

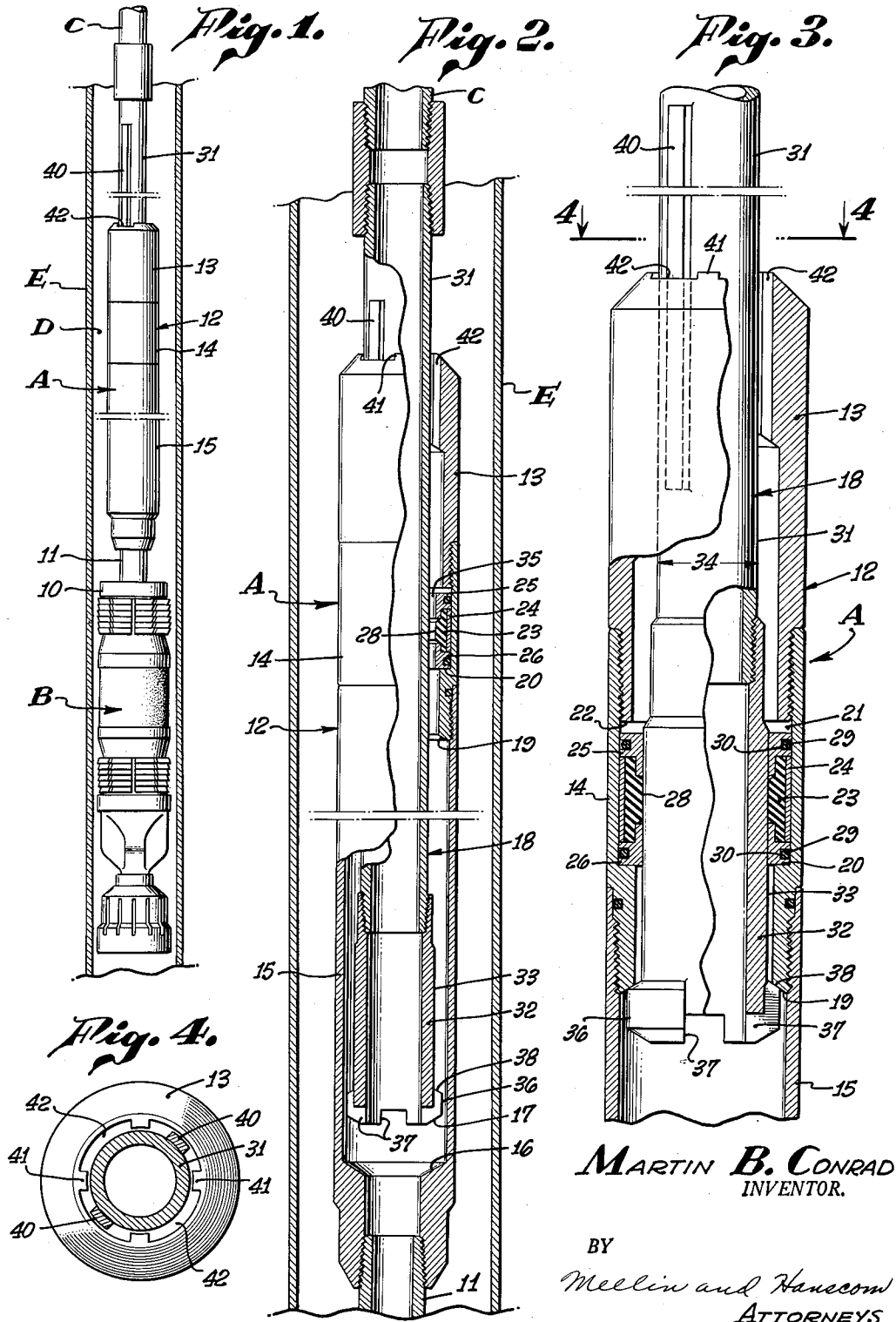
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FLUID CONTROL VALVE

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FLUID CONTROL VALVE

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The present invention relates to valve devices, and more particularly to valve devices adapted to be located in a well bore to control flow of fluids therewithin. Such particular valve devices are disposed in a tubular string above a well device, such as a well packer, to determine the passage of fluid between the interior of the tubular string and the well device, or between the interior of the tubular string and the casing annulus around the latter.

