

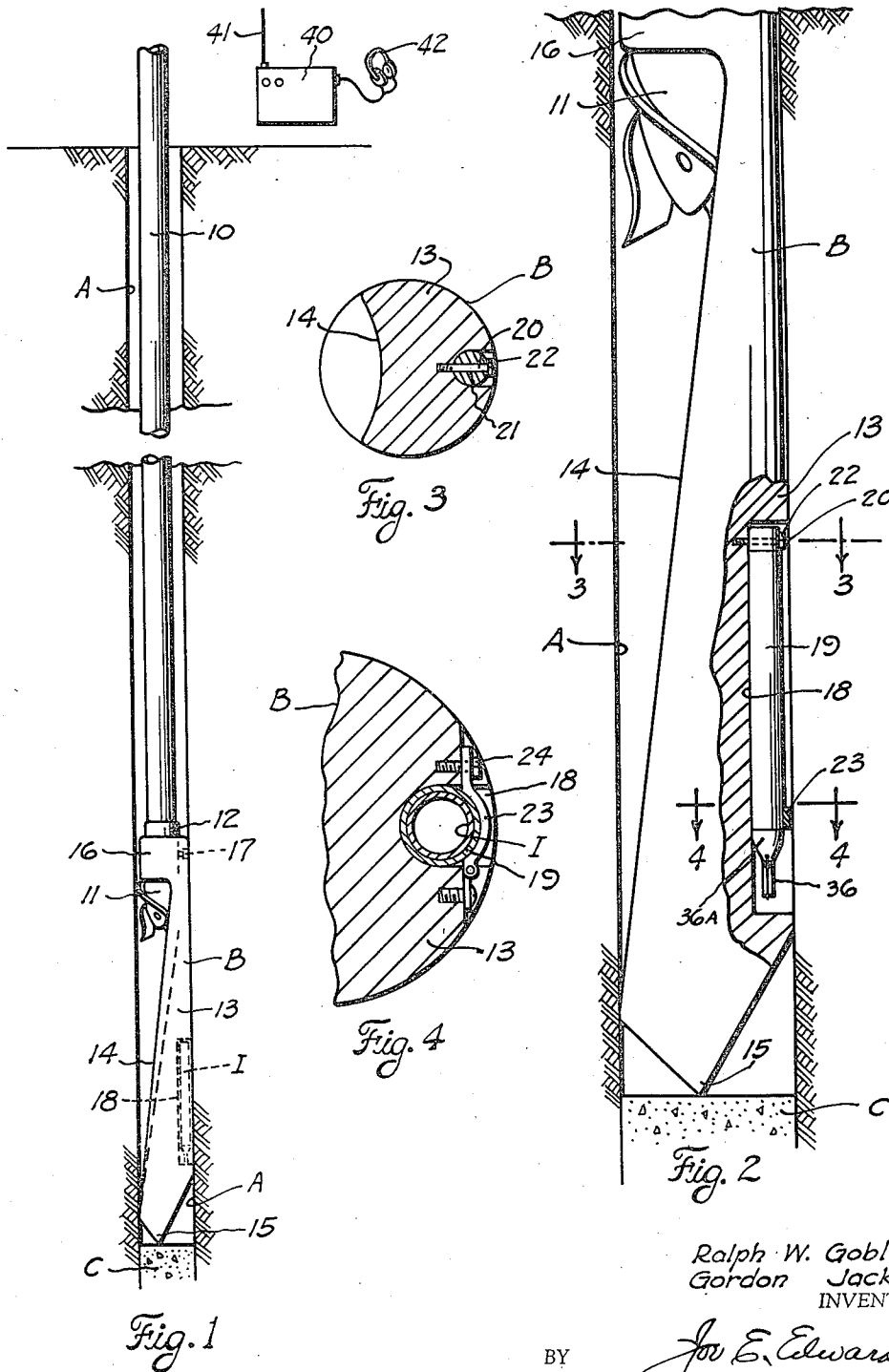
Dec. 27, 1949

R. W. GOBLE ET AL
METHODS OF AND APPARATUS FOR TRANSMITTING
INTELLIGENCE TO THE SURFACE
FROM WELL BORES

2,492,794

Filed Aug. 28, 1944.

5 Sheets-Sheet 1



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BY

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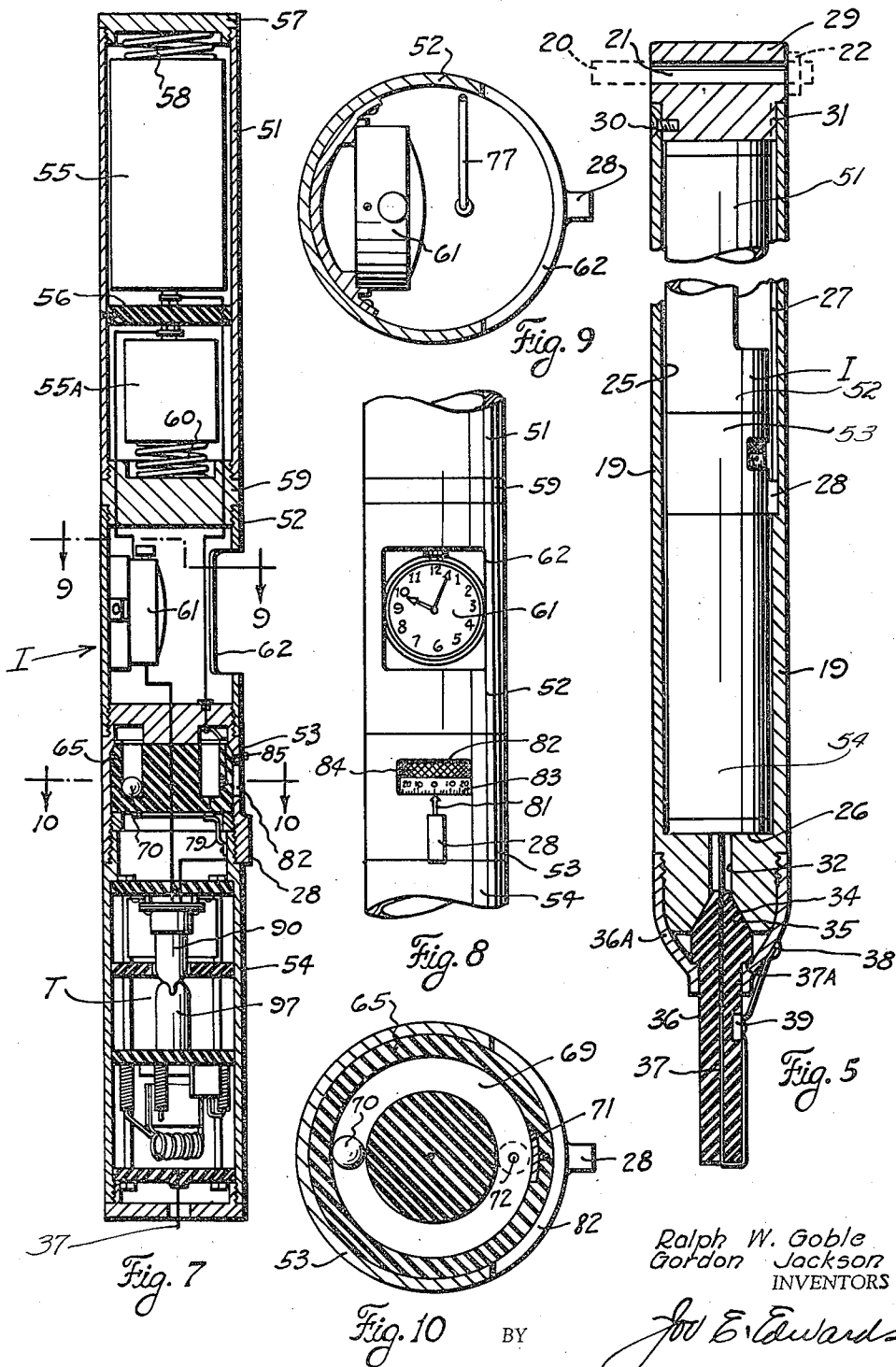
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5 Sheets-Sheet 3

