May 28, 1963 E. H. CLARK, JR 3,091,290

WELL BORE MILLING APPARATUS

Original Filed March 25, 1958 3 Sheets-Sheet 1

FIG. 1.

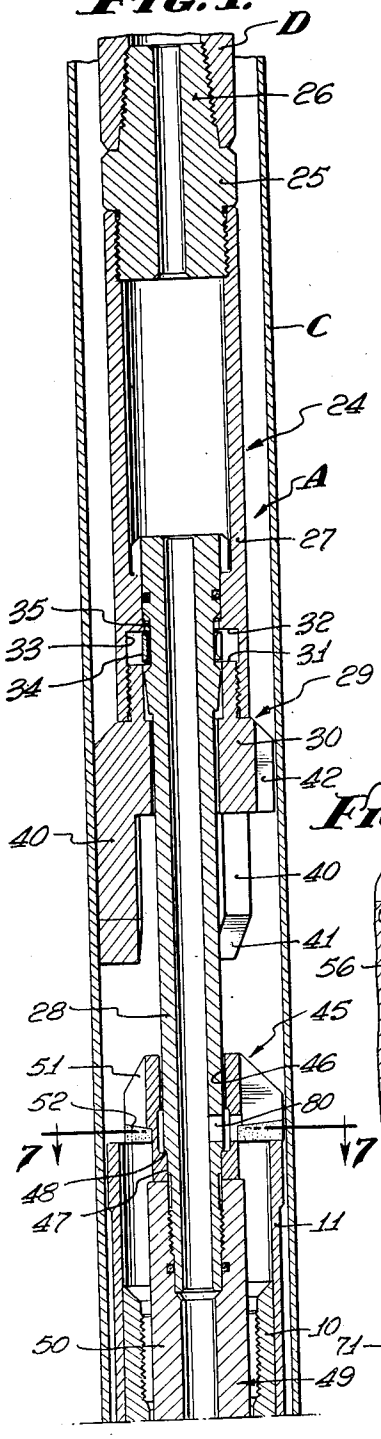


FIG. 8.

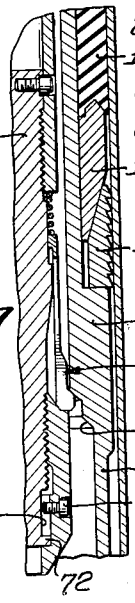
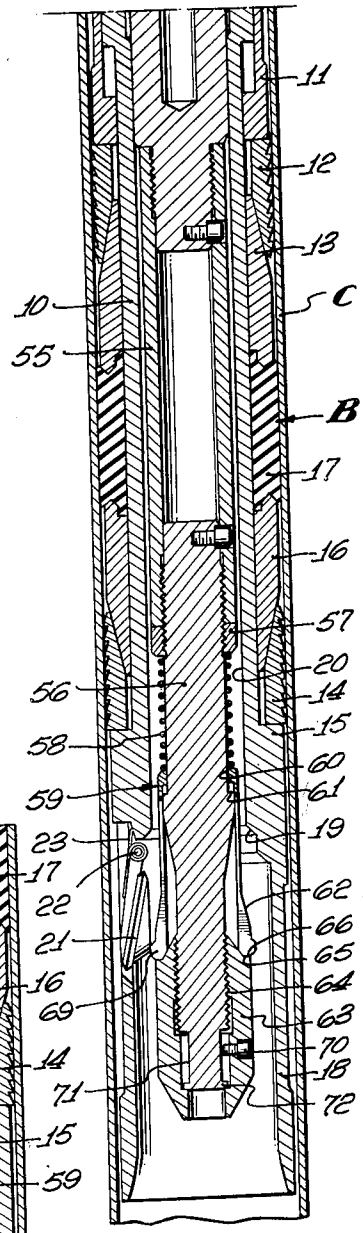


FIG. 1a.



INVENTOR.
EARNEST H. CLARK, JR.
BY
Mellin and Hanscom
ATTORNEYS

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FIG. 2.

