

Feb. 25, 1941.

C. P. GILLESPIE ET AL
WELL CONTROLLING APPARATUS

2,233,077

Filed Oct. 10, 1938

3 Sheets-Sheet 1

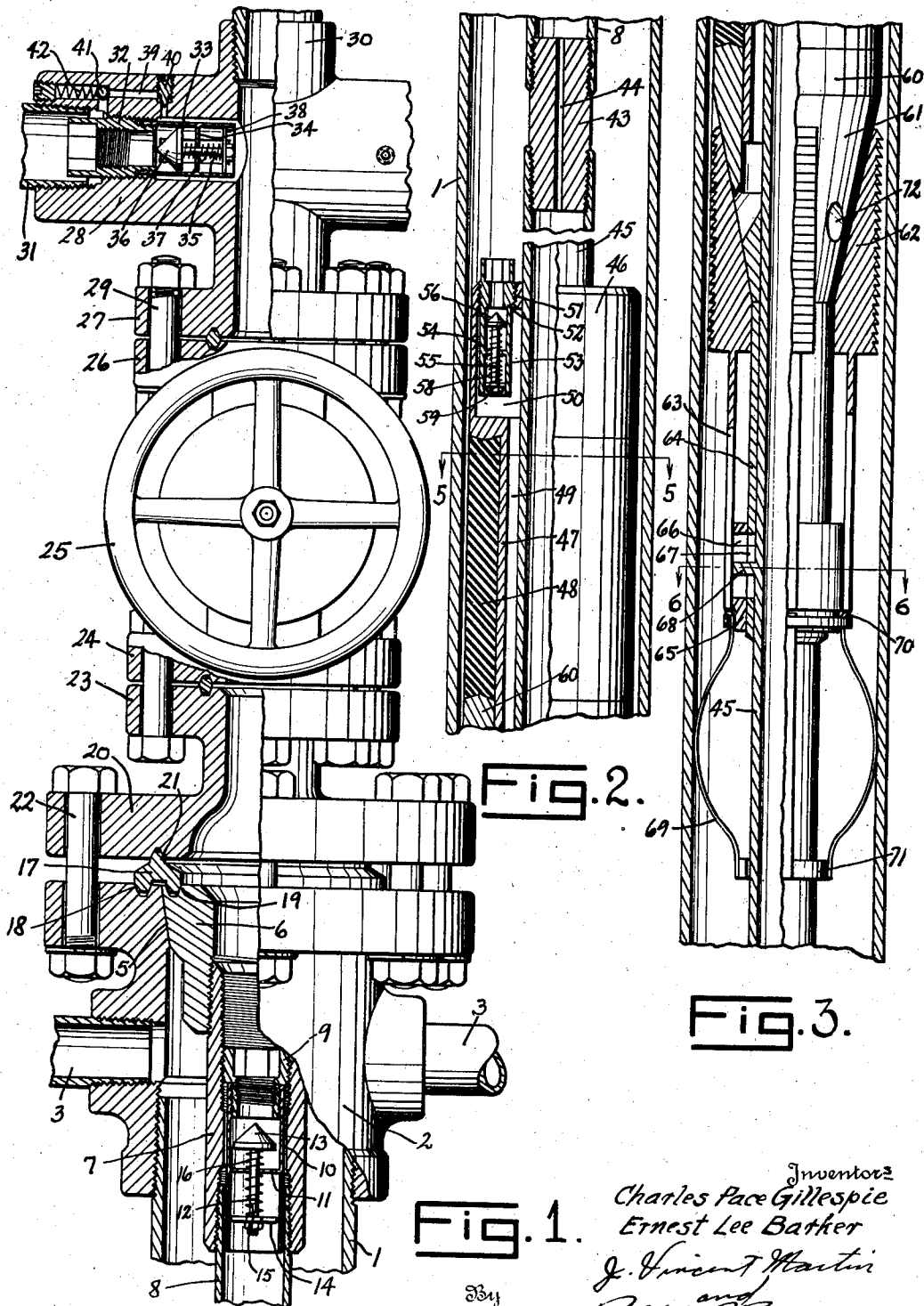


Fig. 1.

