It is another object of the present invention to provide a selectively retractable and expandable caliper for well tools in which the caliper arm may be retracted under the force provided by a selectively actuable motor and is permitted to expand into contact with the well surface under its own spring pressure.

It is yet another object of the present invention to provide a selectively retractable caliper for well tools employing an electric motor for retracting a bow spring forming the caliper and in which a lost motion coupling is employed between the motor and the bow spring so that the motor may move with respect to the bow spring and conversely the bow spring may move relative to the motor.

In accordance with the present invention there is provided a well tool having one end of a bow spring type caliper arm and decalizer pivotally secured to a fixed location on the casing, while the other end is secured to a collar slidably disposed about the wall of the tool. Thus, the bow spring and caliper extension bow is in line with the contours of the well bore. One end of a cable is secured to the well tool approximately under the center of the bow spring and passes over a sheave secured to the center of the bow spring and under the pivotal support of the fixed end of the bow spring which is on the up-well side thereof. The other end of the cable attaches to a drum which passes into a further housing which contains the bow spring control mechanism, which housing is suitably secured to the up-well side of the housing to which the bow spring is secured; the latter housing normally containing the electronic equipment carried into the well tool. The drum is driven from an electric motor through a suitable gear reduction unit and a lost motion coupling. The portion of the spring driving mechanism disposed between the spring and the lost motion coupling also drives a potentiometer which produces a variation in an electrical signal which is an indication at all times of the position of the bow spring relative to a preselected zero position.

When it is desired to retract the bow spring, the motor is simply driven in one direction and after the lost motion coupling has been picked up, the constant tension spring is wound on its drum and pulls in the cable which is secured to the bow spring. The motive power for retracting the caliper comprises a motor geared down considerately through a reduction gear system having a high reduction ratio so as to obtain mechanical advantage for the retraction and expansion apparatus. The purpose for using the mechanical advantage is that the cable employed to transmit power to the well tool has a relatively low current rating of under one ampere and in consequence low power consumption by the motor is mandatory. The motor in conjunction with a reduction gear unit having a very large reduction ratio permits realization of reasonable retraction times in conjunction with low power consumption. Further, the high reduction ratio prevents turning of the motor by spring tension when the motor is de-energized. The gear system may be said to be irreversible due to friction.

It should be noted that the motor and the electronic equipment disposed within the housing to which the caliper is secured, employ the same cable for electrical transmission. The cables that are normally employed in well logging operations have a relatively low maximum current rating and therefore the electronic equipment and the motor cannot generally operate at the same time and must time-share the electric cable. In consequence, when the motor reaches its end of rotation, as determined by a limit switch for each direction of rotation of the motor, further switches must be actuated to change the cable connection from the motor to the electronic equipment or
vice versa. These switches are actually operated upon by the output shaft from the gear reduction unit, and since one of the switches is employed as a limit switch for the motor, the possibility arises that the limit switch of the motor may be actuated before the switches which control transfer of the cable from the motor to the electro-mechanical equipment. The high gear reduction between the motor and the output shaft of the gear reduction unit dictates that the output shaft will cease rotation substantially immediately upon de-energization of the motor and therefore if the motor limit switch is actuated before the other switches, the latter switches will not be actuated. In order to prevent such erroneous operation, an arrangement is provided which assures substantially simultaneous actuation of all switches of each group of switches, that is, of all of the switches of each group which are associated with a limit switch for determining limit of rotation of the motor in two opposite directions.

The slip coupling provided between the motor shaft and the drive mechanism for the constant tension spring is primarily employed to permit lost motion between these two shafts under two sets of circumstances. First, when the motor is energized to permit the spring to expand, and the second is when the spring is operating under a maximum permissible expansion of the bow spring, or other caliper members, the spring contacts the wall of the bore-hole prior to the motor having reached its limit of rotation. Therefore, in this instance the lost motion coupling permits the motor to complete its desired rotation until operation of a limit switch has been effected, even though the bow spring may have contacted the side of the well prior to this occurrence. Further, since the bow spring moves inwardly and outwardly in response to variations in diameter of the well during the taking of measurements while the motor remains stationary the lost motion coupling is employed to permit the movement of the bow spring and a portion of its drive mechanism relative to the motor.

