Sept. 9, 1969 R. Q. FIELDS 3,465,836

TOOL ORIENTING SYSTEM

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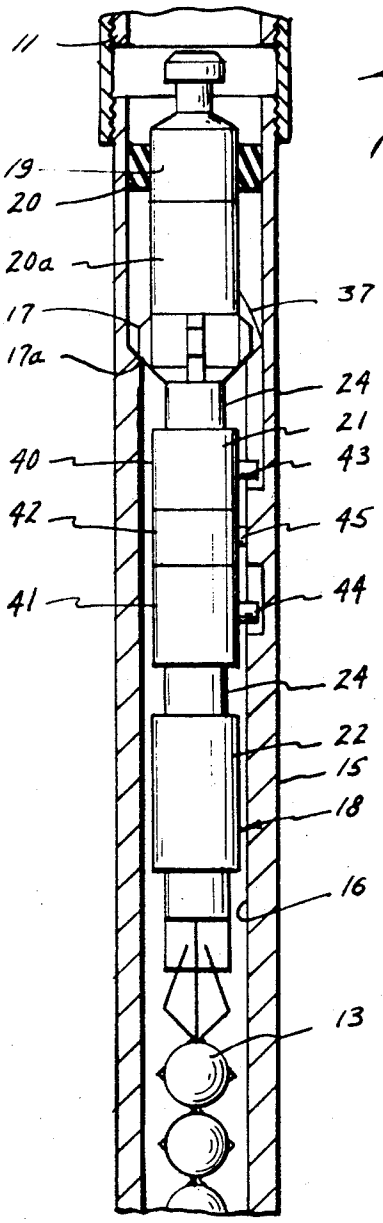
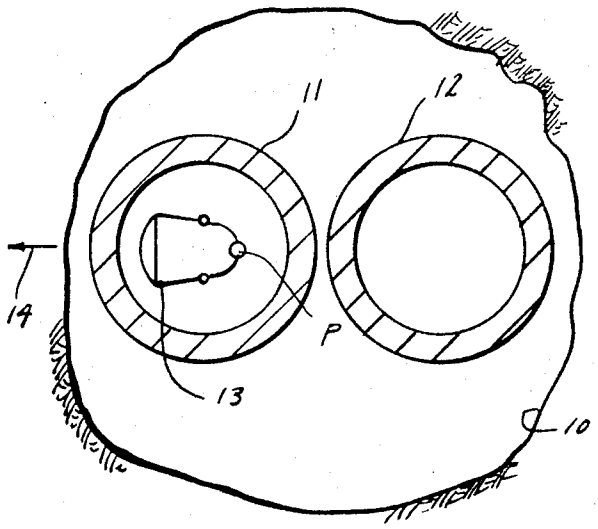


