

June 22, 1943.

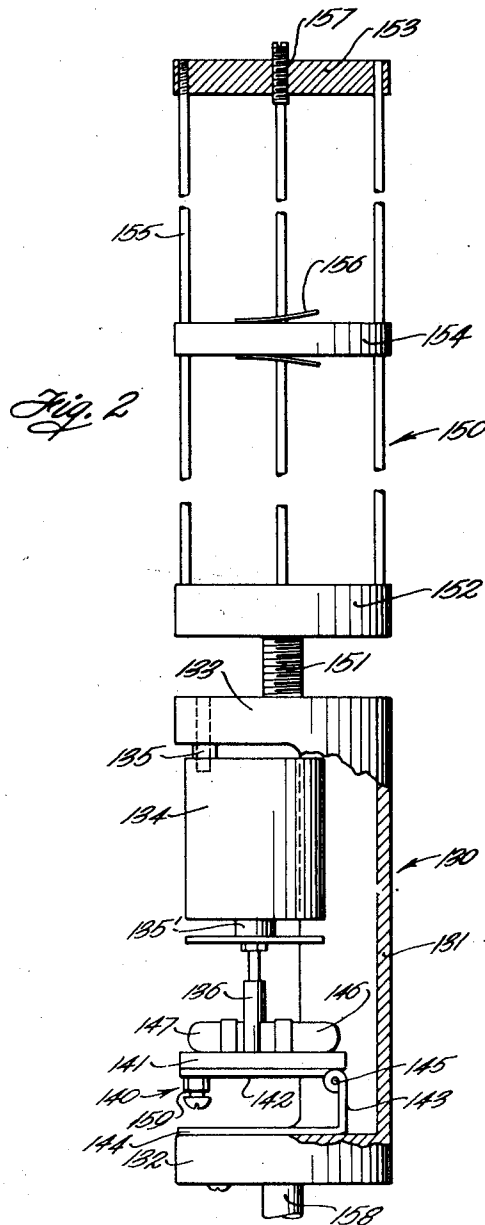
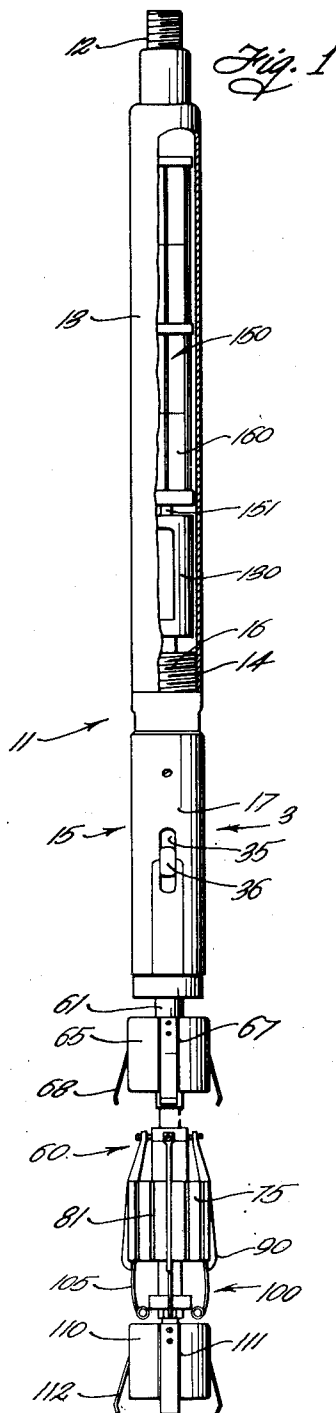
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2,322,343

TUBING WEAR DETECTOR

Filed Oct. 14, 1940

6 Sheets-Sheet 1



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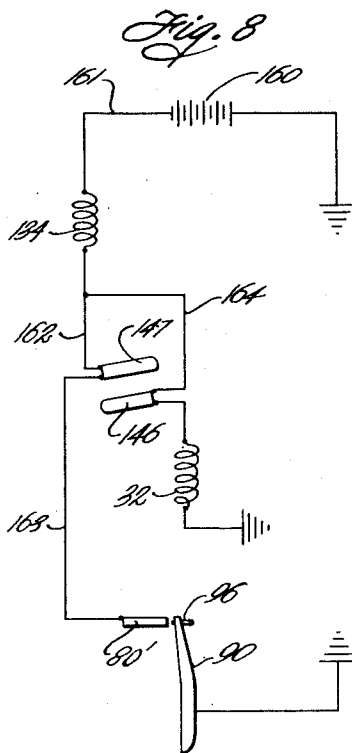
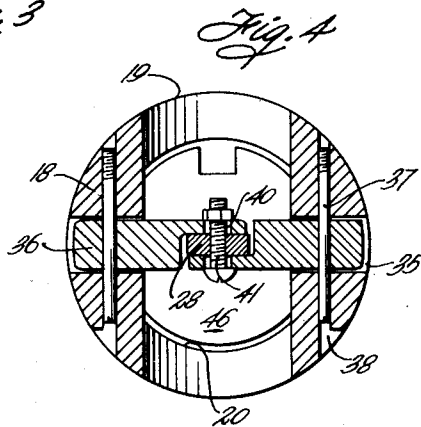
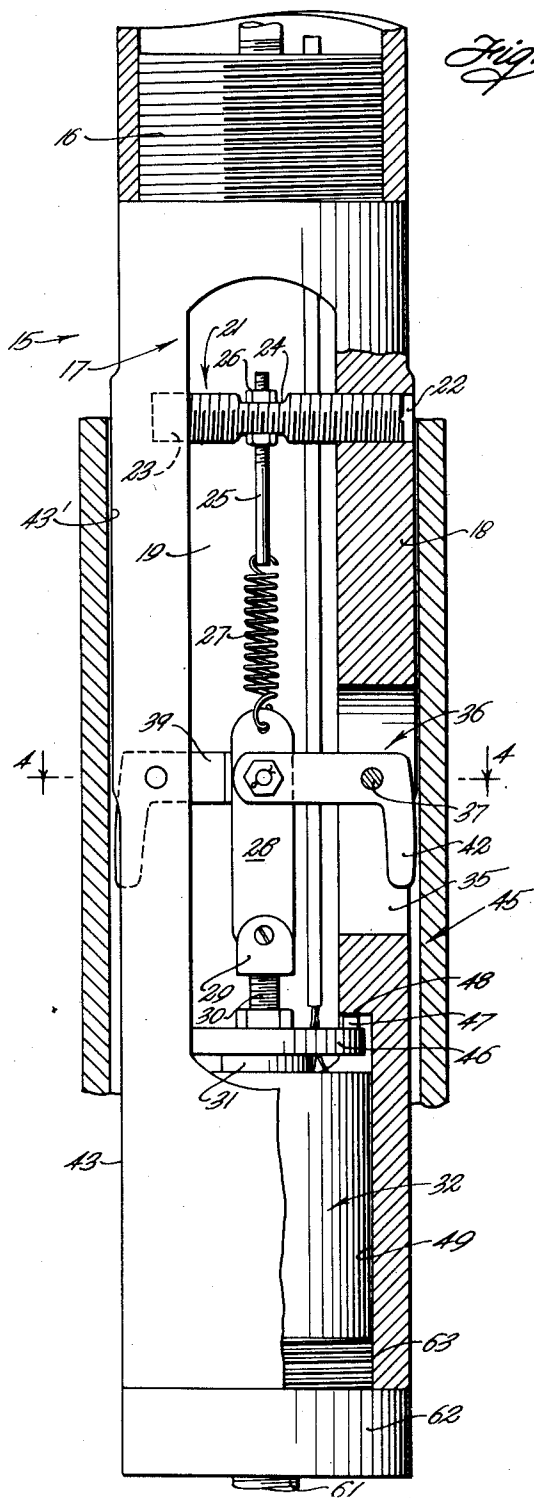
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6 Sheets-Sheet 2



