Feb. 13, 1962 L. H. HAYWARD 3,020,960

TOOL FOR INJECTING FLUENT MATERIAL INTO WELLS

Filed Jan. 27, 1958

FIG. 1.

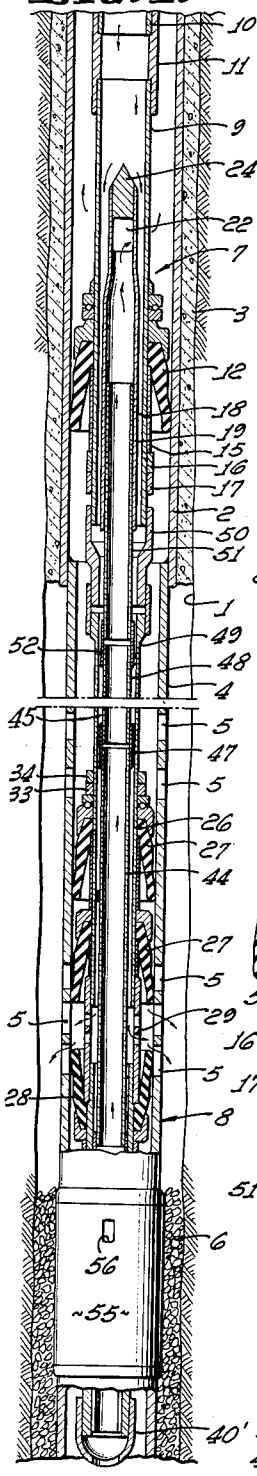


FIG. 2.

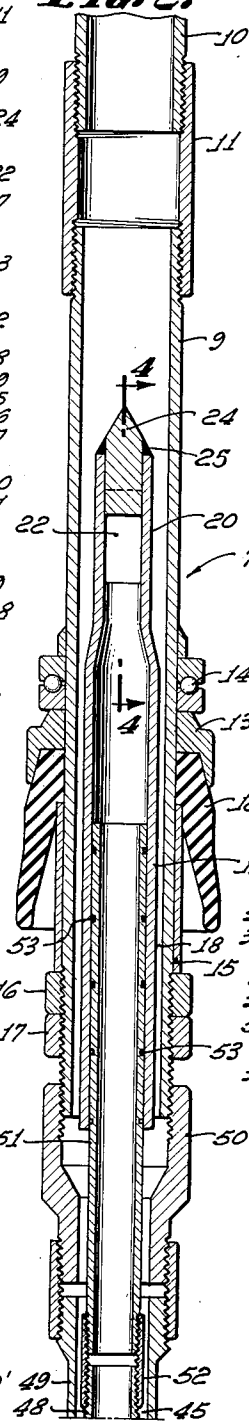


FIG. 3.

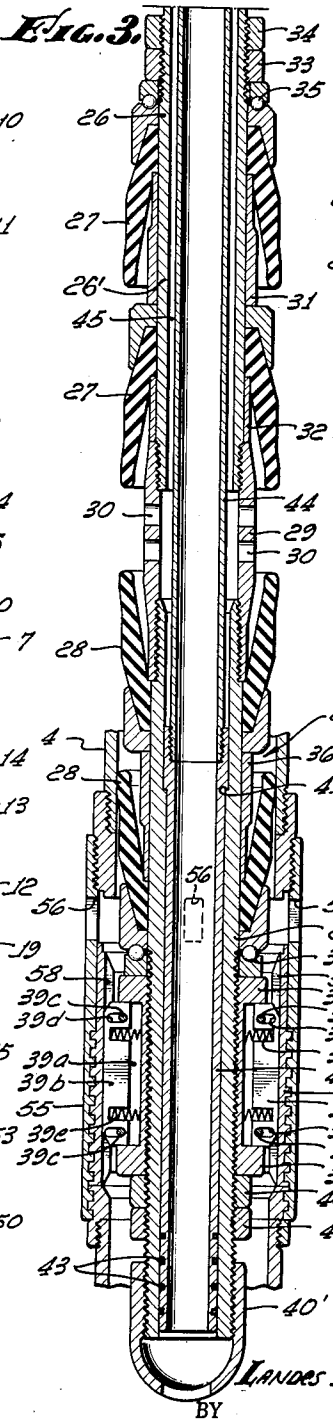


FIG. 4.