Fig. 2

Fig. 1



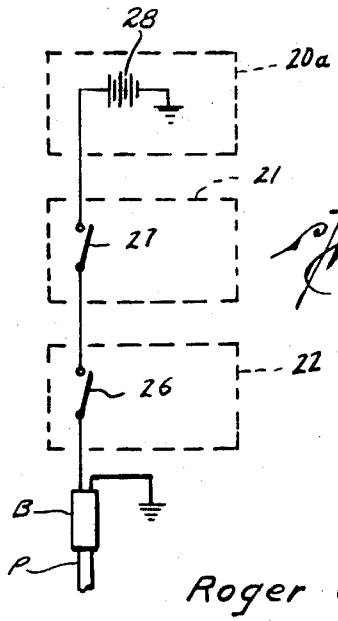


Fig. 3

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Fig. 4

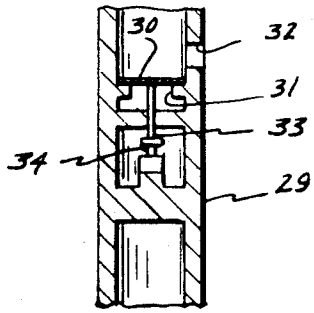


Fig. 5

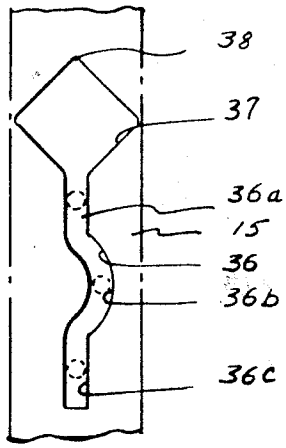


Fig. 6

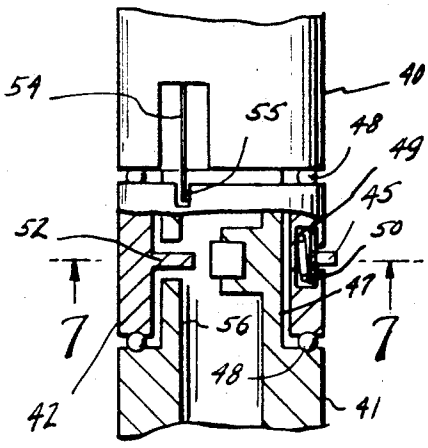
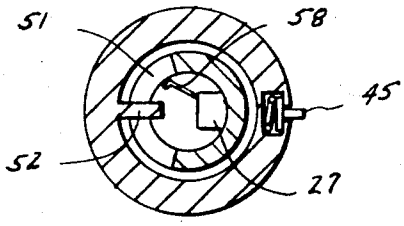


Fig. 7



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TOOL ORIENTING SYSTEM

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U.S. Cl. 175—4.51 16 Claims

ABSTRACT OF THE DISCLOSURE

The present invention is embodied in a self-contained set of tools for pumping through a tubing which include a perforator, a pressure switch, an orienting and control switch, a battery and a pump-down device for use in a flow-line operation. Specifically, the orienting control device includes rotational parts which will operate only when properly seated in an orienting pocket in a well bore.

Recent oil field technology in connection with underwater completion of wells involves the use of flow lines or pipes extending from a central platform or island to various underwater well locations. Tools developed for use in completion of such wells include jointed or flexibly connected tool sections forming an assembly which is capable of being pumped through a flow line to the remote well location. Such tool assemblies include perforating apparatus having a power source and safety control apparatus operative when the perforator is at a predetermined location in the well to produce perforations in a well bore.

Recently it has been proposed to provide dual strings of production tubing in a "tubingless" type of completion so that flow from more than one production level may be obtained. In such instances, as well as others which will be apparent from the reading of the specification to follow, it is desirable to provide an orienting apparatus to properly locate a well tool in a well bore. In particular, it is desirable to locate a directionally firing perforator in one string of tubing relative to an adjacent string of tubing.

Accordingly, it is the object of the present invention to provide a new and improved orienting and actuating mechanism for use in a well bore.

It is a further object of the present invention to provide new and improved apparatus for operation in remote wells where orienting and operational control of the tool are desired.

The novel features of the present invention are set forth with particularity in the appended claims. The operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a view in cross section through a well bore for illustrating use of the present invention;

FIG. 2 is a view in longitudinal cross section through a well conduit and tool embodying the present invention;

FIG. 3 is an electrical schematic system for the tool illustrating the present invention;

FIG. 4 is a partial longitudinal cross section of a portion of the tool illustrating the present invention;

FIG. 5 is a developed view of an orienting means of the present invention;

FIG. 6 is a partial longitudinal cross-section view of the tool of the present invention; and

FIG. 7 is a view in cross section taken along line 7—7 of FIG. 6.

Referring now to FIG. 1, for illustrational purposes a borehole **10** is shown containing parallel pipe strings

11 and **12**. In the more specific aspects of the present invention, it is desired to orient a tool, such as a perforating gun **13** with a desired directional characteristic illustrated by the arrow **14** in one of the strings of tubing **11** relative to the other tubing string **12**.

As shown in FIG. 2, the tubing string **11** in a well bore may include a special tubular seating nipple **15**. The seating nipple **15** typically has a bore **16** sized to a sufficient diameter to permit thru-tubing operations. Nipple **15** has an upwardly facing locating seat or shoulder **17** which is adapted to cooperate with a downwardly facing seat **17***a* on a tool assembly **18** to limit downward movement of the tool assembly within the tubing string.

