July 21, 1931. B. JONES 1,815,672

INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 1.

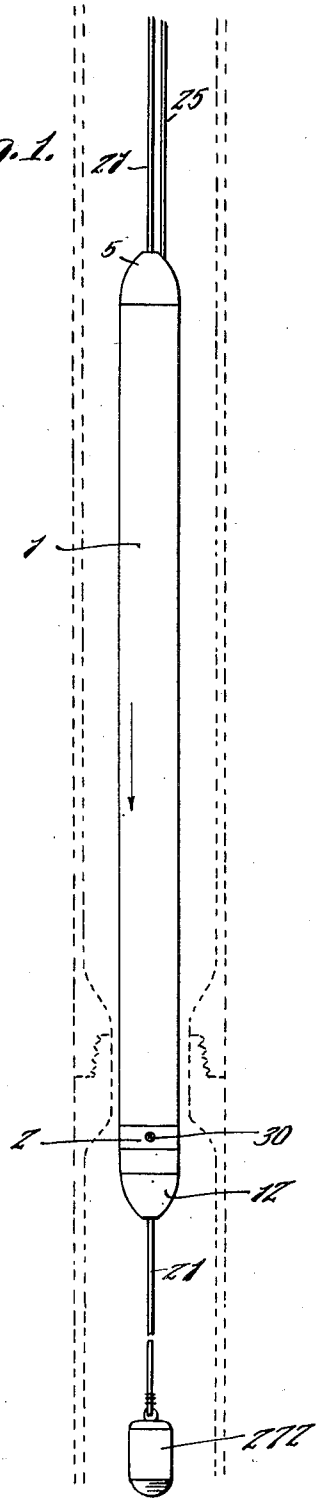


Fig. 17.

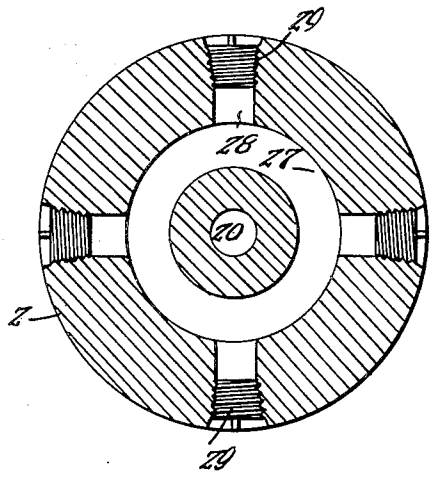
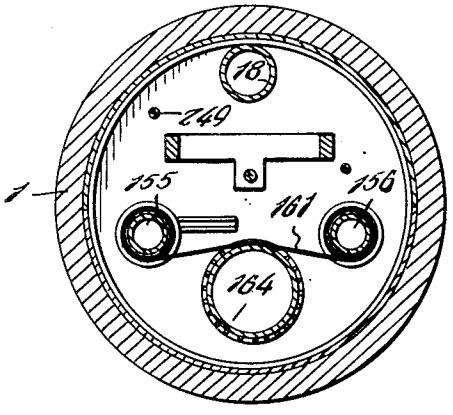


Fig. 18.



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Fig. 2.

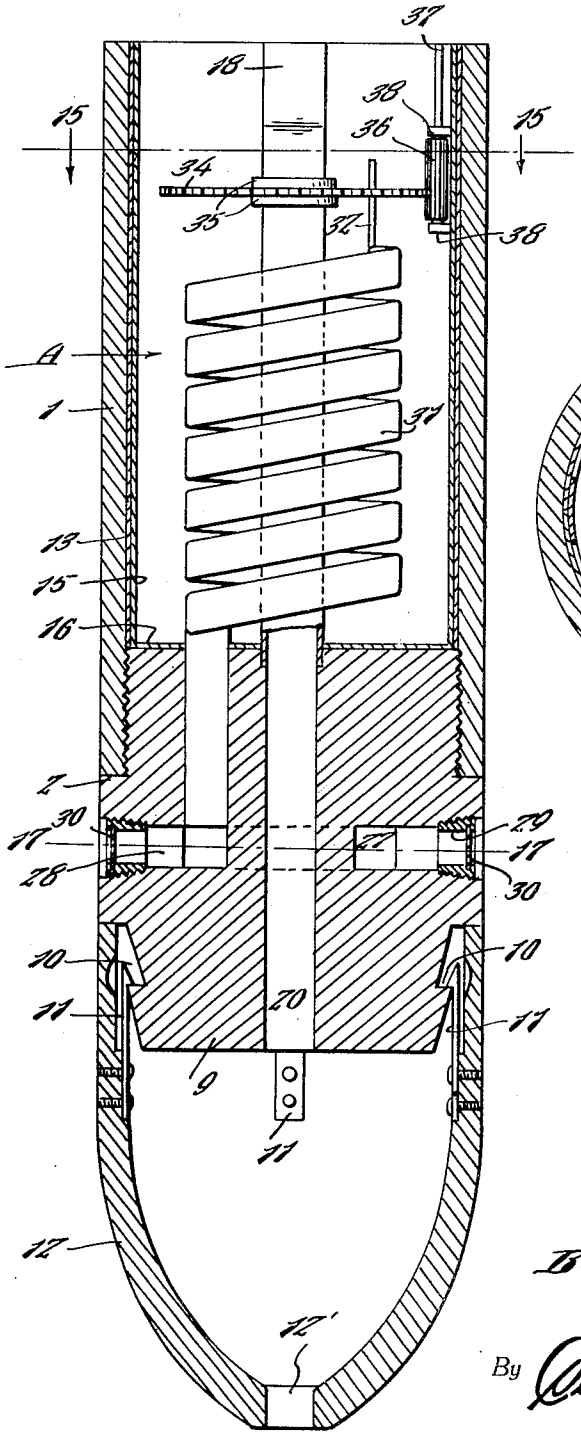


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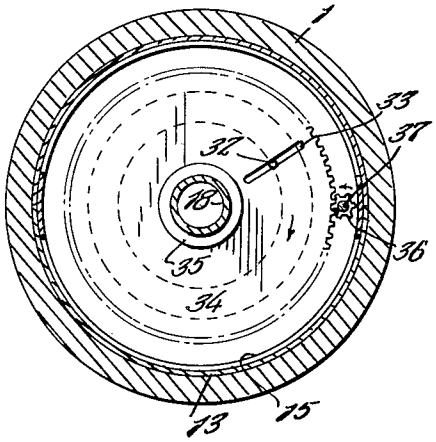
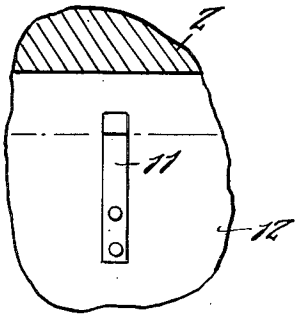


Fig. 16.



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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 3.

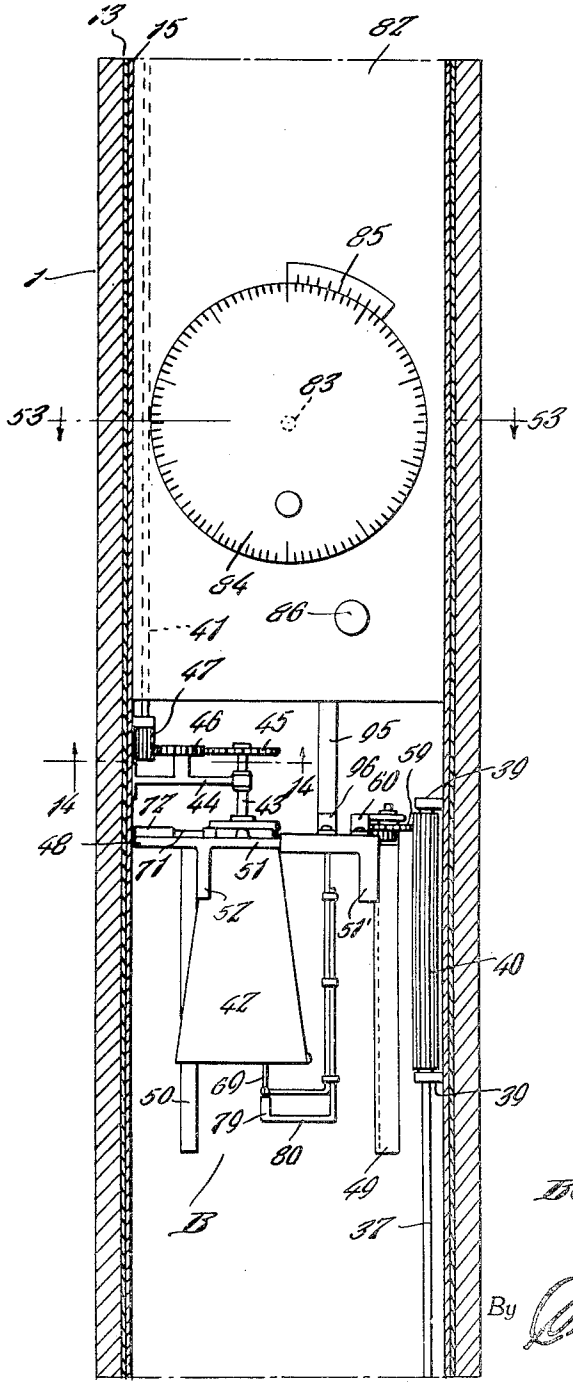
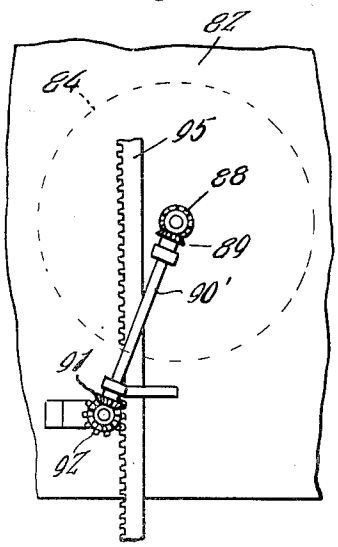


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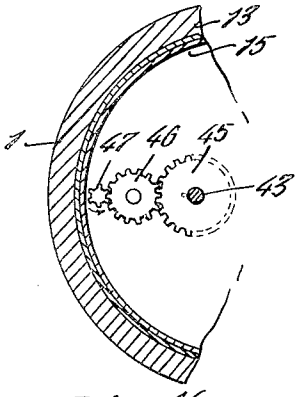


Fig. 14.

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Fig. 4.

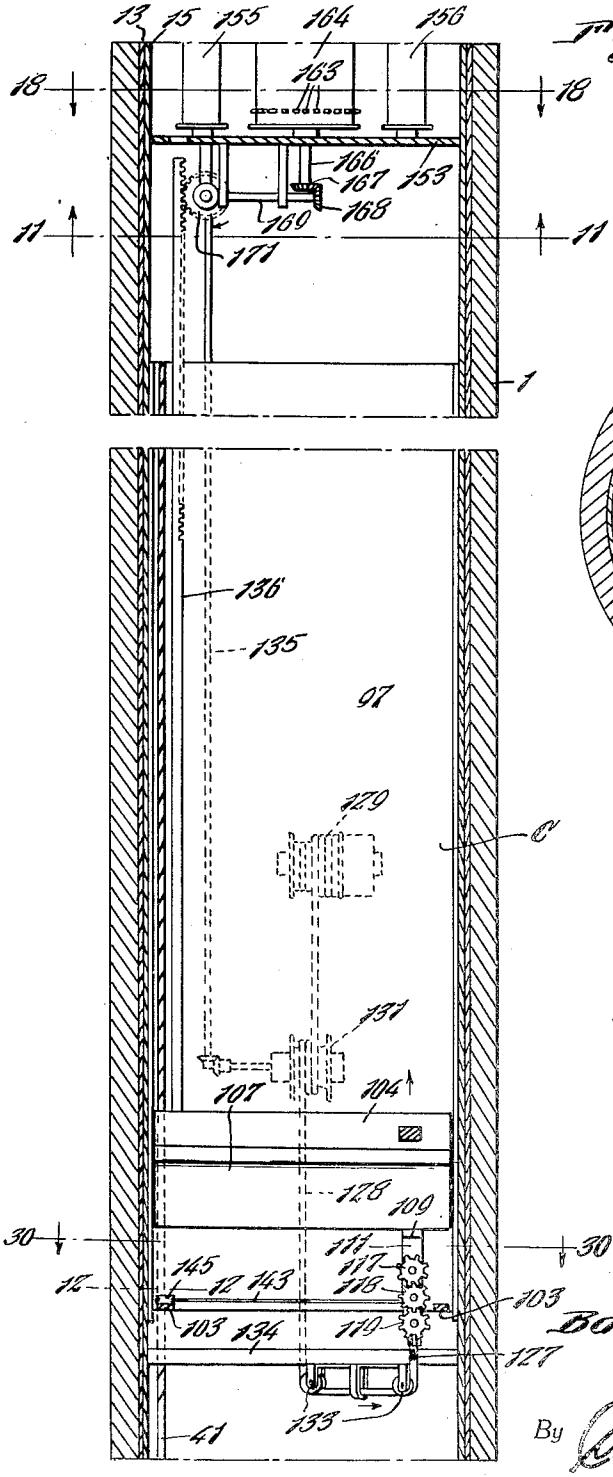


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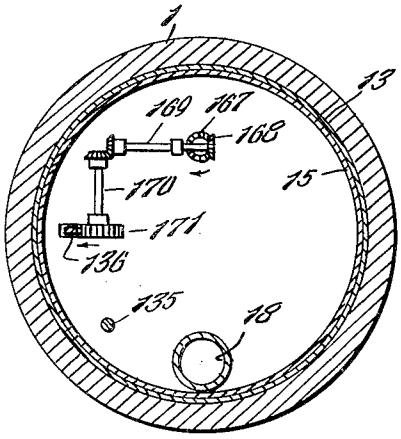
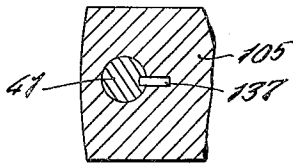


Fig. 12.



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Fig. 5.

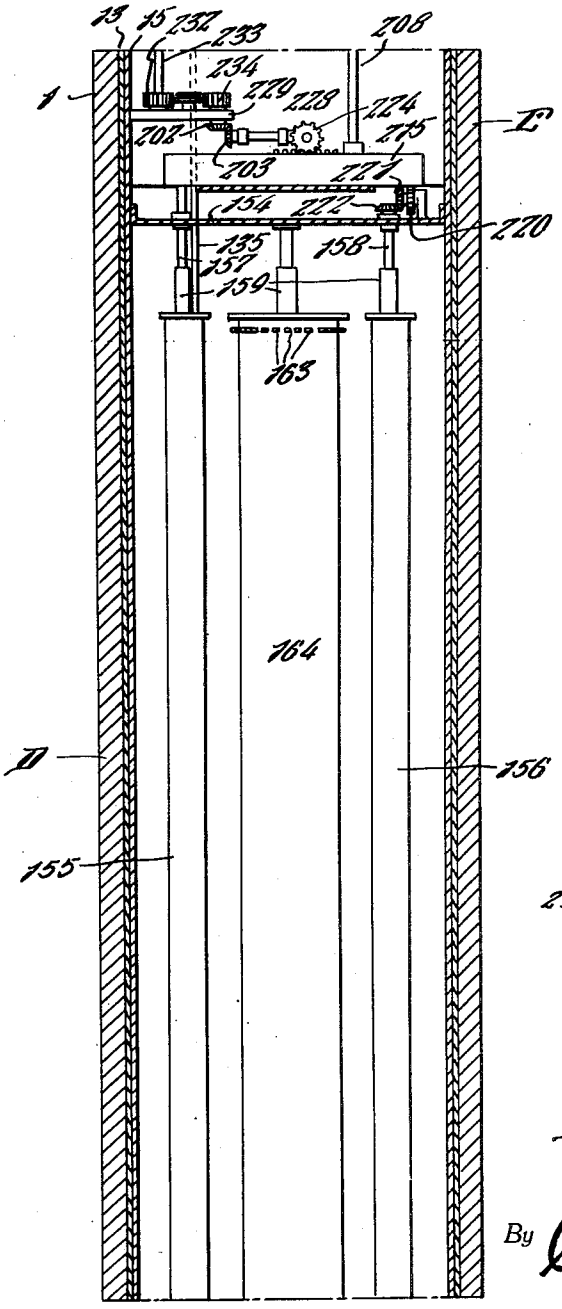


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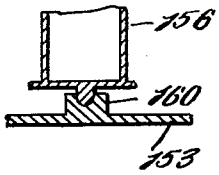


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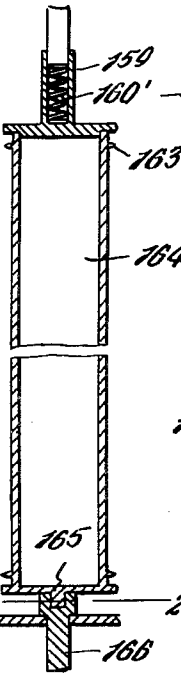


Fig. 29.