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3 Sheets-Sheet 2

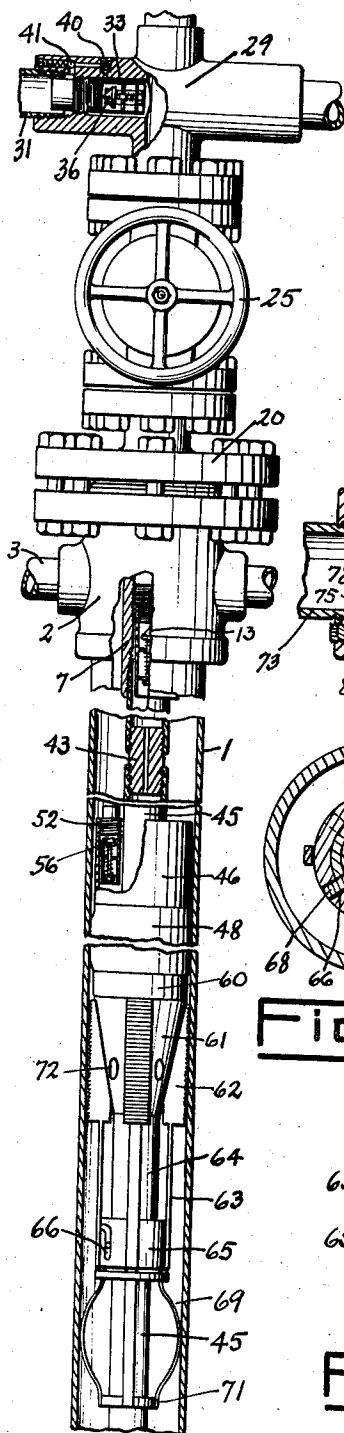


Fig. 4.

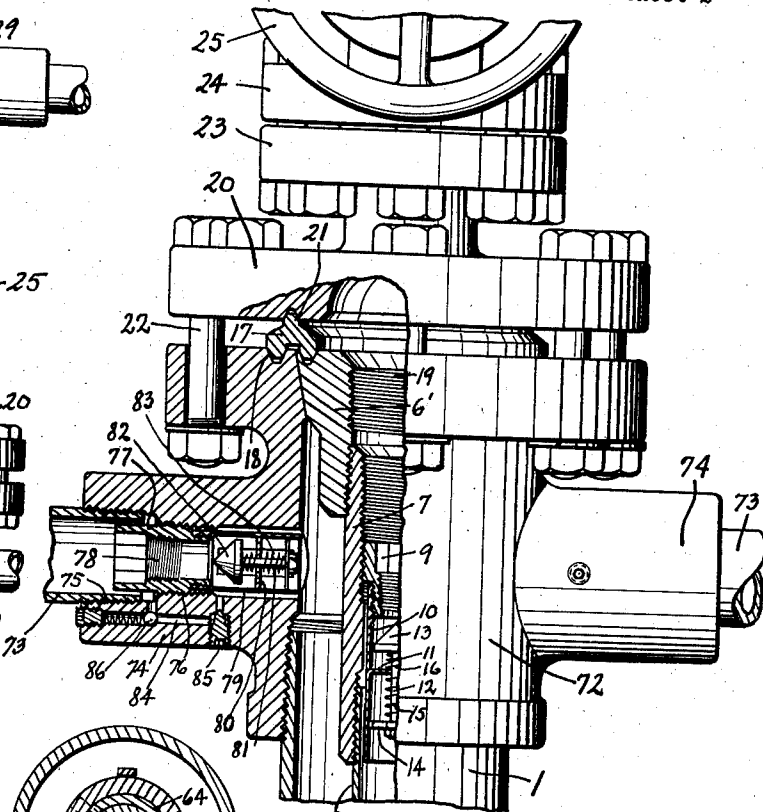


Fig. 8.

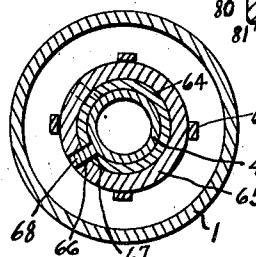


Fig. 6.

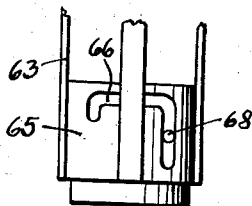


Fig. 7.

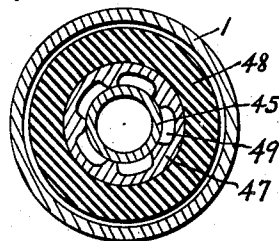


Fig. 5.

