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3,191,677

METHOD AND APPARATUS FOR SETTING LINERS IN TUBING

Filed April 29, 1963

3 Sheets-Sheet 1

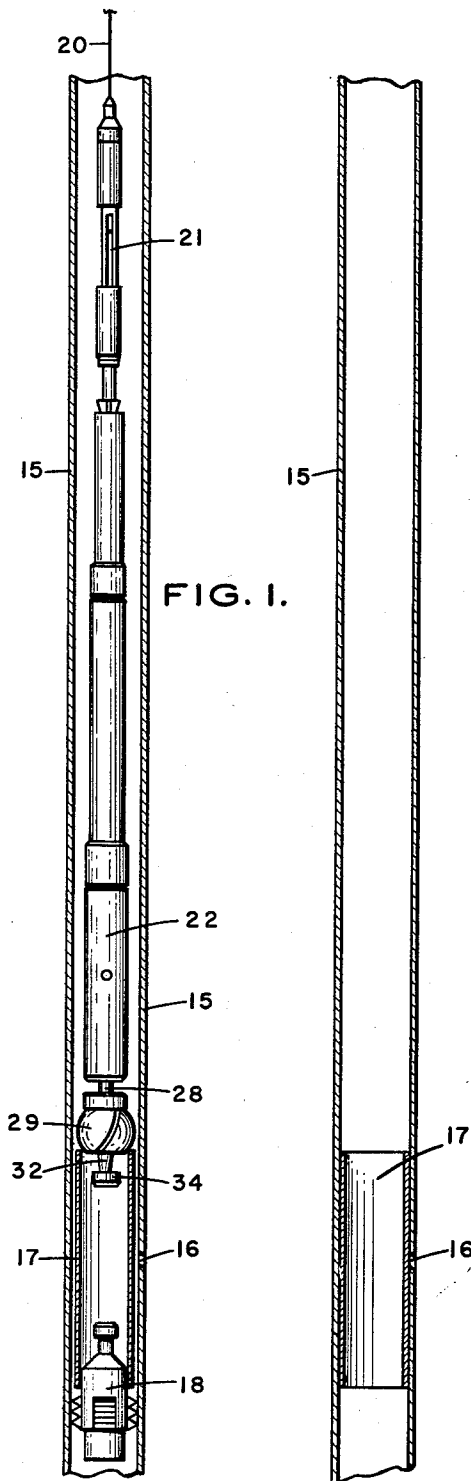


FIG. 1.

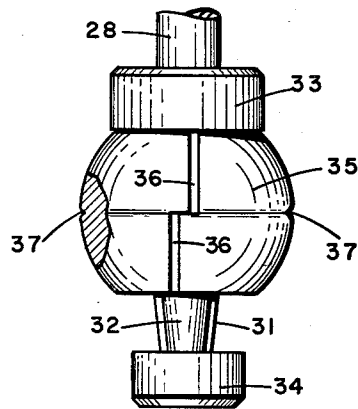


FIG. 8.

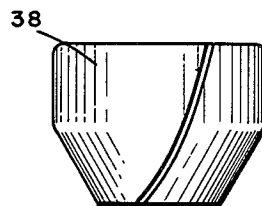


FIG. 9.

FIG. 2.

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FIG. 3.