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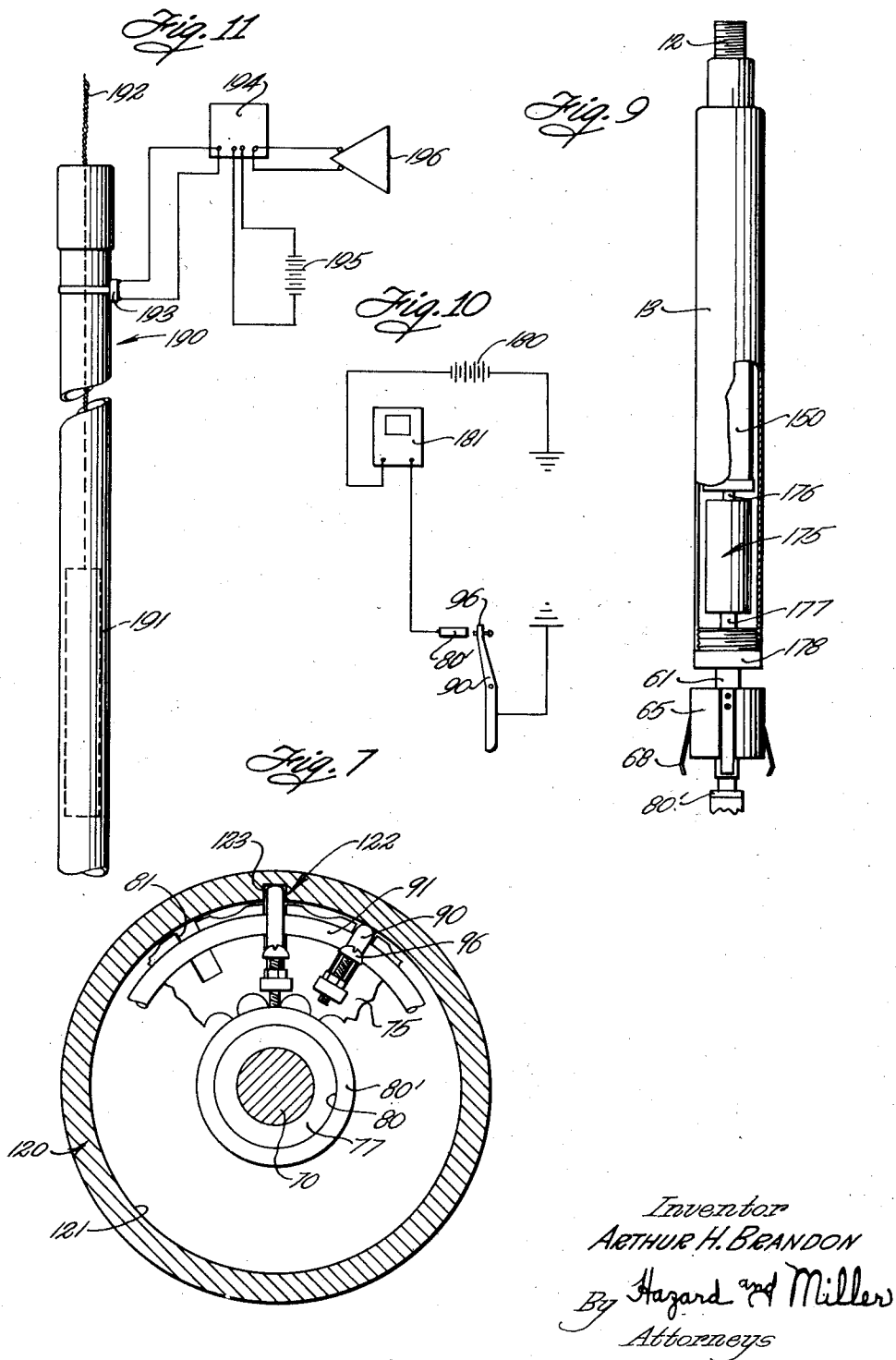
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TUBING WEAR DETECTOR

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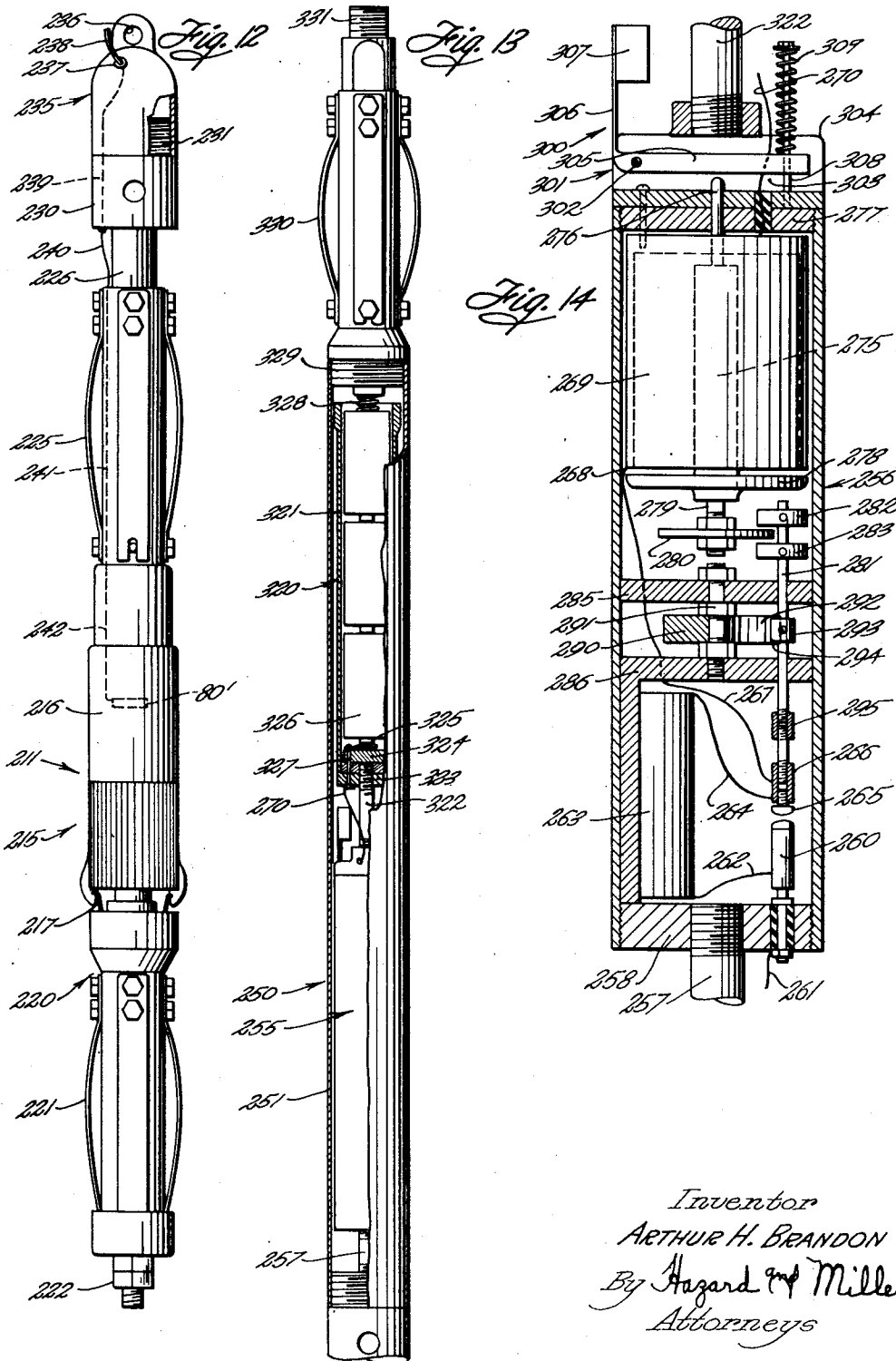
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TUBING WEAR DETECTOR

