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[54] **SIGNAL RESPONSIVE DISPLAY APPARATUS**

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[73] Assignee: **Sperry-Sun Well Surveying Company,** Sugar Land, Tex.

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[52] **U.S. Cl.** **73/151,** 33/313, 340/282
[51] **Int. Cl.** **E21b 47/024**
[58] **Field of Search** ..... 73/151; 33/205 R, 33/205 E, 312, 313; 340/318, 206, 282

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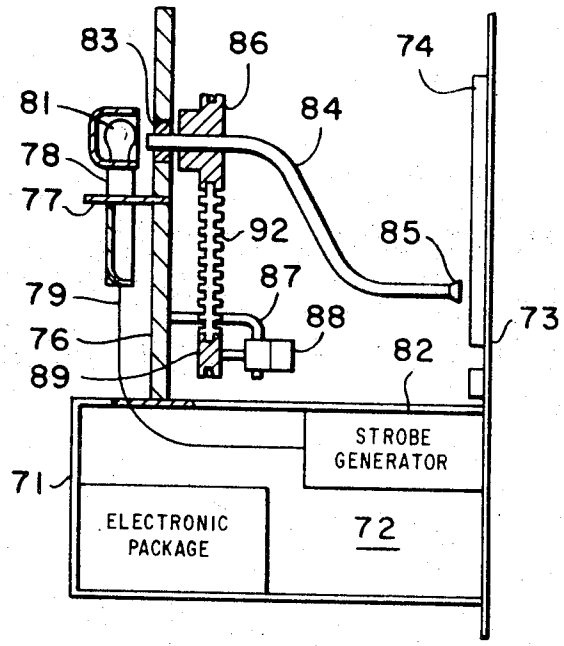
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[57] **ABSTRACT**

A light transmitting rod for carrying a flash of light from a flash source to a point adjacent a translucent scale onto which the flash is projected. The rod is rotated relative to the scale. One or more flashes may be generated during one revolution of the rod relative to the scale with such flashes representing the time relation between electrical signals which in turn may represent the boundaries or limits of a measured parameter.

