United States Patent [19]

Mullins et al.

[11] **3,908,454**

[45] **Sept. 30, 1975**

[54] **METHOD AND APPARATUS FOR LOGGING FLOW CHARACTERISTICS OF A WELL**

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[73] Assignee: **Mobil Oil Corporation**, New York, N.Y.

[22] Filed: **Jan. 9, 1974**

[21] Appl. No.: **432,129**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 297,097, Oct. 12, 1972, Pat. No. 3,816,773.

[52] **U.S. Cl.** ..... **73/155**; 73/61 R; 340/18 FM; 181/102

[51] **Int. Cl.**[2] **E21B 47/12**

[58] **Field of Search** ..... 73/155, 194 A, 194 B, 73/71.5 US, 61 R; 181/102; 340/18 FM; 310/8.1; 166/250; 175/50

[56] **References Cited**

UNITED STATES PATENTS

2,396,935	3/1946	Walstrom	73/151
3,122,707	2/1964	Godbey	340/18 FM
3,509,764	5/1970	Baldwin et al.	73/155
3,841,144	10/1974	Baldwin	73/61

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Stein, N., et al., *Sand Production Determined From Noise Measurements*, In Journal of Petroleum Technology, pp. 803–806, July 1972.

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[57] **ABSTRACT**

A method and apparatus for logging the flow characteristics of a downhole interval in a well. The apparatus includes a tool which is lowered in the well to the downhole interval where flow, if any, into the wellbore (e.g., through perforations in the well casing) excites a transducer within the tool. The transducer generates a signal in response to flow having dominant ultrasonic frequency components which, when processed and analyzed, establish whether or not flow is actually occurring in said interval and whether or not said flow contains particulate material, e.g., sand. The tool further includes encoding circuitry for processing the downhole signal and for transmitting same to the surface where it is processed into a usable format by surface decoding circuitry.

