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WELL TOOL APPARATUS

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Fig. 1

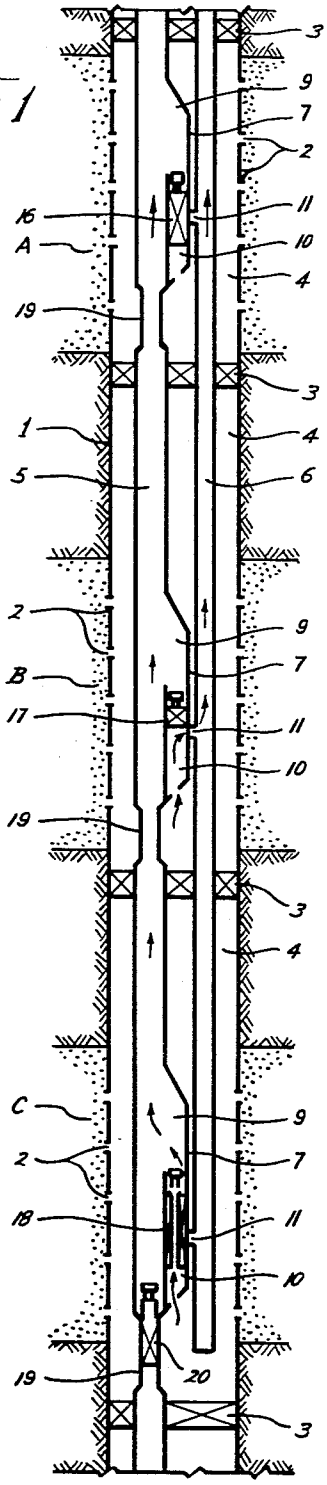
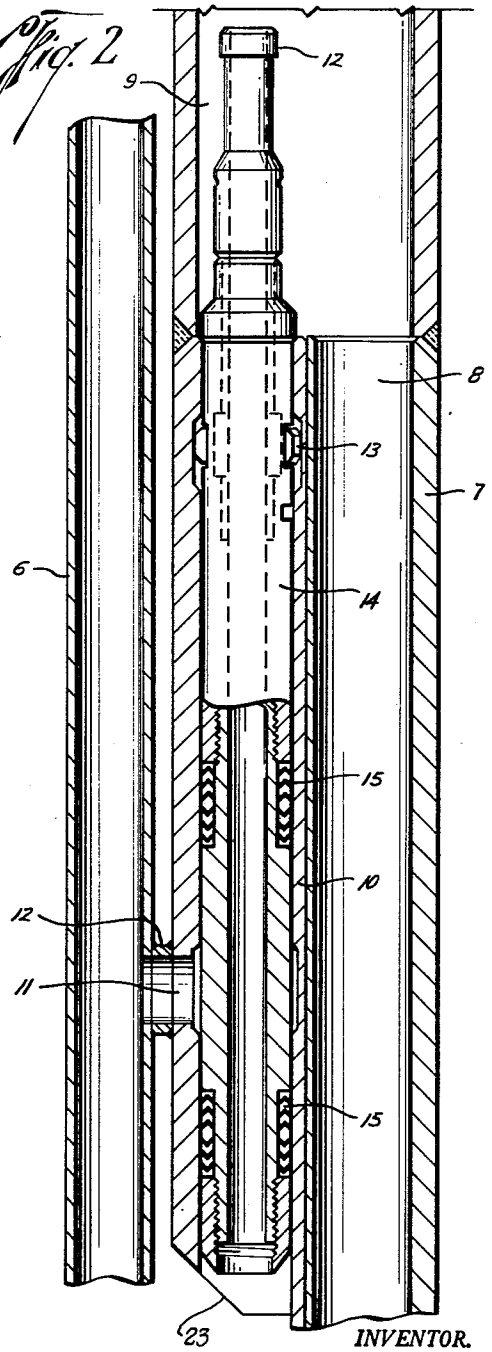


Fig. 2



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WELL TOOL APPARATUS

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This invention relates to multiple completion of fluid producing wells and more particularly to improved selective control of flow communication to the surface from each of several separate fluid bearing sands or distinct zones penetrated by the same well bore and capable of being produced.

When a well bore is drilled through the ground for bringing up fluids from strata below the surface, the bore wall often extends through several spaced apart fluid bearing formations and the well is completed for producing at the most promising zone for a single completion job or at two or more spaces apart strata in the case of a dual or multiple completion installation. At a later time there may be the desire to shut in or abandon a zone which has ceased to be productive and to bring in another zone for production and the usual practice has been to pull and dismantle the production string from the well and rework the well hole followed by tubing string reinstallation. To avoid heavy costs for transporting, setting up and using bulky rig equipment and to save time and manpower involved in such prior practices by eliminating the need for removing and reinstalling massive production equipment is a primary object of the present invention.

