Jan. 9, 1951 J. O. LEWIS 2,537,066

APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 1

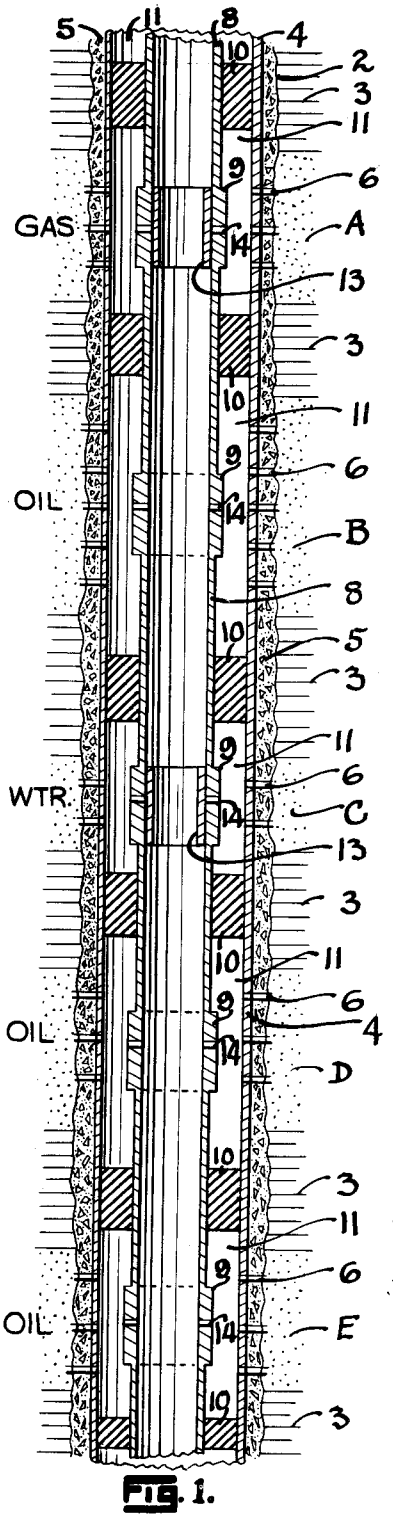



FIG. 1.

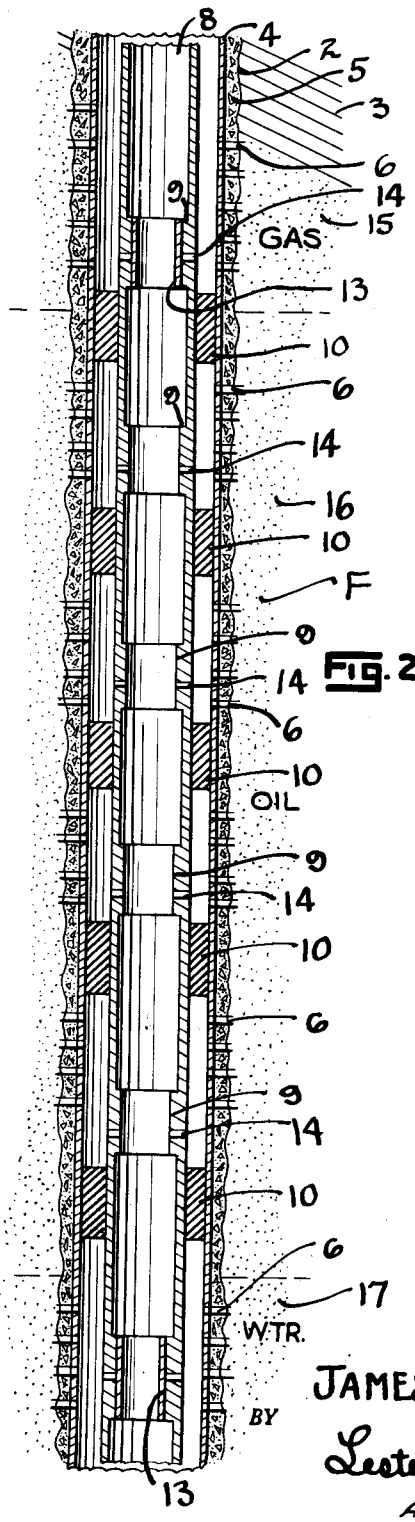



FIG. 2.

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APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 2

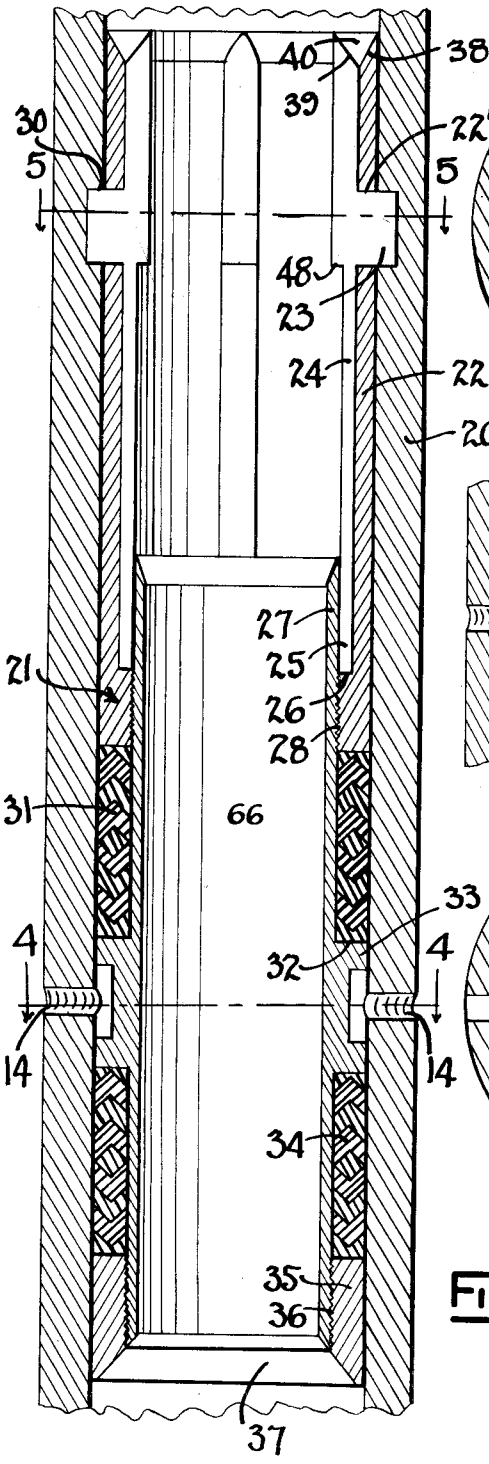



Fig. 3.