22 Claims, 6 Drawing Figures

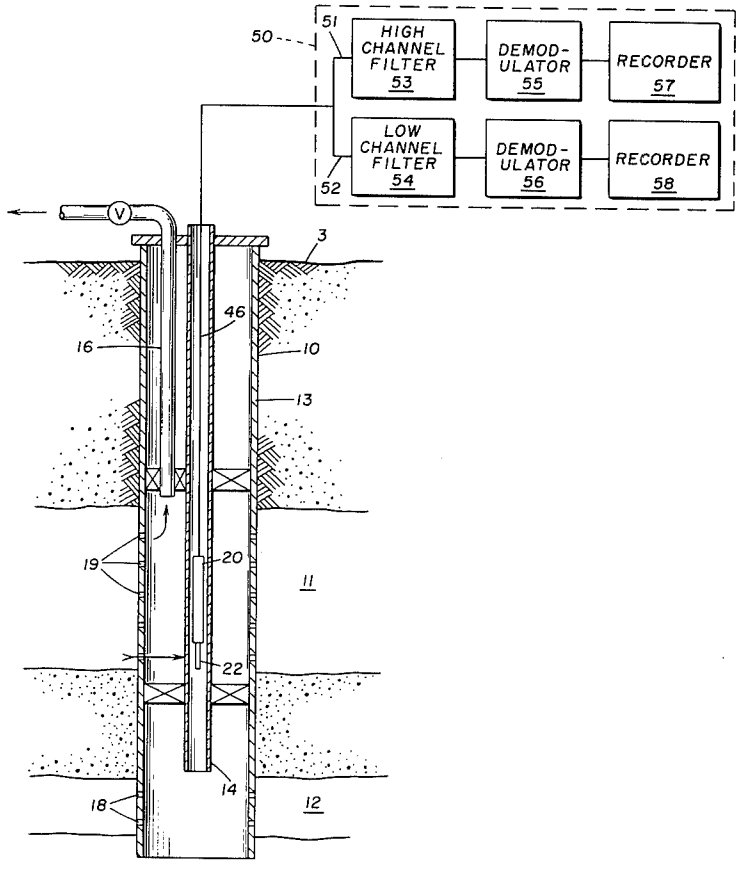


FIG. 1

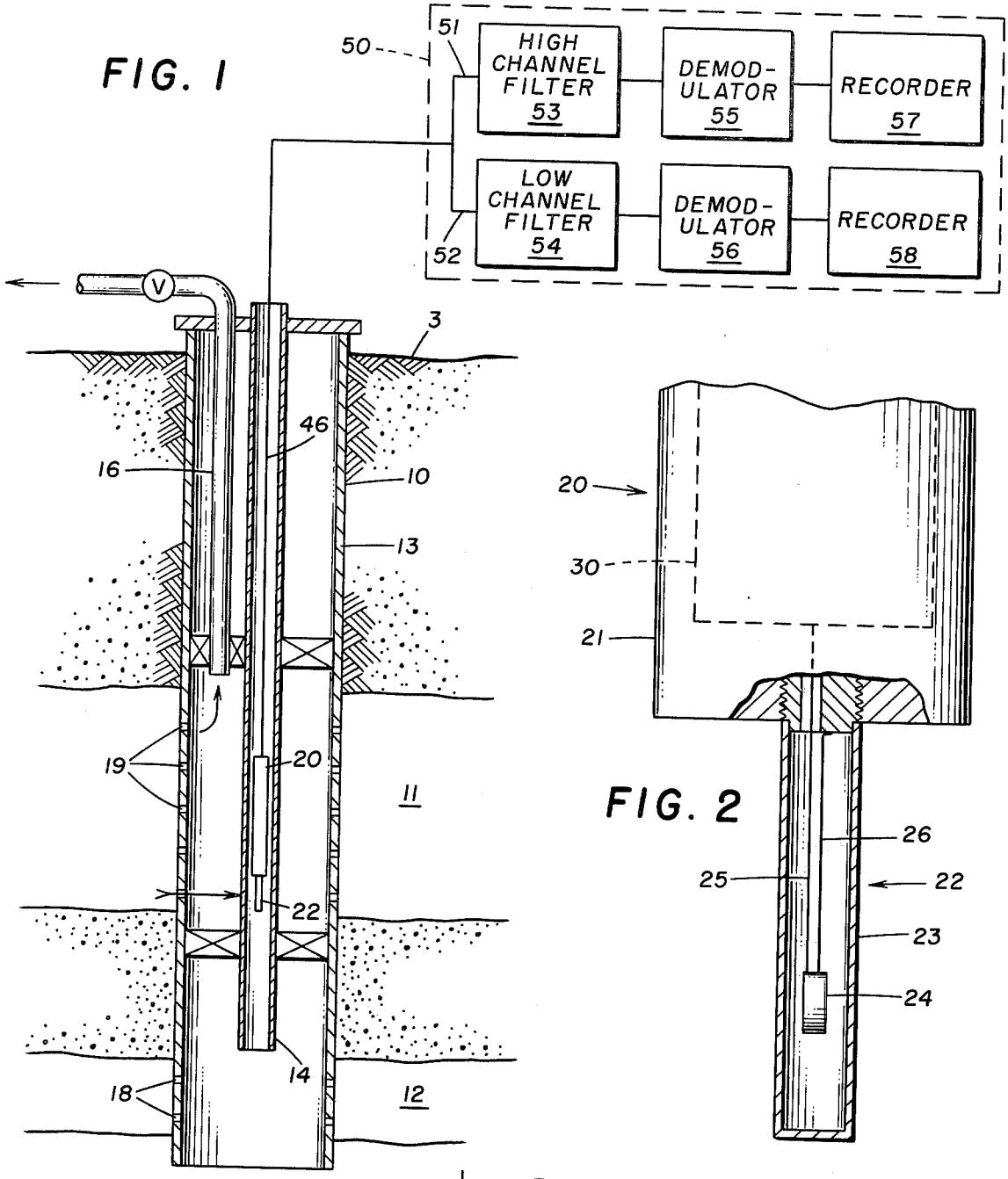


FIG. 2

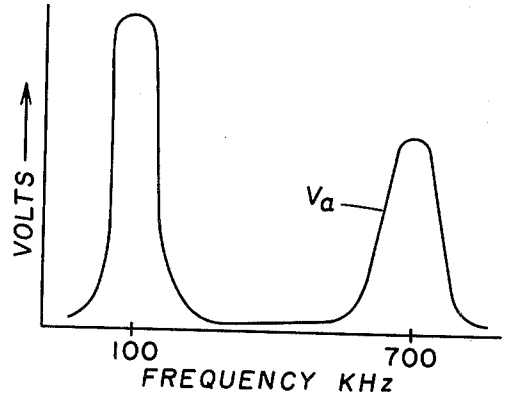


FIG. 6

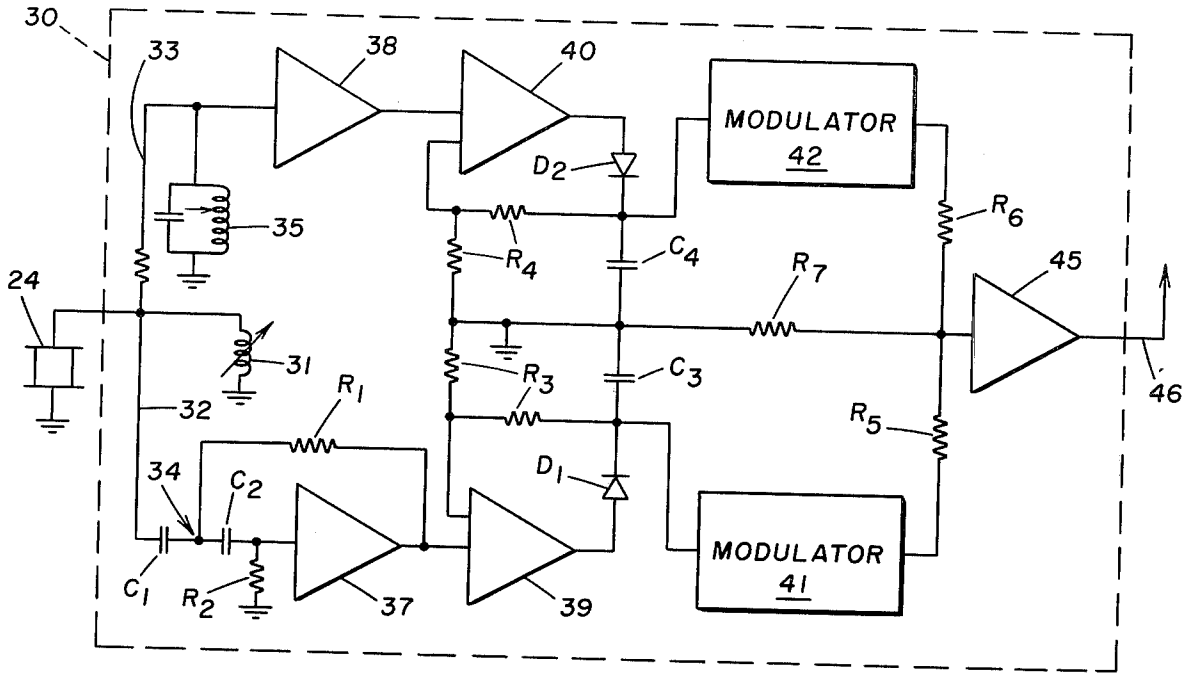


FIG. 3

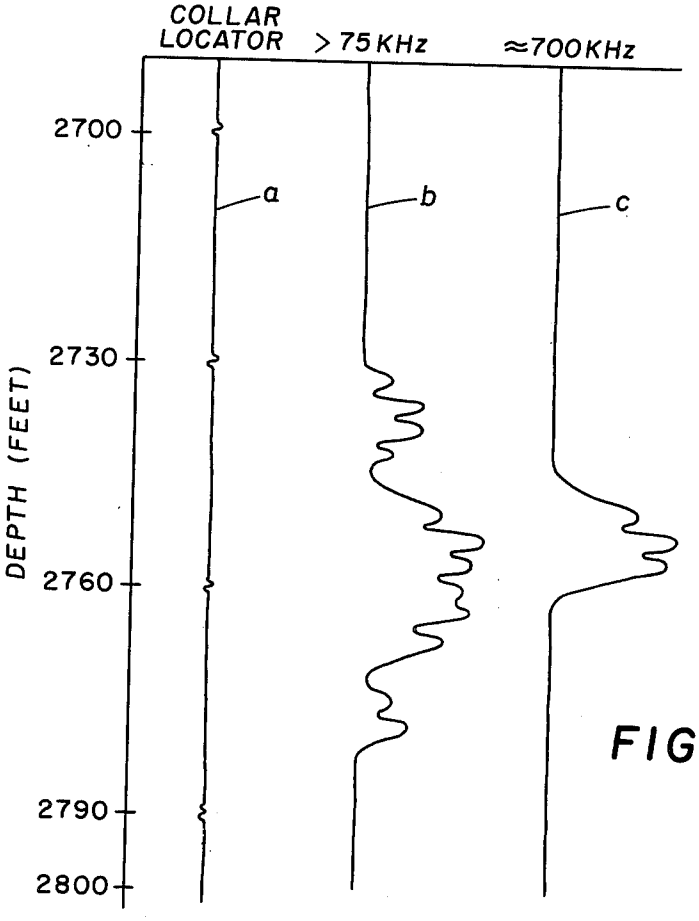


FIG. 4

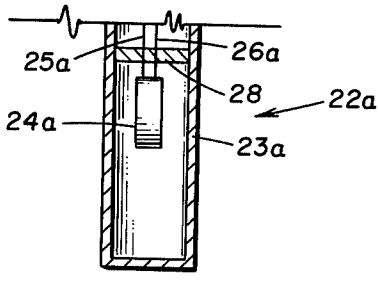


FIG. 5

METHOD AND APPARATUS FOR LOGGING FLOW CHARACTERISTICS OF A WELL

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of copending U.S. Application Ser. No. 297,097, filed Oct. 12, 1972, now U.S. Pat. No. 3,816,773.

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for logging flow characteristics of a well penetrating into the earth and more particularly relates to a method and apparatus utilizing acoustical phenomena for logging a well to determine whether or not flow is occurring through perforations in the well casing and whether or not said flow contains particulate material.

In completing an oil and/or gas producing well, casing is normally cemented throughout the wellbore. A perforating means is lowered in the wellbore to a point adjacent a productive formation and is then actuated to create openings or perforations through the casing to provide paths for the oil and/or gas to flow from the formation into the wellbore. In perforating the casing, however, it is not uncommon for a perforating means to fail to fully perform as designed and, in such instances, several desired perforations are not formed in the casing. Since the number of perforations, their location, size, etc. are important considerations in the overall engineering of a well, it is highly beneficial to determine the effectiveness of a particular perforating operation after it has been carried out.

As an example of why such flow information is important, the pressure and velocity at which production fluid enters the wellbore are normally dependent upon the number and size of the casing perforations in a defined interval. That is, if a perforation operation is designed to provide several perforations throughout a designated interval adjacent a high pressure formation but only a few of these are actually opened, the resultant flow streams entering the wellbore will have much higher velocities than desired. These high flow velocities create problems especially where production is from loose, unconsolidated formations. Particulate material, e.g., sand, from said formations, becomes entrained in these high velocity flow streams and is carried into the wellbore along with the produced fluids. This produced sand is highly undesirable and can cause serious problems, especially where it is produced from the upper zones of a multiply completed well, as will be explained in more detail below. By knowing the downhole flow conditions in a well, corrective measures may be implemented to alleviate several of these problems.