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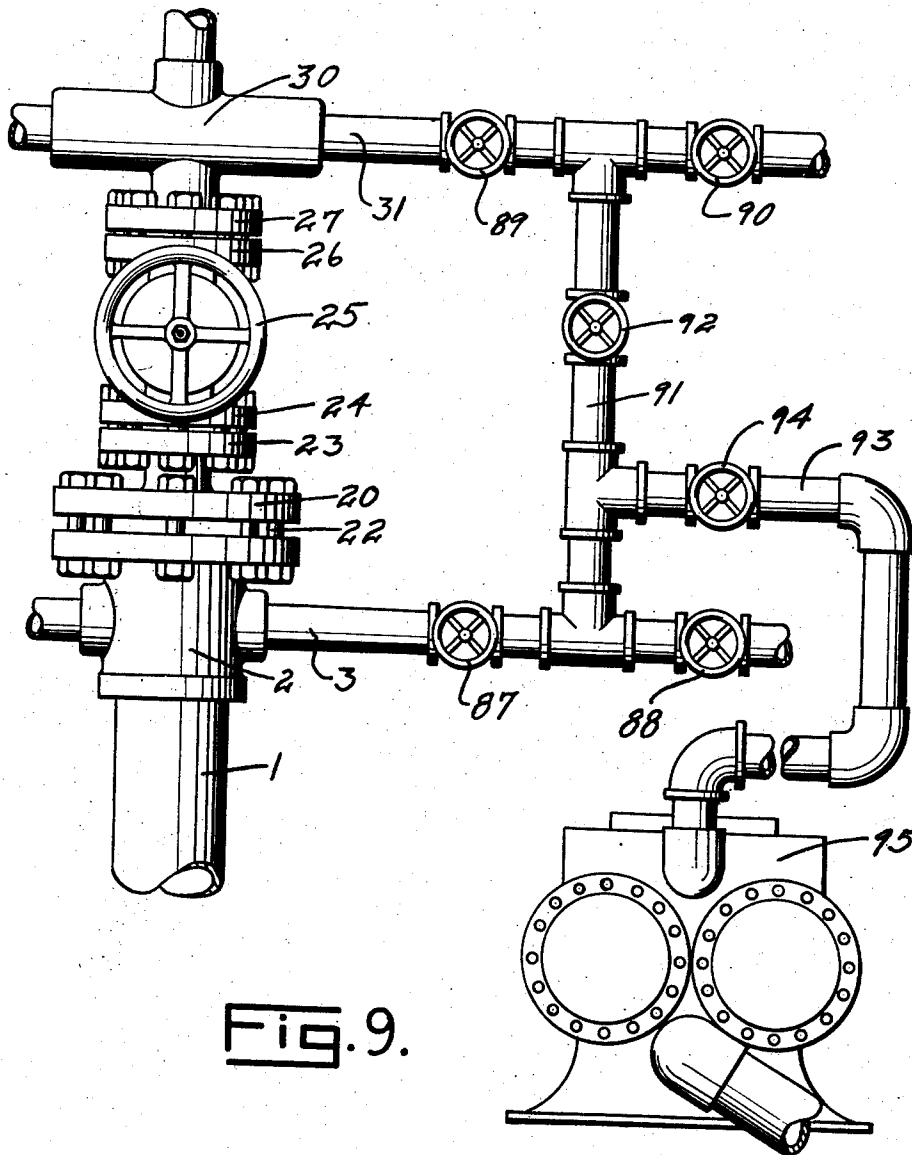


Fig. 9.

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UNITED STATES PATENT OFFICE

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WELL CONTROLLING APPARATUS

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10 Claims. (Cl. 166—2)

This invention relates in general to flowing wells and has for its general object to provide a means for preventing excessive flow from a flowing well.

Although adapted for use in connection with all types of flowing wells, this invention is particularly designed for use in connection with oil wells and the like.

Ordinarily an oil or gas well is provided with a Christmas tree or manifold at the upper end by which the flow from the well is controlled and directed as desired. This Christmas tree as a usual thing includes not only control valves for shutting off and opening the well as a whole or any particularly flow line therefrom, but also includes restricting passages known as chokes which are designed to cut down the flow from the well and maintain a back pressure thereon. As stated, most of these chokes are mounted on the Christmas tree or near the Christmas tree but in some instances they are placed within the well adjacent the bottom of the tubing through which the oil or gas flow to the surface.