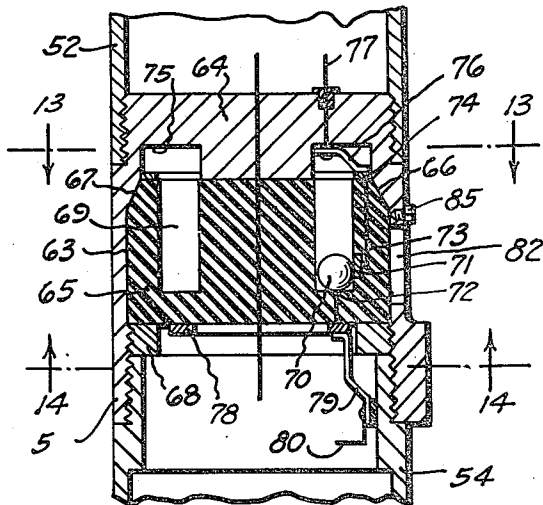


Fig. 11

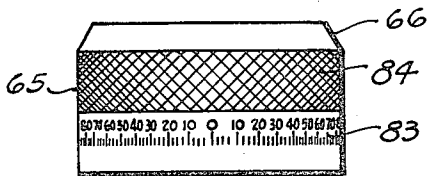


Fig. 12

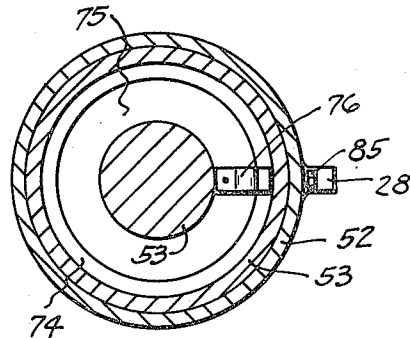


Fig. 13

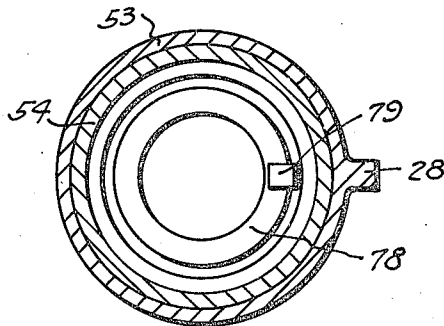


Fig. 14

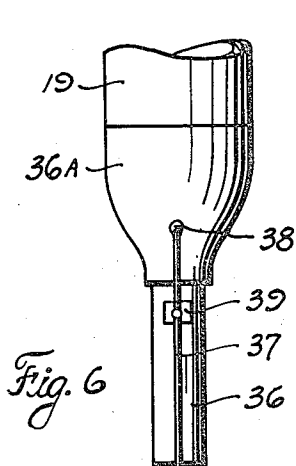


Fig. 6

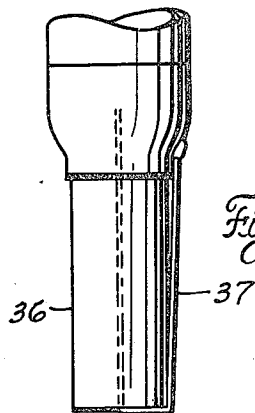


Fig. 18

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5 Sheets-Sheet 4

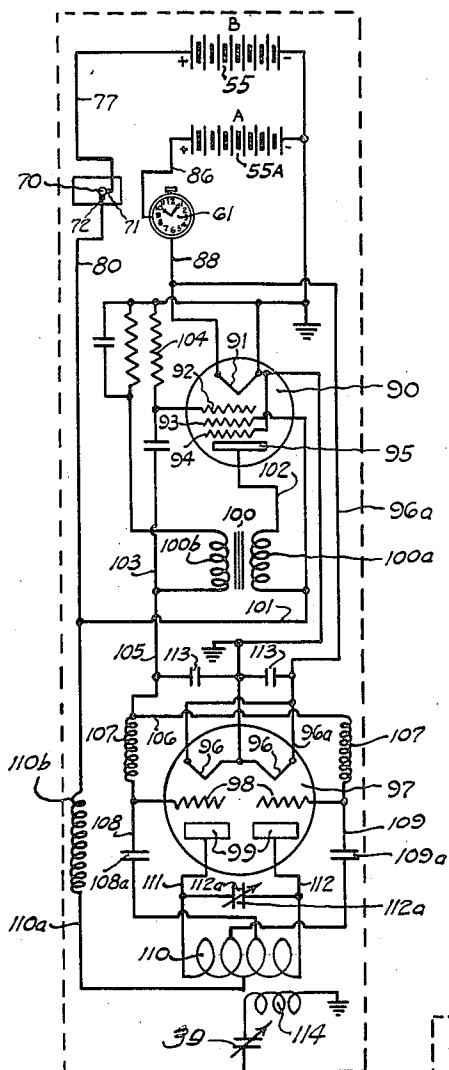


Fig. 15

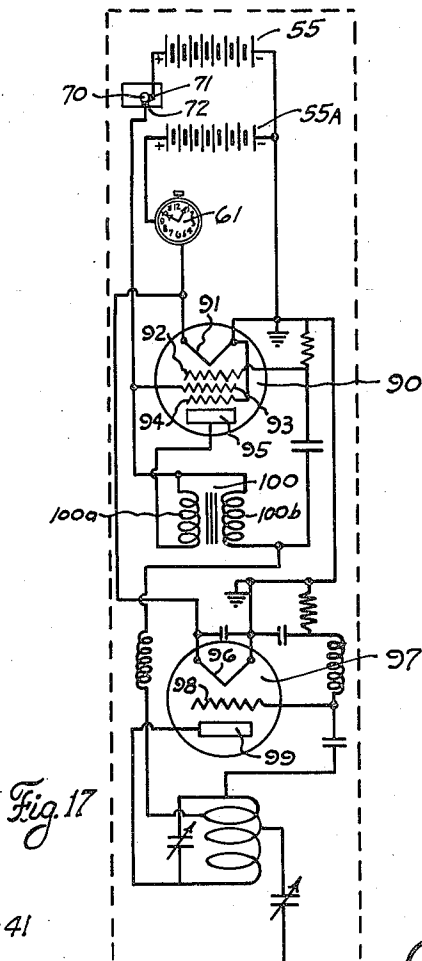


Fig. 17

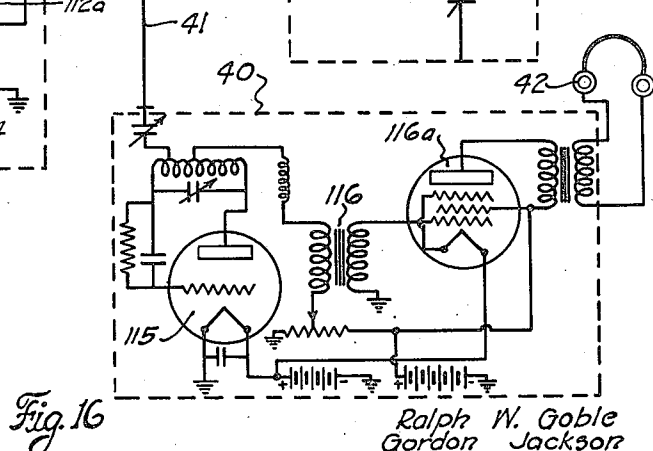


Fig. 16

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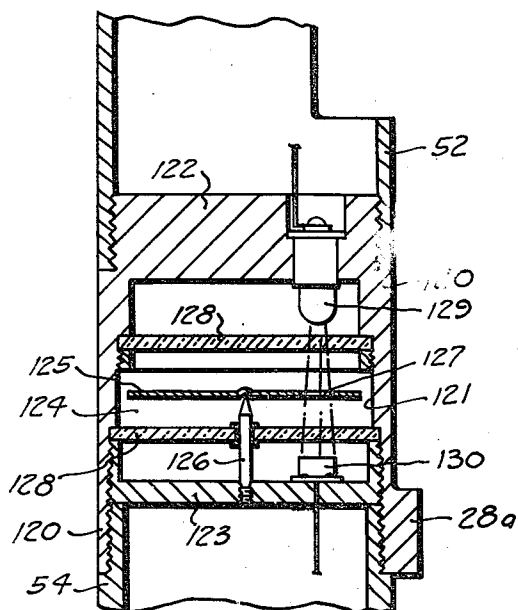