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6 Sheets-Sheet 5



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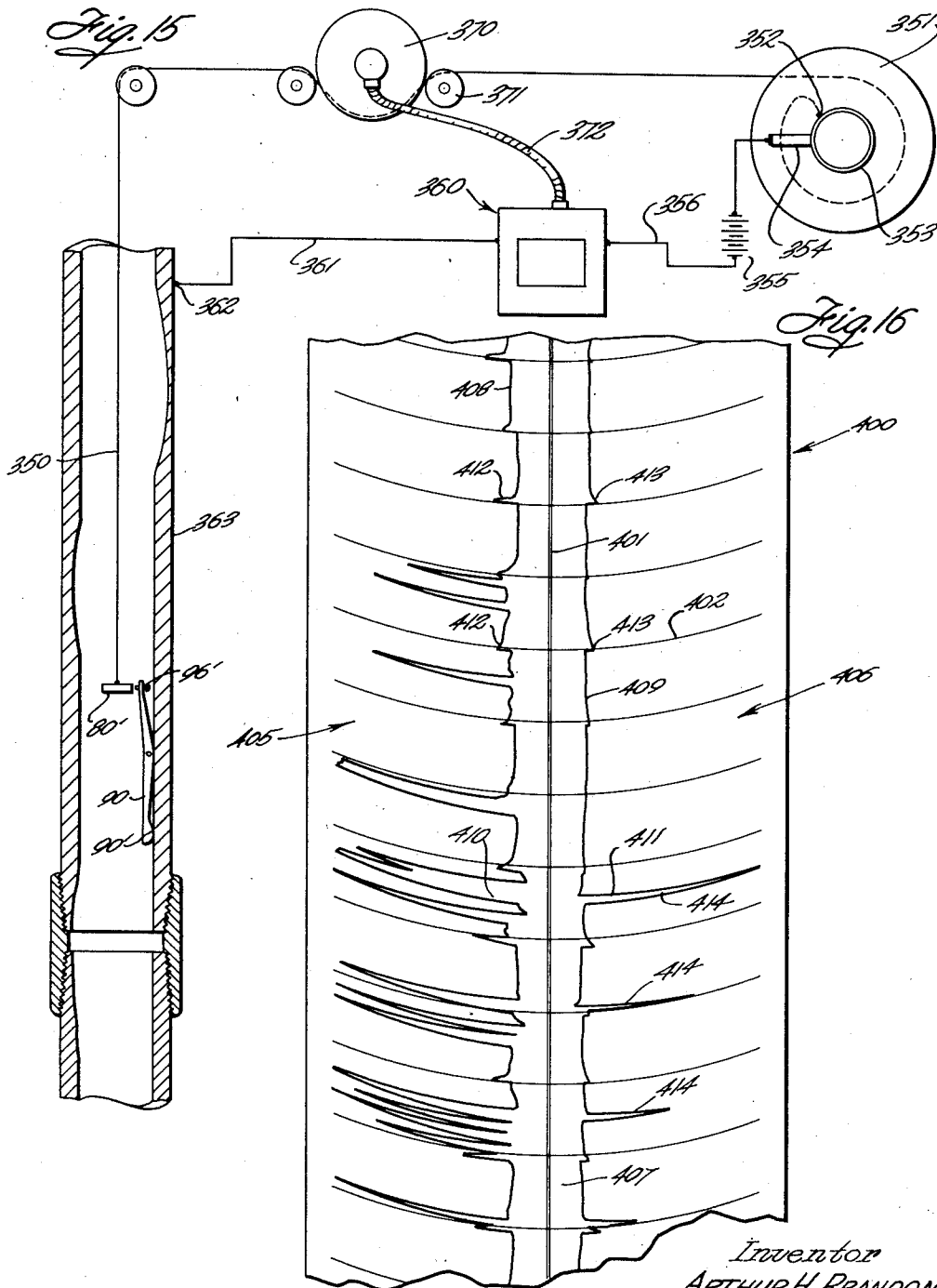
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A. H. BRANDON
TUBING WEAR DETECTOR

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6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

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TUBING WEAR DETECTOR

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Application October 14, 1940, Serial No. 361,197

5 Claims. (Cl. 33—178)

My invention is designated as a tubing wear detector in that it has been especially designed to detect wear in oil tubing such as used in deep oil well pumping by the sucker rod system of operating the pump. In this procedure the pump is located adjacent the bottom of the oil tubing and the pump plunger is reciprocated in a pump barrel by means of a string of connected sucker rods which lead to the surface of the well, these rods being alternately lifted and lowered by conventional equipment. In view of the fact that it is a rare circumstance in which the oil tubing is truly vertical and moreover due to the slight bending of the sucker rods, there are places in the string of oil tubing in which the rod contacts, rubs and wears the inside surface of such tubing forming an elongated groove having substantially a concave curve of approximately the radius of the section of the rod contacting therewith. In addition despite the use of wear protectors, the sucker rod couplings also sometimes cause an interior wear of the oil tubing forming an elongated groove with a concave curve approximating that of the radius of the sucker rod coupling. As this wear in the tubing decreases its strength and occasionally in time wears through the tubing, it is highly desirable to detect the location in a string of oil tubing while it is still in the well, the particular sections which exhibit either or any type of internal wear changing them from a true internal cylinder of the original diameter. In addition when pulling oil tubing from a well, it is desirable to test each stand and length to determine whether or no there is internal wear in order that the particular lengths may be discarded and perfect tubing run into the well.