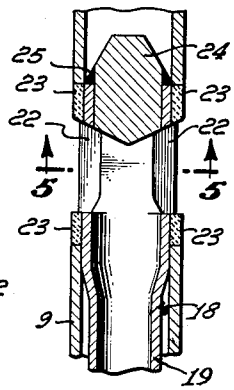
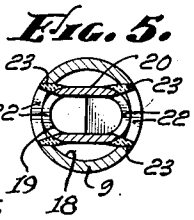


FIG. 5.



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TOOL FOR INJECTING FLUENT MATERIAL INTO WELLS

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The present invention relates to a novel apparatus for injecting fluent materials into oil and gas wells or the like.

In drilling, completing and producing oil wells, it oftentimes becomes desirable or necessary to inject certain fluids into the well. For example, cement slurry may be pumped down into the well for plugging off water bearing strata or cementing casing in place; acidizing is often resorted to for increasing permeability of a producing zone, this being accomplished by injecting an acidizing fluid into contact with the producing zone of the well; gravel packing is resorted to in completing wells, such gravel packing usually including washing the gravel into a tightly packed condition by the injection of fluid into the well. Gravel packs, slotted or perforated liners and the like, oftentimes require washing to remove sand, bituminous deposits or the like therefrom so as to open the liners for the free flow of production fluid therethrough. Indeed, it may be desirable to inject fluid carrying different materials into a well for purposes other than those referred to above.

Devices have been provided heretofore for performing the various well-known fluid treating or placement methods, but such tools have not been altogether satisfactory or adequate. Conventionally, such tools have included means for directing fluid downwardly into a well, from a source of fluid under pressure such as surface pumping units. These conventional tools generally include a central tubing which directs fluid downwardly therein, to the bottom of the tubing, and the fluid is then caused to flow upwardly through the annulus between the tubing and the well bore, liner, casing or the like. Such upward flow of fluid through the annulus or into the zone to be treated, has proven unsatisfactory in many instances, principally because of the presence of other fluids such as well fluids, drilling fluid or the like which must be displaced by the upward-flowing treating, washing or other fluid.

In accordance with the present invention, it is an object to provide a novel apparatus, whereby fluid is pumped down a tubing into proximity to the zone to be treated, washed or the like, at which point the fluid is directed externally of the tubing and is caused to flow downwardly from the point of egress of the fluid from the tubing to the well zone to be treated, the fluid then being directed back to the surface.

The downward flow of fluid to or through the zone to be washed, packed, acidized or the like affords certain significant advantages over fluid treating or placement operations where the fluid must flow upwardly to the zone to be treated. Primary among these advantages is the fact that gravity assists the placement of flow of fluid instead of impeding such placement or flow.

In accordance with the preceding objective, the fluid is caused to flow downwardly through tubing to a novel cross-over in the tubing, at which point the fluid passes on downwardly through an annular space between the tubing and an inner, reduced diameter return tubing. At a desired point, the fluid is then directed outwardly from the tubing into the annulus between the tubing and the borehole wall, casing, liner or the like. The annulus is backed off above the point of discharge so that upward flow through the annulus is prevented, the fluid accordingly flowing downwardly towards the bottom of the well.

Such downward flow of fluid may be availed of for packing gravel in the process of forming a gravel pack in a producing well zone, or such fluid may be availed of for

washing a prepacked slotted or perforated liner or the like; or, for acidizing a producing zone; or for other purposes such as cement placement or the like.

As the treating fluid flows downwardly, any bituminous deposits or other foreign matter, drilling fluid or the like washed from the zone being treated will readily flow downwardly to the lower extremity of the tool, where it will enter the inner reduced tubing mentioned above and flow upwardly to the cross-over, at which point the fluid will pass into the well casing outside the tubing, above the packed-off annulus, and flow on upwardly to the surface through the annulus.

A further object of the invention is to provide a novel apparatus for injecting fluid into wells in accordance with the foregoing, such tool including elongated concentric dual strings of tubing having packer means for preventing the upward flow of fluid between the tool and a well casing or wall and a fluid discharge passage below the packer means for directing fluid from the tubing into the well, an inlet at the bottom of the tool for enabling the entry of fluid into the tubing for flow back to the surface, and means for directing the upwardly flowing fluid into the annular space between the tubing and the well casing above the tool.