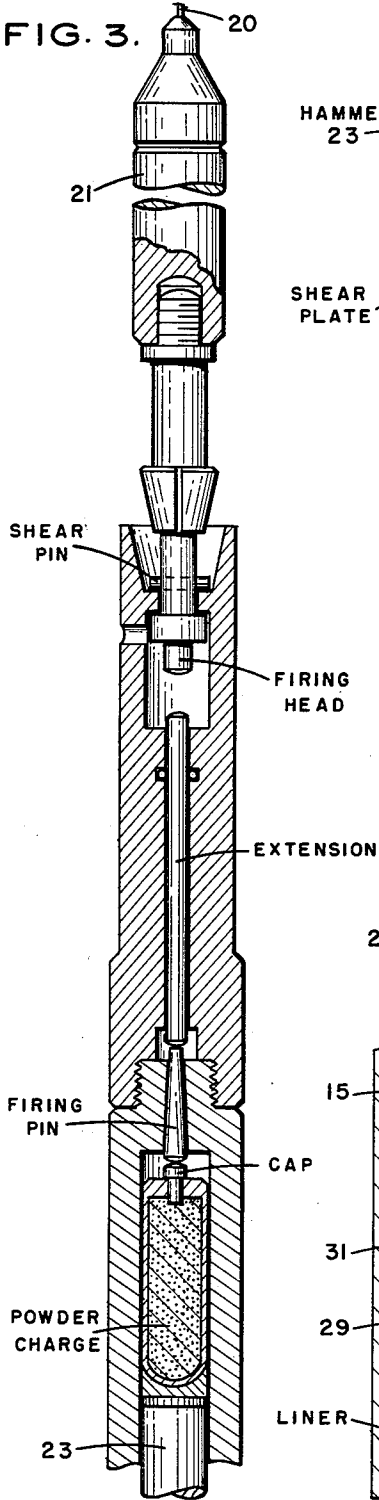


FIG. 4.

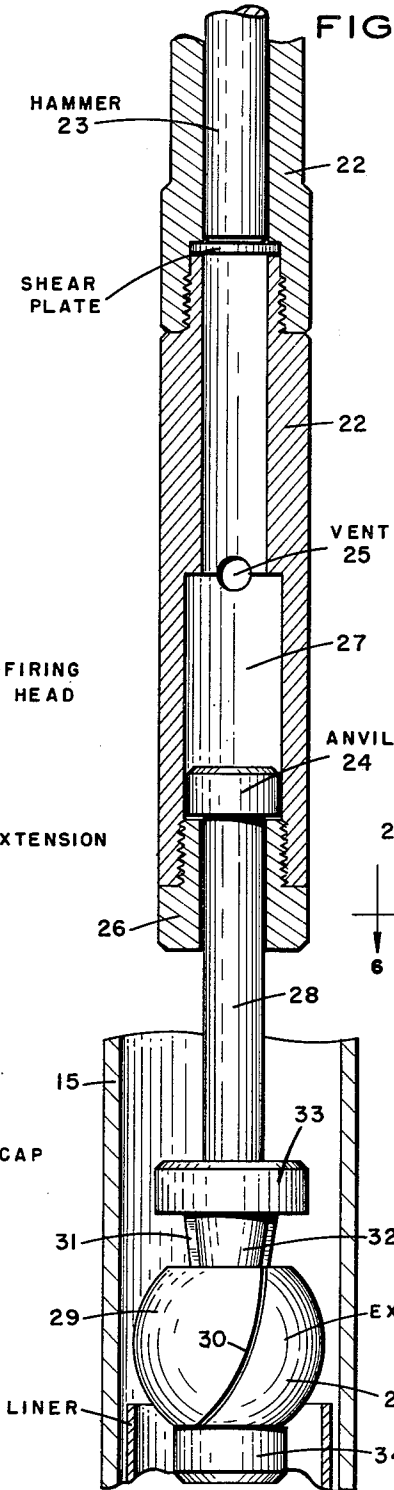
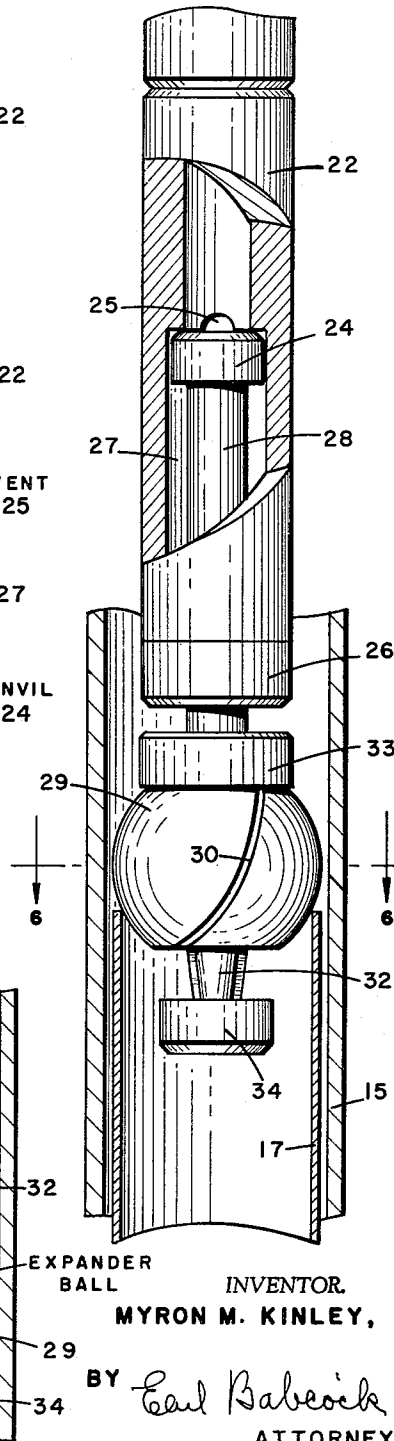