Although my invention may be used and adapted to determine internal enlargements in pipes and tubing which should have a true internal cylindrical shape, nevertheless a main object and feature of my invention is to determine the longitudinal groove-like wear in oil tubing. In view of the fact that it is rare that the ends of the individual tube lengths are connected abutting together but there is a slight longitudinal space at the couplings, it is desirable that the detector be of such a character that it will interpret these spaces at the couplings or other equivalent connections of the individual lengths of the oil tubing. Hence one of the minor problems is to provide devices normally retained in an inactive position while being lowered or moved in tubing of the proper cylindrical inside contour and yet develop a movement where worn grooves or the equivalent are encountered and by this action

give a signal to the operator. Further, this must be done as above mentioned with or without giving an indication of the spaces at the couplings or the like.

5 A further object and feature of my invention is to provide an audible signal which may readily be detected by the operators of the device located on the ground surface and hence such parties by knowing the depth to which the detector has been lowered, may chart the different locations in the well where the signal is given. In one form of my invention the signal may be provided by a clapper type of device which develops a periodic hammering blow on the oil tube. The sound produced by the hammering or clapper action is readily conducted to the surface of the well in part through the metal of the string of oil tubing and in part through the body of oil in the tube. In another form of my invention the signal sound may be produced by an electrically operated buzzer or the equivalent mounted in a suitable container lowered with the detector, the sound from this being transmitted upwardly through the oil and the body of the tubing. A further feature of my invention is housing dry cell batteries lowered in conjunction with the actual detector to operate the buzzer or the clapper.

30 A characteristic and feature of my invention as to the wear detector instrument resides in the provision of a plurality of pivoted fingers or levers pivotally connected to a cylindrical structure for lowering in a well, these being spring urged outwardly but normally held in an inactive position by contact with the inside of the oil tubing which has the true cylindrical surface. A further detail feature relates to the electrical circuits and contacts by which when one or more fingers may expand outwardly when moving into a longitudinally worn section of the tubing, an electric circuit is closed which causes an energizing of the signal equipment, hence by this arrangement the operators at the surface of the well may detect the depth at which a section of worn tubing is encountered and by carefully lowering the instrument may determine the approximate length of the worn section and hence by making the proper record and chart the particular length of oil tubing may be removed when the string of tubing is pulled to the derrick floor.

45 A further feature of my invention relates to the use of an electrical sound or noise pickup to detect the operation of the clapper or of the buzzer in a deep well. For this purpose I utilize a type of microphone known in the trade as a

vibration pickup which may be attached to the well casing at the ground level or if desired, to the oil tubing. This has an electrical connection through an amplifier either to a loud speaker or to earphones.

My invention also comprises obtaining a record of the worn places of the tubing as the wear indicator instrument passes through the tubing. This type is particularly adapted for making an investigation or survey of the oil tubing while in a well. In this case the instrument having the movable fingers developing the electrical contacts is preferably lowered to the depth desired by a cable, such cable having an insulating electrical conductor therein. The tool is then preferably raised by winding the hoisting cable on a drum, this having an electrical connection to the conductor. At the same time through the medium of a chart moving device, a graph formed by a moving pen is made on the chart. This shows the location of the different enlargements due to wear of the tube. A further feature of my invention in this type of recorder comprises operating the hoisting cable over a pulley or the like, the shaft of which may be connected as for instance by a flexible drive to the recording instrument having the chart, thus the chart is moved at a speed and distance proportionate to the movement of the contact instrument in the oil tubing. A further refinement of this construction and method of operation is to set the fingers to record a dangerously thin tubing as for instance one-sixteenth of an inch of tubing wall and a safer tubing thickness of say one-eighth of an inch tubing wall. Then by making two distinct surveying runs through the tubing the chart shows at opposite sides of the medial or other line the places of the extremely thin or the moderately thin worn spots up to the limits for which the contact fingers are set. Another feature of my invention in this type of recorder is preferably to adjust the fingers for a delicate movement to indicate all of the tube joints especially where these are of a type in which there is a slight space in the coupling between the ends of adjacent tubing. The record of these joints shown by a minor mark in the graphs helps locate the different lengths of tubing which may be badly worn. In connection with this procedure it is desirable to have the operator maintain a log of the depth of the contact instrument in relation to the different stands of the oil tubing.

My invention is illustrated in connection with the accompanying drawings, in which:

Fig. 1 is a side elevation broken away illustrating the finger operated circuit closer at the bottom, a clapper mechanism and a casing broken away exposing the dry cells and other equipment.

Fig. 2 is an elevation partly broken away showing an internal cage for the dry cells, the mercury switch and the solenoid.

Fig. 3 is an enlarged vertical elevation in the direction of the arrow 3 of Fig. 1, parts being broken away, with a portion of the oil tubing illustrated showing the clapper and the solenoid for operating the same.

Fig. 4 is a detail horizontal section on the line 4-4 of Fig. 3 in the direction of the arrows showing a portion of the bell crank of the clappers, the oil tubing being omitted.

Fig. 5 is a vertical diametrical section through part of the detector equipment, certain of the

elements being shown in elevation and omitting the oil tubing.

Fig. 6 is a horizontal section on the line 6-6 of Fig. 5 taken in the direction of the arrows illustrating the operation of the switch closing fingers in the worn oil tubing.

Fig. 7 is a cross section of an adjusting sleeve or collar for regulating the movement of the circuit closing fingers, the equipment with the fingers being only shown in part.

Fig. 8 is an electrical diagram of the solenoid, the mercury switches and the clapper actuator.

Fig. 9 is an elevation partly broken away of a modification of the instrument designed for using an electric buzzer.

Fig. 10 is a wiring diagram of the electric buzzer circuit.

Fig. 11 is a diagram of the vibration pickup with the sound amplifying system.

Fig. 12 is an elevation partly broken away of a slightly modified type of contacting instrument with the weighted guides suitable for the recorder at the top of the well or for producing a sound indication by the instruments.

Fig. 13 is an elevation partly broken away showing the contact portion of the instrument of Fig. 12 attached thereto at the bottom after removal of the cap of Fig. 12.

Fig. 14 is an enlargement of a portion of the structure of Fig. 13 shown in a diagrammatic manner to illustrate the control of the clapper or sound producing device.

Fig. 15 is a mechanical and electrical diagram of a recorder set up of the instrument showing a section of oil tubing, the hoist or the pulling cable and the mechanical drive for the chart of the recorder.

Fig. 16 is a view of a section of a chart made by the recorder of Fig. 15.