Various techniques for obtaining downhole flow information have been proposed and are known in the art. One technique involves acoustically logging a wellbore to determine the location where fluids are flowing into the wellbore. Such a method is disclosed in U.S. Pat. No. 2,210,417 to Kinney, issued Aug. 6, 1940, wherein leaks are located in a well casing by determining the downhole location of maximum sound produced by fluid passing through an opening in the casing. A sound detector is moved through the well and is connected to an indicating device at the surface. The intensity of sound produced by liquids passing through the casing is thus indicative of leaks in the casing and location of such leaks is readily discernible from a graphical record of intensity versus the depth of the sound detector within the well. A similar method of determining the location of fluid flow into a well is disclosed in U.S. Pat. No. 2,396,935 to Walstrom.

In U.S. Pat. No. 3,509,764 to Baldwin et al., issued May 5, 1970, a technique is disclosed for detecting flow from an upper producing zone of a multiply completed well onto a tubing string extending through the upper zone. A sound detector is moved longitudinally through the tubing and the sound created by the impingement of flow from the upper zone on the tubing is monitored.

In U.S. Pat. No. 3,563,311 to Stein, issued Feb. 16, 1971, a method is disclosed for using a sound detector lowered into a well to record the sound produced by each of several different production flow rates. From this information, the location and the flow rate at which sand is being produced from a formation may be determined.

Also, a technique of using acoustical data generated within a wellbore to determine if fluids may be leaking behind a cemented well casing is disclosed in the article, "The Structure and Interpretation of Noise from Flow Behind Cemented Casing", JOURNAL OF PETROLEUM TECHNOLOGY, Mar. 1973, pp. 329–338.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for logging intervals within a wellbore to determine the location of flow into the wellbore and also to determine whether or not said flow includes particulate material.

More specifically, the present invention involves lowering a logging tool down the wellbore to a point adjacent the interval of the wellbore to be investigated and then recording acoustical data generated by flow impinging either directly on the tool or on an interface within the well which is adjacent the tool.

The logging apparatus of the present invention is comprised of a downhole logging tool and uphole signal processing circuitry. The downhole tool is comprised of a detection probe having a housing in which a transducer means is freely suspended for maximum vibration. The housing is filled with a nonconductive, noncompressible liquid, e.g., oil, to acoustically couple the transducer means to the wall of the housing. The transducer means is one which is capable of detecting dominant ultrasonic frequency components (and generating a signal representative thereof) when said transducer means is excited by flow into the wellbore. Preferably, the transducer means is a piezoelectric means having one primary ultrasonic resonant frequency in one of its modes which includes dominant ultrasonic frequency components generated by normal fluid flow on the transducer housing and another much higher primary ultrasonic resonant frequency in another of its modes which includes dominant frequency components which are indicative of flow which includes particulate material, e.g., a piezoelectric disc having a primary resonant frequency of 100 kilohertz in its radial mode and primary resonant frequency of 700 kilohertz in its thickness mode. Such a probe means is described in our copending U.S. Application, Ser. No. 297,097, filed Oct. 12, 1972, now U.S. Pat. No. 3,816,773, and also is described and claimed in U.S. Pat. No. 3,841,144.

Circuitry within the downhole tool encodes the signal generated by the transducer means and transmits it to the surface where the uphole circuitry decodes same

and presents the resulting signal in some usable format.

Briefly, the method of the present invention involves lowering the present logging tool to a point adjacent the formation interval to be investigated, i.e., normally an interval of perforations through the well casing. If flow is occurring through the perforations, it will excite the transducer means to generate a signal. Under usual flow conditions, if the generated signal has only dominant frequency components in the lower ultrasonic range, e.g., around 100 kilohertz, it establishes that the perforations are open but that no sand is being produced with the flow. If the signal has dominant frequency components in both the low and high ultrasonic ranges, e.g., 100 and 700 kilohertz, then the flow through the perforations contains particulate material.

BRIEF DESCRIPTION OF THE DRAWINGS

The actual construction, operation, and the apparent advantages of the present invention will be better understood by referring to the drawings in which like numerals identify like parts and in which:

FIG. **1** is an illustration, partly in section, of the logging system of the present invention as it might be applied in a multiply completed well;

FIG. **2** is a partial view, partly in section, of the lower portion of the logging tool in accordance with the present invention;

FIG. **3** is a schematical view of the encoding circuitry which forms a part of the logging tool of the present invention;

FIG. **4** is a graph of idealized curves representing downhole flow data in accordance with the present invention;

FIG. **5** is a sectional view of a modified form of the detection means of FIG. **2**; and

