June 17, 1958 T. A. HUBER 2,839,142

PERMANENT WELL COMPLETION METHOD

Filed May 5, 1954 2 Sheets-Sheet 1

FIG. 1.

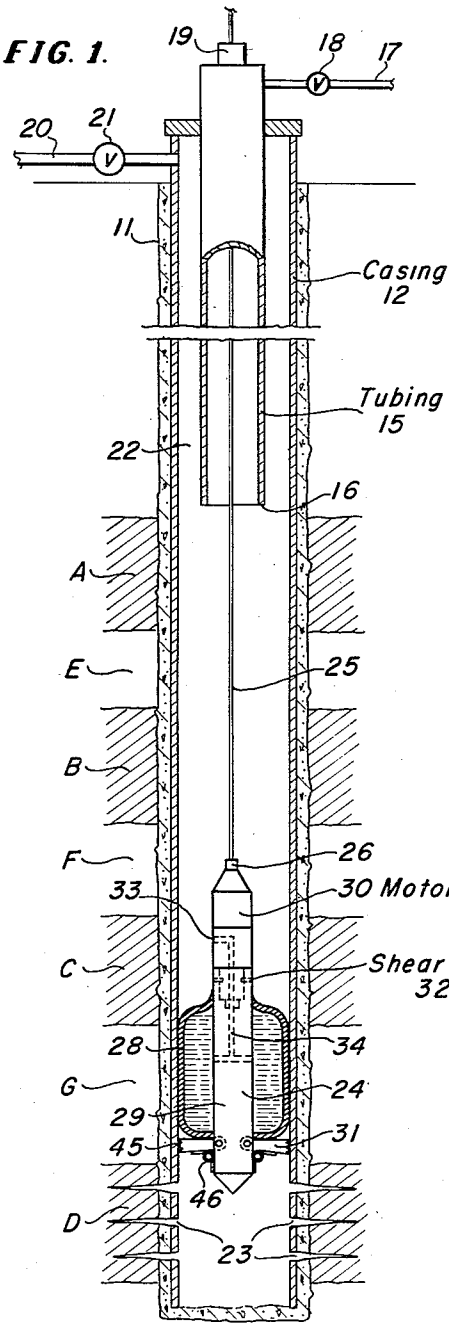
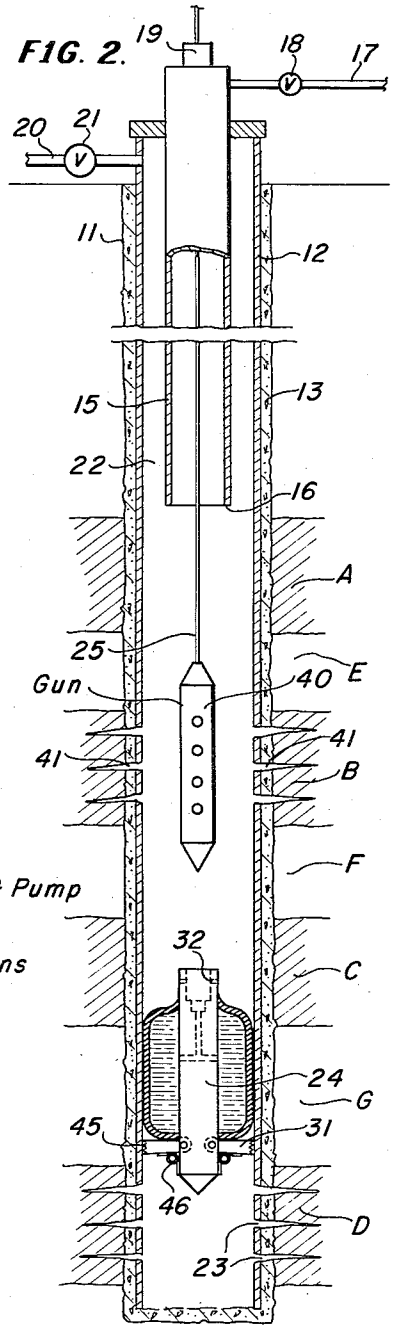


FIG. 2.