One form of my equipment is illustrated in Fig. 1, the assembly being designated by the numeral 11. At the upper end I provide a threaded pin 12 which may be attached to any suitable device for lowering a string of oil tubing in a well by means of a cable or the like or by which the equipment may be lowered in stands of oil tubing in the well derrick. A substantial casing 13 is secured to the threaded pin construction and at the bottom this has a screw threaded connection 14 to the clapper assembly 15, note particularly Figs. 1 and 3, such assembly having a threaded plug 16 at the top into which the casing is threaded and provided with a cage-like frame 17 extending therebelow. This frame is cylindrical on its periphery and has opposite sides 18 with diametrically opposite elongated slots 19 therebetween. There is a central vertical opening 20 providing ample room for the upward flow of the oil, such oil entering and discharging at the vertical slots 19. A suspension pin 21 is inserted through a threaded opening 22 in one of the solid side portions 18 and enters into a seating recess 23 on the opposite solid side. This suspension pin has depressed flattened surfaces 24 and is provided with a vertical opening through which extends a spring hanger finger 25 held in adjusted position by the nuts and lock nuts 26. A coil spring 27 connects from the lower end of the pin to a flat link 28. The lower end of this link is connected by an eye 29 having a threaded stem 30 to the armature 31 of a solenoid assembly 32. Each side 18 is provided with a relatively short vertical slot 35 for mounting the clapper bell cranks 36, these being pivoted on pivot pins 37

threaded into perforations 38 in the solid side members 18. The long arms 39 of the bell cranks are preferably provided with enlarged perforations 40 at their inner end to receive the actuating pin 41 which extends through these perforations and through a perforation in the link 28. The clapper ends 42 which form the short arm of the bell crank extend outwardly through the slots 35, and to give sufficient clearance in action, the lower portion 43 of the cage assembly 17 is of smaller diameter than the upper portion 43'. These clappers, that is, the small arm of the bell cranks, are positioned to strike the inside of the oil tubing, a section of which is indicated at 45. The armature of the solenoid is provided with a bumper disk 46 which has bumper nubs 47 positioned to strike the underside of a shoulder 48 constructed in the solid sides 18, there being an enlarged cylindrical pocket 49 to accommodate the solenoid 32. The upward reaction of the bumper disk is due to the upward pull of the spring 27. This action operates the bell cranks to swing the clapper ends 42 inwardly and the downward reaction when the solenoid is energized gives a downward movement to the armature 31, the link 28 and hence a striking blow of the clappers 42 in the oil tubing 45. This sound is periodic when the finger circuit closer is operated and the sound is conveyed through the oil tubing and the oil therein to the top of the well and is thus readily detected by the observers.

The detector assembly designated by the numeral 60 is supported by a threaded rod 61 which is threaded into the lower end of a closer head 82, this in itself being threaded on the cage structure 17 at the bottom thereof as indicated at 63. A guide and a weight 65 is threaded on the lower end of the rod 61, there being a spacing collar 66. This weight is cylindrical on its outside surface except for the channels 67 in which are mounted expansion finger springs 68 which are tensioned outwardly and develop a slight friction on the inside of the oil tubing as the equipment is lowered therein. Vertical ducts 69 in the weight arranged in a circle provide for the upward flow of the oil.

A second threaded rod 70 extends downwardly to the finger support block 75, being threaded in the upper end thereof, this block also having ducts 76 for the upward flow of oil. An insulating bushing 77 is fitted on the rod, the lower end resting on the upper end of the block 75. There is also a metal spacing ring 78 and a second metal spacing collar 79 between the bushing 77 and the underside of the weight 65. The bushing is provided with an annular rabbet 80 in which is mounted an electrical conductor ring 80'.

The block 75 is provided with a plurality of vertical grooves 81 on its periphery 82, such periphery being cylindrical except for concave shallow vertical grooves 83 located between the grooves 81. These latter are to provide additional space for the upward flow of oil. The grooves 81 are provided to accommodate the feeler and contact fingers 90. These fingers are all of the same construction and are fulcrumed on a ring 91 seated in an annular groove 92 at the upper end of the block 75. These fingers are quite long from their pivot or fulcrum to the lower convex curved nose or end 93 and the outer edge 94 is preferably straight. The upper end tapers inwardly as indicated at 95 and on each finger there is an adjustable contact screw

96 adjusted by means of a screw driver engaging a screw driver kerf in the screw head and retained in position by a set screw. These contact screws are for the purpose of engaging the conductor ring 80', one of which is shown in contact therewith in Fig. 5.

The expander assembly 100 for the fingers employs a lower threaded rod 101 threaded into and thus attached to the lower end of the block 75. On this is mounted a disk 102 retained in place by a nut 103. A metal collar 104 extends from the disk 102 to the underside of the block 75.

For each finger there is a spring 105 having a fixed end 106 caught in a perforation in the disk 102 or otherwise secured thereto. A coil 107 is located well within the radius of the block 75. The pressure end 108 extends upwardly fitting in the slot 81 which accommodates the fingers 94 exerting an outward pressure thereagainst. These springs may be made of wire or other suitable material and the clearance in the grooves is insufficient for the springs to slip out of place. Such springs always urge the fingers towards the electric contacts as shown in Fig. 5, that is, the lower ends being thrust outwardly.

If it is desired to add additional weight to the equipment, a lower weight 110 is attached to the bottom of the lower rod 101. This is cylindrical on its outside surface except for the longitudinal grooves 111 in which are mounted the expander leaf springs 112 to engage the inside surface of the oil tubing.

The manner of operation of the fingers as above described, is indicated in Figs. 5 and 6 in which the section of the oil tubing 45 is shown as being a true cylinder on its inside surface 115 except for the worn vertical groove 116, such groove being of a type worn either by the rubbing contact of the sucker rods or if of larger radius, by a coupling. With my construction an accurate adjustment must be made of the fingers and equipment made as to the proper size for the internal diameter of the oil tubing. Therefore all of the fingers which contact the cylindrical portion 115 of the oil tubing have their lower portions below the fulcrum 91 held pressed inwardly, there being a sliding contact of all of the fingers operating on the true cylindrical surface, however when lowering or raising the device without any necessary rotation thereof, when one or more of these fingers enters the vertical worn groove as 116, the lower end of such finger or fingers is forced outwardly by the spring 106 as indicated by the uppermost finger of Fig. 6, thus causing the contact screw 96 to make an electric contact with the conductor ring 81 and thereby closing an electric circuit described hereunder. As above mentioned, the fingers may be of sufficient length that they will not be forced outwardly in the annular space in an oil tube coupling which is sometimes formed between upper and lower lengths of oil tubing. They however will react on a pivoting movement to an elongated internally worn groove or other enlargement from the true circle if of sufficient radial depth.