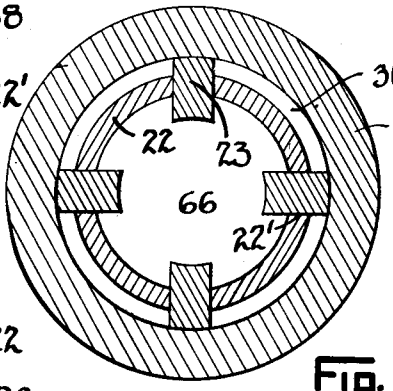



Fig. 5.

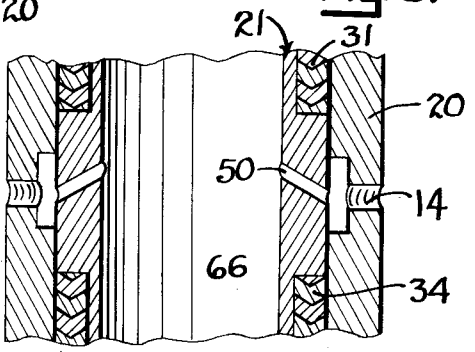



Fig. 6.

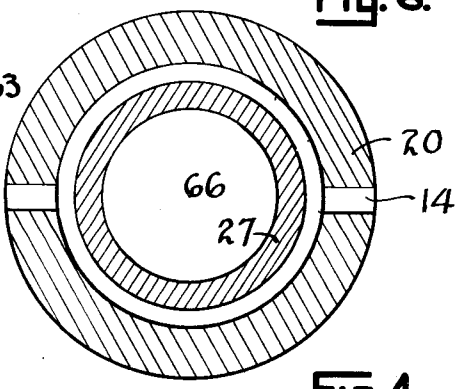



Fig. 4.

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Jan. 9, 1951 J. O. LEWIS 2,537,066

APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 3

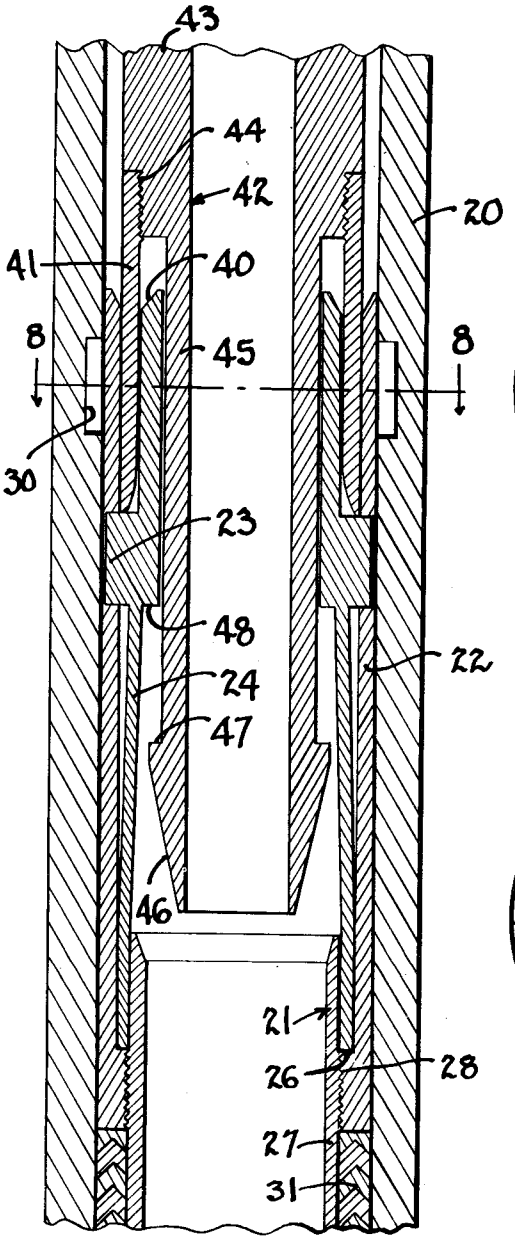



Fig. 7.

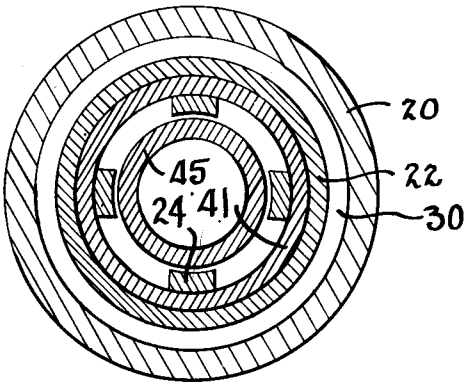



Fig. 8.

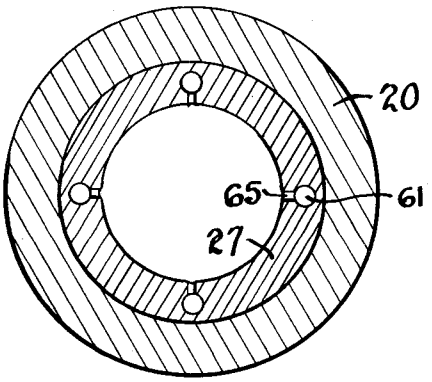



Fig. 13.

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APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 4

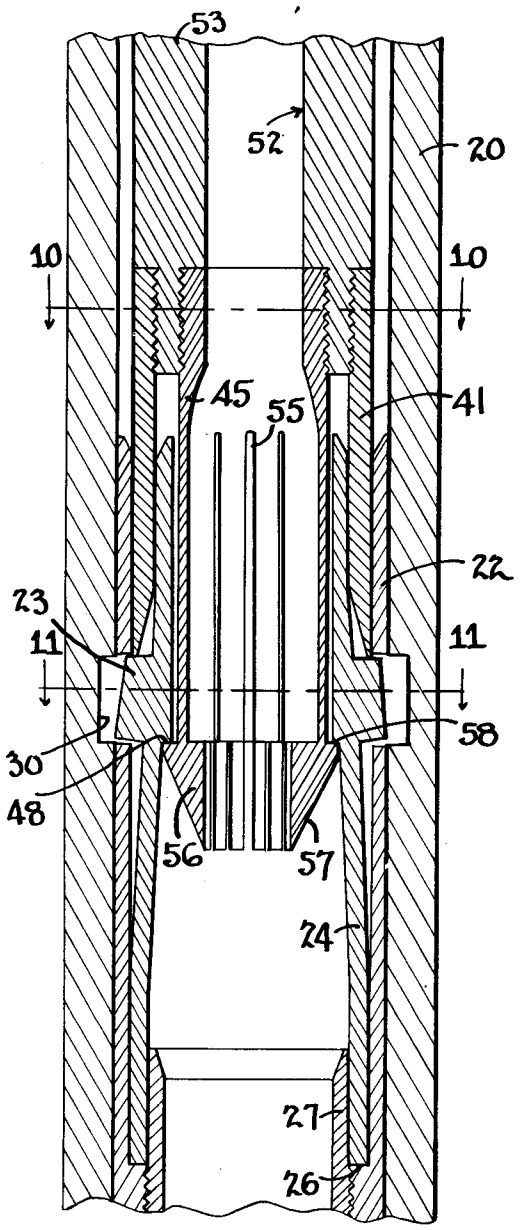



Fig. 9.