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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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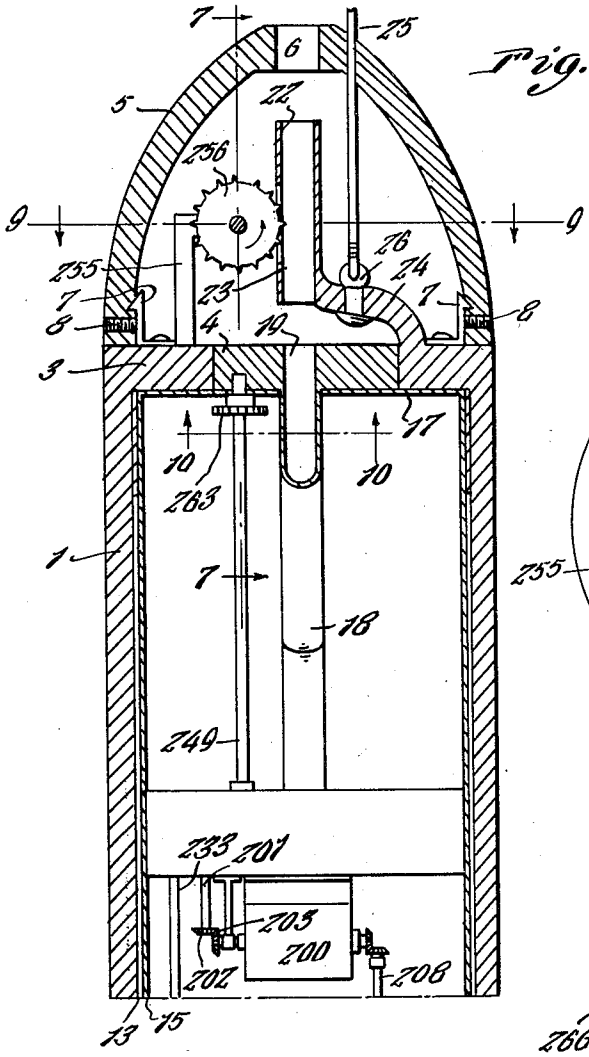


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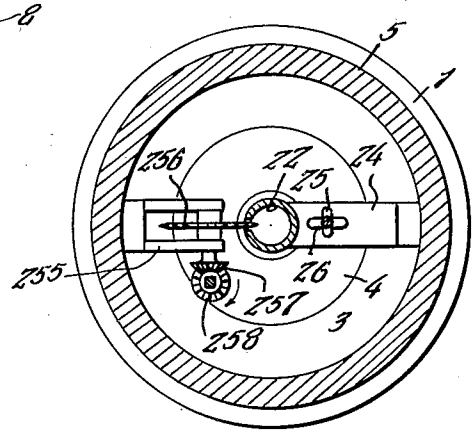


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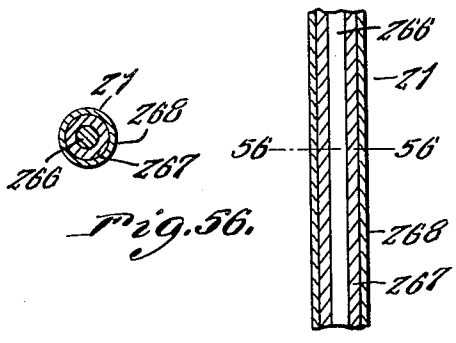


Fig. 55.

Fig. 56.

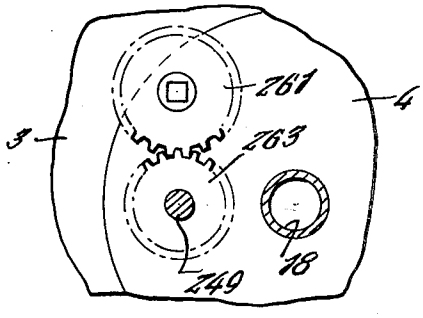


Fig. 10.

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 7.

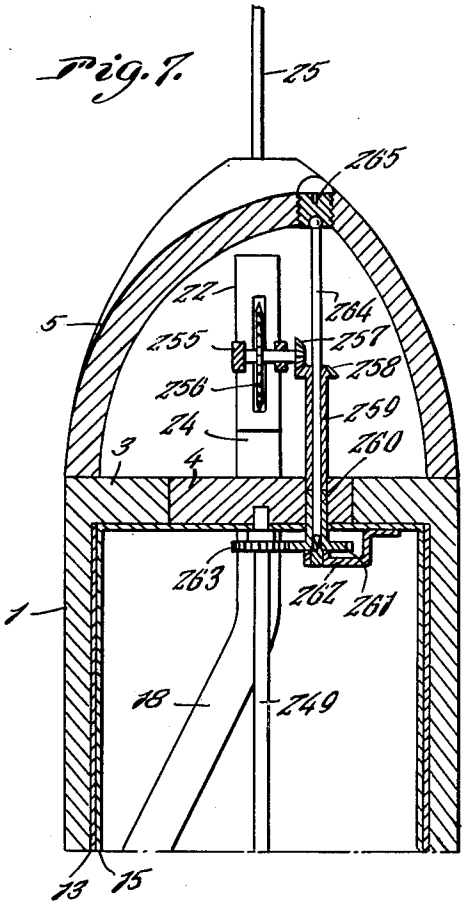


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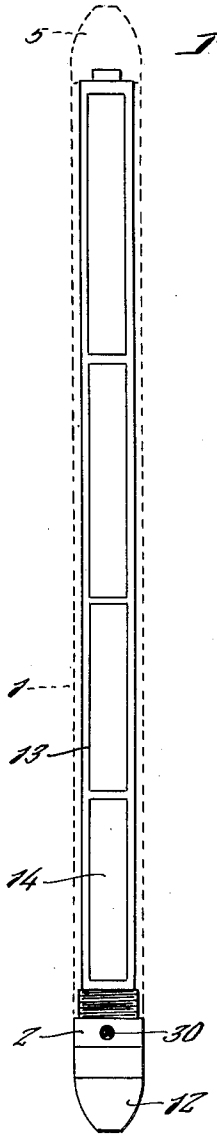
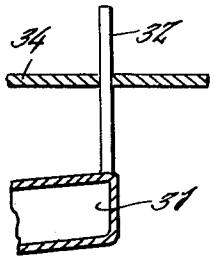


Fig. 37.



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Fig. 19.

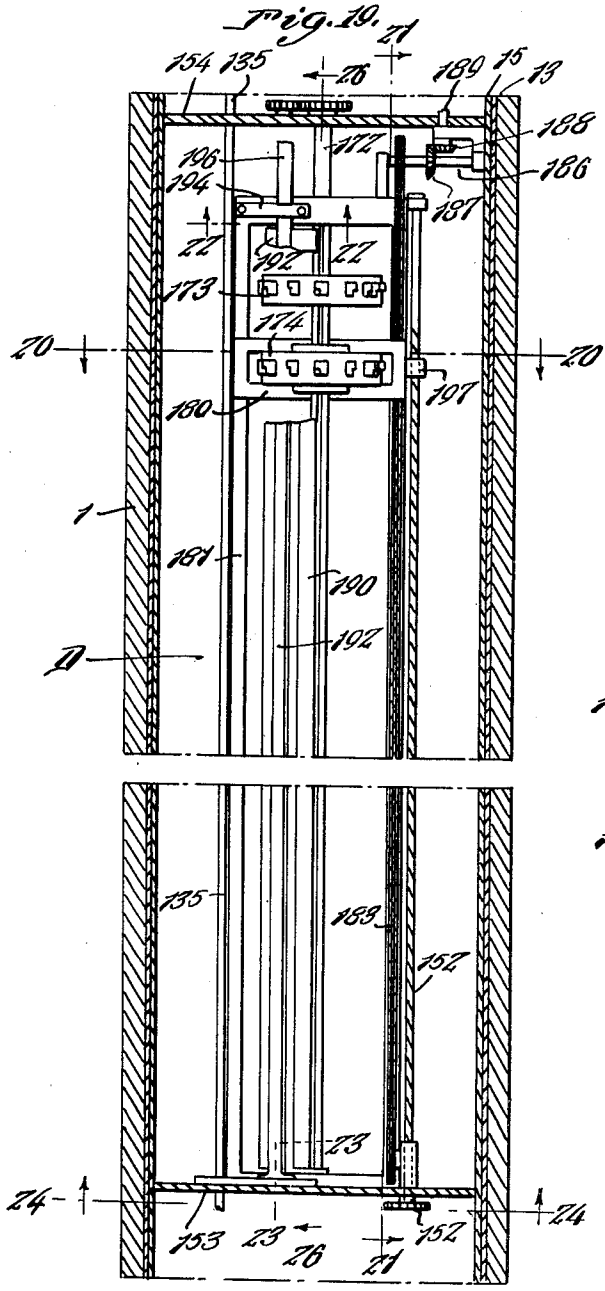


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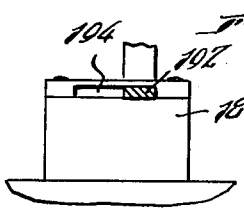


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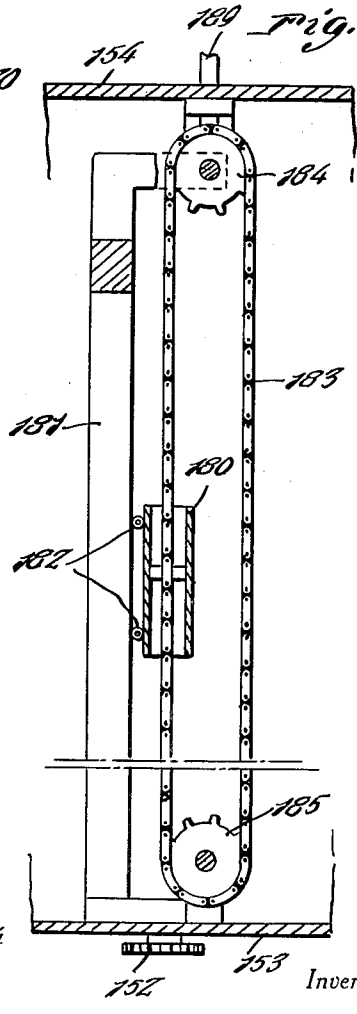
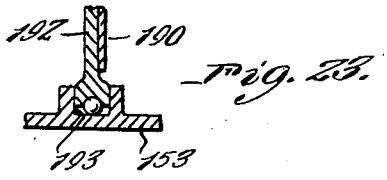


Fig. 23.



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July 21, 1931. B. JONES 1,815,672

INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 20.

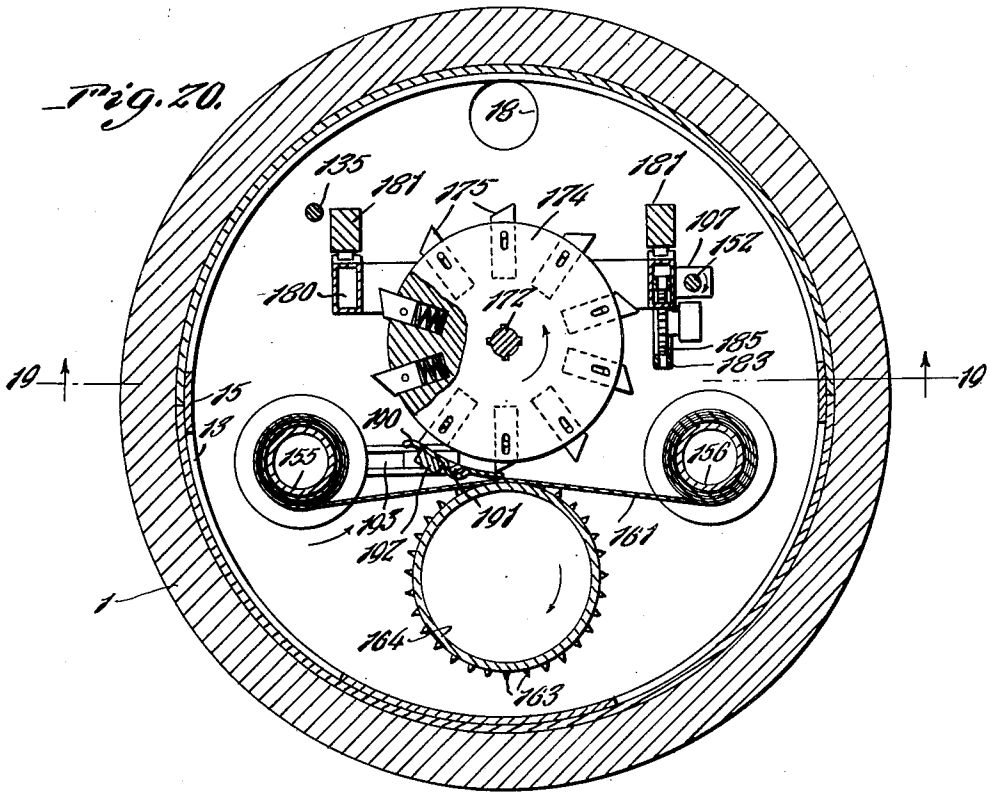
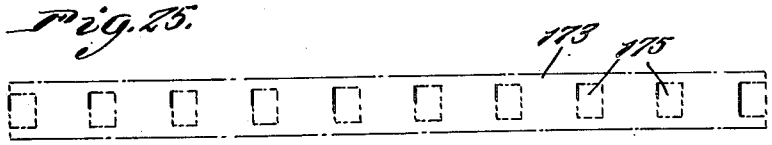


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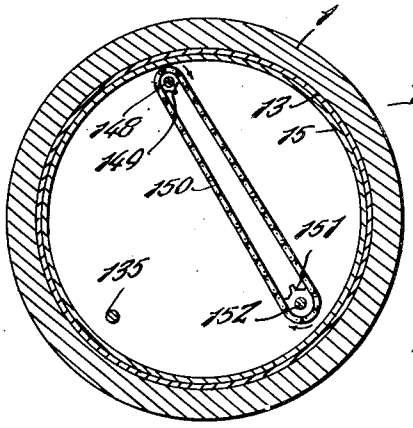


Fig. 24.

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July 21, 1931. B. JONES 1,815,672

INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 26.

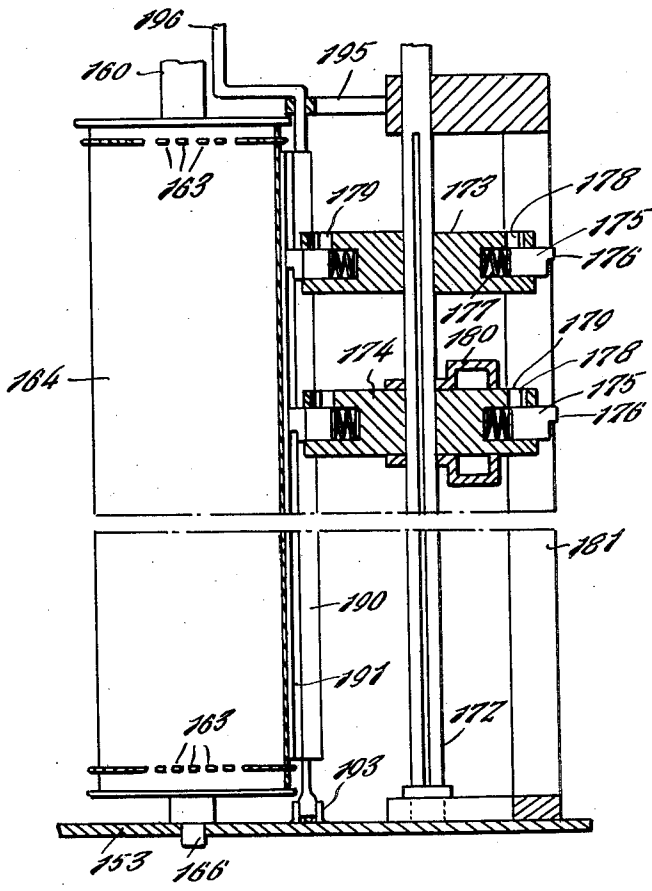


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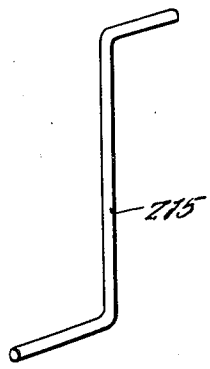


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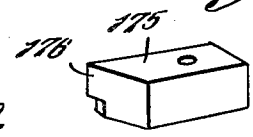
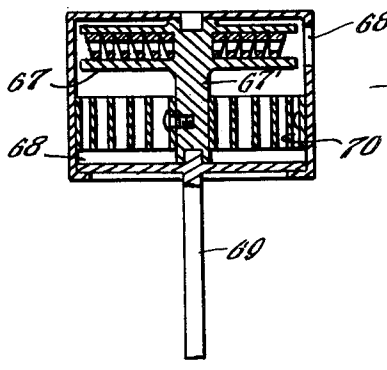


Fig. 59.



