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P. W. MARTIN
DEVICE FOR DETERMINING RELATIVE MOVEMENTS OF PARTS IN WELLS
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2,530,309

Fig. 1

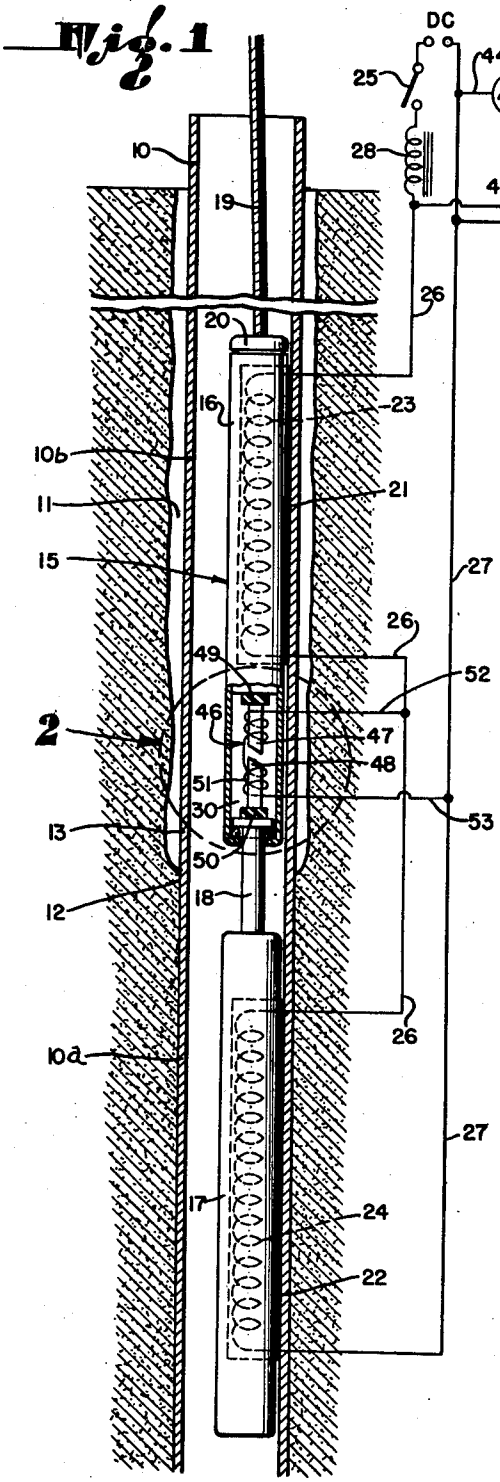


Fig. 2

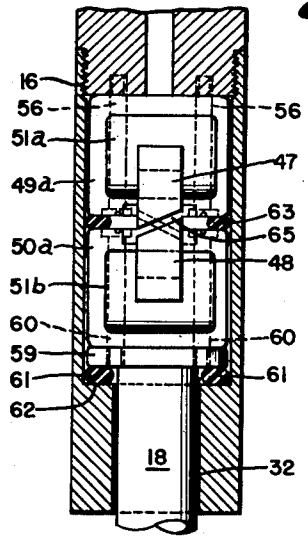
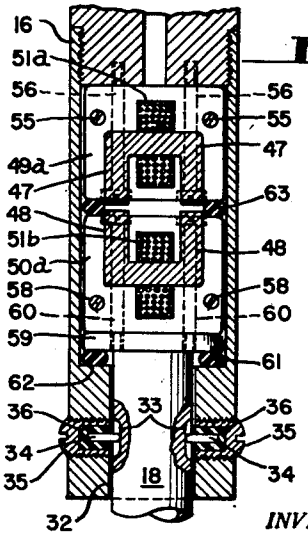


Fig. 3



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DEVICE FOR DETERMINING RELATIVE MOVEMENTS OF PARTS IN WELLS

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11 Claims. (Cl. 73—151)

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My invention relates to a device adapted to be lowered into a well for determining relative movement between parts in the well or for determining whether a selected portion of a pipe in a well is movable by observing whether a change in the stress applied to the pipe produces a change in the form of the selected portion of the pipe in the well. This application is a continuation-in-part of my co-pending application, Serial No. 619,242, filed September 28, 1945, for Method and Apparatus for Determining Movability of Members in Wells.