FIG. 5.



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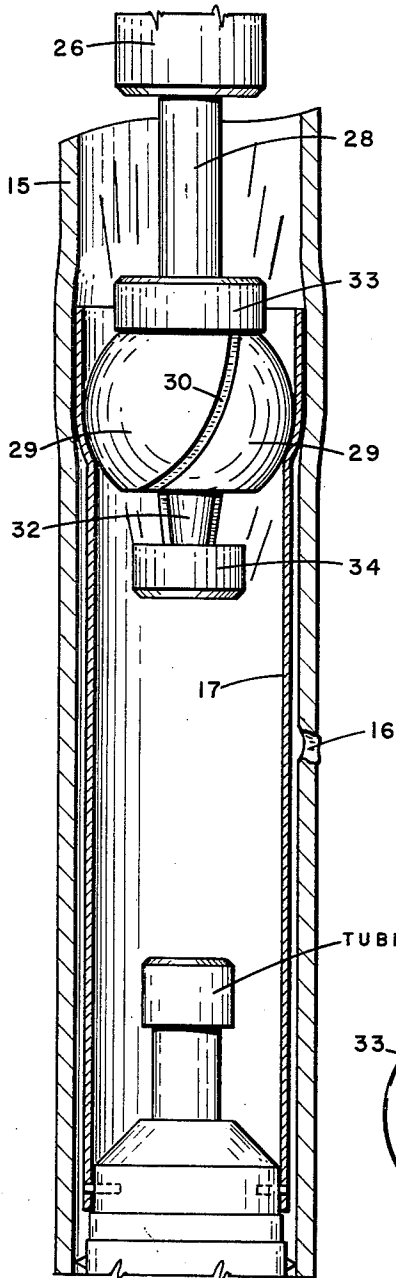


FIG. 7.

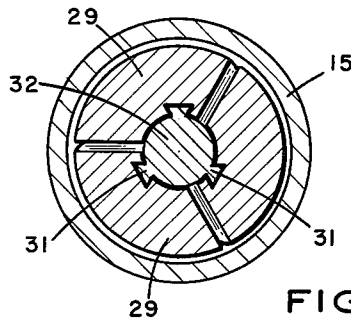


FIG. 6.

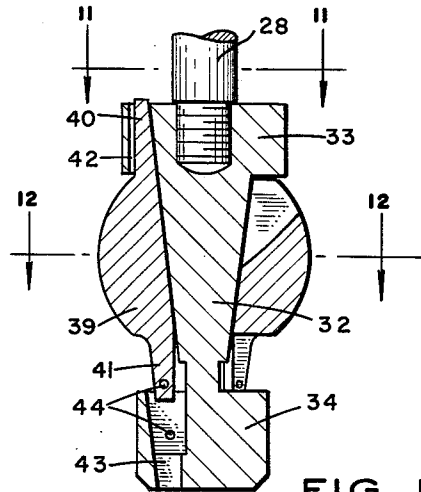


FIG. 10.

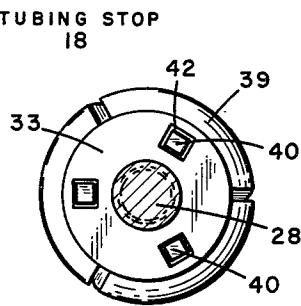


FIG. 11.

