METHOD AND APPARATUS FOR CEMENTING AND CONDITIONING BORE HOLES

Filed Feb. 10, 1964 3 Sheets-Sheet 1

FIG. 1.

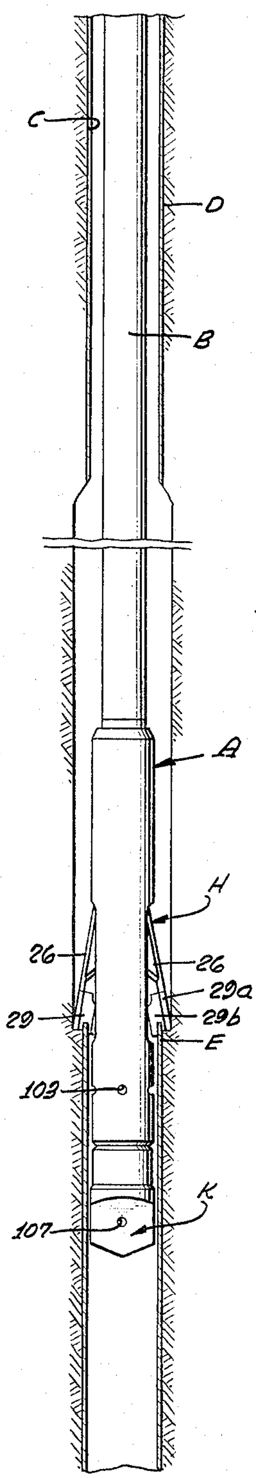


FIG. 2.

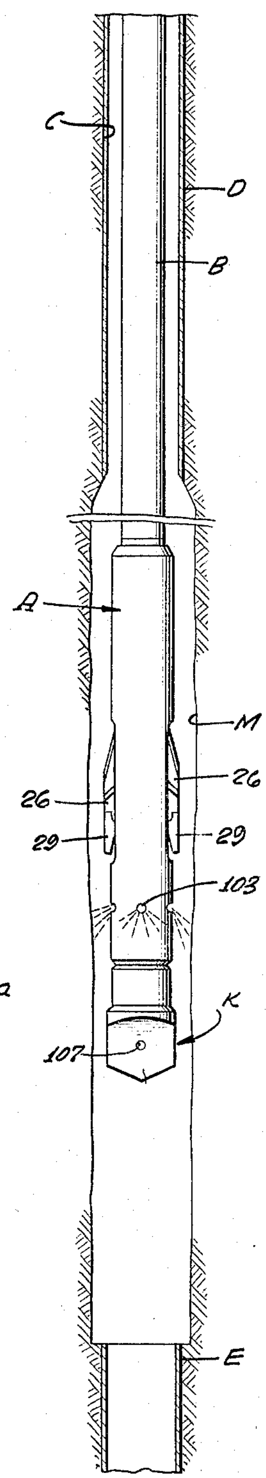


FIG. 3.

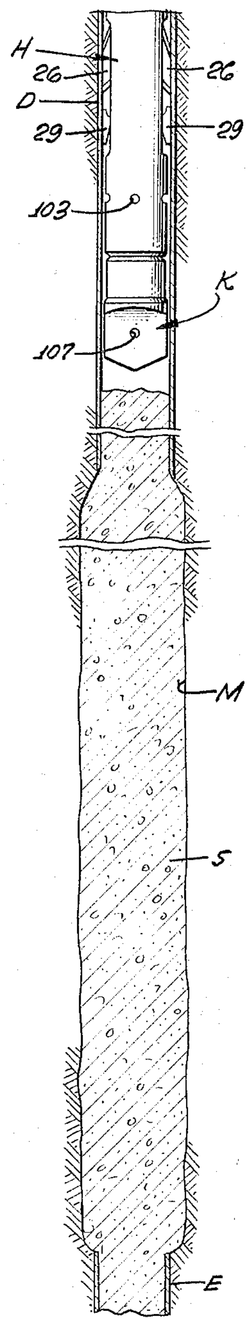
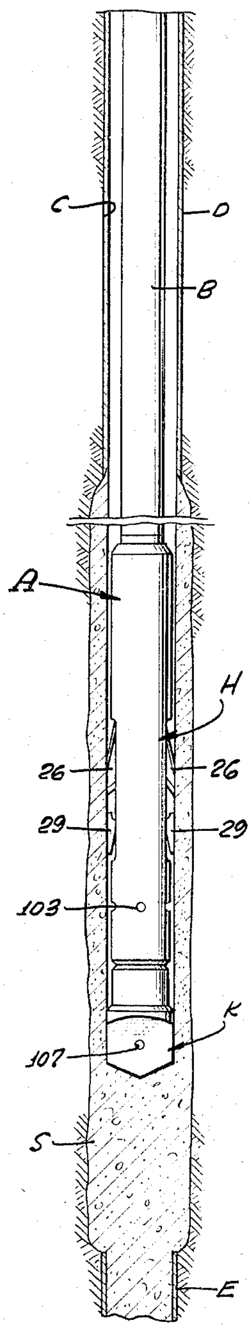


FIG. 4.



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METHOD AND APPARATUS FOR CEMENTING AND CONDITIONING BORE HOLES

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FIG. 5a.

