Feb. 20, 1968 H. K. TROELLER 3,369,606

METHOD AND APPARATUS FOR INCREASING FLUID YIELD OF DRILLED WELLS

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FIG. 1.

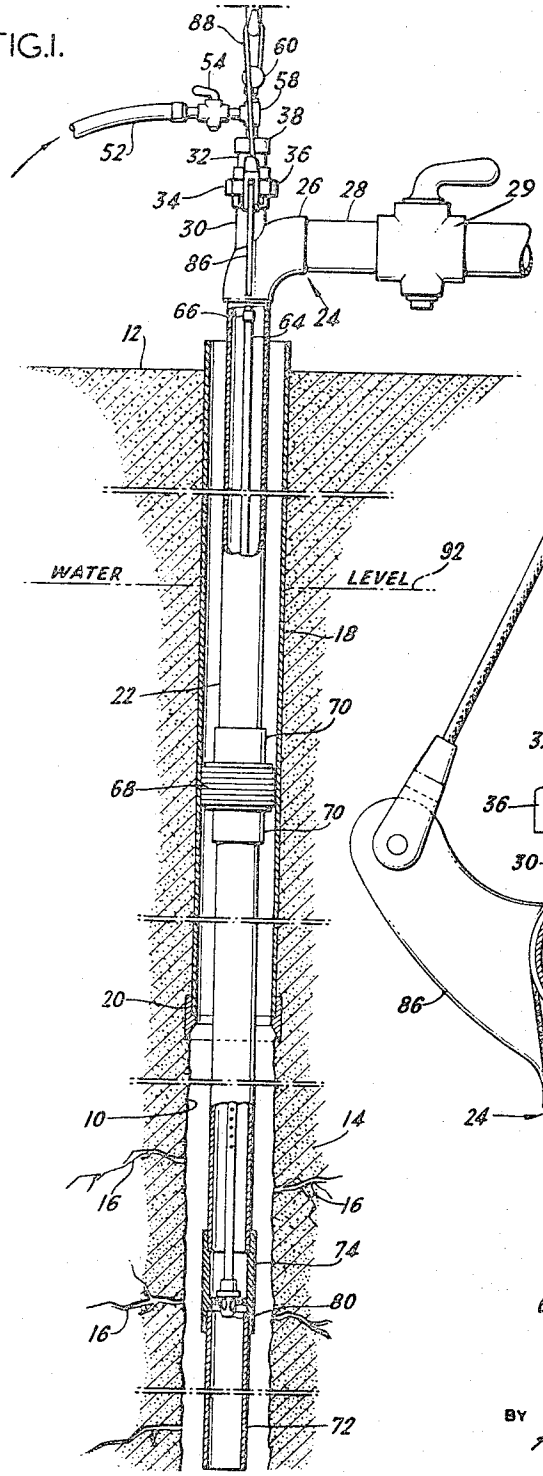
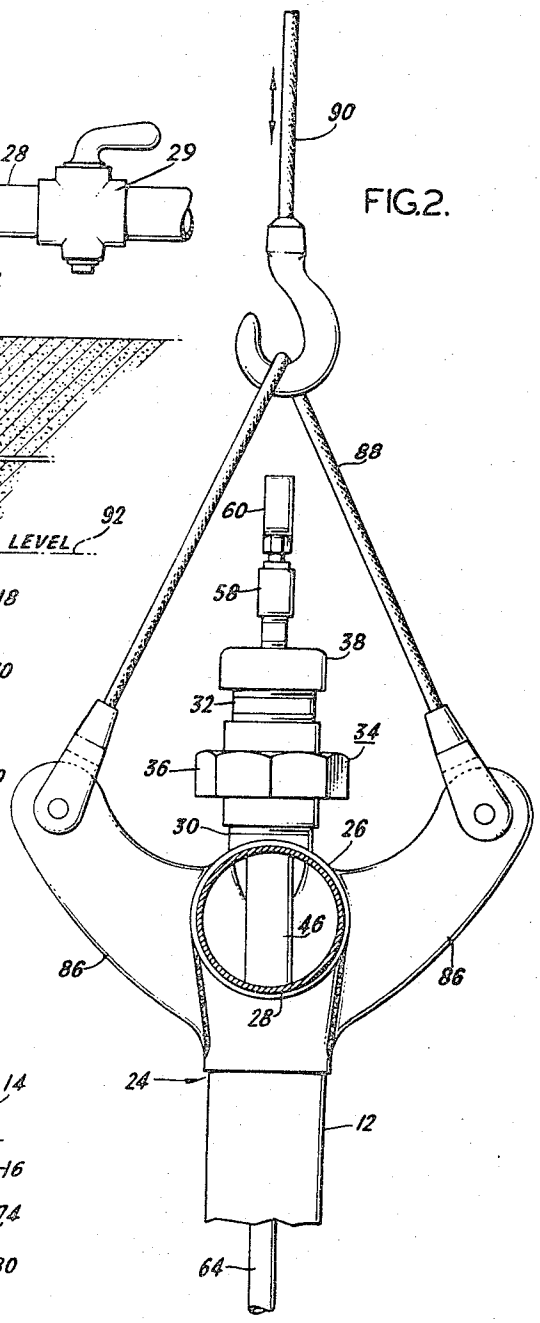


