May 5, 1970 W. F. BALDWIN ET AL 3,509,764

METHOD OF INVESTIGATING WELL BLAST IMPINGEMENT CONDITIONS

Filed July 5, 1968

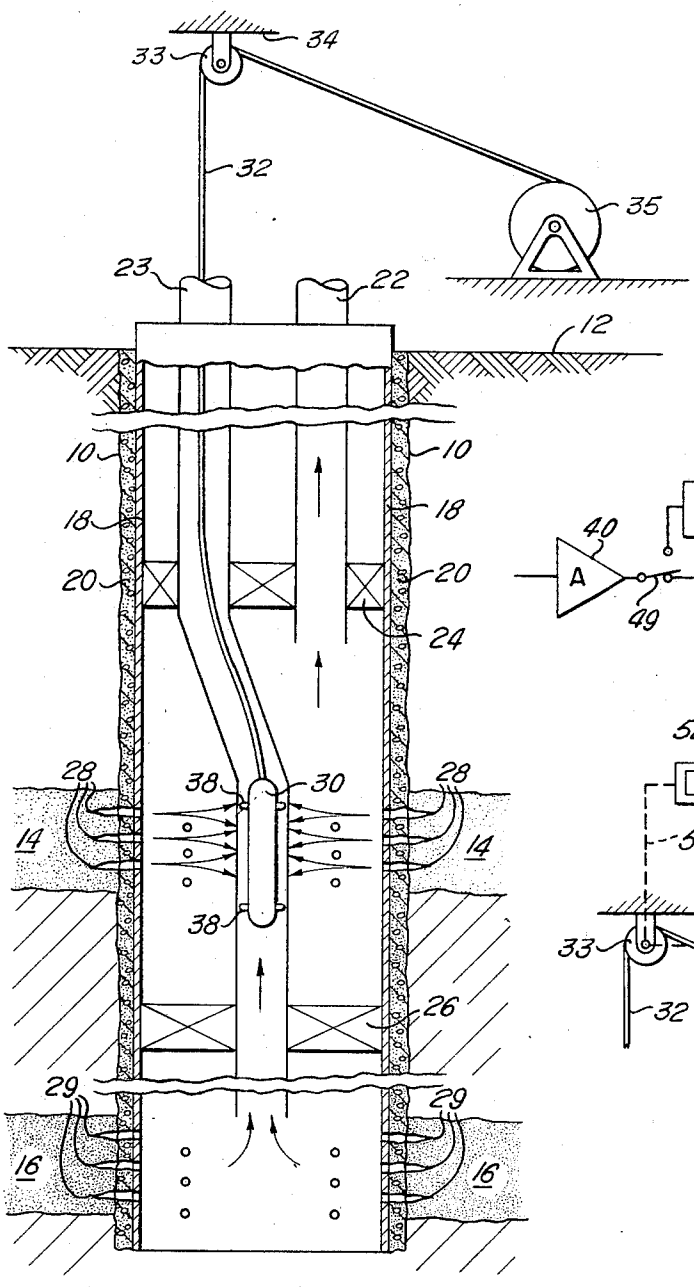


Fig. 1

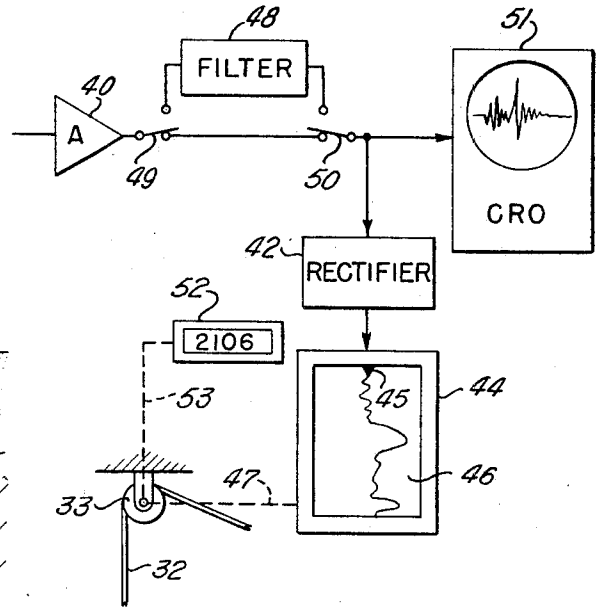


Fig. 2

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United States Patent Office 3,509,764 Patented May 5, 1970