14 Claims, 3 Drawing Figures



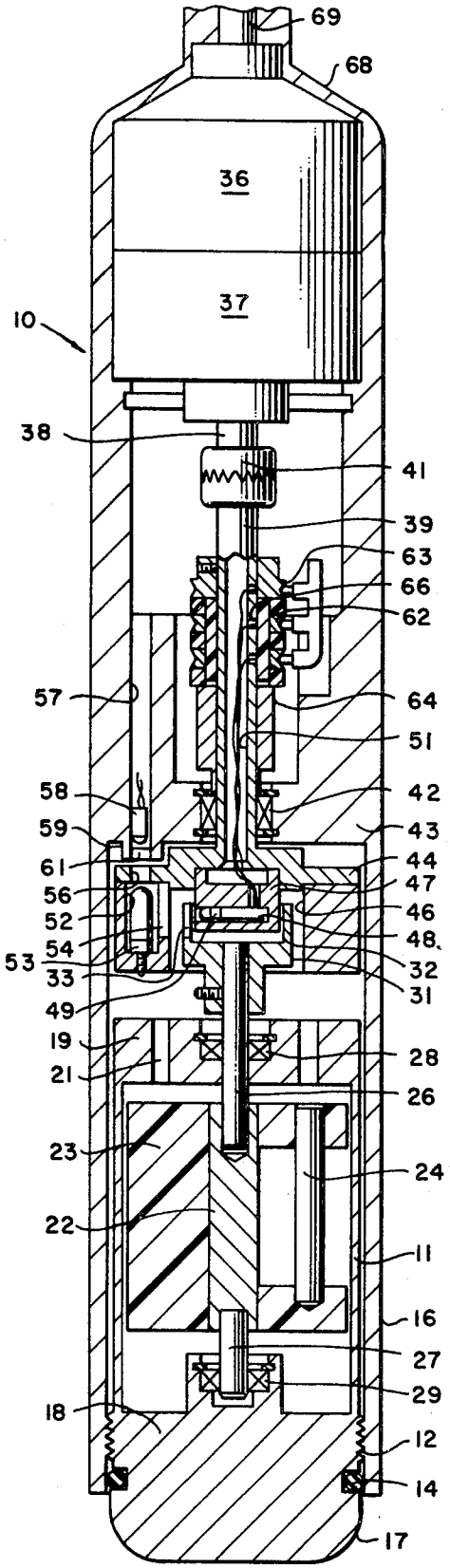


FIG. 1

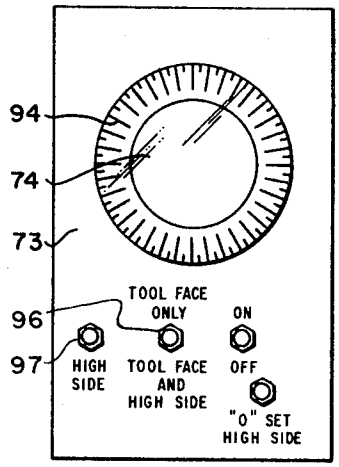


FIG. 2

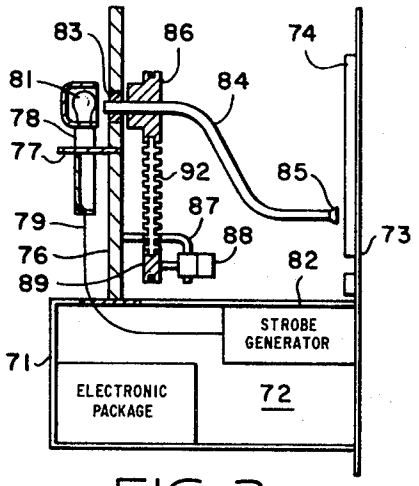


FIG. 3

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SIGNAL RESPONSIVE DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

The present invention pertains to a display apparatus and more particularly an apparatus providing a visual display in response to electrical signals defining a parameter.

The display apparatus is disclosed herein for use with a borehole instrument. When making boreholes into the earth's surface, it is often desirable for various reasons to deviate the holes from a vertical course through earth formations. The term "directional drilling" is applied to such operations. One example of the use of such directional drilling operations is found in the drilling of oil wells from offshore platforms. It is a common practice to build a large drilling platform which is permanently secured to the ocean floor and from which a multiplicity of wells are drilled, sometimes over 40 in number. Because of the number of wells which are drilled from a single platform, it is necessary to drill the holes laterally away from the platform so that the earth formations containing petroleum reservoirs may be penetrated at distances laterally spaced from the platform. This procedure permits production from as great an area as possible from a single platform. The economics of such a system can readily be appreciated. It is also easily understood how important the maintenance of direction and dip of such boreholes is in order to penetrate particular formations at particular depths and thereby intersect the desired petroleum reservoirs.

A present technique for obtaining such information as to the direction of a borehole is to cease drilling and run a surveying instrument into the drill pipe on a wireline. Alternatively, the instrument may be go-deviled to the bottom of the drill pipe. The instrument is oriented with respect to the drill stem by means of a "muleshoe" located in the lower end of the drill stem. The "muleshoe" is simply a device for capturing the tool at the lower end of the drill stem and orienting the tool in a particular radial direction with respect to a determined point on the drill stem. For example, the drill stem normally used in such a directional drilling operation has what is termed a "bent sub" at its lower end which angles the lower end of the stem and thereby permits angular deviation of the drill bit. The muleshoe is normally oriented with respect to the bent sub. This in turn orients the instrument which is being positioned in the lower end of the drill stem. This series of orientation techniques provides a correlation between the direction in which the drill bit is angled and the orientation tool. After the orientation tool is operated, generally by means of a timing mechanism, the tool is retrieved to the surface. Both of these operations are time consuming and costly, and in particular, in offshore operations where the cost of drilling is many fold that of land operations, the economies of decreasing the non-drilling time is readily appreciated. A recent development which is the subject of applicants' co-pending application Ser. No. 86,877 entitled METHOD AND APPARATUS FOR ORIENTING A BOREHOLE DEVICE provides a means for obtaining downhole data indicative of bit orientation and transmitting such data to the surface over a single conductor cable during the drilling operation. In other systems where borehole data is transmitted to the surface, the surface read-out equipment normally includes recorders or printers for recording the data for later use. Sometimes the data is

printed on charts or strips of paper in analog form for subsequent interpretation or for use in calculating unknown parameters.

It is an object of the present invention to provide a new and improved apparatus for presenting a visual display in response to electrical signals indicating parameter limits.

