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2,855,952

VALVE FOR USE IN WELL TUBING

Filed Oct. 25, 1954

2 Sheets-Sheet 1

FIG. 1.

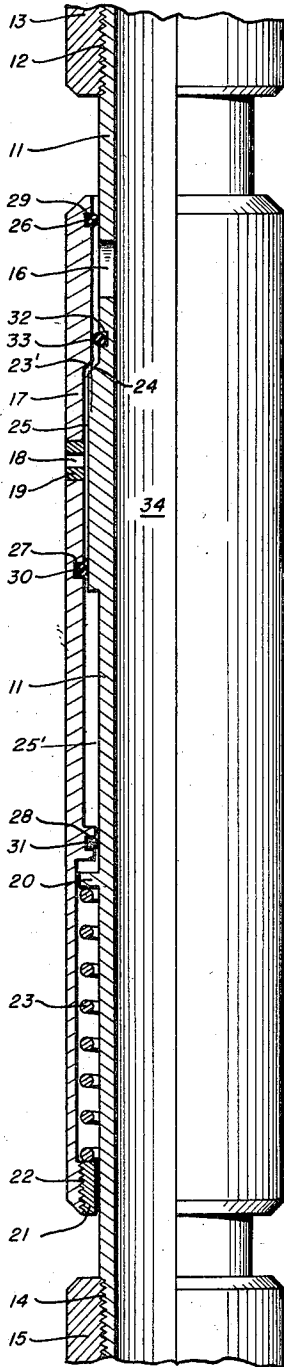


FIG. 2.

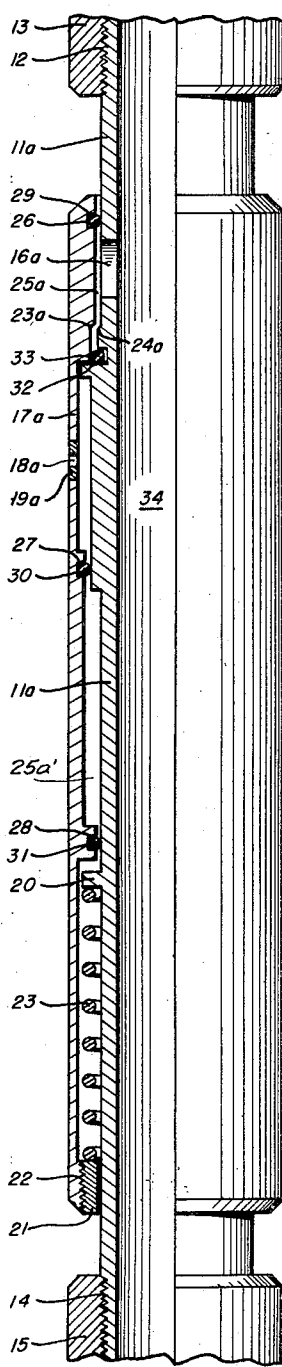
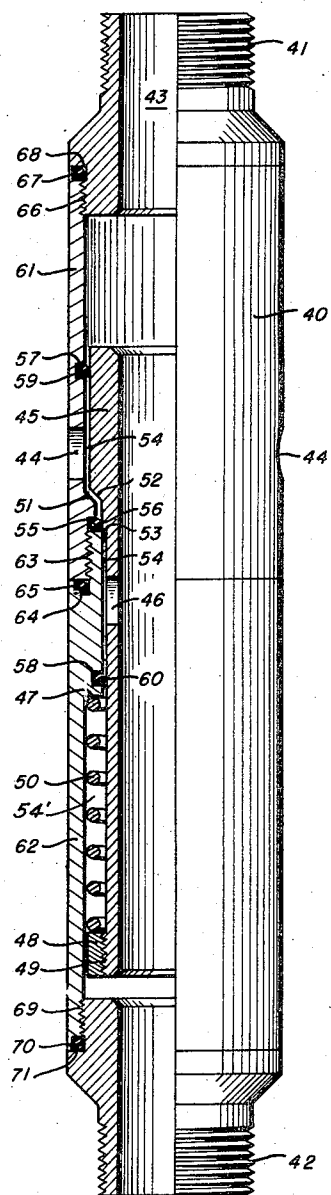


FIG. 3.