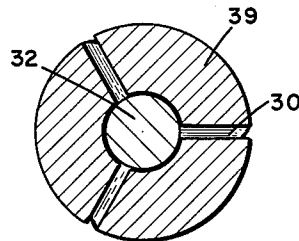


FIG. 12.

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**METHOD AND APPARATUS FOR SETTING  
LINERS IN TUBING**

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Filed Apr. 29, 1963, Ser. No. 276,272

5 Claims. (Cl. 166-14)

This invention relates to liner setting apparatus, and more particularly to methods and apparatus for setting a liner in tubing in an oil well or the like.

When tubing in an oil or gas well has a hole or weak spot in it at a given depth, it has heretofore been proposed to lower a malleable metal liner into the tubing and expand it in such fashion that it spans the hole or weak spot. There may be a hole in the tubing which was purposely put there in some previous operation, or there may be a hole or weak section due to corrosion or erosion by fluids flowing through the tubing.

Prior apparatus for expanding the liner has involved the use of hydraulic pressure on packers or the like. This requires the running of an additional conduit in the tubing. The well cannot be under pressure while the repair of the tubing is being made.

Insofar as known, the prior art does not disclose the setting and expansion of a malleable metal liner in tubing in a well while the well is under pressure. In accordance with the present invention, apparatus is proposed which can be run into a well under pressure through a lubricator, and supported by a single strand wire line, to set such a liner in tubing. The apparatus is controlled by manipulation of the wire line to cause an explosive jar to set the liner. Since the wire line may be run through a stuffing box at the well head, the well may be under pressure, but controlled at all time times during the operation of the apparatus.

It is the main object of the present invention, therefore, to provide a method and apparatus for setting a liner for tubing, whereby the apparatus can be run into a well on a wire line and in which the liner can be caused to expand in the tubing by manipulation of the wire line.

Other objects and advantages will be apparent from the following detailed description of apparatus constructed in accordance with the present invention, when considered with the accompanying drawings, in which:

FIG. 1 is a vertical cross-sectional view of tubing which may be in an oil well, with a liner, also shown in cross-section, located therein opposite a hole in the tubing and supported on a conventional retrievable tubing stop, with apparatus constructed in accordance with the present invention being lowered into the tubing on a wire line;

FIG. 2 is a vertical cross-sectional view of the tubing of FIG. 1 after the liner has been expanded and after the apparatus of the present invention and the tubing stop have been removed from the tubing;

FIG. 3 is a view in side elevation and partial cross-section of an explosive jar which may be run into the well on a wire line, and which forms one element of the apparatus of the present invention;

FIG. 4 is a view in side elevation and partial cross-section of the expander unit of the apparatus of the present invention;

FIG. 5 is a view in side elevation, partially cut away, of the anvil and expander shown in FIG. 4, the parts being shown in position on top of the liner just prior to the delivery of the first jar blow upon the anvil;

FIG. 6 is a transverse cross-sectional view of the expander of FIGS. 4 and 5, the view being taken on the line 6-6 of FIG. 5;

FIG. 7 is a cross-sectional view of the tubing and liner with the expander of FIGS. 4, 5 and 6 shown in the top of the liner after the first jar blow has been delivered, the

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expander being shown in elevation, this figure also showing the top of the tubing stop in side elevation;

FIG. 8 is a view in side elevation, partly cut away, of a modified form of expander;

FIG. 9 is a view in side elevation of still another modification of expander;

FIG. 10 is a view in vertical cross-section of still another modification of expander for use in the present invention;

FIG. 11 is a top view of the expander of FIG. 10, the view being taken on the line 11-11 of FIG. 10;

FIG. 12 is a transverse cross-sectional view of the expander of FIG. 10, the view being taken on the line 12-12 of FIG. 10.

Referring to the drawings in detail, and first to the general assembly shown in FIG. 1, it will be seen that the tubing 15 has a hole 16 therein. Spanning the hole is a liner 17 which may be of steel or other malleable metal. The liner 17 is slightly smaller in diameter than the inside diameter of the tubing, so that it may be lowered down into the tubing to the desired point and be seated on a tubing stop 18.