SUMMARY OF THE INVENTION

With this and other objects in view, the present invention contemplates an apparatus for providing a visual display of signals representing the measured limits of a parameter. The apparatus includes a light source and light transmitting means for transmitting light from the source to a scale. The scale has indicia indicative of values of the measured parameter. Means are provided for moving the light transmitter over the scale in timed relation with a remotely located detecting device. The detecting device transmits electrical signals to the display apparatus which signals are indicative of the parameter limits.

A complete understanding of this invention may be had by reference to the following detailed description, when considered in conjunction with the accompanying drawings, illustrating embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view showing details of a portion of the borehole orientation instrument;

FIG. 2 is a front view depicting the face of the display apparatus for providing visual indications at the surface of parameters measured by the borehole instrument; and

FIG. 3 is a side view of such surface indicating apparatus showing the mechanism for providing such indications.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Equipment utilized in well drilling operations is well known, and is not shown in this application, since it forms no part of the invention. Such equipment is shown however in the co-pending application referred to above. The portion of a drilling apparatus which is positioned above the floor of the drilling platform includes a drill head depending from a swivel, which in turn is connected with a mud line. A bail depending from a derrick holds the upper end of the swivel in place above the platform. A goose neck connects the swivel with the mud line, which in turn is connected with a mud pump system for supplying drilling mud to the drill string which depends from the drill head. The swivel is furnished with a wireline opening boss in its upper side which enables a line wiper to be received in the upper end of the swivel. Such line wipers may be purchased from oil well drilling apparatus suppliers, and are constructed to seal off well pressure at the well head during line operations through the drill pipe. Typically such line wipers include a hydraulically actuated packing member in the interior of the wiper. The packing member is actuated by applying pressure into the apparatus by means of an external pressure line which in turn may be connected to a grease pump or the like for applying a hydraulic fluid under pressure to the interior of the line wiper. A block is positioned on the upper end of the line wiper and is arranged to swivel about the upper end of the wiper by means of bearings.

A sheave is positioned on the block for passing a conductor cable into and through the line wiper. The conductor cable is maintained on a motor driven drum which permits its play-out and take-up during the operations. The cable may be a single conductor cable having an armored covering and similar in construction to well logging cables.

A drill assembly for use in directional drilling operations may include a non-magnetic drill collar and muleshoe orienting sub. A bent sub is positioned in the drill string between the collar and a mud motor which in turn drives a rotating bit. An orienting tool is positioned within the orienting sub and is connected at its upper end with a conductor cable extending to the surface. As will be described, the orienting tool provides signals to the surface indicative of wellbore parameters. The orienting sub provides a means for establishing a predetermined orientation between the orienting tool and the bent sub which in turn is oriented with respect to the top side of the borehole.

The orienting tool houses a pendulum section, which will be described hereinafter in detail, which is used for determining the high side of the hole by means of gravity operated elements. A lamp and photocell scanning section is located in a portion of the tool adjacent the pendulum section, and provides an electrical indication of the tool's orientation for transmittal to the surface. An electronic section for coding electrical signals for transmittal to the surface is included in the tool string.