Another object is to provide a tool in accordance with the preceding objective, which is simple to manufacture and install in a tubing string in a well.

Pursuant to the latter objective, the tool preferably comprises an upper cross-over assembly and a lower discharge and re-entry assembly, each adapted to be made up in a dual tubing string of any desired length, whereby an elongated assembled tool is provided.

Still another object is to provide a novel cross-over device for directing the inter-flow of fluid between dual concentric conduits.

Other objects and advantages of the invention will hereinafter be described or will become apparent in the light of the following detailed description of the invention as illustrated in the accompanying drawing, and the novel features thereof will be defined in the appended claims.

In the drawing:

FIG. 1 is a view partly in vertical section and partly in elevation, schematically depicting a fluid directing tool made in accordance with the invention and which is particularly suited to the performance of the method hereof, the tool being shown as disposed in a well;

FIG. 2 is an enlarged view in vertical section showing the upper or cross-over sub-assembly of the tool hereof;

FIG. 3 is an enlarged view in vertical section showing the lower or discharge and reentry sub-assembly of the tool hereof;

FIG. 4 is an enlarged fragmentary view in section through the cross-over, as taken on the line 4—4 of FIG. 2; and

FIG. 5 is a transverse sectional view as taken on the line 5—5 of FIG. 4.

Like reference characters in the several views of the drawing and in the ensuing description designate corresponding parts.

Referring to FIG. 1, a well bore is shown at 1, the well having been cased with casing 2, and the casing having been cemented in place by cement 3 interposed in the annular space between the wall of the well bore and the casing.

The well bore 1 is uncased below the casing 2, but a liner 4 is secured to the lower extremity of the casing and extends downwardly in the open bore hole. Such liners are conventionally slotted as at 5 or otherwise perforated or rendered pervious to the flow of well fluids from the well into the liner during production of the well. In some instances gravel 6 may be packed between the liner and the well wall to act as a filter where the productive zone

is sandy or otherwise tends to load the production fluid with solid material which might pass into the liner through the slots 5 or through a screen (not shown) disposed about the liner.

Apparatus embodying the invention is shown as being disposed in the well and extending substantially from the lower extremity of the liner upwardly into the casing 2. Such apparatus generally includes an upper cross-over assembly 7 and a lower discharge and re-entry assembly 8, these sub-assemblies being shown in FIG. 2 and FIG. 3, respectively, on an enlarged scale.

The cross-over assembly 7 includes a tubular section 9 connected at its upper end to a string of well tubing 10 as by means of a coupling 11. A packer cup 12 is rotatably disposed on the tubular section 9 in inverted position, the packer cup having a thimble 13 engaged with an anti-friction bearing 14, the upper race of which is fixed on the tubular section 9. The packer thimble 13 is removably held in engagement with the bearing 14 by means of a sleeve 15 encircling the tubular section 9 and engaged at its lower extremity by a nut 16 threaded on the tubular section 9. A lock nut 17 is also threaded on the tubular section 9 for engagement with the nut 16.

Concentrically disposed within the tubular section and providing an annular flow passage 18 in the section 9, is an inner tubular section 19 of reduced diameter. At its upper extremity, the inner tubular section 19 is provided with cross-over means for causing fluid passing downwardly in tubular section 9 to flow into the annular space 18, and to cause fluid flowing upwardly in the tubular section 19 to cross-over through the tubular section 9 and pass exteriorly thereof. Such cross-over means is provided in a novel manner, in that the upper end portion of the tubular section 19 is pressed in diametrically opposed directions so that its cross-sectional configuration is essentially oval as at 20 (see FIG. 5).

This deformation of the tubular section 19 is preferably such that the opposite sides of the section, in the direction of its major axis, engage the inner walls of the outer tubular section 9. The contacting walls are slotted as at 22 in opposed relation and welded as at 23, so as to secure the tubular sections 9 and 19 together and so as to prevent the flow of fluid between the inside of the reduced tubular section 19 and the annular space 18.

In addition, the upper end of the tubular section 19 is plugged at 24 to prevent the flow of fluid between the inside of the tubular section 9. The plug 24 is preferably sealed and retained in place by a weld 25. Thus, the plug 24 and the upper portion 20 of the tubular member 19 effectively bridge and interconnect tubing sections 9 and 19.

