March 16, 1954 B. W. SEWELL 2,672,050

APPARATUS FOR LOCATING UNCEMENTED PORTIONS OF WELL CASINGS

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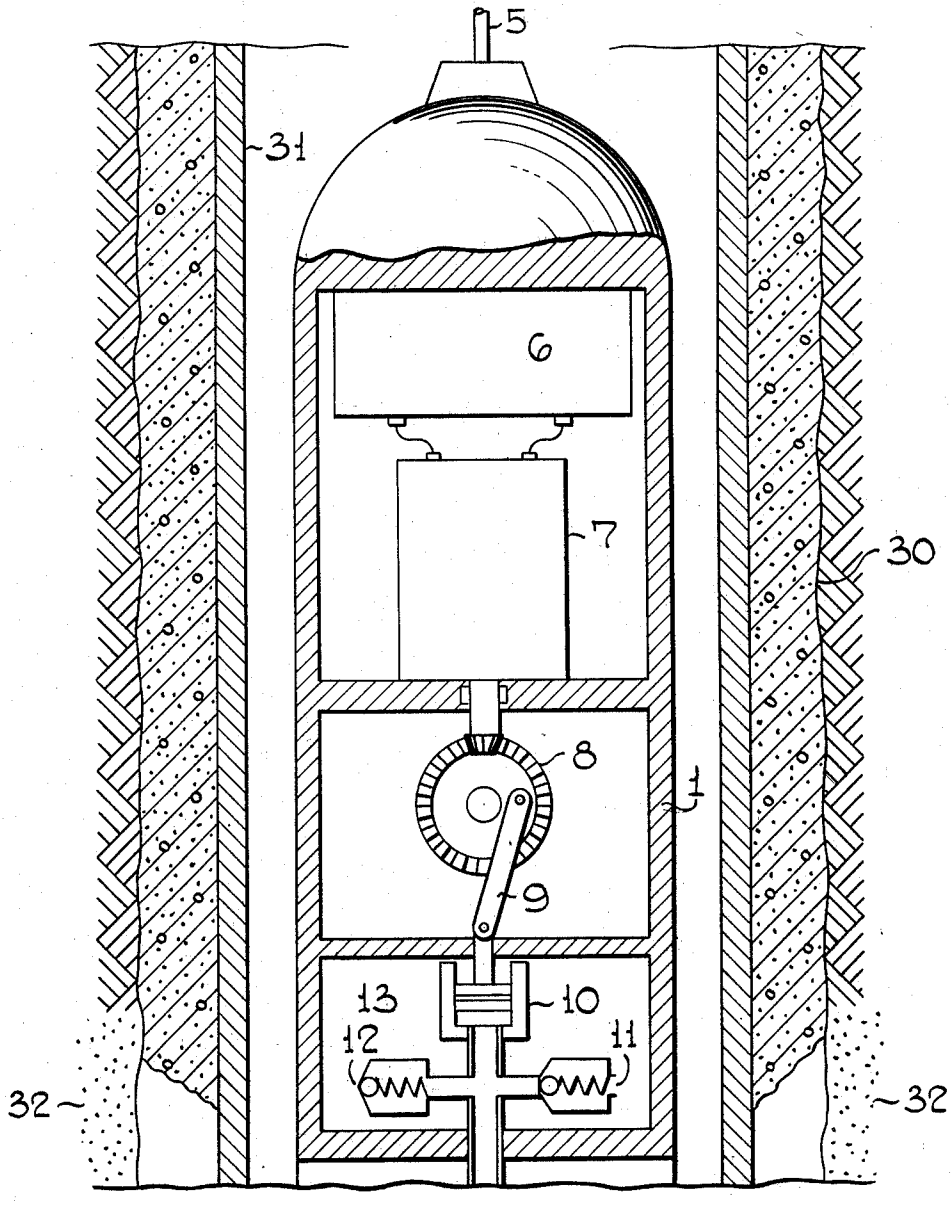