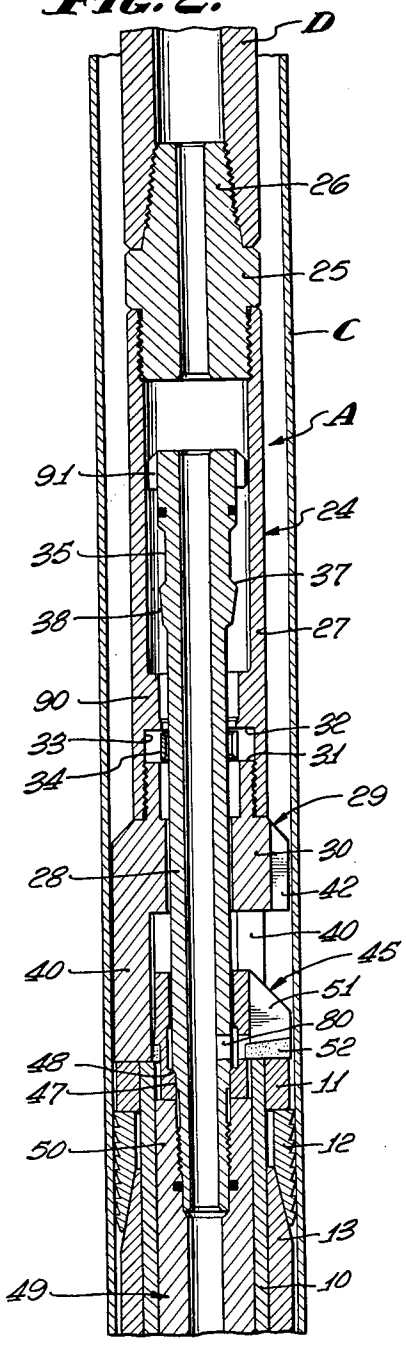
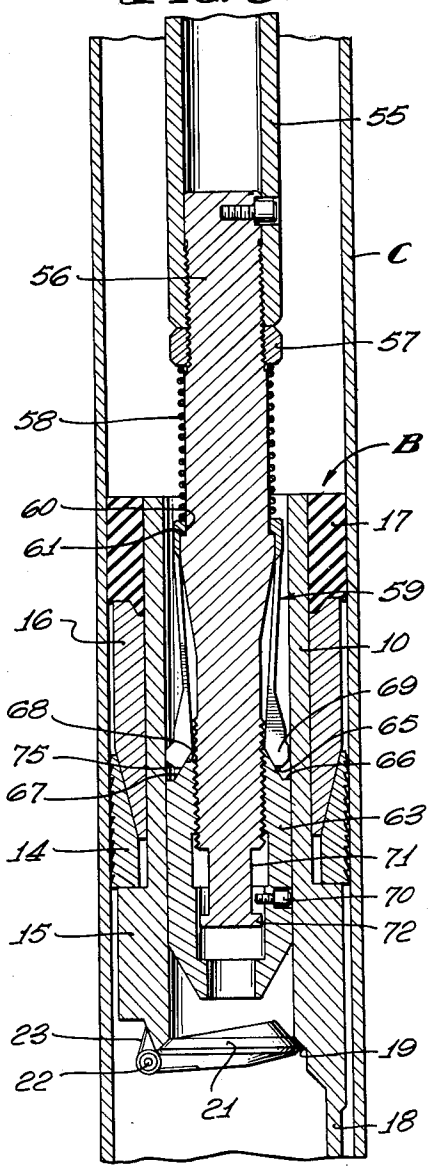


FIG. 3.



INVENTOR.
EARNEST H. CLARK, JR.
BY
Mellin and Hanscom
ATTORNEYS

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FIG. 4.

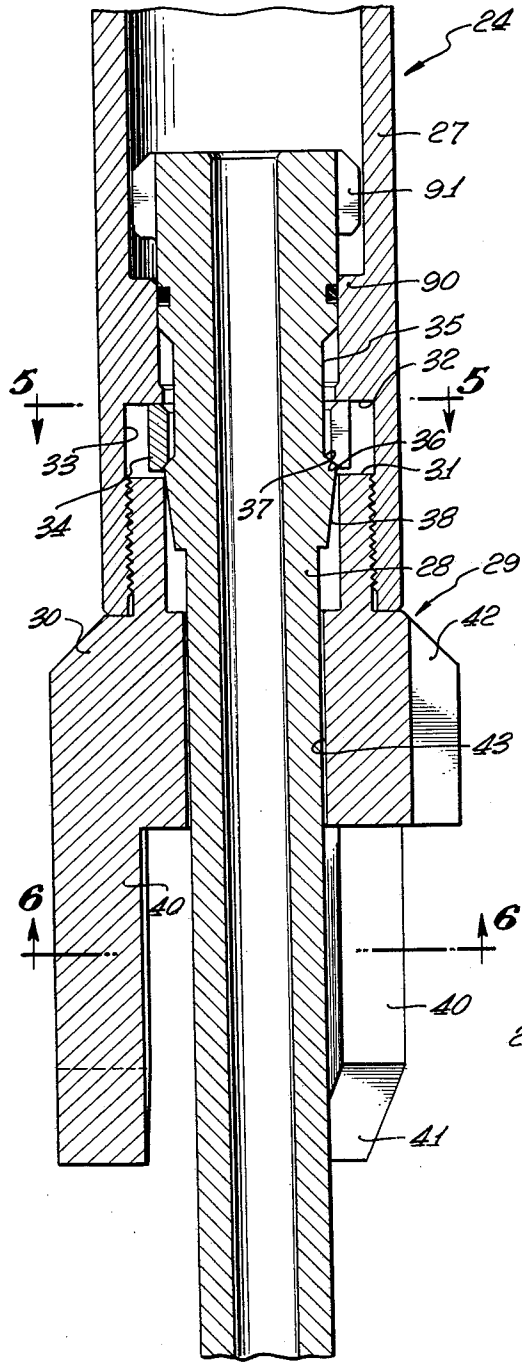


FIG. 5.