A further object of the invention is to provide for completing a drill hole which penetrates a number of formations with good showings by conditioning such formations for production and then segregating from one another those portions of the hole opposite the respective formations and installing production conduit incorporating special tubing sections, one at each zone, for communication therewith as determined by the co-operation with each special section of any one of several different types of retrievable and interchangeable flow control devices whereby the devices can be selectively and interchangeably positioned in predetermined relation in the several tubing sections for initially blanking off or permitting production at will from individual zones and for subsequently, at any time and as often as there is any zone capable of economical production, changing over previous producing and nonproducing relationships of the several zones and through the use of wire line equipment by which a given type of flow control device can be quickly and easily installed, removed or replaced at any selected level.

Another object of the invention is to provide for simultaneous production from more than one zone and separately through parallel conduits, one of which incorporates a straight-through passage for wire line manipulation of retrievable flow control devices into and out of co-operative mounting in side pocket receivers laterally offset from the passage and located one at each production zone in communication therewith and with the respective conduits but controlled individually by said devices for blanking off flow to all conduits or permitting flow into one or another thereof.

Other objects and advantages will become apparent during the course of the following specification having reference to the accompanying drawing wherein FIG. 1 is a vertical section of a fragment of the earth containing a well bore, with production conduits shown somewhat schematically and arranged in accordance with the invention, and FIG. 2 is an enlarged vertical section of a portion of a conduit assembly adjoining a producing formation.

The well hole illustrated in FIG. 1 is to be considered as penetrating a number of fluid bearing formations, of which three zones at spaced apart levels are indicated at A, B and C. Following the drilling operation, each productive zone will be conditioned or completed for flow into the well bore and such completion for purposes hereof is to be considered as inclusive of the customary steps of removing mud cake on the wall surface, setting and cementing a casing 1 to line and seal off the wall and perforating sets of openings 2 through the casing and into the respective zones. In regions between successive zones, there are installed within the well hole a number of vertically spaced apart packers 3 to partition portions of the hole and close them off from one another and to form intervening chambers 4, one at each zone to receive fluid issuing therefrom. These zone connected chambers 4 are to be produced through conduit means, as, for example, two or more separate tubing strings 5 and 6 extended downwardly one beside the other in parallelism within the annular casing 1 and from the well head in traversing relation with the several zones and projected through and sealed in spaced apart packers 3.

Conventionally, each tubing string is made up of long sections or pipe joints coupled in end to end succession and in axial alignment. The tubing string 6 is shown as of a smaller volume than the tubing string 5 but relative size is a matter of choice except that the internal diameter of the string 5 for the purposes of the present disclosure is related to the size of and is for co-operation with wire line tools and equipment to be passaged therethrough. Also, this tubing string 5 incorporates special purpose sections 7 in spaced apart relation and corresponding in number and spacing to the packer segregated chambers 4 at the several productive zones. Each special section 7 is for end to end coupling with adjoining sections of the tubing string and has top and bottom coupling tube portions axially aligned with one another and with a connecting through passage 8 which in transverse dimension for its entire length is as great as and forms an unobstructed and vertically aligned continuation of the conduit space within the rest of the tubing string. Between its opposite ends, the section 7 is enlarged in a transverse direction laterally offset from the open passage 8 and affords an internal side extension having an upper clearance space 9 open to the passage 8 and containing in the lower portion thereof a tubular pocket 10 for removable reception of a suitable flow control device whose manipulation is by well known wire line suspension equipment.

Prior to disposition of a flow control device within the pocket 10, its upper end is open into the passage 8 and its lower end is open at 23 through the bottom to the exterior of the tubing string for communication with one of the segregated chamber portions 4 of the well hole. At a point intermediate the top and bottom openings to and from the pocket, its outside wall contains a port or opening 11 communicating through a connecting joint 12 with the interior of the adjacent section of the companion tubing string 6. The connection 12 joins the adjacent side by side tubing sections as a subassembly unit made up prior to insertion within the well and consists simply of a spacer ring welded to both sections in alignment with the port 11 and a corresponding port in the tubing section 6. Except for the spaced apart intermediate flow port 11 and openings at the top and bottom of the side pocket 10, the wall of the pocket is closed and affords flow paths directed from the bottom opening to both production tubing strings 5 and 6. Selective control of flow from any of the several formations through either of the two paths is dependent on the selective reception within

the respective side pockets of a particular type of retrievable blanking tool or flow control device.