FIG. 2.



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FIG.3.

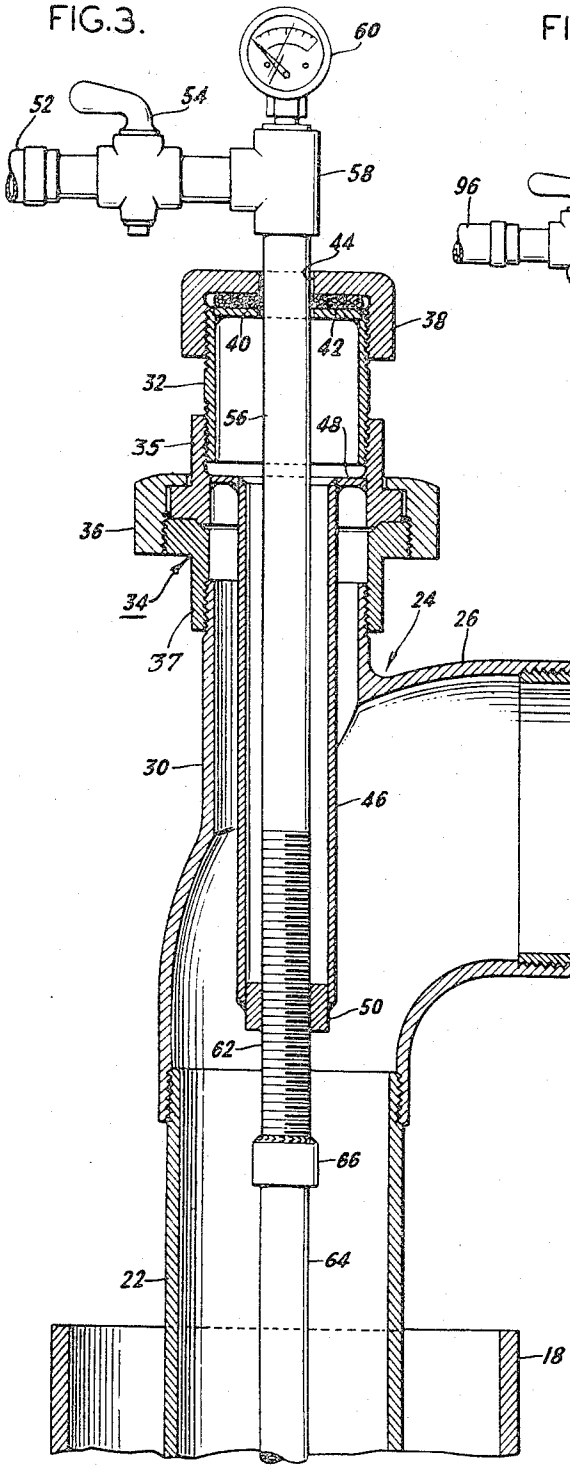


FIG.5.