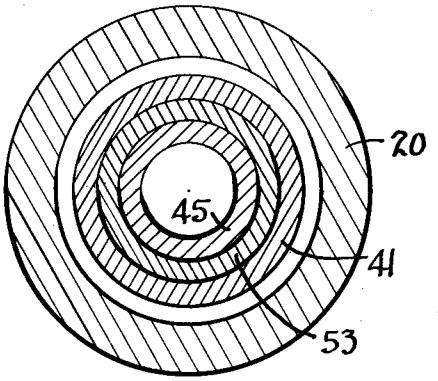



Fig. 10.

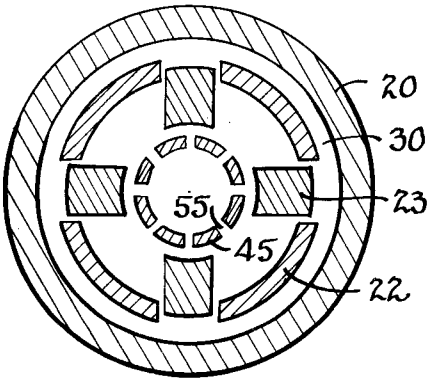



Fig. 11.

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APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 5

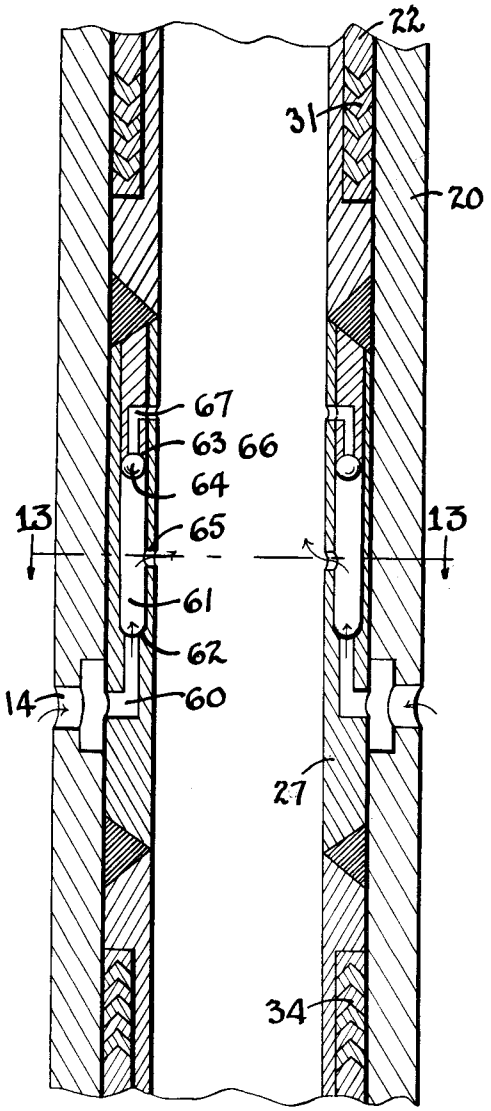



Fig. 12.

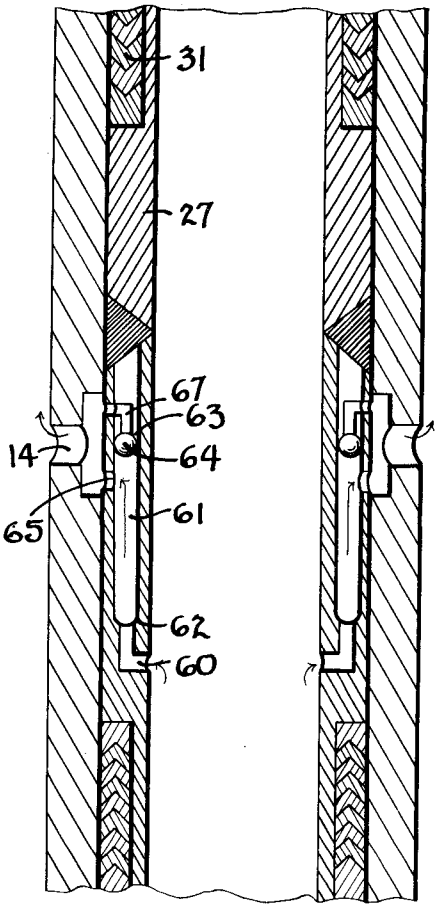



Fig. 14.

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APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 6

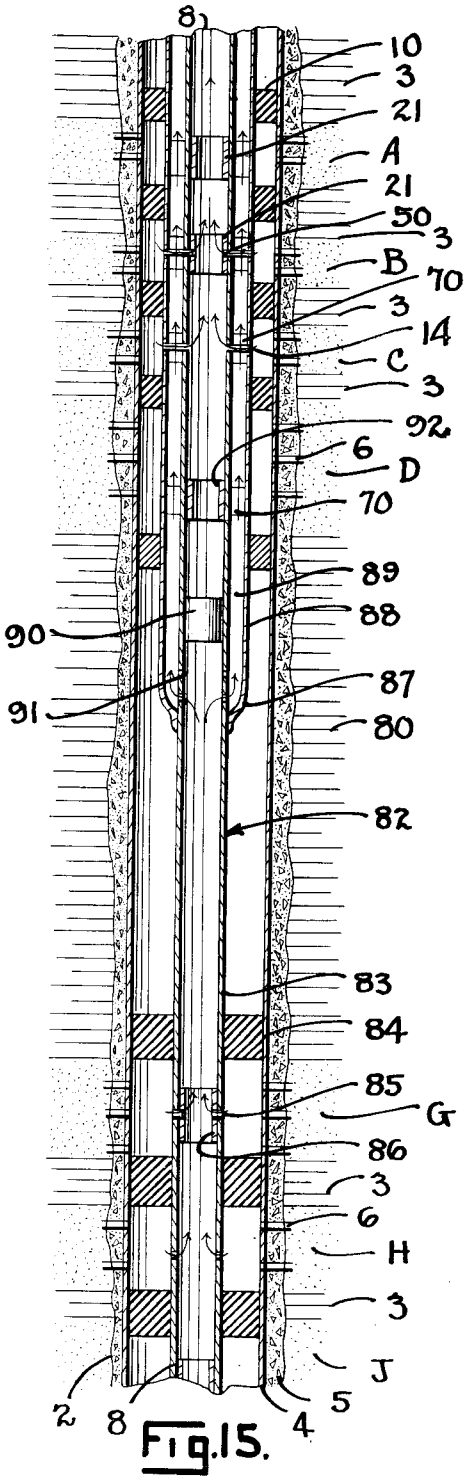



Fig. 15.