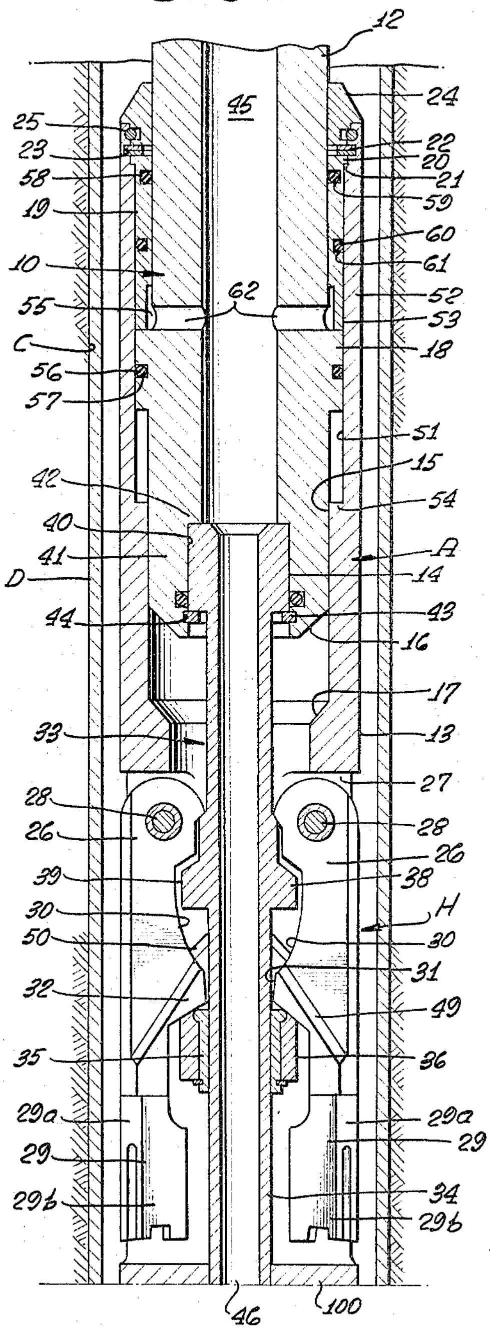

FIG. 5b.

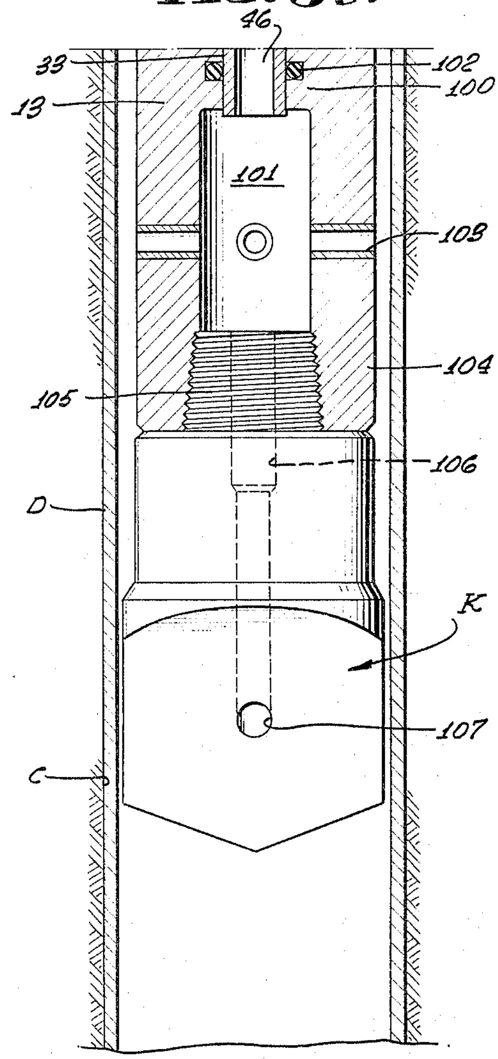

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FIG. 7.

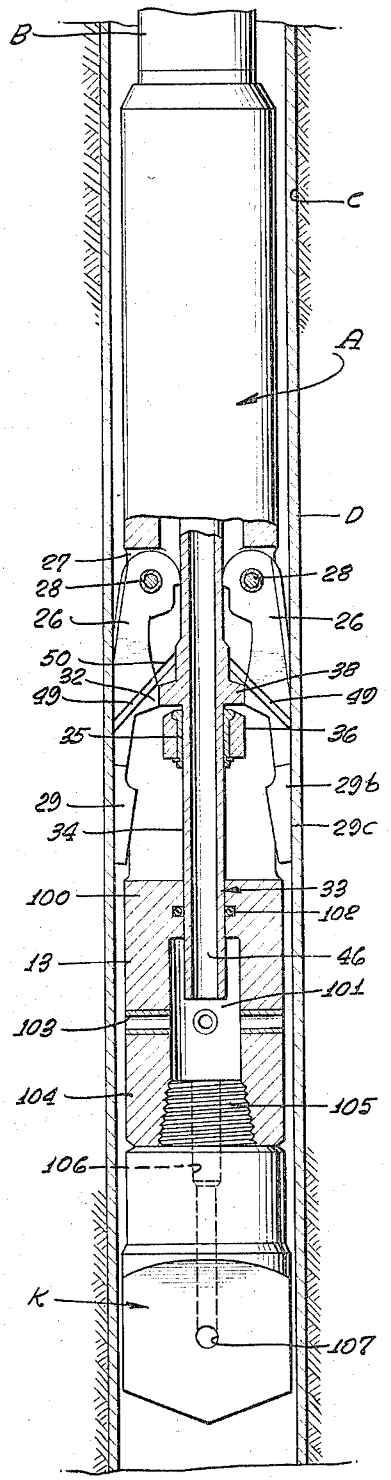
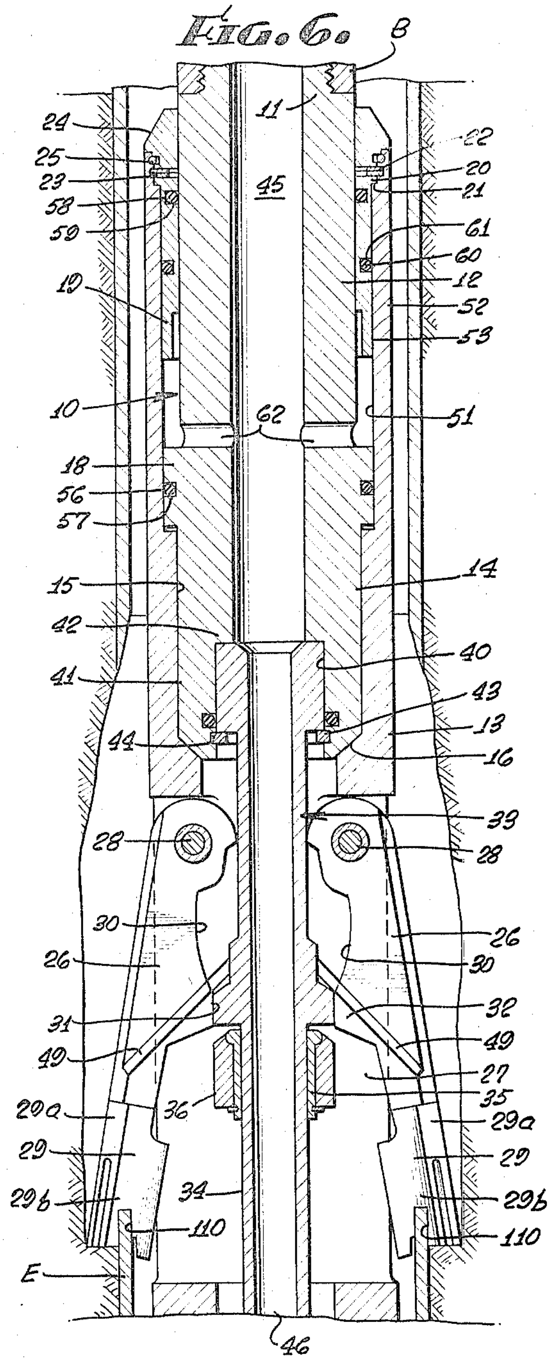