Referring to FIG. 1 of the drawings, the orientating tool **10** is shown having a pendulum section at its lower end including an outer cylindrical housing **11.** The housing **11** has a threaded end portion **12** to accommodate reception of the housing within the tool **10.** An O-ring seal **14** is received within a groove about the lower end of the housing **11** and forms a seal between the housing and the interior bore of the tool housing **16.** An end portion **17** extends downwardly from the housing and has a knurled outer surface to provide a convenient means for threading or screwing the pendulum section into the tool housing. A lower mounting block **18** is positioned within the lower end of the housing **11** and an upper mounting block **19** is positioned in the upper end of the same housing. Vertical holes **21** are provided through the block **19** to provide means for transmitting fluids between the upper end of the upper block **19** and the interior bore of the housing enclosed by the lower and upper blocks, **18, 19.** A pendulum assembly within the housing **11** includes a central core portion **22** made of a lightweight metal. A cylindrical body **23** is positioned about the central core **22.** The body **23** is made of a lightweight plastic material which has a low specific gravity permitting it to be buoyant in a fluid filling the housing. On one side of the core, the plastic material is cut away throughout a substantial portion of its length, and has a steel rod **24** positioned between spaced end portions of the plastic material. Upper and lower shaft members **26, 27** are press-fitted into the ends of the central core. The shafts **26, 27** each have ball bearings **28, 29** respectively fitted thereon. The lower ball bearing **29** is positioned in a recess in the lower block **18.** The upper bearing **28** is received within a bore formed in the upper block **19.** The upper shaft **26** extends upwardly through the block **19** and has a cup member **31** secured thereon by means of a set screw. The cup member has a thin peripheral wall **32** defining the outer perimeter of a hollow chamber within the cup. A slot **33** is formed in the wall of the cup and is parallel with the longitudinal axis of the shaft **26.** A scanning assembly is positioned within the housing **16** above the pendulum section to form a scanning section. The cup member **31** on the pendulum assembly is shown in its cooperative arrangement with the scanning section. The scanning section includes the outer housing **16,** having a synchronous motor **36** positioned in the housing near its upper end. The output of the motor is coupled to a speed reducer **37.** An output shaft **38** from the speed reducer is coupled to the upper end of a scanner shaft **39** by means of coupling **41.** The shaft **39** has a ball bearing **42** fitted about the shaft. The ball bearing is received within a block portion **43** positioned within the lower end of the housing **16.** The bearing **42** is held in the block by retaining rings above and below the bearing. A lamp and photodetector housing **44** is positioned on the lower end of the shaft **39** and has a annular recess **46** formed on the bottom of the central portion of the housing **44** for receiving the cup shaped member **31** extending upwardly from the pendulum assembly. A cylindrical block **47** formed in the center of the recess has a lateral opening **48** sized for receiving a light sensitive device **49** such as a photocell. Appropriate passages in the block communicate with a longitudinal bore **51** in the shaft **39.** The passages and bore provide a means for passage of conduction wires to electrical devices in the housing **44.** The housing **44** also has a cylindrical recess **52** extending upwardly from its lower surface near one peripheral edge thereof for receiving a light source **53** such as a lamp therein. A slot **54** is formed in the wall of the cylindrical recess **52** to provide a slotted opening between the lamp and the annular recess **46.** The slot is arranged so that it is opposite the lateral opening **48** in the block **47** which opening also communicates with the annular recess **46.** Another slot **56** is formed in the top of the cylindrical recess **52** which corresponds in a radial position on the housing **44** with the slot **54** in the inner wall of recess **52** so that the slot **56** is on the same radial spoke as the slot **54.**

A longitudinal opening **57** extends through the block portion **43** for receiving a second light sensitive device **58** such as a photocell at its lower end. The lower end of the opening **57** has a closure **59** with a slot **61** therein which is positioned radially to the central axis of the housing **44.** The light sensor **58** is positioned in the longitudinal opening **57** and will be hereinafter referred to as a case reference light sensor.

A series of collector rings **62** are positioned about the shaft **39** and are held thereon by means of upper and lower collars **63, 64,** positioned above and below the collector rings. The upper collar is held on the shaft by means of a set screw. The collector rings are insulated from the metal portions of the shaft. Slots **66** are formed in the wall of the hollow shaft **39** to permit passage of insulated wires from the collector rings to the photocell **49** and lamp **53** positioned in the housing **44** at the lower end of the shaft. Electrical power is supplied to the scanner assembly including the synchronous motor **36** by means of a connector **68** at the upper end of the housing which is attached to a single conductor armored cable **69.** The armored wires and cable are assembled to the connector in a well known manner for providing an electrical connection between such members, and also for permitting suspension of the tool housing from the armored portion of the cable.

In the case of the present system, the synchronous motor **36** positioned within the housing **16** operates at a speed of 12,000 rpm on a 400 cycle power signal. The speed reducer **37** is arranged to provide a reduction of 100 to 1 so that for every 100 turns of the motor shaft, the shaft **38** extending from the other end of the speed reducer **37** rotates 2 revolutions per second. Thus, the scan shaft **39** and photocell **49** and lamp **53** rotate at the same rate.

The interior bore of the housing **16** below the motor **36** is filled with a fluid which not only lubricates the moving parts therein such as bearings, but also provides a dampening effect as will be described hereinafter with respect to the pendulum assembly attached to the lower end of the housing. The openings **21** are formed in the upper block **19** of the pendulum assembly and permit the fluid in the housing **16** to communicate with the interior bore of the pendulum housing **11.** Preferably the fluid does not stand above the speed reducer so that the synchronous motor is not drowned by the fluid.