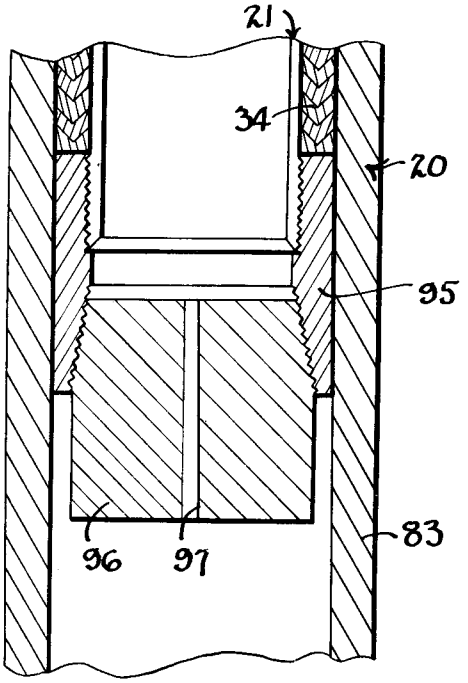



Fig. 18.

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APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

Filed July 24, 1944 7 Sheets-Sheet 7

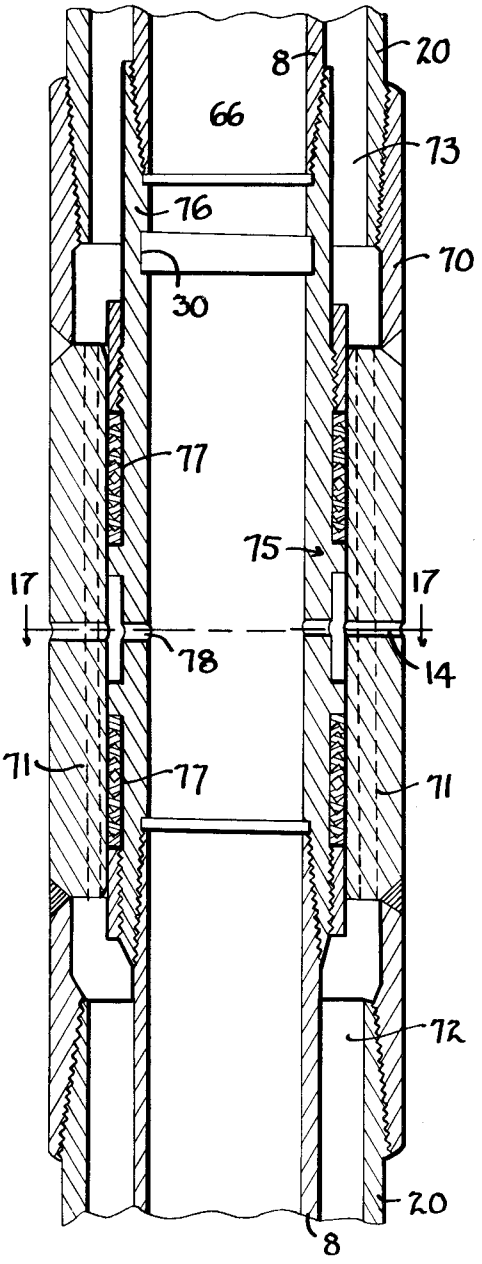



Fig. 16.

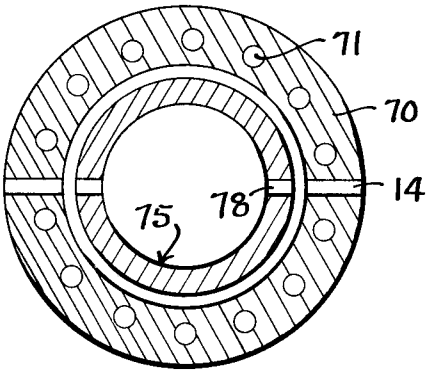



Fig. 17.

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Patented Jan. 9, 1951

2,537,066

# UNITED STATES PATENT OFFICE

2,537,066

## APPARATUS FOR CONTROLLING FLUID PRODUCING FORMATIONS

James O. Lewis, Houston, Tex.

Application July 24, 1944, Serial No. 546,375

10 Claims. (Cl. 166—2)

1

The invention pertains to an improved apparatus for increasing the recovery from gas and oil from wells while reducing the expense of such recovery and more especially in fields where there are a plurality of producing sands or where there are thick producing sands.

It is one of the objects of the invention to equip a well so that production from various formations may be accomplished either independently or simultaneously.

Another object is to produce a well to obtain the maximum production therefrom by excluding the more permeable of a plurality of formations so as to exclude water permeating such formation while continuing to produce from other less permeable formations.

Another object of the invention is to equip a well to yield the maximum production by excluding water intrusion from the bottom of the well.

Another object of the invention is to obtain the maximum oil production from a well due to the inherent gas pressure of the well by producing from formations where the maximum utility of the gas pressure is employed.

Another object of the invention is to obtain the maximum production from a well where the flow is due to formation draining down a dip and the gas cap is in the higher portion of the reservoir by controlling the flow from the formations to minimize gas intrusion.

It is also an object of the invention to control the more permeable formations in a gas recycling system so as to extract the maximum production from less permeable formations.

Another object of the invention is to produce independently from a plurality of formations having unlike permeabilities or unlike products either simultaneously or independently.

Still another object of the invention is to produce a well where various producing formations while being isolated from each other are not plugged off, cemented off, nor are foreign materials introduced into the formations.

