston whereby said piston responds to the pressure differential created by said restriction.
4. A cutting tool for use in well bores comprising,
 - a body,
 - a cutter blade assembly,
 - actuating means,
 - means pivotally securing said cutter blade assembly to said body,
 - means connecting said actuating means to said cutter blade assembly whereby said cutter blade assembly may be pivoted with respect to said body,
 - an upper ring secured to said body above said cutter blade assembly,
 - a lower ring secured to said body below said cutter blade assembly, and
 - at least two stabilizer pads extending from said upper ring to said lower ring,
 - said rings and pads centering said cutting tool within a well string.

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5. A cutting tool according to claim 4, wherein said stabilizer pads are oriented on said body approximately 120 degrees from the cutting surface of said cutter blade assembly.
6. A cutting tool for use in well bores, comprising a body, said body defining a transverse slot, a single cutter blade, means pivotally mounting said cutter blade in said slot, actuating means, 10 means connecting said actuating means to said cutter blade whereby said cutter blade is pivoted to extend from one side of said slot, a stabilizing ring secured to said body above said slot, and 15 a stabilizing ring secured to said body below said slot, said stabilizing rings providing support for said body when said cutting blade is extended to maintain said body in axial alignment with a well string.
7. A cutter tool according to claim 6, wherein said 20 stabilizing means includes, two stabilizing pads secured to said body at positions

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approximately 120 degrees from the extended position of said cutter blade, said stabilizer pads being at least as long as and substantially co-extensive with said slot.

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