An object of the present invention is to provide an improved control valve, or circulation joint, especially useful in being shifted to open position to allow a predominating fluid pressure in the annular space between the well casing and the control valve to flow into the control valve, for passage into a tubular string to which the valve is secured.

Another object of the invention is to provide a control valve, or circulation joint, having an elastic seal ring, or the like, engageable with a companion valve member to close the valve, and in which opening of the valve to allow external fluid to flow therein does not tend to blow or otherwise remove the seal ring from its confined position in the valve, nor does such valve opening otherwise tend to tear or disrupt the seal ring.

A further object of the invention is to provide a simple and sturdy control valve or circulation joint to be incorporated in a tubular string located in a well bore, the valve being easily assembled and disassembled, and being capable of withstanding comparatively high pressure differentials.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a side elevation of apparatus embodying the invention, disposed in a well casing;

Fig. 2 is an enlarged longitudinal section of the control valve device in open position;

Fig. 3 is a further enlarged longitudinal section, similar to Fig. 2, illustrating the valve device in closed position;

Fig. 4 is a cross-section taken along the line 4—4 on Fig. 3.

The control valve or circulation joint A disclosed in the drawings may be used in conjunction with another well device B, such as a well packer, that can be anchored in packed-off condition within a well casing. The lower end of the control device may be attached to the packer body 10 through the intermediary of a suitable sub or nipple 11, and its upper portion may be attached to a tubular string C, such as drill pipe or tubing, extending to the top of the well bore. The particular con-

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trol device illustrated in the drawings is intended to determine the passage of fluid between the interior of the tubular string C and through the well device B, or between the interior of the tubular string and the annulus D between the tubular string and the casing E above the well device B, depending upon the position to which the control valve has been shifted.

The control valve A, or circulation joint, disclosed in the drawings includes an outer cylinder or barrel 12 composed of three sections 13, 14, 15, in order to facilitate assembly of the control device. The lower end of the lower section 15 is threadedly secured to the sub 11, which is attached to the well packer B, the upper end of such lower section being threaded onto the lower end of the intermediate section 14, which is, in turn, threaded onto the lower end of the upper section 13. The lower section 15 is provided with an inwardly directed stop shoulder 16 adapted to cooperate with the lower end 17 of a tubular mandrel 18 telescopically arranged within the outer barrel 12. This mandrel is also cooperable with a lower stop shoulder 19 formed on the lower end of the intermediate section 14, as described hereinbelow.

The intermediate section 14 has a shoulder 20 forming the lower side of an annular groove 21 whose upper side is defined by the lower end 22 of the upper section 13. A sealing structure is disposed in this groove, such structure including a packing ring or sleeve 23 which is molded, or otherwise secured, to the inner wall of an encompassing metallic ring or sleeve 24 of substantially the same length as the packing ring or sleeve 23, which may be made of rubber, or similar pliant and elastic material. The rubber packing ring and the metallic ring 24 to which it is secured are confined between upper and lower heads 25, 26 disposed in the annular groove 21, these heads having opposed skirts 27 extending toward each other and surrounding the end portions of the packing ring 23. In effect, the skirts 27 form annular pockets with the intermediate barrel section 14 in which the end portions of the rubber packing annulus 23 and metallic ring 24 are confined. The intermediate section 28 of the rubber ring, however, may extend inwardly to a slight extent beyond the inner cylindrical surfaces of the heads 25, 26 and their skirts 27, for the purpose of slidably sealing with the mandrel 18. Leakage between the heads 25, 26 and the base of the annular groove 21 is prevented by providing suitable side seals 29, such as rubber or rubber-like O rings, in grooves 30 in the heads, which slidably seal against the base of the groove.

The packing structure, including the rubber sleeve 23, metallic sleeve 24, heads 25, 26 and seal rings 29, may be disposed within the intermediate section 14, whereupon the upper section 13 is threaded into the latter. It is unnecessary for the sealing structure to be tightly confined within the annular groove 21. As a matter of fact, the distance between the sides 20, 22 of the groove is greater than the over-all length of the sealing structure, which allows some slight longitudinal movement of the sealing structure within the barrel 12 to take place. Despite such slight movement, there is no leakage around the sealing structure, since the O rings 29 slidably seal against the base of the groove, and the inner surface of the packing sleeve 23 is capable of properly sealing against the mandrel 18, in the manner described below.