INVENTOR.
Theodore A. Huber,

BY

ATTORNEY.

June 17, 1958 T. A. HUBER 2,839,142

PERMANENT WELL COMPLETION METHOD

Filed May 5, 1954 2 Sheets-Sheet 2

FIG. 3.

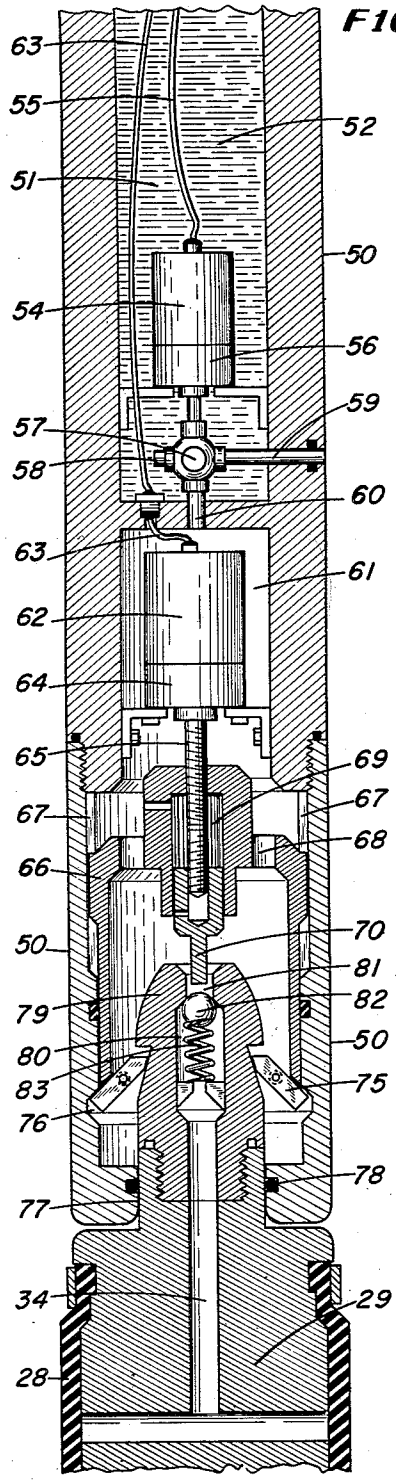
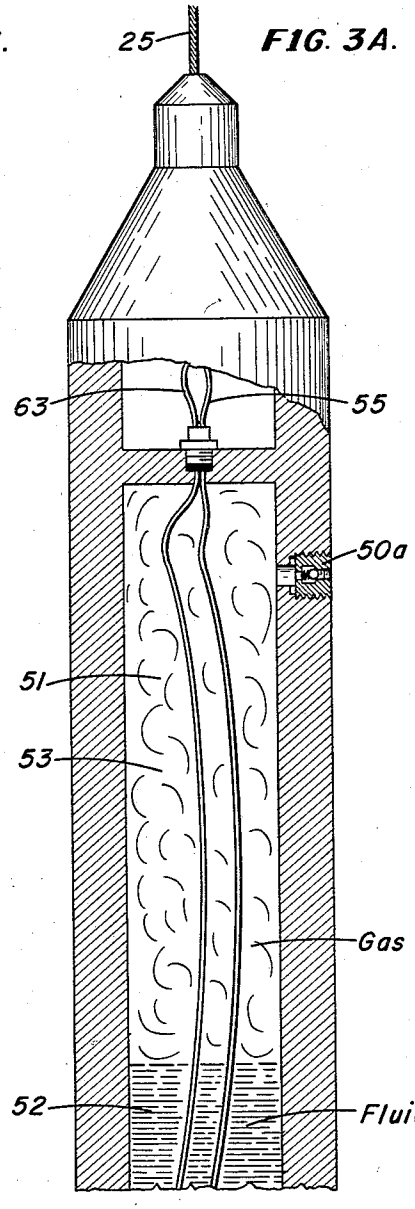


FIG. 3A.