FIG. -1

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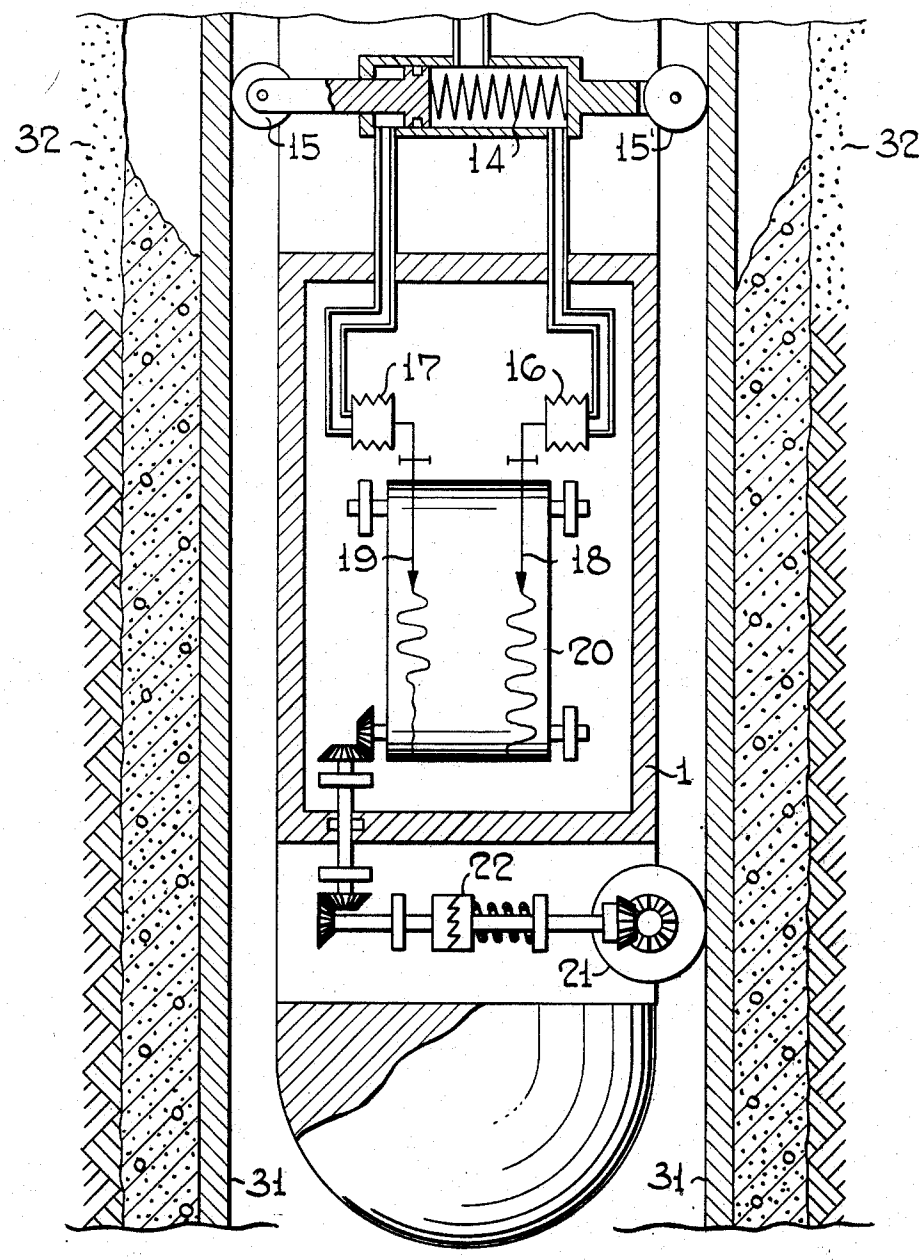

FIG.-2

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APPARATUS FOR LOCATING UNCEMENTED PORTIONS OF WELL CASINGS

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4 Claims. (Cl. 73—151)

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This invention relates to an apparatus for determining the successful, or unsuccessful cementing of a casing in a well. The apparatus is primarily intended for application in oil wells. By means of this invention it is possible to determine what portions of a well casing are, or are not properly cemented in the well.

One of the most important problems in successfully producing oil, or gas from a well relates to the successful exclusion of water from the productive formations. Again, it is generally desirable, particularly in the case of deep wells, to protect the well casing from the tremendous collapsing pressure which may exist in the well. These and other desirable objectives are conventionally attained by cementing the casing in the well bore hole. It is apparent, however, that in order to successfully obtain the benefits of oil well cementing, it is necessary to know the extent to which cement has extended behind the casing, and to know to what portions of the casing cement has not extended. The present invention is directed to this specific objective; that is, to provide operators with information as to what portions of a well casing are properly cemented, or conversely what portions of the well casing are not properly cemented.

The apparatus of this invention, to achieve this objective, applies an internal deforming force to the well casing. In the case in which the well casing is not cemented, the deforming force can cause the casing to assume an elliptical, rather than a circular cross-section. However, in the case in which the well casing is properly cemented in the bore hole, the cement will provide sufficient lateral support to the well casing so that comparatively little or no deformation will occur on application of the deforming force.

