June 11, 1957 E. L. SARTAIN 2,795,280

BRIDGING PLUG

Filed Aug. 6, 1952 2 Sheets-Sheet 1

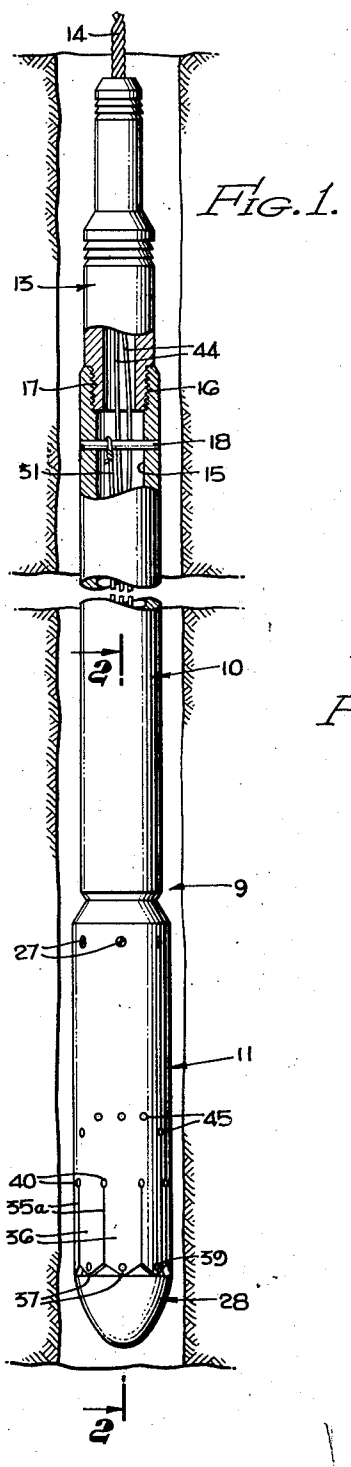


FIG. 1.

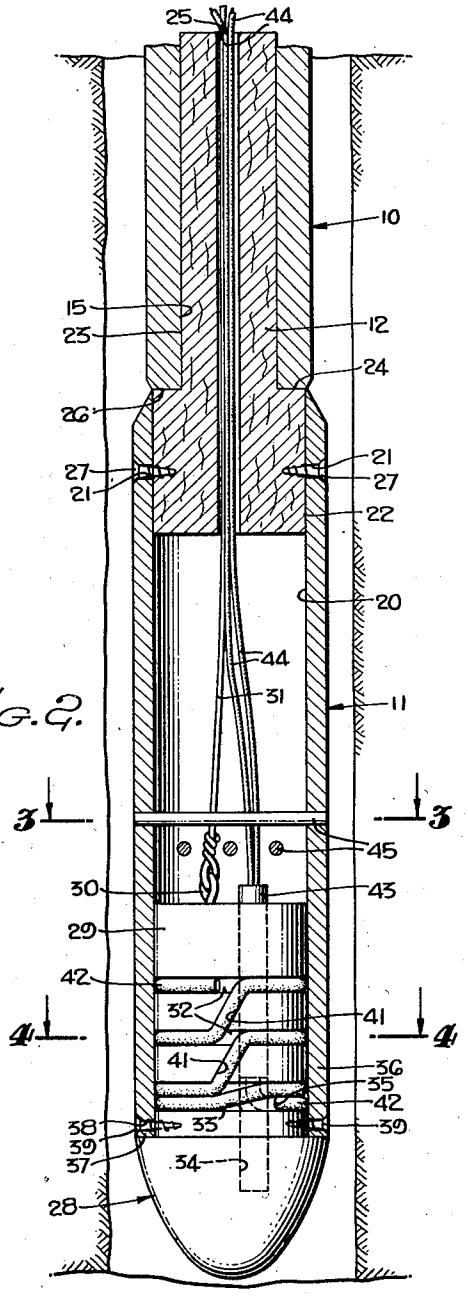


FIG. 2.

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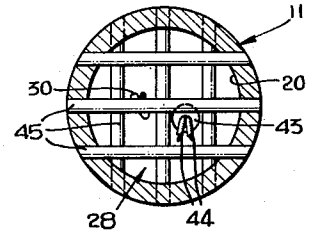


FIG. 3.