A set of three such flow control devices indicated at **16**, **17** and **18** is here proposed for use interchangeably in any tool receiving pocket and each includes, as seen in FIG. 2, an upper fishing head **12** for wire line connection, latching dogs **13** for releasably locking in place the main cylindrical body **14** of the tool which carries suitable sealing elements such as annular packing rings **15** for close fitment and sealing relation with mating interior machined sealing surfaces of the pocket wall. The latching mechanism illustrated is one in which the series of dogs **13** are laterally projectable through windows in the body **14** and co-operate for their projection and retraction with stepped diameter portions on a slide tube fixed to the fishing head **12** and mounted in telescopic slide relation with the body **14**.

One of the interchangeable devices is a blanking plug, indicated at **16** in FIG. 1 as having a solid body and as being positioned in one of the pockets so as to close the upper opening into the production conduit **5** and to overlap and close the intermediate opening **11** into the production conduit **6** and preclude flow to both conduits from the adjacent production zone. Another flow control device is a solid blanking plug which, as indicated at **17** in FIG. 1, blocks the upper opening into the conduit **5** without closing either of the remaining openings to the pocket and establishes a flow path from the adjoining production zone into the conduit **6**. The detail structure of the plugs **16** and **17** and their co-operation with the pockets is shown in Daffin Patent 2,923,357. The remaining flow control device is a hollow plug and, as seen at **18** in FIG. 1 and also as shown in greater detail in FIG. 2, overlaps and blanks the intermediate port **11** while establishing flow through the hollow plug from the lower opening and adjacent production zone and into the production conduit **5**.

In the tubing string **5** and below each section **7** having the side pocket, is preferably incorporated a retrievable tool landing insert **19** for the selective reception in any proper insert of a blocking plug **20** to be removably latched in place below an established flow path to partition and close off the tubing string above and below the plug **20**. A similar arrangement can be provided for use with the tubing string **6** for its closure immediately below the flow path established through any of the communicating ports **11** although in the case of a small diameter tubing string, it is proposed simply to plug its lower end so that its bottom is dead-ended, as illustrated in FIG. 1. With the arrangement as illustrated in FIG. 1, production from the zone C is into the adjacent packed off bore hole chamber **4** and through the side pocket and hollow plug **18** to the tubing string **5** extending upwardly to the well head. Concurrently, the zone B produces through the adjacent bore hole chamber **4** and through the side pocket below the blanking plug **17** and through the production tubing string **6** to the well head. All other production zones, for example, zone A, are shut off from production by means of a blanking plug **16** positioned in the adjacent side pocket in blocking relation to the paths of flow to either of the tubing strings **5** and **6**.

By reason of the novel arrangement of the interconnected tubing strings and the selective flow paths provided through the side pocket control, any of several properly conditioned zones can be selectively cut off or placed in production. The laterally offset relation of the control pockets and the resulting straight-through passage in the conduit **5** enables the usual wire line equipment to reach the level of any side pocket and pass all of those side pockets thereabove for the purpose of placing or retrieving any of the flow control devices **16**, **17** and **18** in and from any selected one of the several spaced apart side pockets. Since these flow control devices can be interchanged one for another in any pocket, it follows that either of the tubing strings **5** and **6** can be placed in communication with or shut off from, as desired, any one of the productive formations. Change over can be accomplished easily and quickly by following wire line methods and without disturbing the original installation of the tubing strings and packers.

At any time, all zones can be shut off from production by installing the type of blocking plug shown at **16** within each of the side pockets. If at any time it is desired to produce from one zone only, then the pocket adjacent that zone will have fitted in it a retrievable flow device of either the type shown at **17** or the type shown at **18**, depending on which production string is to be used. Such selection could be governed by the flow volume of the particular string when strings of different diameters are employed. Commingling of production fluid from different zones can be permitted or prevented and fluids of different characteristics as may be contained in segregated zones can be separately produced at the same time through the separate production systems. In the event production from a previously selected zone decreases or is of a content not wanted at any particular time, that production can be closed off through interchange of the wire line retrievable control devices and the tubing string can be brought into communication with a different zone which theretofore had been shut off. Furthermore, various types of surface controlled circulation and pressurization can be effected for performance of cleanout, formation treatment and other operations at the different levels selectively.

These various relationships are accomplished without the need for pulling tubing string or performing any repair or workover operation other than the simple interchange of flow control devices by wire line manipulations.