3,509,764

METHOD OF INVESTIGATING WELL BLAST IMPINGEMENT CONDITIONS

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Filed July 5, 1968, Ser. No. 742,670
Int. Cl. E21b 47/10
U.S. Cl. 73—155 7 Claims

ABSTRACT OF THE DISCLOSURE

The specification discloses a method of investigating blast-impingement conditions of a multiply completed well. A sound detector is lowered into the tubing string extending through a producing zone. As the sound detector is moved longitudinally adjacent the producing zone, the ambient sound intensity profile is monitored. Impingement of well stream on the exterior of the tubing string creates sound waves which result in fluctuations of the sound intensity profile.

BACKGROUND OF THE INVENTION

In petroleum wells, tubing strings often extend through a producing zone where production streams flow into the well through perforations in the well casing. This is particularly frequent in multiply completed wells which are designed for production from several vertically spaced producing zones. In a conventional dual completion well, for example, a long tubing string extends from the mouth of the well through a packed-off upper producing zone to a lower producing zone; and a short tubing string extends from within the packed-off upper producing zone to the mouth of the well. With this arrangement both the upper and lower producing zones may produce through their respective tubing strings without intercommunication.

In multiply completed wells a serious problem is caused by the continuous impingement of well stream from an upper producing zone onto the exterior of a long tubing string extending through the upper zone to a lower producing zone. The well stream may flow through perforations in the casing in the form of high velocity jets. The impingement of these jets on the long tubing string, which is known as the blast effect, results in abrasion and erosion of the tubing string until ultimately failure occurs and a hole is created. The well stream flowing through the perforations is often laden with sand, silts, clays, and other formation materials which aggravate the blast effect and quicken failure of the long tubing string.

Sometimes all but a few of the perforations in an upper producing zone may become clogged while the total well flow remains constant. This means that flow through the unclogged perforations is probably at excessive velocity. If it were known that well flow was through only a few perforations, steps could be taken to control the reservoir to maintain the well stream velocity impinging on the tubing below known critical rates.

The state-of-the-art technique for detecting blast conditions is by visual observation at the surface of formation materials, such as sand, that appear in the well production. By this time, of course, failure of the production tubing has occurred and generally any remedial action short of well workover is futile. Replacement of the destructed tubing string often costs hundreds of thousands of dollars, particularly in offshore wells.

SUMMARY OF THE INVENTION

The present invention provides a new technique for detecting and diagnosing blast effect conditions in a well

prior to tubing failure with the subsurface well equipment in place. By the present invention a sound detector is positioned inside a tubing string to detect the sound created by the impingement of well stream on the exterior of the tubing string. The sound detector may be lowered into the tubing by a cable from the earth's surface. As the sound detector is moved longitudinally through the tubing adjacent a producing zone to be investigated, the ambient sound intensity profile is monitored. The sound created by impingement of the well stream on the tubing will cause fluctuations in the sound intensity profile.

The sound intensity profile may be correlated with precompletion data to yield information as to the precise location of blast impingement, the velocity of blast impingement, and perhaps the type of materials laden in the impinging stream, as well as the components of the well stream itself.

In a preferred embodiment of the invention, the sound detector comprises an electroacoustic transducer encased in a subsurface logging tool adapted to pass through a tubing string. The logging tool is suspended by a wireline which transmits signals to surface recording equipment and conveys electrical power to the subsurface logging tool. The electrical signal generated by the transducer in the logging tool is rectified and the amplitude of the rectified signal is recorded as a function of depth of the logging tool in the well. Electrical wave filtering may be provided to suppress background noise frequencies which are not pertinent to the impingement of the well stream on the tubing string.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a dual completion well and the technique of logging according to one embodiment of the present invention; and

FIG. 2 is a block diagram of one form of surface recording.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring to the drawing there will now be described in detail certain specific embodiments of the invention.