Fig. 19

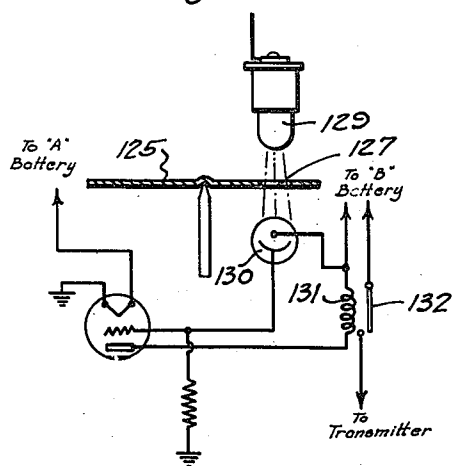


Fig. 20

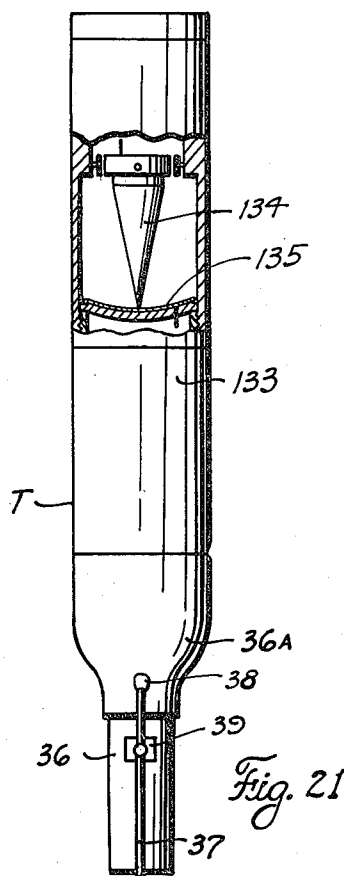
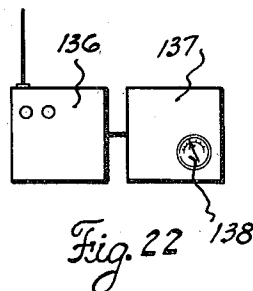


Fig. 21

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UNITED STATES PATENT OFFICE

2,492,794

METHODS OF AND APPARATUS FOR TRANSMITTING INTELLIGENCE TO THE SURFACE FROM WELL BORES

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Application August 28, 1944, Serial No. 551,570

11 Claims. (Cl. 250—2)

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This invention relates to new and useful improvements in methods of and apparatus for transmitting intelligence to the surface from well bores.

As is well known, the drilling of wells for the recovery of petroleum products requires many and varied operations which involve the use of different types of apparatus and tools. Such apparatus and tools must at all times be under the operator's control and also information regarding the well bore being drilled, such as its diameter, its degree of inclination, the direction of inclination, etc., must be known in order that proper drilling procedure may be carried out. The usual drilling operations involve the use and setting of whipstocks, deflecting tools and other equipment which devices must be properly oriented within the well bore to accomplish the desired results. Thus, it becomes apparent that much information regarding the position of tools and devices, the size, degree and direction of the well bore and other data must be made available to the drilling operator to permit him to drill the well bore in the desired manner.

Various methods of transmitting the necessary information to the surface have been in general use and up to the present time probably the most desirable and efficient of these involves the use of various types of photographic instruments. With reference to the information regarding the well bore, instruments incorporating a compass and an inclination indicator with means for photographing the relative positions thereof are in wide-spread use for determining direction and degree of inclination of a well bore. The diameter of the bore is determined by mechanical well calipers which are lowered through said bore and which engage the wall thereof to measure the same. With respect to the orientation and setting of tools, such as whipstocks, photographic types of instruments have been utilized to gain the desired information regarding the position of said tools; in some instances, methods involving instruments other than photographic have been employed.

Although the various instruments which are now in use provide the desired information they are objectionable because they must be run into and removed from the well before the records which are made can be read. Also the photographic recording requires development and the use of photographic film with its inherent disadvantage of accidental exposure is not desirable. The delay in obtaining the information

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given by the instrument is particularly disadvantageous where various well tools are to be oriented and set within the well bore for manifestly, all rig operations are held up while the instrument is run into the well, the record made, the instrument removed, and finally the record interpreted. This involves considerable time and in cases where the drill pipe is within the bore, as in a whipstock setting, there is danger of cave-in which might result in said pipe becoming stuck within said bore. The disadvantages of the present types of instruments for recording and transmitting required information to the surface have been recognized and some attempts have been made to devise methods of signalling the position of tools, or other information, to the surface by sonic means. However, these methods have not proven commercially successful because the sound is absorbed as it travels up the well bore and is not capable of detection at the surface, particularly in wells of any appreciable depth.

It is one object of the present invention to provide an improved method and apparatus for transmitting information regarding a well tool or device or regarding the well bore to the surface of the well, said information being transmitted simultaneously with the operation of the recording mechanism of said apparatus, whereby the information is made available to the operator immediately and without the necessity of removing the apparatus from the well bore; said apparatus including no photographic means whereby the inherent disadvantages of such means are eliminated.

An important object of the invention is to provide an improved method of and means for propagating electrical or radio frequency waves along a metallic conductor, either grounded or ungrounded, within a well bore, whereby said waves may be utilized to transmit intelligence to the surface of said well.

Another object of the invention is to provide an improved apparatus which is particularly adapted for use with whipstocks, or similar tools, for transmitting to the surface information as to the position of said whipstock within a well bore; the apparatus also being usable with well survey instruments for transmitting the indications of such instruments to the surface of the well.

A further object of the invention is to provide an improved transmission system wherein electrical or radio frequency waves are generated

and imparted on the drill pipe or other metallic conductor within the well bore so that said pipe or conductor acts as a guide for the waves and said waves traverse the path afforded by the pipe or conductor, rather than radiating in all directions to become dissipated by the surrounding earth; said transmission system being associated with an indicating mechanism whereby the transmitted waves are representative of the indications of said mechanism and the reception of said waves at the surface provides information in accordance with said indications.

Still another object of the invention is to provide an improved transmission system for generating and transmitting electrical or radio frequency waves, which system includes a coupling circuit connecting the transmitter and the metallic pipe or conductor in the well bore; said coupling circuit being tuned to the resonant frequency of the output of said transmitter whereby the waves are impressed upon and are guided by said conductor and absorption of the radio frequency electrical current energy by the earth is prevented.

A particular object of the invention is to provide an improved apparatus for orienting a well tool, such as a whipstock, and having means for generating and transmitting radio frequency waves to the surface of the well bore to signal the attainment of a predetermined position by said whipstock, whereby the use of wire line or photographic instruments is eliminated and also whereby orientation of the well tool is complete when the signal is received at the surface.

Another object of the invention is to provide an improved apparatus, of the character described, which is adapted to be mounted within the well tool or whipstock and which includes a transmitter for generating and propagating radio frequency waves; said transmitter being controlled in its operation by an orienting switch which is arranged to actuate the transmitter when the well tool moves into a predetermined or desired position. The apparatus also including a radio receiver which is located at the well surface and which is adapted to receive the signal transmitted by said transmitter.