FIG. **6** is a graphic representation of the tuned response curve of the transducer of the tool of FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawings, FIG. **1** depicts a multiply completed well **10** which extends through two producing formations **11, 12.** A well casing **13** is cemented throughout the wellbore of well **10** as is well known in the art. Production tubing **14** extends from the surface to a point adjacent lower formation **12,** while production tubing **16** extends from the surface to an isolated interval adjacent upper formation **11.** This allows flow of fluids from the respective formations to the surface without intermixing, as is also well known in the art. By using commonly available techniques, casing **13** is provided with perforations **18** adjacent lower formation **12** and perforations **19** adjacent upper formation **11.**

As is well known, problems exist in achieving all the desired perforations in a desired interval due to proper centering, misfiring, etc. of the perforating means after it has been lowered into position. This failure to achieve complete perforations may cause several problems in the subsequent production of the well. One major problem caused by insufficient perforations in a multiply completed well is erosion of production tubing **14** which results from high velocity flow streams from perforations **19** impinging on tubing **14,** especially where said high velocity flow contains particulate material, e.g., sand.

In accordance with the present invention, logging tool **20** is lowered down the well to a position adjacent an interval to be investigated and, as will be explained below, provides data from which the flow characteristics of the well, including flow of particulate material, if any, can be determined. Tool **20** has a body **21,** on the lower end of which is mounted flow detection means **22** which, in turn, is comprised of a housing **23.** An acoustical transducer means **24** is freely suspended within housing **23** for maximum sensitivity to vibration by means of its signal output lead **25** which is coupled to circuitry **30** in body **21** and by its ground lead **26.** Leads **25** and **26** are electrically conductive wires which have just enough rigidity to insure transducer **24** will be suspended within housing **23** without touching the walls of the housing and at the same time flexible enough to offer the minimum resistance to vibration of transducer **24** when said transducer is excited. Housing **23** is filled completely with a noncompressible, nonconductive liquid, e.g., oil, to acoustically couple transducer **24** to housing **23.**

FIG. **5** discloses a modified embodiment of the lower portion of detection means **22***a*. Spacer **28** is positioned within housing **23***a* to provide support for leads **25***a*, **26***a* and to prevent failure of said leads which may result from repeated flexing in instances where tool **20** is subjected to harsh handling or severe operating conditions. However, it should be recognized that where spacer **28** is utilized, it is positioned so that transducer **24** will still have maximum sensitivity to vibration when said transducer is excited.

In accordance with the present invention, a transducer is selected which generates a signal having dominant ultrasonic frequency components when excited by flow. The transducer has a first primary resonant frequency in one of its modes which provides for the generation of dominant ultrasonic frequency components in response to flow exciting the transducer and which has a second primary resonant frequency in another of its modes which provides for the generation of higher dominant ultrasonic frequency components when the transducer is excited by flow containing particulate material. By utilizing a transducer which generates dominant signals having frequency components in the ultrasonic range, it is possible to better distinguish the actual depth at which a signal originates. For example, if perforations in a well casing are closely spaced, e.g., 6 inches or so apart, a transducer primarily responsive to low frequency signals in the noise normally generated by flow could generate a signal once the tool moved into the proximate vicinity of the flow, this vicinity being a substantial distance either uphole or downhole from the actual flow itself. On the other hand, in the present invention, the tool has to be substantially adjacent the flow before the transducer can generate the dominant ultrasonic frequency components of interest.

More specifically, transducer **24** is preferably a piezoelectric means which is tuned to the primary resonant frequency of one of its modes so that it provides a peak output at said tuned frequency while attenuating most other frequencies. For the detection of particulate material in accordance with the present invention, this primary resonant frequency has to be well above 100 kilohertz range as will be more fully described below. By tuning transducer **24** to a primary resonant frequency, the transducer responds rapidly to the frequencies generated by the kinetic energy given up by the

particulate material impinging on housing 23 or an interface within well 10, and, in turn, produces a signal indicative thereof. The output of transducer means 24 is fed through lead 25 into encoding circuitry 30 which is contained within body 21 of tool 20 and which will be described in detail below.

An example of transducer 24 is a piezoelectric, ceramic means in the shape of a circular disc (e.g., Vernitron PTZ-5), having a 0.5-inch diameter and a 0.1-inch thickness. This particular piezoelectric means 24 has a primary resonant frequency in one of its modes, i.e., the thickness mode, of approximately 700 kilohertz which is well above the minimum 100 kilohertz frequency range required for positive detection of particulate material in the fluid flow in accordance with the present invention. When transducer 24 is tuned by means in tuner 31 (see FIG. 3) to its primary resonant frequency of 700 kilohertz, the typical voltage response v_a of transducer 24 approximates the curve illustrated in FIG. 6.

It will be noted that the response curve (FIG. 6) of the particular mentioned transducer shows two resonant frequencies, one at approximately 100 kilohertz which occurs in the radial mode of the piezoelectric means and another at approximately 700 kilohertz which occurs in the thickness mode of the piezoelectric means. Under flow conditions normally encountered in a well, the output signal generated by transducer 24 upon particulate material striking housing 23 or an interface within well 10, contains dominant frequency components in both the 100 kilohertz range and the 700 kilohertz range while the output signal of transducer 24 generated by flow containing no particulate material will have dominant frequency components in the 100 kilohertz range and above, but will not have any dominant frequency components in the 700 kilohertz range.