Referring next to FIGS. **2** and **3** of the drawings, surface equipment for providing a read-out of information from the pendulum and scan sections is shown. The read-out apparatus is comprised of a lower base portion **71** having a hollow interior **72** for receiving components of the system. A front panel **73** has a circular opening therein with a translucent plastic or glass face plate **74** placed over the circular opening. Indicia in the form of a radial scale is placed on the plate **74** by means of silk screening or the like. The scale is arcuate, and is marked off in radial degrees from 0 to 180 on both the right and left sides of the scale. Switches such as the toggle type switches shown in FIG. **2** are mounted on the front panel and provide means for operating the surface recording apparatus as will be described hereinafter. A back panel **76** extends upwardly from the base **71** of the surface recorder and has a first mounting bracket **77** thereon extending rearwardly from the panel **76.** Mounting bracket **77** has an opening therein for receiving a strobe light unit **78** including a strobe lamp **81.** Electrical wires **79** connect the strobe light unit with a strobe generator **82** mounted in the hollow base **72** of the apparatus. The strobe generator and light unit may be the same as those popularly used in photographic operations, and which are produced by several manufacturers. An opening is provided in the center of the back plate for receiving a bearing **83** such as a ball bearing, which in turn rotatably supports one end of a light conducting rod **84** extending through the opening. The rod **84** which may be constructed of lucite extends between the back and front panel members **76, 73** respectively and is curved along its length so that its unsupported end **85** adjacent the front panel **73** is in close proximity to the scale on the plate **74.** In other words, the circular path of the rod end **85** when rotated, is approximately coincidental with the arcuate scale on plate **74.** A geared pulley **86** is mounted on the rod **84** near its bearing supported end, with the pulley being locked on the rod by means of a set screw or the like for rotation therewith.

On the inside wall of the rear panel **76** towards its bottom edge is mounted an L-shaped bracket **87** for supporting a synchronous motor **88.** This synchronous motor **88** is operated by the same power supply which operates the downhole synchronous motor **36** described with respect to FIG. **1** of the drawings. Another geared pulley **89** is mounted on an output shaft driven by the synchronous motor **88.** The pulley **89** is aligned laterally with the geared pulley **86** on the lucite rod. A positive drive belt **92** extends around geared pulleys for rotating the lucite rod in response to the rotation of the synchronous motor shaft. The belt has cogs which cooperate with gear teeth on the pulleys to provide a positive no-slip movement of one pulley relative to the other. The bearing supported end of the lucite rod **84** is aligned with the center of the scale plate **74** shown in FIG. **2.** The other end **85** of the rod has an elongated flattened portion thereon aligned axially with line **94** denoting radial degrees on the outer edge of the scale.

In the downhole electrical system, signals are generated by the activation of photocells **49** and **58,** and these signals are transmitted to the surface by means of the conductor cable **69.** The signals may be transmitted to the surface over separate circuit paths or they may be superimposed on the power signal, thus permitting the borehole tool to operate on a single conductor cable. Such a single conductor system is disclosed in applicants' co-pending application referred to above. In any event, such signals are used to drive the strobe generator **82** at the surface. Switching means in the surface equipment permits each of the downhole signals to be displayed individually or simultaneously. For example, if the toggle switch **96** is moved to the "Tool Face Only" position, only signals generated by the activation of photocell **49** are passed to the strobe generator **82.** If switch **97** is moved to the "High Side" position, only signals generated by photocell **58** are passed to the strobe generator. When these signals are received by the strobe generator, the generator is operated to provide an instantaneous flash. If switch **96** is moved to the down position marked "Tool Face And High Side", both of the signals are passed to the strobe generator. In the latter mode of operation, two flashes will appear on the face of the plate **74** during each revolution of the downhole scan system and coincidentally with each synchronous revolution of the rod **84** relative to the plate **74.**

