Dec. 17, 1957 J. S. HUTCHISON ET AL 2,816,612

DEVICE FOR CLEANING WELL PERFORATIONS

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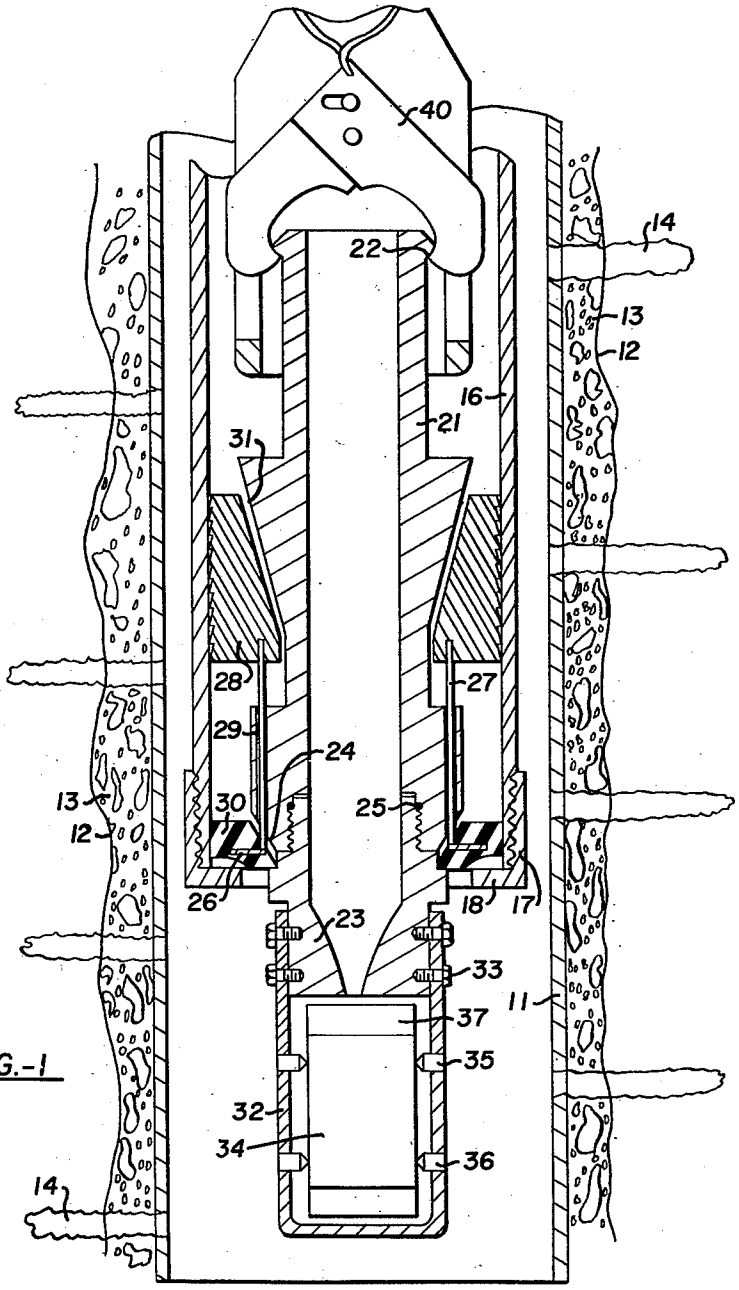