It should be noted that the cross-over means secures the tubular sections 9 and 19 together into a unitary sub-assembly.

The discharge and re-entry assembly 8 includes an outer tubular section 26 having oppositely facing pairs of packer cups 27, 27 and 28, 28 mounted thereon in axially spaced relation. Specifically, as shown, the outer tubular section 26 includes an upper tube 26′ and a lower tube 26″ joined together as by means of a coupling 29 having ports or passages 30 therein leading exteriorly of the assembly between opposed packers 27 and 28.

For rotatably supporting the packers 27 on the upper tube 26′, the upper packer 27 is supported upon a spacer sleeve 31 interposed between the upper packer and the lower packer 27. Another spacer sleeve 32 is interposed between the lower packer 27 and the coupling 29. For holding the packers 27 in engagement with the spacer sleeves, a nut 33 and jam nut 34 are threadedly mounted on the upper tube 26′, with the nut 33 engaging the upper race of a ball bearing 35.

The lower packers 28 which are mounted upon the lower tube 26″ of the tubular section 26 are similarly held in properly spaced relation by means of a spacer sleeve 36 between the packers, the lower packer 28 seating on a ball bearing 37 which is secured in position by an end 38 of an elongated, internally threaded sleeve 39 which is threaded on the tube 26″ and locked in place by means of a nut 40 and a lock nut 40*a*. The sleeve 39 forms part of the mechanism which will be more particularly described hereinafter. Mounted at the lower extremity of the inner tubular section 26 is a bull-nosed or other appropriate end cap 40′.

Seated on an internal shoulder 41 in the lower tube 26″, about midway between the packers 28, 28 is an inner tubular member 42 which loosely fits the tubular section 26″. In order to prevent the passage of fluids between the outer tubular section and the inner tubular member 42, suitable sealing elements such as O-rings 43 are interposed therebetween, preferably adjacent to the lower extremity of the assembly. Threadedly coupled to the inner tubular member 42 at its upper end is a length of tubing 44 of such lesser diameter than the outer tubular section 26 as to provide an annular space 45 therebetween.

The tubing 44 extends upwardly and is joined by a coupling 47 to an inner tubing string 48 concentrically disposed in an outer tubing string 49 which is coupled to the outer tubular section 26 of sub-assembly 8 and to outer tubular section 9 of sub-assembly 7. The latter coupling is preferably in the form of a reducer 50, as best seen in FIG. 2.

Annular space 45 between inner tubular member 44 and the outer tubular section 26 extends upwardly between the inner tubing 48 and outer tubing 49 into communication with annular space 18 in the cross-over assembly 7. A seal sleeve 51 is connected to the upper extremity of the inner tubing 48 as by a coupling 52, the seal sleeve having a suitable number of O-rings or other seals as at 53 for preventing leakage of fluid between the sleeve 51 and inner tubular section 19 of the cross-over assembly 7 into which sleeve 51 projects. It should be noted that with the tool assembled, as shown, the coupling 52 is spaced downwardly from inner tubular section 19 of cross-over assembly 7.

In making up the subject tool in a tubing string, the lower tubular member 26 with the discharge and re-entry assembly 8 carried thereby is run into the well, with the inner tubular section 44 and tubular seal element 42 supported upon the shoulder 41. Dual concentric tubings 48 and 49 are respectively coupled to tubing sections 44 and 26 and may extend for 400 feet more or less. Upper seal sleeve 51 is connected to the uppermost end of inner tubing 48, and the cross-over assembly 7 is made up in the string by coupling 50. Thereafter, the tubing string 10 is completed in the usual manner, as the tool is run into the well. The spacing of coupling 52 downwardly in the outer tubing 49 enables the lower assembly and the upper assembly to be drawn relatively axially, the tubular section 19 sliding on sleeve 51, without interference of the inner tubular section 19 of cross-over assembly 7 with inner coupling 52.