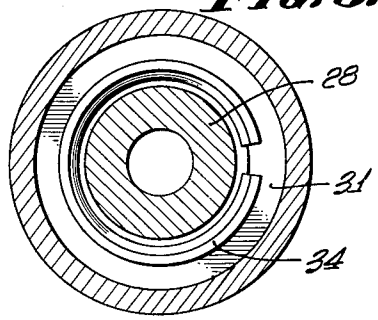


FIG. 6.

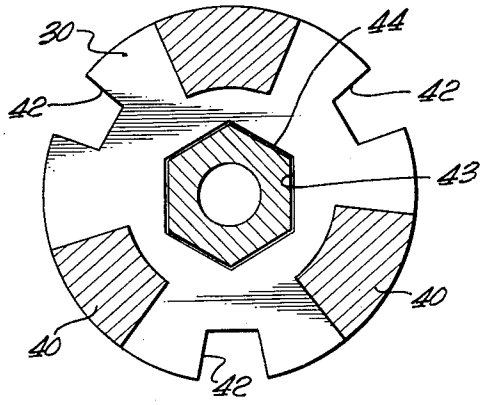
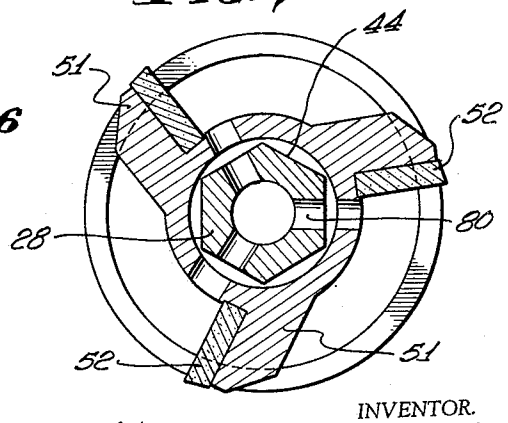


FIG. 7.



INVENTOR.
EARNEST H. CLARK, JR.
BY
Mellin and Hanscom
ATTORNEYS

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3,091,290

WELL BORE MILLING APPARATUS

Earnest H. Clark, Jr., Downey, Calif., assignor to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

Original application Mar. 25, 1958, Ser. No. 723,839, now Patent No. 3,005,493, dated Oct. 24, 1961. Divided and this application Feb. 18, 1960, Ser. No. 13,415

14 Claims. (Cl. 166—55)

The present invention relates to apparatus for milling away devices or obstructions in well bores, and more particularly to apparatus for milling away packers or plugs secured in well casings, and similar conduits, disposed in well bores.

This application is a division of my joint application with Talmadge L. Crowe for "Well Bore Milling Apparatus," Serial No. 723,839, filed March 25, 1958, now U.S. Patent No. 3,005,493.

An object of the invention is to provide milling apparatus for cutting away a well packer, or the like, in a well casing disposed in a well bore, in which the milling apparatus is maintained properly centered with respect to the packer to insure its effective operation on the packer and to prevent the apparatus from digging into or cutting the well casing.

A further object of the invention is to provide milling apparatus capable of cutting away a well packer, or the like, secured in well casing disposed in a bore hole to the extent that the well packer is released from the well casing, whereupon the apparatus is capable of retrieving the remaining portion of the well packer.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURES 1 and 1*a* together constitute a longitudinal section through an apparatus disposed in a well casing, FIG. 1*a* constituting a lower continuation of FIG. 1;

FIG. 2 is a view corresponding to FIG. 1 illustrating the chiseling or impacting portion of the apparatus in operation;

FIG. 3 is a view similar to FIG. 1*a* illustrating the manner of releasing the apparatus from a well packer without withdrawing the latter, or a portion thereof, from the well casing;

FIG. 4 is an enlarged longitudinal section through the chisel portion of the milling apparatus;

FIG. 5 is a cross-section taken along the line 5—5 on FIG. 4;

FIG. 6 is a cross-section taken along the line 6—6 on FIG. 4;

FIG. 7 is an enlarged cross-section taken along the line 7—7 on FIG. 1;

FIG. 8 is a longitudinal section through a portion of the apparatus shown in FIG. 1*a*, with parts shown in another position.