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FIG. 1A.

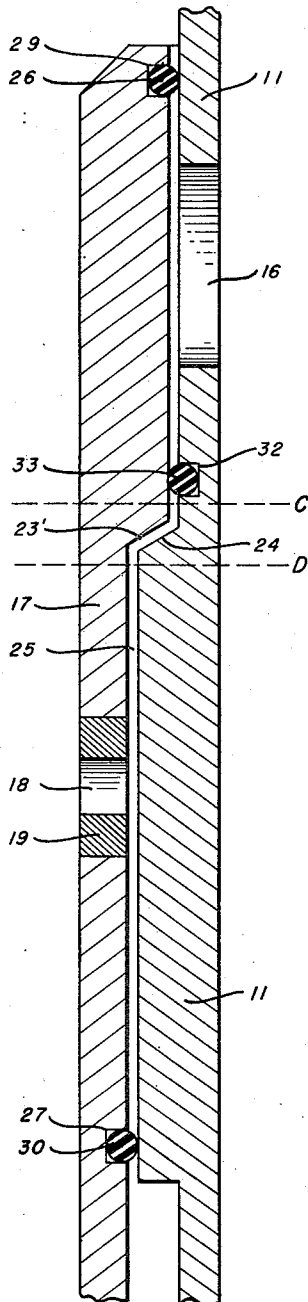


FIG. 3A.

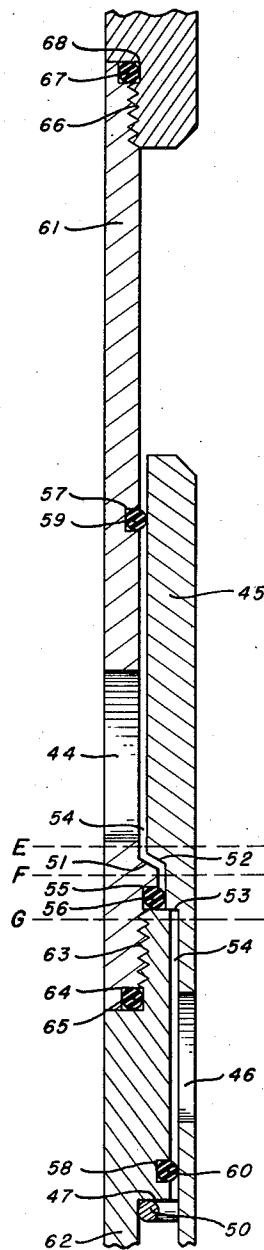
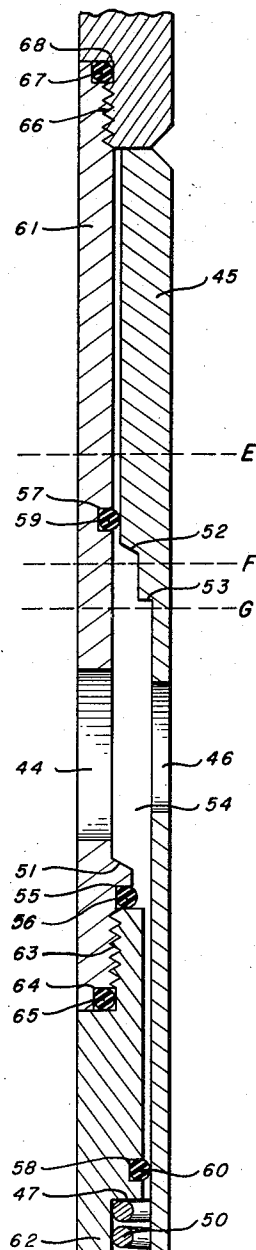


FIG. 3B.



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2,855,952

VALVE FOR USE IN WELL TUBING

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11 Claims. (Cl. 137—508)

The present invention is directed to a valve suitable for use in a well tubing. More particularly, the invention is directed to a gas-lift valve adapted to be incorporated in a tubing string of a well. In its more specific aspects, the invention is directed to a valve, which is actuatable by pressure, for incorporation in a tubing string in a well.