The tool used for adjusting the contact fingers 90 employs a sleeve or collar 120, Fig. 7. This has an inside cylindrical surface 121 slightly smaller than the particular oil tubing in which the tool is to be used and at one or more places there is provided a longitudinal internal groove 122. This groove is illustrated as having parallel sides extending towards the center and the base

gauge surface 123 which is parallel to the axis of the sleeve, thus one finger at a time may be allowed to enter this groove and have the contact screw 96 adjusted to make the electrical contact when the finger is thrust outwardly. By using such a device or setting tool all of the fingers may be twisted and adjusted so that on a predetermined minimum of longitudinal groove, the fingers will make the electric contact, therefore of any groove of greater depth manifestly they will also make the contact and transmit the signal showing that the tool is entering the worn section of the oil tubing.

Fig. 2 illustrates the container for the dry cells and a solenoid operated mercury switch. The solenoid retainer 130 has a partly circular wall 131 with a relatively large opening at the side and provided with a bottom plate 132 and a similar top plate 133. A solenoid 134 is suspended by screws or the like 135 from the top plate 133 and has its armature 135' operating downwardly. This armature has a lower end portion 136 connected to a switch mounting 140 in which a plate 141 is secured to one leaf 142 of the hinge. The fixed leaf 143 has a flange 144 secured to the bottom plate or base 132, the pintle of the hinge being indicated at 145. On the plate 141 there is mounted a pair of mercury switches indicated at 146 and 147, the operating action being detailed hereunder. The cage 150 for the dry cells is connected to the solenoid holder 130 by a threaded rod 151 and the cage is provided with a base disk 152, a top disk 153 and an intermediate disk 154, these being connected by rods 155 of which one or more may be removable to insert the dry cells in position. Leaf springs 156 mounted on the intermediate disk 154 are operative to exert a spring pressure on the bottom and top of the cells. There is also a contact screw 157 in the top disk 153. The leaf springs 156 form electrical contacts between one or more dry cells placed one on top of the other within the cage 150. For this purpose the intermediate disk 154 slides vertically on the rods 155. One of the rods is shown without a screw connection to the top disk 153 so the disk may be pulled upwardly for insertion and removal of the dry cells. The whole equipment including the solenoid holder 130 is supported on a threaded stud 158 fitted into the bottom plate 132 and engaging the threaded plug 16. An adjustable stop screw 159 regulates the downward tilt of the mercury switches.

A suitable wiring for the clapper system of signalling is illustrated in connection with Fig. 8 in which the source of power such as a battery is indicated at 160 having a wiring connection 161 to the switch operating solenoid 134. From this there is one branch 162 which is connected to one of the two mercury switches indicated at 147 and from thence a lead connection 163 to the conductor ring 61 with which contact is made by the contact screws 96 when any individual finger 90 operates inwardly at its upper end. The fingers are grounded through the metal of the structure as is also the battery grounded to the equipment. A parallel circuit to ground is by the lead 164 to the terminals of the second mercury switch indicated at 146 and from thence to the solenoid 32 of the clapper, this having a ground connection. These two mercury switches are mounted on a hinge and are facing in opposite directions, hence when the switch assembly is tilted downwardly one of the mercury switches is closed and the other opened and when it is

tilted upwardly the first switch is open and the second switch closed. As the switch assembly is normally in a position so that for instance the switch 147 is in its closed circuit position, then on a contact being made between the fingers 90 through the contact screws 96 and the conductor ring 81, a circuit is closed through the switch controlling solenoid 134. This operates the hinged assembly of the mercury switches to reverse these, thus for instance opening the mercury switch 147 and closing the mercury switch 146. This then establishes a circuit to the clapper solenoid 32 which causes the clappers to give one stroke. As soon as the solenoid 134 is de-energized, the mercury switches drop thus opening the clapper circuit and again closing the solenoid circuit to the ring 81. By this arrangement and by adjusting the movement of the switch hinge, a timing may be developed for the clapper, thus producing a steady sound with a sufficiently distinct interval to be readily detected. It is to be understood that all of the exposed wires of the electric connections and also the various terminals are thoroughly insulated. The solenoids are also constructed in such a manner to have their windings insulated as the flowing oil comes in contact with the clapper mechanism and the wires leading from one connection to another and connections to the battery.

In the construction of Fig. 9, a somewhat simplified arrangement is made as it is not necessary to have the clapper mechanism and the clapper operating solenoid. The switch cage 150 may be substantially as shown in connection with Figs. 1 and 2. The buzzer assembly 175 is mounted in a housing connected by a threaded stud 176 to the bottom plate 152 of the battery. There is also a threaded stud 177 supporting the buzzer assembly from the threaded plug 178 attached to the tube or casing 13. In this instance the threaded rod 61 supports the upper weight and the contact finger assembly together with the weights may be the same as shown in Fig. 1. The wiring diagram for the buzzer as in Fig. 10, has a suitable battery or current supply 180 with a connection to the buzzer 181, from thence to the contact ring 81 the adjusting screws 96 and the finger 90, the battery and the finger thus being grounded. Therefore by this arrangement so long as the fingers operate and are moved as to at least one of the fingers to a closed circuit position, the buzzer operates and gives a continuous sound.

In order to readily detect the sounds either of a clapper or the buzzer even in a very deep well, it may be advisable to use an equipment such as shown in Fig. 11. In this case a well casing is indicated at 190 with the testing instrument indicated at 191 lowered by a cable 192 or the like. A vibration pickup device of the microphone type 193, is secured to the casing in any suitable manner. This has a wiring connection to an amplifier 194 which may be energized by connections 195 to a conventional alternating electric circuit. The amplifier is wired to a loud speaker 196 or earphones. The vibrations caused by the operation of the clappers or the buzzer thus are much amplified and readily detected by the loud speaker or earphones. It is to be understood however that if desired the microphone pickup may be connected directly to the oil tubing however as this type of device is so sensitive, the mechanical sound transmitted from the clapper direct to the oil tubing or the sound switches of the buzzer acting on the buzzer case and hence

through the spring finger connection to the oil tubing give a sufficient mechanical contact that the sounds are satisfactorily transmitted to carry the vibrations a long distance. In fact, satisfactory results at great depths in oil wells have been obtained by listening to the oil tubing or to the casing with the ear but manifestly the vibration pickup system is much more sensitive.

Referring first to the construction of Figs. 12, 13 and 14, in Fig. 12, the contact section of the instrument designated at 211 has a detector assembly 215, this having pivoted fingers of substantially the type shown in Fig. 1 except that a cover sleeve 216 is inserted over the electrical contact or circuit closure ends. The springs also are shown of a leaf spring type 217. The lower guide weight 220 attached to a rod extending downwardly from the finger assembly has bowed guide springs 221 of a type used in this class of instrument. The lower end of the weight is provided with a coupling 222 for attachment of additional weights if this be necessary. There is also an upper guide weight illustrated at 225 attached to the upper end of the detector assembly. A rod 226 is connected or forms part of the weight 225 and this has a head 230 with a threaded upper end 231. When the detector is lowered and pulled by a cable, a cap 235 is secured to the threads 231, this having an eye 236. The cap has an opening 237 through which passes the lower end 238 of the electrical conductor which is built into the hoisting cable. The electrical leads indicated at 239 pass through the head 230 and the threaded section 231. An open thoroughly insulated conductor 240 leads from the bottom of the head 230 to the upper end of the weight assembly 235, there being a conductor section 241 leading through the weight and having a further connection 242 to the conductor ring 80' which is mounted in the same manner as shown in the details of Fig. 5. The operation of the tool of Fig. 12 will be described in connection with Figs. 15 and 16.