In accordance with a second embodiment of the invention a hydraulic retraction unit is employed in which the cable attached to the bow spring is connected to a slidable piston which is operated upon to effect retraction of the bow spring by an oil pressure system employing a motor and pump. The piston is also connected to a constant tension spring and when it is desired to permit expansion of the bow spring a solenoid actuated relief valve is opened or the motor and pump is reversed so as to reduce the pressure within the piston chamber to permit the piston to move under the influence of the bow spring. The constant tension spring serves the same function as in the first embodiment of the invention and is employed to maintain a predetermined tension on the cable to the bow spring. The connection of the spring to the piston causes the piston to move with movements of the bow spring in response to changes in diameter of the well. The connection between the bow spring cable and piston may include a rack gear which operates on a pinion gear to drive a potentiometer employed to convert movements of the bow spring to an electrical quantity.

It is therefore another object of the present invention to provide a caliper unit for well logging tools which may comprise a completely mechanical or a combined mechanical and hydraulic bow spring retraction system.

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It is another object of the present invention to provide a caliper unit for well logging tools which may comprise a completely mechanical or a combined mechanical and hydraulic bow spring retraction system. It is another object of the present invention to provide a caliper unit for well logging tools which may comprise a completely mechanical or a combined mechanical and hydraulic bow spring retraction system.
essentially parallel to the casing 2. With the bow spring 4 retracted, the well tool may be readily moved or lowered into a well bore without appreciable difficulty and in consequence the movement of the tool downward in the well is facilitated. Once the well tool has reached the bottom of the well bore or other desired depth the cable 9 is released by a mechanism to be subsequently described and the bow spring 4 flexes thereby raising the collar 7 to the left as viewed in FIGURE 1, until the bow spring 4 contacts the surface of the well and forces the casing 2 against an opposite surface of the well. When the bow spring 4 has attained this position, the tool 2 is then in the desired position for well logging measurements by the electronic instruments within the casing 2 as well as by the caliper, and the well tool or mechanism may be hoisted to initiate the logging operation.

Within the housing 1, the rod 12, which is connected through the connector block 11 to the flexible cable 9, is secured to a slide coupling 21 which is adable longitudinally of the casing 1 in a guide assembly 22. The side of the slide 21 remote from the rod 12 is secured to a constant tension spring 23, so that regardless of the position of the bow spring 4, the tension on the cable 9 remains constant. Spring 23 is shown in the preferred embodiment as a strip spring of the type which is prestressed or biased so as to coil itself when about itself in layers thereby producing tension in the uncoiled part thereof. Such springs are available, for example, from the Hunter Spring Company under the trade name Neighbor. The coiled part of spring 23 is coiled about drum 24 and fastened thereto. The tight coiling of the spring means that the spring is wound or unwound from the drum 24 as the drum is rotated and in the amount of drum rotation. The position of the free end of the spring is therefore determined by the position of the drum only and is independent of spring tension. By proper prestressing of the spring, it may be made to provide relatively constant tension irrespective of its extension.

The "constant" tension spring 23 is supported on the drum 24 which is driven by a shaft 26 having its end remote from the drum 24 secured to a bevel gear 27. The bevel gear 27 is driven by means of a second bevel gear 28 secured to one end of the shaft 29, and the other end of the shaft 29 is secured to a first member 31 of a lost motion rotary coupling generally designated by reference numeral 32. A second member 33 of the rotary coupling 32 is connected via a shaft 34 to a gear reduction unit 36 driven in turn by an electric motor 37. The coupling 32, as indicated, comprises a first member 31 and this member carries a pin which is parallel to the shafts 29 and 34 but is offset therefrom. The second coupling member 33 of the coupler 32 is provided with a slot 39 coaxial with shafts 29 and 34 having a radial width to accommodate the diameter of the pin 38 and having an arcuate length equal to approximately 180°. Pin 38 is similar to the pin on first member 31 and is similarly mounted on intermediate member 33a which is slotted to accommodate the pin on said first member. Thus, the coupling 32 comprises a slip coupling in which both of the shafts 29 and 34 may turn relative to one another through a predetermined maximum angle as determined by the arcuate length of the slots.

A spur gear 41 is secured to the shaft 29 between the gear 28 and the coupling member 31 and meshes with a further spur gear 42 secured to a shaft 43 of a potentiometer 44. The purpose of the potentiometer 44 is to measure the instantaneous position of the bow spring 4 relative to the wall of the casing 2 and to convert this position into an electrical quantity which may be transmitted to the surface by the equipment in the casing 2. The shaft 34 carries a switch actuating mechanism 46 between the coupling member 33 and the gear reduction unit 36. The purpose of this mechanism 46 is to provide a further switch actuating mechanism 47 intended to operate switch banks 48 and 49, depending upon direction of rotation of the shaft 34, when the apparatus 46 engages the apparatus 47.