The tool assembly **18** includes a suitable head **19** carrying a packing **20** which sealingly engages the bore of the tubing string **11** and is responsive to hydraulic pressure to move the tool **18** through the tubing. A battery section **20***a*, an orienting and control device **21**, a pressure responsive safety device **22**, and a perforating apparatus **13** complete the tool assembly **18**. Along the length of tool are suitable joints **24** which provide a flexible or articulated connection between appropriate lengths of the tool assembly to permit its passage through the curved portions of tubing string **11**. The various subsections of the assembly are connected to one another to prevent their relative rotation and the perforating apparatus **13** is typically arranged to have all of the shaped charges fire in a single direction. The perforator **13** may, for example, be comprised of individual shaped charge capsules connected to a flexible wire carrier.

With respect to the perforating system, the primacord P for the shaped charges is connected to a blasting cap B in the usual fashion. As shown in FIG. 3, the blasting cap is grounded and has an initiating wire in series with normally open switches **26** and **27** to a battery power source **28**. Switch **26** is associated with the pressure switch device **22** while switch **27** is associated with the orienting and control device **21**.

As shown in FIG. 4, the pressure safety switch device **22** is comprised of a housing **29** which contains a diaphragm **30** across an internal bore **31**, the diaphragm being open on one side to hydrostatic pressure within the tubing string via a suitable port **32** or other type of opening. On the other side of the diaphragm is a mechanism including a pin **33** supported for longitudinal movement within the housing, the pin **33** bearing upon a switch actuator **34** of the normally open switch **26**. Movement of the diaphragm **30** in response to a pressure differential across it, in turn, closes the switch **26**. The purpose of the pressure safety switch device **22** is, of course, to permit safe handling of the apparatus at the surface and insure that the tool is not capable of being actuated until it reaches a position in the well bore where the hydrostatic pressure in the well bore is sufficient to condition the electrical circuitry for operation.

In FIG. 5, a developed view is shown of a portion of the inner wall of the tubing nipple **15** to illustrate the over-all configuration of an orienting and actuating slot or groove therein. It will be noted that a groove **36** in the nipple extends along its length, the groove having an intermediate offset portion **36***b* angularly spaced from upper and lower in-line straight portions **36***a* and **36***c*. At the upper end of groove portion **36***a*, a curved, and upwardly facing guide surface **37** is disposed on an upward spiral around the circumference of the nipple **15** to an apex **38** to provide a guiding function which will hereinafter be made more apparent.

The orienting control device **21** as illustrated in FIGS. 6 and 7 consists of upper and lower rigidly connected housing portions **40**, **41** and a central rotatably supported

collar portion 42. Spring biased buttons or lateral lugs 43, 44, 45 respectively are mounted on the sides of each of the rigid housing portions as well as the central rotating collar 42, with the upper and lower lugs being in vertical alignment with one another.

From the apparatus thus far described, it will be appreciated that when the lower lug 44 of the orienting section 14 enters nipple 15, it engages the spiraled guide surface 37 and rotates the entire tool 18 until the lug has entered the upper groove portion 36*a*. Thereafter, the lower lug 44 is guided by the groove 36 through the central portion portion 36*b* to the lower portion 36*c*. The longitudinal spacing of the lugs 43 and 44 relative to the groove portions 36*a* and 36*c* are such that as the lower lug 44 enters the lower groove portion 36*c*, the central lug 45 will be midway of the central curved portion 36*b* and the upper lug 43 will be located just above the upper end of the upper groove portion 36*a*. The spacing between the upper lug 43 and seat 17*a* on the tool are such that when the tool seat 17*a* engages the nipple seat 17, the upper and lower lugs 43 and 44 are in the groove portions 36*a* and 36*c* and the center lug 45 is disposed in the curve of the offset portion 36*b*. From this, it will be appreciated that the central lug 45 and the rotatable collar 42 on the locating tool can be angularly positioned to a selected orientation with respect to upper and lower lugs 43 and 44.