In a well equipped in the manner just described, the constant wearing action of the flow, particularly when the flow contains abrasives such as sand or the like, will gradually cut out the choke or chokes and make the opening or openings therethrough larger, thus permitting greater and greater flow as this wear takes place. If the flow is permitted to become great enough, it may cause great damage in any one or more of a number of ways. Thus, an excessive flow may cause the well to sand up, that is, become filled with sand so that it cannot properly flow, or it may otherwise injure the well, and many times a well damaged by an excessive rate of flow can never be placed in as good a condition as it was before. It may even be lost entirely. Furthermore, such excessive rates of flow may subject the owner or operator of the well to penalties on account of violation of the proration laws which in many localities limit the amount of oil which may be produced from a given well.

It is, therefore, an object of this invention to provide a means for preventing the unintentional violation of the proration laws and the ruining or damaging of wells by excessive flow therefrom.

Furthermore, it sometimes happens that when a Christmas tree is being assembled or placed upon the well some part of the tree may not be securely fastened and although the leak may not appear immediately when pressure is placed upon

the device, the continued washing action due to the flow of the well will start the actual leak and the cutting action under high pressure will quickly make an opening which will expand more and more until it eventually produces the equivalent of a blowout. Along this line also it has occurred that due to lightening or the handling of heavy materials adjacent a well, the Christmas tree or a part thereof may be broken off, thereby permitting a blowout.

In addition to the foregoing, it is also sometimes necessary to remove part of the Christmas tree, perhaps that part containing the choke, and in some instances it becomes necessary to remove all of the Christmas tree for the purpose of making repairs or replacements. In such case it is customary to close down the well by closing gate valves below the Christmas tree or in the Christmas tree. However, in addition to the fact that gate valves are sometimes very difficult to close under high pressure and high velocity of flow, the labor employed on a well might easily overlook the closing of the valve before breaking a connection preparatory to a replacement or repair such as above mentioned. This, likewise, may cause a blowout.

It is, therefore, another object of this invention to prevent accidents due to defective Christmas tree equipment or assembly thereof or due to accidental displacement thereof.

Another object of this invention is to provide a means for automatically shutting off flow from a well when the flow becomes excessive.

Another object is to provide a means for automatically shutting off flow through a well tubing when the flow therethrough becomes excessive.

Another object of this invention is to provide a means for automatically shutting off flow through a well casing when flow therethrough becomes excessive.

Another object of this invention is to provide a means for shutting off flow through a well casing at a point above the surface of the ground when the flow therein becomes excessive.

Another object of this invention is to provide a means for shutting off flow through a well connection at a point below the surface of the ground when the flow therethrough becomes excessive.

Other objects and advantages of this invention will become apparent from the following description taken with the accompanying drawings, wherein are set forth by way of example and illustration certain embodiments of this in-

vention. It is to be understood, however, that the same are not by way of limitation, the scope of this invention being limited only by the prior art and by the terms of the appended claims.

5 In the drawings:

Fig. 1 is an enlarged view partly in vertical cross section illustrating a portion of the upper end of a well and Christmas tree constructed in accordance with this invention.

10 Fig. 2 is a similar view illustrating a continuation of the lower portion of Fig. 1.

Fig. 3 is likewise a similar view illustrating a continuation of the lower portion of Fig. 2.

Fig. 4 is a reduced assembly view illustrating the arrangement set forth on an enlarged scale in Figs. 1 to 3, inclusive.

Fig. 5 is a horizontal cross section taken along the line 5-5 of Fig. 2.

Fig. 6 is a horizontal cross section taken along the line 6-6 of Fig. 3.

Fig. 7 is a fragmentary detail illustrating a portion of the construction shown in Fig. 3.

Fig. 8 is a view similar to the lower portion of Fig. 1 but illustrating a slight modification.

Fig. 9 is an elevation showing one arrangement for the connections at the upper end of the well.