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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 30.

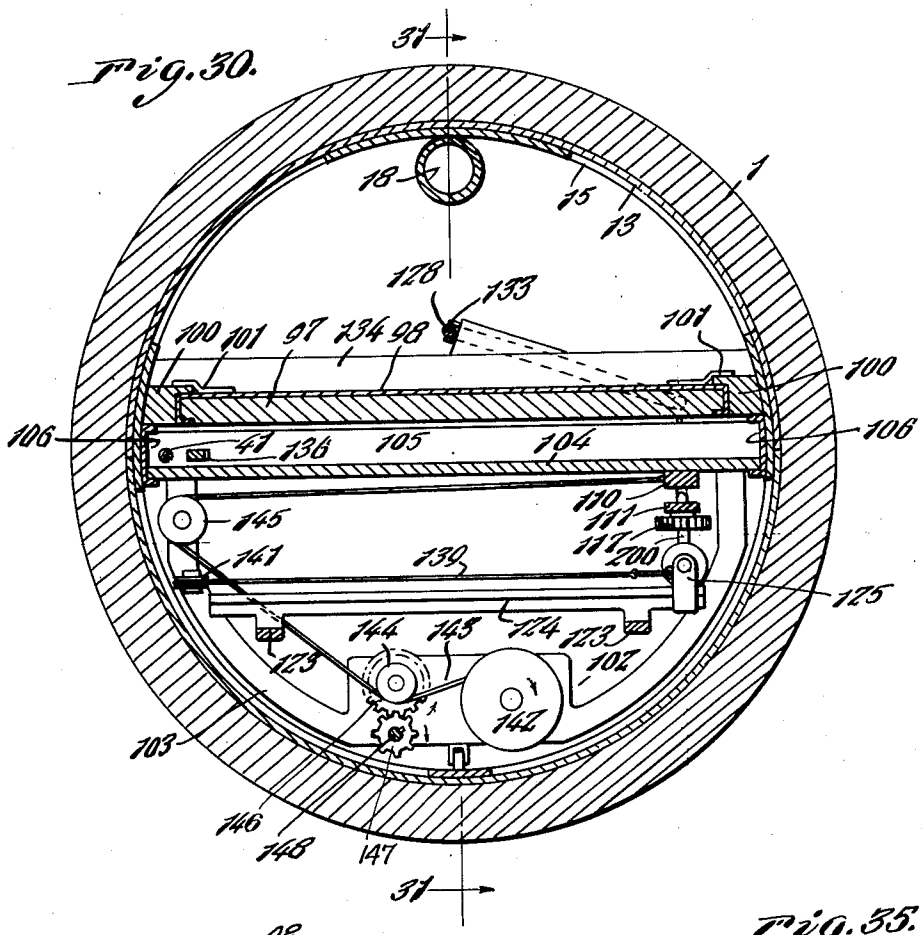
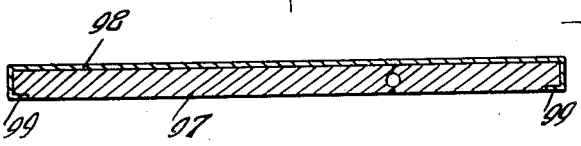


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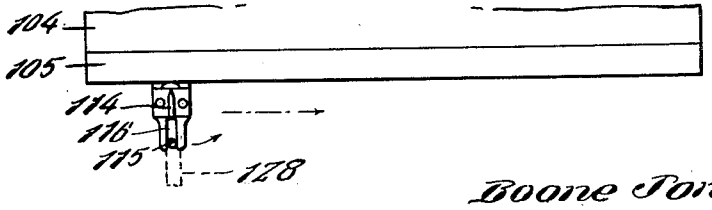


Fig. 36.

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By Clarence A. O'Brien

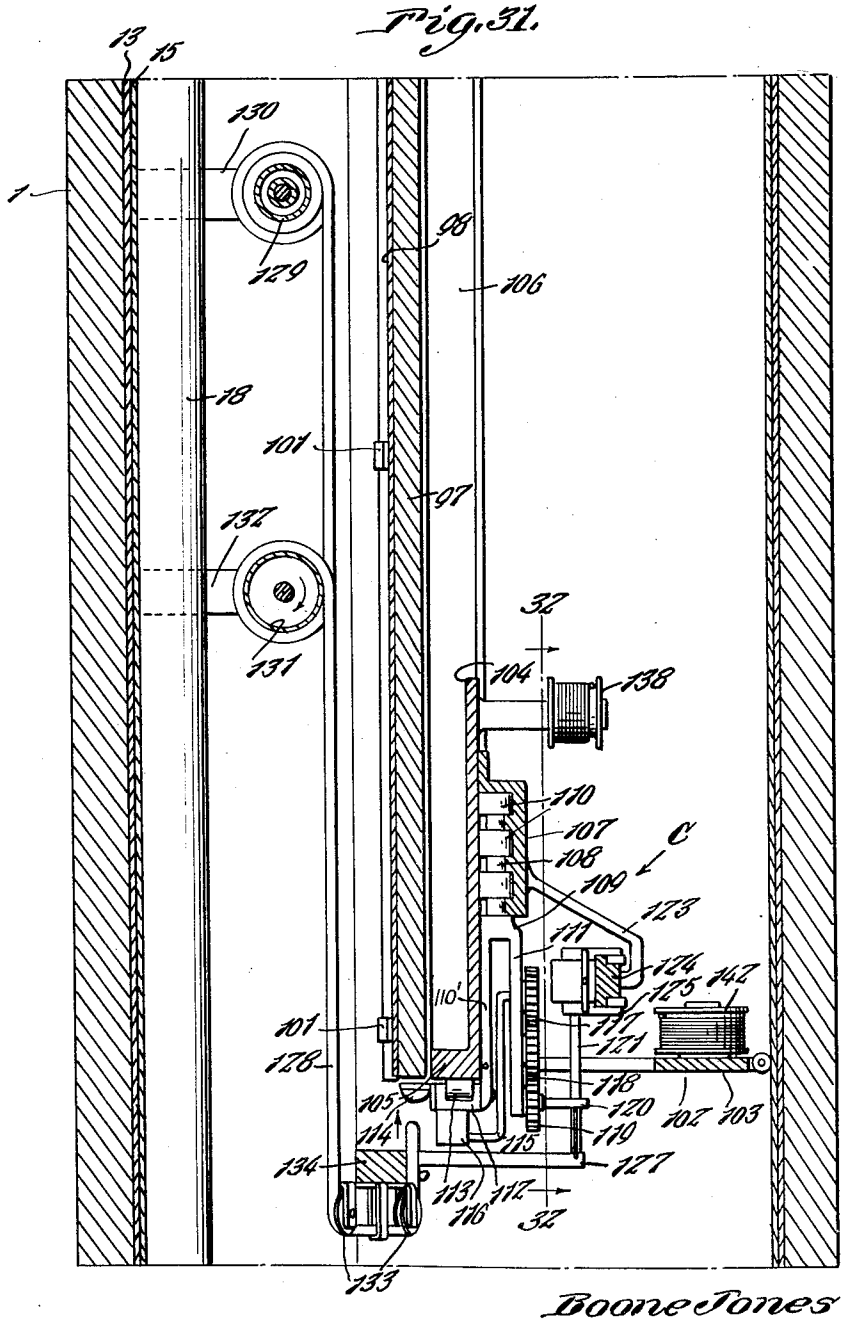
Attorney

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 31.



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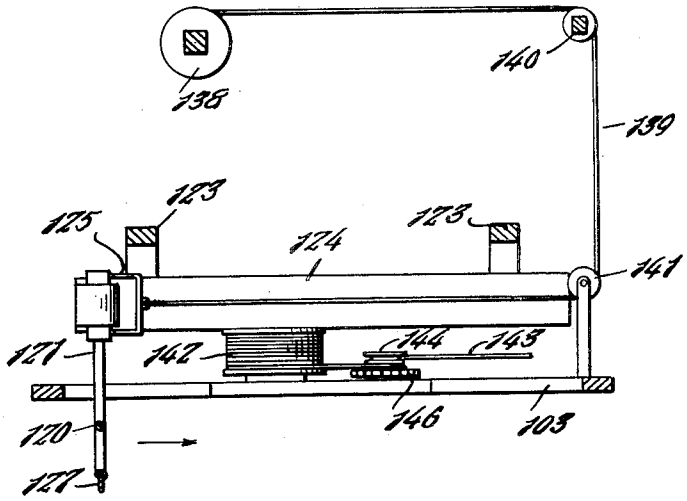
Attorney

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 32.



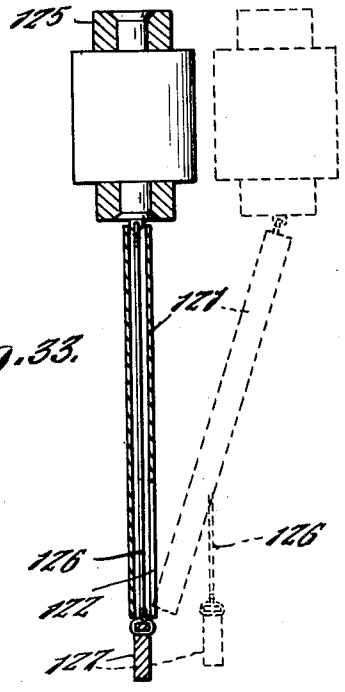


Fig. 33.

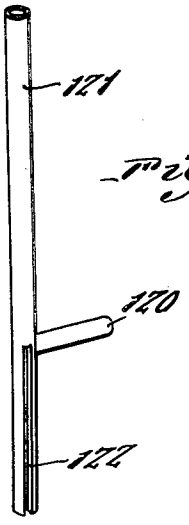


Fig. 34.

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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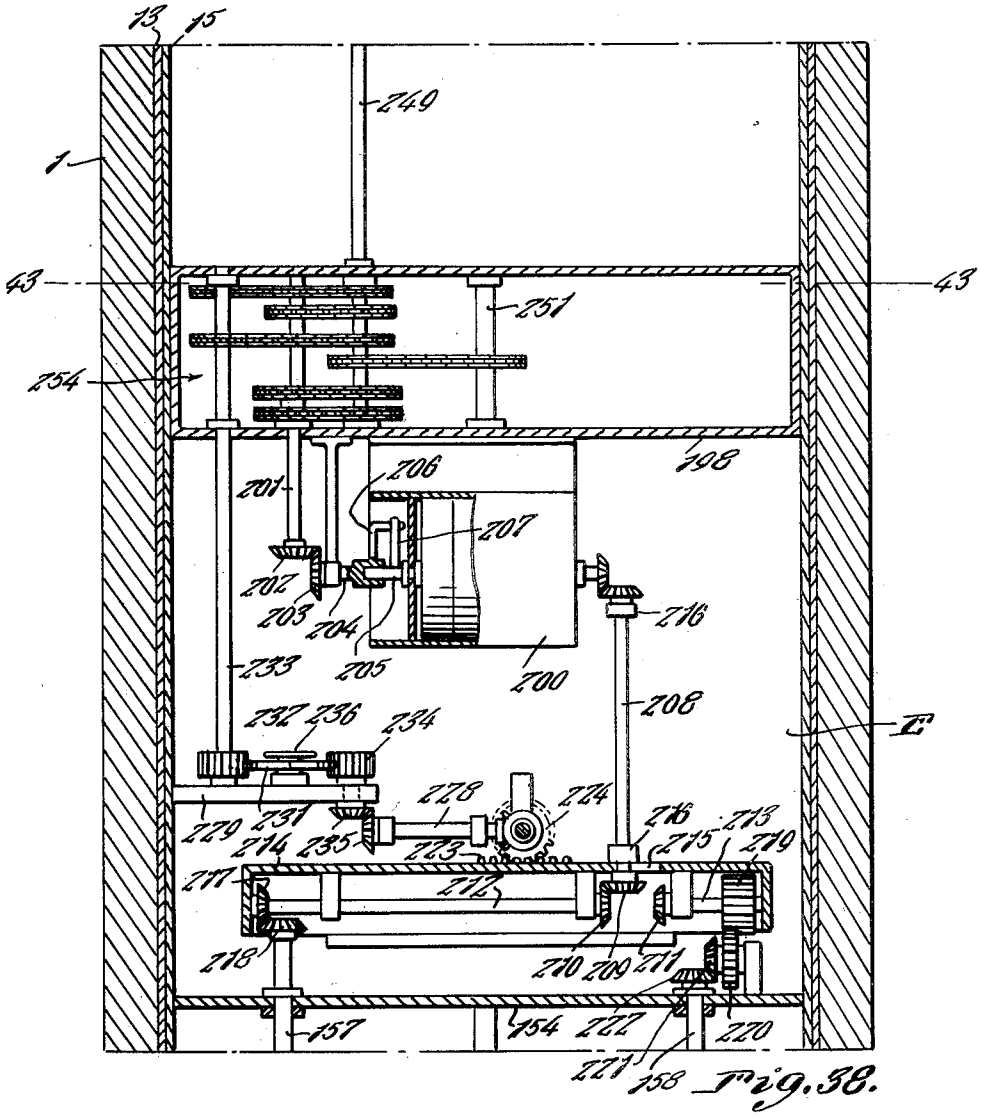


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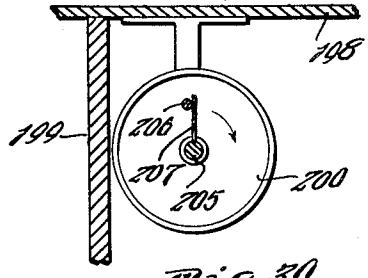


Fig. 39.

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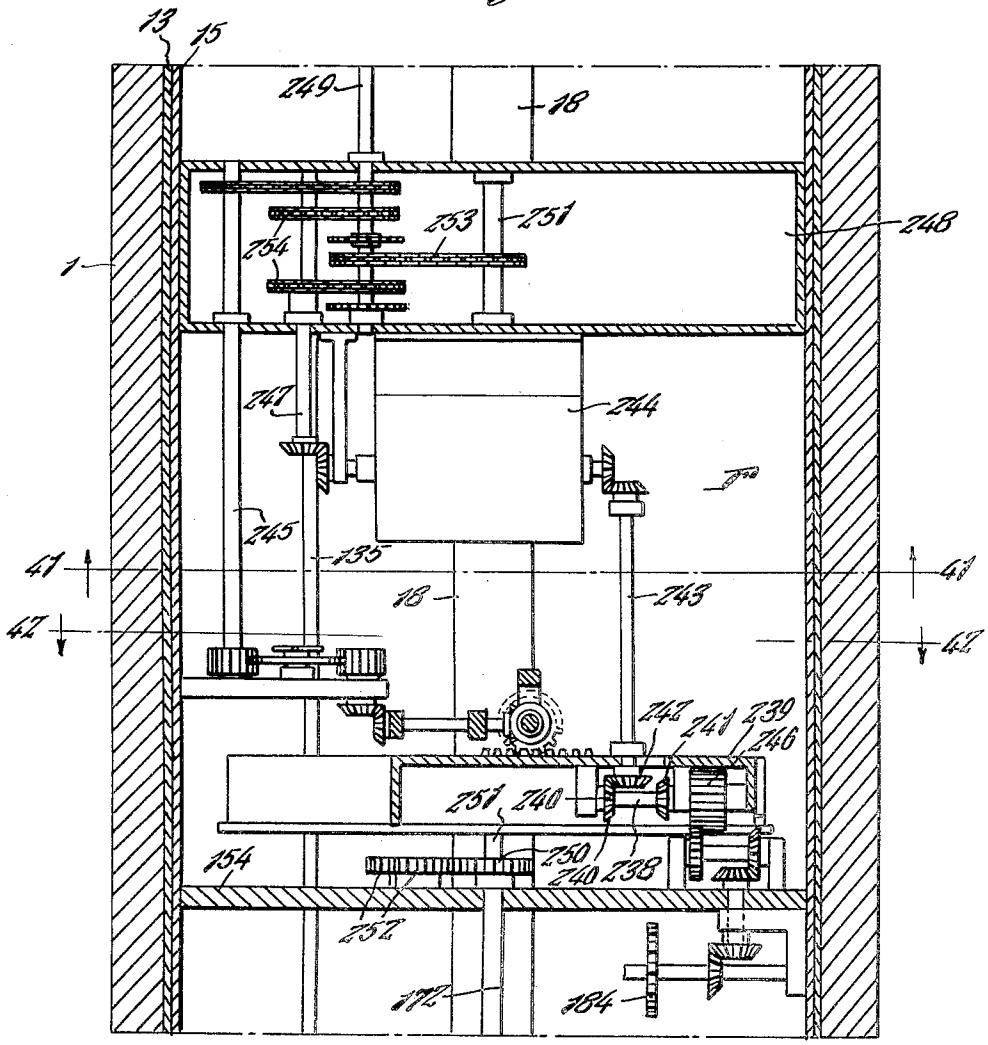
Attorney

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 40.