The tubing stop 18, per se, forms no part of the present invention. Retrievable tubing stops are well known in the art and need not be described here. They are provided with slips which grip the tubing, when set, and may be retrieved from the well by a suitable wire line fishing device.

The liner may be attached to the tubing stop, and lowered into the well with it, or the liner may be positioned after the tubing stop is set in the tubing.

When the liner is in place in the tubing, apparatus for expanding it is lowered into the tubing on a wire line 20. As shown in FIG. 1, this apparatus may include an explosive jar designated generally at 21 and an expander unit designated generally at 22.

The explosive jar 21 will not be described in detail herein. It may be constructed as shown and described in the copending application for U.S. patent of Myron M. Kinley, Serial No. 166,734 filed January 8, 1962 for an Explosive Jar.

When the explosive jar 21 is manipulated by the wire line 20, an explosive charge is fired and this drives a hammer down. As shown in the drawing, and as described in said copending application, there is a firing pin and a cap for igniting the charge; and there is means for actuating the firing pin in response to manipulation of the wire line. In accordance with the present invention, the hammer strikes an anvil in the expander unit 22 and this results in an expander forcing a portion of the liner out into a tight engaging fit with the tubing, the final result, after successive blows have been struck to expand successive portions of the liner, being illustrated in FIG. 2.

The tubing may also be expanded slightly, as the liner is expanded, this being dependent on the dimensions of the expander and like engineering factors.

In FIGS. 3 and 4 of the drawing, the essential parts of the explosive jar 21 and the expander unit 22 are suitably identified.

The hammer 23 of the jar is spaced some distance from the anvil 24 before the firing takes place. This allows the hammer to travel far enough to build up considerable momentum before striking the anvil.

There is a vent 25 in the housing of the expander unit 22 which allows any fluid in the housing to escape when the hammer enters.

The anvil 24 is in the position shown in FIG. 4 when the apparatus is lowered into the well. That is, it is hanging freely in the housing of the expander unit, there being a ring 26 threaded to the lower end of the housing to support the head of the anvil. The anvil is free to travel some vertical distance in the chamber 27, however.

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When the parts are ready for firing the anvil 24 takes the position in the chamber 27 shown in FIG. 5. Thus, when the hammer hits it, it can travel downwardly the length of the chamber 25.

There is a depending stem 28 on the anvil 24 and the lower end of this stem carries the expander, which, before performing the initial operation, rests on the top of the liner 17.

In FIGS. 4, 5, 6 and 7 the preferred type of expander is illustrated as consisting of three segments 29 of a truncated sphere, the segments being formed by diagonal cuts 30, as illustrated. Because of the diagonal cuts, there will be no scoring of the liner 17, and the liner will be expanded radially when the segments 29 enter it without leaving any lands or internal projections thereon.

The segments 29 are connected to the stem 28 by means of splines 31 (see FIG. 6) which are part of a cone 32 which is integral with the stem 28. There are collars 33 and 34 on opposite ends of the cone 32, so the segments 29 are free to move inward and outward radially as the cone 32 is moved vertically with respect thereto. When the apparatus is ready to deliver the first blow to the liner, the segments 29 are in position shown in FIG. 5. That is, they are at the farthest outward position, and the expander is of such diameter in this position as to force the liner 17 outwardly just the desired amount when the expander is driven into the liner, as shown in FIG. 7.

The modified forms of expanders shown in FIGS. 8 to 12 serve the same function as the expander of FIGS. 4 to 7. These are shown to illustrate various ways of providing an arrangement which will drive the liner outward radially but still permit withdrawal upon upward movements.

The expander of FIG. 8 consists of three segments 35 of a truncated sphere somewhat similar to the segments 29 but with the cuts 36 being vertical, but having offset portions above and below an equator line, as illustrated.

There is a groove 37 around the equator to prevent any exposed sharp edges from scoring the liner. Note that the groove is not deep and does not cut the segment in two.

The expander of FIG. 9 is merely to illustrate that the segments may be other than parts of a sphere. Here there are three segments 38, cut diagonally, but the shape is cylindrical with a conical surface at the lower part.