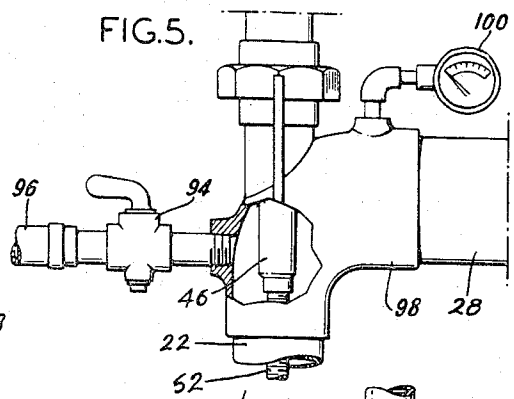
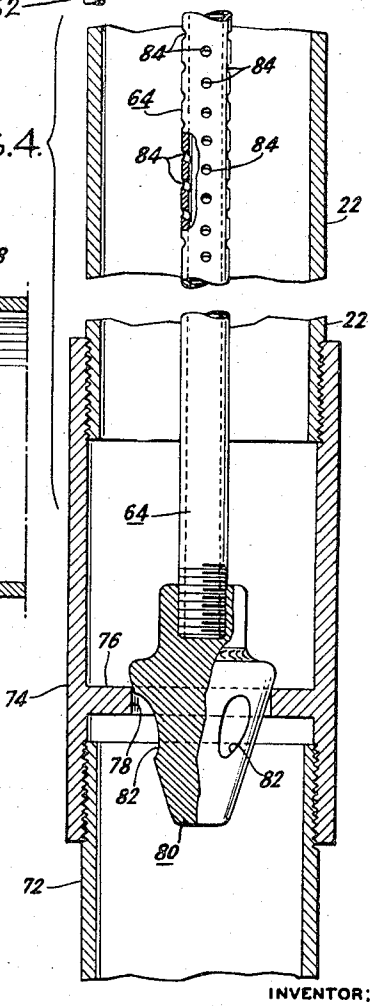


FIG.4.



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United States Patent Office 3,369,606
Patented Feb. 20, 1968

3,369,606

METHOD AND APPARATUS FOR INCREASING FLUID YIELD OF DRILLED WELLS

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Filed Oct. 7, 1965, Ser. No. 493,762
8 Claims. (Cl. 166—44)

ABSTRACT OF THE DISCLOSURE

Apparatus and method for developing wells, particularly wells in consolidated rock formations. The apparatus includes an educer tube having a medial plug slidable in the well casing and operable to be reciprocated vertically, said tube having a restricted opening adjacent its lower end controlled by a conical valve element carried by an air pipe adjustable vertically within said tube and having openings above the opening. In the method, a predetermined developing charge is inserted into the tube and the tube is closed. Thereupon the charge is periodically pressurized to surge the charge out of the tube into the bore to open the fluid passages which admit the well fluid into the bore, thereby developing the well.

The present invention relates to method and apparatus for substantially increasing the fluid yield of drilled wells.

More particularly, the present invention relates to method and apparatus for increasing the fluid yield of wells by developing or re-developing wells completed in consolidated rock formations, or fully developing wells constructed into unconsolidated formations. This is accomplished by cleaning out and opening the interconnected seeps, seams, cracks, crevices, fissures, and like fluid passages out laterally in all directions, both horizontally and vertically up to many hundreds of feet from a well bore, in rock stratas yielding fluid to a well bore or in wells constructed in unconsolidated formations or removing alluvial and other materials from the adjacent subterranean area from which the liquid is drawn.

An object of the present invention is to provide apparatus and a method which is highly effective and economical for developing or re-developing wells, both in consolidated rock structures and unconsolidated formations, thereby eliminating the need for two differest types of apparatus.

Another object of the present invention is to provide a simple and highly effective apparatus which in operation, can be utilized to determine initial yield of a well by test pumping and serve to establish well hydraulics and control tests, as also test pumping operations during and after cycles of development to determine the results of the work. The apparatus also incorporates means for periodical surging and agitating of fluids in the well and chemicals additionally placed therein which have as their purpose, the loosening, dissolving or dispersing of clogging materials such as rock particles, metallic oxides, iron fixing bacteria slimes, clays, slit, mica, lime deposits, cementing agents, and/or others.

The present apparatus accordingly is an adjustable combination surging and pumping apparatus particularly well suited for such well developing or re-developing operations.