The apparatus of this invention by which the indicated method may be successfully conducted consists of two wheel like members adapted to roll along opposing sides of the interior of a well casing. At least one of these wheel like members is so controlled by a hydraulic force, that it can be forced away from the other of the wheel like members so that together the two members can exert a deforming force on the casing. The apparatus includes means for periodically forcing at least one of the wheel like members away from the other of the members, and includes means for measuring the force thus applied, and means for measuring the relative displacement of the two wheel like members. It is apparent that knowing the force applied as a

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mechanical deforming force to the casing, the relative displacement of the two wheel like members applying the force will indicate the deformation of the casing in response to this force. Thus, it is possible to tell when the casing has deformed sufficiently under a given force to show that the casing is not cemented in the bore hole, or whether so little deformation occurs that the casing is shown to be properly cemented.

In order to more clearly exemplify the concepts of this invention, a preferred embodiment of the apparatus constructed in accordance with this invention is illustrated in Figures 1 and 2, of the attached drawings. In these figures, Figure 1, corresponds to the upper portion of the apparatus to be passed down a well casing, while Figure 2, shows a lower portion of this same apparatus, being a continuation of the view shown in Figure 1. Jointly, the figures represent a complete and integral cement fault locator.

In these figures the numeral **30** designates a well bore hole drilled into the earth. The numeral **31** shows a well casing which has been placed in the bore hole. In the annular space around the casing **31** and within the bore hole **30**, it is assumed that cement has been positioned. This cement may be inserted in the annular space in any desired manner, or according to conventional practices in this regard. For the present purposes it may be assumed that cement has successfully penetrated the annular space around the casing, except for a portion of the casing adjacent the particular stratum **32**. It is apparent, therefore, that the casing **31** will be bound by, or laterally supported by this cement except for the portion of the casing adjacent the stratum **32** where cement has not successfully passed into the annular space. In order to determine this deficiency in the cementing, the apparatus depicted may be employed.

Referring now to the apparatus illustrated, a housing **1** is provided to contain the component parts required. This housing may suitably be supported in the well by a cable **5**, so that it can be lowered down into the casing and may be pulled back to the surface of the earth in order to survey the extent and sufficiency of prior cementing operations. An electric motor **7** may be employed to provide the energy required to periodically apply deforming forces to the well casing **31**. The electric motor **7** may be driven by a battery **6** carried in the apparatus, or it may be driven by power lines running through cable **5** to the surface of the earth. The shaft of the motor **7** is connected to a suitable gear as-

sembly 8 that drives a crank arm 9 to translate the rotational motion of the motor shaft to a reciprocating motion suitable for driving the piston of the hydraulic pump 10. An intake check valve 12 is associated with the pump 10 so that on the upstroke of the piston of the pump, fluid may be pulled inwardly through valve 12 from the hydraulic reservoir or sump 13 into the pump. On the downward stroke of the piston, the fluid sucked in through valve 12 will be compressed by the piston to provide hydraulic pressure which may be used to deform the well casing. Thus a hydraulic cylinder 14 is associated with the pump 10. The hydraulic cylinder 14 contains a piston rod, and piston combination directly connected to a rotary wheel member 15. A second rotary wheel member 15' may be fixed to the opposite end of the hydraulic cylinder 14, or if desired, may similarly be provided with a piston rod and piston arrangement. The effect of this construction is that when the piston of pump 10 moves downwardly hydraulic pressure is built up in the cylinder 14 to force the members 15 and 15' against opposite sides of the casing 31. By this means it is possible to periodically apply a deforming force to this casing. It is preferred, but it is not essential, that a relief valve 11 be associated with the pump 10 so that the hydraulic pressure built up in the cylinder 14 cannot exceed a predetermined value for which the release valve 11 may be set.

The remaining portion of the apparatus illustrated may consist of any desired means for measuring the force applied to the casing, and to measure the actual deformation of the casing. In other words, means are required to measure the force with which wheels 15 and 15' are forced outwardly from each other against the casing, and means are required to determine how much the casing yields under the applied force. A suitable means for accomplishing this is to run a hydraulic tap from cylinder 14 to a bellows actuated recording pen 18. By this arrangement movements of the pen 18 will be controlled by the pressure in the cylinder 14 acting to control the expansion of the bellows 16. In a somewhat similar fashion the deformation of the casing may be indicated by recording pen 19, actuated by bellows 17 of the hydraulic bleeder line connected to the hydraulic cylinder 14 between the cylinder head of the cylinder, and the side of the piston opposite to the side to which hydraulic pressure is applied. Bellows 17, the bleeder line, and the opening within the cylinder 14 to which the bleeder line has entry may be filled with a hydraulic fluid so that the movements of wheel 15 and its associated piston will change the hydraulic pressure in bellows 17 to actuate the pen 19.