In FIG. 1 a wellbore **10** is shown extending from the earth's surface at **12** through an upper producing zone **14** an a lower producing zone **16**. A casing **18** is shown anchored by a cement sheath **20** to wellbore **10**. A tubing string (the short string) **22** extends from the mouth of the well into the casing **18** near the upper producing zone **14**. Another tubing string(the long string) **23** extends from the mouth of the well through the upper producing zone **14** to the lower producing zone **16**. A dual packer **24** and a single packer **26** seal off the upper producing zone **14**. Perforations **28** and **29** are shown respectively in producing zones **14** and **16**.

The upper producing zone **14** is in fluid communication with the short tubing string **22**. Petroleum, such as oil or gas, flows through perforations **28** and through the short tubing string **22** to surface tanks or pipelines. Similarly, the well stream from the lower producing zone **16** flows through perforations **29** and through the long tubing string **23**.

As described above, the blast effect results when the well stream, which is often sand laden, flows through perforations **28** in the form of high velocity jets and impinges upon the exterior of tubing string **23**. When tubing string **23** fails under blast conditions, at least a part of the well stream from producing zone **14** flows into tubing string **23** and is mixed with the well flow from the lower producing zone **16**.

In carrying out the present invention, the lower producing zone **16** is preferably shut in by conventional means

not shown so that no well flow passes through tubing string **23**. The upper producing zone **14** is preferably maintained at normal production so that the blast effect of well stream on tubing string **23** may be investigated under normal operating conditions. A sound detector **30** is inserted into tubing string **23** and lowered by means of a cable **32**. Cable **32** is a wireline which includes conductors for transmitting electrical power to sound detector **30** and conveying the detected signals to surface recording equipment. Cable **32** is shown wound around a reel **35** and passing over a sheave **33** fixed to a support **34**. This arrangement permits moving sound detector **30** longitudinally inside tubing string **23**.

In one mode of operation, sound detector **30** is positioned at a number of points along the producing zone **14**; and at each point while the sound detector is stationary the intensity of the sound created by the impingement of well stream on the exterior of tubing string **23** is monitored. In another mode of operation, sound detector **30** is moved continuously inside tubing string **23** and sound intensity is monitored continuously. Regardless of the mode of operation, the detected sound intensity profile is preferably recorded in correlation with the depth of sound detector **30** in the well.

Sound detector **30** is shown encased in a subsurface logging tool which may be of conventional construction. This logging tool includes bumpers or centralizers **38** which keep the logging tool centrally located in the tubing string and reduce any background noise created by the scraping or banging of the tool inside the tubing string.

Sound detector **30** comprises an electroacoustic transducer of conventional acoustic logging tool design with a radial response pattern. Such a transducer may be of the piezoelectric type, such as lead zirconate material, formed in the shape of a right circular cylinder.

FIG. 2 illustrates in block diagram one form of surface recording equipment. The electrical signal from sound detector **30** is amplified by means in the logging tool and conducted through a surface amplifier **40** and rectifier circuit **42** to a strip chart recorder **44**. Rectifier circuit **42**, which may be of the full wave or half wave type, eliminates the negative-going excursions in the detected signal.

Strip chart recorder **44** is of the conventional type used with ordinary acoustic logging equipment. It includes a moving pen or recording element **45** and a recording medium such as paper **46**. The recording medium **46** is moved relative to recording pen **45** in correlation with the depth of the sound detector **30** by means of an electromechanical link **47** coupled to the sheave **33** over which cable **32** passes.

As the sound detector **30** is moved along the tubing string **34**, recorder **44** produces a log or trace of the amplitude of the sound detected. The recording medium **46** is driven at a rate correlated with the movement of the sound detector and the recording pen **45** moves transversely in proportion to the amplitude of the rectified detector signal. Fluctuations in the amplitude of the log produced by recorder **44** may be correlated with impingement of well stream on tubing string **23**.

If desired, an electrical filter **48** may be placed in circuit with the recording equipment by operation of switches **49** and **50**. Filter **48** may be used to suppress background noise frequencies unrelated to the impingement of well stream on tubing string **23**. Filter **48** may be of any type, such as low pass, high pass, or band pass. Filter **48** may be manually adjustable so that the effect of filtering can be varied to suit different blast effect or noise conditions.

The waveform of the detected signal is shown visually displayed on a cathode ray oscilloscope **51**. The detected signal is applied to the vertical deflection plates of oscilloscope **51**. An arbitrary time base generated within oscilloscope **51** is applied to the horizontal deflection plates.

