

June 6, 1939.

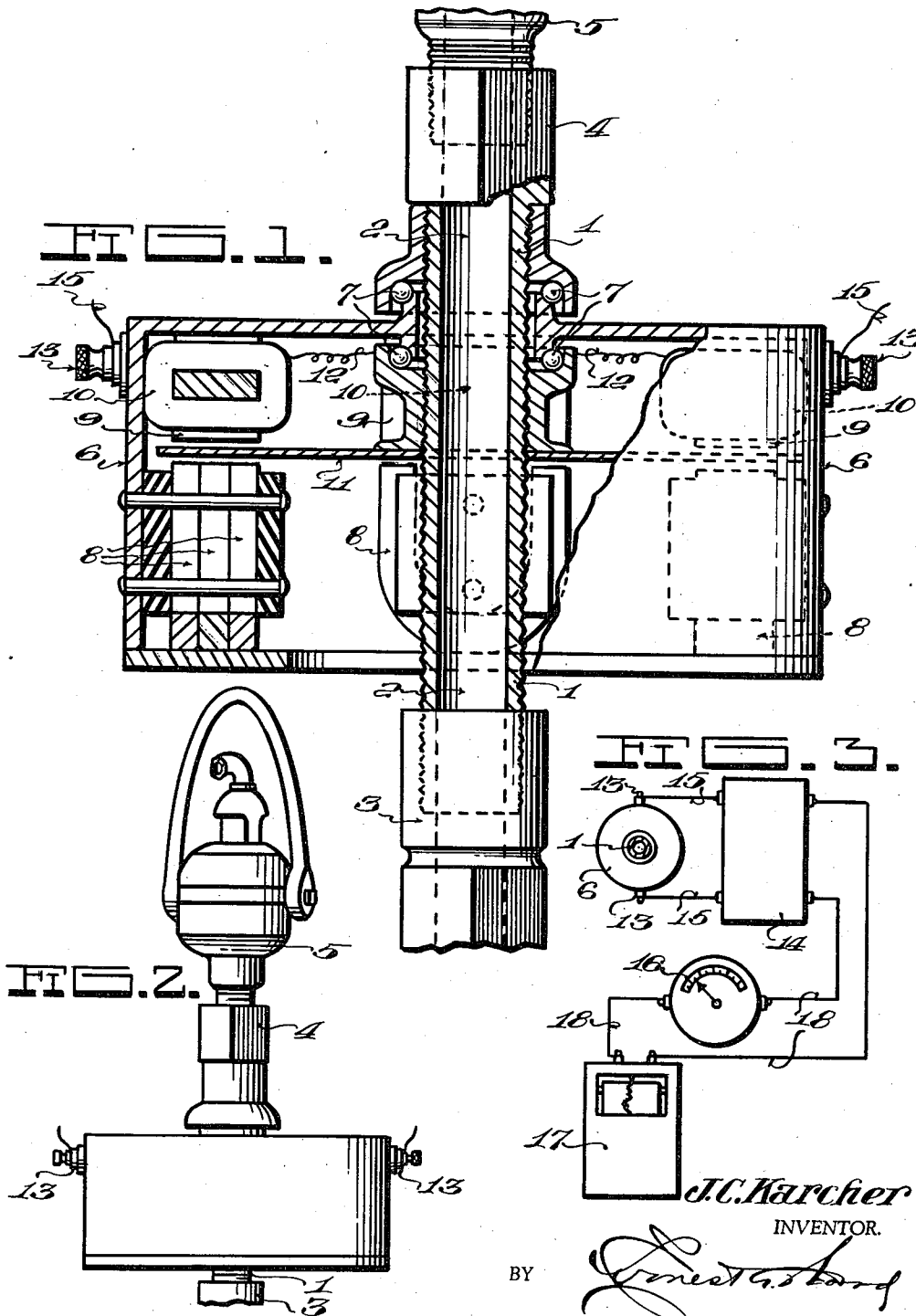
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APPARATUS FOR DETERMINING THE HARDNESS OF SUBSURFACE FORMATIONS

Filed April 27, 1936

2 Sheets-Sheet 1



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FIG. 4.