The present invention may be described as a valve for use in a well tubing and adapted to be connected therein which comprises, in combination, a valve mandrel provided with a first port intermediate the ends of the mandrel and a slidable sleeve carried by the mandrel provided with a second port intermediate the ends of the sleeve. The slidable sleeve and mandrel cooperate to provide at least one unbalanced area therebetween exposed to pressure. The first and second ports are adapted for passage of fluid therethrough when in correspondence with each other, the mandrel and the sleeve defining a passageway from one of the ports to allow fluid pressure to be exerted against the unbalanced area. The mandrel has means arranged thereon, such as a helical coil spring or other suitable biasing means, which normally urges the sleeve to a first position such that the ports are out of correspondence. Means are provided in the valve which are arranged in the sleeve and in the mandrel for sealing between the mandrel and the sleeve such that pressure exerted from one of the ports against said areas overcomes the means normally urging the sleeve to a first position and urges the sleeve to a second position and places the ports in correspondence for passage of fluid therethrough.

In the present invention it is contemplated that the slidable sleeve may be carried exteriorally or interiorally by the mandrel such that fluid may be exerted from the interior of the tubing on the unbalanced areas or from the exterior of the tubing.

The biasing means may be arranged on the lower end of the mandrel, and the sleeve and the mandrel are provided with recesses in which the sealing means are arranged. Suitably the sealing means may be O-rings or other similar packing material to provide for a fluid-tight seal.

It is contemplated that the biasing means, such as a helical coil spring, may be adjustable in tension by arranging the biasing means between a shoulder on the mandrel and an adjustable nut carried by the sleeve, such that the tension of the biasing means may be adjusted.

In one embodiment of the invention a slidable sleeve and a mandrel cooperate to provide two unbalanced areas which are successively exposed to pressure such that the valve will open under a high pressure but will be maintained open under a lesser pressure.

The port may be of various sizes through which the fluid pressure is introduced which opens the valve, this port through which the fluid pressure is imposed usually being smaller than the other port.

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

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Fig. 1 is a view, partly in section, of one embodiment of the present invention;

Fig. 1A is an enlarged vertical sectional view of the sleeve and mandrel of Fig. 1;

Fig. 2 is a modified embodiment of Fig. 1;

Fig. 3 is a view, partly in section, of a further modification of the invention;

Fig. 3A is an enlarged vertical sectional view of the mandrel of Fig. 3 showing the valve in closed position; and

Fig. 3B is an enlarged vertical sectional view of the sleeve and mandrel of Fig. 3 showing the valve in full open position.

Referring now to the drawing in which identical numerals will be employed to designate identical parts, numeral 11 designates a valve mandrel which is adapted to be connected by means of mating threads 12 into a pipe connecting means 13 of a pipe string and by mating threads 14 into a pipe connecting means 15 of the pipe or tubing string. The mandrel 11 has a port 16 intermediate its ends and arranged on the mandrel 11 is a slidable sleeve 17. The slidable sleeve 17 has a port 18 intermediate its ends which is adapted to be placed in correspondence with port 16. The port 18 may be provided with a replaceable choke 19 for obtaining the desired flow area of the port.

Arranged between a shoulder 20 of the mandrel 11 and an adjusting nut 21 connected to the sleeve 17 by mating threads 22 is a biasing means, such as a helical coil spring 23, which urges the sleeve 17 to a first position such that the port 18 is not in correspondence with the port 16. An annular space 25' extends the length of sleeve 17 between the sleeve and the mandrel 11.

The slidable sleeve 17 defines a surface 23' and the mandrel 11 defines a surface 24. These surfaces form unbalanced areas between the sleeve and the mandrel as more clearly seen in Fig. 1A wherein dotted lines C and D designate the different areas across annular space 25' between the sleeve and the mandrel. Communicating with the surfaces 23' and 24 from the port 18 is a fluid flow passageway 25 provided by annulus 25'. The sleeve 17 is provided with recesses 26, 27 and 28 in which are arranged, respectively, O-rings or sealing members 29, 30 and 31 to seal between the sleeves 17 and the mandrel 11. A recess 32 in the mandrel 11 is provided with an O-ring 33 to seal between the sleeve and the mandrel and between the ports 16 and 18.