A still further object of the invention is to provide an improved apparatus, of the character described, wherein the coupling circuit includes a variable condenser which permits accurate tuning of said circuit to the output of the transmitter.

The construction designed to carry out the invention will be hereinafter described together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, wherein an example of the invention is shown, and wherein:

Figure 1 is an elevation of a drill pipe having a whipstock connected to its lower end and illustrating the transmitting instrument, constructed in accordance with the invention mounted within said whipstock and also showing the receiver on the surface.

Figure 2 is an enlarged view, partly in section and partly in elevation, of the lower portion of the whipstock and showing the mounting of the transmitting instrument therein.

Figure 3 is a horizontal, cross-sectional view, taken on the line 3—3 of Figure 2,

Figure 4 is an enlarged, horizontal cross-sectional view, taken on the line 4—4 of Figure 2.

Figure 5 is an enlarged view, partly in section

and partly in elevation and showing the outer barrel of the instrument in detail.

Figure 6 is an elevation of the lower portion of the outer barrel.

Figure 7 is an enlarged, transverse vertical sectional view of the instrument proper.

Figure 8 is a partial elevation of the central portion of the instrument, said view being taken at a right angle to the parts as shown in Figure 7.

Figure 9 is an enlarged, horizontal cross-sectional view, taken on the line 9—9 of Figure 7.

Figure 10 is an enlarged, horizontal, cross-sectional view, taken on the line 10—10 of Figure 7.

Figure 11 is an enlarged sectional detail of the orienting switch.

Figure 12 is an elevation of the rotatable block of the orienting switch.

Figure 13 is a horizontal, cross-sectional view, taken on the line 13—13 of Figure 11.

Figure 14 is a horizontal, cross-sectional view, taken on the line 14—14 of Figure 11.

Figure 15 is a wiring diagram of the transmitting unit.

Figure 16 is a wiring diagram of the receiving unit.

Figure 17 is a wiring diagram of a modified form of transmitting unit.

Figure 18 is a view, similar to Figure 6 illustrating a modified form of coupling between the transmitting unit and outer barrel.

Figure 19 is a sectional detail of a compass unit arrangement which may be substituted for the orienting switch unit.

Figure 20 is a wiring diagram of the compass unit shown in Figure 19.

Figure 21 is a view partly in section and partly in elevation illustrating the transmitter unit applied to an inclination indicating instrument, and,

Figure 22 is an elevation of a receiving unit which is employed with the inclination indicating instrument shown in Figure 21.

The invention is illustrated herein as applied to the orientation of a whipstock within a well bore but it is pointed out that the apparatus may be combined with well survey instruments, well calipers, temperature and pressure indicating instruments or other devices for transmitting the indications of said instruments and devices to the surface. In other words, the invention resides in the efficient transmission of electrical or radio frequency waves to the surface from within a well bore whereby said waves may be utilized to provide information regarding the indications of any device or instrument disposed within said bore; although the apparatus is specifically described in connection with whipstock orientation it is not to be limited to this use.

In the drawings, the numeral 10 designates a drill pipe or stem which is adapted to be lowered within the well bore A. A drill bit 11 is carried by the lower end of the drill pipe and has its tubular shank 12 threaded onto the lower end of said pipe. A whipstock B of the usual construction is arranged to be connected with the shank 12 of the drill bit and said whipstock comprises an elongate wedge-shaped body 13 having a longitudinally extending inclined guide face 14 which is generally concave in cross-section. Due to the concave guide surface which extends longitudinally of the body, said body is generally arcuate in cross-section throughout the major portion thereof with the lower end being fully cylindrical in cross section. This extreme lower end of the body is sharpened or pointed as in-

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licated at 15 while a collar 16 is formed integral with its upper end, said collar encircling the shank 12 of the bit and being fastened thereto by a shear pin 17.

The whipstock is used in the usual manner and is lowered within the well bore A by means of the drill pipe 10. The lower pointed end of the whipstock is seated upon a cement or other plug C within the well bore and through a rotation of the pipe, the inclined guide face 14 of the whipstock is directed into a desired azimuthal position. After the whipstock is set, a downward force is exerted upon the drill pipe to impose the weight thereof upon the shear pin 17 with the result that said pin is sheared to permit the drill pipe and drill bit to move downwardly with respect to the whipstock. The inclined face 14 of the whipstock will guide the bit into the formation at an angle with respect to the axis of the well bore and if the face has been properly oriented will also guide said bit in a desired or predetermined compass direction. After drilling is complete the whipstock may be retrieved because the bit 11 is of a larger diameter than the whipstock collar 16 and an upward movement of the pipe and bit will result in raising the whipstock therewith. It is pointed out that the particular construction of the whipstock and its connection to the drill pipe form no part of the present invention and the foregoing description is merely explanatory to permit better understanding of the invention.

In carrying out the present invention, the rear or trailing surface of the whipstock body 13 is formed with a longitudinal recess 18 which is disposed within the lower portion of the whipstock where the body of said whipstock is larger. An indicating and transmitting instrument I is mounted within an outer barrel 19 (Figure 5) and this barrel is arranged to be attached in position within the whipstock. As will be hereinafter explained in detail the instrument is oriented within the barrel and the barrel in turn is fastened in the recess in a predetermined or known position with respect to the inclined guide face 14 of the whipstock, whereby when the instrument is mounted within the whipstock its position with relation to the whipstock face is known. The orientation of the barrel 19 within the recess is accomplished by an outwardly extending bolt 20 which is secured in the whipstock body and which engages a diametrically extending opening 21 provided in the upper end of the barrel. The bolt not only positions the barrel and instrument in a known position relative to the whipstock but also receives a nut 22 on its outer end to fasten the upper end of the barrel firmly within the recess 18 (Figure 3). The lower end of the barrel is secured within said recess by means of a hinged clamping strap or bar 23 (Figure 4) which overlies the outer surface of the barrel and which is fastened in clamping position by a bolt 24. With this arrangement the instrument and barrel are removably mounted within the whipstock proper and it is noted that no change other than the provision of the recess 18 need be made in the usual or ordinary whipstock now in general use.

It is noted that the instrument is mounted directly within the body of the whipstock and the indications of said instrument are made in the plane in which the whipstock is disposed, whereby greater accuracy is assured. Also the instrument is not disposed within the drill pipe, as has been the usual practice, and there is no obstruc-

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tion to the flow of circulating fluid through said pipe. Further by mounting the instrument in the whipstock said instrument is lowered and raised with the whipstock and the use of auxiliary lines or cables for lowering and raising said instrument is entirely eliminated.

The outer barrel 19 within which the instrument I is mounted is clearly shown in Figure 5 and comprises an elongate tubular section which has a longitudinal bore 25 of slightly larger diameter than the diameter of said instrument. An internal annular shoulder 26 is formed within the lower end of the barrel and the instrument I is adapted to seat or rest upon said shoulder. The wall of the bore 25 of the barrel is provided with a longitudinally extending keyway or groove 27 and the instrument has a radially extending key or lug 28 integral with its outer surface, said lug being engageable within the keyway to orient the instrument I within the barrel. A cap 29 closes the upper end of the barrel being secured to the barrel by a plurality of screws 30 and said cap is provided with a lug or key 31 for engagement with the keyway or groove 27 when said cap is inserted within the upper end of the barrel. The orienting opening 21 which is engaged by the orienting bolt 20 of the whipstock extends through the cap 29 and this opening is disposed in the same vertical plane as the keys 31 and 28 as well as in the same plane as the longitudinal keyway or groove 27. Thus, it becomes apparent that the instrument I is mounted within the barrel 19 in a known position with respect to the orienting opening 21 of the barrel and when said opening bears a known relationship to the whipstock face 14 as it does when said barrel is in position within the recess 18 of the whipstock, the instrument I is in a known or predetermined position with respect to said whipstock face.