The signal generated by transducer 24 by the kinetic energy given up by flow impinging on housing 23 (as is the case with perforation 18) or on tubing 13 (as is the case with perforation 19) is processed by encoding circuitry 30 within body 21. Referring now to FIG. 3, circuitry 30 provides the output signal from transducer 24 a low (flow) channel 32 and a high (sand) channel 33.

The output signal is processed through high pass filter means 34 in low channel 32 and through narrow bandpass means 35 in high channel 33. High pass filter means 34 which is comprised of capacitors C_1, C_2 and resistors R_1, R_2 is designed to pass all frequency components in the output signal beginning near the lowest response, e.g., 75 kilohertz, of the lower primary resonant frequency of transducer 24 (see FIG. 6). Narrow bandpass filter means 35 modifies the output signal to pass only a narrow band of frequencies as small as feasible, e.g., approximately 50 kilohertz wide or less, centered about the tuned frequency of transducer 24, i.e., filter 35 will pass a narrow band of frequencies from approximately 675 to 725 kilohertz while attenuating all other frequencies in the output signal. The outputs of filter means 34 and 35 are amplified by amplifiers 37 and 38, respectively, whose outputs, in turn, are fed into electronic comparators 39 and 40.

The outputs from comparators 39 and 40 are rectified by diodes D_1 and D_2, respectively, and stored on capacitors C_3 and C_4, respectively. One-half the voltage stored on capacitors C_3 and C_4 is fed back to its respective comparator input via respective resistors R_3 and R_4. When the input signals from amplifiers 37 and 38 swing to a voltage more positive than the respective feedback voltage, the respective comparator output swings positive and more charge is added to its respective capacitor. This charge is bled through its respective resistor which lowers the voltage across the capacitor at a rate determined by the respective RC product. Hence, the voltage across capacitors C_3 and C_4 represents a running average of the positive peak voltages from amplifiers 37 and 38, respectively.

Modulators 41 and 42 convert the average peak voltages from respective capacitors C_3 and C_4 to a proportional frequency signal. Modulators 41 and 42 are preferably of the type commonly referred to as a variable voltage-controlled oscillator which is controlled by a variable DC voltage and which outputs an AC frequency signal proportional to said input DC control voltage. The actual output frequency range of each modulator is not critical and the following description is merely illustrative of the generic encoding concepts involved.

Modulator 41 is responsive to the average peak voltages from capacitor C_3 and is designed to have an output signal of 500 hertz when said average peak voltage equals zero. The output signal of modulator 41 varies proportionally downward to 100 hertz with increasing average peak voltages on capacitor C_3. The range of DC to AC frequency conversion of modulator 41 is set by the limits of the average peak voltage normally expected on capacitor C_3.

Modulator 42 performs in a similar manner in response to the average peak voltage from capacitor C_4 except it has a frequency output range of 5000 hertz down to 1000 hertz. Therefore, modulator 41, having a range of 500 to 100 hertz, measures the response of "flow" channel 32 and modulator 42, having a range of 5000 to 1000 hertz, measures the response of "sand" channel 33.

The outputs from modulators 41 and 42 are added, i.e., mixed, by resistors R_5, R_6, R_7 which serve as the driver for amplifier 45 which, in turn, outputs a single mixed output signal which is representative of the sum of the two modulated signals. The mixed output signal from amplifier 45 is then transmitted to the surface by an appropriate means, e.g., logging cable 46 (see FIGS. 1 and 3).

The mixed output signal from cable 46 is received at the surface by decoding means 50 (FIG. 1). The mixed signal is supplied to both a high decoding channel (sand) 51 and a low decoding channel (flow) 52. The mixed signal is processed through filter means 53 in high decoding channel 51 to allow only the 5000–1000 hertz component of the signal to be applied to demodulator 55 which, in turn, converts the processed signal back into a signal indicative of the 675–725 kilohertz detected by transducer 24. The output signal of demodulator 55 is then recorded on a suitable recorder 57.

The mixed signal is processed through filter means 56 in low decoding channel 52 to allow only the 500–100 hertz component of the mixed signal to be applied to demodulator 56, which, in turn, converts the processed signal back into a signal indicative of the dominant frequencies in excess of 75 kilohertz detected by transducer 24. The output signal of demodulator 56 is then recorded on a suitable recorder 58. Although separate recorders are shown for clarity in the drawings, it should be understood that a single recorder, e.g., multi-

ple-pen type, can be used to record the high and low channel information on a single graph or the like.