One important utility of the invention is to find the point in the well where a casing, drill pipe or tubing may be stuck by the measurement of the change in form of the casing, drill pipe or tubing when stress is applied thereto at the surface of the well or at a selected point within the well. A specific example of the utility of the invention is where a drill pipe becomes stuck in the well at an unknown distance below the surface of the ground. If a pull is applied to the upper end of the stuck pipe, there will be an extension or stretching of the pipe throughout the entire length thereof above the point in the well at which the pipe is stuck, but this pull upon the pipe will not produce an extension of that portion of the pipe which is stuck or which extends below the stuck part.

It is an object of the present invention to provide a device which may be lowered within the stuck pipe by which a workman at the top of the well may determine whether the portion of the pipe adjacent the device in the well moves or stretches when a pull is applied to the upper end of the pipe. By lowering the device throughout consecutive positions within the pipe the workman may make a number of observations of whether the pipe moves or stretches in response to a pull applied to its upper end. Through use of the device he will observe that the pull on the pipe will produce a stretch therein until the device reaches the point at which the pipe is stuck in the well, but at the stuck point and therebelow the device will produce no indication of stretch in the pipe, thereby indicating to the workman the point at which the pipe is stuck in the well. When this point is determined a cutting off tool may be lowered into the drill pipe and the drill pipe may be cut off at or immediately above the point at which it is stuck in the well; whereupon the portion of the drill pipe above the cut may be pulled from the well. In the foregoing manner a great deal of time in the recovery of drill pipe stuck in the well is saved, and the possibility of losing drill pipe in the well is minimized.

It sometmes occurs that a pipe, for example, the drill pipe, may become stuck in a well at an intermediate point, the portions of the drill pipe above and below that portion which is stuck be-

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ing free. It is possible by use of the invention to determine the length and position of that portion of the drill pipe which is stuck in the well. When this knowledge is obtained it will be possible, under some circum tances, to jar loose the portion of the drill pipe which is stuck by the firing of an explosive charge within the stuck portion; whereupon the drill pipe may be pulled from the well without the necessity of cutting it.

It is an object of the invention to provide a device which may be lowered through consecutive positions within a well, this device having an anchor member equipped with means for connecting or affixing it to a part in the well, the device also having means associated with the anchor member which will indicate relative movement of another part in the well. For example, in the preferred form of the invention the device is provided with an anchor member having means for attaching it to one part of a pipe in the well and a means which will indicate relative movement of another or adjacent part of this pipe when the value of the stress applied to the pipe is changed. It will be understood that when a pull is applied to the upper end of a pipe, the change in the stress applied to the pipe will produce an elongation or extensile change in form of the pipe, and that when the value of this stress is changed—for example, a decrease in the stress—the change in the form of the pipe will consist in contraction or shortening of all portions of the pipe in which the stress is relieved. Also, the stress applied to the pipe to deform the same may be torsional instead of tensile, under which circumstances all portions of the pipe between the stuck point and the point at which the stress is applied will deform in torsion, or, in other words, twist, thereby changing the relation of consecutive portions of the pipe, such changes in relation being observed or indicated by the device. These changes in torsional relation will be indicated when the torsional stress is applied and when it is relieved.

A further object of the invention is to provide a device of the general character referred to in the foregoing having associated with the anchor means thereof a means which responds to relative movement or change in relative position of another part in the well to produce an indication of this relative movement, the invention having means for transmitting to a workman at the top of the well knowledge of the indication and therefore knowledge of the relative movement whereby the workman may determine whether the stress applied at the top of the well has accomplished relative movement of the part to which the anchor is connected and another part adjacent thereto.

A further object of the invention is to provide a device of the character set forth herein wherein the relative movement between parts in a well

produces a change in the resonance or impedance of an electrical circuit, which change is employed at the top of the well to produce an indication of the relative movement which may be observed by persons desiring the information.