The milling or disintegrating apparatus A illustrated in the drawings is particularly adapted for partially or fully disintegrating a well packer B, bridge plug, or the like, secured in a well casing C disposed in a well bore. The milling apparatus is adapted to be lowered in the well casing and operated therewithin by means of a tubular string D, such as drill pipe or tubing, extending to the top of the well bore, the apparatus also being effective to retrieve at least a portion of the well packer B, or similar apparatus, as a result of its proper manipulation and elevation of the tubular string D in the well casing C.

The well packer shown by way of example in the drawings is particularly described in United States Patent No. 2,624,412. Essentially, it includes a tubular body **10** having an upper setting sleeve **11** slidable thereon adapted to engage an upper set of segmental slips **12** that coact with an upper expander **13** to secure the packer to the well casing C against upward movement thereon. A lower set of segmental slips **14** engages the lower portion **15** of the body and is held in anchoring engagement with the wall of the well casing by a lower expander **16** to prevent downward movement of the well packer within the well casing. A packing unit **17**, such as a rubber or rubber-like packing sleeve, is compressed between the upper and lower expanders **13**, **16** in sealing engagement with the wall of the well casing and the exterior of the packer body **10**, to prevent leakage of fluid around the exterior of the body and the inner wall of the well casing.

The well packer B may also have a lower junk catcher and feeler portion **18**, which is useful in insuring that the well packer can be lowered to the desired setting point in the well casing preparatory to expansion of its upper and lower slips **12**, **14** and the packing unit **17** into engagement with the wall of the well casing. The lower portion of the body **10** has a valve seat **19** formed therein surrounding its control passage **20** adapted to be engaged by a flapper valve head **21** pivotally mounted on a hinge pin **22** suitably secured to the packer body, the valve head being urged upwardly into engagement with its companion valve seat by a spring **23**. The valve seat **19** provides a downwardly facing shoulder which is tapered in an upward and inward direction for coaction with the milling apparatus A in retrieving the lower portion of the well packer, as described hereinbelow.

The milling apparatus A is capable of disintegrating the well packer B, either fully or partially, by either a rotary action in response to rotation of the tubular string D, or by an impacting or chiseling action, by delivering blows through lowering of the tubular string D. As shown, the milling apparatus includes an outer tubular structure, housing or cylinder **24**, consisting of an upper sub **25** having an upper pin **26** threadedly secured to the lower end of the tubular string D. An intermediate housing portion **27** has its upper portion threadedly secured to the upper sub **25** and is telescoped over an inner tubular member **28**, such as a kelly or mandrel. The lower portion of the outer tubular member **24** includes a chisel device **29**, the upper head portion **30** of which is threadedly secured within the lower end of the intermediate housing **27**, the upper end **31** of the head being spaced downwardly from an inwardly directed shoulder **32** on the housing to define an internal circumferential groove **33** in which a split snap ring **34** is contained. This snap ring is adapted to engage either the upper side **32** of the groove or the lower side **31** of the groove.

The snap ring 34 inherently tends to contract into engagement with the mandrel 28 extending therethrough, being received within an external groove 35 in the mandrel to longitudinally couple the latter to the outer tubular member 24 for movement therewith. Thus, the snap ring 34 is received partially in the internal groove 33 and partially in the external groove 35, its lower end 36 being adapted to engage an upper cam or tapered surface 37 on the mandrel inclined in an upward and inward direction. The imposition of a sufficient downward force on the outer tubular member 24 will cause it to force the lower tapered end 36 of the snap ring against the upper cam surface 37, which will expand the ring 34 outwardly and thus permit the outer housing 24 to move downwardly very rapidly over the inner mandrel 28, for a purpose described hereinbelow. Upward movement of the housing 24 relative to the mandrel 28 will cause a lower tapered surface 38 on the mandrel to engage the snap ring 34 and expand it outwardly.

The upper cam surface 37 has a relatively shallow taper, so that a comparatively great force is required to expand the ring 34 outwardly and to permit downward movement of the outer tubular member 24 over the mandrel 28. However, the lower cam surface 38 has a comparatively steep taper, so that a much lesser force is necessary to expand the snap ring 34 and permit the outer, upper tubular member 24 to shift back over the mandrel to its initial upper position, such as shown in FIG. 1.

The chisel portion 29 of the apparatus includes the chisel head 30 described above, from which depends a plurality, such as three, of circumferentially spaced chisel-like teeth 40 terminating in chisel edges 41. Between the chisel teeth 40, the head has longitudinal grooves or passages 42 therethrough to permit upward movement of the cuttings and drilling fluid therethrough. The head 30 of the chisel has a non-circular, such as a hexagonal, bore 43 slidably fitting a companion external non-circular configuration 44 on the mandrel below the lower tapered surface 38. This hexagonal and non-circular shape 44 on the mandrel extends downwardly and through a lower milling cutter 45 having a companion non-circular or hexagonal bore or socket 46 therethrough, to rotationally couple the mandrel 28 to the milling cutter.