As filter **48** is adjusted the effect on the detected waveform may be observed visually on oscilloscope **51**.

The depth of the sound detector in the wellbore is indicated visually by a depth readout device **52** coupled by an electromechanical link **53** to sheave **33**. At points along the tubing string at which high sound intensity is shown by the strip chart log, special attention may be given to the adjustment of filter **48** and the resultant effect of the detected waveform observed on oscilloscope **51**. Photographs may be taken of the waveform depicted on oscilloscope **51** for later study and analysis.

Other types of indication or recording of the detected sound may be employed. For example, the intensity of the detected signal may be displayed on a meter and the visual meter readings may be recorded in correlation with depth of the sound detector. Furthermore, the intensity of the sound may be indicated aurally by any suitable means, such as a pair of earphones worn by an operator. By listening to the audio sound created by the impingement of the well stream, an operator may deduce information about blast conditions.

The detected sound may be recorded magnetically for later playback or visual readout. By magnetically recording the detected sound, the signal may be fed to a computer for frequency analysis or signal enhancement.

Various types of measurements of the amplitude of the detected sound signal are suitable. For example, where the impingement of well stream on a tubing string is at substantially constant velocity so that a steady state condition results, a peak measurement may be taken of the amplitude of the detected signal. Alternatively, any of the various time measurements may be made, such as average amplitude or root means square amplitude.

Some of the recording equipment illustrated in FIG. 2 may be located in the subsurface logging tool. For example, the rectifier **42** could be located in the subsurface logging tool so that only the rectified signal would be transmitted to the surface.

Now that several specific embodiments of this invention have been described, it will be apparent to those skilled in the art that still other embodiments may be made still within the true spirit and scope of the invention. It is intended to cover all such embodiments as fall within the scope of the appended claims.

The invention claimed is:

1. A method of investigating a multiply completed cased well including a tubing string extending through an upper producing zone to produce from a lower producing zone, comprising the steps of:

(a) positioning a sound detector inside the tubing string adjacent the upper producing zone, and

(b) while producing from the upper producing zone, monitoring with said sound detector the sound created by the impingement of well production stream from the upper producing zone on the exterior of the tubing string.

2. The method as defined by claim **1** including the steps of:

(a) locating said sound detector at a number of longitudinal points in the tubing string adjacent the upper producing zone; and

(b) recording a signal proportional to the amplitude of the sound detected at each of said points in correlation with the depth of said sound detector in the well.

3. The method as defined by claim **1** further comprising the step of:

filtering the detected sound to suppress background noise frequencies unrelated to the impingement of well production stream on the exterior of the tubing string.

4. A method of investigating a multiply completed cased well including a tubing string extending through an upper producing zone to produce from a lower producing zone, comprising the steps of:

(a) moving a sound detector longitudinally inside the tubing string adjacent the upper producing zone; and

(b) while producing from the upper producing zone with the lower producing zone shut in, monitoring the ambient sound intensity profile with said detector, whereby impingement of well stream from the upper producing zone on the exterior of the tubing string results in fluctuations in the sound intensity profile.

5. A method of investigating a multiply completed, cased well including a tubing string extending through an upper producing zone to produce from a lower producing zone, comprising the steps of:

(a) producing from the upper producing zone in the normal manner;

(b) shutting in the production of the lower producing zone;

(c) lowering a sound detector into the tubing string by means of a cable from the earth's surface;

(d) moving said sound detector inside the tubing string adjacent the upper producing zone and detecting the sound intensity created by the impingement of well production stream on the exterior of the tubing string; and

(e) making a record of the detected sound intensity.

6. A method of investigating a multiply completed, cased well including a tubing string extending through

an upper producing zone to produce from a lower producing zone, comprising the steps of:

(a) producing from the upper producing zone in the normal manner;

(b) shutting in the production of the lower producing zone;

(c) lowering a sound detector into the tubing string by means of a cable from the earth's surface;

(d) locating said sound detector inside the tubing string adjacent the upper producing zone and detecting the sound created by the impingement of well production stream on the exterior of the tubing string; and

(e) making a record of a characteristic of the detected sound.

7. The method of claim 6 wherein said characteristic of the detected sound is recorded as a function of depth.

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U.S. Cl. X.R.

181—0.5; 340—15.5; 166—253