A further object of the invention is to provide a device of the character set forth in the foregoing having two relatively movable anchors, with means for connecting the anchors to separate parts in a well, so that the relative movement of the parts in the well will produce relative movement of the anchors which in turn acts upon means for varying the characteristic or characteristics of an electrical circuit, such as phase shift, change in resonance or variations in impedance, these variations being observable by use of suitable instruments at the top of the well. Herein, the term "impedance" means inductance or capacitance.

A further object of the invention is to provide a testing device of the character set forth herein having a novel form of electromagnet for producing attachment of one or more parts of the device to a metal wall, such as the metal wall of a pipe in the well, for example, the electromagnet being of such slender form that the testing device may be made of a diameter which will pass through the opening through devices or tools such as employed in wells, making it possible to employ the invention in a well below a tool which is disposed in the well. For example, a pipe may be stuck in a well at an intermediate point and may be free below this point. In one use of the invention a spear may be locked to the pipe in the well so as to transmit force thereto, and a testing device incorporating the present invention may be lowered through the spear into a position below the spear and there utilized for the purpose of making observations of relative movement.

Further objects and advantages of the invention will be brought out in the following part of the specification.

Referring to the drawings which are for illustrative purposes only,

Fig. 1 is a schematic sectional view showing a preferred embodiment of the invention in a pipe and showing in schematic form the electrical constituents of the device.

Fig. 2 is an enlarged fragmentary sectional view of that portion of the device shown in Fig. 1, indicated by the dotted circle 2 therein.

Fig. 3 is a fragmentary section corresponding to Fig. 2 but taken at right angles thereto.

In Fig. 1 I have shown a portion of a pipe 10 which is stuck in a well 11 at 12. It will be understood that this pipe 10 may be any pipe which may become stuck in the well, but for the purpose of the present invention, it may be regarded as a part of a drill pipe. The portion 10*a* of the pipe 10 below the position indicated by the numeral 12 may be referred to as the stuck portion of the pipe; whereas, the upper portion 10*b* of the pipe 10 constitutes the free or unstuck portion. When this pipe 10 is standing in the well without any pull exerted on its upper end, the lower part 13 of the free portion 10*b* will be under compression due to the weight of the pipe portion 10*b* extending upwardly therefrom, this compression gradually diminishing toward the upper end of the free portion 10*b* of the pipe 10. If an upward pull is applied to the upper end of the pipe 10, the free portion 10*b* will be elongated, and this elongation will be substantially constant throughout the entire length of the free portion of the pipe for the reason that the change in stress ap-

plied to the pipe due to the upward pull thereon will be substantially constant throughout its free portion 10*b*. For example, if an upward pull of 10,000 pounds is applied to the upper end of the free portion 10*b* which is standing on the stuck portion 10*a*, the change in stress throughout the entire length of the free portion 10*b* will be 10,000 pounds and therefore every portion of the pipe 10 above the stuck portion 10*a* will elongate due to the change in stress.

In Fig. 1 I have shown a testing device which consists of vertically spaced upper and lower members 16 and 17 connected by a relatively slender tubular part 18 in such a manner that the parts 16 and 17 may have limited relative movement. The device 15 is lowered into the pipe 10 by a cable 19 which is connected at 20 to the upper end of the member 16. The members 16 and 17 have therein vertically elongated electromagnets 21 and 22 which may be made as disclosed in detail in my copending application, Serial No. 619,242, for Indicator Method and Apparatus, filed September 28, 1945, these electromagnets 21 and 22 having windings 23 and 24 respectively which may be connected in series with a source of direct current through a switch 25 and conductors 26 and 27, the conductor 26 having a choke 28 therein, the purpose of which will be later explained. When the device 15 is lowered into the well, closing of the switch 25 will result in energization of the electromagnets 21 and 22 so that they will, by magnetic attraction, attach themselves to the wall of the pipe 10 as shown in Fig. 1, thereby fixing the members 16 and 17 against movement relatively to the pipe wall.