INVENTOR.
Theodore A. Huber,
BY
ATTORNEY.

United States Patent Office 2,839,142
Patented June 17, 1958

2,839,142

PERMANENT WELL COMPLETION METHOD

Theodore A. Huber, Houston, Tex., assignor, by mesne assignments, to Esso Research and Engineering Company, Elizabeth, N. J., a corporation of Delaware

Application May 5, 1954, Serial No. 427,715

6 Claims. (Cl. 166—46)

The present invention is directed to a method for completing a well. More particularly, the invention is directed to a method for completing and servicing a cased well, in which a tubing string is arranged, without moving the tubing. In its more particular aspects, the invention is concerned with a well completion and servicing method in which all operations are conducted through the tubing.

The present invention may be briefly described as a method for completing and/or servicing a cased well in which a tubing string is permanently arranged with its lower end at a level above a highest of a plurality of hydrocarbon productive strata. The feature of the invention comprises obtaining production of hydrocarbons from a first of said strata until production of said hydrocarbons declines or is reduced by water encroachment, and then lowering a barrier through said tubing and placing the barrier at a level in the casing in or above the first stratum but below a productive level in the same strata or below a second hydrocarbon productive stratum to terminate production from the non-productive level or from the first stratum. The casing may be perforated in the productive interval in the first strata or in the second stratum to obtain production of hydrocarbons from the productive interval or from the second stratum as the case may be.

The barrier after placement at a level in the casing above the non-productive interval or above the first stratum but below the second hydrocarbon productive stratum, or a productive interval or zone in the first strata, obstructs the casing and terminates the production of fluids from the zone from which hydrocarbons are no longer commercially obtainable. A gun perforator may then be lowered through the tubing at a level adjacent the second stratum or the second productive interval and is fired to perforate the casing in the second stratum or in the upper portion of first stratum at a point above the barrier. In some instances it is unnecessary to reperforate where only a portion of the perforations produce water.

It is contemplated in the practice of the present invention that the barrier member may be movable in the casing such that it may be moved vertically in the casing from one level to another level. In short, it is contemplated in the practice of the present invention that after the barrier has obstructed the casing at a first level it may be moved upwardly in the first casing below the lower end of the tubing to obstruct the casing at a second level following which the casing may be perforated as desired or if necessary and production had, for example, from a third hydrocarbon productive stratum or zone.

It is also contemplated in the present invention that a plurality of barrier members may be employed. For example, a first barrier member may be lowered through the tubing and placed in the casing to obstruct the casing to terminate production from a first interval, zone, or stratum. The casing may then be perforated in a second interval, zone, or stratum and production of hydrocarbons obtained therefrom until said production of hydrocarbons from the second interval, zone, or stratum becomes noncommercial or declines due to water encroachment, and the like; or such zones may be separated for testing purposes. Thereafter a second barrier member may be lowered through the tubing to obstruct the casing and terminate production from the second stratum or a non-commercial interval in the same stratum following which a gun perforator is lowered through the tubing and production opened up from a third hydrocarbon productive zone, interval or stratum.

The barrier member employed in the practice of the present invention is suitably a plug or a deformable member which may be lowered through the tubing. For example, the barrier member may be constructed of rubber or other elastic material and lowered in a non-expanded or collapsed condition through the tubing to the level in the casing where it is to be placed and employed to obstruct the casing. The barrier member may be provided with an electric motor to operate a pump to expand the barrier member by drawing into the barrier member for expansion thereof fluid from the well. Suitably, fluid may be contained within the barrier member for expansion thereof. It is also contemplated that the barrier member will be provided with means for holding same firmly against the walls of the well bore to resist pressure from below the barrier member and allow the barrier member to be held firmly in place. It is contemplated that a fluid plastic material may be used to inflat the packer or barrier and then allow same to set to form a barrier. In this situation, the barrier would not be movable but remain where placed. Employment of a plastic to inflate the barrier may be desirable where high pressures are to be sealed off.