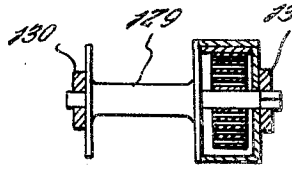


Fig. 60.

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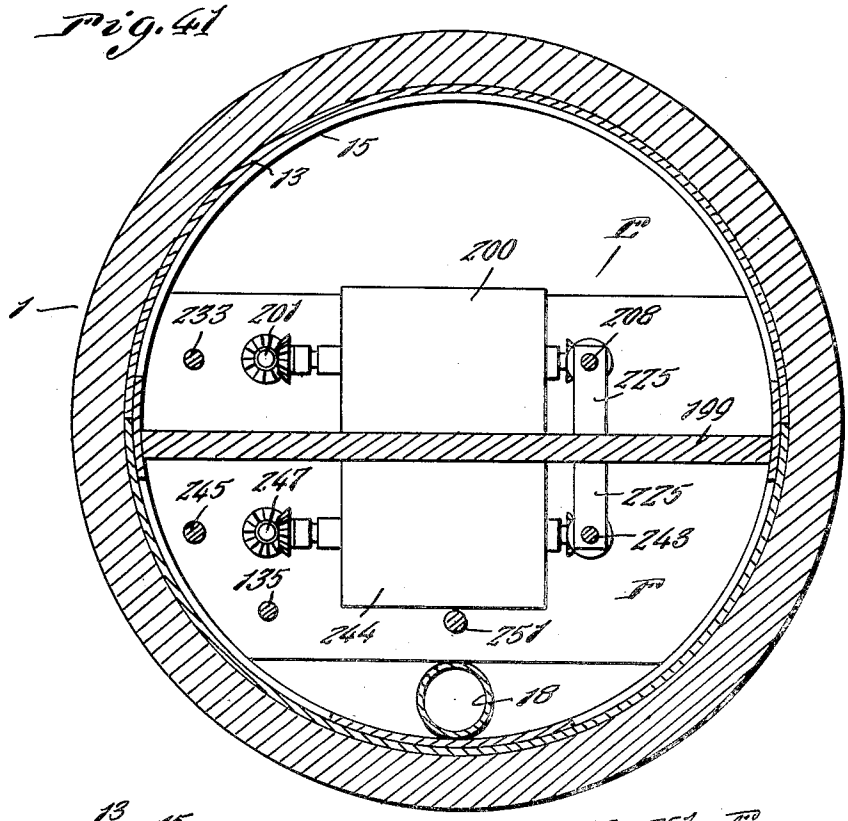
Attorney

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 41



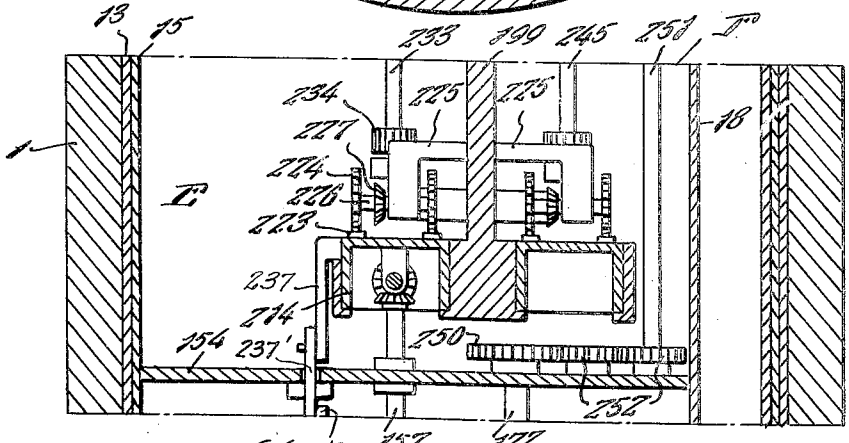


Fig. 44

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Fig. 42.

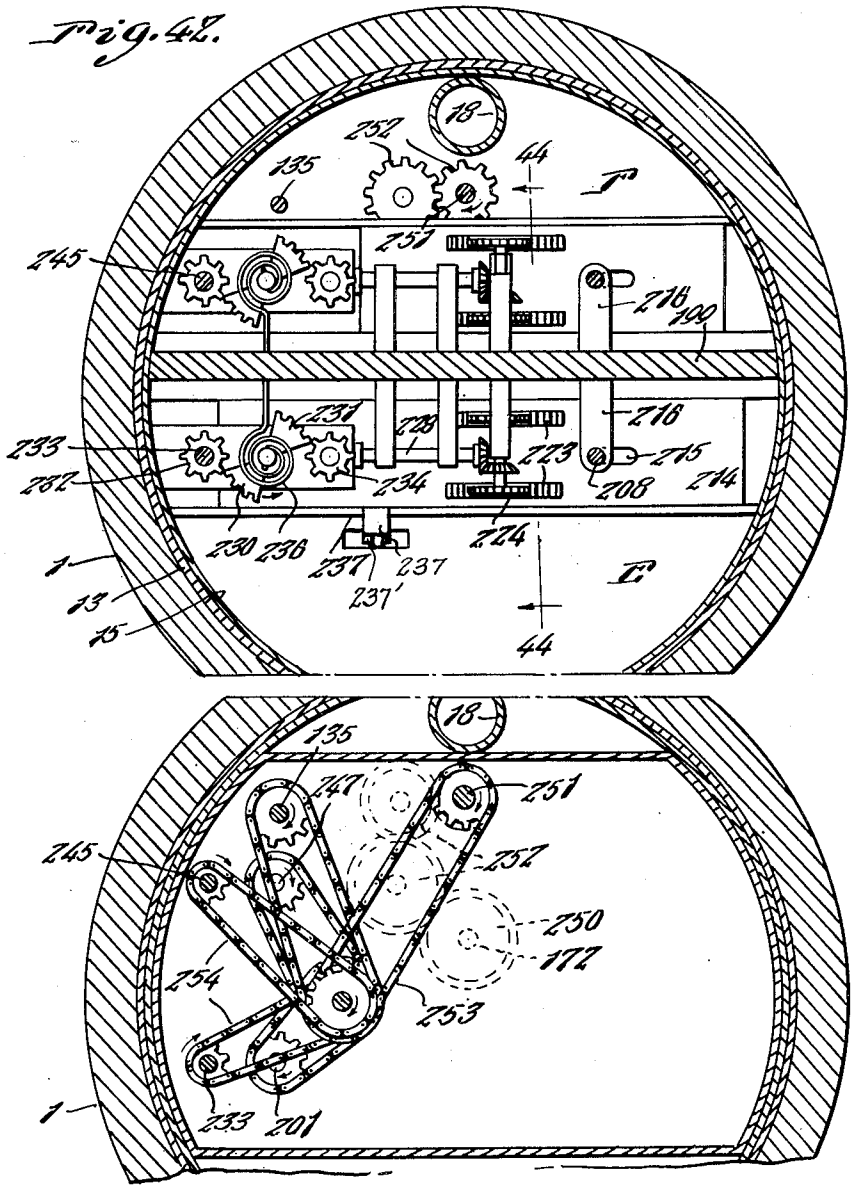


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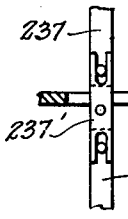


Fig. 63.

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Fig. 45.

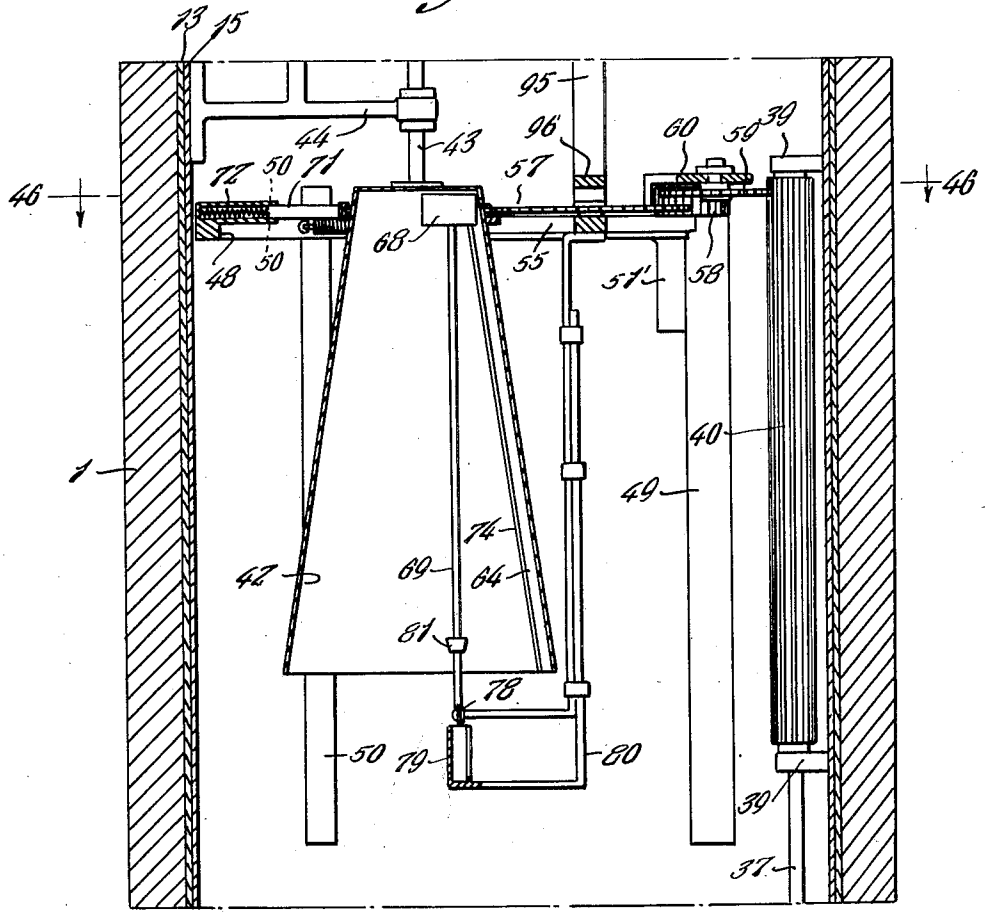
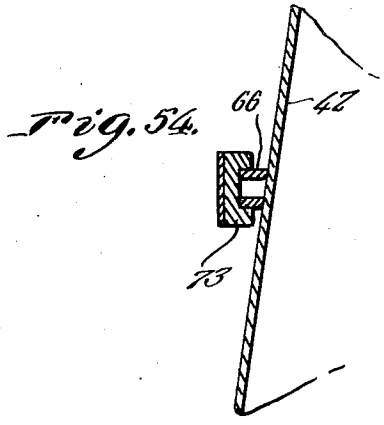


Fig. 54.



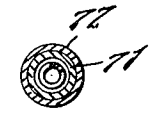


Fig. 50.

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Fig. 46.

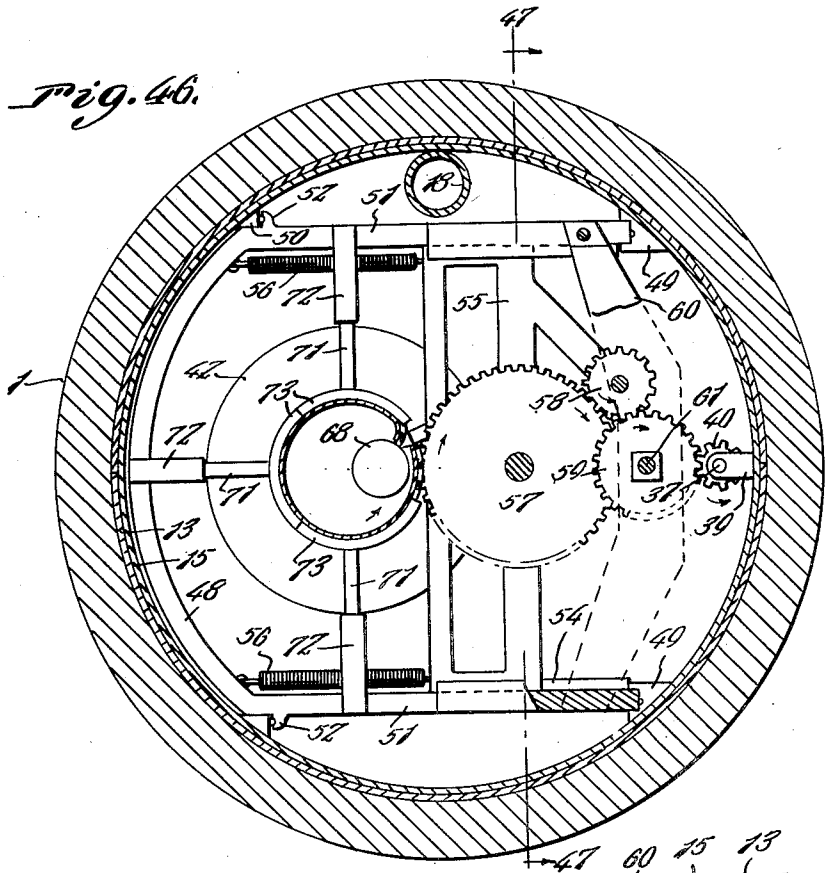


Fig. 48.

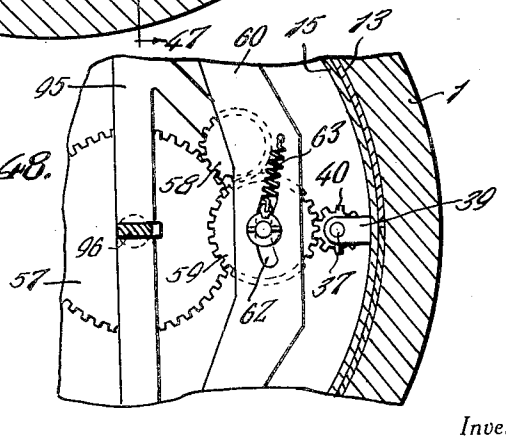
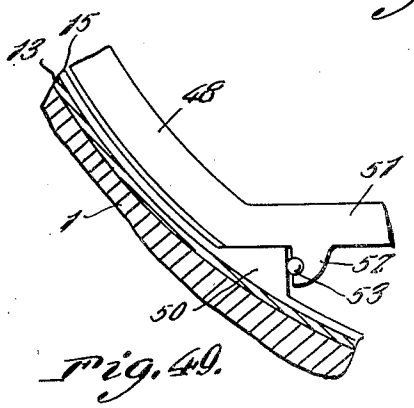


Fig. 49.



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Fig. 47.

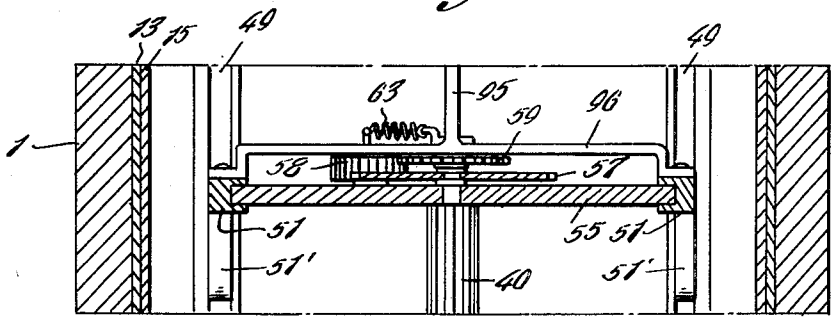


Fig. 52.

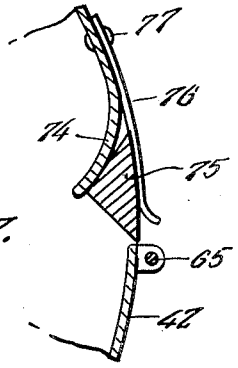
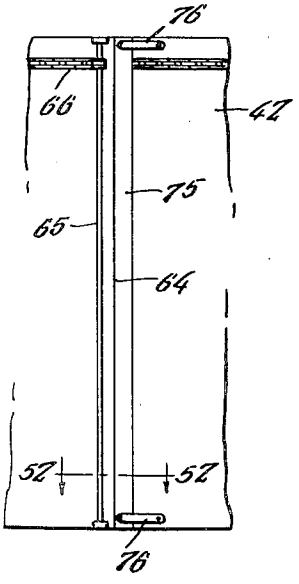


Fig. 51.