The mandrel 18 of the control valve is composed of an upper section 31 and a lower section 32 threaded onto the latter. The lower section has an enlarged external cylindrical seating surface 33 having substantially the same diameter as the inside diameter of the generally cylindrical rubber packing ring or sleeve 23. The diameter of the seating surface is substantially greater than the outside diameter 34 of the mandrel

portions thereabove, in order that a substantial annular space 35 be provided between the seal ring 23 and the periphery of the upper portion of the mandrel, when the mandrel is shifted downwardly within the barrel 12 to open the control valve.

The lower portion of the mandrel section 32 has an external flange 36 thereon that has aligned longitudinal and radial grooves 37 therein through which fluid can flow. The upper surface 38 of this flange 36 provides an upper stop shoulder engageable with the companion stop shoulder 19 at the lower end of the intermediate barrel section 14, to locate the cylindrical seating surface 33 of the mandrel 18 completely within and in sealing engagement with the elastic ring 23. Downward movement of the mandrel 18 within the barrel 12 is limited by engagement of a lower stop shoulder 17 of the flange 36 with the companion stop shoulder 16 of the lower portion of the lower barrel section 15. Despite such engagement, it is evident that fluid can pass between the interior of the mandrel 18 and the annular space between the mandrel and the cylinder or barrel 12 by flowing through the radial and longitudinal passages 37 formed in the flanged portion 36 of the lower mandrel section 32.

It is desirable to transmit rotation or turning effort of the tubular string C to the outer barrel member 12, and from this member through the sub 11 to the body 10 of the well packer B, as for the purpose of unscrewing the sub 11 from the well packer, or to perform some other function in connection with the well packer. Such motion can be transmitted without interfering with the ability of the mandrel 18 to telescope longitudinally in both directions within the barrel 12. For this purpose, a plurality of circumferentially spaced and longitudinally extending splines or keys 40 are welded, or otherwise suitably secured to the mandrel 18, being cooperable with a plurality of circumferentially spaced, longitudinally extending ribs 41 projecting inwardly from the upper section 13 of the barrel. Arcuate clearance space 42 is provided between the ribs 41 and splines 40 to allow fluid to pass into and out of the annular space between the mandrel 18 and the barrel 12.

When the mandrel 18 is shifted upwardly within the barrel 12, to the extent determined by engagement of the upper mandrel stop shoulder 38 with the stop shoulder 19 on the intermediate section 14, the cylindrical seating surface 33 is disposed completely within the elastic packing sleeve 23, to close the annular space 35 between the mandrel 18 and the outer barrel or cylinder 13. Accordingly, fluid is incapable of passing between the annulus D defined by the tubular string C and the well casing E and the interior of the mandrel and the tubular string C.

Upon telescoping the mandrel 18 downwardly within the barrel 12, to completely remove the cylindrical seating surface 33 from the elastic packing ring 23, the valve is disposed in open position and fluid can now flow in both directions between the interior of the mandrel 18 and the exterior of the barrel 12. As an example, if a predominating fluid pressure is present in the tubing-casing annulus D, the shifting of the mandrel 18 in a downward direction to open position will allow the fluid to flow through the arcuate passages 42 between the splines 40 and ribs 41, and into the annular space between the mandrel 18 and the barrel 12, such fluid passing through the elastic sleeve and on downwardly through the lower end of the mandrel, thence proceeding upwardly through the mandrel and on into the tubular string C.

By virtue of the arrangement just disclosed, a predominating fluid pressure in the tubing-casing annulus D cannot move or blow the elastic packing ring 23 from its desired position in the barrel 12, when the mandrel is shifted downwardly to open position. As the mandrel is lowered, the cylindrical seat 33 is also shifted down-

wardly along the elastic packing sleeve 23. When the upper end of the cylindrical seat 33 begins uncovering the inner surface of the packing ring 23, the predominating pressure of the tubing-casing annulus D, which is also present in the annular space between the mandrel and barrel above the packing ring, engages the inner surface of the packing ring and tends to press it laterally outward, holding it confined between the head 25, 26 and within the annular groove 21. The pressure of the tubing-casing annulus fluid will progressively act along the inner surface of the elastic seal ring or sleeve 23, as the upper end of the cylindrical seat 33 moves downwardly along such inner surface until the cylindrical seat has been completely removed from engagement with the packing ring. When such complete disengagement occurs, the greater pressure in the tubing-casing annulus is acting on all sides of the packing ring 23, and there are no forces present tending to shift the ring out of the annular groove 21.