The barrier member is conveniently lowered through the tubing on an electrical conductor cable and the like which will provide energy for pumping up or pumping out the barrier member to obstruct the casing or to allow the barrier member to be moved vertically in the casing.

The barrier member may be constructed such that the motor and pump are disengageable from the barrier member for retrievement through the tubing from the well.

The present invention will be further illustrated by reference to the drawing in which:

Fig. 1 shows an arrangement of a barrier member to obstruct the casing to terminate flow of well fluid from the first hydrocarbon stratum;

Fig. 2 shows the barrier member with the motor and pump disengaged and a gun perforator lowered through the tubing to form perforations in a second hydrocarbon productive stratum; and

Figs. 3 and 3*a* are detailed sectional views of a releasable setting tool for use in Figs. 1 and 2.

Referring now to the drawing in which identical numerals will be employed to designate identical parts, numeral 11 designates a well which has been drilled in the earth to penetrate hydrocarbon productive intervals, zones or stratum A, B, C and D which are separated by nonproductive intervals E, F and G. These nonproductive intervals may be shale, and the like, and may separate productive zones from nonproductive zones in the same stratum. Likewise, it is contemplated that a higher interval in the same stratum may be hydrocarbon productive after a lower interval or level in the same stratum has become commercially unattractive as to hydrocarbon production or hydrocarbon production may have declined or become reduced in amount. The present invention may be employed in all such instances.

The well 11 is provided with a casing 12 which is cemented in place with cement 13. Arranged in the casing 12 from the earth's surface 14 is a tubing string 15

which is set with its lower end **16** above the hydrocarbon producing interval or stratum A. The tubing **15** is provided with flow line **17** controlled by valve **18** and a lubricator **19** through which the various well servicing equipment is lowered. The casing is provided with a conduit **20** controlled by valve **21** for flow through the annulus **22** as may be desired under some circumstances.

The well **11** has initially been completed in the interval or stratum D by forming perforations **23** through the casing **12** and cement **13** and hydrocarbon production, such as oil and gas, has been secured from the stratum D until the production of hydrocarbons has declined or become noncommercial due, for example to invasion of water or to production of excessive quantities of gas when oil is the principal hydrocarbon productive fluid. Under these conditions, a barrier member, such as **24**, is lowered through the tubing **15** by means of electrical cable **25**. The barrier member **24** is attached to the cable **25** by means **26**.

The barrier member **24** comprises a deformable or expandable member **28** which is designed to be expanded by well fluids to obstruct the casing **12**. However, such fluid might also be internally contained in the member **28** and the member expanded by exerting pressure thereon and includes a mandrel **29**, a motor and pump generally indicated by the numeral **30** and latching means, such as dogs or slips **31**. The motor and pump **30** are releasably connected to the mandrel **29** by releasable connecting means such as shear pins **32**. The pump has an inlet **33** opening into the casing and communicating by conduit **34** with the interior of the deformable member **28**. Thus, by providing energy to the electric conductor cable **25**, the motor may be energized to pump well fluids into the deformable member **28** and expand same to obstruct the casing and, when it is desired to move the barrier, by means of a reverse switch it is possible to pump out the well fluids and collapse the barrier.