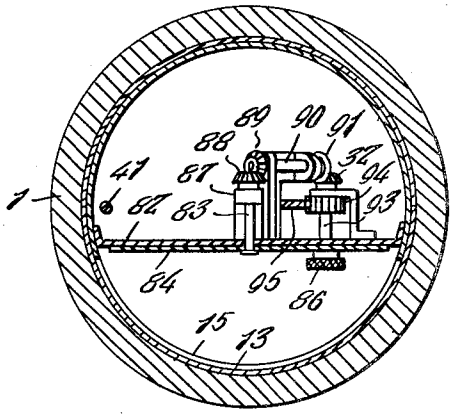


Fig. 53.

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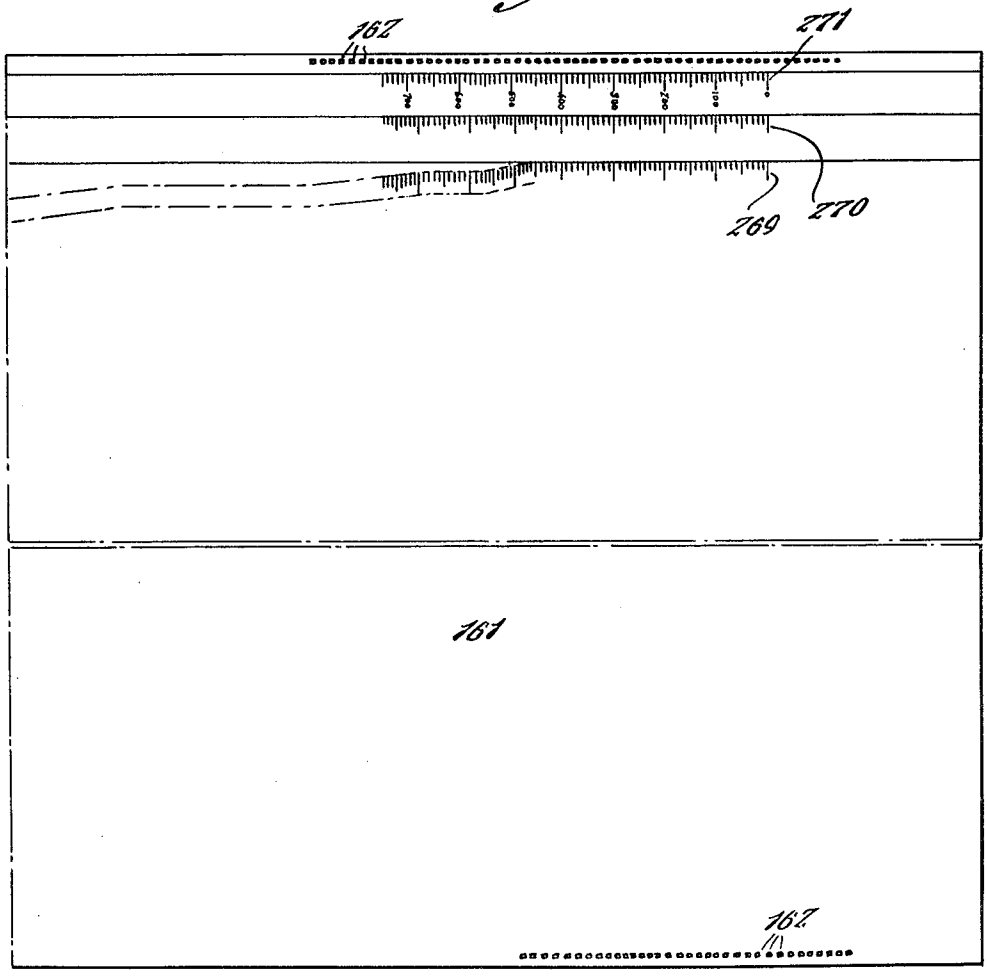
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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

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Fig. 61.



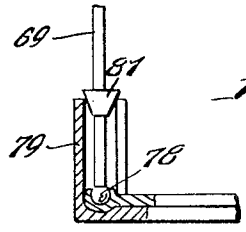


Fig. 62.

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Patented July 21, 1931

1,815,672

UNITED STATES PATENT OFFICE

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INSTRUMENT FOR RECORDING DEVIATIONS AND VERTICAL CORRECTIONS IN BOREHOLES

Application filed June 21, 1930. Serial No. 462,856.

This invention relates to a useful improvement in instruments for recording deviations in bore-holes and more particularly to devices of this character which are especially adapted for use in the bore holes of oil wells.

The primary object of the invention is to provide, in a manner as hereinafter set forth, a device of the aforementioned character embodying a mechanism adapted to make a permanent record of the deviations from the vertical which occur in the bore-hole, which will indicate substantially the degrees of the deviations and which will also indicate the depths at which the deviations occur.

Another important object of the invention is to provide an instrument for plotting deviations in bore-holes which embodies a charting or plotting mechanism adapted to provide a permanent record which will accurately indicate the vertical depth of the bore-hole regardless of the deviations which may occur therein.

Another object of the invention is to provide an instrument for plotting deviations in bore holes including a charting or plotting mechanism which is operatively connected and controlled by a pressure responsive operating means or unit which units is, in turn, actuated by the various degrees of pressure which obtain at different depths in the bore holes.

Another important object of the invention is to provide an instrument of the character set forth embodying a novel construction and arrangement of driving means for the various elements and wherein said driving means, the plotting means and the pressure responsive actuating unit are operatively connected together in a manner to co-act with each other for accurately recording the deviations in the bore holes.

All of the foregoing and still further objects and advantages of the invention may become apparent from a study of the following specification, taken in connection with the accompanying drawings, wherein like characters of reference designate corresponding parts throughout the several views, and wherein:—

Figure 1 is a view in side elevation showing the instrument lowered in position in the bore hole.

Figure 2 is a longitudinal sectional view through the lower end portion of the instrument showing what will be hereinafter referred to as the pressure responsive power unit.

Figure 3 is a longitudinal sectional view through an intermediate portion of the instrument which joins the portions illustrated in Figure 2 and showing what will be hereinafter referred to as the adjustable transmission unit which is operatively connected to the pressure responsive power unit.

Figure 4 is a longitudinal sectional view through an upper intermediate portion of the instrument which joins the portions illustrated in Figure 3 and showing what will be hereinafter referred to as the recording until, the lower end portion of the adjoining mechanism thereabove being also shown.

Figure 5 is a longitudinal sectional view through an intermediate portion of the instrument disposed immediately above the recording unit illustrated in Figure 4 and showing what will be hereinafter referred to as the plotting unit.

Figure 6 is a longitudinal sectional view through the upper end portion of the instrument which joins the portions illustrated in Figure 5 illustrating the construction and arrangement of the upper portion of the casing and the cable power take-off wheel disposed therein.

Figure 7 is another longitudinal sectional view of the upper end portion of the instrument taken substantially at right angles to Figure 6 and on the line 7—7 of said Figure 6.

Figure 8 is a view in side elevation showing the instrument with the outer casing and upper cap removed therefrom.

Figure 9 is a horizontal sectional view taken substantially on the line 9—9 of Figure 6.

Figure 10 is a fragmentary view in horizontal section taken substantially on the line 10—10 of Figure 6 looking upwardly as indicated by the arrows.

Figure 11 is a horizontal sectional view

taken substantially on the line 11—11 of Figure 4 looking in the direction indicated by the arrows.

Figure 12 is a fragmentary horizontal sectional view taken substantially on the line 12—12 of Figure 4.

Figure 13 is a fragmentary view in elevation illustrating the mechanism for adjusting the transmission unit shown in Figure 3.

Figure 14 is a detail view in horzontal section taken substantially on the line 14—14 of Figure 3 looking upwardly as indicated by the arrows.

Figure 15 is a horizontal sectional view taken substantially on the line 15—15 of Figure 2 looking downwardly as indicated by the arrows.

Figure 16 is a fragmentary detail view showing one of the spring latches mounted on the nose cap which is detachably secured to the lower extremity of the instrument as illustrated to advantage in Figure 2.

Figure 17 is a horizontal sectional view taken substantially on the line 17—17 of Figure 2.

Figure 18 is a horizontal sectional view taken substantially on the line 18—18 of Figure 4 looking downwardly as indicated by the arrows.

Figure 19 is a longitudinal sectional view showing the chart or plot printing mechanism and the driving means therefor.

Figure 20 is a horizontal sectional view taken substantially on the line 20—20 of Figure 19 looking downwardly as indicated by the arrows.

Figure 21 is a longitudinal sectional view taken substantially on the line 21—21 of Figure 19 looking in the direction indicated by the arrows.

Figure 22 is a fragmentary horizontal sectional view taken substantially on the line 22—22 of Figure 19 looking upwardly as indicated by the arrows.

Figure 23 is a fragmentary vertical sectional view taken substantially on the line 23—23 of Figure 19.

Figure 24 is a horizontal sectional view taken substantially on the line 24—24 of Figure 19 looking upwardly in the direction indicated by the arrows.

Figure 25 is a diagrammatic view showing certain of the printing members.

Figure 26 is a longitudinal sectional view taken substantially on the line 26—26 of Figure 19.

Figure 27 is a longitudinal sectional view through the chart supporting roll.

Figure 28 is a fragmentary sectional view through the lower end portion of one of the chart driving rolls.

Figure 29 is a horizontal cross-sectional view taken substantially on the line 29—29 of Figure 27.

Figure 30 is a horizontal sectional view through the recording unit taken substantially on the line 30—30 of Figure 4 looking downwardly as indicated by the arrows.

Figure 31 is a longitudinal sectional view taken substantially on the line 31—31 of Figure 30 looking in the direction indicated by the arrows.

Figure 32 is a detail view in section taken substantially on the line 32—32 of Figure 31 looking in the direction indicated by the arrows.

Figure 33 is a detail view in longitudinal section showing the device which controls the angularity of the recording knife to be hereinafter referred to.

Figure 34 is a detail view in perspective showing one of the elements of the mechanism for controlling the angularity of the recording knife.

Figure 35 is a horizontal cross sectional view through a rubber recording slab or plate after the operation has been completed.

Figure 36 is a view showing the lower end portion of the vertically movable carriage which supports the recording unit with the cutting knife which operates on the rubber slab associated therewith, the latter being shown in end elevation.

Figure 37 is an enlarged detail view in section showing the means for operatively connecting the pressure responsive coil of the unit illustrated in Figure 2 to the gear mounted thereabove.

Figure 38 is a longitudinal sectional view showing the mechanism for driving and reversing the chart.

Figure 39 is a detail end view showing one of the spring motors constituting a part of the chart driving mechanism.

Figure 40 is a longitudinal sectional view illustrating the mechanism for driving the printing elements.

Figure 41 is a horizontal sectional view taken substantially on the line 41—41 of Figure 40 and looking upwardly as indicated by the arrows.

Figure 42 is a horizontal sectional view taken substantially on the line 42—42 of Figure 40 looking downwardly as indicated by the arrows.

Figure 43 is a horizontal sectional view taken substantially on the line 43—43 of Figure 38 looking downwardly.

Figure 44 is a longitudinal sectional view taken substantially on the line 44—44 of Figure 42 looking in the direction indicated by the arrows.

Figure 45 is a longitudinal vertical sectional view taken through the adjustable transmission unit illustrated in Figure 3 of the drawings.

Figure 46 is a horizontal sectional view taken substantially on the line 46—46 of Figure 45 looking downwardly as indicated by the arrows.

Figure 47 is a longitudinal sectional view taken substantially on the line 47—47 of Figure 46 looking in the direction indicated by the arrows.

Figure 48 is a fragmentary detail view in horizontal section showing the gearing train constituting a part of the adjustable transmission unit, said gearing train being shown in top plan.

Figure 49 is a detail view on an enlarged scale showing the means for mounting the adjustable transmission unit for vertical movement.

Figure 50 is a detail view in cross-section taken substantially on the line 50—50 of Figure 45.

Figure 51 is fragmentary view in front elevation showing the cone which forms part of the adjustable transmission unit.

Figure 52 is a fragmentary horizontal sectional view taken substantially on the line 52—52 of Figure 51 looking downwardly as indicated by the arrows.

Figure 53 is a horizontal sectional view taken substantially on the line 53—53 of Figure 3 looking downwardly.

Figure 54 is an enlarged fragmentary sectional view through one side of the cone showing the means for retaining the cone driving chain in position against said cone.

Figure 55 is a fragmentary view in longitudinal section showing a portion of the driving cables.

Figure 56 is a horizontal transverse sectional view taken substantially on the line 56—56 of Figure 55.

Figure 57 is a detail view in perspective illustrating the knife adjusting arm.

Figure 58 is an enlarged detail view in perspective showing one of the printing elements or stamps.

Figure 59 is an enlarged sectional view showing the spring controlled chain supporting drum which is associated with the cone of the adjustable transmission unit.

Figure 60 is a vertical sectional view through the uppermost spring controlled drum of the recording unit as illustrated in Figure 31.

Figure 61 is a view in front elevation showing a section of a completed chart or plot.

Figure 62 is a fragmentary view in section showing the means for supporting the chain reel within the cone as illustrated in Figure 45.

Figure 63 is a view showing the means for operatively connecting the chart shield to the movable casing which is mounted in an upper portion of the device.

Referring to the drawings in detail, the reference character 1 designates an elongated cylindrical barrel of uniform diameter throughout having its lower end portion internally threaded for connection with an externally threaded plug 2 which projects downwardly from the barrel and is provided with a horizontally disposed annular shoulder for abutting engagement with the lower end of the barrel in such a manner that the periphery of the plug and the barrel are flush with each other as clearly seen in Figure 2 of the drawings. At its upper end, the barrel 1 is provided with an inturned flange 3 which provides a central opening which is closed by the metallic disc 4 and a dome shaped cap 5, having a central opening 6 in its upper end, is detachably mounted on the upper end of the barrel through the medium of the spring latch hooks 7 secured on the flange 3 for engagement in notches on the inner wall of the cap which are provided for this purpose, as illustrated to advantage in Figure 6. The cap 5 is further provided adjacent its lower end with transverse threaded passages for the insertion of a suitable tool for disengaging the latches 7 from the cap in order that said cap may be removed from the barrel. Threaded plugs 8 are screwed into the openings provided in the lower portion of the cap 5 for the purpose of closing the same to prevent the entrance of water or other liquid thereinto when the device is lowered into the well.

Referring again to Figure 2 it will be seen that the plug 2 is provided with an integral, reduced extension 9 having shoulders 10 thereon for receiving the spring latch hooks 11 of a nose cap 12 which is fitted over the reduced extension 9 and adapted for abutting engagement with the shoulder formed on the plug 2 by said reduced extension.

As best illustrated in Figure 8 of the drawings, the barrel 1 is removably telescoped over a tubular elongated metallic casing 13 having a series of superposed openings disposed longitudinally therein which are closed by the doors 14. A skeleton frame 15 formed of metal is permanently mounted in the tubular casing 13 and said skeleton frame is closed at its lower end as indicated at 16 and at its upper end as indicated at 17. A cable housing or tube 18 extends longitudinally through the skeleton frame 15 and has its upper end communicating with an opening 19 in the disc 4 (see Figure 6) and its lower end is in communication with the bore 20 which extends centrally through the plug 2. The tube 18 is adapted to slidably receive a driving cable 21 and has its intermediate portion laterally offset and disposed in parallel abutting engagement with one of the side walls of the skeleton frame 15. As best seen in Figure 6, a guide tube 22 having a longitudinally extending slot 23 in one side thereof is mounted on a supporting arm 24 extending from the flange 3 of the barrel 1 and said guide tube 22 is disposed in the cap 5 in alignment with the opening 6 and the opening 19 of the disc 4. A suspension cable or wire 25 extends through the upper portion of the cap 5 and

is anchored as at 26 to the arm 24 and constitutes means for raising and lowering the instrument in the bore.

A pressure responsive power unit is illustrated to advantage in Figure 2 of the drawings and is designated generally by the reference character A. The unit A includes the plug 2 and said plug is provided with a chamber 27 which encircles the bore 20 of the plug and from which chamber extend the radial openings or passages 28 which communicate with the periphery of the plug intermediate the lower end of the barrel 1 and the upper end of the nose cap 12. The passages 28 have their outer end portions threaded to receive the sleeves 29 in which are mounted the membranes 30. A coiled Bourdon tube 31 encircles the lower centrally disposed end portion of the cable tube or casing 18 and has its lower end extending downwardly through the plug 2 and communicating with the circular chamber 27 therein. The upper end of the Bourdon tube 31 has rigidly mounted thereon an upstanding pin 32 which extends through a radial slot 33 (see Figures 2 and 15) of a gear 34 mounted for rotation on the cable tube 18 between the flanges 35. The gear 34 is operatively connected to a pinion gear 36 fixed on the lower end of a vertical shaft 37 which is rotatably mounted in the bearing bracket 38 extending inwardly from the skeleton frame 15.