My invention is an improved apparatus for accomplishing these purposes whereby it becomes practical to separate the formations into more parts at less expense and either shut a part off or open it or regulate the amount of flow therefrom at less expense and less chance of harming the well. This I do preferably by first sealing all the formations one from the other behind the casing by cement and then perforating through the casing and cement into the parts of the formation to be produced leaving unperforated casing between. This step follows usual practices in

2

the oil fields. I then insert a flow pipe within the casing on which are set packers which will seal between each group of perforations and prevent migration from one part of the formation to the other through the annular space between the pipe and the casing. In each section of the pipe between the packers, I include a coupling through which there is a port to permit fluids to enter the flow pipe, the couplings being adapted to receive and to anchor in place a packer sleeve which can be lowered into the pipe on a wire line and anchored into position without killing the well by introducing mud or liquids which is expensive and may be harmful to the producing formation. The sleeve so introduced into the pipe can either blank off the port or it may contain an orifice of predetermined capacity which will regulate the flow from that part of the formation. Sleeves can be set at any or all ports and withdrawn at will though it is to be noted that the upper sleeves must be withdrawn before the lower sleeves can be introduced or withdrawn.

Another object is to provide an apparatus for producing well formations whereby all or any part of a formation may be produced while other parts or formations are temporarily closed to production.

By use of this device, I can separate a formation into as many parts as is wanted and I can blank off any ports I want or I can regulate the fluid flow out of every port or if I am using the well to inject fluids, and I can regulate or shut off the flow into any part of the formation.

Still another object is to equip a well to either flow from, inject to, or exclude various parts of one or more formations.

Among the advantages gained by my invention are, that I can in turn shut off all but one part of the formation and test it separately for gas, oil or water contents and for pressure or for its capacity to produce fluids or to receive fluids injected from the surface and the undesirable parts can then be excluded from production thus reducing or prohibiting the entry of water, free gas or dry gas. Or I can proportion the fluids from or into different parts of the formation by means of orifice size in the sleeve. Because of the better control of the formations, I can open to production a thicker section of producing formations thus speeding up recovery or reducing the number of wells needed without sacrificing the advantages of less production expense and less trapping of oil in the formations.

It is also an object of the invention to so equip a well that all or any part of a formation may be

opened, closed, or controlled in order to permit testing for oil, gas or water, pressure, and capacity to produce or receive fluids.

It is to be understood that though I show my preferred apparatus I can accomplish the same purposes by variants. For example, where the producing formation is firm, it is sometimes possible to set packers directly against the formation and to do away with casing through the productive section with cement behind. Or pipe can be cemented in and sections opposite the producing parts can be reamed or shot out instead of opening the sand to production through perforations. Or packers can be attached to the casing between the groups of perforations and the flow pipe run through them, each packer being equipped to seal against the flow pipe as well as against the casing. I can also use other devices for opening, sealing or regulating the flow from each separated part of the productive section into the pipe.

Where a well penetrates several productive formations, it has been usual to cement in casing, open up one or two of the formations and when they are depleted, to cement them off and open up a new formation production. This requires that the well be killed with mud and worked over each time a change is made. By my device, all of the formations can be perforated upon when the well is first completed, each formation separated by packers the manner set forth and blank sleeves set against all by the formation to be produced first. Later, when this is depleted, it can be blanked off and the blank removed from an undepleted formation at slight cost.

It is still another object of the invention to pack off between a plurality of formations which have been perforated through the casing and then the formation opened or closed at will to produce or exclude any one or more of such formations.

I know of no means whereby a number of formations can be separated and controlled independently or when one formation can be subdivided into several parts and each part controlled independently by mechanical means and the control exercised through a single flow pipe. It is to the control by mechanical means of several separated formations or separated parts of one formation, through a single flow pipe, that my invention is directed.

It is to be noted that though better results can be obtained by grouping the perforations and leaving blank casing between where a packer can be set, that I can set packers to divide a producing section that has already been perforated though usually not so effectively. Also, I can adapt my device to lock within the recess between adjacent flow pipe sections in the usual coupling joint and I can close perforations that have been made through the tubing either before the tubing had been inserted in the well or after the tubing had been inserted in the well. In this manner, I can adapt my invention often to existing conditions in an old well.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the accompanying drawings wherein:

Fig. 1 shows diagrammatically a vertical sectional view of a well which has been equipped with the apparatus for practicing the method of the invention where a plurality of productive formations have been encountered in spaced relation and where packers are attached to the flow pipe.

Fig. 2 is a vertical sectional view diagrammatically illustrating the equipment for practicing the method of the invention where a relatively thick formation having no natural subdivisions has been encountered, and where packers are attached to the casing.

Fig. 3 is a vertical sectional view illustrating the internal construction of a coupling, flow ports and a closure sleeve.

Figs. 4 and 5 are sections taken on the lines 4—4 and 5—5 respectively of Fig. 3 to illustrate the arrangement of the structure.

Fig. 6 is a broken detailed sectional view illustrating a form of closure sleeve having a control orifice or flow port therein.

Fig. 7 is a vertical sectional view illustrating the setting tool and the manner of locating a control sleeve.

Fig. 8 is a section taken on the line 8—8 of Fig. 7.

Fig. 9 is a vertical sectional view illustrating a withdrawing tool for removing a control sleeve.

Figs. 10 and 11 are sections taken on the lines 10—10 and 11—11 respectively on Fig. 9.

Fig. 12 is a vertical sectional view of a modified form of control sleeve where a check valve permits flow into the well, but prohibits flow from the well into the formation.

Fig. 13 is a sectional view taken on the line 13—13 of Fig. 12.

Fig. 14 is another modified form of the control sleeve which permits flow from the well into the formation, but prohibits a return flow.

Fig. 15 is a vertical sectional view of a well which has been equipped with apparatus for practicing the invention where a plurality of producing formations in one group are spaced by a thick impermeable strata from other formations which are to be produced, so as to produce two independent and separate flow pipes.

Fig. 16 is a vertical sectional view of a modified form of coupling and closure sleeve whereby a flow may be conducted vertically through the coupling and also a separated flow permitted into the interior of the control sleeve.

Fig. 17 is a section taken on the line 17—17 of Fig. 16.

Fig. 18 shows still another modified form of closure wherein the lower end of the closure is either completely closed with a plug or a control choke.

In Fig. 1 a well bore 2 has been drilled through a plurality of formations such as the impervious formations 3 which have spaced between them the permeable formations such as the gas formation A, an oil formation B, a water formation C and additional oil formations D and E. Some of these formations are to be produced while others are to be blanked off to exclude production. To equip the well the casing 4 has been run into position and a body of cement 5 has been pumped down through the casing and upwardly thereabout so as to fill the space between the wall of the well bore 2 and the outside of the casing 4.

During the drilling operations or prior to or subsequent to the setting of the casing it is usual to make a survey or to in some other manner obtain a log of the well so as to locate the respective elevations of the impervious formations 3 and the productive formations A, and so forth. With this information before him, the operator is enabled to perforate the casing at the desired elevations in order to prepare for com-

pletion and production of the well. These perforations are shown generally by the perforations 6 which are shown as having been made at each of the formations A to E inclusive and no perforations have been made at the impervious formations 3.