Referring now more in detail to the drawings, the well casing is illustrated in Fig. 1 by the numeral 1 and on the upper end of this casing is mounted the casinghead 2. This casinghead 2 has lateral flow lines 3 extending in opposite directions therefrom and is provided within its upper end portion with a tapering seat 5 adapted to receive the tapered exterior portion of the tubing hanger 6. Threaded into the lower end of this tubing hanger 6 is a special fitting 7 which is in turn internally threaded at its lower end to receive the upper end of the tubing 8. The fitting 7 is also internally threaded for a considerable distance from its upper end for the reception of a supporting bushing 9, this bushing being threaded at its lower end to receive the valve housing 10. The lower end of the bushing 9 forms a valve seat. The valve housing 10 is a continuous tubular member having a transverse spider or similar supporting part 11 intermediate its ends having an opening therein for the reception of a valve stem 12. The valve 13 is carried upon the upper end of this stem 12 and adapted when moved upwardly to seat against the valve seat on the lower end of the bushing 9. Secured on the lower end of the valve stem 12 is a guide member 14 for maintaining the valve stem 12 in proper alignment with the housing 10. Between the guide 14 and the spider 11 and surrounding the valve stem 12 is a spring 15 which normally holds the valve 13 in its lowermost position and always exerts a force tending to move it to that position. Above the spider 11 is a second spring 16 which tends to cushion any such downward movement of the valve and prevent it from hammering against its support.

The joint between the tapered seat 5 and the exterior of the tubing hanger 6 is bridged by means of a triple seating sealing ring 17 having one sealing part seated within a groove 18 in the upper end of the casinghead, and a second sealing part seated within the groove 19 in the upper end of the tubing hanger.

Mounted above the ring 17 is a fitting 20 having a groove 21 in its lower surface adapted to receive a third sealing portion of the ring 17. Thus, a seal is formed preventing any flow between the space outside the tubing and within

the casing and the atmosphere or between that space and the interior of the tubing. At the same time, the interior of the tubing is sealed against communication with the space outside the tubing and within the casing and with the outside atmosphere. The fitting 20 is held in place by means of bolts 22 which secure it to the casinghead.

The upper end of the fitting 20 has a flange 23 to which the lower flange 24 of a valve 25 10 is secured by means of bolts or the like and sealed in any conventional manner.

The upper flange 26 of the valve 25 is likewise secured to the flange 27 of a cross fitting 28 by means of bolts 29 or the like and sealed thereto by any conventional means. This cross fitting 28 is provided with an upwardly extending branch 30 which may be either closed with a plug or used in some other manner customary and with lateral extensions adapted to receive lateral flow lines 31. Each of these lateral extensions is also internally threaded to receive a bushing 32 which is similar in all substantial features to the bushing 9 previously described. This bushing 32 threadedly receives the valve 25 housing 33 which has a spider 34 intermediate its ends for the receipt of valve stem 35. The valve 36 is carried on the end of this valve stem adjacent the bushing 32 and a spring 37 surrounds the valve stem in the same manner as previously described in connection with the spring 15. A guide member 38 is likewise mounted on the end of the valve stem opposite the valve 36.

In connection with this last described valve arrangement the extension within which the valve is mounted is provided with a by-passing channel 39 through which fluid may flow from one side of the valve to the other without passing through the valve. For the purpose of shutting off entirely all flow through this by-passing channel there is provided a needle valve 40 accessible from the outside of the fitting so that it can be moved from open to closed position and vice versa. There is also a check valve 41 within this passage which is spring pressed toward closed position by a spring 42, this check valve serving to permit flow in the normal direction of flow of the well but to prevent flow in the opposite direction.

It has been previously stated that the location of the choke which normally controls the rate of flow of a well of this type may be either above the ground within a portion of the Christmas tree or below the ground. As here illustrated in Fig. 2, the choke 43 is connected in the tubing below the ground and at a point remote from the surface of the ground. This choke has an opening 44 therethrough which is of a predetermined diameter usually fixed by law.

To the lower end of the choke 43 is threadedly connected a tubing section 45 which in effect forms a continuation of the tubing 8. Surrounding this tubing section 45 and secured thereto is a housing and abutment member 46 having a downwardly extending generally tubular part 47 surrounding the tubing 45 but spaced radially therefrom in certain of its parts as shown in Fig. 5 to provide a passageway between this tubular section 47 and the exterior of the tubing. Surrounding this tubular portion 47 is an expansible packing member 48 and the space between this tubular portion and the tubing 45 is designated by the numeral 49.