Referring now to Fig. 2, it is to be noted that the barrier member **24** has obstructed the casing **12** and the motor and pump **30** have been disengaged from the mandrel **29** by an upward pull on the cable **25** causing the shear pins **32** to shear at a predetermined tension. Thereafter, in accordance with this invention, a gun perforator, such as **40**, which may be a bullet gun or a shaped charge perforator is lowered on the conductor cable **25** adjacent the stratum B or C as may be desired. For purposes of this illustration, the gun perforator **40** has been lowered adjacent the stratum B and perforations **41** have been made in the stratum or interval B by firing the bullets or shaped charges as the case may be. Such gun perforators are commercially available and their use is well known in the art. After forming the perforations **41**, the gun perforator **40** is retrieved through the tubing **15** and production is then had through the perforations **41** and up the tubing.

It is contemplated that after production from the stratum B has declined or become noncommercial for the aforementioned reasons, it may be desirable to place a barrier in the casing adjacent the nonproductive stratum or interval E and this may conveniently be done by lowering another barrier member, such as **24**, through the tubing and placing same adjacent the stratum E following which the casing would be perforated in the stratum A. If desired not to provide a second barrier member, the barrier member **24** may be re-engaged by lowering the motor and pump **30** connected to fishing tool **26** connected to cable **25** to engage with a suitable locking device, not shown, connected to the mandrel **29**. The dogs or gripping means **31** are disengaged by collapsing the deformable member **28** by pumping out the well fluids which allows springs **46** to move the dogs **31** upwardly. An upward pull then serves to move the barrier **24** upwardly in the casing to a level adjacent the stratum E for obstructing the casing at that level.

It is to be noted that the gripping means for the barrier member **24** has been illustrated by dogs **31** provided with pipe engaging teeth **45**. Also it is to be noted that the dogs **31** are biased outwardly by means of the packer **28** overcoming springs **46** which serves to urge the dogs **31** into engagement with the casing **12**.

Referring now to Figs. 3 and 3*a*, apparatus is illustrated which allows the mandrel **29** and the deformable member **28** to be re-engaged and/or released. In this apparatus a setting tool, such as **50**, is provided with an internal chamber **51** in which a body of hydraulic fluid is indicated by the shaded portion **52** which is arranged below a body of gas, such as **53**, which serves to pressure the fluid in the chamber **51**. The reservoir **51** may be filled at the earths' surface with a suitable hydraulic fluid such as oil, aqueous fluid and the like by way of plugged opening **50***a* in the upper end of body **50**. Arranged within the chamber **51** is a valve motor **54** which is energized by electrical connecting means **55** which extends preferably to the earth's surface through cable **25** and is connected to a source of electrical energy. The valve motor **54** is connected by a reduction gear unit **56** to a three-way valve **57** which connects by way of conduit **58** to the chamber **51** and by conduit **59** to the exterior of the tool **50**. Also a conduit **60** communicates with a chamber **61** in the lower portion of the setting tool **50**. Arranged in the chamber **61** is a second motor **62** which allows the tool **50** to be disengaged and re-engaged with the mandrel **29**. The motor **62** is provided with electrical connecting means **63** for energizing same, the electrical connecting means being carried to a source of electrical energy preferably at the earth's surface through electrical cable **25**.

The latching-on motor **62** has a reduction gear unit **64** which is connected to a driving screw **65**. Driving screw **65** is provided with left-hand threads on its upper portion and right-hand threads on its lower portion.

Operably mounted on the upper portion of driving screw **65** is a latching dog yoke **66**. Yoke **66** is confined to vertical motion in body **50** by keyways **67**. Yoke **66** is also provided with ports **68** at its upper end.

Yoke **66** defines adjacent its upper end a cylindrical splined cavity **69**. Slidably arranged in cavity **69** and threadably connected to the lower end of driving screw **65** is a valve actuating plunger **70**, which protrudes from the lower end of splined cavity **69**. Upon turning of driving screw **65** to the right the yoke **66** is forced down and the valve actuating rod **70** is forced up. Upon turning the screw **65** to the left the yoke **66** is forced up and the actuating rod **70** is forced down.

Pivotally connected to the inner wall of body **50** and adjacent the lower end of yoke **66** are a plurality of spring-biased latching dogs **75** having one end thereof extending inwardly toward the vertical axis of body **50** and their other end held against upward movement by shouldered recess **76**.