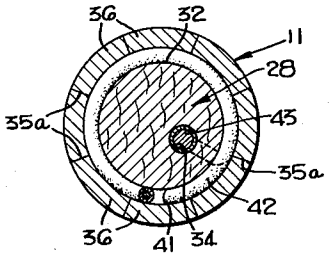


FIG. 4.

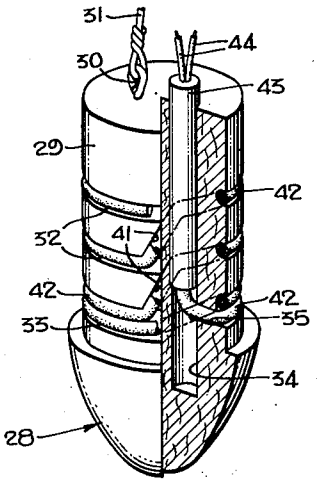


FIG. 5.

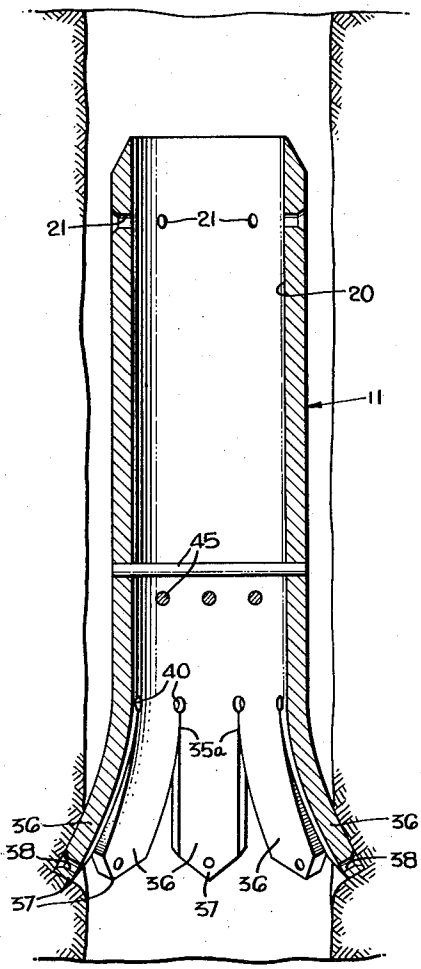


FIG. 6.

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BRIDGING PLUG

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Application August 6, 1952, Serial No. 302,927

20 Claims. (Cl. 166—63)

This invention relates generally to oil and gas wells, and more particularly to a cement retainer bridging plug for use in uncased boreholes.

In the drilling of oil and gas wells, it is often necessary or desirable to close or seal off a lower section of a well borehole, such as when a lower zone in the well has ceased to be productive or where the well borehole has been drilled into water producing strata or thief sands, or for any other reason, so that production from a higher zone may be obtained without contamination by fluids having foreign matter therein. Bridging or cementing plugs of a wide variety have been developed for this general purpose. However, when a cementing operation is to be performed, plugs heretofore developed for supporting a quantity of cement in an open hole or well bore have been subject to numerous difficulties and disadvantages. In many cases the plug is driven down by the weight of the cement placed on top thereof, and often the formation pressure below the plug rises, with the result of forcing the plug upward or displacing the plug in the wall hole in such manner that channeling through the cement placed in or on the plug often occurs. In many cases the placing of the bridging or cementing plugs has required the use of pipe or tubing, necessitating a considerable expenditure of material and time. Objections and difficulties of this character have been met and overcome by the present invention, which is directed to a novel and improved type of open-hole cement retainer plug.

It is accordingly an object of the invention to provide an improved cement retainer plug for open-hole well bores which can be quickly and firmly set in a well borehole, using wire line methods.

Another object of the invention is to provide an open-hole cement retainer plug capable of being used to assist in forming a fluid-tight seal even in irregular shaped borehole cavities.

A further object of the invention is to provide a cement retainer plug for open-hole well bores having self-contained formation gripping means which can be actuated into position for gripping the wall of the formation by a simple electrically actuated means electrically controlled through an electrical conductor carried with or within the wire supporting line.

A still further object of the invention is to provide a cement retainer plug of the character set forth in the preceding objects, wherein the formation gripping elements are projected into the wall of the surrounding borehole by an electrically detonated explosive means, which at the same time separates the plug from a body portion originally forming a part thereof and connected to the wire line, and which body portion may be removed with the wire line after the plug has been set in formation gripping position.