Where it is desired to make the tests by sound indication of the worn spots of the tubing, I mount the sounder equipment 250 of Fig. 13 on the detector assembly 211 of Fig. 12. This requires removal of the cap 235. A covering sleeve 251 is then threaded onto the threads 231 abutting against the head 230. In this sleeve there is the operating equipment 255 for the sounder, this being shown in detail in Fig. 14 in which there is an inner casing 256 mounted on a stud 257 which is threaded into the upper end of the head 230 and holds this inner sleeve in the proper location, there being a closure plug 258 at the bottom of the inner casing 256. A fixed contact point 260 is mounted in insulation in the plug 258 and from the lower end of the connection there is a lead wire 261 extending downwardly and forming a connection with the leads 239, 240, 241, 242 to the contact ring 80'. A lead 262 connects to one end of a condenser 263. From the opposite end of this condenser there is another lead 264 to an adjustable contact point 265. This is adjustably connected to a sleeve 266. An electric lead 267 extends upwardly from the connection to the point 265 to a connector 268 of a solenoid 269. From the solenoid a lead 270 extends upwardly to connect to the batteries hereunder detailed.

The solenoid has a reciprocating core 275 with a pin 276 extending upwardly through an upper plug 277 of the case 256. A head disk 278 is on the lower end of the core. From this head there extends a stud 279 on which is clamped a disk 280.

This is to operate the vertical rod 281 which has an upper and a lower set collar 282 and 283. The stem passes through a guide partition 286. This partition and a lower partition 286 form a mounting for a permanent magnet 290, this being secured in place by studs and nuts 291. This is a horse-shoe magnet and the two poles 292 are positioned closely contiguous to an armature 293 secured to the rod 281. There are two soft iron keepers 294 which bridge across the poles and the armature having a rubbing contact. The lower end of the rod is connected by a coupling 295 to the sleeve 286 and thus actuates the vertical reciprocating movement of the contact 265.

The clapper assembly 300 employs a bell crank 301 pivoted at 302 to a metal web 303 on a cap-piece 304 of the sound or operating equipment 255. A horizontal arm 305 extends across the pin 276 and the resilient arm 306 extends upwardly from the pivot of the bell crank and has a clapper 307 mounted thereon. A stem 308 is secured to the cap structure 304 and has a coil spring 309 mounted thereon bearing on the end of the arm 305 and normally retracting the clapper and shifting the arm downwardly towards the pin 276.

The battery assembly 320 includes the sleeve 321, note Fig. 13, which is supported on a rod 322 extending upwardly from the cap 304. Within this sleeve there is a bottom plug 323 and an insulating plug 324. This latter has a spring finger 325 which engages a center contact of a dry cell 326. A connector 327 extends from the spring through the bottom plugs and has the wire lead 270 connected thereto. As many cells as desired are stacked one above the other and are pressed downwardly by a spring 328 which engages the base of the threaded end 329 of an upper weight assembly 330, this being secured to the covering sleeve 251. This weight has a threaded connector end 331 at the top and may be used for attaching a cable for passing the whole assembly into an oil duct or for attaching rods where it is forced through the oil tubing where the tubing is pulled from the well and laid horizontally.

The manner of operation of the construction of Figs. 12, 13 and 14 when assembled to give a sound indication is substantially as follows: when the assembled device is moved through the oil tubing and this tubing forms a uniform cylinder, there is no outward movement of the fingers 90 however when one or more of the fingers swing outwardly into a worn groove or the like in a pipe, they establish an electric circuit by engagement with the contact ring 80', the dry cells being grounded through the spring 328 and the lower end 329 of the upper weight 330. Normally the contacts 265 and 260 engage, these having point tips resistant to sparking and hence the complete circuit is established through the solenoid. The condenser is for the purpose of damping or preventing any sparking. When the solenoid is energized it exerts an upward lift on its armature 275 and hence an upward thrust on the pin 276 actuating the bell crank 300 to strike a blow with the clapper 307 against the covering sleeve 251. In this upward action the disk 280 exerts a lift on the upper set collar 282 thus lifting the rod 281 and through its downward connections breaks the contact between the points 260 and 265 by lifting the point 265 upwardly. The purpose of the permanent magnet 290, its armature and keepers is to develop a friction in the action of a lift and drop of the contact point 265. Thus as long as one of the fingers is

riding in a groove in the oil tubing and maintains a contact with the connector ring 80', there is a continuous striking of the clapper at a predetermined frequency, this depending on the make and break of the contact points 260 and 265. Manifestly as soon as the circuit is open between the lower contact 260 and hence the lead 261 and the upper contact 265 and the lead 267, the armature drops causing the disk 280 to engage the lower set collar 283 thrusting this downwardly to again establish the circuit. Due to the bridging of the condenser across these contact points sparking is avoided or reduced. As the operator by his record knows the position of the instrument in the oil tubing, he can then by noting the clapper sound make a record as to which stand of tubing has the worn spots. In testing the tubing in place in a well a sound pick-up equipment of Fig. 11 might be utilized or when this is run through the stands of tubing as they are pulled from the well, the sound gives the indication direct as to which length of tubing of a stand has the worn places. The individual pipe lines can also be tested by either thrusting or pulling the instrument through the pipe and determination of any worn spots obtained by the sound.

The equipment of Figs. 15 and 16 illustrates the construction used in a diagrammatic manner together with a diagram of the electric circuit. In this case as above mentioned, only the portion of the tool shown in Fig. 12 is lowered into the oil tubing, this having the detector assembly 215 in which one of the fingers 90 is illustrated with its adjustable contact end 96 makes a contact with the connector ring 80'. This through the medium of the upper portion of the tool and the cap 235 is suspended by the hoisting cable 350 which leads upwardly to the ground surface to the oil well derrick and is wound on the drum 351. The cable as above mentioned, has an insulated electrical conductor incorporated therein, one end of which has the connection 352 to a conductor ring 353 on the drum. By means of a brush 354 an electrical connection is made to a source of electric current such as a battery 355. A lead 356 connects to a recording instrument 360. This is of a standard type in which a band of paper or the like which forms the chart moves through the instrument and a record is made by a moving pen or stylus. As this particular instrument is standard equipment, it is not illustrated in detail. The return connection by the lead 361 has a ground 362 to the string of oil tubing 363 to be tested. In order to provide the drive for the chart, the cable leads over a pulley 370 being pressed and retained thereagainst by idler wheels 371 and from this pulley as from the axle there is a flexible shaft drive 372 to the instrument 360. As above mentioned, in making the instrument record it is preferable to lower the detector tool to the bottom of the string of oil tubing or at least to a position below the sections to be tested. It may then be drawn up at a more or less uniform rate by winding in on the drum and due to the flexible shaft connection 372 to the instrument 360, the chart moves at a speed proportionate to that of the lift of the indicator. In making a test of course the operator knows the depth at which the test is being started and hence as the various stands of oil tubing are designated by numbers, he knows in what particular stand the test starts. In making tests of this type, the fingers 90 are preferably set so that they will

make a contact in passing each coupling provided that there is a sufficient space which is usually the case between the ends of contiguous tube lengths. This forms a guide therefore to the identification of the particular stand or pipe which has a worn section. These are identified in connection with the graph chart in Fig. 16.