In carrying out the method of the present invention as illustrated by the drawings, tool **20** is lowered by logging cable **46** down tubing **14** until it is adjacent the interval of well **10** which is to be investigated. In one instance, tool **20** might be lowered out of tubing **14** where it would be exposed directly to flow from formation **12** through perforations **18.** As detection means **22** on the lower portion of tool **20** moves into position adjacent a perforation through which flow is occurring, said flow impinges on housing **23** and gives up kinetic energy which in turn excites transducer **24** within oil-filled housing **23** to generate a signal related to said energy. Tool **20** may be stopped adjacent a particular point in well **10** or it may be moved continuously through an interval to make a continuous log, as explained more fully below. The signal from transducer **24** is continuously processed and encoded by encoding circuitry means **30,** as fully described above, and the resulting mixed signal is transmitted to the surface through cable **46.** The mixed signal is received and processed by decoding means **50** and the final signal(s) is recorded by recorder **57, 58.**

In the illustrative embodiment, after the lower interval adjacent formation **12** is logged, production from formation **12** is shut in and tool **20** is moved upward through tubing **14** to a position adjacent formation **11.** Any flow through perforations **19** will impinge on tubing **14** and will give up kinetic energy. Under proper conditions within tubing **14** (see below), this energy is transferred to housing **23** which, in turn, excites transducer **24,** as described above. The signal generated by transducer **24** is encoded, transmitted, decoded, and recorded in the same manner as previously described. Preferably, in logging through tubing **14,** said tubing is filled with a liquid. This effectively couples housing **23** to tubing **14** and provides an acoustical path for the travel of kinetic energy between tubing **14** and housing **23.** In situations where production from lower formation **12** through tubing **14** is substantially liquid and is under sufficient pressure to flow said liquid to the surface without assistance, there will normally be a sufficient head of liquid present in tubing **14** to carry out the present method. In those instances where there is not sufficient liquid present in tubing **14,** tool **20** is removed from well **10** and tubing **14** is blocked at a point below formation **11** by a tubing packer (not shown) or the like as is well known in the art. Tubing **14** is filled with a liquid, e.g., oil, and tool **20** is then lowered to log the desired interval. Although it is recommended that liquid always be present in tubing **14** for best results when upper formation is logged, laboratory experiments have indicated that flow onto a tubing filled with gas under high pressure, e.g., 4000 psi, will produce a signal which can be detected by tool **20** positioned within said tubing.

After the mixed signal from logging tool **20** has been processed and recorded at the surface, it can be analyzed to determine what the downhole flow characteristics of a particular well interval are. Referring now to FIG. **4,** there is illustrated a typical, idealized record of a logged interval in accordance with the present invention. Curve *a* depicts the signal from a "collar locator" (not shown) which is commonly associated with a downhole logging tool and is used in standard commercial logging operations to identify the depth within the well at which recorded information originates. Curves *b* and *c*, lying parallel to curve *a*, represent dominant frequency components of 75 kilohertz and above and the dominant 675–725 kilohertz components, respectively, in the signal generated by downhole tool **20.** From looking at curve *b*, it can be determined that there is no flow in the logged interval (2700 to 2800 feet) until a depth of 2730 feet is reached and that there is flow into the well between 2730 and 2780 feet. Next, looking at curve *c*, it can be seen that a signal having a predominant frequency component of 675–725 kilohertz occurs only from 2745 to 2760 feet, thereby indicating that flow in this region contains particulate material. If the entire interval of 2700 to 2800 feet was to have been perforated, the log of FIG. **4** would establish that in the 2700 to 2730 foot interval and in the 2780 to 2900 foot interval, the perforation operation was a failure and should be repeated if the well is to be produced as designed. The perforation operation was successful in the 2730 to 2780 foot interval but corrective measures, if desired, should be taken in the 2745 to 2760 foot interval to alleviate sand production.

What is claimed is:

1. A method of investigating the flow characteristics of a downhole interval in a well, said method comprising:

generating a signal at said downhole interval in response to flow into said interval, said signal having dominant ultrasonic frequency components; and

processing said generated signal to provide two processed signals, one of said processed signals having dominant ultrasonic frequency components indicative of flow and the other of said processed signals having dominant ultrasonic frequency components indicative of flow which contains particulate material.

2. The method of claim **1** wherein said processing of said generated signal includes:

filtering said generated signal to pass dominant ultrasonic frequency components of 75 kilohertz and greater to provide said one of said processed signals; and

filtering said generated signal to pass a narrow band of frequency components centered around approximately 700 kilohertz to provide said other of said procssed signals.

3. A method of investigating the flow characteristics of a downhole wellbore interval in a well, said method comprising:

generating a signal at said downhole interval in response to flow into said wellbore interval, said signal having dominant ultrasonic frequency components;

processing said generated signal at said downhole interval to provide a first signal having dominant ultrasonic frequency components indicative of said flow and a second signal having dominant ultrasonic frequency components indicative of flow which contains particulate material;

transmitting said first and second signals to the surface of said well; and

processing said first and second signals into a usable format at the surface.

4. The method of claim **3** wherein said processing of said generated signal at said downhole interval includes:

filtering said generated signal to pass dominant ultrasonic frequency components of 75 kilohertz and greater to provide said first signal; and

filtering said generated signal to pass a narrow band of frequency components centered around approximately 700 kilohertz to provide said second signal.

5. The method of claim **3** where said transmitting said first and second signals includes:

mixing said first and second signals at said downhole interval to provide a single, mixed signal; and

transmitting said single, mixed signal to the surface.

6. The method of claim **5** wherein said well is cased throughout its depth and said interval to be investigated is an interval in which a perforation operation has been carried out.