FIG. 6.



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METHOD AND APPARATUS FOR CEMENTING AND CONDITIONING BORE HOLES

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Filed Feb. 10, 1964, Ser. No. 343,625

15 Claims. (Cl. 166—21)

The present invention relates to methods and apparatus for performing various operations in bore holes, and more particularly to methods and apparatus for performing operations, including the depositing of cementitious materials, in a bore hole and subsequently placing such bore hole in a desired condition following its cementing.

As described in United States Patent No. 3,083,765, a section of casing or linear in a well bore is milled away to expose a desired length of the well bore, the wall of the exposed well bore washed or otherwise conditioned, and cement deposited in the well bore along part or all of its exposed length to form a cementitious plug therein, all of the above steps being performed with a single round trip of well apparatus in the bore hole.

As an example, a cement plug is required to support a whipstock used for subsequent hole deflection or deviation operations. However, before the whipstock is set, a portion of the cement plug may require removal by a drilling operation. In addition, it is desirable for the cement coating formed on the wall of the casing or liner during the cementing operation above the milled away section to be scraped off to prevent its potential interference with subsequent operations in the bore hole. Even in the absence of any need to drill out a portion of the plug, the cement coating formed on the wall of the casing or liner, which may have resulted from flushing excess cement from the latter, should preferably be removed. Such drilling out, scraping, or both operations have heretofore been performed with appropriate equipment requiring separate round trips in the well bore, which consumes substantial additional time and adds greatly to the cost of obtaining a final desired well bore condition, the increased cost resulting from the cost of the equipment in addition to the value of the time consumed in effecting its running in and out of the well bore.

It is an object of the present invention to provide methods and apparatus for milling away a desired length of casing or liner in a bore hole, accomplishing one or more other operations in the well bore, including introducing cementitious material into the exposed region of the bore hole, and drilling away a portion of the cementitious material so introduced, all with a single trip of the apparatus in the well bore.

Another object of the invention is to provide methods and apparatus for milling away a desired length of casing or liner in a bore hole, accomplishing one or more other operations in the well bore, including introducing cementitious material into the exposed region of the well bore, and scraping the wall of the casing of liner, all with a single trip of the apparatus in the well bore.

A further object of the invention is to provide methods and apparatus for milling away a desired length of casing or liner in a bore hole, accomplishing one or more other operations in the well bore, including introducing cementitious material into the exposed region of the bore hole, drilling away a portion of the cementitious material so introduced, and scraping the wall of the casing or liner, all with a single trip of the apparatus in the well bore.

This invention possesses many other advantages and has other objects which may be more clearly apparent from a consideration of a method and apparatus embodying the invention. Such method and apparatus are shown and described in the present specification and in the drawings

accompanying and constituting a part thereof. They 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:

FIGURE 1 is a diagrammatic section through a well bore illustrating apparatus milling away a section of casing or liner in the well bore;

FIG. 2 is a view similar to FIG. 1 illustrating the conditioning or depositing of cementitious material in the well bore to form a plug therein;

FIG. 3 is a view similar to FIGS. 1 and 2 illustrating a hardened cement plug in the well bore, and the apparatus in position for drilling out a portion of the cement plug and for scraping the wall of the well casing or liner thereabove;

FIG. 4 is a view similar to FIGS. 1, 2 and 3 illustrating a portion of the cement plug drilled away;

FIGS. *5a* and *5b* together constitute a longitudinal section through an apparatus used in performing the steps illustrated in FIGS. 1 to 4, with the parts in their initial or retracted position, FIG. *5b* being a lower continuation of FIG. *5a*;

FIG. 6 is a longitudinal section similar to FIG. *5a* illustrating the cutters of the apparatus in expanded condition;

FIG. 7 is a longitudinal section, with parts shown in elevation, of the apparatus in its condition for performing the operations shown in FIGS. 3 and 4.