The foregoing operations are usually conducted while the well is filled with a drilling fluid having sufficient specific gravity to prevent the inflow of fluids from the formation. When these perforations have been made, the production string of pipe 8 is run into position in the well bore. This tubing may be run into position either before or after the drilling mud has been washed from the well and replaced either with water or oil or some other liquid having a lesser specific gravity so as to encourage inflow into the well.

This production string or tubing 8 has been illustrated diagrammatically as having been provided with couplings 9 which are so spaced and arranged in the string that the couplings will be opposite the formations A to E inclusive.

Arranged on the outside of the production string 8 are a plurality of packers 10 which are arranged to close the area 11 between the production string and the inside of the casing. These packers may be of any desired form which may maintain a seal and provide a producing chamber such as 11 at each of the formations A to E inclusive. It will be observed that each of these chambers 11 is open to but a single producing formation and is excluded on the inside of the casing by the packers 10 from the other productive formations above and below it and, of course, the cement 5 on the outside of the casing forms a seal with each impermeable strata such as 3. Thus with the construction and arrangement of Fig. 1 five different formations have been opened into the well bore and may be produced, controlled, or closed off at will. Such closing off or control is accomplished by means of a control sleeve 13, one of which has been illustrated at each of the formations A and C. These sleeves, as will be hereinafter described, are capable of either closing the ports 14 in the respective couplings 9 or controlling the flow therethrough depending upon the type of closure or sleeve which is positioned adjacent the coupling. In some instances the upper and lower packers 10 as seen in Fig. 1 may be omitted and as indicated before, the packers may be of any desired type carried by either the tubing string 8 or by the casing 4 so long as they are capable of forming a barrier between the casing and tubing or production string.

Omitting the details of construction of the apparatus it seems obvious that an arrangement such as shown in Fig. 1 permits a selective or simultaneous opening, closing or controlling of the various formations to admit gas, oil or water, or to exclude such products at will, and to comingle or exclude the various oil formations depending upon the conditions and circumstances encountered with a view of obtaining the maximum production in the most economical manner.

Fig. 2 shows an arrangement which is applied to a well bore 2 having a casing 4 cemented at 5 in a thick formation F which is composed of a gas area 15, an oil area 16 and a water area 17 which will occur in the order shown with the gas at the top, the oil in the middle and the water below because of their relative specific gravities. Under such conditions, it is often desirable to close off, control, or flow the well from different elevations in the thick formation so as to obtain



the maximum productive effect from the inherent pressures occurring in the formation and to prevent the intrusion of either gas or water if the oil is being produced. In this arrangement the production string 8 has been run into position with the couplings 9 thereon located opposite the perforations 6 so as to provide ports 14 at the desired elevations. In Fig. 2 the upper series of ports have been located in the gas area, the four series of ports have been located in the oil area 16 and another series have been located in the water area 17. The packers 10 have been provided between the series of openings so that any particular section of the formation may be produced while excluding or controlling production from other sections of the formation. The closure or control sleeves 13 have been shown as disposed in the couplings 9 opposite the gas and the water formations while all of the couplings at the oil formations have been illustrated as remaining open.

With a formation such as shown in Fig. 2 which may have considerable dip as shown by the inclination of the impermeable stratum 3 at the top of the figure, the gas-oil contact may subside or the oil-water contact may rise to higher levels depending upon pressures, rates of flow and other conditions so that the elevation at which production is to be obtained may be changed. Thus the upper area of the oil section may be denuded of oil and occupied by the gas and the lower portion may be denuded of oil and occupied by the water.

The ports 14 in the production string 8 have been shown as disposed in the couplings 9, but, of course, it is obvious that they may be formed either directly in the pipe or in the coupling and that they may be provided before the pipe and couplings are lowered into the well or with known equipment they can be formed by a gun perforation through the pipe to provide an opening of the desired size. It is to be understood, of course, that the various series of perforations may be spaced as desired with suitable blank pipe sections and packers arranged between the various series of openings.

In order to close off, control or open the ports of the various formations, devices have been arranged which can be inserted and removed at will at the various locations in order to obtain the results desired.

In Fig. 3 a section of pipe 20 has been illustrated and this section may be a diagrammatic showing of either the production pipe 8 or the coupling 9 as the case may be, and it has been provided with the ports 14 extending radially therethrough.

In order to close off the ports 14 or control the rate of flow therethrough a closure sleeve or member 21 has been shown as having been lowered through the pipe 20 and located in position so as to close the ports 14. This sleeve 21 is made up of a cylindrical section or body 22 having a plurality of radial openings 22' therein adjacent the upper end, which openings are arranged to receive the lugs 23 mounted on the spring fingers 24 whose lower ends 25 are disposed against a shoulder 26 in the sleeve 22. These fingers are held in place by a tube 27 threaded at 28 inside of the member 22. The lugs 23 are of a size to move outwardly into the annular recess 30 formed in the inner periphery of the pipe 20 so that when the closure member 21 arrives at the desired elevation it will be locked in place by these spring fingers and lugs.

In order to close off the ports 14 the closure

member 21 is provided with a series of packing rings 31 arranged outside of the tube 27 and disposed upon a shoulder 32 thereon which is provided due to the external rib 33. This rib is of the same size as the sleeve 22 so as to have a sliding fit on the inside of the pipe 20. In order to provide a seal below the rib 33 another set of packing cups 34 have been shown about the tube 27 below the rib and these packings are confined by a collar 35 threaded at 36 on the lower end of the tube. It will be noted that this collar is beveled at 37 to direct the well flow therethrough. The tube 27 is also beveled at its ends for the same purpose. The upper end of the sleeve 22 is beveled at 38 so as to provide an inwardly inclined surface while the fingers 24 are beveled outwardly at 39 so as to form a tapered pocket 40. This pocket 40 is arranged to receive the skirt 41 of a setting tool 42 which is best seen in Fig. 7 as including a mandrel 43 and the skirt 41 threaded at 44 thereon in spaced relation to the extension 45 which has a beveled face 46 thereon. This setting tool is arranged to be positioned as shown in Fig. 7 by having the skirt 41 forced into the pocket 40 so as to cause the fingers 24 and the lugs 23 to be sprung inwardly to retract the lugs inside of the periphery of the sleeve 22. In this manner the closure sleeve 21 can be lowered through the pipe 20 to the desired position whereupon if the setting tool 42 is moved sharply upward the inertia of the closure member will cause the skirt 41 to withdraw from between the fingers 24 and the sleeve 22. This permits the fingers to spring outwardly to engage the inner surface of the pipe 20. Additional upward movement of the setting tool 42 will cause the shoulder 47 thereon to move against the lower edge 48 of the lugs 23 on the fingers 24 and cause the closure member to move upwardly until the lugs 23 arrive at the elevation of the recess 30 whereupon they will snap outwardly into the recess and the shoulder 48 will in this manner release from the shoulder 47. The setting tool can now be raised upwardly and the operator is advised by such movement that the closure member has been properly set and locked in position.