Referring now to FIGS. 6 and 7, intermediate of the housing portions 40, 41 of the orienting device 22 is a central reduced-diameter portion 47 on which the collar 42 is rotationally mounted by means of upper and lower bearings 48. Within the confines of the collar 42, the lug 45 is arranged to be extended outwardly of the collar by means of a spring 49 contained within a cavity 50. The lug 45 has offset tang portions to retain it within the cavity.

The reduced portion 47 has a peripheral slot 51 extending therearound somewhat less than one-half of its circumference and receives an inwardly projecting pin 52 which is attached to the rotating collar 42. The pin 52 is normally centrally positioned within the slot 51 by means of leaf springs 54 or the like attached to the stationary housing portions 40, 41 and received within grooves 55 in the collar. Thus, the springs 54 tend to maintain the collar in a central angular position with respect to the upper and lower housing portions 40 and 41. A longitudinal bore 56 is arranged in the reduced housing portion 47 to receive the switch 27 which has an actuator 58 adapted for operation when the inwardly extending pin 52 reaches an appropriate angular position by rotation relative to the orienting device 22.

From the foregoing, it will be appreciated that the springs 54 normally tend to maintain the button or lug 45 in a given central position. When the force of the springs is overcome by positioning of the lug 45 in the groove 36*b*, the switch 27 is actuated.

In operation, the tool assembly is inserted at the top of the flow pipe at is remote location and pump pressure applied to move the tool assembly through the flow line. While not shown, it is customary to have a fluid return conduit for the operation, this being a well-known operational feature. During motion through the flow line, the springs 54 on the control section prevent actuation of the switch 27. At the depths in the flow line where the hydrostatic pressure is sufficient to operate the diaphragm 30, the pressure operated safety switch 26 is closed. Thereafter, the tool at some point in the string reaches its positioning within the seating nipple 15. The seating nipple 15 in the string is arranged in the tubing pipe prior to its installation in the well so that the longitudinal groove portions 36*a* and 36*c* are in a selected orientation with respect to an adjacent tubing string so that the lugs 42, 43, 44 upon engaging the groove system, automatically orient the perforating apparatus 13 with respect to the adjacent string and when the proper orientation is accomplished, rotation of the collar 42 by entrance of the lug 45 into the offset groove portion 36*b* automatically actuates the perforator by closing switch 27 which couples the battery to the blasting cap which, in turn, initiates the primacord and shaped charges.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Apparatus for use in a well bore comprising: orienting means having a passageway therethrough and adapted for coupling in a string of well conduit, said orienting means having a programmed slot arrangement with circumferentially offset portions for receiving indexing means on a well tool, an orienting control device having indexing parts thereof arranged for relative rotation between first and second positions, said parts being arranged to cooperate with said offset portions to promote a relative rotation between said parts, and means cooperable with said parts for providing a control function in one of said positions.

2. The apparatus of claim 1 wherein said orienting means and orienting control device have complementary seating shoulders respectively arranged relative to said slot arrangement and said parts for limiting downward travel of said control device in said orienting means.

3. The apparatus of claim 1 wherein said parts include upper, intermediate, and lower lugs, said intermediate lug being rotatably supported relative to said upper and lower lugs.

4. Apparatus for use in completing wells comprising: orienting means having a passageway therethrough and adapted for coupling in a string of well conduit, said orienting means having a programmed slot arrangement with circumferentially offset portions for receiving indexing means on a well tool, an assembly adapted for passage through a well conduit and including fluid pump-down means, an orienting control device, a perforating means, and power means for initiating operation of said perforating means, said orienting control device having indexing parts thereof arranged for relative rotation between first and second positions, said parts being arranged for cooperation with said offset portions for promoting a relative rotation between said parts, and means cooperable with said parts upon relative rotation for connecting said power means to said perforating means.

5. The apparatus of claim 4 wherein said orienting means and orienting control device have complementary seating shoulders respectively arranged relative to said slot arrangement and said parts for limiting downward travel of said control device in said orienting means, and wherein said parts include upper, intermediate, and lower lugs, said intermediate lug being rotatably supported relative to said upper and lower lugs.