Similarly, with a predominating pressure in the tubing-casing annulus D, the shifting of the mandrel 18 upwardly to close the control valve will first engage the upper end of the cylindrical seat 33 with the lower inner surface of the packing ring 23. At this time, there is a pressure differential imposed upon the packing ring 23, tending to shift it in a downward direction. However, the lower head 26 and its skirt 27 make a comparatively close sliding fit against the cylindrical seating surface 33 on the mandrel 18, and do not provide any substantial clearance or annular space into which the rubber, or rubber-like, material of the packing ring can be forced. The pressure will do nothing more than deform the packing ring in both an outward direction and an inward direction into firmer sealing engagement with the cylindrical seat 33. As the mandrel 18 is moved upwardly to its fullest extent, the inner surface of the packing sleeve 23 is merely brought into further engagement with the cylindrical seat 33 over a substantially great area, to insure against leakage between the seat and the seal ring, and precluding passage of fluid between the interior of the mandrel 18 and the exterior of the barrel 12.

If the seal ring 23 were reversely arranged, as by being disposed on the mandrel 18, and the cylindrical seat 33 provided on the barrel 12, then a predominating tubing-casing annulus pressure would tend to blow the seal ring out of its confining groove when the control valve is shifted to open position. The arrangement of the parts in the manner described above, and as illustrated in the drawings, precludes this undesirable action from occurring.

The inventor claims:

1. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; said outer member having non-metallic packing means therein; said inner member having a substantially cylindrical external seating surface adapted to be engaged by the inner face of said packing means to effect a seal between said members to close said passage; said inner and outer members being moved longitudinally with respect to each other to disengage said seating surface from said packing means to expose said inner face and open said passage; and means on one of said members for connecting said one member to the tubular string.

2. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members, said passage opening to

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the exterior of said outer member at one end of said outer member; said outer member having non-metallic packing means therein; said inner member having a substantially cylindrical external seating surface movable by said inner member within and in sealing engagement with the inner face of said packing means to effect a seal between said members to close said passage; said inner and outer members being moved longitudinally with respect to each other to disengage said seating surface from said packing means to expose said inner face and open said passage; and means on one of said members for connecting said one member to the tubular string.

3. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; said outer member having non-metallic packing means therein; said passage having an opening to the exterior of said outer member at one side of said packing means; said inner member having a substantially cylindrical external seating surface movable within and in sealing engagement with the inner face of said packing means to close said passage upon longitudinal movement of said inner member relative to said outer member to shift said seating surface in a direction toward said opening; said seating surface moving out of sealing engagement with the inner face of said packing means to open said passage upon longitudinal movement of said inner member relative to said outer member to shift said seating surface in a direction away from said opening; and means on one of said members for connecting said one member to the tubular string.

4. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; said outer member having an elastic non-metallic packing element therein; retaining means on opposite sides of and engaging said element; said passage having an opening to the exterior of said outer member at one side of said packing element; said inner member having a substantially cylindrical external seating surface movable within said retaining means and within and in sealing engagement with the inner face of said packing element to close said passage upon longitudinal movement of said inner member relative to said outer member to shift said seating surface in a direction toward said opening; said seating surface moving out of sealing engagement with the inner face of said packing means to open said passage upon longitudinal movement of said inner member relative to said outer member to shift said seating surface in a direction away from said opening; and means on one of said members for connecting said one member to the tubular string.

5. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; said outer member having an elastic non-metallic packing element therein; said passage having an opening to the exterior of said outer member at one side of said packing element; said inner member having a substantially cylindrical external seating surface movable within and in sealing engagement with the inner face of said packing element to close said passage upon longitudinal movement of said inner member relative to said outer member to shift said seating surface in a direction toward said opening; said seating surface moving out of sealing engagement with the inner face of

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said packing means to open said passage upon longitudinal movement of said inner member relative to said outer member to shift said seating surface in a direction away from said opening; said outer member having retaining means engaging said packing element on the other side of said packing element and slidable along said cylindrical seat; and means on one of said members for connecting said one member to the tubular string.