The invention is specifically illustrated in the drawings in connection with an apparatus A specifically designed for cutting or milling away a portion of well casing D, or other well conduit disposed in a well bore, along a desired length. The same apparatus can be used for performing a jetting action upon the exposed well bore for the purpose of conditioning the latter, enlarging the diameter of the same, depositing cementitious material in the well bore, drilling out any excessive undesired cementitious material so deposited, or scraping the wall of the well casing, or a combination of any of the aforementioned operations.

The apparatus A is secured to the lower end of a string of drill pipe B that extends to the top of the well bore C, and by means of which the apparatus is lowered through the string of well casing to a location therein at which a casing milling operation is to commence, and where other operations are also to be performed without removing the apparatus from the well casing.

As disclosed most clearly in FIGS. *5a*, *5b*, 6 and 7, the apparatus A may include a rotary expansible drill bit H, to the lower end of which is secured a rotary drill bit K of any desired type. The specific rotary drill bit illustrated in the drawings for simplicity of illustration is of the drag type. However, it is to be understood that roller cone and other types of drill bits may be employed.

The upper expansible rotary drill bit H includes a mandrel **10** having an upper pin **11** threadedly connected to the lower end of the string of drill pipe B. This mandrel includes an upper kelly or drill stem member **12** slidably splined to the main body **13** of the bit. The exterior of the lower portion **14** of the kelly is non-circular in shape, being telescopically received in a companion non-circular socket **15** formed in the main bit body **13**. As an example, the kelly exterior and the socket **15** may be of hexagonal shape to enable the kelly **12** to be moved longitudinally with respect to the body **13**, while still being capable of transmitting rotary motion to the body.

The mandrel **10** has a limited range of longitudinal movement within the body, downward movement being determined by engagement of the lower end **16** of the kelly with an inwardly directed body shoulder **17**. Its upward movement is limited by engagement of an external shoulder or piston portion **18** of the kelly with a cylinder head **19** secured to the body. The upper end of the head has a flange **20** engaging a body shoulder **21**, the flange being prevented from moving upwardly of the body by split snap retainer rings **22** fitting in a body groove **23** and overlying the flange **20**. An annular guide **24** is releasably secured to the body **13** by a split snap ring **25** above the retainer rings **22**.

The body has a plurality of expansible parts mounted on it. These include cutter supporting members **26** pivotally mounted in body slots **27** on hinge pins **28** suitably secured to the body to prevent their loss therefrom. Each cutter supporting member **26** depends from the hinge pin **28** and carries a drap or milling cutter structure **29** at its lower end, which may be welded or otherwise suitably attached to each supporting member **26**.

The cutter supporting members **26** and the cutter structures **29** themselves tend to occupy a retracted position substantially entirely within the confines of the main body **13** of the bit. These cutter supporting members and the cutter structures are expandible outwardly to sever the casing D and mill it away by operating upon the upper end E of the casing therebelow. To accomplish the expansion, each cutter supporting member has an inclined expander surface **30** on its inner portion below the hinge pin **28** which tapers in a downward and inward direction. Each expander surface terminates in a lock surface **31** formed on a lock portion **32** of the cutter supporting member. The outward expansion is accomplished by producing relative longitudinal movement between the mandrel **10** and the bit body **13**, which will produce relative longitudinal movement between the cutter supporting members **26** and the tubular member **33** of the mandrel **10**.

The tubular member includes a portion **34** slidable within a guide bushing **35** mounted in a bridge **36** secured to the body and extending across the body slot **27**. This guide bushing **35** is disposed below the lock portions **32** of the cutter supporting members **26**. The tubular member **33** extends downwardly of the guide bushing to a substantial extent and is piloted within a lower head portion **100** of the body below its slots **27**, extending into a body chamber or central passage **101**. Leakage of fluid between the mandrel **33** and the body of the tool below the slots is prevented by a suitable side seal ring **102** mounted in the body and slidably and sealingly engaging the periphery of the mandrel or tubular member **33**. Accordingly, fluid under pressure discharging from the tubular member into the body chamber **101** cannot pass upwardly out of the chamber. Instead, such fluid in the chamber passes outwardly through radial nozzels **103** capable of discharging fluid against the wall of the surrounding well bore or casing. The lower end of the chamber or passage **101** opens into a lower threaded box portion **104** of the body, that threadedly receives the upper pin **105** of the drill bit K, the fluid being capable of passing from the body or chamber into the usual fluid passage or passages **106** in the drill bit for discharge through one or a plurality of lower nozzels or outlets **107** in the latter, for the purpose of removing the cuttings produced by the drill bit and flushing them upwardly around the apparatus A and the drill pipe B to the top of the well bore.

Located initially and substantially above the guide bushing **35** and below the hinge pins **28**, and in cutter member recesses **37**, is a mandrel lock and expander **38** which has outer surfaces **39** adapted to engage the expander surfaces **30** and lock surfaces **31**. The lock and expander **38** may be formed integrally with the tubular member **33**, the upper end of the latter being piloted within a socket **40** formed in the lower portion **14** of the kelly **12**. An enlarged boss **41** on the tubular member

33 engages a downwardly facing shoulder **42** of the kelly, the tubular member being held against this shoulder by a suitable slip retainer or lock ring **43** snapped into an internal groove **44** encompassing the kelly socket and engaging the lower end of the tubular member boss **41**.