In the lower end of the member 16 there is a chamber 30, into the lower part of which projects the upper portion of the connector 18. The connector 18 is fixed onto the upper end of the member 17 and has limited axial and torsional movement relatively to the member 16. As shown in Fig. 3, the member 18 projects through an opening 32 in the lower end of the member 16 and has in its surface longitudinal keyways 33 which are engaged by the inner ends of pins 34 which are resiliently mounted in plugs 35 threaded in diametrally opposed relation in the wall of the member 16 surrounding the opening 32. The pins 34 are shown resiliently mounted in the plugs 35 by means of rubber bodies 36. The member 16 may be moved a limited distance axially on the connecting member 18, the pins 34 at this time sliding in the key slots 33. Also, the member 16 may have limited rotation on the connecting member 18, in view of the fact that the pins 34 are resiliently supported, so that they may deflect laterally from their normal centralized positions.

As shown in Fig. 1, the invention includes a circuit wherein electrical flow is established, this circuit extending down within the well to the testing device 15 and having means associated therewith whereby relative movement between the parts 16 and 17 of the testing device 15 will produce a change in one or more of the charaterristics of the electric flow through the circuit, such change being indicated by a suitable responsive instrument, such as a meter 38 at the top of the well. This circuit includes a source 40 of non-continuous electrical potential such as an alternator, a conductor 41, resistor 42, conductor 43, which is connected to the conductor 26, and a conductor 44 which is connected to the conductor 27 of the direct current circuit, through which the windings 23 and 24 of the electromagnets 21

and 22 are energized. In the chamber 30 of the member 16 there is a variable inductance unit 46 having magnetic field elements 47 and 48, one of which is connected by supporting means 49 to the member 16 and the other of which is connected by supporting means 50 to the upper end of the connecting member 18 so that relative axial or torsional movement of the members 16 and 17 will produce like relative movements of the field pieces 47 and 48. The variable inductance unit 46 has a winding 51 which may be divided between the two field pieces 47 and 48, the ends of such winding 51 being respectively connected through conductors 52 and 53 with the conductors 26 and 27, so as to be thereby connected in series with the source of electrification 40. The choke 28 is for the purpose of preventing a flow from the alternator 40 through the direct current source DC. As shown in Fig. 1, the ends of the field pieces 47 and 48 are cut diagonally and are spaced so as to provide a small gap, the variations in the size of this gap producing variations in the inductance value of the unit 46 which is in circuit with the source 40, and therefore produces a change in current flow through the indicating circuit, which change may be observed by use of the meter 38. In view of the fact that the gap between the adjacent ends of the field pieces 47 and 48 is diagonal, the size of this gap will be varied either by axial or torsional relative movement of the members 16 and 17.

As shown in further detail in Figs. 2 and 3, the field pieces 47 and 48 are of horseshoe form, and the two sections of the winding 51, indicated as 51*a* and 51*b*, are disposed around the transverse portions of the horseshoe field pieces 47 and 48. The anchoring means 49 for the field piece 47, shown schematically in Fig. 1, comprises matching recessed parts 49*a* which by transverse bolts 55 are bolted against opposite faces of the field piece 47 in a position to surround the coil section 51*a*, and which are secured to the member 16 by screws 56. In a similar manner the anchoring means 50 for the piece 48, shown schematically in Fig. 1, consists, as shown in Figs. 2 and 3, of matched recessed parts 50a bolted against opposite faces of the field piece 48 by transverse bolts 58 and secured to the upper face of the flange 59 at the upper end of the connecting member 18 by screws 60.

A rubber ring 61 is disposed between the lower face of the flange 59 and the annular shoulder 62 of the member 16 at the upper end of the opening 32 thereof, and resilient means such as rubber 63 is placed between the adjacent ends of the parts 49*a* and 50*a* which support the field pieces 47 and 48, the rubber elements 61 and 63 thereby producing yieldability between the members 16 and 17 in axial direction, and also permitting relative torsion between the members 16 and 17. In view of the connecting of the field pieces 47 and 48 respectively to the member 16 and to the connecting member 18 which is rigidly secured to the member 17, relative axial or torsional movement of the members 16 and 17 will vary the gap 65 between the field pieces 47 and 48.