6. In a control valve adapted to be connected to a tubular string positionable in a well bore: a lower, outer tubular member; an upper, inner tubular member telescopically arranged within said outer member and spaced therefrom to form a passage establishing communication between the interior and exterior of said members; said outer member having non-metallic packing means therein; said passage having an opening to the exterior of said outer member above said packing means; said inner member having a substantially cylindrical external seating surface movable upwardly within and into sealing engagement with said packing means to close said passage upon upward movement of said inner member along said outer member; the external diameter of said inner member above said seating surface being substantially less than the external diameter of said seating surface, whereby downward movement of said inner member along said outer member moves said seating surface out of sealing engagement with said packing means and locates the portion of the inner member above said seating surface within said packing means to open said passage; and means on said inner member for connecting said inner member to the tubular string.

7. In a control valve adapted to be connected to a tubular string positionable in a well bore: a lower, outer tubular member; an upper, inner tubular member telescopically arranged within said outer member and spaced therefrom to form a passage establishing communication between the interior and exterior of said members; said outer member having non-metallic packing means therein; said passage having an opening to the exterior of said outer member above said packing means; said inner member having a substantially cylindrical external seating surface movable upwardly within and into sealing engagement with said packing means to close said passage upon upward movement of said inner member along said outer member; the external diameter of said inner member above said seating surface being substantially less than the external diameter of said seating surface, whereby downward movement of said inner member along said outer member moves said seating surface out of sealing engagement with said packing means and locates the portion of the inner member above said seating surface within said packing means to open said passage; said outer member having retaining means engaging the lower portion of said packing means and slidable relatively along said cylindrical seat; and means on said inner member for connecting said inner member to the tubular string.

8. In a control valve adapted to be connected to a tubular string positionable in a well bore: a lower, outer tubular member; an upper, inner tubular member telescopically arranged within said outer member and spaced therefrom to form a passage establishing communication between the interior and exterior of said members; said outer member having non-metallic packing means therein; said passage having an opening to the exterior of said outer member above said packing means; said inner member having a substantially cylindrical external seating surface movable upwardly within and into sealing engagement with said packing means to close said passage upon upward movement of said inner member along said outer member; the external diameter of said inner member above said seating surface being substantially less than the external diameter of said seating surface, whereby downward movement of said inner member along said outer member moves said seating surface out of sealing engagement with said packing means and locates the por-

tion of the inner member above said seating surface within said packing means to open said passage; said outer member having upper and lower retaining means engaging the upper and lower portions, respectively, of said packing means and slidable relatively along said cylindrical seating surface; and means on said inner member for connecting said inner member to the tubular string.

9. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; said outer member comprising upper and lower sections defining an inner annular groove therebetween and threadedly secured to each other; non-metallic packing means in said groove; said inner member having a substantially cylindrical external seating surface adapted to be engaged by said packing means; annular retainers in said groove on opposite sides of and engageable with said packing means and slidable relatively along said cylindrical seating surface; and means on one of said members for connecting said one member to the tubular string.

10. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; said outer member comprising upper and lower sections defining an inner annular groove therebetween and threadedly secured to each other; non-metallic packing means in said groove; said inner member having a substantially cylindrical external seating surface adapted to be engaged by said packing means; annular retainers in said groove on opposite sides of and engageable with said packing means and slidable relatively along said cylindrical seating surface; seal means between said annular retainers and outer member to prevent leakage therebetween; and means on one of said members for connecting said one member to the tubular string.

11. In a control valve adapted to be connected to a

tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; one of said members comprising upper and lower sections defining an annular groove therebetween and threadedly secured to each other; non-metallic packing means in said groove; the other of said members having a substantially cylindrical external seating surface adapted to be engaged by said packing means to effect a seal between said members to close said passage; annular retainers in said groove on opposite sides of and engaging said packing means and slidable longitudinally along said cylindrical seating surface; and means on one of the members for connecting such member to a tubular string.

12. In a control valve adapted to be connected to a tubular string positionable in a well bore: inner and outer tubular members telescopically arranged one within the other and spaced from each other substantially throughout their telescoped length when in open position to form a passage establishing communication between the interior and exterior of said members; one of said members comprising upper and lower sections defining an annular groove therebetween and threadedly secured to each other; non-metallic packing means in said groove; the other of said members having a substantially cylindrical external seating surface adapted to be engaged by said packing means to effect a seal between said members to close said passage; annular retainers in said groove on opposite sides of and engaging said packing means and slidable longitudinally along said cylindrical seating surface; seal means between said retainers and said one member; and means on one of said members for connecting such member to a tubular string.

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