Drilling mud or other fluid can pass down through the central passage **45** in the kelly or drill stem member **12** and into the central passage **46** that extends completely through the tubular member 33, this fluid or fluent material passing into the body chamber **101** and then outwardly through the radial nozzles **103** and the drill bit nozzles or outlets **107**.

Assuming the body **13** of the tool to be elevated relatively along the tubular mandrel **10**, the inclined expander surfaces **30** of the cutter supporting member **26** will be shifted upwardly along the lock and expander portion **38** of the tubular member **33**. During such upward shifting, the cutter supporting members **26** and the cutter structures **29** carried thereby will be pivoted about the hinge pins **28** and urged in an outward direction. The upward movement of the body **13** with respect to the tubular mandrel **10** can continue until the cutter structures **29** have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulders **49** on the cutter supporting members **26** with companion shoulders **50** formed in the body on opposite sides of the body slots **27**. When such engagement occurs, the lower end **16** of the kelly portion **12** of the tubular member will engage the body shoulders **17** and the lock and expander **38** on the tubular member **33** will be disposed behind and in engagement with the lock portions **32** on the cutter supporting members **26**, as illustrated in FIGS. 6 and 7.

Relative movement between the tubular mandrel **10** and the body **13** of the tool is accomplished hyraulically in the specific form of apparatus disclosed in the drawings. Thus, the piston or enlarged portion **18** on the drill stem **12** is received within a counterbore **51** in the upper portion of the body of the tool. This upper portion actually constitutes a cylinder **52** having a cylindrical wall **53** extending from the lower shoulder **54** defining the bottom of the counterbore **51** to the cylinder head **19**.

A confined cylinder space **55** is formed between the piston portion **18** of the kelly, the periphery of the kelly above the piston, and the cylinder **52**. A suitable packing or side seal ring **56** may be disposed in a suitable piston ring groove **57** formed in the piston portion **18**, which is adapted to slidably seal against the cylindrical wall **53** of the cylinder **52**. Fluid is thereby prevented from passing in a downward direction between the piston and cylinder. Similarly, fluid is prevented from passing in an upward direction out of the annular cylinder space **55** by an inner side seal ring **58** carried in an internal groove **59** in the cylinder head **19** and slidably and sealingly engaging the periphery of the kelly **12** above the piston **18**, and also by an outer side seal ring **60** disposed in an external groove **61** in the head **19** and sealingly engaging the cylinder wall **53**.

Fluid under pressure in the string of drill pipe B and in the tubular mandrel passage **45** can be fed into the cylinder space **55** through one or more side ports **62** establishing communication between the central passage **45** through the kelly and the cylinder space. Such fluid under pressure is developed, in the form of invention disclosed in the drawings, by virtue of the fact that the total area through the jets or nozzles **103**, **107** in the lower portion of the body **13** and in the drill bit K secured to the body is substantially less than the area of the passage **45** through the kelly portion of the mandrel, or because of the fact that the passage **46** through the tubular member **33** of the mandrel is of a restricted diameter as compared to the passage **45**. As a result, the pumping of drilling mud or other fluid at an adequate rate through the apparatus will build up a back pressure of fluid in the passage **45**, which pressure will be imposed on the fluid in the cylinder space

55, acting upon the cylinder head **19** to urge the body **13** of the tool in an upward direction with respect to the tubular mandrel **10**, to secure outward expansion of the cutter supporting members **26** and cutter structures **29** to their fullest extent, as above described.

As apparently disclosed in the drawings, a set of diametrically opposed supporting members **26** and cutter structures **29** is supplied and arranged substantially 180 degrees from each other. Actually, it is preferred to supply three sets of supporting members and cutter structures displaced substantially 120 degrees from each other to secure a smoothly running apparatus. The two sets of supporting member structures **26, 29** are shown in the drawings in the interest of simplicity of illustration. However, regardless of the number of cutters used, the generally radial jet nozzles **103** employed can be of any suitable number disposed circumferentially from one another to the desired extent, and also, if desired, displaced somewhat axially with respect to one another.

When the casing or conduit D is to be severed at a particular location in the well bore and along a desired length for the purpose of depositing a cementitious plug therein, the apparatus A is run in the well casing with the cutter supporting members **26** and the cutter structures **29** in their initial retracted positions, such as disclosed in FIGS. *5a* and *5b*. When the apparatus has been lowered to the desired point in the well casing at which the latter is to be severed, the pumps (not shown) at the top of the well bore are started to pump fluid at a sufficient rate through the drill pipe B and into the mandrel passages **45, 46**, and through the body nozzles **103** and drill bit nozzles **107**, building up a back pressure in the kelly passage **45**, the port **62** and cylinder space **55**, which pressure acts upon the cylinder head **19** to urge the body **13**, the cutter supporting members **26** and the cutter structures **29** in an upward direction with respect to the mandrel **10**. During such upward movement, the expander surfaces **30** are brought to bear against the lock and expander portion **38** of the mandrel, the cutter structures being urged in an outward direction against the wall of the well casing D. The drill pipe B and the apparatus A are rotated at the proper speed while fluid is being pumped through the apparatus, the outer edges of the cutters **29** acting upon the wall of the casing and gradually milling it away, as described in United States Patent No. 2,922,627, for example. During this operation, the apparatus is retained in substantially the same longitudinal position in the well casing. As the casing is cut away, the hydraulic force acting upon the body **13** raises it and the cutter supporting members **26** and cutter structures **29** to a further extent, until the outer edges of the cutters have completely severed the casing. Thereafter, rotation of the drill pipe B and the apparatus A continues so that the reaming portions of the cutters **29** continue to cut away the casing and dig into the formation until the cutters have been fully expanded outwardly to the maximum extent, as determined by coengagement of the stop shoulders **49, 50** and the lower end **16** of the kelly portion **12** of the mandrel with the body shoulders **17**. With the parts in this position, the lock portions **32** of each cutter supporting member **26** will bear against the lock and expander portion **38** of the tubular member **33** to preclude the inadvertent partial retraction of the cutter structures **29** from their fully expanded positions.