An additional object of the invention is to provide a cement retainer plug of novel construction, which is durable, efficient, inexpensive, simple to operate, and which will remain securely positioned in the borehole.

Other objects, advantages, and features of novelty will be apparent and brought out more fully hereinafter.

In the drawings, which illustrate a preferred embodiment of the invention, and in which like reference numerals designate the same or similar parts throughout the several views:

Figure 1 is an elevational view, partly in section, of a retainer plug embodying a preferred form of the invention shown in a well borehole;

Figure 2 is an enlarged sectional view of a portion of the apparatus of Figure 1;

Figure 3 is a sectional view taken along line 3—3 of Figure 2;

Figure 4 is a sectional view taken along line 4—4 of Figure 2;

Figure 5 is a perspective view, partly in section, of the end plug and cap which secures the explosive charge; and

Figure 6 is a view in sectional elevation of the retainer plug element of Figures 1 and 2 shown in set position in the well borehole.

Referring more particularly to the drawings, the cement retainer plug 9 of this invention consists essentially of a two-part structure comprising a tubular body 10 and a retainer plug cylinder or sleeve 11, which is likewise tubular, the two parts being initially joined together coaxially end to end by an interconnecting pin member 12, the body part 10 in turn being secured to a cable head 13 which is suspended from a lowering conductor cable 14, according to well known practice. Body 10 may be made of any suitable material, such as steel, and plug sleeve 11 may be made of suitable metal, such as iron or steel, but preferably of a relatively soft, readily drillable material, such as aluminum, aluminum alloy, or the like, when it is desired that the plug sleeve 11 be readily removable by drilling. The body portion 10 has a bore 15, the upper end of which is threaded at 16 for engaging the threaded portion 17 of the cable head 13. An anchor bar 18 extends across the bore 15 near the upper end of the body 10 for securing the upper end of a link member 31, to be more fully described hereinafter.

Plug sleeve 11 is, as stated hereinbefore, hollow or tubular, having a bore 20, and the wall of the plug sleeve is formed with a plurality of holes 21 therethrough adjacent the upper end thereof. Pin member 12 has a lower cylindrical head portion 22 and an upper cylindrical shank portion 23 of reduced diameter relative to the head portion, forming a shoulder 24, and is further formed or provided with a longitudinal bore or passage hole 25 therethrough. The pin member 12 is preferably of wood or other suitable material and adapted to effect a sliding but firm fit of the cylindrical head portion 22 within bore 20 of plug sleeve 11, and a similar fit of cylindrical shank portion 23 in bore 15 of body 10, the connection being such that shoulder 24 engages and seats against the lower end 26 of body 10. Screws 27 extend radially through holes 21 in the wall of plug sleeve 11 into the head portion 22 of the pin member 12 and serve to secure the plug sleeve 11 to the pin member 12.

A plug cap 28, also preferably of wood, is provided for the lower end of plug sleeve 11 and has a cylindrical portion or supporting plug member 29 for interfitting engagement within the lower end of bore 20 of plug sleeve 11, and is provided with a hook or eyelet 30 at its upper end for attachment thereto of the lower end of a wire or other link member 31 as before mentioned, which extends upward through the before-mentioned passage hole 25 in connecting pin member 12 for attachment at its upper end to the before-mentioned anchor bar 18 in body 10. Cylindrical portion or plug member 29 of cap 28 is formed with a plurality of exterior, annular grooves as shown at 32 and 33, groove 33 being substan-

tially twice the size of groves 32, and the cap 28 and cylindrical portion or plug member 29 are formed with a vertically extending passage 34 therein and a radial port 35 making connection between the passage 34 and groove 33. Plug sleeve 11 has its lower end provided with a plurality of longitudinally extending slots 35*a* forming fingers 36, the lower ends of which are sharpened or pointed at 37, the fingers being provided adjacent the lower ends thereof with holes 38 therethrough for wood screws 39 which extend into cap 28 and secure the cap in position in bore 20. The upper ends of slots 35*a* are preferably enlarged, as at 40, to facilitate outward bending movement of the fingers during actuation. Cylindrical portion 29 of cap 28 is further formed with exterior, longitudinally extending or diagonal grooves 41 which interconnect the adjacent grooves 32 and 33. An explosive charge is provided in grooves 32, 33, and 41 which preferably comprises an explosive or detonating fuse 42 extending from passage 34 out through port 35 and secured around the cylindrical portion 29 by being wrapped twice around the cylindrical portion 29 in groove 33 and once around in each of grooves 32, the intermediate portions between grooves extending through the diagonal interconnecting grooves 41. Fuse 42 is preferably of the type known commercially as "P. E. T. N. Reinforced Primacord," designated as "50 Gr/Ft.," manufactured by E. I. du Pont de Nemours & Co. As can be clearly seen in Figure 2, grooves 32 and 33 of the cylindrical portion 29 of cap 28 are positioned opposite and adjacent the inner surfaces of fingers 36, the larger groove 33 being adjacent the lower ends of the fingers. A suitable detonating cap 43 is positioned in passage 34 and is connected to a pair of insulated electrical circuit wires 44, which are passed through passage 25 in pin member 12 and upwardly through body 10 and into the cable head 13, where electrical connection is made with electrical conductors in the cable 14 which extend to the top of the well. The Alexander Patent No. 2,414,349 discloses a detonating cap arrangement suitable for this purpose.