The surface indicating equipment of FIGS. **2** and **3** is operative in response to the signals received from the downhole tool in the following manner. If the switches **96, 97,** are activated together with the on-off switch, signals are passed from the downhole equipment to the strobe generator **82.** Thereupon the strobe generator fires to momentarily light the lamp **81** on the strobe **78.** Light emanating from the lamp **81** is directed onto the end of lucite rod **84** adjacent the lamp. The LUCITE rod conducts the light down the rod to its opposite end **85** where the light is directed onto the translucent plate **74.** The end **85** of the rod is arranged so that light emanating therefrom in the form of a beam is opposite the scale which is placed about the periphery of plate **74.** Because of the transparency of plate **74,** the light beam is superimposed on the plate scale. The strobe lamp **81** is not continuously operated, but rather is activated only by the data signal derived from downhole equipment. Thus the light appearing on the scale is intermittent and coincident with data signals. The Lucite rod **84** from which the light beam is directed, is rotatable by means of the synchronous motor **88** on the surface indicator. The motor **88** is driven by the same power supply as motor **36** in the downhole scanning system, and has an equivalent speed reduction mechanism so that the Lucite rod **84** makes one revolution about the plate scale for every revolution of scan shaft **39** in the

downhole scanner. Thus, if a reference correlation is made at the surface between the light beam position on the surface indicating scale and a known reference on the tool a similar correlation will exist when the tool is downhole and the orientation of such known reference can be followed at the surface. Such a technique for making this correlation will be described hereinafter with reference to the overall operation of the system.

The relation between the downhole detection and scan system relative to the surface indicator will now be described. In the downhole tool shown in FIG. **1**, the weighted rod **24** in the pendulum section will seek the low or gravity side of a wellbore into which it is positioned. The pendulum is arranged to turn freely within its housing. The cup **31** which is attached by means of shaft **26** to the pendulum is free to rotate therewith. As the cup **31** rotates, a slot **33** in the wall **32** of the cup, permits light to pass therethrough. Therefore, when the scan shaft **39** turns the lamp **53** and photocell **49**, the lamp and photocell periodically pass the slot **33** in cup **31** once each revolution of the shaft **39.** Since the lamp and photocell are oppositely aligned, when slot **33** passes between them, the photocell **49** is activated by the lamp **53** to provide a signal. As described previously, this signal is sent to the surface indicating equipment.

In a similar manner a reference signal is generated by rotation of shaft **39** when the slot **56** in the housing **44** permits periodic light passage from the lamp **53** onto a reference or high side photocell **58.** This also generates a periodic signal upon each revolution of shaft **39.** Thus, upon each revolution of shaft **39** a signal is generated by each of the photocells and passed to the surface indicating equipment.

In the operation of the well tool system described herein, the following method is employed in the operation of the system. At the surface before the tool string is inserted in the drill pipe, a reference mark on the tool housing is leveled with respect to the earth's surface, i.e., it is placed in an up position relative to the surface. This reference mark is in the form of a slot which cooperates with a key in the orienting sub of the drill pipe so that when the tool is lowered into the drill pipe, the reference mark assumes a predetermined position with respect to the bent sub of the drill stem. This orientation technique is set forth in detail in Applicants' copending application referred to above. The portion of the tool having the reference mark (slot) extends from the portion containing the pendulum and scan section shown in FIG. **1** and may be rotated relative thereto for purposes to be described later.

Next, the surface recording equipment shown in FIGS. **2** and **3** is turned on, and the switch marked "High Side" is depressed to complete a circuit for providing an indication of the high side of the tool. Such indication is in the form of a flashing light which will correspond to the activation of the case reference photocell **58** in the downhole tool. This light will appear somewhere on the scale on face **74** of the surface recording instrument. Since during this calibration operation, the instrument is not being moved, the light beam should repeatedly occur at periodic intervals at the same position on the scale. The appearance of the flashing light beam will coincide with movement of the scanner housing **44** past the lamp **53** and thus passing light on to the detector photocell **58.** Since the light beam moves synchronously with the scanner, the position of the light beam occurring upon closing of the high side switch will always be relative to the position of the photocell **58** which is fixed with respect to the tool housing. Thus, when the housing is aligned with respect to vertical, and the high side switch thus activated, the position of the light beam at that time on the scale is representative of the tool housing in that particular orientation.