Downweight in the proper amount is now imposed on the string of drill pipe B, this downweight being transmitted through the kelly **12** to the body shoulder **17** and from the body **13** to the stop shoulders **50, 49** and directly to the cutter supporting members **26** and the cutter structures **29**, urging the latter against the upwardly facing severed end E of the well casing. The imposition of the proper downweight or drilling weight on the apparatus and its rotation at the proper speed will cause the cutters to effect a cutting action upon the severed end E of the casing and mill it away, as shown in FIG. 1. During such milling action, drilling fluid is being pumped down through the drill pipe B and through the mandrel **10** and chamber **101**, discharging from the body nozzles **103** and the drill bit nozzles **107** into the well bore, carrying the cuttings upwardly around the apparatus A and the drill pipe B to the top of the hole.

During the operation of milling away the casing in a downward direction, the upper end E of the casing will wear away the milling cutter or drag structure **29** by cutting an upwardly extending groove **110** therewithin. If milling of the casing by the set of cutters **29** continues for too long a time, such progressive formation of the groove **110** in the cutter blades may continue until the casing cuts completely through the cutter structures, severing their outer portions **29***a* from their inner portions **29***b*, at which time the longitudinal outer surfaces **29***c* of the remaining cutter structures **29***b* will have the same diameter as the inside diameter of the well casing D.

After the desired length of casing has been milled away, which, for example, may be of the length of 20 feet to 40 feet, the downweight imposed on the apparatus is discontinued. A subsequent operation can now be performed in the well bore without removing the apparatus A from the well bore. Preferably, as shown in FIG. 2, the well bore is conditioned by pumping circulating fluid down through the drill pipe B and through the apparatus A, discharging from the radial nozzles **103** which direct jets of fluid against the wall of the exposed well bore M. The drill string and apparatus connected thereto are rotated at the desired speeds during such pumping operation, so that the entire circumference of the well bore is covered by the jets of fluid issuing from the nozzles **103**. During the rotation and pumping operation, the drill pipe B and the apparatus A can be gradually elevated from a lowermost end of the exposed bore hole M, so that the jet or fluid streams are caused to impinge upon the desired length of the wall of the well bore above the lower shoulder E produced by the cutters. If, for example, the well casing D has been severed along a length of about 20 feet, the tool may be elevated a distance of about 20 feet so that the jets discharge fluid along the entire length of the exposed hole M. Of course, the apparatus can be raised and lowered as many times as desired.

The elevation of the apparatus A while fluid is being pumped through it and the apparatus rotated by the drill pipe will cause the fluid jets to act against the wall of the exposed well bore to remove the drilling mud cake therefrom. If desired, not only can the mud cake be removed, but the fluid jet may be employed for effecting a hydraulic enlarging of the diameter of the exposed well bore M (FIG. 2).

Assuming the well bore to have been conditioned by pumping fluid through the nozzles **103**, a cement plug may be formed therein, as by pumping the proper amount of cement slurry S down through the drill pipe B, passing through the mandrel passage **45, 46** and into the body chamber **101**, then discharging through the radial nozzles **103** against the wall of the hole, as well as through the drill bit nozzles **107**. As the cement is discharged from the nozzles, the drill pipe B and the apparatus A are gradually elevated in the well bore from the lower region of the exposed hole M, while the drill pipe and the apparatus are rotated at a proper speed to insure uniform deposition of cement slurry S in the well bore, the latter sloughing downwardly to completely fill the entire cross-sectional area of the well bore and along the desired length of the latter. As disclosed in FIG. 3, a cement plug S is thereby formed along the entire length of the well bore M, and, in fact, extends upwardly into the well casing D thereabove. It is to be understood, however, that the upper end of the cement plug may terminate in the enlarged well bore M substantially below the lower end of the well casing thereabove.

The cement slurry pumped down through the drill pipe B is followed by a suitable displacement fluid. After all of the required cement slurry has been discharged from the nozzles, the apparatus is elevated above the deposited slurry S and displacement or washing fluid forced through the apparatus A and its nozzles **103**, **107** to clear all passages of the apparatus and all regions of the tool of cement slurry. The tool may require elevation above the mass of cement slurry S deposited in the open well bore as a plug, or even above the plug S extending upwardly into the lower portion of the upper well casing D. During such upward flushing of the excess cement slurry from the casing, a certain portion thereof will adhere to the wall of the casing above the severed section and harden thereon as a cement coating or sheath.

Following flushing of the excess cement slurry from the well bore, the pumping action can be stopped, which will relieve the pressure in the apparatus, allowing the body **13** of the tool to drop downwardly along the mandrel **10**, the cutters **29** retracting and placing the apparatus A in condition for removal through the well casing D to the top of the well bore. However, such removal need not occur at this time, and preferably does not occur. Instead, the apparatus cleared of cement slurry is allowed to remain suspended in the well casing a convenient distance in the casing above the upper end of the cementitious material S deposited in the well bore, as disclosed in FIG. 3.