The utility of the invention may be explained with reference to Fig. 1. By means of the cable 19 the device 15 has been lowered into the stuck pipe 10 to a position wherein the member 16 is disposed adjacent the lower portion of the free part 10*b* of the pipe and the member 17 is in the upper part of the stuck portion 10*a*. When the switch 25 is closed, current from the direct current source will flow through the windings of the upper and lower electromagnets 21 and 22, causing the members 16 and 17 to become attached to the adjacent walls of the pipe 10 through the attractive action of the magnetic flux of the electromagnets. The source of alternating, or pulsating if desired, current 40 is then employed to produce an electrical flow through the winding 51 of the unit 46, one or more of the characteristics of this electrical flow being observed at the top of the well. For example, the current strength or potential may be observed by use of the meter generally indicated at 38.

With the device 15 attached to the pipe 10, as shown in Fig. 1, an upward pull or a torsional strain may be applied to the upper end of the pipe 10, causing a change in the stress applied through all portions of the free part 10*b* of the pipe. This will result in relative movements of the members 16 and 17 and relative movement between the field pieces 47 and 48 to change the gap therebetween, which change in the size of the gap will produce a change in the inductance-impedance or capacity of the unit 46 to change at least one characteristic of the electrical flow in the indicating circuit, which may be observed by use of suitable instruments at the top of the well. For example, if the alternator 40 is of mechanical type, the variable inductance 46 will produce a change in the current strength which will be indicated by the meter 38. If the source 40 consists of a thermionic tube oscillator, the variable impedance unit 46 may be employed to vary the frequency of the oscillator, this variation or change being indicated by a frequency meter.

Either of the foregoing types of indications will inform the observer that at least one of the members 16 or 17 of the device 15 is attached to a free portion 10*b* of the pipe 10. As long as the device is attached to the pipe 10 above the stuck portion 12, application of stress to the upper end of the pipe will produce relative movement of the members 16 and 17, but when the entire device 15 is lowered into the stuck portion 10*a* of the pipe, relative movement of the members 16 and 17 will not be produced; therefore, the operator by making consecutive tests down through the pipe 10 may determine the point at which it is stuck in the well. A steel pipe, by upward pull applied to its upper end, may be readily elongated .005 inch per lineal foot, thereby producing ample relative movement of the upper and lower members 16 and 17 attached to a free portion of the pipe for actuation of the device in the manner described in the foregoing.

Another change in a characteristic of the current flow in the indicating circuit is that which is produced by iron core saturation or near saturation. In the device shown there is a direct current potential through the coils 51*a* and 51*b* to impress a magnetic flux on the iron core structure consisting of the parts 47 and 48. If this flux is brought to a high level, harmonics will be produced in the current flow of the indicating circuit, which harmonics may be measured or indicated at the top of the well by use of a voltmeter at 38 sensitive to one or more of the harmonic frequencies developed in the indicating circuit. The change in the gap between the parts 47 and 48 will vary the flux strength or concentration in the iron core, and thereby produce a change in the harmonic frequencies developed.

I claim as my invention:

1. In a device for obtaining from a well information of the movement of parts therein, the combination of: a pair of members connected together in movable relation and adapted to be lowered into the well; means operable to produce such engagement of said members with separate parts in the well that relative movement of said parts will cause relative movement of said members; conductors forming an electric circuit having a part thereof supported in close relation to one of said members; energizing means for producing a fluctuating electrical flow in said circuit; current control means separate from said energizing means connected to said members so that relative movement of said members will cause relative movement of portions of said current control means and responding to relative movement of said members to change at least one of the characteristics of the electrical flow in said circuit; and means having an indicator at the top of the well coupled to said circuit and adapted to respond to said change in said electrical flow in said circuit and thereby indicate relative movement of said members.