FIG.-1

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FIG.-3

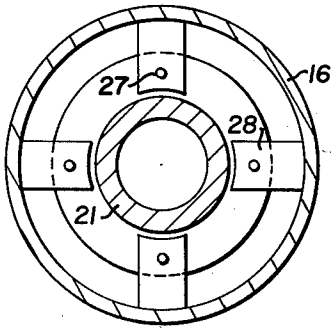
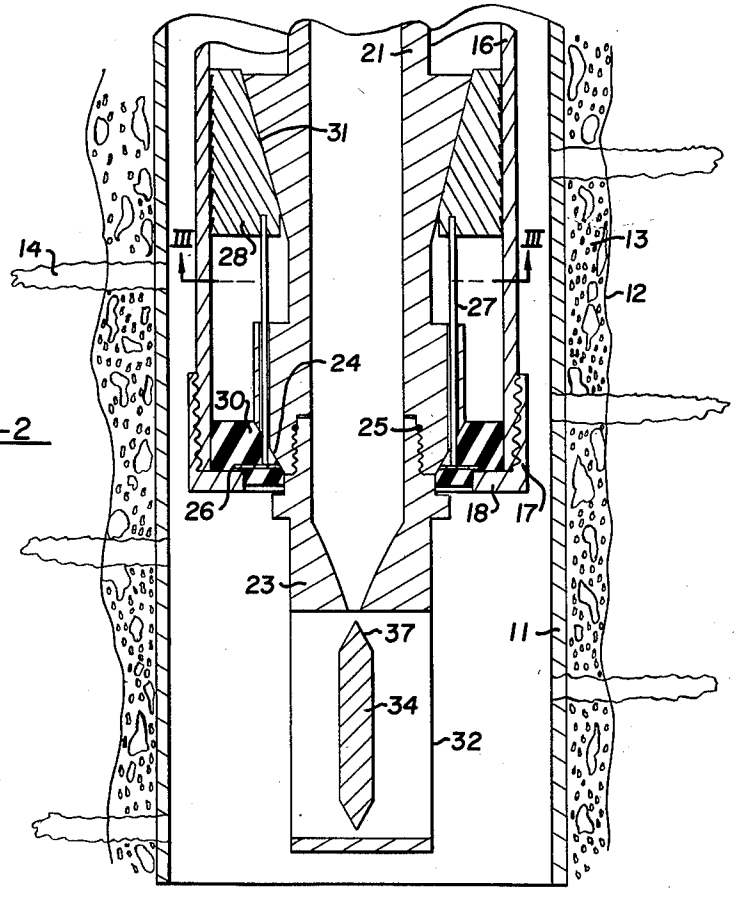


FIG.-2



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DEVICE FOR CLEANING WELL PERFORATIONS

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3 Claims. (Cl. 166—177)

The present invention concerns an apparatus adapted for lowering through a string of tubing for the purpose of cleaning out perforations in a producing formation penetrated by a well bore. The apparatus is designed to generate vibratory energy when fluids are circulated down through the tubing string.

It is common practice in completing a well to perforate the cemented well casing opposite the producing formation. Although in theory the oil will readily flow through the perforations into the well, it often happens that the perforations become plugged by solids in the drilling mud, by particles of the formation, or even by unburnt powder from the explosive charge used for the perforating. It is then necessary to disaggregate and/or dislodge such particles in order that the well will flow freely. One method that has been proposed for cleaning out such perforations involves the use of sound waves, particularly ultrasonic waves, generated by a device lowered through the casing to a position opposite the perforations. The devices used for this purpose have heretofore required either that a power cable be used to supply the necessary energy or else that vibrations be supplied from the surface through a suspending wire line, cable, or tubing. The latter procedure has the disadvantage that considerable attenuation of the vibrations occurs during transmission down the borehole; and the former procedure, involving the use of power cables, entails considerable investment, operating and handling costs.

It is an object of the present invention to provide a retrievable device that can be lowered through the well tubing and set in place at the bottom of the tubing, the device providing a convenient and economical method for generating the required energy by circulation of fluid through the tubing.

The nature and objects of the invention will be readily appreciated when reference is made to the accompanying drawings in which:

Figure 1 is an elevational view in section showing an embodiment of the invention being lowered through the tubing just above the position at which it is set in place;

Figure 2 is a similar view showing the apparatus after it has been set in place, the apparatus being viewed at right angles to the position of Figure 1; and

Figure 3 is a cross section taken on line III—III of Figure 2.

With particular reference to the figures, a string of casing **11** is cemented in place in the bore hole **12** by a body of cement **13**. The casing and the cement as well as the adjacent formation have been penetrated by a plurality of perforations **14** made with conventional perforating apparatus.

A string of tubing **16** is positioned within the string of casing and terminates in the vicinity of the perforations. This tubing is the conventional tubing used for production of oil from the well. Attached to the lower end of the tubing is a collar **17** presenting an inner projection or ledge **18** whose purpose is to receive and retain the apparatus of this invention. The apparatus itself comprises a generally tubular body **21** provided with a spearhead **22** at its upper end by means of which the apparatus may be lowered on a wire line to which is fastened an overshot device **40**.