Within the member 46 is a chamber 50. Into

the upper end of this chamber 50 is inserted and threaded as at 51 a fitting 52 which may be integral with the valve housing 53. As in the previous instances, a study of this valve arrangement discloses that the valve housing 53 has a spider 54 extending thereacross for the purpose of slidably supporting the valve stem 55 carrying the valve 56 on its upper end. Surrounding this valve stem 55 is a spring 58 bearing at its lower end upon a guide member 59 in a manner similar to the previously described valve arrangements.

Abutting the lower end of the packer 48 and slidable upon the tubular portion 47 is an abutment ring 60 having a downwardly tapered portion 61 adapted to receive and cause the expansion of slips 62. These slips are carried by resilient arms 63. Extending downwardly from the tapered portion 61 of the abutment 60 is a sleeve-like extension 64 about which is slidably mounted a collar-like member 65.

A J-slot 66 is formed within the collar 65 as shown more clearly in Fig. 7 and a similar J-slot adapted to register with the J-slot 66 is formed at 67 in the sleeve-like portion 64. Extending into and through these two J-slots is a pin 68 carried upon the tubing section 45. Secured at their upper ends to the collar 65 are a plurality of spring members 69. These spring members have their upper ends bent as at 70 to engage a ring carried by the collar 65 and are mounted at their lower ends upon a free floating ring 71. Each of these springs is bowed outwardly so as to frictionally engage the inner wall of the casing ing.

Referring now to Fig. 8, a slight modification is illustrated. In this figure, the casinghead 72 is provided with flow lines 73 threaded into its lateral branches 74 by means of threaded connections 75. Each of these lateral connections is also internally threaded at 76 to receive a bushing 77 having internal threads 78 and carrying a valve housing 79. Each valve housing therein has a transverse spider 80 adapted to support in sliding fashion a valve stem 81 carrying a valve 82 adapted to seat against the end of the bushing 77 when moved to the left as seen in the left hand portion of Fig. 8. A spring 83 surrounding this valve stem tends to hold the valve at all times in open position.

This valve arrangement is likewise provided with means for by-passing fluid consisting of the by-passing passageway 84. This passageway 84 is controlled and may be closed or opened by means of a needle valve 85 accessible from the exterior. A check valve 86 is arranged to permit flow from within the well through the passageway 84 past the valve 82 when the same is closed, but to prevent passage of fluid in the opposite direction.

In Fig. 9 there is shown a means for by-passing fluid under pressure from the casing to the tubing or vice versa or for applying pump pressure to either the casing or the tubing or both for the purpose of raising the pressure on the down stream side of a closed valve in the casing or the tubing and causing the opening of such valve. For this purpose, the casing flow line 3 is provided with valves 87 and 88 and the tubing flow line 31 is provided with valves 89 and 90. A by-pass 91 controlled by a valve 92 is connected between the flow lines 3 and 31 between the valves 87 and 88 and between the valves 89 and 90, respectively. A line 93 controlled by a valve 94 is connected to the by-pass line 91 and to the outlet of a pump 95, respectively, and by this

means pump pressure may be applied to valves either in the tubing or in the casing or both.

In operation, each of the valves, 13, 36, 56 and 82 will as previously stated be normally held in open position. In this position they will, of course, permit flow to take place from the well in the usual manner. It is noted, however, that around each of these valves there is a valve housing of tubular form, these housings being designated, respectively, by the numerals 10, 33, 53 and 79. Through these housings all flow past the valves in question must take place. The springs holding the respective valves in open position are so tensioned and adjusted that they will hold the valves open against the wash and the consequent pressure exerted thereupon by the normal flow from the well. Thus, during normal operations the valves remain each in its open position in which position it does not materially affect the operation of the well.

Now, in the event that the choke for example should become excessively cut out so that a larger amount of fluid than desired is permitted to flow therethrough, this flow will when it attains a predetermined value dependent upon the tension of the springs holding the respective valves in their open position, cause these valves to suddenly close. Thus, considering the arrangement to be as illustrated at Figs. 1 to 7, inclusive, when the choke opening 44 cuts out excessively so as to permit greater flow than desired, this flow may cause a closure of the valve 13 because the entire flow is directed about this valve through the housing 10. However, it is preferable that the valves be so adjusted that the valve 36 will close first, thus stopping the excessive flow from the well and preventing any damage which might have otherwise resulted therefrom. In the event the choke is situated in the Christmas tree as is also customary, the result would be the same, as it would make no difference whether the choke be located ahead of or down stream from the control valves disclosed. These control valves are substantially unaffected by changes in pressure and the same control valve may ordinarily be used on a very high pressure well that is used on a low pressure well with substantially the same adjustment. The only substantial force governing the closing of these valves is that provided by an increase in the velocity of flow of fluid past the valves.