2. In a device for obtaining from a well information of the movement of parts therein, the combination of: a pair of members connected together in movable relation and adapted to be lowered into a well; electromagnetic means operable from the top of the well to produce such engagement of said members with separate parts in the well that relative movement of said parts will cause relative movement of said members; conductors forming an electric circuit extending down from the top of the well and connected to said electromagnetic means for energization thereof and having a part thereof supported in close relation to one of said members; means for producing a fluctuating electrical flow in said circuit; current control means connected to said members so that relative movement of said members will cause relative movement of portions of said current control means and responding to relative movement of said members to change at least one of the characteristics of the electrical flow in said circuit; and means having an indicator at the top of the well coupled to said circuit and adapted to respond to said change in said electrical flow in said circuit and thereby indicate relative movement of said members.

3. In a device for obtaining from a well information of the movement of parts of an iron or iron alloy tube extending in the well, the combination of: a pair of members connected together in movable relation and adapted to be lowered into the well; electromagnetic means operable from the top of the well acting by magnetic attraction of at least one of said members to at least on part of said tube to produce such frictional engagement of said members with separate parts of said tube in the well that relative movement of said parts will cause relative movement of said members; conductors forming an electric circuit having a part thereof supported in close relation to one of said members; means for producing a fluctuating electrical flow in said circuit; current control means connected to said members so that relative movement of said members will cause relative movement of portions of said current control means and responding to relative movement of said members to change at least one of the characteristics of the electrical flow in said circuit; and means having an indicator at the top of the well coupled to said circuit and adapted to respond to said change in said electrical flow in said circuit and thereby indicate relative movement of said members.

4. In a device for obtaining from a well information of the movement of parts of an iron or iron alloy tube extending in the well, the combination of: a pair of members connected together in movable relation and adapted to be lowered into the well; electromagnetic means operable from the top of the well acting by magnetic attraction of at least one of said members to at least one part of said tube to produce such frictional engagement of said members with separate parts of said tube in the well that relative movement of said parts will cause relative movement of said members; conductors forming an electrical circuit extending from the top of the well and connected to said electromagnetic means for electrical energization of the same, said circuit including an inductance supported by one of said members; means for producing fluctuating current electrical flow in said circuit; armature means positioned in such relation to said inductance that its movement will produce a change in a characteristic of the electrical flow in said circuit; means connecting said armature means to at least one of said members so that relative movement of said members will produce said movement of said armature means; and means having an indicator at the top of the well coupled to said circuit adapted to respond to said change in a characteristic of the electrical flow in said circuit and thereby indicate said relative movement of said members.

5. In a device for obtaining from a well information of the movement of parts of an iron or iron alloy tube extending in the well, the combination of: a pair of members connected together in movable relation and adapted to be lowered into the well; electromagnetic means operable from the top of the well acting by magnetic attraction of at least one of said members to at least one part of said tube to produce such frictional engagement of said members with separate parts of said tube in the well that relative movement of said parts will cause relative movement of said members; means operable from the top of the well for energizing said electromagnetic means; conductors forming an electrical circuit extending from the top of the well, said circuit including an inductance supported by one of said members; means for producing fluctuating current electrical flow in said circuit; armature means positioned in such relation to said inductance that its movement will produce a change in a characteristic of the electrical flow in said circuit; means connecting said armature means to at least one of said members so that relative movement of said members will produce said movement of said armature means; and means having an indicator at the top of the well coupled to said circuit adapted to respond to said change in a characteristic of the electrical flow in said circuit and thereby indicate said relative movement of said members.

6. In a device of the character described, for obtaining information from a well of movement of parts in the well, the combination of: a pair of members connected together in movable relation and adapted to be lowered into a well; means for connecting each of said members to separate parts in a well so that movement of said parts will produce relative movement of

said members; means forming an electrical circuit having a winding supported in close relation to one of said members; an armature disposed in movable relation to said winding; means for producing a fluctuating current flow in said circuit; means connecting said armature and one of said members so that relative movement of said members will cause relative movement of said armature and said winding and thereby change at least one of the characteristics of said current flow; and means at the top of the well adapted to act in response to said change in said current flow and indicate said relative movement of said members.