Fig. 6 shows a modified arrangement of the closure member 21 wherein the rib 33 has been provided with the control passages 50 which will be of a size to control the rate of flow through the ports 14 from the particular formation which is being produced. The passage 50 is inclined upwardly to facilitate the flow and prevent sand blasting. The remaining portion of the closure assembly 21 can be identical with that shown in Fig. 3 and it may be set with the tool 42 of Fig. 7. It seems obvious that either a closure or a controlled passage assembly may be set at an elevation depending upon whether the formation at that elevation is to be closed off or subjected to a controlled flow.

Fig. 9 illustrates the construction and the manner of removing a closure assembly by using a withdrawing or retrieving tool 52. This tool is operated on a string of pipe such as 53 or it may be connected to a wire line and is formed with the annular skirt 41 the same as the setting tool 42. The extension 45, however, of the tool 42 as seen in Fig. 7 has been modified by forming a plurality of slits 55 therein to provide the spring arms 56, each of which has a beveled face 57 and a shoulder 58. When this tool is lowered into position the beveled face 57 will cause the arms 56 to be compressed toward each other so as to pass inside of the fingers 24 and then the skirt 41 will move in between the fingers 24 and the sleeve 22 so as to cause the fingers 24 and the lugs 23 to move inwardly and be released from the recess 30. This inward movement causes the shoulder 48 on the lugs to engage over the shoulder 58 on the extension arms 56 so that the closure member is securely locked to the withdrawing tool. Upward movement of the withdrawing tool raises the closure assembly with it so that it may be withdrawn from position to be replaced with a different type of assembly to permit either closure or controlled flow or to be replaced with another unit.

With the closure or control units so far provided it is contemplated that the flow from the various formations will be directed into the production string or tubing 8 so that the products will be co-mingled and flow or be pumped to the surface.

It seems obvious that the introduction and removal of these closure units may be accomplished in any desired manner as by the use of a string of small or macaroni pipe, or by means of a wire line, either of which may be passed through a suitable stuffing box at the well head so that control of the pressures can be had at all times and it will be unnecessary to kill the well during these operations, which is of substantial advantage and avoids injury or damage to the well.

With the arrangement and control units above described it seems obvious that the various sleeves to close or control the flow can be set in sequence with the lower unit being positioned first and the other units being subsequently positioned. Of course, if one of the lower units is to be replaced or another type of unit substituted, it will be necessary to remove the other closure units above it in the assembly.

Quite often the various formations which are to be opened into the well are not of the same pressure and it may be desirable to provide a control unit which will permit either inflow or outflow as to a particular location thus restricting the flow to one direction. For instance, the flow from a high pressure formation might enter the production pipe and move along to a formation having a lesser pressure and flow out into that lower pressure formation. In order to control such a situation a unit such as shown in Fig. 12 may be provided. In this unit the tube 27 may be arranged of such a length and a thickness as to provide an inlet passage 60 to conduct the liquid from the port 14. This passage may be directed upwardly into a chamber 61 having a seat 62 at one end and a stop shoulder 63 at the other end. A ball check valve 64 is arranged for movement in this chamber. A discharge opening 65 leads into the interior passage 66 so that a flow entering the unit will lift the check ball 64 upwardly to the position shown in Fig. 12. This movement is caused by the equalizing passage 67 formed in the unit. In event the pressure in the interior of the unit should exceed that at the port 14, then, of course, the force of gravity would cause the ball 64 to drop down to the seat 62 so as to effect a closure. In this manner the flow would enter the ports 14 only so long as the pressure was predominant on the outside of the unit.

Any desired number of these check valves may be provided, two having been illustrated in Fig. 12. With this arrangement there may be an inflow, but no outflow as to that formation controlled by a unit of this type.

In some instances it may be desirable to force a fluid into a formation and prevent any back flow into the tubing. The closure unit of Fig. 14 is arranged to accommodate such a procedure and the parts of the unit of Fig. 12 have been reversed so that the check valve seats when there is a predominant pressure on the outside, tending to flow into the well which will cause closing of the check valve.

In some instances where it is desirable to conduct two columns of fluid to the surface as a separate and independent production from a different formation, it is desirable to permit the flow from one formation to pass the coupling or unit which controls the flow from another formation. A structure to accomplish this function is shown in Fig. 16 where the pipe **20** is shown as having a coupling **70** therein which is formed with inlet ports **14** as previously described. This coupling **70** is of special construction however in that it has a plurality of bores or passages **71** circumferentially arranged therein as seen in Fig. 17 and these passages will permit a flow from the annular space **72** in the pipe **20** through the coupling **70** and into the annular space **73** thereabove. The production pipe or tube **8** is then connected to the inlet ports **14** by a closure unit **75** which is shown as having been incorporated in the form of a coupling **76** between the sections of the tubing. This unit **75** is provided with packing **77** above and below the inlet passages **78** which open into the ports **14**. When the production string is run into position this coupling **76** will be in the position seen in Fig. 16. The recess **30** which is arranged to receive the locking lugs **23** is shown as having been formed inside of this coupling so as to receive a suitable control unit such as that shown in either Figs. 3, 9, 12 or 14. In this manner the flow from one unit will extend through the central passage **66** in the production string or tubing **8** while another flow can be had through the pipe **20** so that two independent columns of liquid may be conducted to the surface.

While the closure units have been described as being locked in an annular recess such as **30** formed on the inside of the pipe it seems clear that they may be arranged to engage in the spaces between the pipe ends inside of a coupling of conventional construction which would avoid the expense of a special recess. The ports, however, would have to be properly positioned in the pipe with respect to such connection. In other instances the sleeve valve or control unit could be positioned by anchoring it in suitable openings or holes in the pipe and, of course, the unit may be used as a flow valve to control only a single flow from a single formation.

Figs. 15, 16 and 17 show another condition which is encountered in the production from various formations and this arrangement shows the impermeable formations **3** as being interspaced between the productive formations such as A, B, C and D. These productive formations are in turn spaced upon a relatively thick impermeable formation such as **80** which in turn has spaced below it productive formations G, H and J which are also spaced between impermeable formations **3** with such a construction. It may be desirable to produce from the upper formations A to D inclusive through one string of pipe and from the formations G and H through another string of pipe. To accomplish this the assembly **82** of Fig. 15 has been provided. Only a single pipe is required in the lower formations and for this purpose the pipe **83** carries the packers **84** and has the openings **85** therein to permit the inflow from the formation. Any particular section such as G may be controlled by a unit **86** which will either close off the formation or limit the flow with a suitably restricted closure unit.