In addition to the foregoing use for the valves disclosed, it is to be noted that if in assembling a part of the Christmas tree should not be securely connected, and a leak should appear after the well has started flowing, this leak would gradually increase as the washing of fluid there-through continued and would eventually produce such a velocity in the fluid flowing from the well that it would cause the closure of, for example, the valve 13. Upon this closure the well would, of course, be shutdown and no further damage could be done until repairs were effected and the operator desired to continue the operation of the well.

Likewise, in the event that an accident should occur such as in dismantling the derrick over a well, and the Christmas tree or a part thereof should be knocked off, or if such should occur as a result of a bolt of lightning or the like, then the well would immediately be closed in automatically by the valves 13 and 56. The valve 13 is, of course, below the point where the tubing is hung and when closed would prevent any flow

through the tubing, whereas the valves 56 are located far down in the well and would naturally prevent any flow through the casing when they are closed. The packer 48 when seated in a customary manner clearly apparent would form a seal between the inside of the casing and the outside of the tubular member 47, leaving only the passageway 49 about the tubing within the casing. Fluid could flow through this passageway so long as the flow was not excessive but upon the occurrence of an accident such as referred to and the resulting increase in flow through the opening 49 past the valves 56, these valves would be immediately closed preventing any further flow through the casing.

In the form shown in Fig. 8, flow through the casing instead of or in addition to being controlled by valves located down in the well as in Figs. 2 and 4 is controlled by valves located in the flow lines from the casinghead. The operation of these valves is identical with the operation of the valves 56 and accomplishes the same result. The advantage of putting the valves down in the well as shown in Fig. 2 is, of course, that when in this position they are out of any danger due to an accident to the well caused by external means. When in the position shown in Fig. 8, however, they are more readily accessible and can be more easily changed or reopened once they have been closed.

On this latter point, it will be appreciated that any of the valves illustrated may be caused to reopen by simply raising the pressure on the downstream side of the valve in question. This may be accomplished in the case of any of the valves disclosed, and particularly in the cases of the valves 13 and 56, by means of operating the pump 95. If the valve 13 is in closed position and it is desired to open it by means of the pump 95, the valves 87, 88 and 90 will be closed and the valves 89, 92 and 94 will be opened, whereupon the operation of the pump will raise the pressure on the downstream side of the valve 13 until the same can be opened by the spring 15. If the valve or valves 56 be closed, these may be opened by closing the valves 88 and 92 and opening the valves 87 and 94, whereupon operation of the pump will increase the pressure above the valves 56 until they can be opened by the springs 58. The other valves disclosed may be opened in a similar manner.

If either the casing or the tubing is opened for flow, and one of the valves in the other is closed, the same can be opened by simply by-passing pressure from the casing to the tubing or vice versa to raise the pressure on the downstream side of the closed valve. This by-passing may be accomplished by closing the valves 88, 90 and 94 and opening the valves 87, 89 and 92. This will permit the raising of the pressure until the spring associated with the closed valve is able to open the valve.

In the case of the valves illustrated at 36 and 82, however, additional provision is made for raising the pressures on the downstream side for the purpose of opening these valves. Taking the valve 36 as an example, let it be assumed that this valve has been closed due to excessive flow therethrough. Once it is closed, the pressure within the well will keep this valve in closed position against the tendency of the spring 37 to cause it to open. If the difficulty is caused by a break or by the washing out of a choke located on the downstream side of this valve, the re-placement necessary is first made and the parts

repaired and the well placed in condition for flowing. The line 31 would be closed, however, at a relatively short distance from the valve 36 by some suitable means such as the hand operated valve 89. The needle valve 40 would then be manipulated to open the passage 39 and permit fluid under pressure to be by-passed through the passage 39 past the check valve 41 and into the space on the downstream side of the valve 36. The pressure in this space would gradually increase due to this flow until it would approach the pressure within the well, at which time the spring 37 would cause the valve 36 to open and the well could then be opened by further normal flow. Thus, the provision of a by-pass passageway and a valve such as shown in connection with the valve 36 and the valve 82 eliminates in many cases the necessity for pumping into the well to cause the opening of one of these control valves once it has been closed.