The mandrel 11 defines a fluid passageway 34 for passage of fluid through the tubing.

In the embodiment of Fig. 2, the mandrel is designated by the numeral 11a and is modified by having the surface 23a exposed to fluid from the passageway 25a of the mandrel 11a through port 16a rather than through port 18 as in the embodiment of Fig. 1. The annulus 25a' corresponds to the annular space 25' of Fig. 1. In this embodiment of the present invention the recess 32 in which the O-ring 33 is arranged prevents passage of fluid from the port 16a through passageway 25a to port 18a. In other respects, the embodiment of Fig. 2 is similar to the embodiment of Fig. 1.

Referring now to Fig. 3, a mandrel 40 is provided with threads 41 and 42 for arranging in a tubing string and the like and defines a passageway 43 therethrough. The mandrel is provided with ports 44 for passage of fluid from the annulus between the casing and the tubing to the passageway 43. Arranged within the mandrel is a slidable sleeve 45 provided with a port 46 intermediate the ends thereof. Carried by the mandrel 40 between a shoulder 47 and an adjusting nut 48 which is threadably and adjustably connected to sleeve 45 by mating threads 49 is a biasing means, such as a helical coil spring 50,

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which normally urges the slidable sleeve 45 to a first position such that the ports 44 and 46 are out of correspondence. The mandrel 40 is provided with a first surface 51 and the slidable sleeve is provided with a second surface 52 and a third surface 53. These surfaces form two unbalanced areas designated by dotted lines E, F, and G in Figs. 3A and 3B.

A passageway 54 between the ports 44 and 46 is closed by means of a seal defined by a recess 55 containing an O-ring or other sealing means 56. A seal in annulus 54' between the mandrel 40 and the sleeve 45 is provided by recesses 57 and 58 in the mandrel 40 containing, respectively, O-rings or other sealing means 59 and 60.

A seal between the sections 61 and 62 of the mandrel 40 which are connected by mating threads 63 is provided by recess 64 containing an O-ring or sealing member 65.

The section 61 is connected to the upper end of the mandrel 40 by mating threads 66 and section 61 is sealed by means of a sealing member 67, such as an O-ring, located in recess 68. Likewise, the section 62 is connected to the lower end of the mandrel 40 by means of mating threads 69 and the section 62 is sealed to the lower end of the mandrel 40 by an O-ring or sealing means 70 in recess 71.

In the embodiment of Fig. 1, the valve, as described, is arranged in a tubing string, as shown, and is opened by allowing the pressure to build up in the annulus between the casing, not shown, and the tubing to such an extent that the pressure is exerted through the port 18 and thence into the space or passageway 25 until it is stopped by the O-ring 33 in the recess 32 sufficient to open the valve. This pressure in the annulus is exerted against the unbalanced area designated by dotted lines C and D in Fig. 1A, and forces the sleeve 17 upwardly until the port 18 is nearly adjacent the port 16 in the mandrel 11. The device comes into equilibrium when the difference in the pressure exerted against the unbalanced area equals the tension exerted by the spring 23.

As an example of the way the embodiment of Fig. 1 may be used is in a well where there is a limited amount of gas at a pressure of approximately 800 pounds per square inch. The valve may be adjusted so that where gas pressure builds up to 800 pounds per square inch and opens the valve, gas passes through the ports 18 and 16 into the tubing to gas lift the fluid in the tubing. When the pressure drops below the value selected, the sleeve 17 moves downwardly by the tension of spring 23 to close off port 16 and shut off gas flow and remains in this position until the pressure in the annulus between the casing and tubing again builds up sufficiently to open the valve.

The embodiment of Fig. 2 differs from that of Fig. 1. Whereas in Fig. 1 the valve opens because the pressure in the annulus between the casing and the tubing is greater than the tension of spring 23, the valve in Fig. 2 opens up when the pressure inside the tubing is greater than the tension of spring 23. The unbalanced area in Fig. 2 formed by surfaces 23a and 24a, correspond to the area designated by dotted lines C and D formed by surfaces 23' and 24 in Fig. 1. In Fig. 2 the pressure is imposed through port 16a and passes through the passageway 25a between the sleeve 17a and the mandrel 11a. This pressure is exerted against the unbalanced area and causes sleeve 17a to move upwardly on overcoming the tension of spring 23.