The graph chart of Fig. 16 designated by the numeral 400 is of a strip type and if desired may be ruled with the center line 401 indicating a division line for two distinct graphs made on the chart. This may also be transversely ruled in curved lines 402 which are substantially on the curve made by the pivoted stylus which marks the graph. In making a test and survey of the oil tubing installed in a well, the operators are interested to learn the remaining wall thickness of the tubing. They do not desire necessarily to know the amount of wear but this can readily be determined and calculated but by learning the remaining thickness of the wall of the tube, a determination may be made before pulling the tubing from the well as to what particular stands or lengths have badly worn spots which might give out and also indicate whether it is safe or not to leave the tubing in the well for a further pumping. In the graph presented, an actual tracing of full size has been made of a section of a long chart showing the arbitrary determinations of a wall thickness on one graph of $\frac{1}{8}$ " or less and on the other side a graph of a remaining wall thickness of $\frac{1}{4}$ " or less. In this record the graph 405 indicates the wall thickness remaining of $\frac{1}{8}$ " or less and the graph 406 of $\frac{1}{4}$ " or less. While the graph is being made counter-checking with the known record of the depths of the different stands and then if desired cross checking with the finished graph, numerals 407 are inserted on the graph showing the different stands or length of oil tubing. The graph indicates 12 stands or lengths of pipe from 20 to 31. The graph usually indicates an approximately straight or even line such as 408 on the graph 405 and 409 on the graph 406 indicating sections of the tube which are of substantially even diameter and of the proper diameter so that the detecting fingers have not moved outwardly. In making the record, the instrument has a certain time lag due in part to the inertia movement of the stylus so that the distance the mark moves to the left or to the right of the lines 408 or 409 is more or less immaterial. What counts particularly in indicating the wear is the length considered longitudinally of the space such as 410 of the graph 405 or 411 of the graph 406. In checking the graph there are usually slight indication marks such as 412 on one graph and a corresponding mark 413 on the other which show a location of couplings or joints. It will be noted that there are a series of these substantially opposite on the graph 405 and 406. These aid in checking the numeral markings 407 of the identifying number of the stand or length of pipe. The graph 405 shows that there are quite a number of places in which the remaining wall is $\frac{1}{8}$ " thick or less but the graph 406 only shows that there are a few places that are $\frac{1}{4}$ " remaining wall or less. These are identified by the numeral 414 and it is to be noted that one of these worn spots coincides with the relatively wide opening 411 and 412 showing that at this section of the pipe there is quite a long length of the stand which has been worn to at least a remaining thickness of $\frac{1}{8}$ " and a shorter section that has been

worn to a remaining thickness of $\frac{1}{16}$ ". This whole stand likewise shows considerable wear indicating that it is in very poor condition. The stands which indicate considerable wear and thus poor condition are in the neighborhood of 27, 28, 29 and 30. The person responsible for making the test and survey then takes the chart having the two graphs and may with a rubber stamp indicate thereon wording or symbols which interpret the graph to a person who may not be familiar with reading the same, however this latter feature is open to so many changes, such is not described herein. The particular indicia marked thereon is made in accordance with the desires of the operators of the particular well under survey.

In order to give a signal and record of the couplings, it is desirable to provide the fingers 90 with rubbing nubs 90' (note Fig. 15), these being faced with hard metal. The nubs may then extend into the space between upper and lower tubings at a coupling and give the type of signal and record identified on the chart at 412 and 413. It is desirable also to use this type of finger where the sound indication is being used; a person making the test soon learns to distinguish between the sound produced by the finger tip momentarily passing into the enlargement at a coupling from the prolonged sound made by the finger entering a groove. This slight movement of the finger at the coupling aids in identifying the location of the particular coupling. Of course it sometimes happens in tubing installed in a well for a long period of time that the space becomes substantially filled with corrosive material in which case practically no signal or record is given of the joints. By my construction therefore due to varying the shape of the fingers and their contact end with the tubing, signals or records may be made or not at the tool joints as desired but will be positively given at the rather long grooves caused by wear in the tubing.

Various changes may be made in the details of the construction without departing from the spirit or scope of the invention as defined by the appended claims.

I claim:

1. In a device as described, the combination of an instrument adapted for movement through tubing having a cylindrical inside surface, the instrument having a central block with a plurality of vertical grooves, a feeler finger pivotally mounted in each of the grooves, a spring means

urging one end of each finger outwardly, the fingers being pivoted to move in a radial direction, an electric conductor ring located adjacent one end of the fingers and insulated from the said block and from the fingers, each of the fingers having an adjustable contact to engage the conductor ring when such portion of the finger moves inwardly on another portion moving outwardly into a worn groove and means forming an electric circuit including the conductor ring and the electric contacts.

2. A tubing wear detector comprising a body adapted to be moved through a tubing, a plurality of independently movable feelers pivotally mounted upon said body, means urging said feelers to expand, adjustable contacts on the feelers, and contact means engageable by the adjustable contacts when the feelers are allowed to expand, and indicating means in electrical circuit with the contact means.

3. A tubing wear detector comprising a body adapted to be moved through a tubing, a plurality of independently movable feelers pivotally mounted upon said body, means urging said feelers to expand, adjustable contacts on the feelers, and contact means common to all adjustable contacts engageable by the adjustable contacts when the feelers are allowed to expand, and indicating means in electrical circuit with the contact means.

4. A tubing wear detector comprising a body adapted to be moved through a tubing, a plurality of independently movable feelers pivotally mounted upon said body intermediate their ends, said feelers having rounded lower ends, spring means urging the lower ends of the feelers outwardly, adjustable contacts at the upper ends of the feelers, a contact ring engageable by the adjustable contacts, and indicating means in electrical circuit with the contact ring.

5. A tubing wear detector comprising a body adapted to be moved through a tubing, a plurality of feelers pivotally mounted upon said body for movement independently of each other, spring means urging each feeler outwardly with respect to the body independently of other feelers, adjustable contacts on the feelers, and means engageable by the adjustable contacts of any feeler moved outwardly beyond a predetermined distance for closing an electrical circuit.

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