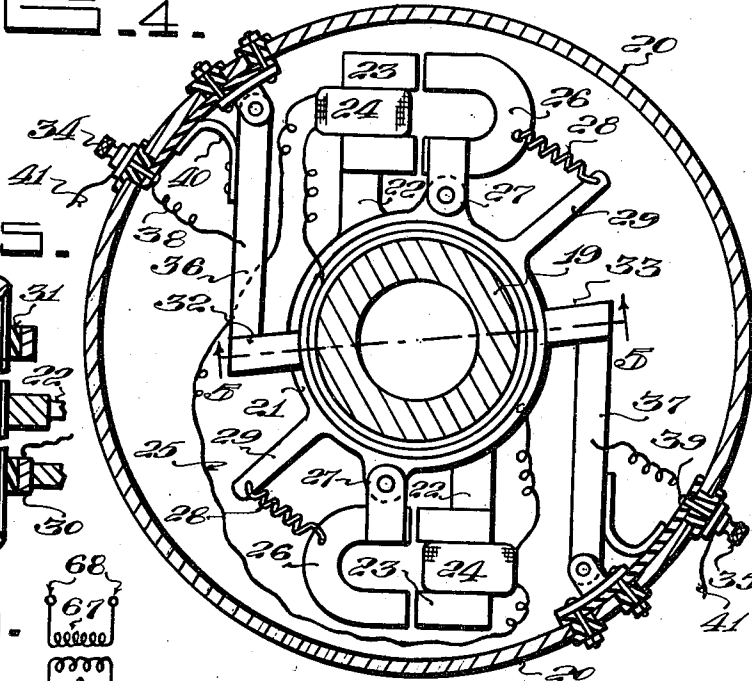


FIG. 5.

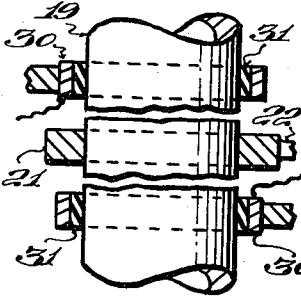
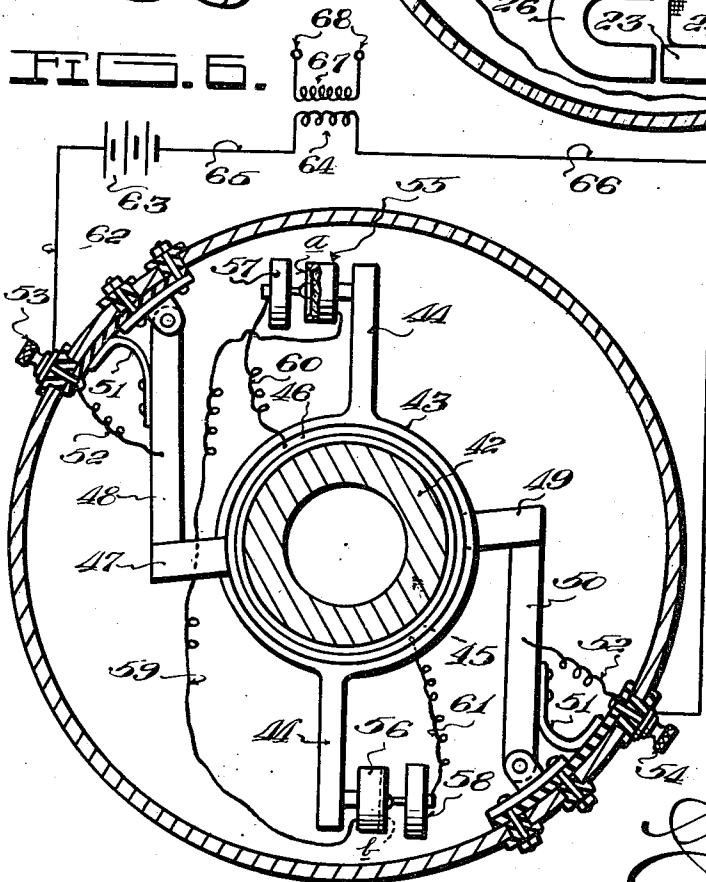


FIG. 6.



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APPARATUS FOR DETERMINING THE HARDNESS OF SUBSURFACE FORMATIONS

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3 Claims. (Cl. 73—51)

This invention relates to apparatus for exploring bore holes as drilling proceeds, and it has particular reference to apparatus for determining the hardness of formations encountered by the drill bit of a rotary drilling machine.

The principal object of the invention is to provide an apparatus whereby the relative hardness of formations encountered during the drilling operation may be observed and permanently recorded as drilling proceeds.

With the foregoing object as paramount the invention has particular reference to its salient features of construction and arrangement of parts, to become manifest as the description proceeds, taken in connection with the accompanying drawings in which

Figure 1 is an elevational view of the preferred embodiment of the invention, with portions of the housing broken away.