7. In a device of the character described, for obtaining information from a well of movement of parts in the well, the combination of: a pair of members connected together in linearly and torsionally movable relation and adapted to be lowered into a well; means for connecting each of said members to separate parts in a well so that movement of said parts will produce relative movement of said members; means forming an electrical circuit having a winding supported in close relation to one of said members; magnetic field means for said winding having a gap, said field means being disposed so that said gap will be varied by linear and torsional relative movement of parts of said field means defining said gap; means for producing a fluctuating current flow in said circuit; means connecting said members and said field means and responsive to relative movement of said members for producing relative movement of said parts of said field means so as to vary the gap therebetween and thereby change at least one of the characteristics of said current flow; and means at the top of the well adapted to act in response to said change in said current flow and indicate said relative movement of said members.

8. In a device for determining the point at which a tube is stuck in a well: a pair of members connected together in movable relation and adapted to be lowered into the well; means for supporting said members in the well adjacent a selected portion of said tube; means operatively connected to said members and operating in consequence of relative movement of spaced parts of said selected portion of said tube to produce relative movement of said members; conductors forming an electric circuit having a part thereof supported in close relation to one of said members; means for producing a fluctuating electrical flow in said circuit; current control means having relatively movable portions and means connecting said portions respectively to said members so that relative movement of said members will cause relative movement of said portions of said current control means and responding to relative movement of said portions to change at least one of the values of the electrical flow in said circuit; and means having an indicator at the top of the well coupled to said circuit and adapted to respond to change in at least one of the values of said electrical flow in said circuit and indicate relative movement of said members.

9. In a device for determining the point at which a tube is stuck in a well: a pair of members connected together in movable relation and adapted to be lowered into the well; suspension means for moving said members in the well to a position adjacent a selected portion of said tube; means operating independently of said suspension means to support said members; means operating in consequence of relative movement of spaced parts of said selected portion of said tube to produce relative movement of said members; conductors forming an electric circuit having a part thereof supported in close relation to one of said members; means for producing a fluctuating electrical flow in said circuit; current control means comprising impedance means coupled to said circuit and connected to said members so that relative movement of said members will cause change in the value of said impedance means; and means having an indicator at the top of the well coupled to said circuit and adapted to respond to said change in the value of said impedance means as evidenced by said electrical flow in said circuit so as to indicate relative movement of said members.

10. In a device of the character described, for use with a circuit which extends down into a well and means for producing a fluctuating electrical flow in said circuit: a pair of members connected together in movable relation and adapted to be lowered into the well; means operable to produce such engagement of said members with separate parts in the well that relative movement of said parts will cause relative movement of said members; and variable inductance means arranged for coupling to said circuit, said inductance means having relatively movable elements, at least one of which elements comprises a winding, and one of said elements being connected to one of said members and another of said elements being connected to the other of said members, to effect relative movement of said elements and variation of said inductance means in consequence of relative movement of said members.

11. In a device of the character described, for use with a circuit which extends down into a well and means for producing a fluctuating electrical flow in said circuit: a pair of members connected together in movable relation and adapted to be lowered into a well; means for moving said members in the well to a position adjacent a selected portion of a tube in said well; means operating independently of said first named means to support said members; means operating in consequence of relative movement of said selected portion of said tube to produce relative movement of said members; and current control means comprising a variable inductance means arranged to be coupled to said circuit and connected to said members so that relative movement of said members will cause a change in the inductance of said variable inductance means, as an indication of movement of said selected portion of said tube.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,654,819	Kinley	Jan. 3, 1928
1,889,730	Lake	Nov. 29, 1932
2,045,474	Kemler	June 23, 1936
2,180,175	Sivertsen	Nov. 14, 1939
2,231,702	Burgwin et al.	Feb. 11, 1941
2,275,532	Lamberger et al.	Mar. 10, 1942
2,300,384	Johnston	Oct. 27, 1942

FOREIGN PATENTS

Number	Country	Date
139,211	Great Britain	Sept. 23, 1920