7. A method of investigating the flow characteristics of a multiply completed cased well including a tubing string extending through an upper producing zone to produce from a lower production zone, said method comprising:

generating a signal within said tubing string adjacent said upper producing zone in response to flow from said upper producing zone onto said tubing string, said signal having dominant ultrasonic frequency components; and

processing said generated signal to produce a first signal having dominant ultrasonic frequency components indicative of flow and a second signal having dominant ultrasonic frequency components indicative of flow which contains particulate material.

8. The method of claim **7** wherein said processing of said generated signal includes:

filtering said generated signal to pass dominant ultrasonic frequency components of 75 kilohertz and greater to provide said one of said processed signals; and

filtering said generated signal to pass a narrow band of frequency components centered around approximately 700 kilohertz to provide said other of said processed signals.

9. Apparatus for investigating the flow characteristics of a downhole interval in a well, said apparatus comprising:

flow detection means adapted to be positioned in a well adjacent the downhole interval to be investigated;

transducer means within said flow detection means which when excited by flow will generate a signal indicative of same, said transducer having a first primary resonant frequency in the range of dominant ultrasonic frequencies normally generated by flow into said downhole interval and a second primary resonant frequency in the range of dominant ultrasonic frequencies normally generated by flow containing particulate material into said downhole interval; and

circuitry means for processing said generated signal to produce a first processed signal having only dominant frequency components beginning near the lowest response of said first primary resonant frequency and greater and a second processed signal having only dominant frequency components in a narrow band centered about said second primary resonant frequency; and

means for transmitting said first and second signals to the surface of the well.

10. The apparatus of claim **9** including:

means for tuning said signal generated by said transducer to said second primary resonant frequency of said transducer.

11. The apparatus of claim **9** including:

decoding circuitry means adapted to be positioned at the surface of the well to process said transmitted first and second signals into a usable format.

12. The apparatus of claim **9** wherein:

said first primary resonant frequency is approximately 100 kilohertz and said second primary resonant frequency is approximately 700 kilohertz.

13. The apparatus of claim **12** including:

means for tuning said signal generated by transducer to approximately 700 kilohertz.

14. The apparatus of claim **13** wherein said circuitry means includes:

encoding circuitry for processing said generated signal to produce a first processed signal having those dominant frequency components in said generated signal of 75 kilohertz and greater and a second processed signal having those dominant frequency components in said generated signal which lie in a narrow band centered about approximately 700 kilohertz.

15. The system of claim **14** wherein said encoding circuitry means includes:

modulator means for converting said first processed signal into a first AC signal proportionate to said first processed signal and for converting said second processed signal into a second AC signal proportionate to said second processed signal; and

means to add said first and second AC signals to produce a single, mixed signal for transmission to the surface

16. The apparatus of claim **15** including:

decoding circuitry means adapted to be positioned at the surface of the well, said decoding circuitry means comprising:

means to separate said single, mixed signal into said first and second AC signals; and

demodulator means to convert said first AC signal into a first signal representative of said first processed signal and to convert said second AC signal into a second signal representative of said second processed signal.

17. Apparatus for flow the flow characteristics of a downhole interval in a well, said apparatus comprising:

a body adapted to be positioned in a well adjacent the downhole interval to be investigated;

a housing mounted on said body;

transducer means suspended in said housing for maximum sensitivity to vibration to generate a signal in response to said vibration, said transducer means having a first primary resonant frequency in the range of dominant ultrasonic frequencies normally generated by flow into said downhole interval and a second primary resonant frequency in the range of dominant ultrasonic frequencies normally generated by flow containing particulate material into said downhole interval;

noncompressible liquid filling said housing to acoustically couple said transducer means to said housing;

encoding circuitry means in said body for processing said signal generated by said transducer means to produce a first processed signal having only domi-

nant frequency components beginning near the lowest response of said first primary resonant frequency and greater and a second processed signal having only dominant frequency components in a narrow band centered about said second primary resonant frequency; and

means for transmitting said first and second processed signals to the surface of the well.

18. The apparatus of claim **17** wherein said first primary resonant frequency is approximately 100 kilohertz and the second primary resonant frequency is approximately 700 kilohertz.

19. The apparatus of claim **18** wherein said encoding circuitry means includes:

means for processing said generated signal to produce a first processed signal having only dominant frequency components of 75 kilohertz and greater and a second processed signal having only a narrow band of dominant frequency components centered about approximately 700 kilohertz.

20. The apparatus of claim **19** including:

decoding circuitry means adapted to be positioned at the surface of the well to receive and process said transmitted signal into a usable format.

21. The system of claim **20** wherein said encoding circuitry means includes:

modulator means for converting said first processed signal into a first AC signal proportionate to said first processed signal and for converting said second processed signal into a second AC signal proportionate to said second processed signal; and

means to add said first and second AC signals to produce a single, mixed signal for transmission to the surface;

and wherein said decoding circuitry means includes:

means to separate said single, mixed signal into said first and second AC signals;

demodulator means to convert said first AC signal into a first signal representative of said first processed signal and to convert said second AC signal into a second signal representative of said second processed signal.

22. The system of claim **21** wherein said decoding circuitry means further includes:

means for recording said first and second representative signals.

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