In operation, fluid such as cement, acidizing, washing or other fluid, will be pumped down tubing 10 into the cross-over assembly, where it will be forced by cross-over plug 24 to flow into annular space 18. Such fluid will then flow on downwardly through annular space 45 and into discharge and re-entry assembly 8. Ports or passages 30 in collar 29 will then direct the fluid into the annular space in the liner or casing as the case may be, outside of the tool, between the opposing packers 27 and 28. Presuming the liner or casing to be slotted or perforated above the packers 27, as is the liner 4 of FIG. 1, casing packer 12 at the cross-over assembly 7, will prevent the fluid from flowing upwardly into the annulus outside of the tool. Accordingly, the fluid will flow downwardly, aided by gravity in the case of heavy fluids, as indicated by the arrows in FIG. 1, and re-enter the assembly 8 at the bottom through end cap 40′. The fluid will then flow upwardly through seal sleeve 42, tubular

member 44, inner tubing 48 and into inner tubular section 19 of the cross-over assembly. The cross-over plug 24 will deflect the fluid flow through openings 22 into the annular space outside of tubing 10 for continued flow to the surface.

Accordingly, the treating fluid will have been caused to flow downwardly through the well zone to be treated, so that the gravel may be better packed, sand may be washed from a producing zone, cement may be better placed, and other fluid treating operations may be more advantageously conducted than is possible with many types of well known tools where the flow of fluid in the zone to be treated is upwardly.

Referring to FIGS. 1 and 3, it will be noted that the 39 on the lower tubular member 26'' of outer tubular section 26, constitutes the body of a casing port collar operating means. Therefore, the sleeve 39 is provided with a number of circumferentially spaced, axially extended grooves or seats 39*a* in each of which is disposed a laterally shiftable pad or key 39*b*. The pads or keys 39*b* are retained in the slots 39*a* by means of pins 39*c* extending through elongated slots 39*d* in the keys 39*b*. Coiled springs 39*e* seated in sockets in the keys 39*b* act on the bases of the grooves 39*a* to urge the keys outwardly. The liner 4 is provided with a port collar 55 therein having ports 56 therethrough. Threadedly mounted in the collar 55 by a large lead angle thread is a closure sleeve 57 having internal keyways or tracks in which the keys or pads 39*b* are adapted to engage when the tool is run into the well, whereby rotation of the string of pipe through relatively few, say 3, revolutions will open or close the ports 56, as may be desired. With such a construction, the ports 56 may be opened to enable the passage of fluid from the casing or liner hole annulus into the liner.

While the tool hereof has been described in relation to certain types of fluid treating operations where downward circulation of fluid in a selected zone is desirable, it is to be understood that certain novel features of construction are also applicable to other tools for use in various fluid injection well treatments where upward flow of fluid is desired in the zone to be treated.

Other changes and alterations may be resorted to, without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. Fluid injection apparatus for wells, comprising a fluid conducting cross-over assembly; a fluid discharge and re-entry assembly; and means interconnecting said assemblies; said assemblies each including inner and outer concentrically disposed and spaced tubular members; said cross-over assembly including fluid passage means sealed off from the interior of said outer tubular member for directing fluid between said inner tubular member and the exterior of said outer tubular member; said discharge and re-entry assembly having a port extending through the outer tubular member and an opening in said inner tubular member spaced from said port axially of the discharge and re-entry assembly, whereby fluid may be discharged from said discharge and re-entry assembly through said port and re-enter said discharge and re-entry assembly through said opening; and means for preventing flow through said outer tubular member of the discharge and re-entry assembly between said port and said opening; the means interconnecting said assemblies comprising a pair of tubular conduits interposed between and interconnected with the respective inner and outer tubular members of said assemblies; the conduit interconnected with said inner tubular members of said assemblies having a sliding fit with one of said inner tubular members.

2. Apparatus as defined in claim 1, wherein said cross-over means includes means defining a passageway bridging the inner tubular member of said cross-over assembly, said bridging means being connected to and bridging said outer tubular member of said cross-over assembly.

3. Apparatus for injecting fluid into a well, comprising a tubular assembly of concentric inner and outer tubings adapted to be disposed in a well having a liner having vertically spaced openings therein, a packer about said assembly for preventing the flow of fluid upwardly in the well from below the packer, a pair of opposing packers on said assembly beneath the first mentioned packer and engageable with said liner, with said pair of packers straddling openings in said liner and with other liner openings diposed between the first-mentioned packer and one of said pair of packers, said tubular assembly having an outlet between the packers of said pair of packers and an inlet below said pair of packers, cross-over means in said inner and outer tubings of said tubular assembly having separate passageways for directing separate streams of fluid to flow in said tubular assembly one of which flows to the outlet and the other of which flows from the inlet out of the tubular assembly into the well space above the first mentioned packer, said cross-over means including a tubular part carried by said outer tubing and slidably fitting said inner tubing.