The lower end of the tubular barrel is externally screw-threaded and is formed with a reduced counterbore 32 which extends downwardly from the internal shoulder 26. The lower portion of the counterbore is provided with an annular seat 34 which is arranged to be engaged by the upper conical head 35 of a cylindrical supporting member or rod 36. The member 36 is constructed of an electrical insulating material and is held in position against the seat 34 by a bull plug or closure 36A, the latter having an internal shoulder 37A which engages an external shoulder on the member for forcing the conical head 35 against the seat when the plug is screwed onto the barrel. The member or rod forms a support for a coupling circuit which electrically connects the instrument I with the exterior surface of the barrel 19 and as is clearly shown in Figure 5 a conductor 37 extends from the instrument and downwardly through the member; this conductor is then directed upwardly along the exterior of the member and is connected to the exterior of the plug at 38 to make electrical connection therewith. A variable condenser 39 is connected in the conductor and permits tuning of the coupling circuit formed by said conductor as will be hereinafter more fully explained. It is preferable that the conical head 35 of the member 36 be constructed of a resilient or elastic material whereby when said head is forced against the seat 34 said head is moved into tight engagement with the conductor to seal off around said conductor and thereby prevent fluids which might be present in the well bore from entering the interior of the barrel. It is noted that the mem-

ber 36 is subject to variation and the exterior thereof is preferably spaced from the walls of the recess 18 of the whipstock when the barrel is mounted within said recess (Figure 1) whereby the conductor 37 is not in direct engagement with the metallic whipstock.

It is pointed out that the coupling circuit which is illustrated and described herein may be varied in physical structure without departing from the invention.

As will be explained, the instrument within the barrel 19 is adapted to generate electrical radio waves to indicate the attainment of a predetermined position by the whipstock and said waves are transmitted over the conductor 37 and are propagated along the barrel 19. Since this barrel is metallic and directly engages the whipstock said waves are guided upwardly along the whipstock and then upwardly along the drill pipe 10 to the surface. Thus the drill pipe becomes the guiding medium for said waves whereby the arrival of such waves at the surface is assured. The reception of the transmitted radio waves at the surface is accomplished by a common super-regenerative receiver 40. This receiver includes a receiving antenna 41 and head phones 42 and will be described more in detail in connection with the wiring diagram thereof shown in Figure 16. The use of head phones is not essential and any other means of indicating the reception of the transmitted radio frequency waves may be employed. Upon receiving the transmitted waves at the surface the operator is advised that the whipstock face 14 has attained a predetermined or known position, that is, said face is directed in a known compass direction. Obviously, by arranging the instrument I so that the radio waves are transmitted when the whipstock face is properly located, the reception of such waves indicates that the whipstock is in proper position for the subsequent drilling operation. It is then only necessary to shear the pin 17 and move the drill pipe and bit downwardly with respect to the whipstock after which rotation is imparted to the drill pipe to perform the drilling operation. The arrangement provides an instantaneous indication and the instrument need not be removed before drilling can be continued; the instrument remains attached to the whipstock until the drilling operation is complete and is subsequently removed from the well bore when the whipstock is recovered upon lifting of the drill pipe.

The instrument I which is mounted within the barrel 19 is illustrated in detail in Figure 7 to 14. It might be pointed out that the particular construction of this instrument is subject to variation so far as specific structural features are concerned and therefore several modifications of the basic principle of the instrument are possible without departing from the spirit of the invention. As illustrated, the instrument includes an outer casing or housing which is constructed of four separate sections 51, 52, 53 and 54. The uppermost section 51 is a tubular battery section and houses a "B" battery 55 and an "A" battery 55A, said batteries being separated by an insulated partition 56. A cap 57 closes the upper end of the battery section and a coil spring 58 which is confined between said cap and the battery 55 urges said battery against the partition 56. The lower end of the battery section 51 is connected to the section 52 therebelow by a coupling 59. A suitable spring 60 is interposed between the coupling and the lower end of the battery 55A and holds said battery in position within its section.

The second section 52 of the instrument has a timing mechanism or watch 61 mounted therein and this mechanism may be of the usual type which is ordinarily used in well survey instruments. Such timing mechanism includes an electrical switch which is closed after a predetermined lapse of time following setting of the mechanism. The timing mechanism is electrically connected with the "A" battery and upon actuation closes the electrical circuit to the transmitter of the instrument, as will be explained. A window or opening 62 is formed in the section 52 to permit access to the timing mechanism for setting and viewing said mechanism.

The lower end of the section 52 is threaded onto the upper end of the next section 53 of the instrument, this latter section comprising an orienting switch unit. The unit is clearly illustrated in Figures 10 to 14 and as shown, the section 52 has a bore 63 which has its upper end closed by an integral top plate 64. An orienting block 65 is rotatably mounted within the bore 63 and is constructed of electrical insulating material. The upper marginal edge portion of said block is bevelled at 66 and this bevelled portion abuts an internal inclined shoulder 67 formed within the upper end of the bore 63 of the section 52, the block being held in position within said section by a retaining ring 68 which is threaded into the lower end of the section.

An annular groove or recess 69 is provided within the block and is adapted to receive a metallic ball 70 which is responsive to gravity as the instrument is inclined. The ball is arranged to close an electrical circuit between an arcuate contact 71 which is embedded in one vertical wall of the recess 69 and a second contact 72 which is embedded in the bottom of said recess; unless the ball is engaging both contacts the electrical circuit between said contacts is open. The contact 71 is connected through a wire 73 with a contact ring 74 secured to the upper surface of the block. The top 64 of the block has an annular recess 75 within which the contact ring is disposed and a contact brush 76 is also mounted within this recess and constantly engages the contact ring. A lead wire 77 is connected to the brush and extends upwardly through the instrument to one side of the "B" battery 55.

The lower contact 72 of the orienting switch unit has electrical connection with a lower contact ring 78 secured to the underside of the block 65 and a contact brush 79 rides upon this ring. The contact brush is secured to the wall of the lowermost section 54 of the instrument and a wire 80 connects said brush with the transmitter mechanism housed within the lowermost section. It is apparent that because of the brush and contact ring connections, the block 65 may be rotated to various positions within the section 53 without interrupting the electrical connection.

The section 53 within which the orienting switch unit is mounted has the orienting key or lug 28 secured thereto and as previously explained, it is this key or lug which orients the instrument I within the barrel 19 and thereby orients said instrument with respect to the whipstock face. Since the angular position of the key 28 with relation to the whipstock face 14 is known, it is only necessary to know the position of the contacts 71 and 72 with respect to said key in order to ascertain the relative angular positions of the whipstock face and said contacts. In order to adjust these contacts accurately with respect to

the key 28, the section 53 is provided with an arrow or marker 81 (Figure 8) above said key. An opening or window 82 is cut in the section 53 so that a portion of the exterior of the block 65 is visible therethrough. The exterior of the block has an indicating dial 83 thereon and this dial is marked off in degrees. The "0" indication on the dial is radially aligned with the contacts 71 and 72 (Figure 10) and thereby indicates the position of said contacts within the block. The dial reads from "0" to "180" to the right and left of the "0" (Figure 12) and thus by adjusting the block to locate said dial in a desired position with reference to the indication 81 and key 28 the exact angular relationship between the contacts and the key 28 is indicated. To facilitate rotation of the block 65, the upper portion may be knurled as shown at 84 and a portion of this knurling is exposed through the window to permit manual manipulation of the block. A set screw 85 (Figure 11) is threaded through the wall of the section 52 and engages the exterior of the block to frictionally hold the same in its adjusted position.