Additional objects and advantages of the present invention will be more readily apparent from the following detailed description of embodiments thereof when taken together with the accompanying drawings in which:

FIG. 1 is an elevational view, partly in section, of the combined apparatus of the present invention as inserted in a well bore;

FIG. 2 is a fragmentary elevational view taken at right angles to FIG. 1 showing the developing apparatus head and means for suspension and spudding of the apparatus in the well bore;

FIG. 3 is an enlarged sectional view of the head portion of the developing apparatus;

FIG. 4 is an enlarged sectional view of a portion of an educer showing detals of a surge force control valve; and

FIG. 5 is a fragmentary elevational view of a modified form of developing apparatus head, parts being broken away for clarity.

In the following detailed description of embodiments of the present invention, there is shown and will be described, apparatus used in connection with the developing or redeveloping of wells bored in consolidated rock formations wherein the well casing terminates either at the top of consolidated bed rock formation or at some point in the bed rock formation above the fissures from which fluid feeds into the well. However, the combined apparatus of the present invention is also highly effective for fully developing wells constructed in unconsolidated formations as will be appear hereinafter.

A typical installation of the present apparatus is disclosed in FIG. 1. It is to be noted that in this figure, several breaks have been indicated by broken lines since the apparatus is susceptible of use in wells varying, for example, from 50 feet to 1000 feet in depth. In this figure, a well bore is indicated at 10 which has been drilled in the ground 12 and as indicated at 14, the strata consists of a consolidated bed rock formation having a plurality of fissures 16 from which fluid feeds into the well in a known manner. A well casing 18 is inserted in the bore and in consolidated rock structures terminates either at the top of the bed rock formation or at some point therein above the fissures from which fluid feeds into the well. The casing 18 is provided with a shoe 20 at its lower end which is angularly cut at the lower end in a known manner. The apparatus which comprises the present invention includes an educer 22 consisting of lengths of pipe of adequate size and joined together to provide a length preferably to extend to within approximately one foot of the bottom of the bore of the well being developed. The various sections of pipe can be joined together by means of standard couplings or the like. The upper end of the educer is attached to a top fitting generally designated 24. This section is shown in detail in FIG. 3, and includes an elbow 26 having the discharge opening attached to an educer discharge pipe 28 which has a discharge valve 29 therein. A branch 30 of the elbow 26 is attached to a pipe section 32 by means of a ground joint union 34 having upper and lower halves 35 and 37, and a union nut 36 to permit a tight, water-proof joint.

A cap 38 is screw-threadably attached to the upper end of pipe section 32. The top opening of pipe section 32 is partially closed by a flange 40 welded in the opening and adapted to coact with cap 38 through the medium of packing rings 42 to close the upper end of the apparatus. The cap 38 has a bore therethrough at 44 of dimensions corresponding to the opening in the flange 40. A pipe 46 is secured at its upper end to the upper half of the union 34, shown at 48, and at its lower end has a threaded collar 50.

An air hose 52 is adapted for connection to a suitable source of air under pressure. A quick opening valve 54 is secured to the air hose 52 to control air volume as will appear hereinafter. An upper air pipe section 56 is attached, in an operative manner, to the air hose 52 by a fitting such as at 58, and also operatively connected to the air pipe 56 is a pressure gauge or direct reading altitude gauge 60 to permit accurate setting and control of air pressure and under test pumping operation by momentarily closing the quick opening valve 54 reading the then water level in a known manner. The lower end of the pipe section 56 has a long running thread at 62 engaged

in the threaded collar 50. Additional sections of air pipe shown at 64 can be interconnected one with the other, and to the upper pipe section 56 by a suitable fitting such as at 66. A surge piston 68 is operatively associated with the exterior of educer pipe 22. This surge piston includes an assembly of cupped washers or other known types of ring washers in assembly which can be affixed to the educer tube by slipping the surge piston assembly over a nipple forming a section of the educer tube between two couplings with the couplings with the couplings shown at 70 properly compressing the elements including the washers or the like in a usual manner. The outer periphery of the washer elements fits in a fluid-tight manner within the well casing to plug the bore of the well for purposes hereinafter to be explained.