Body **50** defines in its lower end an opening **77**, having a circular groove containing a sealing means such as O-ring **78**.

Arranged in opening **77** and in latching engagement with dogs **75** is a running or retrieving head **79** which is attached to the upper end of a casing plug such as **29**.

Head **79** defines a valve cavity **80** which is in fluid communication with an opening **81** in the upper end of head **79**. A ball valve **82**, arranged in cavity **80** and biased upwardly by spring **83** normally closes the opening **81**. Cavity **80** is in fluid communication with passageway **34** and deformable sleeve **28** of plug assembly **29**. The device of Figs. 3 and 3*a* operates in the following manner.

The device is lowered into the casing with parts in the position shown to the depth the plug **29** is to be set.

Motor **54** is activated therefore opening valve **57** and allowing the fluid in chamber **51** to be forced down through conduit **60**, chamber **61**, opening **81** in head **79**, passageway **34** of plug **29** and inflating sleeve **28**.

When plug 29 is suitably set, valve 57 is again turned by motor 54 so as to close off the passage of fluid through conduit 58, therefore allowing ball valve 82 to close off opening passage 81 in head 79.

Body 50 is then ready to be withdrawn from the well. Motor 62 is then activated so as to rotate driving screw 65 to the right. This forces the yoke 66 down therefore unlatching the dogs 75 from the head 79, and allowing body 50 to be disconnected from plug 29.

If it is desired to remove plug 29 from the casing, the device 50 is again lowered until the body 50 is again latched to head 79 as shown. Valve 57 is rotated so as to place conduit 60 in fluid communication with conduit 59. Motor 62 is then activated so as to turn drive screw 65 to the left. This rotation of screw 65 forces the plunger 70 down so as to push ball valve 82 off its seat and allowing fluid in plug to escape by way of conduit 60 and 59 therefore deflating the sleeve 28.

The entire assembly is then ready to be withdrawn from the well or, if desired, to be set at another depth.

The present invention has considerable utility in that it is unnecessary to provide any auxiliary equipment in completing or servicing a well besides the barrier member and the tubing gun perforator, both of which may be lowered on a cable and the like. Also the present invention eliminates the use of costly, heavy duty well serving equipment since this invention eliminates the need of moving the tubing as in conventional operations where, in such operations as producing from a plurality of producing intervals were conducted, it was necessary to manipulate the tubing each time a zone or interval was completed. Furthermore the present invention eliminates the necessity in conventional operations of killing the well each time a zone, stratum or interval is worked over or completed. Such elimination of killing a live well is quite important in that it is unnecessary to pump drilling mud into the well or to perforate in the drilling mud which quite frequently will plug the perforations formed by firing a gun. The invention is also of wide utility since it eliminates the necessity of secondary cementing jobs to seal perforations, such as 23, which frequently may not be successful.

In the present invention, it is to be understood that where stratum is used, this term signifies a producing zone part or all of which may become unattractive for production of commercial amounts of hydrocarbon due to water invasion or other causes. It is contemplated that other intervals in the same stratum or zone vertically displaced or adjacent the same stratum from which hydrocarbon production has been had may then be worked over or recompleted in the practice of my invention. Also it is contemplated that the invention, as described, may be used in obtaining hydrocarbon production from strata vertically displaced from the first stratum, zone, or interval.