Prior to lowering of the instrument I, the orienting switch block is adjusted with respect to the key and for the purposes of this description it will be assumed that the "0" indication is aligned with the marker 81 and key 28. Thus when the instrument is inserted within the barrel, the contacts 71 and 72 are aligned with the key way and upon attachment of the barrel to the whipstock said contacts are 180 degrees opposite the whipstock face. Since the ball 70 will always seek the low side of the well bore, it is obvious that said ball can engage the contacts 71 and 72 only when said contacts are at the low side of the well bore. Therefore, since the direction of inclination of the well bore is known, the compass direction of the low side of said bore is known with the result that the closing of the circuit between contacts 71 and 72 by the ball 70 is indicative of the compass position of said contacts. Assuming that the whipstock face is 180 degrees opposite the contacts, then it follows that the closing of the circuit between said contacts indicates the azimuthal or compass position of the whipstock face.

The engagement of the contacts 71 and 72 by the gravity responsive ball 70 closes an electrical circuit to a radio frequency wave transmitter T which is mounted within the lowermost section 54 of the instrument. This transmitter is connected to the conductor 37 of the coupling circuit and when actuated propagates radio frequency waves which are guided along the whipstock and drill pipe 10 to the surface of the well. These waves, as has been stated, are received by the receiver 40 at the surface of the well, such reception indicating that the ball 70 has engaged the contacts 71 and 72 and that said contacts are adjacent the low side of the well bore. Since the angular relationship between the contacts and the whipstock face 14 is known, the reception of the radio waves by the receiver 40 indicates the exact compass position of said whipstock face.

The transmitter T may within certain limits be varied in design and a suitable arrangement is illustrated in Figure 15 wherein a complete wiring diagram of the instrument is shown. The "B" battery 55 has its positive pole connected through the wire 77 with the orienting switch unit which includes the gravity responsive ball 70 and contacts 71 and 72. The negative side of

the battery is grounded. The positive side of the "A" battery 55A is connected by wire 86 with the timing mechanism 61 and the switch of said mechanism controls flow through said mechanism. The negative side of said "A" battery is also grounded. The orienting switch unit has connection through the conductor 80 with the transmitter, while the timing mechanism also has connection with said transmitter through a wire 88. Thus it is apparent that both the switch of the timing mechanism 61 and the orienting switch formed by the ball 70 and contacts 71 and 72 must be closed before the transmitter T can be operated. If one or the other of these switches is not closed, operation of the transmitter is impossible. The timing switch is arranged to close in accordance with a predetermined setting of the timing mechanism while the orienting switch closes when the contacts 71 and 72 are disposed adjacent the low side of the well bore and are engaged by the ball. In actual operation, the timing mechanism is set in accordance with the time required to lower the whipstock in position and the switch closes automatically after such predetermined lapse of time. The drill pipe is then rotated to rotate the whipstock and instrument I which is attached thereto; the ball seeking the low side of the well bore will remain substantially stationary and as soon as the contacts 71 and 72 move into alignment with the ball the transmitter is actuated.

The transmitter includes an audio oscillator tube 90 which comprises a filament or cathode 91, a control grid 92, screen grid 93, suppressor grid 94 and a plate 95. The filament 91 has the wire 88 extending from the timing mechanism and "A" battery connected thereto, whereby as soon as the timing switch closes, said filament is heated. The "A" battery is also utilized to heat the filaments or cathodes 96 of a modulated radio frequency oscillator tube 97, the electrical connection being made through a conductor 95a which extends from the wire 88 to said filaments. This latter tube includes grids 98 and plates 99. A transformer 100 has its primary winding 100a connected through wire 101 with the wire 80 extending from the orienting switch unit whereby a current flow occurs when the orienting switch is closed. The primary is connected by wire 102 with the plate 95 of the audio oscillator tube 90. The secondary 100b of the transformer has connection through wire 103 with the control grid 92 of the audio oscillator tube and a bias resistor 104 is connected in the transformer secondary circuit. The secondary 100b of said transformer is also electrically connected with the grids 98 of the radio frequency oscillator tube 97 by leads 105 and 106. Suitable R. F. chokes 107 are interposed in these leads. Conductors 108 and 109 extend from the leads 105 and 106 respectively and have connection with a tank coil or winding 110. This coil is energized through a conductor 110a which extends from the wire 80 leading from the orienting switch unit and "B" battery and an R. F. choke 110b is interposed in this conductor. Condensers 108a and 109a are connected to grids 98 through wires 108 and 109, and feed back energy to the tube 97 in such manner as to sustain oscillation in the usual manner. The coil 110 has its terminals connected by wires 111 and 112 with the plates 99 of the R. F. tube 97, and a variable condenser 112a is connected between the wire 111 and 112, whereby the tube oscillates at the resonant tuned frequency of the

coil 110 and condenser 112a. The usual bypass condensers 113 are associated with the filaments and grids of the tube 97.

With the particular arrangement above described, the timing switch 61 is first closed to direct current to the filament or cathode 91 of the audio tube 90 and also to the filaments or cathodes 96 of the R. F. tube 97. At such time the transmitter is inactive so far as radio frequency wave transmission is concerned and it is only when the orienting switch formed by ball 70 and contacts 71 and 72 is closed that radio waves are generated. Upon closing of the orienting switch, a current flow from the "B" battery to the primary 100a of the transformer 100 and thence to the plate 95 of the audio tube 90 occurs; simultaneously the coil 110 and plates 99 of the R. F. tube 97 are energized through the wire 80 and conductor 110a. The primary 100a of the transformer induces a voltage in the secondary 100b and this induced voltage affects the control grid 92 of the tube 90 and at the same time affects the grids 98 of the R. F. tube. Actually, the transformer is a tuned circuit for controlling the audio tube oscillation and for modulating the grids of the R. F. oscillator tube 97. The voltage applied to the transformer primary varies in accordance with the oscillations of the audio tube and therefore the voltage applied to the secondary 100b of said transformer increases and decreases the total bias voltage, thus varying the output of the R. F. oscillator tube at the rate at which the voltage is varied across the secondary of said transformer.

From the foregoing it will be seen that when the orienting switch is closed the transmitter is set into operation and the R. F. tube oscillates at the resonant tuned frequency of the coil 110 and condenser 112a. The power output of the coil 110 is transmitted to the conductor 37 of the coupling circuit which is mounted on the lower end of the barrel 19 of the instrument I, such transmission being effected by a coupling coil or link 114 located in the lower portion of the transmitter unit T. The radio frequency waves propagate and are guided along the whipstock and drill pipe 10 to the surface where said waves are received by the receiving unit 40.

It is pointed out that the coupling circuit formed by the conductor 37 which connects the transmitter T to the metallic barrel 19 and drill pipe 10 is an important feature of the invention. This conductor is of sufficient length to provide a circuit which is tuned to the resonant frequency of the transmitter output. The variable condenser 39 which is connected in the conductor is merely for the purpose of properly tuning the circuit without the necessity of extending the length of conductor; in other words, when the condenser 39 is used the conductor may be shortened whereas omission of said condenser would require a longer conductor 37. In both instances, however, the requirement for efficient operation is that the coupling circuit be tuned to the resonant frequency of the transmitter output. Actual practice has proven that with this type of coupling the absorption of the radio frequency electric current energy by the surrounding earth is defeated and the propagated waves are guided along the metallic drill pipe to the surface. Since the waves might be said to be attached to the drill pipe, it is apparent that the depth of the well bore has no material effect on the operation of the mechanism since said waves will be guided by said pipe throughout its entire length, there-

by making the apparatus practical in wells of any depth.

The receiving unit 40 is a common superregenerative receiver and is shown in the wiring diagram of Figure 16. The receiver includes a radio frequency oscillator tube 115 which has its plate circuit coupled to the primary of a transformer 116 and audio current variations across the transformer induce a voltage in the secondary of said transformer, which voltage is amplified by tube 116a and conducted to the head phones 42. The tube 115 oscillates at the frequency of the received signal at an interrupted rate which is ordinarily above the audio range. When the signal is received by the antenna 41, it is applied to the grid of the tube and affects the amplitude of the oscillator. The variation of the transmitter results in a corresponding variation in the power output of the tube 115. Thus, the received signal is audible through the head phones 42 to indicate that the whipstock face has reached a predetermined compass position.