The milling cutter 45 is prevented from moving axially of the mandrel 28 by a lower flange 47 on the cutter engaging a downwardly directed shoulder 48 on the mandrel, the flange being clamped against the shoulder by a pilot portion 49 of the apparatus adapted to extend into the bore 20 of the well packer B. This pilot portion includes an upper sub 50 threaded on to the lower portion of the mandrel 28 and engaging the milling cutter flange 47. The milling cutter itself has circumferentially spaced cutter blades or teeth 51 thereon provided with hard facing material 52 on their leading faces and adapted to engage and operate upon the packer setting sleeve 11, the packer body 10, slips 12, 14, expanders 13, 16, packing sleeve 17, and, for that matter, all portions of the well packer B, or other device, disposed in the well bore. It is evident that the rotation of the tubular string D is transmitted through the outer tubular member 24 to the mandrel 28 by virtue of the slidable spline connection 43, 44 therebetween, and from the mandrel 28 to the milling cutter 45 by virtue of the slidable spline connection 44, 46 therebetween.

The chisel portion 29 of the apparatus is normally disposed a substantial distance above the milling cutter portion 45 and is retained in such elevated position by the fitting of the snap ring 34 in the external circumferential groove 35. However, when the snap ring 34 is released, as by imparting sufficient downward force on the tubular string D and the outer tubular member 24, the chisel 29 will shift downwardly rapidly, its teeth 40 being arcuately displaced with respect to the milling cutter teeth 51, so as to pass between the latter and strike the well packer B.

The pilot portion 49 of the milling apparatus includes the upper sub 50 referred to above, this upper sub being

threadedly secured to the upper portion of an extension sleeve 55, the lower end of which is threadedly secured onto a lower pilot mandrel 56. A lock nut 57 is also threaded on the lower pilot mandrel, engaging the lower end of the extension sleeve 55, and also serving as a spring seat for the upper end of a helical compression spring 58 encircling the pilot mandrel 56 and bearing at its lower end against a catch sleeve 59. This catch sleeve can move downwardly of the mandrel to the extent limited by engagement of its inwardly directed flange 60 with an upwardly directed shoulder 61 on the mandrel. It includes a plurality of circumferentially spaced depending spring-like legs 62 normally urged by the helical compression spring 58 downwardly into engagement with a holding and safety member 63 in the form of a sub threaded onto the lower portion of the pilot mandrel 56 by means of a left-hand threaded connection 64. The lower ends 65 of the spring-like legs 62 are normal to the axis of the apparatus engaging a companion shoulder 66 at the upper portion of the holding sub 63. Such normal surface 66 of the holding sub terminates at an upward and inwardly inclined holding surface 67 adapted to engage companion inclined surfaces 68 at the lower portions of the spring legs, so as to hold such legs in an outward direction. When disposed in such outward direction, lower foot portions 69 of the legs are adapted to engage the catch shoulder or valve seat 19 of the well packer, coupling the pilot mandrel 56 to the body of the tool. When the pilot mandrel 56 and safety sub 63 are moved down through the packer B, the safety sub will engage the flapper valve head 21 and swing it downwardly from its seat 19 completely to one side of the passage 20 through the packer body 10.

The safety and holding sub 63 has a safety screw 70 threaded radially therein and extending into an elongate groove 71 in the lower portion of the safety mandrel 56. Such safety screw is provided to prevent complete unthreading of the safety sub 63 from the mandrel 56, inasmuch as the safety screw will engage the lower flange portion 72 of the mandrel.

When it is desired to disintegrate or mill up the well packer B, or a portion thereof, which is anchored in packed-off condition in the well casing, the milling apparatus A is secured to the lower end of the tubular string D and is lowered in the well casing C. At this time the snap ring 34 is disposed in the mandrel groove 35 and will couple the outer tubular member 24 to the mandrel 28 for joint longitudinal movement. The holding and safety sub 63 moves into the packer body passage 20, followed by the pilot mandrel 56, pilot extension sleeve 55, and upper pilot sub 50, the spring legs 62 engaging the upper end of the body 10 and being shifted upwardly of the pilot mandrel 56 against the force of the compression spring 58 and inwardly, such inward action being assisted by the tapered lower ends 75 of the feet 69 of the spring legs 62. The spring legs will then slide along the wall of the body passage 20 until they are disposed below the catch shoulder or valve seat 19 of the body 10, whereupon they can shift outwardly again, being forced down along the upper tapered portion 67 of the holding and safety sub 63 by the helical compression spring 58 and into engagement with the normal shoulder 66 of the holding sub, such as shown in FIG. 1*a*. The safety sub 63 will have shifted the flapper valve head 21 away from its seat 19 and to one side of the body 10 of the tool.