Referring to Figure 3 of the drawings, it will be seen that the upper end portion of the shaft 37 is mounted for rotation in the bearing 39 extending inwardly from the skeleton frame 15 and fixed on said shaft between said bearing 39 is an elongated cylindrical gear 40. It may be well to here say that the shaft 37 is operatively connected with a shaft 41 in a manner to drive the latter at various speeds and to this end an adjustable transmission unit designated generally by the reference character B is provided. The transmission unit B includes a hollow frusto-conical shell 42 open at its lower end and closed at its upper end and mounted on the lower end of a vertical shaft 43 which is supported for rotation in the outer end of the bracket 44 which extends inwardly from the skeleton frame 15. The shell 42 is fixed to the shaft 43 for rotation therewith. The shaft 43 is operatively connected to the shaft 41 through the medium of a gear 45 fixed on its upper end which meshes with a gear 46 which is supported for rotation on an intermediate portion of the bracket 44 and is in turn meshed with a pinion gear 47 fixed on the lower end of the shaft 41.

The transmission unit B further includes a metallic frame 48 which encircles the shell 42 and is adapted for vertical reciprocatory movement in the skeleton frame 15. For shiftably mounting the transmission frame 48 in the skeleton frame 15, said skeleton frame is provided with a pair of longitudinally extending channelled lugs 49 which are disposed in opposed relation to a pair of elongated lugs 50 which are also mounted on said skeleton frame. As illustrated to advantage in Figure 46, the frame 48 is substantially U-shaped in top plan and includes the parallel co-extensive arm portions 51 having their free ends slidably disposed in the channels of the elongated lugs 49. The arm portions 51 of the frame 48 are further provided, adjacent their opposite ends with integral projections 52 disposed in opposed relation to the elongated lugs 50 and anti-friction balls 53 (see Figure 49) are disposed between said projections 52 and lugs 50. Anti-friction balls are also disposed between the free ends of the arm portions 51 and the bottom of the channels in the lugs 49. The inner side of the free end portions of the arm portions 51 are provided with opposed, longitudinally extending channels 54 for slidably receiving the end portions of a horizontally shiftable gear supporting carriage 55 which is yieldingly urged toward the shell 42 by a pair of coil springs 56 having one end connected to said gear carriage and their other ends connected to the frame 48. Constantly meshed gears 57 and 58 are mounted for rotation on the carriage 55 and the gear 58 is in mesh with a gear 59 mounted for rotation on a horizontally disposed supporting bar 60 which extends between the arm portions 51 of the frame 48. The pin 61 upon which the gear 59 is mounted is disposed through an arcuate slot 62 in the supporting bar 60 in a manner to permit said gear 59 to be moved toward or away from the gear 58. It should be here mentioned that the gear 58 is of double thickness to permit both of the gears 57 and 59 to mesh therewith in the manner illustrated in Figures 46 and 48. The gear 59 is maintained in engagement with the gear 58 through the medium of the coil spring 63, as best illustrated in Figure 48. The gear 59 is in mesh with the elongated cylindrical gear 40 which is fixed on the shaft 37. As seen in Figure 47, the arm portions 51 of the frame 48 are provided with depending extensions 51′ which extend longitudinally in the channels of the elongated guide lugs 49.

As illustrated to advantage in Figures 51 and 52 of the drawings, the frusto-conical shell 42 is provided on one side with a slot 64 which extends from the upper end to the lower end thereof. Rigidly mounted in spaced parallelism to the shell 42 and adjacent the slot 64 therein is an elongated rod 65 to which one end of a sprocket chain 66 is slidably connected. The inner side of the chain 66 is inclined to conform to the surface of the shell 42 as seen in Figure 54 of the drawings and said chain encircles said shell

and extends thereinto through the slot 64. The chain 66 is windable on a spring controlled drum 67 (see Figure 59) which is mounted for rotation in a housing 68 disposed within the shell 42 and fixed on the upper end of a substantially U-shaped supporting arm 69 which has its opposite end rigidly connected to the horizontally slidable gear carriage 55 and depends therefrom. The housing 68 is provided with an opening 68′ for the passage of the chain 66 thereinto. The spring drum 67 is provided with an elongated hub portion 67′ which is encircled by a coil spring 70 having one end anchored to the said hub portion and its other end anchored to the wall of the housing 68 in a manner to wind the chain 66 on said drum.

Referring to Figures 45, 46 and 54, it will be seen that spring pressed plungers 71 are mounted for sliding movement in the sleeves 72 which extend inwardly from the arm portions 51 of the frame 48 on opposite sides of the frusto-conical shell 42 and said plungers 71 are provided, on their free ends, with the arcuate channeled cross heads 73 through which the chain 66 is slidable and said cross heads are adapted to maintain the said chain 66 in yielding engagement against the adjacent side portions of the shell 42. As seen in Figure 52 of the drawings, the marginal portion of the shell 42 on one side of the slot 64 is curved inwardly as indicated at 74 and disposed against said inwardly curved portion is an elongated resilient strip 75 of suitable material, such as rubber, which is adapted to bridge or close the slot 64. The closure strip 75 is detachably maintained in place through the medium of the pivotally mounted spring fingers 76 which are mounted as at 77 on the shell 42. The spring fingers 76 extend transversely across the resilient strip 75 and securely maintain said strip in place. The chain 66 passes between the resilient strip 75 and the curved portion 74 of the shell 42. As seen in Figure 46 the gear 57 is operatively engaged with the chain 66 and is adapted to impart rotary movement to the frusto-conical shell 42. The resilient strip 75 is adapted for engagement with the teeth of the gear 57 and functions in a manner to bridge the space between the ends of the chain 66 which is slidably connected to the rod 65 and the portion of said chain which emerges from the shell 42 through the slot 64. When the chain 66 is to be adjusted vertically on the shell 42, the strip 75 is removed from the slot 64 and replaced thereafter.

As seen in Figure 62, a universal joint 78 is provided upon which the portion of the arm 69 which supports the chain reel or drum 67 is swingable. A keeper in the form of a split socket member 79 is shiftably mounted, as at 80 on the vertical portion of the reel supporting means 69 which depends from the gear carriage 55 and said socket member is adapted to engage at its upper end with the conical head or flange 81 which is mounted on that portion of the chain reel or drum which extends upwardly into the shell 42. When the socket member 79 is in the position indicated in Figure 62, the chain reel 67 and the housing 68 therefor is maintained against swinging movement and when the socket 79 is in the position indicated in Figure 45 said chain reel and said housing are free to swing on the universal joint 78.

As illustrated to advantage in Figures 3, 13 and 53 of the drawings, a vertical partition plate 82 extends across the skeleton frame 15 and has mounted for rotation on one side thereof through the medium of the shaft 83 a graduated dial 84 for co-action with a vernier 85 mounted on said partition plate. An actuating knob or handle 86 is mounted on the dial 84. The shaft 83 has its rear end supported for rotation in a bearing bracket 87 and fixed on the rear end of said shaft is a beveled gear 88 which meshes with a beveled gear 89 mounted on the upper end of an inclined rotary shaft 90. The shaft 90 has fixed on its lower end a beveled gear 91 which meshes with a beveled gear 92 fixed on the end of a shaft 93. The shaft 93 carries a pinion gear 94 in operative engagement with a vertical rack bar 95 which has its lower end rigidly connected to the vertically movable frame 48 through the medium of the cross bar 96 (see Figure 47).

It will thus be seen that when the dial 84 is rotated, the frame 48 is moved vertically in the guide lugs 49 and 50 of the skeleton frame 15. The frame 48 moves all of the gears thereon and the chain 66 up or down with respect to the frusto-conical shell 42 and in this manner the shaft 41 may be driven at the desired speed by the shaft 37. As the chain 66 is moved vertically on the shell 42 the spring controlled chain reel 67 either pays out or takes in said chain in a manner to compensate for the progressive increase or decrease of the shell. It will also be seen that the gear carriage 55 having the gears 57 and 58 thereon will slide horizontally on the arm portions 51 of the frame 48 to allow for the progressive increase or decrease in the circumference of the portion of the cone which is opposite the gear 57 when the same is moved up or down. The slot 62 in which the gear 59 is mounted permits said gear 59 to shift in a manner to remain constantly in mesh with the gears 40 and 58 when the latter gear is shifted horizontally with its carriage 55. As before stated, the spring 63 urges the gear 59 into engagement with the gear 58. It will further be apparent that the gear 59 is adapted to slide vertically on the elongated gear 40. When the shell 42 is driven through the train of gearing just described the chain reel hous-

ing 68 swings in a circular path with said shell on the universal joint 78.

Figures 4, 12 and 30 to 36, inclusive, of the drawings illustrate what will be hereinafter referred to as the recording unit of the instrument which is designated generally by the reference character C. Figures 57 and 60 also illustrate in detail certain elements of the recording unit C. This unit is disposed above the transmission unit B within the barrel 1 and operatively connected thereto by the shaft 41. The recording C includes a slab or sheet of rubber 97 which is mounted in a metallic backing plate 98 having its longitudinal marginal portion turned back as at 99 in a manner to provide channels for the reception of the longitudinal vertical edges of said rubber slab. The outer surface of the slab 97 is preferably treated in a manner to render the same comparatively non-elastic. The rubber slab is adapted to be detachably supported between a pair of vertical opposed recessed bars 100 (see Figure 30) through the medium of the spring clips 101. It will thus be seen that the rubber slab is disposed transversely across the skeleton frame 15 and extends longitudinally in the barrel of the instrument. The clips 101 frictionally support the slab against vertical movement but any desired means may be provided for detachably supporting the same.

A knife carriage 102 is mounted for vertical movement in the barrel 1 of the instrument adjacent the exposed face of the rubber slab 97. The knife carriage 102 comprises a horizontally disposed arcuate bar 103 having its ends rigidly connected to a vertically disposed metallic plate 104 adjacent the lower end of said plate. On its lower end, the plate 104 is provided with an integral flange or extension 105. The vertical edges of the plate 104 and the ends of the flange 105 are disposed for vertical sliding movement in the substantially U-shaped opposed channel members 106 mounted in the skeleton frame 15 immediately adjacent the bars 100 which support the rubber slab 97. Secured to the outer face of the plate 104 is a transversely extending channelled bracket 107 in which the shank 108 of a knife supporting device 109 is slidably supported for horizontal movement through the medium of the rollers 110 fixed on said shank 109, said rollers being disposed for travel in the channels of the bracket 107 as clearly illustrated in Figure 31 of the drawings. The knife supporting device 109 is bifurcated to provide parallel arms 110′ and 111. Rotatably mounted on the lower end portion of the arm 110′ is a horizontally disposed member 112 which extends beneath the flange 105 and has journaled therein an anti-friction roller 113 adapted to travel across the lower face of said flange. Rigidly secured to the free end of the member 112 is a knife 114 which is disposed beneath the lower end of the rubber slab 97 when in inoperative position. An arm which is illustrated in detail in Figure 57 of the drawings has an angular upper end portion extending through the arm 111 of the knife supporting device 109 and is designated by the reference numeral 115. At its lower end, the arm 115 terminates in an angular portion which extends between a pair of depending fingers 116 mounted on the member 112. The arm 115 is mounted for swinging movement in a vertical plane on the arm 111 and is adapted to rotate the member 112 together with the knife 114 on the arm 110′ in a manner to vary the angularity of said knife with respect to the rubber slab 97. The arm 115 projects through and beyond the arm 111 of the knife supporting device 109 and has fixed on the projecting end portion thereof a gear 117 which meshes with a gear 118 which in turn is in mesh with a gear 119. The gears 118 and 119 are mounted on the arm 111. The gear 119 has fixed thereto an outwardly projecting shaft 120 on the outer end of which is fixed an open end tube 121 which, as best illustrated in Figure 34 of the drawings, has its lower end portion longitudinally slotted on one side as indicated at 122.

Arms 123 project outwardly and downwardly from the outer side of the channelled bracket 107 in a manner to support a horizontally disposed track bar 124 on their lower ends. Mounted for longitudinal movement on the track bar 124 is a carriage 125 to which is connected the upper end of a flexible rod or wire 126 (see Figure 33) which extends longitudinally through the tube 121 and said wire has its lower end connected to one end portion of a horizontal bar 127. The other end of the bar 127 is rigidly connected to a cable 128 which is windable on a spring controlled drum 129 mounted for rotation between the arms 130 which extend inwardly from the skeleton frame 15. The spring controlled drum 129 is illustrated in detail in Figure 60 of the drawings. Below the spring controlled drum 129 the cable 128 is wrapped around a driving drum 131 supported for rotation between the arms 132 projecting inwardly from the skeleton frame 15 and after leaving said driving drum 131 the cable is trained under a pair of pulley wheels 133 mounted for rotation on the lower side of a transverse supporting bar 134 which has its ends supported on the skeleton frame 15. The free end of the cable is disposed beneath the knife 114 and is adapted to be drawn upwardly through the rubber slab 97 in the incision which the knife forms therein. The driving drum 131 is operatively connected to a shaft 135 (see Figure 4) which is driven from a suitable source of power which will be hereinafter described.

The upper portion of the shaft 41 is pro-

vided with a spiral groove and said shaft extends rotatably through the flange 105 of the plate 104 adjacent one end thereof as best illustrated in Figure 30. A vertical rack bar 136 is also anchored to the flange 105 and extends upwardly to an operating mechanism which will be presently set forth. As shown in detail in Figure 12, a pin 137 is mounted in the flange 105 and projects into the spiral groove in the upper portion of the shaft 41 in a manner to operately connect the recording unit C to said shaft 41. A spring controlled drum 138 is mounted on the upper end portion of the plate 104 and windable thereon is a cable 139 (see Figure 32) which is trained over the pulleys 140 and 141 and is connected to the carriage 125 in a manner to yieldingly urge said carriage longitudinally across the track bar 124 from right to left as viewed in Figure 30 of the drawings. The pulley wheel 141 as well as the pulley 140 are mounted on the knife carriage 102. A spring controlled drum 142 is mounted for rotation on the arcuate portion 143 of the knife carriage 102 and has windable thereon a cable 143 which is wrapped around a drum 144 and extends therefrom around a pulley wheel 145 and has its end connected to the knife supporting arm 110′ and is adapted to draw said arm and the elements connected thereto transversely with respect to the plate 104 and the rubber slab 97. The drum 144 has fixed on one side thereof a gear 146 which is in mesh with a gear 147 fixed on the shaft 148 the lower end of which extends slidably and rotatably through the arcuate portion 103 of the knife carriage 102. It will thus be seen that upon winding movement of the spring controlled drum 142, the shaft 148 will be caused to rotate. The gear 147 is keyed to the shaft 148 in a manner to slide vertically thereon with the knife carriage 102. A gear 149 is fixed on the upper end of the shaft 148 (see Figure 24) and an endless sprocket chain 150 is trained over said gear 149 and a gear 151 which, in turn, is fixed on the lower end of a spirally grooved vertical shaft 152 which extends for rotation through a horizontal partition 153 provided in the skeleton frame 15. It should be here mentioned that the upper portion of the shaft 148 is also journaled in the partition 153.

Disposed within the barrel of the instrument between the horizontal partitions 153 and 154 and above the recording unit C is mounted what will be hereinafter referred to as a plotting or charting unit designated generally by the reference character D of which the spirally grooved shaft 152 is a part. As best seen in Figure 5 the plotting or charting unit D includes a pair of elongated spools 155 and 156 mounted on shafts 157 and 158, respectively, said shafts being of polygonal cross section and adapted to fit within sockets 159 mounted on the upper ends of the spools. A coil spring 160′ (see Figure 27) is disposed in the sockets 159 for engagement with the ends of each of the shafts for yieldingly urging the spools downwardly. The lower ends of the spools 155 and 156 are provided with a lug (see Figure 28) which is disposed for rotation in a socket provided in the lug 160 on the partition 153. The spools 155 and 156 are of duplicate construction and the manner of mounting the same in the instrument is identical. A web or chart 161 is windable back and forth between the spools 155 and 156 as best illustrated in Figure 20. As best seen in Figure 61 of the drawings, the longitudinal marginal portions of the chart 161 are provided with rows of perforations 162 for the reception of the teeth 163 which project radially from the opposite end portions of a chart supporting roller 164. The lower end of the chart supporting roller 164 is provided with a polygonal lug 165 adapted to seat in a complemental socket formed in the upper end of a shaft 166 which extends rotatably through the partition 153 and depends from said partition. It will be seen that the manner of mounting the spools 155 and 156 and the chart supporting roller 164 is such that all of these elements may be expeditiously removed by simply shifting the same against the coil springs 160 until the lugs on the lower ends thereof clear the sockets in which they are mounted and said spools and the roller may then be removed.

Referring again to Figure 4 of the drawings, it will be seen that the shaft 166 has fixed on its lower end a beveled gear 167 which meshes with the beveled gear 168 fixed on one end of a shaft 169 which, as best illustrated in Figure 11, is operatively connected to a shaft 170 having a gear 171 fixed thereon which meshes with the ratchet bar 136 which is anchored to the flange 105 of the plate 104 forming a part of the recording unit C. As will be apparent, the movement of the web or chart 161 from one of the spools to the other will drive the supporting roller 164 and the mechanism of the recording unit C will thus be raised or lowered through the medium of the rack bar 136 and the gearing mechanism which operatively connects said rack bar with the chart supporting roller 164.