What is claimed is:

1. In a multiple completion well system in which a well bore penetrates several vertically spaced apart fluid producing strata, a series of vertically spaced apart well bore packers sealing off each producing stratum from others and providing a number of well fluid receiving chambers separated by successive packers, a pair of production conduits extending through each of the packers and traversing each of said chambers and one of the conduits presenting continuous straight line passage therethrough and having a number of tool receiving pockets laterally offset from said passage and located one adjacent each chamber, each pocket being provided with means communicating each pocket in spaced apart relation with the adjoining chamber, with said passage and with the other conduit respectively and wire line retrievable tools selectively positionable in said pockets for co-operation therewith in controlling the communicating means and said tools differing in kind and being constructed and arranged one for blocking pocket communication with said passage while communicating one chamber and said other conduit, another for blocking pocket communication with said other conduit while communicating another chamber and said passage and another for blanking off pocket communication with each of the chambers adjoining the pocket, said other conduit and said passage.

2. In a multiple completion well installation, well hole packer means segregating production zones one from another, a pair of conduits extending through the packer means, a laterally offset tool receiving pocket in one conduit at each production zone, a first flow connection between the pocket and said one conduit, a second flow connection between the pocket and the other conduit, a third flow connection between the pocket and the production zone adjacent thereto and means for variously closing off said flow connections including a series of interchangeable wire line retrievable devices selectively receivable in the respective pockets and each of said devices co-operating with a pocket upon reception therein, one tool being constructed and arranged to close communication between all of the flow connections, another tool being constructed and arranged to close off said first

flow connection and still another tool being constructed and arranged to close off said second flow connection.

3. In a multiple completion well installation enabling a large number of production zones to be completed and followed by closing off certain of the zones while producing from others and subsequently, whenever it is desirable to do so, effecting a different selection of zones to be closed and to be opened, well hole packer means separating each completed zone from others, a pair of production conduits traversing all the zones, one of said conduits having an end to end assembly of tubing sections having flow passages therethrough in continuing axial alignment for the unobstructed passage of wire line equipment, a number of said tubing sections of said one conduit having internal enlargements offset laterally from said passage and located one at each completed zone, a retrievable tool receiving pocket located within the laterally offset portion of each enlargement and adapted for removable mounting therein of any one of a series of wire line retrievable tools and each such pocket having spaced apart communicating means between the pocket and each said passage, the other of said conduits and the completed zone adjacent the pocket, said communicating means affording paths of communication adapted to be controlled by positioning in the pocket of selected ones of the series of tools.

4. In an installation for producing well fluids from a plurality of zones penetrated by the same bore, a first production conduit extending through the well bore and having adjacent each of the several producing zones a section containing a side pocket having spaced apart openings, one to the exterior thereof and the other to the interior of the conduit, a second production conduit extending beside the first conduit and having communicating connections with the several side pockets, each in spaced relation with said spaced apart openings, a group of flow control devices interchangeably receivable in said side pockets and each being adapted for manipulation through the first conduit and selective disposition in and removal from any such side pocket, one of said devices when received in a side pocket co-operating therewith and having means to direct well fluid flow from the exterior opening to the interior opening to the first conduit and to block the communicating connection with the second conduit, another of said devices when received in a side pocket co-operating therewith and having means to direct well fluid flow from the exterior opening to the communicating connection with the second conduit and to block the interior opening to the first conduit and other of the devices when received in a side pocket co-operating therewith and constituting a block to block well fluid flow between the exterior opening, the interior opening to the first conduit and the communicating connection to the second conduit and well bore packer means surrounding said conduits between adjacent production zones and segregating the several zones from one another.

5. In an installation for producing well fluids from selected ones of a plurality of zones penetrated by the same bore, a pair of parallel production conduits extending through the well bore and one thereof having a side pocket adjacent each producing zone, each side pocket having means communicating the pocket separately with the respective conduits and with the well bore space exteriorly of the conduits, a group of flow control devices interchangeably receivable within said side pockets and being of different types, each device being constructed and arranged for blocking the separate communication means in predetermined relationships differing in each type of device and packer means in the well bore segregating the several zones one from another.

6. In a multiple completion well installation in which the well bore penetrates several vertically spaced apart fluid producing formations, packer means positioned in the well bore between adjoining formations and sealing off separate formation fluid chambers and a pair of production conduits positioned in the well bore for segregated formation fluid production, one of said conduits having a straight line passage therethrough and having side pockets offset laterally from said straight line passage and within the sealed-off chambers, each offset pocket being provided with relatively spaced apart means separately and respectively communicating the interior thereof in fluid flow relation with the straight line passage, with the other of said conduits and with the chamber at the pocket, each offset pocket means being adapted for the mounting therein of a retrievable flow control device in valving relation with said spaced apart means selectively.

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