Figure 2 is an elevational view of the invention shown attached to attendant parts of the drilling machine.

Figure 3 is a diagrammatic view of the wiring arrangement and appurtenances.

Figure 4 is a modified form of the invention shown in Figure 1.

Figure 5 is a view on the line 5—5 on Figure 4, and

Figure 6 is a further modified form of a device embodying the invention.

Heretofore the operator of a rotary drilling machine has had to rely upon his observations of the general behavior of the drilling equipment as a means of determining the hardness of formations in which the machine is drilling at any given time. Determination by such a method is very indefinite and often results in erroneous conclusions as to the kind of formation in which the bit is working.

The present invention provides instrumental means for observing and recording the variations in behavior of the drilling machine as drilling proceeds through the various formations, and thereby provides means for determining the variation in the kind of formation in such a way that the observations are independent of the judgment of the operator of the machine.

Continuing with a more detailed description of the drawings, reference is primarily made to Figure 1 in which 1 denotes a shaft having a central passage 2 therethrough. The lower end of the shaft 1 is threadably connected to a grip stem 3 of a conventional rotary drilling machine. The lower end of the grip stem 3 is threadably connected to the upper end of the top

section of drill stem. The lower end of the bottom section of drill stem is threadably connected to a conventional type of rotary bit. These units are well known to those skilled in the art, and are not illustrated in the drawings. The upper end of the shaft 1 is comprised of an integrally formed box 4 into which is screwed a conventional water swivel 5.

A cylindrical housing 6 is mounted concentrically on the shaft 1, and is supported thereon by the bearings 7 thereby enabling the shaft 1 to rotate while the housing 6 stands still.

A plurality of permanent magnets 8 are rigidly mounted within the housing 6. Opposite the poles of the magnets 8, armatures 9 are positioned, which carry electric coils 10. Interposed between the magnets 8 and the armatures 9 and spaced apart therefrom, a copper disc 11 is positioned and is coaxially and rigidly attached to the shaft 1, thereby constraining the disc 11 to rotate with the shaft 1. The coils 10 are connected in series by wires 12, and are further connected to a pair of binding posts 13.

Referring now to Figure 3, 14 denotes an amplifier-rectifier, which is connected to the binding posts 13 by wires 15. An indicating meter 16 and a recording meter 17 are connected by wires 18 to the amplifier-rectifier 14 as shown.

The operation of the device is as follows: When the drill pipe, and consequently the shaft 1 is turning at a uniform rate, there will be no change in the magnetic flux between the magnets 8 and the armatures 9, consequently no current will be generated in the coils 10. If, however, there is a chattering or vibration of the drill bit, this motion will be transmitted to the shaft 1, and accordingly to the disc 11. This will cause the disc 11 to have an irregular rotational motion. This irregular rotational motion will cause changes in the amount of flux passing from the magnets 8 to the armatures 9, and consequently will induce a current in the coils 10. This induced current passing through the amplifier-rectifier 14, will cause the indicating meter 16 and the recording meter 17 to be actuated, and a consequent deflection of the indicating elements of these meters.

Another embodiment of the invention is illustrated in Figures 4 and 5, wherein 19 is a hollow shaft corresponding to the shaft 1 illustrated in Figures 1 and 2. A cylindrical housing 20, corresponding to the housing 6 previously described is concentrically mounted upon the shaft 19 through the medium of bearings such as illustrated in Figure 1. A ring 21 is rigidly attached to the shaft 19, from which armature supports 22 are

disposed which carry the armatures 23. Coils 24 are wound upon the armatures 23, and are connected in series by a wire 25.

A pair of permanent magnets 26 are hingedly connected to the ring 21 by hinges 27, and are held in position by springs 28, which latter are connected to the rotating ring 21 through a pair of radial arms 29. Thus it will be seen that the magnets 26, while constrained to rotate with the shaft 19, are free to vibrate when there is a chattering of the drill pipe.