4. Apparatus of the class described, comprising: an outer tubular assembly, an inner tubular assembly, a shoulder in said outer tubular assembly, a shoulder on said inner tubular assembly and supporting said inner tubular assembly on said shoulder of the outer tubular assembly, said inner tubular assembly also including cross-over means having an inner tubular section slidably disposed on said inner tubular assembly, said cross-over means being rigidly connected to said outer tubular assembly, a coupling in each of said outer tubular assembly and said inner tubular assembly adjacent to said cross-over means, said outer tubular assembly and said inner tubular assembly each having an opening communicating with the well in spaced relation axially of the apparatus, and said cross-over means providing a passage leading from said inner tubular assembly to the outside of said outer tubular assembly above said openings and sealed off from the interior of said outer tubular assembly.

5. Apparatus as defined in claim 4, including opposing packers on opposite sides of the opening in the outer tubular assembly.

6. Apparatus as defined in claim 4, including a packer located above the opening in the outer tubular assembly.

7. Fluid injection apparatus for oil, gas wells and the like, comprising a tubing string extending into said well; packer means disposed about said tubing for preventing the upward flow of fluid in the well space outside of said tubing; and means including a fluid cross-over means and fluid discharge and re-entry means for directing the flow of fluid from said discharge means into the well space below said packer means; the re-entry means being disposed below said discharge means; and said cross-over means communicating with said re-entry means and having a passage leading to the well space outside of said tubing string above said packer means; whereby fluid will flow down said tubing string to said discharge opening, down the well space outside the apparatus to the re-entry opening, and upwardly through the latter opening and through the return opening of said cross-over means upwardly in the well space outside of said tubing string; and concentric tubular conduits detachably interconnecting said cross-over means and said discharge and re-entry means, so that said conduit may be of a selected length.

8. Fluid injection apparatus for wells, comprising: first tubing adapted to be disposed in a well; said tubing having a passage for the flow of fluid from the tubing into the well; a second tubing concentrically disposed within said first tubing and having a passage for the flow of fluid from said well into the second tubing; and cross-over means interconnecting said first and second tubings; said cross-over means including a generally elliptical section on said second tubing; said generally elliptical section

being engaged at its opposite ends on its major axis with said first tubing and spaced from said first tubing at its opposite sides on its minor axis to provide a flow passage between said first tubing and said second tubing; said first tubing and said second tubing having openings extending therethrough at opposite ends of said elliptical section on the aforesaid major axis of the latter; means closing the upper end of said elliptical section; and means securing said elliptical section to said first tubing.

9. Fluid injection apparatus as defined in claim 8, wherein the means closing said elliptical section comprises a closure plug at the upper end of said elliptical section; said plug extending into said elliptical section.

10. Fluid injection apparatus as defined in claim 8, wherein said elliptical section is welded to said second tubing entirely about said openings through said first tubing and said elliptical section.

11. Fluid injection apparatus for wells, comprising: a fluid cross-over assembly; a fluid discharge and re-entry assembly; and means fluidly interconnecting said assemblies; said assemblies each including inner and outer concentrically disposed and spaced tubular members; said cross-over assembly including means for directing flow of fluid between said inner tubular member and the exterior of said outer tubular member; said discharge and

re-entry assembly having a port extending through the outer tubular member and an opening in said inner tubular member spaced from said port axially of the discharge and re-entry assembly whereby fluid will be discharged from said assembly and re-enter said assembly; means for preventing flow through said outer tubular member of the discharge and re-entry assembly between said port and said opening; the means interconnecting said assemblies comprising a pair of tubular conduits interposed between the respective inner and outer tubular members of said assemblies, a tubular section axially slidably interposed between the inner tubular member of said cross-over assembly and the tubular conduit connecting the latter assembly to the discharge and re-entry assembly, and means detachably connecting the outer tubular members of said assemblies to the other tubular conduit.

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