It will be seen from the foregoing that a means has been provided for preventing any unintentional excessive flow from a flowing well either when the same is caused by accidents or by constant wear upon such means as may be employed to keep the flow within predetermined limits. It will be seen that blowouts due to these causes will be practically eliminated and that great damage not only to the property surrounding the wells but to the wells themselves will be avoided by this invention.

Having described our invention, we claim:

1. In combination with a flowing well, a passageway leading from the bottom thereof and a Christmas tree at the upper end thereof for receiving the flow from said passageway, and a normally open valve in the path of flow from said passageway and adapted to be closed when the flow through said passageway exceeds a predetermined rate, said valve being located in one of the branches of said Christmas tree.

2. In combination with a flowing well, a passageway leading from the bottom thereof and a Christmas tree at the upper end thereof adapted to receive flow from said passageway, an upwardly closing normally open valve in the path of flow through said passageway and adapted to be closed when the flow through said passageway exceeds a predetermined rate, and a second normally open valve in the path of flow from said passageway adapted to be closed when said flow exceeds a predetermined rate, said second valve being located in one of the branches of said Christmas tree.

3. In combination with a flowing well, a casing in said well, and a tubing within said casing, and a normally open valve in the path of fluid flowing through both said tubing and said casing, each of said valves being adapted to be closed when the flow therethrough exceeds a predetermined rate.

4. In combination with a flowing well, a casing within said well and a tubing within said casing, a packer surrounding said tubing and adapted to form a sealing engagement with said casing, means providing a passageway through said packing, and a normally open valve in the path of flow through said passageway adapted to be closed when the flow through said passageway exceeds a predetermined rate.

5. In combination with a flowing well, a passageway leading from the bottom thereof and a normally open valve in the path of flow through said passageway adapted to be closed when the velocity of flow through said passageway exceeds a

predetermined rate, means for by-passing fluid from the upstream side to the downstream side of said valve to raise the pressure on the downstream side of said valve and cause it to open after it has been closed, and a needle valve accessible from the exterior of said passageway for controlling the opening and closing of said by-pass means.

6. In combination with a flowing well, a passageway leading from the bottom thereof and a normally open valve in the path of flow through said passageway adapted to be closed when the velocity of flow through said passageway exceeds a predetermined rate, means for by-passing fluid from the upstream side to the downstream side of said valve to raise the pressure on the downstream side of said valve and cause it to open after it has been closed, a needle valve accessible from the exterior of said passageway for controlling the opening and closing of said by-pass means, and a check valve in said passageway for permitting flow in said one direction and for preventing flow in the opposite direction there-through.

7. In combination with a flowing well, a passageway leading from the bottom thereof, and means for preventing more than a predetermined substantial rate of flow upwardly through said passageway, comprising an upwardly closing valve in said passageway, which valve remains open during substantial upflow not exceeding said predetermined rate of flow and is closed by a velocity of flow exceeding said predetermined rate.

8. In combination with a flowing well, a passageway leading from the bottom thereof, and means for preventing more than a predetermined substantial rate of flow upwardly through said

passageway, comprising an upwardly closing valve in said passageway, which valve remains open during substantial upflow not exceeding said predetermined rate of flow and is closed by a velocity of flow exceeding said predetermined rate, and a choke in said passageway normally restricting the flow through said valve to a velocity not exceeding said predetermined rate of flow.

9. In combination with a flowing well, a passageway leading from the bottom thereof, and means for preventing more than a predetermined substantial rate of flow upwardly through said passageway, comprising an upwardly closing valve in said passageway, which valve remains open during substantial upflow not exceeding said predetermined rate of flow and is closed by a velocity of flow exceeding said predetermined rate, and a choke in said passageway normally restricting the flow through said valve to a velocity not exceeding said predetermined rate of flow, the choke being below the valve.

10. In combination with a flowing well, a casing in said well, a tubing with said casing, and means for preventing more than a predetermined rate of flow upwardly through said tubing, comprising a closure between said tubing and said casing in the path of flow through the space between said tubing and said casing and below the surface of the ground, a flow passage through said closure, a valve controlling said passage, said valve being normally open against a substantial predetermined rate of flow and adapted to be closed when the velocity of flow therethrough exceeds said predetermined rate.

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