Means (not shown or described) may be provided for desynchronizing the motor used to drive the light rod on the surface indicator. This desynchronization of the motor will cause the motor to temporarily run slower and thus cause the light flash to move with respect to the scale. This permits the light flash to be moved so that it occurs at the 0 position on the scale, and thus provides easier reading of the instrument. Since this 0 point on the scale is merely a reference point, it will readily be seen that the flash could occur at any position on the scale for ready reference; however, for the sake of simplicity and minimizing errors in the operation of the system, it would probably be better to place the high side light at the 0 position, which now corresponds to the reference mark on the tool housing being on top of the tool relative to the earth's surface. Upon establishing the high side light at this position, the operator turns off the high side light. The operator then operates the switch to the "Tool Face Only" position. Similarly, a flashing light will appear somewhere on the face scale, this light always occurring at a position which is relative to the position of the pendulum in the tool. The operator then loosens a locking collar (not shown) which separates the portion of the tool having the reference marker (slot) from the pendulum-scan section shown in FIG. **1**, and turns the upper body portion of the tool (containing the pendulum and scan assemblies), making sure that the lower portion with the reference marker is maintained in its present position, i.e., in an up position. This turning of the upper portion of the tool housing is continued until the "Tool Face Only" light, which is flashing now, appears at the 0 position on the scale. When the tool face light is in the 0 or other such reference position, the portions of the housing are once again locked together by tightening the locking collar. If the "Tool Face and High Side" switch on the surface indicator is now turned on, both signals occur simultaneously to provide a single light flash on the scale. The tool system is thus calibrated and ready for lowering into the drill pipe. It is noted that with less convenience, the system can be operated without utilizing the orientation procedure outlined above. For example, the position of the "High Side" light on the scale may be noted when the reference mark is in the up position. Then the position of the "Tool Face Only" light may be noted to give the operator a picture of the relative light positions when the reference mark is in an up position, the reference mark having a predetermined positional relationship with respect to the drill. Thereafter, upon operation of the tool in the bore-hole, changes of the tool face only light from its initial position with respect to the "High Side" light will give the operator an indication of the direction in which the drill assembly is turned, and how many degrees of turn are involved.

In order to lower the tool into the drill pipe, the conductor cable **69** is passed over the sheave of the line block, through the line wiper and opening boss in the top of the swivel, and through the kelly. Upon emer-

gence of the cable at the lower end of the top section, the cable is connected to the tool string at connector **68** and the assembly is pulled up into the top section. The drill pipe is held by means of slips on the platform floor. The top section is then made up with the top of the remaining pipe string, and by means of the spooling apparatus at the surface, the cable is let out, whereupon the tool is lowered into the drill string. When the tool reaches the lower end of the drill string, the portion having the reference marker slot is received within the orienting sub. A muleshoe key in the sub for receiving the orienting slot is in turn aligned with a portion of the drill, and preferably the bent sub portion of the drill, so that it is known that the key is pointing in the direction that the drill is pointing. Thus, because the "High Side" light is set to occur at 0 on the indicator when the reference slot is up, the high side reading now indicates the direction the bent sub and bit is pointing.

After the tool string has seated downhole, the "High Side Only" switch is activated to provide a flashing light on the scale corresponding to the signals emanating from the high side photocell. Since the tool has now in all probability been rotated from its calibrating position at the surface, the high side photocell light will no longer occur at the same position, i.e., 0 position on the scale as during the calibrating operation. Again by desynchronizing the surface indicator, the flashing light may drift on the scale until it occurs on the 0 position. Again, the 0 position is only used as a convenient reference. When this is accomplished, the "High Side Only" switch is moved to the "Tool Face And High Side" switch position. At this time, two flashing lights should occur on the scale, non-simultaneously. These lights will show the angular difference on the scale representing the angular difference between the slit **61** in the housing which passes light from lamp **53** to the high side photocell **58** and the slot **33** in the cup **31** at the upper end of the pendulum assembly, which slot **33** passes light to the tool face photocell **49**. This in turn represents the angular difference between the direction which the drill is pointing as a result of its being attached to the bent sub and the high side of the hole. This occurs because the pendulous member was set initially so that the slot **33** on the cup produces a signal from the tool face photocell **49** corresponding to the reference slot which in turn, in the hole, corresponds to the direction in which the bent sub and drill are pointing. On the surface indicator scale, this angular difference can be measured in terms of degrees to the right or left at which the bit is pointing relative to the top side of the hole. Again, this orienting step may be omitted, i.e., not desynchronizing the surface motor **88** wherein the operator may determine the direction the bit is turned by counting the number of degrees and direction the "Tool Face Only" light is displaced from the "High Side" light.