The present invention is also applicable in situations where production of hydrocarbons may be obtainable in commercial quantities but water production is increasing and it is desirable to reduce or eliminate this undesirable water production. Thus, it is contemplated that water production is reduced or excluded by setting the barrier in the casing below the open end tubing to cover and/or seal perforations in the casing either by locating the barrier above or in direct contact with the perforations from which water is being produced. In this aspect of the invention reperforating becomes unnecessary since production of hydrocarbon may be obtained through the open perforations while water is excluded by the barrier sealing the perforations by way of which water enters the casing. In other words, the perforations in the casing extended from a point below to a point above the barrier but the barrier effectively closes off those perforations below the barrier and allows production from the perforations above the barrier.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and to secure by Letters Patent is:

1. A method for completing and servicing a cased well in which a tubing string is permanently arranged in a casing with its lower open end at a level above the highest of a plurality of hydrocarbon productive strata without killing the well which comprises obtaining production of hydrocarbons from a first interval in said casing until production of said hydrocarbons declines, lowering a movable barrier through said tubing, placing said barrier at a level in said casing above said first interval but below a second hydrocarbon productive interval, obstructing said casing with said barrier to terminate production from said first interval, lowering a perforator through said tubing to a level adjacent said second interval, perforating said casing in said second interval with said perforator and obtaining production of hydrocarbons from said second interval, moving said barrier from said level above said first interval, placing said barrier at a level above said second interval but below a third hydrocarbon productive interval obstructing said casing with said barrier to terminate production from said second interval, lowering said perforator through said tubing to a level adjacent said third interval, and then perforating said casing in said third interval and obtaining production of hydrocarbons from said third interval, the perforations in all of said intervals remaining open into the well, said movable barrier obstructing flow from the first interval while production is being obtained from the second interval and said movable barrier obstructing flow from the first and second intervals while production is being obtained from the third interval.

2. A method in accordance with claim 1 in which the first, second and third intervals are in the same stratum.

3. A method in accordance with claim 1 in which the first, second and third intervals are in different strata.

4. A method in accordance with claim 1 in which the perforator is a bullet gun perforator.

5. A method in accordance with claim 1 in which the perforator is a shaped charge perforator.

6. A method for completing and servicing a cased well in which a tubing string is permanently arranged in a casing with its lower open end at a level above the highest of a plurality of hydrocarbon productive strata without killing the well which comprises obtaining production of hydrocarbons from a first interval in said casing until production of said hydrocarbons become noncommercial, lowering a first movable barrier through said tubing, placing said first barrier at a level in said casing above said first interval but below a second hydrocarbon productive interval, obstructing said casing with said first barrier to terminate production from said first interval, lowering a perforator through said tubing to a level adjacent said second interval, perforating said casing in said second interval with said perforator and obtaining production of hydrocarbons from said second interval until said production of hydrocarbons from said second interval becomes noncommercial, lowering a second movable barrier through said tubing, placing said second barrier at a level in said casing above said second interval but below a third hydrocarbon productive interval, obstructing said casing with said second barrier to terminate production from said second interval, lowering said perforator through said tubing to a level adjacent said third interval and then perforating said casing in said third interval and obtaining production of hydrocarbons from said third interval, the perforations in all of said intervals remaining open into the well, said first movable barrier obstructing flow from the first interval while production is being had from the second and third intervals in sequence and said second movable barrier obstructing flow from the second interval while production is being had from the third interval.

(References on following page)

References Cited in the file of this patent

UNITED STATES PATENTS

2,016,919	Church	Oct. 8, 1935
2,029,491	Lane	Feb. 4, 1936
2,159,640	Strain	May 23, 1939
2,168,116	Crites	Aug. 1, 1939
2,187,487	Burt	Jan. 16, 1940
2,189,703	Burt et al.	Feb. 6, 1940
2,262,117	Roe	Nov. 11, 1941
2,368,428	Saurenman	Jan. 30, 1945
2,374,922	Byrd	May 1, 1945
2,543,814	Thompson	Mar. 6, 1951
2,714,931	Bouvier	Aug. 9, 1955
2,749,989	Huber	June 12, 1956
2,760,578	Tausch	Aug. 28, 1956
2,776,013	Tausch	Jan. 1, 1957
2,781,852	Rumble	Feb. 19, 1957
2,781,853	Rumble et al.	Feb. 19, 1957