Mounted for rotation in spaced parallelism with the chart supporting roller 164 is a shaft 172 having printing wheels 173 and 174 mounted thereon, for rotation therewith. The construction and arrangement of these wheels is best illustrated in Figures 20 and 26 of the drawings. The upper printing wheel 173 is fixed on the upper portion of the shaft 172 and the lower printing wheel 174 is mounted for vertical sliding movement thereon. The construction of the printing wheels is the same and a description of one will therefore suffice for both. Each printing wheel is pro-

vided with a series of radially extending sockets in its periphery in which are slidably mounted the printing stamps 175 having beveled outer ends provided with the printing projections 176. Coil springs 177 are disposed in the sockets behind the printing stamps 175 in a manner to yieldingly urge the same outwardly. Stop pins 178 are mounted on the stamps 175 and adapted to travel in slots 179 which communicate with the sockets in the printing wheels and said pins serve to limit the outward movement of the printing stamps as will be obvious. Figure 58 of the drawings illustrates in detail one of the printing stamps. The width of the printing projections 176 on the stamps 175 is such that the marking on the chart will be as illustrated in Figure 61. This is also illustrated to advantage in Figure 25 of the drawings.

The lower printing wheel 174 is mounted in a frame 180 adapted to move vertically against a pair of upright bars 181, anti-friction rollers 182 being mounted on said frame for engagement against the adjacent faces of said bars. The frame 180 is anchored to an endless sprocket chain 183 which is trained over an upper drive sprocket 184 and a lower idling sprocket 185. The upper sprocket 184 is mounted on a shaft 186 having a beveled gear 187 fixed thereon which meshes with a gear 188 fixed on the lower end of a vertical shaft 189. The shaft 189 extends rotatably through the horizontal partition 154 and is operatively connected to a source of power to be hereinafter more fully referred to.

A vertically disposed elongated metallic shield is shiftably mounted with one of its vertical edges disposed against the web or chart 161 opposite the chart supporting roller 164 and said shield is provided with a longitudinally extending depression for the reception of an inking pad 191. The shield 190 is mounted on a vertical bar 192 having its lower end disposed for longitudinal sliding movement in a channel 193 on the horizontal partition 153. The upper end of the bar 192 is slidable in a slot 194 of a supporting bracket 195. The bar 192, above the supporting bracket 195, is provided with an offset portion 196 which extends upwardly to a mechanism for shifting the shield 190 in a horizontal plane and said mechanism will be hereinafter more fully described. When the printing wheels 173 and 174 are rotated, the beveled ends of the printing stamps 175 engage with the shield 190 and said printing stamps are caused to move inwardly in the sockets against the tension of the coil springs 177 until said printing stamps pass the forward edge of the shield where they will be projected outwardly into engagement with the web or chart 161 and an indicating mark will thus be printed thereon. It is understood, of course, that the stamps are inked by passing across the pad 191 which is mounted on the shield 190. The shield 190 is adapted to be moved to a position where it will not be engaged by the printing stamps in order that the direction of rotation of the printing wheels 173 and 174 may be reversed for a purpose also to be hereinafter set forth.

It may be well to here set forth that the frame 180 in which the lower printing wheel 174 is mounted is also operatively connected, as at 197, to the spirally grooved shaft 152.

Mounted within a compartment formed in the barrel 1 of the instrument above the plotting or charting unit D is a chart driving and reversing unit designated generally by the reference character E. The compartment in which this unit is disposed is formed by the horizontal partition 154, an upper horizontal partition 198 and a vertical partition 199. The chart driving and reversing unit E is illustrated in Figures 5, 38, 39, 41, 42 and 44 of the drawings. A spring motor 200 is suspended from the horizontal partition 198 and is wound from a source of power to be presently set forth through the medium of the shaft 201 having a beveled gear 202 fixed on its lower end which meshes with a beveled gear 203 fixed on one end of a shaft 204 having a socket in its other end for rotatably receiving the shaft 205 which winds the spring motor 200. The shaft 204 has an angular arm 206 extending therefrom for engagement with a spring finger 207 which projects laterally from the spring motor shaft 205. By this arrangement overwinding of the spring motor will be prevented as the finger 207 will yield after the motor has been wound to a certain extent and permits the arm 206 to pass thereover. The spring motor 200 drives a shaft 208 having a beveled gear 209 fixed on its lower end adapted for engagement with the beveled gears 210 and 211 fixed on the opposed ends of the longitudinally aligned shafts 212 and 213, respectively, which are mounted for rotation in a horizontally movable housing or casing 214.

The casing 214 is of elongated rectangular configuration and has an open bottom. The upper wall of the casing is provided with a longitudinal slot 215 through which passes the shaft 208, said shaft 208 being mounted on supports 216 which extend from the vertical partition 199. The shaft 212 has a beveled gear 217 fixed thereon which meshes with a gear 218 fixed on the upper end of the shaft 157 to which the chart spool 155 of the plotting unit D is operatively connected. Fixed on the outer end portion of the shaft 213 is an elongated gear 219 which is constantly in mesh with a gear 220 mounted for rotation on the horizontal partition 154 and having fixed thereto a beveled gear 221 which meshes with a beveled gear 222 fixed on the upper end of the shaft 158 with which the chart spool 156 is operatively connected. It

will thus be seen that the spring motor 200 is adapted to drive the spool 155 in a manner to wind the chart thereon from the spool 156 when the beveled gear 209 is engaged with the gear 210 on the shaft 212 and said spring motor 200 is adapted to drive the spool 156 in a manner to wind the chart thereon from the spool 155 when the gear 209 is in mesh with the gear 211 of the shaft 213.

Formed longitudinally on the upper wall of the casing 214 is a pair of series of teeth 223 with which are engaged the gears 224 mounted for rotation on a supporting arm 225 which extends from the vertical partition 199. The gears 224 are mounted on the supporting arm 225 through the medium of a shaft 226 having a beveled gear 227 fixed on an intermediate portion thereof for engagement with a beveled gear fixed on a rotary shaft 228. Mounted for oscillatory swinging movement in a horizontal plane on a support 229 is a pair of oppositely disposed integrally connected segmental gears 230 and 231. The segmental gear 230 is engageable with a gear 232 fixed on the lower end portion of a shaft 233 which extends upwardly and rotatably through the horizontal partition 198. The segmental gear 231 is engageable with a gear 234 which drives the shaft 228 alternately in opposite directions through the medium of the intermeshing gears 235. An equalizing spring 236 has one end anchored on the vertical partition 199 and its opposite end connected to the shaft upon which the segmental gears 230 and 231 are mounted and said spring is adapted to yieldingly maintain the segmental gears in contact with the adjacent gears 232 and 234 at all times. When the shaft 233 is rotated in one direction, as when lowering the instrument into the well, the casing 214 will be shifted in a manner to connect one of the chart spools with the spring motor and when the direction of the shaft 233 is reversed, the other chart spool is operatively connected to the spring motor.

As best seen in Figures 63, 42 and 44 of the drawings, the bar 192 upon which the shield 190 of the plotting unit D is mounted has its offset upper end portion 196 operatively connected to an arm 237 on the casing 214 by a rocker arm 237′ which is pivotally mounted on the partition 154 and which extends through an opening provided therefor in said partition and in this manner said shield is moved back and forth to operative or inoperative position when the casing 214 is shifted. The rocker arm 237′ has pin and slot connections with the upper portion 196 of the bar 192 and with the arm 237.

A unit designated generally by the reference character F is mounted on the other side of the vertical partition 199 from the chart driving and reversing unit E for shifting the lower printing wheel 174 longitudinally up and down on the shaft 172 and said unit F is best seen in Figures 40, 41, 42 and 44 of the drawings. The unit F is similar in construction and operation to the unit E with the exception that a single shaft 238 is mounted for rotation in a casing 239 and has fixed thereon spaced oppositely disposed beveled gears 240 and 241 for alternate engagement with the beveled gear 242 fixed on the lower end of the shaft 243 which is operatively connected to a spring motor 244. The casing 239 is shifted horizontally by a vertically disposed rotary shaft 245 through a reversing mechanism which is similar to that which connects the casing 214 to the shaft 233 in the chart driving and reversing unit E. The shaft 238 has fixed thereon an elongated gear 246 which, through a train of gearing clearly illustrated in Figure 40 of the drawings, drives the upper sprocket gear 184 over which the endless chain 183 is trained and on which the frame 180 in which is mounted the lower printing wheel 174 is mounted. Thus when the shaft 245 is driven in one direction, as when the instrument is being lowered into the well, the lower printing wheel 174 will be moved downwardly and transversely across the chart 161 when the bore hole deviates from the vertical and when the direction of rotation of the shaft 245 is reversed as when raising the instrument from the well, the lower printing member 174 is raised to its original position. The shaft which winds the spring motor 244 of the unit F is designated by the reference numeral 247.

The shafts 201 and 233 from the unit E, the shafts 245 and 247 from the unit F, the shaft 135 which drives the power drum 131 of the recording unit C extend upwardly through a compartment 248 disposed immediately above said units E and F. As clearly seen in figures 38, 40 and 43 of the drawings, all of these shafts are operatively coupled through chain and sprocket connections within the chamber 248 with a main power drive shaft 249. The shaft 172 upon which the printing wheels 173 and 174 are mounted extends rotatably through the horizontal partition 154 and has fixed on its upper end a gear 250 (see Figure 40) which is operatively connected to the lower end of a vertical shaft 251 by a train of gears 252 as indicated in dotted lines in Figure 43. The shaft 251 extends upwardly adjacent the unit F, as seen in Figure 42 and extends through the compartment 248 and is operatively connected to the main power drive shaft 249 through a chain and sprocket connection as indicated at 253. All of the chains which connect the remaining shafts to the main power shaft 249 within the compartment 248 are designated generally by the reference character 254.

As illustrated to advantage in Figures 6 and 7 of the drawings, the main power drive shaft 249 extends upwardly and has its up-

per end journaled for support in a socket provided therefor in the disc 4 which closes the upper end of the barrel 1 of the instrument. An upstanding bifurcated bracket is disposed within the cap 5 on the upper end of the barrel 1 and said bracket is designated by the reference numeral 255. Mounted for rotation between the furcations of the bracket 255 is a spur wheel 256 the peripheral portion of which projects through the slot 23 in the guide tube or sleeve 22 for engagement with and actuation by the driving cable 21 (not shown in Figures 6 and 7) which passes through said guide tube. As best seen in Figures 7 and 9 the spur wheel 256 has connected thereto a beveled gear 257 which meshes with a beveled gear 258 formed on the upper end of a shank 259 which extends downwardly into an opening provided therefor in the disc 4 and is adapted to rest on the upper end of a shank 260 which extends upwardly into the opening in the disc 4 and has formed integrally on its lower end a gear 261 which is supported by a bracket 262. The gear 261 is in mesh with a gear 263 which is fixed on the upper end portion of the main power drive shaft 249. The beveled gear 258 and the shanks 259 and 260 are provided with aligned polygonal bores which extend therethrough for the reception of a polygonal rod 264 which extends upwardly and is swivelly connected at its upper end with a removable plug 265 which is threaded into the cap 5. The rod 264 constitutes means for operatively connecting the shanks 259 and 260 together. This arrangement of driving connection between the spur wheel 256 and the main power drive shaft 249 permits the removal of the cap 5 when it is so desired.

By removing the plug 265 and withdrawing the polygonal rod 264 from the bores of the shanks 259 and 260, the beveled gear 258 may be shifted laterally far enough to clear the gears 257, it being understood that the opening in the disc 4 into which the shank 259 extends is of sufficient size to permit the very slight movement which this operation requires. The plugs 8 are then removed and a tool is inserted through the openings left thereby to disengage the spring latches 7 from the cap 5 and said cap may then be removed from the barrel 1.

As illustrated in detail in Figures 55 and 56 of the drawings, the driving cable 21 comprises a flexible metallic central core or strand 266 which is enclosed in an inner casing of suitable material 267. The inner casing 267 is enclosed in a pliant waterproof outer casing 268 which is preferably formed of rubber but which may be of any suitable material.

Referring to Figure 61 of the drawings, it may be well to state that the indicating marks 269 are placed on the chart 161 by the vertically shiftable printing wheel 174 and the indicating marks indicated at 270 are made by the stationary printing wheel 173. The indicating marks 271 are printed on the chart when said chart is manufactured.

Referring to Figure 1 of the drawings, it will be seen that a weight 272 is attached to the lower end of the cable 21 and, as illustrated in Figure 2, the nose cap 12 is provided in its lower end with an opening 12′ which is in vertical alignment with the bore 20 of the plug 2. It should also be here stated that the coiled Bourdon tube 31, the circular chamber 27 and the radial passages 28 which communicate with said circular chamber in the plug 2 are filled with a suitable liquid.

When a survey of the bore hole is to be made, it is desirable that this be done just after the water and mud therein have been thoroughly circulated or agitated for a few moments when the specific gravity of the liquid will be substantially uniform from top to bottom. The level of the liquid in the bore hole should be flush with the floor of the derrick used in the drilling operation and the specific gravity of the liquid should then be determined by any suitable means such as a hydrometer. The barrel 1 and cap 5 are removed from the inner casing 13 and access may then be had to the interior of the instrument through one of the doors 14 of said inner casing and the dial 84 is rotated manually to adjust the transmission unit B so that the shaft 41 will be rotated at the correct speed according to the specific gravity of the liquid in the bore hole. The chart 161 is then inserted in the recording unit D on the spool 155 and said chart is threaded between the printing wheels and the chart supporting roller 164 and is connected for winding on the spool 156. A new slab or rubber 98 must be put in each time instrument is used. The barrel 1 and cap 5 are then replaced and the coupling rod 264 is removed to disconnect the shanks 259 and 260 from each other. The cable 21 is then inserted through the instrument and the weight 272 is secured to the end thereof after which said cable is lowered in the bore hole. The lowering of the cable 21 into the bore hole does not operate the mechanism connected with the spur wheels 256 owing to the fact that the rod 264 is removed. When the cable 21 has been lowered to the desired depth the instrument is inserted in the mouth of the bore hole and the coupling rod 264 is inserted to operatively connect the spur wheel 256 with the mechanism to be driven thereby. The device is then lowered into the bore hole by means of the suspension cable 25 and as the same travels along the actuating cable 21 the spur wheel 256 engages therewith through the slot 23 of the guide tube 22 and is actuated thereby. The main power shaft 249 is thus rotated and the spring motors 200 and 244 are wound through the medium of

the shafts 201 and 247, respectively, which are operatively connected to said main power shaft by the hereinbefore described chain and sprocket connections within the chamber 248. The main power shaft 249 also drives the shaft 233 of the unit E (Figure 38) in a direction to shift the casing 214 in a manner to disengage the gear 210 from the gear 209 and to engage the gear 211 with said gear 209. This movement of the casing 214 simultaneously shifts the shield 190 to operative position as best illustrated in Figure 20 of the drawings. The spring motor 200 is thus operatively connected to the spool 156 of the plotting unit D and the chart 161 is drawn from the spool 155 and wound on said spool 156. The shaft 172 is rotated through the train of gearing 252, the shaft 251 and the sprocket chain connection 253 with the main power shaft 249 in a manner to rotate the printing wheels 173 and 174 which are mounted thereon in the direction in which the chart 161 is moving.

As the instrument starts to travel downwardly in the bore hole the power shaft 249, through the shaft 245 of the unit F (see Figure 40) moves the horizontally shiftable casing of this unit to the position shown and the spring 244 urges the endless chain 183 to which is connected the frame 180 carrying the lower printing wheel 174 in a direction to shift said printing wheel downwardly and transversely with respect to the printing chart 161 but such movement of said lower printing wheel is normally prevented by the spirally grooved shaft 152 which is operatively connected to the frame 180, said shaft 152 being stationary so long as the instrument is traveling in a straight downward path, as when no deviations occur in the bore hole and as will be presently more fully described. Thus when the bore hole is straight the lines of indication 269 and 270 on the chart 161 which are printed by the stamp 175 of the printing wheels 173 and 174 will both extend in a straight line longitudinally on the chart, and will be exactly the same as lines printed on 161 originally.

Movement of the chart 161 imparts rotary movement to the chart supporting roller 164 through the medium of the teeth 163 thereon which engage in the sprocket holes 162 formed adjacent the longitudinal edges of said chart. Referring to Figure 4 of the drawings, it will be seen that rotary movement of the chart supporting roller 164 will elevate the recording unit C relative to the rubber slab through the medium of the rack bar 136 which is operatively connected to said roller at its upper end and is rigidly anchored to the recording unit at its lower end. It should be borne in mind that the chart supporting roller 164 derives its power from the spring motor 200 and the speed at which the recording unit C is elevated by reason of its operative connection with said chart supporting unit is regulated by the speed at which the spirally grooved shaft 41 is rotated, said shaft 41 being operatively connected with the recording unit. It will further be seen that the speed of the shaft 41 will also restrain and control the speed of the spools 155 and 156 and consequently the speed at which the chart 161 is moved.