The expander of FIGS. 10, 11 and 12 employs segments of a sphere but this arrangement differs from that of FIGS. 4-7 in the manner of supporting the segments on the cone 32 of the stem 28.

Here the segments 39 are provided with upwardly extending prongs 40 and downwardly extending prongs 41 which fit loosely within sockets 42 and 43, respectively, in the upper collar 33 and lower collar 34. This takes the place of the splines 31 in the preferred form of expander.

There may be provision for holding the segments 39 in their downward, retracted position, for making it easier to lower the assembly into the tubing. In FIG. 10, holes 44 are provided for this purpose, so that a shear pin or the like can be inserted. When the expander strikes the liner 17, the pin will shear and the parts take the position shown in FIG. 10.

If desired, there may be some plastic material, such as rubber, placed in between the liner and the tubing to facilitate the sealing, but this has not been shown in the drawing since it need not necessarily be used.

The operation of the apparatus to expand the liner 17 is as follows:

With the parts in the position shown in FIGS. 1 and 5, the wire line 20 is manipulated to cause the firing head of the explosive jar 21 to strike the firing pin and ignite the powder charge. This drives the hammer 23 down to strike the anvil 27 of the expansion unit 22.

As the anvil moves downwardly, under the impact of the hammer, the expander segments 29 move into the liner and force it outwardly as illustrated in FIG. 7.

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The wire line apparatus may then be retrieved, the segments 29 retracting inwardly as the expander unit 22 is raised.

The explosive jar may then be re-loaded and again lowered into the well. This time, the expander will come to rest inside the liner 17, with the parts in the position shown in FIG. 7, ready to deliver a second expanding operation upon the liner.

Thus successive portions of the liner are successively expanded until the entire liner is forced out into the position shown in FIG. 2.

When the expansion of the liner is completed, the tubing stop 18 may be retrieved, and the well is then in condition for new operation.

While only a few embodiments of the invention have been shown and described herein, it is obvious that various changes may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. The method of repairing tubing in a well under pressure which includes the steps of lowering a retrievable tubing stop through a lubricator into the tubing and setting it beneath the point to be repaired, then lowering a malleable liner through the lubricator into the tubing and setting it on the tubing stop, then lowering, on a wire line, an explosive jar and an expander unit through the lubricator into the tubing until the expander unit is in place on the liner, manipulating the wire line to cause the explosive jar to deliver a hammer blow upon the expander unit to expand a portion of the liner into tight engagement with the tubing.

2. The method of claim 1 in combination with the steps of bringing the explosive jar and the expander unit back up to the surface of the ground through the lubricator, re-loading the explosive jar, again lowering, on the wire line, the explosive jar and the expander unit through the lubricator into the tubing until the expander unit is located at a second position with respect to the liner, and again manipulating the wire line to cause the explosive jar to deliver a second hammer blow upon the expander unit to expand the liner into tight engagement with the tubing at said second position.

3. Apparatus for securing a malleable liner in tubing in a well including the combination of a wire line, an explosive jar connected to and suspended on the wire line, and a retrievable expander unit connected to and suspended by the explosive jar, said explosive jar having an explosive charge, a firing pin and cap for firing the charge, means for actuating said firing pin in response to manipulation of said wire line, and an explosive actuated hammer, and said expander unit having an anvil adapted to receive blows from said hammer and an expander actuated by said anvil, the arrangement being such that as a blow is delivered to said anvil the expander forces a portion of the liner outwardly radially into tight engagement with the tubing.

4. The apparatus of claim 3 in which the expander consists of segments of a truncated sphere provided with means causing the same to have radial movement on a cone connected to said anvil.

5. Apparatus for repairing tubing in a well including, in combination, a retrievable tubing stop, a malleable liner resting on said tubing stop, a retrievable expander unit having an expander adapted to force a portion of said liner outwardly radially into tight engagement with the tubing when driven into said portion, an explosive jar connected to said expander unit for driving said expander into said portion of the liner, said explosive jar having an explosive charge, a firing pin and cap for igniting the charge, and control means for actuating said firing pin, and a wire line connected to said explosive jar and expander unit for supporting the same in the tubing and for manipulating said control means.

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