A plurality of rods or wires 45 are arranged in cylinder 11 in crisscross fashion across an intermediate portion of the bore 20 of the plug sleeve 11, as best shown in Figure 3, to form a trap for rocks or other aggregate to provide a seat for retaining the cement or other material which may be deposited on the plug after it is set in the well borehole, as hereinbefore described.

Assembly of the plug 9 is carried on as follows: A suitable length of Primacord 42 is attached to the detonating cap 43, from which extend the cap ignition wires 44. Detonating cap 43 is then placed in passage 34, with the Primacord extended out through radial port 35, and the Primacord is then wound around and positioned in grooves 32 and 33, being wound twice around in the lowermost groove 33 and once around in each of the upper grooves 32. Cap 28 is then inserted in the lower end of plug cylinder or sleeve 11 and secured therein by the use of screws 39 extending into the cylindrical portion 29 of cap 28 through holes 38 in fingers 36. Insulated conductor wires 44, together with link 31, are extended through passage hole 25 of pin member 12, after which the head portion 22 of pin member 12 is inserted into the upper end of cylinder or sleeve 11 and secured therein by screws 27. The shank portion 23 of pin member 12 is then inserted into the lower end of body 10, and link 31 suitably secured to anchor bar 18. Ignition wires 44 are then connected to the conductor wires of the cable 14 which extend into the cable head 13, and the cable head 13 is then screwed at threads 16, 17 to the top of body 10. The plug 9 is then in condition for operation.

In the operation of the invention, the plug 9 is lowered in the well borehole to the desired location. An electric current is then sent through the conductor or conductors in cable 14 and thence through conductors 44 to detonate detonating cap 43, thus in turn detonating the explosive cord 42. The force of the firing or explosion of the explosive cord 42 will deform and bend fingers 36 outwardly into the walls of the surrounding formation or borehole, as shown in Figure 6, so that the plug cylinder or sleeve 11 is firmly secured in the borehole. The force of such explosion, under most circumstances, blows the cap 28 including the cylindrical portion 29 out of the lower end of the sleeve 11 and separates the sleeve 11 from the pin member 12. The plug body 10 may thereupon be pulled up out of the borehole, leaving the plug sleeve 11 firmly anchored in the borehole, as shown in Figure 6. The plug sleeve 11 is then in condition to have the rocks or other suitable aggregate deposited on the wire trap 45, and the cementing operation can then be carried out. By providing the double winding of the explosive cord, such as Primacord, in the lowermost groove 33 and igniting the lowermost winding thereof first, the explosive force progresses upwardly therefrom, resulting in a better shape of bend of the fingers than otherwise would be accomplished because the explosive force is thereby applied first to the lower ends of the fingers.

It is understood that the foregoing is illustrative only and that the invention is not limited thereby, but may include various modifications and changes made by those skilled in the art without distinguishing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member; and explosive means between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug.

2. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having an annular groove; and explosive means in said groove between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug.

3. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member; explosive means between said plug member and fingers adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug; and means for securing said sleeve member to a cable head.

4. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member; explosive means between said plug member and fingers adapted when fired to deform said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug; and means for securing said sleeve member to a cable head, said means including a tubular member having a pin connection with said sleeve member.

5. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member; explosive means between said plug member and fingers adapted when fired to deform said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug; and means for securing said sleeve member to a cable head, said means including a tubular member, a pin member interconnecting said sleeve member and

said tubular member, and a link connection between said plug member and said tubular member.

6. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having a plurality of annular grooves; and explosive means in said grooves between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug.

7. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having a plurality of annular grooves; and explosive means in said grooves between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug, the explosive means in one of said grooves being of greater power than that in an adjacent groove.

8. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having a plurality of annular grooves; and explosive means in said grooves between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug, the explosive means in the groove adjacent the ends of said fingers being of greater power than that in the adjacent groove.

9. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member; explosive means between said plug member and sleeve member adapted when fired to deform said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug; and means for securing said sleeve member to a cable head, said means including a tubular member having an anchor means therein, a pin member interconnecting said sleeve member and said tubular member, and a link connection between said plug member and said anchor means in said tubular member, said pin member having a longitudinally extending bore, and said link connection extending through said bore.

10. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member; explosive means between said plug member and sleeve member adapted when fired to deform said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug; means for securing said sleeve member to a cable head, said means including a tubular member having an anchor means therein, a pin member interconnecting said sleeve member and said tubular member, and a link connection between said plug member and said anchor means in said tubular member, said pin member having a longitudinally extending bore, and said link connection extending through said bore; and a detonating conductor for said explosive means extending from said cable head through the bore of said pin member to said explosive means.

11. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having a plurality of annular grooves, one of said grooves being larger than an adjacent groove; and explosive means in said grooves between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug.

12. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having a plurality of annular grooves, one of said grooves being larger than an adjacent groove; and explosive means in said grooves between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug, said explosive means comprising an explosive cord wrapped around said plug member in said grooves.

13. A retainer plug adapted to be lowered in a well borehole comprising: a sleeve member having a plurality of longitudinal slots at one end forming fingers; a plug member in said end of said sleeve member having a plurality of annular grooves, one of said grooves being larger than an adjacent groove; and explosive means in said grooves between said plug member and sleeve member adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole for supporting a load on said plug, said explosive means comprising an explosive cord wrapped around said plug member in said grooves, said cord being wrapped around said plug member at least twice in said larger groove.

14. A retainer plug adapted to be lowered in a well borehole comprising: an annular member having a plurality of circumferentially disposed, downwardly depending, parallel fingers; a plug member positioned within the confines of said fingers and having a plurality of spaced annular grooves, the lowermost one of said grooves being larger than the others; an explosive cord wound around said plug member and in said grooves; and means for detonating said explosive cord.

15. Apparatus according to claim 14 wherein said explosive cord is wound twice around said plug member in said larger groove and once around it in said other grooves.

16. A retainer plug adapted to be lowered in a well borehole comprising: an annular member having a plurality of circumferentially disposed, downwardly depending, parallel fingers; a plug member positioned within the confines of said fingers; an explosive cord wound around said plug member a plurality of turns; and means for detonating said explosive cord.

17. A retainer plug adapted to be lowered in a well borehole comprising: an annular member having a plurality of circumferentially disposed, downwardly depending, parallel fingers; a cylindrical supporting member positioned within the confines of said fingers; a winding of an explosive cord disposed about said supporting member and having a greater number of turns per unit of length parallel to the axis of said member adjacent the lower end of the said downwardly depending fingers; and means for detonating said explosive cord.

18. A retainer plug adapted to be lowered in a well borehole comprising: an annular member having a plurality of circumferentially disposed, downwardly depending, parallel fingers; a cylindrical supporting member positioned within the confines of said fingers; a winding of an explosive cord disposed about said supporting member with the concentration of said explosive cord per unit of length along the axis of said member increasing downwardly along said depending fingers; and means for detonating said explosive cord.

19. Apparatus adapted to be lowered into and secured in a well borehole comprising: an annular member having a plurality of circumferentially disposed, longitudinally directed fingers; explosive means positioned adjacent the inner surface of said fingers and adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole; means for lowering said annular

member into a well borehole; and means for detonating said explosive means.

20. Apparatus adapted to be lowered into and secured in a well borehole comprising: a sleeve member having a plurality of circumferentially spaced-apart, longitudinally directed slots therein forming a purality of longitudinally directed fingers; a cylindrical supporting member within said sleeve member adjacent said fingers; a body of explosive material extending around said supporting member intermediate said cylindrical member and the inside surfaces of said fingers adapted when fired to bend said fingers outwardly for engaging the surrounding wall of a borehole; means for lowering said sleeve member into a well borehole; and means for detonating said body of explosive material.

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