The transmitter which has been described and which is illustrated in Figure 15 is a grid modulated transmitter and a modified form which is plate modulated is illustrated in Figure 17. In this arrangement, the tubes 90 and 97 as well as the transformer 100 are employed. However, instead of the secondary of the transformer being connected to the grids 98 of the tube 97, said secondary is directly connected with the "B" battery supply and then to the plate circuit of the tube 97. In this instance the transmitter is plate modulated but will function to transmit radio frequency waves in the same manner as the transmitter T hereinbefore described. It is evident that various transmitter hook-ups could be employed and for this reason, the invention is not to be limited to the particular structures illustrated.

When the apparatus is to be used, a preliminary survey of the well bore is first made by any of the well known survey instruments to determine the direction in which the well bore inclines at the elevation at which the whipstock B is to be set. For purposes of this description, it will be assumed that the bore A is inclining "north" adjacent the plug C in said bore and also that it is desired to drill in the "north" direction; this means that the whipstock face 14 must be oriented so that said face is directed "north." With the bore inclining toward "north" it is obvious that the low side of the well bore will be 180 degrees opposite "north," or "south." It might be noted that in most instances, previous well surveys have made this information available so that said survey just prior to use of the present apparatus may not be necessary.

The timing mechanism 61 of the instrument I is first set so that sufficient time may elapse to allow lowering of the whipstock before the switch is closed. The orienting block 65 is adjusted with respect to the key 28 on the instrument housing or casing so as to dispose the contacts 71 and 72 in the desired angular relation thereto. Because the key 28 is always 180 degrees opposite the whipstock face, due to the mounting of the barrel 19 in a predetermined position, the angular relationship between the contacts 71 and 72 and whipstock face must be adjusted in accordance with the direction in which drilling is to proceed. It is known that the circuit between the contacts 71 and 72 will be closed by the gravity responsive ball 70 when said contacts move adjacent the low side of the well bore, which as assumed herein is "south" direction. Drilling is to

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proceed in a "north" direction so in the assumed instance, the contacts 71 and 72 must be 180 degrees opposite the whipstock face; the block 65 is therefore adjusted to locate the "0" indication (which indicates the location of the contacts) in alignment with the marker 81. Of course if the whipstock face 14 was to be directed due east or due west, the block would be rotated in one direction or the other 90 degrees from south to locate one of the "90" indications on the dial in alignment with the marker 82 and key 28. It is obvious that any desired adjustment of the block to vary the angular relationship between the contacts 71 and 72 and the whipstock face 14 is possible.

After the timing mechanism and orienting switch unit are adjusted, the instrument I is inserted within the barrel 19 and said barrel is mounted and attached within the recess 18 of the whipstock. The instrument is oriented in the barrel by the key 28 and groove 27 while the barrel is oriented with respect to the whipstock face by the orienting opening 21 and bolt 20. Thus when the instrument is mounted in the whipstock, the contacts 71 and 72 bear a known fixed angular relationship to the whipstock face 14. The whipstock is then lowered through the well bore A to the elevation at which it is to be set. The timing mechanism is so adjusted that the timing switch 61 is closed at approximately the time the whipstock has reached the desired position so that current from the "A" battery is flowing to the filaments of the tubes 90 and 91.

As the whipstock reaches position and its lowering is halted, the gravity responsive ball 70 seeks the low side of the well bore and since such low side has been presumed to be in a "south" direction the ball will roll to such position within the annular groove 69 of the orienting block and will remain there. If by coincidence the contacts 71 and 72 are also disposed in a "south" direction the ball engages the contacts to close the circuit therebetween and actuate the transmitter. However, in almost every instance the contacts 71 and 72 will be misaligned with the ball resting in a position adjacent the low side of the well bore and a rotation must then be imparted to the drill pipe 10.

As the pipe rotates, a rotation is imparted to the whipstock and to the instrument mounted therein whereby the contacts 71 and 72 are moved circumferentially within the bore A. As the contacts move adjacent the low side of the well bore or in a "south" direction, said contacts are engaged by the ball 70 which closes the circuit therebetween. As soon as this occurs, the transmitter T is actuated to generate and transmit radio frequency waves. As explained these waves are conducted to the exterior of the barrel 19 through the coupling circuit 37 and are propagated upwardly along the whipstock and drill pipe. The coupling circuit prevents absorption of the radio frequency electrical current energy by the surrounding earth and the waves attach to and are guided by the metallic drill pipe to the surface. The radio signal transmitted by the transmitter unit T is received at the surface by the receiver 40 and as soon as said signal is received, it is known that the whipstock face 14 is facing in the desired compass direction. Obviously, in the assumed case the signal is transmitted when the contacts 71 and 72 are located adjacent the low side of the bore, which is south

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and since by prior adjustment said contacts were disposed 180 degrees opposite the whipstock face 14, said face is directed "north" when the signal is transmitted. Upon reception of the signal, the pin 17 connecting the drill pipe and whipstock may be sheared and the drilling operation immediately begun. The timing mechanism may be constructed so as to again open the switch 61 after a sufficient time to obtain orientation of the whipstock has elapsed whereby the transmitter unit is automatically shut off after orientation is complete.

The device as hereinbefore described for whipstock orientation includes the orienting switch unit which depends upon the gravity responsive ball 70 whereby the position of the whipstock face is determined by correlation with the low side of the well bore. In this apparatus it is necessary that a preliminary survey of the well bore be made so that the direction of inclination of the well bore is known. Thus the apparatus utilizes what might be termed an indirect method of orientation.

Under certain conditions it might be desirable to obtain a direct method by means of a direct compass reading and in such instance the unit illustrated in Figures 19 and 20 will be substituted for the orienting switch arrangement shown in Figure 11. The compass unit includes a tubular section 120 which is arranged to be substituted for the section 53 of the instrument I. The section 120 has a bore 121 which has its upper end closed by an integral top 122 with its lower end closed by a plate 123, the space between the top and the plate forming a compass chamber 124. A compass 125 is mounted on a compass pin 126 and said compass is formed with an opening 127 which is indicative of a compass direction which in this case will be presumed to be "north." Thus, the opening 127 is always in a position directed toward "north." Transparent plates 128 are mounted within the chamber 124 and provide a chamber in which a dampening fluid for the compass may be contained. A lamp 129 is mounted in the top 122 of the section and is in vertical alignment with a photo-electric cell 130 secured to the bottom plate 123. The lamp and photo-electric cell are in radial alignment with an orienting key 28a similar to the key 28 on the section 52, whereby said lamp and cell are located in a predetermined known angular relationship to the whipstock face. It is evident that when the opening 127 is aligned with the lamp and photo-electric cell, the light rays from the lamp are directed onto the cell 130. Reception of the light rays will actuate a relay 131 which closes a relay switch 132. The relay switch 132 is comparable to the orienting switch formed by the ball 70 and contacts 71 and 72 whereby the transmitter T is actuated whenever the compass opening 127 is in alignment with the photo-electric cell.

In this structure the whipstock and instrument will be constructed of a non-magnetic material so that the free operation of the compass 125 is not affected. The apparatus is lowered in the well bore and the angular relationship of the photo-electric cell 130 to the whipstock face is known. The compass will, of course, maintain the opening 127 directed toward "north." The drill pipe and whipstock will then be rotated to impart a rotation to the instrument so that the photo-electric cell 130 is moved circumferentially within the well bore and beneath the compass which is, of course, held stationary. The lamp

129 is illuminated by the timing switch and when the photo-electric cell moves beneath the opening 127, said cell receives light rays to actuate or close the relay switch 122. At such time the transmitter is actuated to send a radio frequency signal to the surface. The reception of this signal will indicate that the photo-electric cell is in the "north" direction and since the operator knows the angular relationship between said cell and the whipstock face the direction of said face is known. This particular arrangement which includes a compass might be termed a direct method as compared to the indirect method which utilizes the low side of the well bore as the point from which the position of the whipstock face is determined.