This flow moves upwardly through the pipe **83** until it reaches the elevation at **87** where an additional flow pipe **88** is arranged concentrically about the pipe **83** so as to form an annular flow passage **89** extending to the surface. The flow moving up through the pipe **83** is forced outwardly into this annular space **89** by means of a closure plug **90** through the outlets **91** arranged in the pipe **83**.

At the formation D a coupling such as **70** shown in Fig. 16 may be provided so as to permit a flow upwardly around the inside pipe and a closure unit **92** is shown as closing off the formation D. At the formation C no closure unit has been provided and the flow enters through the passages **14** of the coupling unit **70** so that a full flow from the formation C is permitted. At the formation B a closure unit having the inlet passages **50** of the type shown in Fig. 6 has been used which will act to control the flow from the formation B while the formation A has been completely shut off by a blank closure unit **21** of the type shown in Fig. 3.

With this arrangement it seems obvious that by suitably positioning the desired type of closure unit that full, partial or no flow at all may be obtained from any one of the formations and that like products may be combined in the flow pipe from several formations while unlike products may be directed into another and entirely independent flow pipe depending upon the circumstances and requirements encountered. This plug **90** may be positioned or removed as desired in the same manner as one of the closure units or if desired a closure unit may be utilized of the type shown in Fig. 18 where the bottom end **95** of the unit is arranged with a plug **96** which may be a solid plug so as to prevent any flow through the pipe **83** or a plug may be provided which has a choke passage **97** therein of a size to permit a predetermined flow. In this manner, for instance, gas being produced from the lower formations G and H might be permitted to pass upwardly through the pipe **83** so as to effect a lifting action with the liquids being produced from the formations A, B, C or D as the case may be. In other words, it will permit comingling of a desired volume from one area or section with the flow from another section. A suitable check valve may be provided to prevent back flow if desired.

While the units have been designated as closure units it seems obvious that they may be designated as side door control or chokes on the one hand and they may be used as a support for packers, liners, plugs or chokes if and when required.

Broadly the invention contemplates a means whereby the maximum product may be obtained by using a minimum of equipment and with the greatest economy possible to avoid an excessive number of strings of pipe in the well, the killing of the well to effect production or change and the flowing from several formations either independently or simultaneously with the flowing from other formations.

What is claimed is:

1. A well flowing assembly for a plurality of spaced producing formations including a flow pipe in the well, packing means therearound to pro-

vide a seal outside said pipe and between each of said formations, a port through the flow pipe to provide communication with each of said separated formations; valve means insertable into and removable from said flow pipe whereby any one or more of said ports may be closed or controlled, and means to anchor said valve in said pipe against displacement by well pressure.

2. A well flowing assembly for a plurality of spaced producing formations including a flow pipe in the well, packing means therearound to provide a seal outside said pipe and between each of said formations, a port through the flow pipe to provide communication with each of said separated formations; valve means insertable into and removable from said flow pipe whereby any one or more of said ports may be closed or controlled, and means to anchor said valve in said pipe against displacement by well pressure, said valve means being annular to furnish a maximum flow space through the pipe, and including latch members to engage said flow pipe.

3. An assembly for flowing wells including a flow pipe, flow ports therein at different formation elevations, a control unit for each port, cooperating interengaging means on said unit and pipe to latch the unit at a port, a tool for depositing the unit, and another tool for removing the unit, said tools having members thereon to engage with and actuate said latch.

4. A flow pipe for wells including a plurality of spaced couplings disposed at the elevations of production formations, a flow port in each coupling leading into the pipe, a control sleeve insertable into a coupling, means to anchor the sleeve by gripping the pipe to control the flow through the port whereby a plurality of the formations may be controlled as to flow.

5. In a cased well with a plurality of vertically spaced producing formations, the combination of a flow pipe in said well extending through the producing formations, means forming seals between the flow pipe and the casing of the well intermediate each pair of spaced producing formations, ports through the flow pipe above each seal to admit fluid into the flow pipe from each of the producing formations, removable sleeve valves in the flow pipe adapted to cooperate with each of the ports whereby the flow through each port can be selectively regulated, means to positively anchor said valves in the flow pipe, sealing means to prevent leakage between the sleeve and the flow pipe, each valve being movable from one port to any other port.

6. A sleeve valve to control the flow of a flow port in a flow pipe in a well comprising a hollow annular body, a tube connected thereto, a collar on the lower end of said tube, a rib on said tube adapted to be disposed at the elevation of the flow port, packing about the tube above said rib and confined by said body, another packing below said rib and confined by said collar, and means including a plurality of lugs to project radially through said body into a recess in the flow pipe to anchor the valve in the flow pipe.



7. A sleeve valve to control the flow of a flow port in a flow pipe in a well comprising a hollow annular body, a tube connected thereto, a collar on the lower end of said tube, a rib on said tube adapted to be disposed at the elevation of the flow port, packing about the tube above said rib and confined by said body, another packing below said rib and confined by said collar, and means including a plurality of lugs to project radially through said body into a recess in the flow pipe to anchor the valve in the flow pipe, said rib having a flow passage therethrough.

8. A sleeve valve to control the flow of a flow port in a flow pipe in a well comprising a hollow annular body, a tube connected thereto, a collar on the lower end of said tube, a rib on said tube adapted to be disposed at the elevation of the flow port, packing about the tube above said rib and confined by said collar, means including a plurality of lugs to project radially through said body into a recess in the flow pipe to anchor the valve in the flow pipe, and a check valve in such body.

9. A control assembly for production from a plurality of formations including a flow pipe, a flow coupling therein having flow ports radially thereof, a flow tubing disposed in said pipe, a flow valve in said tubing, packing on said valve to seal the inside of the coupling above and below said port so as to control the flow therethrough, and flow passages longitudinally of said coupling to conduct a flow through the flow pipe independently of the flow through said ports and tubing in combination with an anchor means for said valve in the flow pipe.

10. A flowing assembly for a plurality of producing formations in a well bore comprising a flow pipe, a flow tubing therein extending below the lower end of said pipe, flow ports in said extended portion of the tubing for the admission of fluid, means to seal a plurality of formations one from the other about said flow pipe, means to direct the tubing flow out into the flow pipe, a plurality of couplings in the flow pipe to direct the flow from said couplings into said tubing in combination with an anchor means for said valve in the flow pipe, and means to conduct the tubing flow through said couplings up through said flow pipe.

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