With the spring legs 62 in the position illustrated in FIG. 1*a*, the milling cutter blades 51 will engage the upper end of the setting sleeve portion 11 of the well packer B, and the milling action can commence. The pilot portion 49 of the milling apparatus will appropriately center the cutter blades 51 relative to the packer tool B, keeping the cutter blades away from the wall of the well casing C, preventing them from digging into the latter. The radial extent of the cutter blades is such as to clear the inner wall of the casing C, but to extend

outwardly beyond the exterior of the setting sleeve 11. The pilot portion 49 of the apparatus purposely makes a slightly loose fit in the bore 20 of the well packer, since it is found that the milling cutters operate more effectively with such relatively loose fit. For example, the maximum diameter of the pilot portion 49 might be about one-eighth of an inch less than the minimum inside diameter of the body 10 of the well tool.

The tubular string D is rotated, rotating the outer tubular member 24 and the mandrel 28, because of the non-circular connection 43, 44 between the chisel and the mandrel. The rotation of the mandrel 28 is transferred through the non-circular connection 44, 46 to the milling cutter 45, the cutter teeth 51 being rotated while being urged against the setting sleeve 11 by a sufficient downward force imposed on the tubular string D, the outer tubular member 24 and the mandrel 28. The snap ring 34 will not be cammed out of the mandrel groove 35 by the usual downward force imposed thereon and necessary to provide a cutting action of the blades 51 on the packer parts, since the force required to release the snap ring is quite extensive. For example, a downward force of 10,000 pounds may be necessary, before the snap ring 34 is cammed out of the groove 35 and permit downward movement of the outer tubular member 24 along the mandrel 28. With the proper downward force imposed on the cutter blades 51 and with the apparatus rotating, the cutter blades will mill away the packer portions. The cuttings are circulated out of the hold by pumping drilling fluid down through the tubular string D, the outer tubular member 24 and mandrel 28, the fluid discharging through ports 80 in the lower portion of the mandrel opposite the cutter blades 51, to flush the cuttings from the cutting region upwardly around the exterior of the tool A and tubular string D back to the top of the well bore.

The drilling action continues by rotating the apparatus B at a proper speed and with a proper down weight imposed on the cutter blades 51, until the setting sleeve 11 is disintegrated, as well as the upper slips 12, upper expander 13, packing sleeve 17, and the lower expander 16, slips 14 and body 10 of the tool, down to the position in which the lower slips 14 are no longer backed up by the lower expander, which will permit the remaining parts of the lower slips 14 to release from the well casing. When this occurs, the remainder of the packer body 10 will probably drop down along the pilot mandrel 56 until the catch shoulder 19 engages the feet 69 at the lower ends of the spring legs 62. It is unnecessary to perform any additional milling action on the well packer, since the tubular string D need merely be elevated to raise the outer tubular member 24, mandrel 28 and pilot mechanism 49, 59, and lower portion of the well packer in the well casing, to withdraw the apparatus and the lower well packer portion to the top of the hole, leaving the well casing C free from any packer material therewithin.

In the event that the milling cutters 51 may not be milling up the well packer effectively, most portions of which are normally made of readily drillable material, such as cast iron, the destruction or breaking of the well packer can be effected through use of the chisel teeth 40 that have staggered relation with respect to the milling teeth 51. Thus, the imposition of a sufficient downward force on the tubular string D and the outer tubular member 24 will press the snap ring 34 against the upper cam surface 37, which tends to urge the snap ring out of the mandrel groove 35. When the downward force exceeds a predetermined value, which, for example, may be 10,000 pounds, the snap ring 34 is expanded out of the groove 35, whereupon the outer tubular member 24 and its chisel teeth 40 are propelled downwardly at a rapid rate, the chisel teeth moving downwardly between the milling cutter teeth 51 to strike a comparatively great impact blow upon the well packer, tending to break the latter into pieces. Fluid may be circulated down through the tubular string D and the apparatus to wash away any pieces that have been broken away by the chisel teeth.

Repeated blows can be struck by the chisel tool 29 on the packer B by recocking the apparatus. This is done with comparative little force imposed on the tubular string D and the outer tubular member 24, since elevation of the apparatus will move the spring legs 62 up against the catch shoulder 19 to prevent upward movement of the pilot portion 49 of the apparatus and the mandrel 28. The outer tubular member 24 is moved upwardly along the kelly or mandrel 28, the snap ring 34 engaging the steeply tapered cam surface 38 which expands it outwardly until the outer tubular member 24 is returned to its uppermost position, as determined by engagement of a housing shoulder 90 with the outwardly extending flange 91 at the upper end of the mandrel 28. The force required to recock the apparatus, that is, to place the snap ring 34 back in its external groove 35, as has been stated above, is relatively small. Whereas the angle of taper on the upper cam 37 might require about 10,000 pounds to expand and release the ring, the very steep taper on the lower cam 38 is such that only about 100 pounds, or even a lesser force, is necessary to shift the outer tubular member 24 back upwardly along the hexagonal kelly 28 to a position in which the snap ring 34 can move back into the external groove 35.