The lower end of the educer 22 is in effect a suction line to the bottom of the well and is open at the bottom. As shown, a lower educer section 72 is provided and is open at the bottom, and preferably consists of an adequate length of pipe to extend to within approximately one foot of the bottom of the well bore. A fitting 74 in the nature of a coupling is provided having an internal flange 76 with a restricted central opening 78 therein. A solid surge control valve 80 is attached to the lower end of the pipe sections 64 as shown in detail in FIG. 4. This solid valve is generally conical and has a plurality of indentations or grooves milled in the peripheral face thereof as shown at 82. The function of the valve 80 is to adjust the restriction of the opening 78 in flange 76 to control the surge force during functioning of the apparatus. The indentations or grooves are of importance as, while surging and slowly pumping simultaneously, the valve is usually just cracked open, and these indentations are designed so that large pieces of solids being pumped are accommodated through the valve. At a distance above the valve 80, of approximately six feet, there are provided a plurality of air discharge holes 84 in the periphery of the air pipe and which preferably are slanted upwardly from the interior to the exterior to provide air discharge openings through which air will be directed upwardly into the educer tube to facilitate liquid discharge therethrough.

Ears or lugs 86 are secured to the elbow 26 as shown in FIG. 2 by welding or the like, adapted for attachment to a cable 88 for engagement with a suspension and spudding cable 90. The cable 90 is adapted for operative connection with a usual type of well drilling or spudding apparatus, not shown, for alternate upward and downward movement with respect to the well bore. It will be apparent that during such movement, the surge piston 68 will, being below the water level in the casing indicated at 92, cause a surging action with respect to liquid in the well.

Control of the surged force can be effected by adjusting the valve 80 with respect to opening 78. To accomplish this end, the union nut 36 and packing cap 38 are loosened. The air line 56 is held above the cap 38 and a tool is used to turn the upper half 35 of union 34 to which is secured the pipe 46 and threaded collar 50. Turning of the collar 50 on the threaded portion 62 of the pipe section 56 displaces the pipe sections 56 and 64 vertically. Adjustment of the valve 80 is thus accomplished by turning the upper portion 35 of union 34 in the desired direction, and then tightening the nut 36 to anchor the pipe 46 and tightening the cap 38 to reaffect the seal.

In operation, the adjustable combination surging and pumping apparatus is inserted into a well bore with the educer set to approximately one foot off the bottom of the well, and the air line set to a depth of approximately 250 feet more or less depending on known or estimated well hydraulics and with the surge piston set at just below the lowest anticipated pumping level at 10% to 20% of the then maximum yield. A test pumping operation is then performed to establish control test data; then, the well is tested to maximum of test pump capacity to establish initial well hydraulics. A developing charge of

a predetermined amount and type of chemicals is then placed in the educer discharge 28 and a predetermined amount of fluid is injected on top of the chemicals to place the chemicals a desired distance from the well bore into the formation. The chemicals are selected to loosen, dissolve or disperse any clogging material which might be in the crevices or fissures, etc. The valve 29 is closed and the apparatus is then actuated to periodically surge and agitate the chemicals from any degree, from very mildly to extremely vigorously until the chemicals have performed their function. Preferably, the chemicals are agitated for a five minute period for example, every two to four hours over a forty-eight hour period after installation of the apparatus. Subsequently, a surging action can be continued while simultaneously slowly to rapidly or at any desired rate inbetween that may be indicated, pumping the loosened and dissolved material from the formation into the well bore and simultaneously to the surface by opening the valve 29. A test pumping is then conducted to establish the effectiveness of the operation and determine the amount of increased yield. This is repeated a predetermined number of times such as for example, two or more times varying the amount and chemicals as indicated by effectiveness of a preceding cycle. By use therefore of the same apparatus, test pumping operations can be conducted immediately after a cycle of development to determine the results of the work and the feasability of continuing further cycles of development. When the desired yield has been obtained, or no further results appear indicated, then a final full capacity test pump run is conducted to establish the new well hydraulics. Subsequently, the developing apparatus is withdrawn from the well bore and the usual pumping apparatus installed therein.

The foregoing description has been primarily for developing and redeveloping wells completed in consolidated rock formations and under these circumstances, the casings in the wells are not perforated nor are strainers affixed, but solid casings are utilized. The bore below the casing must be uncased through rock structures whether for a few feet or for many hundreds of feet to allow the fluid from the fissures or other fluid passages in the formation intercepted by the well bore to flow into the well.