A pair of slip rings 30 are rigidly mounted upon the shaft 19, and are insulated therefrom by insulating rings 31. One of the coils 24 is electrically connected to one of the slip rings 30, and the other coil is similarly connected to the companion slip ring. A brush 32 bears against one of the slip rings 30, and a companion brush 33 likewise makes electrical contact with its corresponding slip ring. The brushes 32 and 33 are electrically connected to the binding posts 34 and 35 respectively through the medium of the hinged arms 36 and 37 and the wires 38 and 39, the brushes 32 and 33 being held in contact with their respective slip ring by means of springs 40, which are attached to the arms 36 and 37. It will be noted that the arms 36 and 37 and the springs 40 are insulated from the housing 20. Wires 41 serve to connect the device to an amplifier-rectifier, such as illustrated in Figure 3, which in turn is connected to a suitable indicating meter and recording meter. The latter instruments will be actuated, due to an induced current, whenever there is a chattering of the drill pipe resulting from the encountering of a hard formation by the drill bit.

A further embodiment of the invention is illustrated in Figure 6, in which 42 denotes a hollow shaft corresponding to the shafts 1 and 19, previously described. The shaft 42 has rigidly attached thereto a ring 43, to which are attached a pair of radial arms 44. Slip rings 45 and 46 are disposed on either side of the ring 43 and are insulated from the shaft 42, as illustrated in the modification shown in Figure 5.

A brush 37, attached to a pivoted and conducting arm 48 bears against the slip ring 46, and a similar brush 49, attached to an arm 50, has electrical contact with the lower slip ring 45, the brushes being held in contact with their respective slip rings by means of springs 51. Wires 52 serve to electrically connect the arms 48 and 50 with the terminals 53 and 54.

A microphone 55 is suitably attached to the arm 44 and insulated therefrom, and a similar microphone 56 is attached to the arm 44. A weight 57 is attached to the diaphragm *a* of the microphone 55, and a similar weight 58 is attached to the diaphragm *b* of the microphone 56.

The microphones 55 and 56 are electrically connected in series by a wire 59, the weight 57 being connected to the slip ring 46 by a wire 60 and the weight 58 connected to the slip ring 45 by a wire 61.

A wire 62 serves to connect the terminal 53 with a battery 63, which in turn is connected to the terminal 54 through the primary 64 of a transformer by wires 65 and 66. The secondary 67 of the transformer is connected to a pair of terminals 68, which are operatively connected to an amplifier-rectifier. The latter in turn is con-

nected to the meters as previously described. During the time of drilling in a hard formation, the chattering of the drill assembly will cause vibration of the weights 57 and 58 and a consequent change in the electrical resistance of the circuit, due to the increasing and decreasing pressure exerted upon the diaphragms *a* and *b*. This results in an induced voltage in the secondary 67 of the transformer, and a consequent change in readings on the indicating and recording meters.

It has been found that when a drill bit is drilling in soft shale or clay there will be little or no vibration, and particularly torsional vibration in the drill stem. As a consequence the indicating meter will read substantially zero, since little or no current is generated in the modifications of the invention shown in Figures 1 and 4, and the current flow is substantially a constant in the variation of the invention illustrated in Figure 6.

If, however, the bit is drilling in a hard formation the tendency of the bit will be to grind and chatter, thus causing large torsional vibrations to progress up the drill pipe which will be transmitted to the copper disc 11, illustrated in Figure 1. Likewise, these vibrations result in vibrations of the magnets 26, illustrated in Figure 4 and vibrations of the weights 57 and 58, shown in Figure 6. These changes in current strength, after amplification and rectification, will cause the indicating meter to show considerable voltage. This voltage becomes an indication that the bit is drilling in a hard formation.

Manifestly the apparatus herein disclosed is capable of considerable modification, and such modification as is considered within the scope of the appended claims is likewise considered within the scope and intent of the invention.

What is claimed is:

1. Apparatus for determining the variation in hardness of earth formations encountered by a rotary drill bit while drilling, said apparatus including a conducting disc rigidly and co-axially attached to the drill stem, a stationary electrically conducting coil and a permanent magnet adjacently arranged and positioned near the periphery of said disc, and a similarly arranged coil and permanent magnet positioned on the opposite side of said disc.

2. Apparatus for determining the variation in hardness of earth formations encountered by a rotary bit while drilling, said apparatus including a conducting disc rigidly and co-axially attached to the drill stem, stationary magnetic elements mounted on opposite sides of said disc and symmetrically arranged with reference to the plane of the disc, and electrically conducting coils stationarily disposed adjacent to said magnetic elements.

3. Apparatus for determining the variation in hardness of earth formations encountered by a rotary bit while drilling, said apparatus including a conducting disc rigidly and co-axially attached to the drill stem and arranged to rotate between the poles of one or more magnets stationarily disposed around the periphery of said disc at spaced intervals and electrically conducting coils stationarily disposed adjacent to said poles of said magnets.

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