It is preferred that the recording paper associated with recording pens 18 and 19 be driven by a wheel running along the casing wall. By this means it is possible to calibrate the record paper directly in terms of well depth so that the depth in the well at which a particular deformation is encountered may readily be determined. For this purpose, therefore, a wheel 21 may extend outside the housing 1 to roll along the casing 31. This measuring wheel may drive suitable gears as diagrammatically illustrated to cause the rotation of record paper 20. It is a preferred feature of the gear drive illustrated that a clutch 22 is employed which will cause the paper to turn only when the wheel 21 is turned either clockwise or counterclockwise, as desired. Thus, as illustrated the teeth of the clutch 22 are such that when the apparatus is passed downwardly in the well, the friction of the record paper drive will be sufficient so that the clutch teeth will simply slip over each other without turning the paper. However, when the apparatus is pulled upwardly in the well, the teeth will engage and turn the record paper.

It is apparent that should it be desired, suitable electrical expedients may be used to provide electrical signals indicating the deforming force applied to the casing, and the deformation of the casing, for recording at the surface of the earth through leads which may be carried in cable 5. Again, by such an expedient, electrical signals can be directly produced for recording in the apparatus.

The manner in which the apparatus described indicates improper cementing may be understood by reference to the portions of the records indicated on record paper 20. As shown, the pen 18 indicates a continuously cycling hydraulic pressure variation sinusoidally changing from a maximum to a minimum. It is apparent that when the casing 31 is properly backed by cement, the hydraulic pressure applied to the casing and recorded by pen 18 will be insufficient to materially deform casing 31. Consequently, wheel 15, and its associated piston will not be moved outwardly enough to follow the variations in hydraulic pressure applied to the piston. In other words, pen 19 will draw a substantially straight line as shown in the lower portions of the record produced. However, if the casing 31 is not properly cemented in the bore hole, as adjacent stratum 32 for example, then on application of the hydraulic pressure in cylinder 14, wheel 15 will move outwardly to deform the casing. This then will alter the hydraulic pressure in bellows 17 causing pen 19 to draw a sinusoidal curve similar to that drawn by pen 18. Consequently, by inspection of a record such as that diagrammatically indicated, the apparatus of this invention indicates portions of the casing which are not properly cemented by the sinusoidal type line produced by pen 19 in this case.

What is claimed is:

1. An apparatus for locating uncemented portions of a well casing in place in a bore hole comprising a housing adapted for lowering into the casing, said housing including a hydraulic reservoir, a cylinder held in an essentially horizontal position by said housing, said cylinder having an interior chamber, a piston slidably held in said chamber, a first projection on said piston extending laterally from said housing, a spring behind said piston urging said projection into contact with the wall of said casing, a second projection carried by said housing in the general vicinity of and on the opposite side from said first projection and extending laterally from said housing into contact with the opposite wall of said casing, a reciprocating pump communicating with said hydraulic reservoir, a conduit connecting said pump with said interior chamber behind said piston, drive means for periodically reciprocating said pump whereby a periodically varying force of known periodicity is produced within said chamber, and means for recording the extent of lateral motion of said piston with respect to said housing as a result of deformation of said casing whereby said lateral motion may be compared with the known periodicity of the force.

2. Apparatus according to claim 1 wherein said

lateral motion recording means comprises an expansible bellows, a conduit connecting said bellows with said interior chamber on the side of said piston that carries said first projection, a reciprocating scriber actuated by said bellows, a movable record medium contacted by said scriber and means for moving said record medium past said scriber.

3. Apparatus according to claim 2 in which said means for moving said record medium past said scriber includes a wheel rotatably held by said housing in frictional engagement with the wall of said casing whereby said record medium will most past said scriber in proportion to the movement of said housing lengthwise of said casing.

4. Apparatus according to claim 2 including pressure change measuring means comprising a second expansible bellows, an additional conduit connecting said bellows with said interior chamber behind said piston and a second reciprocating scriber actuated by said second bellows, said second scriber contacting said record medium.

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