Although the invention is particularly useful in the orientation of whipstocks or other deflecting tools, the principles of said invention may be applied to other types of well survey instruments and in Figure 21 the invention is shown as employed with a drift indicator or inclination instrument 133. The instrument includes the transmitter T and control of the audio oscillator frequency is effected by means of a plumb bob 134 which is movable over a carbon plate 135. The plumb bob forms a contact arm and obviously as it moves over the plate to various positions due to different degrees of inclination, the resistance in the circuit to the frequency of the audio oscillator is changed whereby the transmitter is modulated at different frequencies in accordance with the position of the plumb bob. A receiving unit 136 is located at the surface and includes a frequency meter 137. The radio frequency signal is received by the unit 136 and demodulated and the audio component is conducted to the frequency meter for the frequency determination. The dial 138 of the frequency meter may be computed in degrees whereby the various frequencies are representative of different degrees of inclination of the well bore. The instrument 133 may be lowered on a metallic cable or wire line and the propagated radio waves are guided to the surface along said conductor; in this arrangement the cable or wire line functions as the guide medium in place of the drill pipe when the apparatus is used in whipstock or deflecting tool orientation.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What we claim and desire to secure by Letters Patent is:

1. An apparatus for transmitting intelligence to the surface from within a well bore including a metallic conductor, an indicating mechanism having a metallic housing connected to the metallic conductor extending through the well bore, a transmitter within the lower portion of the housing for transmitting radio frequency waves, means for electrically connecting the indicating mechanism with the transmitter whereby the radio waves generated by the transmitter are representative of the indication of the indicating mechanism, and means for electrically connecting the transmitter to the metallic conductor by a coupling circuit to reduce earth absorption losses, said circuit including a longitudinal supporting member of electrical insulating material secured to the lower portion of the housing and projecting longitudinally therefrom,

an electrical conductor extending longitudinally through the center of said supporting member and having one end electrically connected to the transmitter with its opposite end extending outwardly from the support and then extending parallel to the exterior thereof, the outer extremity of said conductor being electrically connected to the exterior of the metallic housing within which the transmitter is mounted.

2. An apparatus as set forth in claim 1, together with a radio wave receiver at the surface for receiving the transmitted waves.

3. An apparatus as set forth in claim 1, wherein the coupling circuit is tuned to the resonant frequency of the transmitter output.

4. An apparatus adapted to be lowered into a well bore for signalling to the surface the attainment of a predetermined compass position of an element within said well bore including a metallic conductor extending through said bore, an electrical switch unit including a metallic housing attached to said conductor and having fixed circuit closing contacts which are normally in electrical disengagement and which are movable circumferentially within said bore when the conductor is rotated, said switch unit also having a gravity responsive movable contact member adapted to engage the fixed contacts to close the circuit therebetween when said contacts move into alignment with said gravity responsive contact member, whereby said circuit is closed when the fixed contacts assume a predetermined known compass position, a radio frequency transmitter mounted within the metallic housing electrically connected to said switch unit and actuated when the contacts of said switch are in circuit closing position to transmit radio waves of a fixed frequency, whereby said transmitter is operated only when the fixed contacts of the switch unit are in a known predetermined compass position, and means for coupling the transmitter to the metallic conductor to impress the radio frequency waves on said conductor so that said waves are guided by the conductor and transmitted to the surface thereby and also whereby absorption of the radio frequency electrical energy by the surrounding earth is reduced, said coupling means comprising a longitudinal supporting member of electrical insulating material secured to the lower portion of the metallic housing, an electrical conductor extending longitudinally through the support and having one end electrically connected to the transmitter with its opposite end extending outwardly along the exterior surface of the member and with the extremity thereof electrically connected to the metallic housing within which the transmitter is mounted.

5. An apparatus as set forth in claim 4, together with a radio wave receiving unit at the surface of the well bore and spaced from the metallic conductor for receiving the transmitted waves and transposing the same into an audible signal.

6. An apparatus as set forth in claim 4, together with a timing mechanism having an electrical circuit-closing means connected in the transmitter circuit, whereby said transmitter cannot operate until the timing mechanism circuit-closing means is actuated, and means for adjusting the operation of the timing mechanism to control the time of actuation of the transmitter.

7. An apparatus as set forth in claim 4, wherein the means for coupling the transmitter to the conductor is tuned to the frequency of the output of said transmitter.

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8. An apparatus adapted to be lowered into a well bore for generating and transmitting a signal to the surface including, a rotatable metallic conductor extending through said bore, an electrical switch unit having a metallic housing attached to said conductor and having circuit closing means for closing an electrical circuit when the unit is moved into a predetermined known compass position by rotating the metallic conductor, a radio frequency transmitter mounted within the housing and electrically connected to said switch unit and actuated when the switch is in circuit closing position to transmit radio waves of a fixed frequency, whereby the transmitter is operated only when the switch unit is in a predetermined compass position, and means for coupling the transmitter to the metallic conductor to impress the radio frequency waves on said conductor so that said waves are guided by the conductor and are transmitted to the surface by said conductor, said coupling means reducing absorption of the radio frequency electrical energy by the surrounding earth. and comprising a longitudinal supporting member of electrical insulating material secured to the lower portion of the metallic housing, an electrical conductor extending longitudinally through the support and having one end electrically connected to the transmitter with its opposite end extending outwardly along the exterior surface of the member and with the extremity thereof electrically connected to the metallic housing within which the transmitter is mounted.

9. An apparatus as set forth in claim 8, wherein the means for coupling the transmitter to the conductor is turned to the frequency of the output of said transmitter.

10. An apparatus as set forth in claim 8, together with a timing mechanism having an electrical circuit-closing means connected in the transmitter circuit, whereby said transmitter cannot operate until the timing mechanism circuit-closing means is actuated, means for adjusting the operation of the timing mechanism to control the time of actuation of the transmitter, and a radio wave receiving unit at the surface of the well bore and spaced from the metallic conductor for receiving the transmitted

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waves and transposing the same into an audible signal.

11. As a sub-combination in a transmitting apparatus having a housing, a coupling circuit including, a longitudinal supporting member of electrical insulating material fastened to one end of the housing and projecting longitudinally therefrom, an electrical conductor extending longitudinally through the center of said supporting member and having one end electrically connected to the transmitter within the transmitter housing, the opposite end of said conductor extending outwardly from the support and then extending parallel to the exterior thereof, with its extremity electrically connected to the exterior of the transmitter housing.

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REFERENCES CITED

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

999,012	Danziger	July 25, 1911
1,626,567	Steinbrecht	Apr. 26, 1927
1,633,775	Esau	June 28, 1927
1,926,327	Burrell et al.	Sept. 12, 1933
1,999,215	Smith	Apr. 30, 1935
2,012,138	Palmer	Aug. 28, 1935
2,018,080	Martienssen	Oct. 22, 1935
2,064,894	Espenschied	Dec. 22, 1936
2,129,711	Southworth	Sept. 13, 1938
2,139,460	Potapenko	Dec. 6, 1938
2,165,062	MacKay	July 4, 1939
2,167,201	Dallenbach	July 25, 1939
2,184,931	Straatman	Dec. 26, 1939
2,208,147	Eisler	July 16, 1940
2,225,668	Subkow	Dec. 24, 1940
2,268,256	Knouse	Dec. 30, 1941
2,271,951	Person et al.	Feb. 3, 1942
2,282,431	Smith	May 12, 1942
2,340,861	Breukelman	Feb. 8, 1944
2,344,014	Allison, Jr.	Mar. 14, 1944
2,354,887	Silverman et al.	Aug. 1, 1944

FOREIGN PATENTS

Number	Country	Date
412,962	France	July 28, 1910