Threadedly inserted in the lower end of the bore of tubular body **21** is a jet nozzle **23**, an O-ring seal **25** being provided in the threaded connection. The lower end of the tubular body is provided with an exterior tapered portion **24** surrounding which is an annular seal **30** of flexible material such as rubber or the like. Embedded in the sealing material are a plurality of plate segments **26** each of which is fastened to a vertical rod **27** which slidably fits within an appropriate hole or guide **29** drilled through the tapered portion **24**. Conveniently four such rods and plates may be used evenly distributed about the circumference of the tubular body. Each of the rods is fastened to and supports a toothed slip **28** which is adapted to mate with a second tapered portion **31** on the exterior of the tubular body. As will be seen from Figure 2, when the apparatus has been lowered through the tubing to the lower end thereof the sealing material **30** will seat against the ledge **18**. The tubular body will continue to travel downwardly a short distance, causing the tapered portion **24** of the body to expand the seal outwardly to form a fluid tight seal at the bottom of the tubing. At the same time the plates **26** in the compressed sealing material which is against the ledge will cause the rods **27** to remain fixed in elevation, thereby holding the slips at a fixed elevation and enabling the tapered portion **31** of the body to force the slips **28** outwardly by a wedging action upon downward movement of the body, thus anchoring the device solidly within the tubing. After the apparatus has been set in place the overshot device **40** is released from the spearhead by conventional means and retrieved through the tubing by the wire line that was used to lower the apparatus into place.

Attached to the lower end of the body **21** or to the jet nozzle member **23**, as shown, by means of the screws **33** is a U-shaped bracket or holder **32** which holds a vibrator plate **34** in position below the jet nozzle by means of the support pins **35** and **36**. The vibrator plate **34** is provided with a wedge shaped plate edge **37** that is aligned with the nozzle opening. By proper spacing of the vibrator plate with respect to the nozzle opening and by proper spacing of the support pins **35** and **36** the plate will be caused to vibrate by fluid being circulated down through the bore of the support body and leaving the nozzle as a fluid jet that impinges on the wedge shaped edge of the plate. The principles involved in the proper design of the vibrating mechanism are fully described by T. F. Hueter and R. H. Bolt in pages 288 through 295 of Sonics (John Wiley and Sons, Inc., New York, 1955).

In general the design will be such as to produce vibrations within the frequency range of about 15,000 to about 20,000 per second, although the practice of the invention is not to be limited to that range. The fluid will be pumped down through the tubing, through the bore of the support body and will return up the annulus between the tubing and the casing. When the fluid leaves the jet nozzle and impinges on the plate at least a portion of the pressure energy of the fluid in the tubing will be converted into vibratory energy. Any suitable fluid may be used, including water, oil, air or gas. Preferably the fluid employed is a liquid. The vibrations set up in the plate will be transmitted by means of the fluid medium through the perforations to the formation being treated. By raising and lowering the tubing dur-

ing the generation of the vibrations, the entire perforated area of the casing can be treated.

After the well has been treated, the device is retrieved through the tubing by an overshot and wire line and production of oil through the tubing is conducted in the conventional manner.

Use of the invention is of course not limited to the removal of particles tending to plug well perforations, as it is obvious that it can be extended to the removal of mud cake from the walls of the bore hole as well as to the stimulation of oil flow from producing formations.

The scope of the invention is limited only by the following claims.

What is claimed is:

1. An apparatus for supplying vibratory energy to a selected region within a borehole in the earth which comprises a string of well tubing supported at the surface of the earth and extending to the selected region, a generally tubular body adapted to be lowered through said string of tubing, means for seating said tubular body within the lower end of the tubing in an annular fluid tight relation therewith, the lower end of the tubular body extending below the lower end of the tubing and terminating in the form of a jet nozzle, means for passing a stream of fluid down through the string of tubing and thence through the tubular body and the jet nozzle, a vibrator plate, and means attached to the lower end of said tubular body for supporting said vibrator plate adjacent said jet nozzle so as to be vibrated by the jet stream issuing from said nozzle.

2. An apparatus as defined in claim 1 including interengaging means supported by said tubular body and adapted to lock said tubular body within the tubing.

3. An apparatus for supplying vibratory energy to a selected region within a bore hole which comprises a string of tubing extending down the hole to said region, an inwardly extending projection attached to the lower end of the tubing, a generally tubular body adapted to be lowered within said tubing, a passageway extending longitudinally through the tubular body and terminating at its lower end in a jet nozzle, annular sealing means attached to a lower portion of the tubular body and adapted to be moved within said tubing, an exterior tapered portion of said tubular body adapted to compress said sealing means against said projection upon downward movement of the tubular body within the tubing, a plurality of plate segments embedded within said sealing means, a toothed slip for each plate segment, a rod interconnecting each plate segment and its respective slip and supporting the slip above said sealing means, a second exterior tapered portion on said body adapted to expand said slips outward against said tubing upon downward movement of said tubular body relative to said slips, said tapered portions being spaced vertically to compress said seal and to then expand said slips in that sequence, a vibrator plate, means to support said vibrator plate below said jet nozzle, and means to direct a stream of fluid down through said tubing and said tubular body to impinge upon said plate.

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