6. A well tool subcombination for use in a well conduit comprising: an orienting control device having parts thereof arranged for relative rotation about a longitudinal axis between first and second positions, means on said parts for cooperation with an orienting means in a well conduit for causing a relative rotation between said positions, and means cooperable with said parts for providing a control function in one of said positions.

7. A well tool subcombination for use in a well conduit comprising: a fluid pump-down means, an orienting control device, a perforating means, and power means for initiating operation of said perforating means, said orienting control device having indexing parts thereof arranged for relative rotation between first and second positions, said parts being arranged for cooperation with

angularly-offset portions within such a well conduit for promoting a relative rotation between said parts, and means cooperable with said parts upon relative rotation for connecting said power means to said perforating means.

8. The apparatus of claim **7** and further including means normally restraining relative rotation between said indexing parts, but permitting rotation for connecting said power means to said perforating means.

9. A well tool subcombination for use in a well conduit comprising: relatively rotatable housing portions each having projections for cooperation with an orienting means in a well conduit, control means on said housing portions operable in response to relative rotation between said housing portions, and means for normally restraining relative rotation between said housing portions, but permitting rotation in relation to the orienting means for operating said control means.

10. Apparatus for use in a well bore and comprising: a tubular body having a passageway therein and adapted for coupling in a well conduit, said tubular body having upper and lower orienting means arranged within said passageway in distinctive angular relationships; a well tool adapted to enter said passageway and including upper and lower indexing means thereon arranged for relative angular movement and adapted, upon engagement therewith, for cooperable movement by said upper and lower orienting means to corresponding angular positions upon entrance of said well tool into said passageway; and means on said well tool operable only upon movement of said upper and lower indexing means to a relative angular position corresponding to one of said angular relationships of said orienting means.

11. The apparatus of claim **10** wherein said upper and lower orienting means are angularly spaced in relation to one another to establish said one angular relationship; and further including means normally urging said upper and lower indexing means away from said corresponding angular position.

12. The apparatus of claim **11** wherein said operable means on said well tool include: switching means adapted to be actuated only upon movement of said upper and lower indexing means to said corresponding angular position; and perforating means adapted to be operated only upon actuation of said switching means.

13. Apparatus adapted for use in a well bore having a pipe string arranged therein and comprising: a tubular body having a passageway therethrough and adapted for coupling into such a pipe string, said tubular body having a plurality of angularly-offset guide surfaces spaced along said passageway in a predetermined relationship; a well tool adapted for passage through such a pipe string and having a control device adapted to enter said passageway, said control device including an angularly-fixed indexing member adapted to contact one of said guide surfaces, an angularly-movable indexing member spaced from said fixed indexing member and adapted upon contact with another of said guide surfaces to be moved to a selected angular position in relation to said fixed indexing member corresponding to the angular relation between said one of said other guide surfaces, and switching means operable only in response to movement of said movable indexing member to its said selected angular position; and perforating means on said well tool and operable only in response to operation of said switching means.

14. The apparatus of claim **13** further including means on said control device normally urging said movable indexing member away from its said selected angular position.

15. The apparatus of claim **14** further including means on said well tool adapted for pumping said well tool freely through such a pipe string to said tubular body.

16. Apparatus adapted for use in a well bore having a pipe string arranged therein and comprising: a tubular body having a passageway therethrough and adapted for coupling into such a pipe string, said tubular body having upper and lower angularly-aligned guide surfaces spaced along said passageway and an intermediate guide surface between said upper and lower guide surfaces and angularly misaligned in relation thereto; a well tool adapted for passage through such a pipe string and having a control device adapted to enter said passageway, said control device including upper and lower angularly-aligned indexing members respectively adapted to contact said upper and lower guide surfaces, an intermediate angularly-movable indexing member between said upper and lower indexing members and adapted upon contact with said intermediate guide surface to be moved to a selected angular position corresponding to the angular misalignment of said intermediate guide surface to said upper and lower guide surfaces, and switching means operable only in response to movement of said movable indexing member to its said selected angular position; and perforating means on said well tool and operable only in response to operation of said switching means.

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