Another jarring blow can now be imposed on the well packer B by imposing a downward force on the tubular string D which will first reengage the cutter blades 51 with the existing upper end of the well packer. When the downward force is sufficient to overcome the contracting strength of the snap ring 34 (10,000 pounds for example), the latter is released, and the tubular string D and outer member 24 will move downwardly and cause the chisel teeth 40 to deliver another impact blow against the well packer, breaking it into more fragments. This recocking of the apparatus by elevating the tubular string D and the outer tubular member 24, and then delivering another blow by imposition of a downard force on the tubular string and the outer member, can be repeated as often as necessary for the purpose of breaking up the packer parts into sufficiently small particles to be washed away from the drilling region and out of the well bore. During the impacting action, drilling fluid can be pumped through the tubular string D and the apparatus A, discharging through the ports 80 to carry the cuttings back to the top of the hole. The impacting action can continue until the apparatus has been disintegrated to the extent at which the lower slips 14 are released, whereupon the spring legs 62 are again brought up against the catch shoulder 19 and the apparatus elevated to withdraw the remaining lower portion of the well packer from the well casing. If desired, of course, the well packer can be completely disintegrated and flushed from the well casing.

In the event of difficulty being encountered in milling up or removing the packer completely, the milling apparatus A can still be withdrawn from the well bore. It is elevated until the spring legs 62 engage the catch shoulder 19. Such engagement and the further engagement of the holding and safety sub 63 against the spring legs will resist rotary movement of the holding and safety sub 63. The tubular string D, outer tubular member 24, mandrel 28 and pilot members 49, including the lower pilot mandrel 56, are rotated. In view of the left hand threaded connection 64 between the pilot mandrel 56 and the holding and safety sub 63, a right hand rotation of the mandrel 56 will cause it to elevate itself relative to the holding and safety sub. The shoulder 61 on the pilot mandrel will engage the flange 60 of the catch sleeve 59 and will then pull the latter upwardly, the feet 69 sliding inwardly along the catch shoulder 19 until they are disposed within the body passage 20, whereupon the lower pilot mandrel 56, safety sub 63 and the spring

legs 62 can be moved upwardly through the passage 20 of the packer body and the apparatus withdrawn from the well casing (FIG. 3).

For the purpose of insuring that the holding and safety sub 63 will not be completely unthreaded from the pilot mandrel 56, the engagement of the safety screw 70 with the lower flange 72 will prevent such action from occurring, by limiting the extent of unthreading of the pilot mandrel from the safety sub.

It is, accordingly, apparent that a milling apparatus has been provided which is very effective in disintegrating a well packer or corresponding barrier set in a well casing or the like. The milling action or disintegration of the well packer or barrier can occur as the result of a rotary action, or can occur as the result of a jarring action, by causing the chisel teeth 40 to strike impacting or breaking blows upon the packer parts. Such breaking blows will be particularly effective on a well packer of the type illustrated, since most of the parts of the latter are made of frangible material, such as cast iron. For that matter, if desired, a combination of the milling action may occur to disintegrate part of the well packer, supplemented by a repeated jarring action by the chisel portion of the apparatus upon the well packer, or other barrier set in the well casing. It is not necessary for the entire well packer to be disintegrated by the milling apparatus, but as soon as a sufficient portion has been drilled away, the remaining portion can be retrieved through use of the catch device 59 to 75.

In the event that the complete well packer cannot be removed, the catch device can still be released therefrom through the relative downard threading of the holding and safety sub 63 along the pilot mandrel 56.

The pilot portion 49 of the apparatus maintains the cutter blades 51 and the chisel teeth 40 properly centered with respect to the packer and the well casing, in order that the cutter blades and the chisel teeth are effective for operation only upon the well packer, and cannot engage the well casing itself for the purpose of cutting a hole or otherwise damaging the latter.

The inventor claims:

1. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with said well tool to disintegrate the same progressively in a downward direction in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible means on said pilot adapted to be coupled to the well tool below the point at which said cutter means commenced disintegrating the well tool to elevate the well tool in the well conduit; and means on said pilot for expanding and holding said expandible means laterally outwardly while said cutter means is engaging and disintegrating the well tool.

2. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; cutter means secured to said mandrel and engageable with the well tool to disintegrate the same progressively in a downward direction in response to rotation of the tubular running-in string and mandrel; a pilot secured to said mandrel for reception in the passage to center the cutter means with respect to the well tool; means on said pilot adapted to be coupled to the well tool below the point at which said cutter means commenced disintegrating the well tool to elevate the well tool in the well conduit; and means on said pilot for expanding and holding said expandible means laterally outwardly while said cutter means is engaging and disintegrating the well tool.

3. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with said well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; catch means including laterally movable spring legs carried by said pilot and adapted to engage the well tool shoulder; and means on said pilot engaging said legs to hold said legs under said shoulder, whereby elevation of said apparatus and the running-in string elevates the well tool therewith in the well conduit.

4. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with said well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; catch means including laterally movable spring legs carried by said pilot and adapted to engage the well tool shoulder; and holding means threaded on said pilot and engaging said legs to hold said legs under said shoulder, whereby elevation of said apparatus and the running-in string elevates the well tool therewith in the well conduit, rotation of said pilot relative to said holding means feeding said holding means downwardly on said pilot from its position holding said legs under said shoulder.

5. An apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with said well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; catch means carried by said pilot and adapted to be coupled to the well tool below the point at which said cutter means commenced disintegrating the well tool; means on said pilot engageable with said catch means to hold said catch means coupled to said well tool, whereby elevation of said apparatus and the running-in string elevates the well tool therewith in the well conduit; and means carried by said pilot for releasing said catch means from coupling relation to the well tool to permit upward withdrawal of said pilot and catch means through the well tool passage.

6. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same progressively in a downward direction in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible means on said pilot adapted to be coupled to the well tool below the point at which said cutter means commenced disintegrating the well tool to elevate the well tool in the well conduit; and means on said pilot engaging said expandible means to hold said expandible means laterally outwardly while said cutter means is engaging and disintegrating the well tool, whereby said expandible means is adapted to be coupled to the well tool upon elevation of the apparatus in the bore hole.

7. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same progressively in a downward direction in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible means on said pilot adapted to be coupled to the well tool below the point at which said cutter means commenced disintegrating the well tool to elevate the well tool in the well conduit; and means engaging said expandible means and constantly urging said expandible means laterally outwardly while said cutter means is engaging and disintegrating the well tool.

8. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same progressively in a downward direction in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible means on said pilot adapted to be coupled to the well tool below the point at which said cutter means commenced disintegrating the well tool to elevate the well tool in the well conduit; means for expanding and holding said expandible means laterally outwardly while said cutter means is engaging and disintegrating the well tool; and means for relatively shifting said expandible means and expanding and holding means to a position permitting uncoupling of said expandible means from the well tool and upward withdrawal of said pilot and expandible means through the well tool passage.

9. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible catch means carried by said pilot and adapted to pass downwardly through the well tool passage to a position below the shoulder before said cutter means initially engages the well tool; and means for expanding said catch means laterally outwardly when positioned below the shoulder and while said cutter means is engaging and disintegrating the well tool, whereby said catch means is adapted for engagement with the shoulder upon elevation of the apparatus and the running-in string to elevate the well tool therewith in the well conduit.

10. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible catch means carried by said pilot and adapted to pass downwardly through the well tool passage to a position below the shoulder before the cutter means initially engages the well tool; and means for expanding said catch means laterally outwardly for engagement with the shoulder upon elevation of the apparatus and the running-in string to elevate the well tool therewith in the well conduit, said expanding means including spring means for shifting said catch means relative to said pilot and laterally outwardly.

11. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; laterally expandible catch means carried by said pilot and adapted to pass downwardly through the well tool passage to a position below the shoulder before the cutter means initially engages the well tool; means for expanding said catch means laterally outwardly for engagement with the shoulder upon elevation of the apparatus and the running-in string to elevate the well tool therewith in the well conduit; and means for relatively shifting said catch means and expanding means to permit retraction of said catch means from the shoulder and upward withdrawal of said pilot and catch means through the well tool passage.

12. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; catch means including laterally movable spring legs carried by said pilot and adapted to engage the well tool shoulder; means on said pilot engaging said legs to hold said legs under said shoulder, whereby elevation of said apparatus and the running-in string elevates the well tool therewith in the well conduit; and spring means engaging said catch means and urging said catch means downwardly of said pilot to yieldably engage said legs with said holding means.

13. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same in response to manipulation of the running-in string; a pilot secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; catch means including laterally movable spring legs carried by said pilot and adapted to engage the well tool shoulder; means on said pilot engaging said legs to hold said legs under said shoulder, whereby elevation of said apparatus and the running-in string elevates the well tool therewith in the well conduit; and means for relatively shifting said catch means and holding means to permit retraction of said legs from the shoulder and upward withdrawal of said pilot and catch means through the well tool passage.

14. In apparatus for disintegrating a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding the passage: supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means on said supporting means for engagement with the well tool to disintegrate the same in response to manipulation of the running-in string; a pilot

secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; catch means including laterally movable spring legs carried by said pilot and adapted to engage the well tool shoulder, said legs being located below said cutter means such that said legs are disposed below the shoulder before the cutter means initially engages the well tool; and means on said pilot engaging said legs to hold said legs outwardly and below said shoulder, whereby elevation of said apparatus and the running-in string engages said legs with said shoulder and elevates the well tool therewith in the well conduit.

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