The apparatus of the present invention, however, is also highly effective and economical for fully developing wells constructed into unconsolidated formations where either the casing is perforated through the fluid yielding strata or stratas, or a well screen or strainer is installed and exposed opposite the strata or stratas. Therefore, the need for two different types of apparatus is precluded.

In FIG. 5 of the drawings there is shown a modification of the present invention. The modification includes the addition of a valve 94 and an additional air feed hose connection 96 to the elbow 98 of the developing apparatus head, and additionally, a gauge 100 connected into the elbow. In other respects, the apparatus is the same. The purpose of this modification is to provide for an additional and separate function as follows: This modified form provides for compressed air or gas under controllable pressure to force the fluid standing within the educer column 22 of the apparatus down and out into the well and far out into the surrounding formation, thus creating a prolonged, high volume and far reaching surge. Subsequently, by quickly opening the educer discharge valve 29, a reversal of pressures can be accomplished. This provides also for an alternate means of surging the well and formation. Additionally, in case of failure of spudding action of a well drilling rig actuating surging operation or failure of surge leather cups, or jamming of apparatus in the well due, for example, to rock sections becoming dislodged from the wall of the well bore and temporarily jamming the apparatus. This alternate method of surging saves the loss of the effects of the chemical injection applied.

It will thus be seen that the present invention provides a method and apparatus for substantially increasing the fluid yield of drilled wells by cleaning out and opening the interconnected seeps, seams, cracks, crevices, and similar fluid passages. This action takes place in all direction from the well bore up to many hundreds of feet therefrom, to thereby increase the fluid yield to the well bore.

Manifestly, minor changes and variations can be effected in the present invention without departing from the spirit and scope thereof as defined in and limited solely by the appended claims:

1. Apparatus for developing drilled wells having an extended bore having in its walls fluid passages through which fluid normally enters the bore, comprising an educer tube extending the full length of said bore and having a restriction adjacent the lower end thereof to define a restricted inlet from said bore into said tube, said restriction comprising an internal flange in said tube having a central opening therein, a valve element in said opening, and means to adjust said valve to vary the flow area through said opening, a surge piston on said tube operable to plug said bore below the fluid level therein and above said inlet, means to effect axial reciprocation of said tube and thereby said plug within said bore, an educer discharge line connected to said tube at its upper end, and a discharge valve in said line operable when closed to prevent pumping of fluid from said well bore and operable when open to afford discharge of fluid from said well bore.

2. Apparatus according to claim **1** including an air pipe extending within said tube and having openings closely above said restriction in said tube to facilitate fluid flow upwardly therethrough, and having a closed lower end mounting said valve element in said opening.

3. Apparatus according to claim **2** wherein said valve element is generally conical and is mounted for displacement axially within said opening, said adjusting means comprising means adjacent the upper end of said pipe for axially displacing the same.

4. Apparatus according to claim **3** including means defining grooves or indentations in the peripheral conical surface of said valve element to afford passage therethrough of particles of material in the fluid flow.

5. Apparatus according to claim **1** including a gas inlet into said tube intermediate said discharge line and said restriction and means to introduce gaseous pressure fluid into said gas inlet operable when said discharge valve is closed to effect pressurized discharge of fluid within said tube outwardly through said restricted inlet at the lower end thereof.

6. A method of developing wells in consolidated rock formations having an extended well bore having in its walls fluid passages through said formations through which the fluid normally enters the bore, comprising the steps of inserting into said bore an educer tube having a lower terminal portion with a diameter less than the bore diameter and a restricted inlet opening therein, and means surrounding said tube above said lower terminal portion to plug said bore below the fluid level therein, inserting a developing charge into said educer tube, closing the upper end of said educer tube, periodically varying the pressure upon said charge to surge said developing charge through said inlet opening into said bore below said plugging means and into said passages so as to clear any clogging materials blocking said passages, and thereafter opening said educer tube and pumping said charge and any cleared clogging material from said bore through said educer tube.

7. A method according to claim **6** wherein said surging step is performed by periodically displacing said educer tube and plug axially within said well bore to expel said charge through said opening.

8. A method according to claim **6** wherein said surging step is performed by periodically injecting pressure fluid into said closed tube below said closure to expel said charge through said opening.

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