As the sleeve 17a moves upwardly, the ports 16a and 18a come into correspondence and allow fluid to pass from the port 16a. In the embodiments of Figs. 1 and 2, an adjusting nut 21 is provided for adjusting the tension of the spring 23.

In the embodiment of Fig. 2, the pressure exerted through the port 18a is balanced when the valve is closed and explains why the valve is actuated by the pressure inside the tubing rather than the pressure in the annulus between the tubing and the casing as in Fig. 1.

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The embodiment of Fig. 2 is particularly useful for application to the tubing of a well in which the well produces such an amount of gas along with the liquid that the pressure of the column of fluid in the tubing is sufficiently low to allow the well to flow most of the time, but occasionally there is insufficient gas to keep the liquid column light enough to flow so that the well "loads up" occasionally and stops its flow. If the well tubing is provided with a valve, as embodied in Fig. 2, and gas at the proper pressure is maintained in the annulus between the tubing and casing, then when the tubing loads up and stops flow the increase in the pressure exerted by the column of fluid in the tubing, which causes the flow to stop, also opens the valve and allows gas to flow from the annulus between the tubing and the casing into the tubing thereby aerating the column of fluid in the tubing so that the well may resume its flow. When the column of fluid in the tubing is light enough so that the well resumes its flow the valve will close again to conserve the gas.

Fig. 3 differs from Figs. 1 and 2 and is designed for insertion in a string of tubing in a cased borehole with a packer arranged on a tubing immediately below the valve to seal off the annulus between the tubing and the casing.

The embodiment of Fig. 3 is designed as a circulating port to allow fluid to be circulated from the casing into the tubing when such an operation is to be performed but which will stay closed during the time the well is being produced by gas-lift. The embodiment of Fig. 3 is designed so that gas-lift valves may be installed on the tubing at a point above the structure of Fig. 3.

For purposes of illustration, the apparatus of Fig. 3 is installed on a tubing below gas-lift valves (not shown) and it may be assumed that 800 pounds of gas pressure is imposed in the annulus between the tubing and casing to gas lift the well, this gas entering the tubing through the gas-lift valves to aerate the column of fluid. When it is desired to use the valve of Fig. 3 for reverse circulation, a pump at the wellhead is used to build up the fluid pressure in the annulus between the casing and the tubing too, for example, approximately 1000 pounds which pressure when imposed against the unbalanced area designated by dotted lines E and F of Fig. 3A formed by the surface 52 will cause the sleeve 45 to move upwardly. A slight upward movement of the sleeve 45 will cause the unbalanced area formed by the surface 53 to clear the O-ring 56 which substantially increases the amount of unbalanced area exposed to the well fluid and causes the sleeve 45 to move upwardly at a faster rate until the ports 44 and 46 are in alignment and in full open position. Fluid then circulates from port 44 through port 46 into the passageway 43. After the sleeve 45 has moved upwardly to expose the additional area formed by surface 53, much less pressure will be required to maintain the valve in an open position. Thus while 1000 pounds initial pressure will open the valve after which the reverse circulation of the fluid in the well may be carried out at much less pressure, say slightly above 300 pounds. Then when the pressure drops to 300 pounds the valve will close and if the well is then put into production the valve will remain closed when 800 pounds of gas is being used to gas-lift the well tubing through the gas-lift valve, not shown. However, when it is desired to work over the well and circulate fluid by reverse circulation, the valve may again be opened by imposing 1000 pounds pressure on the fluid in the annulus of the well.

Thus the present invention is of considerable utility in well stimulation and work-over operations. The invention may have important application in the completion of slim holes. The valve of the present invention offers the advantage of full opening which will retard paraffin deposition and also enables pressure bomb checks of the

valve operation. The valve of the present invention allows bottom hole pressure measurements to be made without disturbing the valve since there is a full opening through the valve at all times.

In the present invention improved operations are obtained in that it is unnecessary to rotate to open the valve but the valve is operated by providing an unbalanced area which allows the valve to open and close as is desired.