The drilling operator now knows which way the drill assembly must be turned in order to achieve the desired direction. Based on this information, he will continue the drilling operation, periodically taking readings from the surface indicator to determine if the corrections he is applying to the drill assembly are producing the desired results. Means are provided in the drill stem to permit drilling fluid to bypass around the tool string while the tool string is positioned in the drill pipe. When drilling has continued to the extent that another section or stand of drill pipe need be added to the drill string, the drilling operator will then slow the circulation of mud as much as possible, whereupon the pressure on the line wiper is released to the point that the conductor cable can be moved through the line wiper by rotating the reel at the surface. The tool is then retrieved to a position within the kelly, whereupon the tool joint between the kelly and top section of pipe is opened and another section or stand of pipe is placed in the drill string in a well known manner. Thereupon, the tool string is again lowered to the bottom of the drill string and seated in the orienting sub and the drilling operation is continued.

Although the invention described herein is shown for use with a particular borehole tool, it is readily seen that the display apparatus could have many other uses with or without borehole tools. Therefore, while particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. An improved visual display apparatus of the type wherein there is provided: means for generating recurring data signals; means responsive to said data signals for providing a momentary light source; and scale means spatially separated from the light source means wherein the improvement comprises: means for conducting light from said light source means to a point adjacent said scale means; and means for positioning the portion of the conducting means adjacent the scale means at a multiplicity of locations adjacent said scale means, whereby multiple light signals may be displayed on the scale means in a spatially separated manner indicative of a relationship between such signals.

2. The apparatus of claim **1** wherein said scale is translucent.

3. The apparatus of claim **1** wherein the means for generating the momentary light source is a strobe generator.

4. An apparatus for displaying multiple periodic light signals in a spatially manner indicative of a relationship between the signals, which comprises: a light source; circular translucent scale means on which to display the light signals; a rotatable light conducting member having a first end positioned adjacent said light source and a second end positioned adjacent the scale means, said member having its second end laterally displaced from its first end and the longitudinal axis of its said ends parallel; and means for rotating said member about the longitudinal axis of its first end, thereby directing its second end at a multiplicity of locations on the scale.

5. The apparatus of claim **4** and further including means for intermittently operating said light source in response to multiple periodic electrical signals.

6. The apparatus of claim **5** wherein the rotatable light conducting member rotates in a timed relationship with the intermittent operation of the light source.

7. The apparatus of claim **6** wherein the multiple periodic electrical signals are generated in a borehole by parameter measuring means.

8. The apparatus of claim **7** wherein the means for measuring the parameters in the borehole is a periodically rotating measuring means for generating periodic

electrical data and reference signals, whereby the magnitude of the measured parameters may be represented.

9. The apparatus of claim **8** wherein the periodically rotating measuring means is rotated by a first synchronous motor and wherein the means for rotating the light conducting means is a second synchronous motor operating in a timed relationship with the first synchronous motor.

10. The apparatus of claim **9** wherein said light signal generating means is a strobe generator.

11. An apparatus for detecting the positional attitude of an apparatus in a borehole and providing visual indications thereof at the surface, comprising: a housing arranged for positioning in a borehole; means rotatable in said housing for detecting a position in said housing having a predetermined relationship with the earth's gravitational field; means attached to said detecting means for generating a periodic data signal indicative of the position of said housing; means having a predetermined fixed relationship with said housing for generating a periodic reference signal; means for transmitting said signals to the earth's surface; light source means at the earth's surface responsive to said periodic data and reference signals; elongated light conducting means having one end positioned adjacent said light source means; scale means positioned adjacent the other end of said light conducting means; and means for moving said light conducting means relative to said scale means, whereby the relationship between said periodic data and reference signals may be displayed.

12. The apparatus of claim **11** and further including movable scan means in said housing for generating said first and second signals within a fixed cyclic period and wherein said moving means is operated to move said light transmitting means over said scale once during each said cyclic period.

13. The apparatus of claim **12** wherein said scan means and moving means are operated by synchronously operated motors.

14. An apparatus for visually displaying signals generated in a borehole, which comprises: downhole means for generating multiple recurring signals in a timed relationship which is indicative of the magnitude of a borehole parameter; surface means responsive to the downhole means for generating multiple recurring signals at the surface in a timed relationship with the downhole signals; scale means; means responsive to the multiple recurring signals generated at the surface for displaying recurring light signals on the scale means; and means for positioning the recurring light signals on the scale means in such a manner that the positional relationship between the recurring light signals is indicative of the timed relationship between the downhole multiple recurring signals.

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