As the recording unit C moves upwardly the knife 114 is drawn through the rubber slab 97 in a manner to cut a longitudinal slit therein. Simultaneously, the cable 128 is payed out from the spring controlled drum 129 by the power drum 131 which is driven from the main power shaft 249 by the shaft 135. The cable 128 is normally maintained under tension and is payed out at the same speed at which the recording unit is elevated as long as the bore hole through which the instrument is being lowered is straight.

As the instrument is lowered into the bore hole the progressively increasing pressure of the liquid therein actuates the coiled Bourdon tube 31 of the pressure responsive power unit A through the yieldable membranes 30, as hereinbefore stated. As the Bourdon tube 31 gradually expands or uncoils, the same imparts rotary movement to the shaft 37 through the gears 34 and 36 and the shaft 37 in turn drives the spirally grooved shaft 41 which is operatively connected to the recording unit C through the medium of the adjustable transmission unit B. The rotation of the shaft 41 permits the elevation of the recording unit C by the spring motor 200. The speed at which the shaft 41 is rotated by the pressure responsive power unit as the instrument is lowered into the well and which governs the speed at which the recording unit may be elevated is the same as the speed at which the cable 128 will be payed out from the spring controlled drum 129 by the power drum 131. This is true so long as the instrument is traveling downwardly in a true vertical line. It is understood that the gear ratio between the power drum 131 and the main power shaft 249 is to be reduced so that this movement will take place. The tension of the cable 128 normally maintains the tube 121 in the position illustrated in full line in Figure 33 of the drawings in which position the knife 114 is maintained in a true vertical plane by the arms 115 and the gears 117, 118 and 119 which are operatively connected to said tube 121 by the shaft 120. When the instrument is passing through a deviation in the bore hole, the speed of rotation of the shaft 41 and consequently the speed at which the recording unit is elevated remains the same as though the instrument were disposed at the same depth in a straight bore hole but the increased distance which the tool must travel in order to reach that depth by reason of the

deviation in the hole will cause the cable 128 to be payed out slightly faster than the recording unit C will be elevated and the tension on said cable 128 will thus be eliminated. When the tension on the cable 128 is eliminated the spring controlled drum 138 (see Figures 32 and 33) will move the carriage 125 and consequently the tube 121 to the position indicated in dotted lines in Figure 33 and this movement of the tube 121 will turn the knife 114 to a slight angle with respect to the rubber slab 97 through which said knife is traveling through the medium of the swingable arm 115 which extends between the fingers 116 depending from the member 112 upon which said knife is fixed. The member 112 is mounted for rotation on the arm 110′ of the knife supporting device 109. Swinging movement is imparted to the arm 115 from the tube 121 by the gearing train which operatively connects the elements together. When the angle of the knife 114 is changed the path of said knife through the rubber slab 97 deviates from a true vertical course toward the left of the said rubber slab. The deviation of the knife from right to left in the rubber slab causes a corresponding shifting movement of the knife supporting device 109 in the channeled bracket 107 of the vertical plate 104 and this shifting movement of the knife supporting device is assisted by the spring controlled drums 138 and 142. When the deviation in the bore hole has been passed and the instrument again descends in a true vertical line the cable 128 will again be placed under tension, the tube 121 will again be swung to the vertical position indicated in full line in Figure 33 of the drawings by the wire 126 which is operatively connected to the cable 128 and the knife 114 will again assume a vertical position and travel in a true vertical plane through the rubber slab 97.

When the knife supporting device 109 moves horizontally from the right to left on the plate 104 the cable 143 is wound on the spring controlled drum 142 and the pulley 144 will be rotated owing to the fact that said cable 143 is wound therearound. Rotation of the pulley 144 imparts rotary movement to the gear 147 mounted for vertical sliding movement on the shaft 148 through the medium of the gear 146 which is fixed to said pulley. Rotation of the shaft 148 imparts rotary movement to the shaft 152 (see Figure 24) through the endless sprocket chain 150 and, as best illustrated in Figure 19, the shaft 152 which is spirally grooved and operatively connected to the frame 180 in which the lower printing wheel 174 is mounted is rotated to permit said frame to be moved downwardly by the chain 183 which, in turn, is actuated by the spring motor 244. This movement of the lower printing wheel 174 prints the line of indicating marks 269 in the manner illustrated in Figure 61 of the drawings, the deviations in said line indicating the deviations in the bore hole.

When the device is being withdrawn from the bore hole, the direction of the main power shaft 249 is, of course, reversed and the casing 214 of the chart driving and reversing unit E is shifted to the position illustrated in Figure 38 in which position the beveled gear 210 is engaged with the gear 209 and the chart spool 155 is operatively connected to the spring motor 200 in a manner to wind the chart 161 thereonto from the spool 156. This movement of the casing 214 shifts the shield 190 out of the path of the now reversely rotating printing wheels 173 and 174. Simultaneously, the reversing mechanism in the unit F functions and the direction of travel of the endless chain 183 is reversed in a manner to elevate the lower printing wheel 174. The direction of movement of all of the units and elements which are driven by the cable 21 and the spring motors is reversed as is also the units and elements operatively connected to the pressure responsive unit A. When the device has been drawn to the top of the bore hole all of the elements and units thereof will have returned to the position in which they were disposed before the survey was made, as will be obvious.

The embodiment of the invention shown in the drawings is for the purpose of illustration and it is understood that reduction gearing or step up gearing of the desired ratio is to be incorporated wherever necessary to assure proper relative speed of each of the various interconnected units and elements.

It is believed that the many advantages of an instrument for recording deviations in bore holes constructed in accordance with this invention will be readily understood, and although the preferred embodiment of the invention is illustrated and described, it is to be understood that changes in the details of construction may be had which will fall within the scope of the invention as claimed.

What is claimed is:

1. An instrument for recording deviations in bore holes of the character described comprising a support, a plotting unit disposed on the support and including a slidably shiftable printing member, means for shifting said printing member and pressure responsive means mounted on the support and operatively connected to the printing member in a manner to control the sliding movement thereof.

2. An instrument for recording deviations in bore holes of the character described comprising a support, a recording unit disposed on the support for longitudinal movement relative to said support, means for shifting the recording unit and pressure responsive means mounted on the support and operatively connected to the recording unit in a manner to control the movement thereof.

3. An instrument for recording deviations in bore holes of the character described comprising a support adapted to be lowered into the bore holes, a plotting unit disposed on the support and including a longitudinally slidable printing member, means for sliding said printing member longitudinally, a recording unit mounted for longitudinal movement on the support, means for actuating the recording unit, pressure responsive means mounted on the support and operatively connected to the recording unit in a manner to control the movement thereof and means operatively connecting the slidable printing member to the recording unit in a manner to control the sliding movement of said printing member.

4. An instrument for recording deviations in bore holes of the character described comprising a cable to be positioned in the bore hole, a barrel slidable on the cable, a plotting unit disposed in the barrel and including a longitudinally slidable printing member, means for shifting said printing member and pressure responsive means mounted on the barrel and operatively connected to the printing member in a manner to control the sliding movement thereof.

5. An instrument for recording deviations in bore holes of the character described comprising a cable adapted to be positioned in the bore hole, a barrel slidable on the cable, a plotting unit disposed in the barrel and including a longitudinally slidable printing member, means for shifting said printing member, a recording unit mounted for longitudinal shifting movement in the barrel, means for shifting said recording unit, pressure responsive means mounted in the barrel and operatively connected to the recording unit in a manner to control the movement thereof and means operatively connecting the recording unit to the shiftable printing member in a manner to control the shifting movement of said member.

6. An instrument for recording deviations in bore holes comprising a plotting unit, means for actuating said plotting unit and pressure responsive means operatively connected to the plotting unit in a manner to control the operation thereof.

7. An instrument for recording deviations in bore holes of the character described comprising a barrel adapted to be lowered into the bore hole, a plotting unit mounted in the barrel and including a longitudinally slidable printing member, means for actuating the plotting unit, means for actuating the slidable printing member, a recording unit mounted for shifting movement in the barrel, means operatively connecting the recording unit with the plotting unit for actuation thereby, pressure responsive means mounted in the barrel and operatively connected to the recording unit in a manner to control the movement of same and the plotting unit and means operatively connecting the recording unit to the slidable printing member in a manner to control the sliding movement of said member.

8. An instrument for recording deviations in bore holes of the character described comprising a cable adapted to be disposed in the bore hole, a barrel slidable on the cable, a plotting unit mounted in the barrel, means for actuating said plotting unit, a recording unit mounted in the barrel, means for operatively connecting the recording unit to the plotting unit for actuation thereby and pressure responsive means mounted on the barrel and operatively connected to the recording unit in a manner to control the actuation thereof and the plotting unit.

9. An instrument for recording deviations in bore holes of the character described comprising a cable to be disposed in the bore hole, a barrel slidable on the cable, a plotting unit mounted in the barrel a spring motor mounted in the barrel and operatively connected to the plotting unit to actuate the same, winding means for the motor mounted in the barrel and engageable with the cable for actuation thereby, and pressure responsive means mounted in the barrel and operatively connected to the plotting unit in a manner to control the operation thereof.

10. An instrument for recording deviations in bore holes of the character described comprising a cable adapted to be disposed in the bore hole, a barrel slidable on the cable, a plotting unit mounted for operation in the barrel and including a longitudinally slidable printing member, a spring motor operatively connected to the plotting unit, winding means mounted in the barrel operatively connected to the spring motor and engageable with the cable for actuation thereby, a spring motor mounted in the barrel and operatively connected to the slidable printing member for shifting the same, winding means for the second named spring motor mounted in the barrel and operatively connected with the cable for actuation thereby and pressure responsive means mounted in the barrel and operatively connected to the plotting unit in a manner to control the operation thereof and to the slidable printing member in a manner to control the sliding movement thereof.

11. An instrument for recording deviations in bore holes of the character described comprising a cable adapted to be disposed in the bore hole, a barrel slidable on the cable, a plotting unit mounted for operation in the barrel, a spring motor mounted in the barrel and operatively connected to the recording unit in a manner to actuate the same, winding means operatively connected to the spring motor and engageable with the cable for actuation thereby, means mounted in the barrel and actuated by the cable for reversing the operation of the recording unit and pressure

responsive means mounted on the barrel and operatively connected to the recording unit in a manner to control the operation thereof.

12. An instrument for recording deviations in bore holes of the character described comprising a cable adapted to be disposed in the bore hole, a barrel slidable on the cable, a plotting unit mounted for operation in the barrel and including a longitudinally slidable printing member, a spring motor mounted in the barrel and operatively connected to the plotting unit in a manner to actuate the same, winding means disposed in the barrel and operatively connected to the spring motor and the cable for actuation by the latter, means mounted in the barrel and actuated by the cable for reversing the operation of the plotting unit, a spring motor mounted in the barrel and operatively connected to the longitudinally slidable printing member for shifting the same in one direction, winding means operatively connected to the second named spring motor and actuated by the cable, means mounted in the barrel and driven by the cable for reserving the movement of the slidable printing member and pressure responsive means mounted in the barrel and operatively connected to the plotting unit and to the printing member for controlling the operation thereof.

13. An instrument for recording deviations in bore holes of the character described comprising a barrel adapted to be lowered into the bore hole, a plotting unit mounted for operation in the barrel, means mounted in the barrel and operatively connected to the plotting unit in a manner to actuate the same, the bore hole having liquid therein, pressure responsive means mounted in the barrel and operatively connected to the plotting unit in a manner to control the actuation thereof and means disposed intermediate the plotting unit and pressure responsive means and operatively connected thereto for manually regulating the operative connection between said pressure responsive unit and the plotting unit.

14. An instrument for recording deviations in bore holes having liquid therein comprising a barrel adapted to be lowered into the bore hole, a plotting unit mounted for operation in the barrel, means for actuating said plotting unit, fluid pressure responsive means mounted in the barrel, a driving shaft operatively connected to the fluid pressure responsive means, a driven shaft operatively connected with the plotting unit and adapted to be driven by said driving shaft and manually operable means operatively connecting the driving and driven shafts in a manner to vary the speed at which the driven shaft will be rotated by said driving shaft.

15. An instrument for recording deviations in bore holes which contain liquid comprising a barrel adapted to be lowered into the bore hole, a plotting unit mounted for operation in the barrel, said plotting unit including a slidably shiftable printing member, means for actuating the plotting unit, means for slidably shifting the printing member, a fluid pressure responsive unit mounted for operation in the barrel, a driving shaft operatively connected to the pressure responsive unit for actuation thereby, a driven shaft operatively connected to the plotting unit and to the slidable printing member thereof, and an adjustable transmission unit operatively connecting the driving shaft and the driven shaft, the fluid pressure responsive unit constituting means for controlling the operation of the plotting unit and the slidable printing member.

16. An instrument for recording deviations in bore holes having liquid therein comprising a barrel adapted to be disposed in the bore hole, a plotting unit mounted for operation in the barrel, means mounted in the barrel for operating the plotting unit, a recording unit mounted for operation in the barrel and operatively connected to the plotting unit for actuation thereby, a fluid pressure responsive unit mounted for operation in the barrel, a driving shaft operatively connected to the pressure responsive unit for actuation thereby, a driven shaft operatively connected to the recording unit, and a manually adjustable transmission unit operatively connecting the driven shaft to the driving shaft in a manner to regulate the speed at which said driven shaft is rotated, the pressure responsive unit constituting means for controlling the speed of operation of the recording unit and the plotting unit.

17. An instrument for recording deviations in bore holes having liquid therein comprising a barrel adapted to be lowered into the bore hole, a plotting unit mounted for operation in the barrel and including a longitudinally slidable printing member, a spring motor mounted in the barrel and operatively connected to the plotting unit for actuating the same, means for winding the spring motor, a spring motor mounted in the barrel and operatively connected to the slidable printing member in a manner to move the same longitudinally, means for winding the second named spring motor, a recording unit mounted for operation in the barrel and operatively connected to the plotting unit for actuation thereby, means for operatively connecting the recording unit to slidable printing member, a fluid pressure responsive unit mounted for operation in the barrel, a driving shaft operatively connected to the fluid pressure responsive unit for actuation thereby, a driven shaft operatively connected to the recording unit and an adjustable transmission unit operatively connecting the driving and the driven shafts in a manner to manually regulate the speed of rotation of said driven shaft relative to the driving shaft, the pressure responsive unit constituting means for controlling the

speed of operation of the plotting unit, the recording unit and the slidable printing member.

18. An instrument for recording deviations in bore holes having liquid therein comprising a cable adapted to be lowered in the bore hole, a barrel slidable on the cable, a plotting unit mounted for operation in the barrel, means mounted in the barrel for operating the plotting unit, reversing mechanism mounted in the barrel and operatively connected to the plotting unit, said reversing mechanism operatively connected with the cable for actuation thereby when the barrel moves longitudinally thereon, pressure responsive means mounted for operation in the barrel and operatively connected to the plotting unit in a manner to control the operating speed thereof, and a manually adjustable transmission unit operatively connected with the means for connecting the pressure responsive unit to the recording unit to regulate the operation of said pressure responsive unit in accordance with the specific gravity of the fluid in the bore hole.

19. An instrument for recording deviations in bore holes having liquid therein comprising a cable adapted to be lowered into the bore hole, a barrel slidable on the cable, a plotting unit mounted for operation in the barrel and including a longitudinally slidable printing member, a spring motor mounted for operation in the barrel and operatively connected to the plotting unit for actuating the same, means operatively connected with the cable for winding the spring motor as the barrel moves on said cable, a spring motor mounted for operation in the barrel and operatively connected to the slidable printing member for shifting the same longitudinally, winding means for the second named spring motor operatively connected to the cable for actuation thereby when the barrel is moved thereon, reversing means mounted for operation in the barrel and operatively connected to the plotting unit for reversing the operation thereof, said reversing means operatively connected to the cable for actuation thereby when the barrel is moved thereon, reversing means operatively connected to the slidable printing member and to the cable for actuation thereby when the barrel is moved thereon, a recording unit mounted for operation in the barrel and operatively connected to the plotting unit for actuation thereby, means for operatively connecting the recording unit to the slidable printing member in a manner to control the operation of said member, a fluid pressure responsive unit mounted in the barrel, a driving shaft operatively connected to the fluid pressure responsive unit, a driven shaft operatively connected to the recording unit, an adjustable transmission unit operatively connecting the driver shaft and the driven shaft in a manner to manually adjust said driven shaft with respect to the driving shaft, the fluid pressure responsive unit constituting means for controlling the movement of plotting unit, the recording unit and the slidable printing member.

In testimony whereof I affix my signature.

BOONE JONES.