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

1. A valve for use in well tubing comprising a mandrel having an axial passage therethrough and provided with a first port, a sleeve slidably carried by said mandrel provided with a second port spaced axially of said first port when the valve is closed, one of said ports fluidly communicating with said passage, a passageway between said mandrel and said sleeve adapted to fluidly communicate said first and second ports, said sleeve being provided with at least one shoulder to thereby form at least one unbalanced area in said passageway, sealing means in said passageway between said ports adapted to seal off fluid flow through said passageway when said valve is closed, and biasing means arranged on said mandrel adapted to urge said sleeve to a position wherein said passageway is sealed off by said sealing means.

2. A valve as recited in claim 1 wherein said sleeve is carried exteriorly of said mandrel.

3. A valve as recited in claim 1 wherein said sleeve is carried interiorly of said mandrel.

4. A valve for use in well tubing comprising a mandrel having an axial passage therethrough and provided with a first port, a sleeve slidably carried by said mandrel provided with a second port spaced axially of said first port when the valve is closed, one of said ports fluidly communicating with said passage, a passageway between said mandrel and said sleeve adapted to fluidly communicate said first and second ports, said sleeve having a shoulder intermediate the length of said passageway thereby forming an unbalanced area in said passageway, sealing means in said passageway between said ports adapted to seal off fluid flow through said passageway when said valve is closed, and biasing means arranged on said mandrel adapted to urge said sleeve to a position wherein said passageway is sealed off by said sealing means.

5. A valve as recited in claim 4 wherein said sleeve is carried exteriorly of said mandrel.

6. A valve as recited in claim 4 wherein said sleeve is carried interiorly of said mandrel.

7. A valve for use in well tubing comprising a mandrel having an axial passage therethrough and provided with a first port, a sleeve slidably carried by said mandrel provided with a second port spaced axially of said first port when the valve is closed, one of said ports fluidly communicating with said passage, a passageway between said mandrel and said sleeve adapted to fluidly communicate said first and second ports, said sleeve having

two spaced apart shoulders intermediate the length of said passageway thereby forming two unbalanced areas in said passageway, sealing means in said passageway between said ports adapted to seal off fluid flow through said passageway when said valve is closed, and biasing means arranged on said mandrel adapted to urge said sleeve to a position wherein said passageway is sealed off by said sealing means.

8. A valve for use in well tubing comprising a mandrel having an axial passage therethrough and provided with a first port, a sleeve slidably carried by said mandrel provided with a second port spaced axially of said first port when the valve is closed, one of said ports fluidly communicating with said passage, said sleeve and said mandrel cooperating to form an annulus therebetween, said annulus providing a fluid flow passageway between said first and second ports adapted to fluidly communicate said first and second ports, said sleeve being provided with at least one shoulder to thereby form at least one unbalanced area in said passageway, first sealing means in said passageway between said ports adapted to seal off fluid flow through said passageway when said valve is closed, second sealing means adapted to seal off said annulus above said first port, third sealing means adapted to seal off said annulus below said second port and biasing means arranged on said mandrel adapted to urge said sleeve to a position wherein said passageway is sealed off by said first sealing means.

9. A valve as recited in claim 8 wherein said sleeve is positioned exteriorly of said mandrel.

10. A valve as recited in claim 8 wherein said sleeve is positioned interiorly of said mandrel.

11. A valve for use in well tubing comprising a mandrel having an axial passage therethrough and provided with a first port, a sleeve slidably carried by said mandrel provided with a second port spaced axially of said first port when the valve is closed, one of said ports fluidly communicating with said passage, said sleeve and said mandrel cooperating to form an annulus therebetween, said annulus providing a fluid flow passageway between said first and second ports adapted to fluidly communicate said first and second ports, said sleeve having two spaced shoulders intermediate the length of said passageway forming two unbalanced areas in said passageway, first sealing means in said passageway between said ports adapted to seal off fluid flow through said passageway when said valve is closed, second sealing means adapted to seal off said annulus above said first port, third sealing means adapted to seal off said annulus below said second port, and biasing means arranged on said mandrel urging said sleeve to a position wherein said passageway is sealed off by said sealing means.

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