The deposited cement or cementitious material is allowed to set and harden in the well bore, forming the cement plug S therein. This plug remains in place and cannot be displaced particularly in a downward direction, since its outer margins are resting upon the lower formation shoulder E produced by the cutters in the well bore. The cement plug will extend laterally beyond the internal diameter of the well casing D, insuring against downward dislodgment of the cement plug in the well bore, as under the subsequent drilling action of a drill bit, including the drill bit K attached to the lower end of the bit body **13**, or under the drilling action of a drill bit (not shown) which is deflected laterally by a whipstock (not shown) set in the well bore upon the cement plug.

After the cement plug is set and hardened, it is desired to determine that the upper end of the plug S is at the required location in the well bore below the upper end of the exposed well bore M, so as to allow the whipstock to be set thereon. However, the upper end of the cement plug may be at too high an elevation in the well bore, and, in fact, as illustrated in FIG. 3, may actually extend upwardly into the well casing above the exposed well bore. The drill pipe B and apparatus A can be lowered in the well casing until the drill bit engages the upper end of the cement plug S, which will indicate its location to the operator at the top of the well bore. If the upper end of the plug is found to be too high, the drill pipe string and apparatus are rotated at the proper speed and an appropriate drilling weight imposed on the apparatus to cause the drill bit K to act upon the plug and drill it away, drilling fluid being pumped through the drill string and the apparatus during this time, which will result in elevation of the body **13** along the mandrel **10** of the expansible drill bit to expand the cutters **29** outwardly against the wall of the well casing. Since the drill bit K usually has an effective drilling diameter slightly less than the inside diameter of the casing D, such bit cannot remove all of the cement within the casing, nor can it even act effectively upon the cement sheath that remains adherent to the wall of the well casing above the plug as a result of flushing excess cement slurry from the well casing. The expansible cutters **29**, however, will engage the wall of the well casing and effect a scraping action thereon to remove the cement sheath, the cement particles from the casing sheath, as well as the cuttings from the cement plug S produced by the drill bit K, being flushed by the drilling fluid upwardly around the apparatus A and the drill pipe B to the top of the well bore. In fact, at the commencement of the operation of drilling out a portion of the cement plug S, the apparatus may be elevated a desired distance in the well casing and rotated while circulating fluid is being pumped downwardly through the drill pipe and apparatus to cause the elevation of the body **13** along the mandrel and outward expansion of the cutters **29** against the wall of casing, the drill pipe and apparatus then being gradually lowered to cause the expanded cutters **29** to scrape the cement sheath from the wall of the well casing. When the bit K engages the upper end of the cement plug S, it will commence drilling such cement plug out while, at the same time, the expanded cutters **29** are scraping the wall of the well casing to remove the adherent cement sheath or coating that the drill bit K was incapable of removing.

Drilling out of the cement plug S by the drill bit K will continue until the drill bit is at the desired depth in the plug at which the whipstock is to be set, such as disclosed in FIG. 4. When the expanded cutters **29** enter the cement plug at the upper end of the exposed well bore M, they will slightly enlarge the diameter of the hole through the plug produced by the bit K, in the event that the outer portions **29***a* of the milling cutters have been completely severed by the well casing D as a result of the casing milling operation, to insure an adequate diameter of hole in the cement plug that will allow subsequent free downward movement by the whipstock into the plug.

In the event the milling cutter structures or drag cutters **29** were not completely severed, the hydraulic force acting upon the body **13** and tending to elevate it upon the mandrel **10** will still result in outward expansion of the cutters **29** against the wall of the well casing, such cutters being effective for scraping the cement sheath, and other foreign substances, from the wall of the well casing, as well as to at least slightly enlarge the bore in the cement plug S produced by the drill bit K. With the outer portions **29***a* of the cutters severed from the inner portions **29***b*, a substantial length of each cutter structure portion **29***b* is effective for scraping action upon the wall of the well casing, to insure its being placed in a clean condition, so that no cement sheath remains for interference with subsequent equipment that might be run in or set in the well casing.

In the event that the cement plug S deposited along the exposed wall of the well bore M has not risen too high, as determined by subsequent engagement therewith by the drill bit K, the rotation of the apparatus A by the drill pipe B while fluid is being pumped downwardly therethrough will still effect a scraping by the expanded cutters **29** of the wall of the well casing during the time the apparatus is in the casing above the hole M.

After the casing D has been scraped and the cement plug placed in condition for reception of the whipstock at the proper location, as disclosed, for example, in FIG. 4, or in the event the cement plug did not require any drilling out for reception of the whipstock thereupon, pumping of fluid through the drill pipe B and apparatus A can cease, permitting the body **13** and cutters **29** to drop downwardly along the mandrel **10**, the cutters shifting laterally inwardly to a retracted position, whereupon the drill pipe and apparatus can be elevated in the well bore M and casing D and withdrawn to the top of the hole.

By virtue of the apparatus and method illustrated and described, not only can the well casing or liner D be milled away to expose the well bore M, the hole then being properly conditioned, and a cementitious plug S deposited therein, but the same apparatus A, in the same trip in the well bore C, can be used to determine the location of the upper end of the hardened cement plug S, such cement plug being drilled out to the desired depth if required, and the well casing D scraped above the cement plug, thereby effecting substantial economies in equipment cost and in time required for preparing the well bore for reception of the whipstock, or the like, and for subsequently scraping the wall of the well casing above its milled away portion.

I claim:

1. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting and fluid discharging apparatus in the bore hole on a tubular drill string, rotating the drill string and apparatus to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the well bore while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to scrape the wall of the conduit.

2. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting and fluid discharging apparatus in the bore hole on a tubular drill string, the apparatus having expandible cutters, rotating the drill string and apparatus to cause the cutters to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to cause the expandible cutters to scrape the wall of the conduit.

3. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting and fluid discharging apparatus in the bore hole on a tubular drill string, the apparatus having expandible cutters, rotating the string and apparatus to cause the cutters to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole and to cause the conduit to sever the outer portions of the cutters from their inner portions, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to cause the inner portions of the severed expanded cutters to scrape the wall of the conduit.

4. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting, bore hole drilling and fluid discharging apparatus in the bore hole on a tubular drill string, rotating the drill string and apparatus to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to scrape the wall of the conduit above the exposed bore hole and to drill away cementitious material in the bore hole.

5. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting, bore hole drilling and fluid discharging apparatus in the bore hole on a tubular drill string, rotating the drill string and apparatus to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to scrape the wall of the conduit above the exposed bore hole and to drill away cementitious material in the conduit above the exposed bore hole, and continuing rotation and lowering of the apparatus to drill out at least a portion of the cementitious material deposited in the exposed portion of the bore hole.

6. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting, bore hole drilling and fluid discharging apparatus in the bore hole on a tubular drill string, the apparatus having expandible cutters, rotating the drill string and apparatus to cause the cutters to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to cause the expandible cutters to scrape the wall of the conduit and to drill away cementitious material in the bore hole.

7. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting, bore hole drilling and fluid discharging apparatus in the bore hole on a tubular drill string, the apparatus having expandible cutters, rotating the drill string and apparatus to cause the cutters to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to cause the expandible cutters to scrape the wall of the conduit above the exposed bore hole and to drill away cementitious material in the conduit above the exposed bore hole, and continuing rotation and lowering of the apparatus to drill out at least a portion of the cementitious material deposited in the exposed portion of the bore hole.

8. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting and fluid discharging apparatus in the bore hole on a tubular drill string, rotating the drill string and apparatus to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping washing fluid down the drill string and discharging the washing fluid laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping cementitious material down the drill string and through the apparatus laterially against the exposed wall of the well bore while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to scrape the wall of the conduit.

9. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting and fluid discharging apparatus in the bore hole on a tubular drill string, the apparatus having expandible cutters, rotating the drill string and apparatus to cause the cutters to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole,

pumping washing fluid down the drill string and discharging the washing fluid laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to cause the expandible cutters to scrape the wall of the conduit.

10. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting and fluid discharging apparatus in the bore hole on a tubular drill string, the apparatus having expandible cutters, rotating the string and apparatus to cause the cutters to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole and to cause the conduit to sever the outer portions of the cutters from their inner portions, pumping washing fluid down the drill string and discharging the washing fluid laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to cause the inner portions of the severed expanded cutters to scrape the wall of the conduit.

11. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting, bore hole drilling and fluid discharging apparatus in the bore hole on a tubular drill string, rotating the drill string and apparatus to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping washing fluid down the drill string and discharging the washing fluid laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, and rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to scrape the wall of the conduit above the exposed bore hole and to drill away cementitious material in the bore hole.

12. The method of conditioning a bore hole having a conduit therein, comprising lowering conduit cutting, bore hole drilling and fluid discharging apparatus in the bore hole on a tubular drill string, rotating the drill string and apparatus to cut the conduit away along a desired length in the bore hole to expose the surrounding wall of the bore hole, pumping washing fluid down the drill string and discharging the washing fluid laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping cementitious material down the drill string and through the apparatus laterally against the exposed wall of the bore hole while rotating the drill string and apparatus, pumping flushing fluid through the drill string and apparatus to clear the drill string and apparatus of cementitious material, rotating and lowering the drill string and apparatus in the conduit above the exposed bore hole to scrape the wall of the conduit above the exposed bore hole and to drill away cementitious material in the conduit above the exposed bore hole, and continuing rotation and lowering of the apparatus to drill out at least a portion of the cementitious material deposited in the exposed portion of the bore hole.

13. In apparatus adapted to be lowered on a tubular drill string in a conduit disposed in a bore hole: a rotary drill bit having expandible milling cutting means for milling away a length of the conduit after the bit has been lowered in the conduit, said bit having a fluid passage adapted to receive fluid from the tubular string; means secured to said bit to receive fluid from said passage and direct such fluid laterally against the wall of the bore hole without impinging on said cutting means; and a lower drill bit secured to the lower end of said rotary drill bit, said lower drill bit having a fluid passage communicating with said other passage.

14. In apparatus adapted to be lowered on a tubular drill string in a conduit disposed in a bore hole: a body; expandible milling cutter means on said body for milling away a length of the conduit after the bit has been lowered in the conduit; a mandrel movable longitudinally in said body and having a passage adapted to receive fluid from the drill string; coengageable expander means on said mandrel and cutter means for expanding said cutter means in response to relative longitudinal movement between said body and mandrel; said body having a chamber into which said mandrel discharges fluid; a generally radial nozzle secured to said body and communicating with said chamber to receive fluid therefrom and discharge said fluid against the wall of the bore hole; the lower end of said body having a threaded connector portion communicating with said chamber; and a drill bit having its upper end threadedly attached to said connector, said drill bit having fluid passage means communicating with said chamber.

15. In apparatus adapted to be lowered on a tubular drill string in a conduit disposed in a bore hole: a body; expandible milling cutting means on said body for milling away a length of the conduit after the bit has been lowered in the conduit; a mandrel movable longitudinally in said body and having a passage adapted to receive fluid from the drill string; coengageable expander means on said mandrel and cutter means for expanding said cutter means in response to relative longitudinal movement between said body and mandrel; a generally radial nozzle secured to said bit below said cutter means and adapted to discharge fluid received from said mandrel passage laterally against the wall of the well bore; the lower end of said body having a threaded connector portion communicating with said passage; and a lower drill bit having its upper end threadedly attached to said connector portion, said lower drill bit having fluid passage means communicating with said other passage.

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