The purpose of the slip coupling 32 is to permit relative rotation between the shafts 34 and 29 under two different circumstances. Specifically, when it is desired to extend the bow spring 4, the motor 37 is energized so as to rotate counterclockwise as viewed in FIGURE 1. The side 31, rod 12 and cable 9 are urged to the right under an outward force on the cable 9 exerted by the bow spring 4. This tends to unwind spring 23 and rotate shafts 26 and 29. Such motion is permitted when motor 37 rotates shaft 34 counterclockwise. The system is proportioned such that the bow spring 4 reaches its maximum outward extension as determined by the limit position of the apparatus 47 before the motor has rotated sufficiently to produce actuation of one of the limit switches. Therefore, movement of the spring 4 and of the shaft 29 normally discontinues, and the slip coupling 32 permits the motor 37 to rotate the shaft 34 to the extent necessary to operate the limit switch even though the shaft 29 does not rotate. Further, the slip coupling is then positioned to permit rotation of the shaft 29 in response to movement of the bow spring 4 with variations in well diameter during periods when the shaft 34 is stationary. The gear box 36 prevents motion of shaft 34 except upon energization of motor 37.

Referring now specifically to FIGURE 3 of the accompanying drawings, there is illustrated a detailed end view of the switch actuation mechanisms 46 and 47. The switch actuation mechanism 46, which is supported on the shaft 34, comprises a semicircular collar 51 secured to the shaft 34 by a second lost motion device 5La, said second lost motion device permitting shaft 34 to make several revolutions before driving collar 51. The semicircular collar 51 has two diametrically opposed shoulders to which are secured two longitudinally extending leaf springs 52 and 53, both of which are illustrated in FIGURE 3 and only one of which, spring 53, is illustrated in FIGURE 1. Disposed in the path of rotation of the ends of the springs 52 and 53 remote from the collar 51, are two stationary stop members 54 and 56, the member 54 cooperating with the leaf spring 52 and the stop 56 cooperating with the leaf spring 53. The stops 54 and 56 may be secured to the front of the gear unit 36. Extending downwardly from above the shaft 34, as viewed in FIGURES 1 and 3, is the mechanism 47 comprising shaft 57 supported for rotation about its longitudinal axis and having a downwardly depending tab 58 disposed between the stops 54 and 56 and in the path of movement of the ends of the leaf springs 52 and 53 remote from the collar 51. The shaft 57 also carries an upwardly extending plate 59 disposed between the sets of limit switches 48 and 49 and are more particularly being disposed adjacent the actuating mechanisms of the switches which are indicated as buttons 61 and 62 disposed on opposite sides of the plate 59.

The operation of the apparatus is such that upon a predetermined rotation of the shaft 34—and for purposes of example, rotation of the shaft in a clockwise direction, as indicated by the arrow in FIGURE 3, is selected—the end of the leaf spring 52 engages the stop member 54 and is flexed until it is bent sufficiently to cause the spring 52 to jump over the stop 54 and hit the downwardly depending tab 58. The impact of the leaf spring 52 against the tab 58 causes the shaft 57 to rotate counterclockwise about its axis so that the plate 59 strikes the operating mechanism 61 of all of the switches 48. The length and resiliency of the leaf spring 52 are such that it does not jump the stop 54 until the surface of the collar 51 abutting the spring is past the arcuate position of the plate 58 as illustrated in FIGURE 3 of the drawings. Therefore, when the leaf spring 52 does jump it also maintains a predetermined force against the tab 58 and therefore positively maintains a pressure between the plate 59 and the
operating mechanism 61 of the switches 48 and insures that the switches remain actuated.

The assembly illustrated in FIGURE 3 of the accompanying drawings is required since one of the switches in each of the groups 48 and 49 is a limit switch for the motor and the possibility of the limit switch for the motor becoming actuated and discontinuing rotation of the shaft 34 before the other switches are operated must be precluded. More particularly, each of the switches in each of the groups 48 and 49 must be actuated in order to establish certain switching functions as required by the control and measuring circuits in conjunction with the apparatus of the present invention. The control and electronic circuits which require the energization of three sets of switches each time the motor 37 reaches the limit of rotation are described and claimed in co-pending U.S. patent application No. 883,758, filed on Aug. 14, 1959, by Marshall B. Broome and Robert L. Tucker and entitled Respondor and Telemetering Transmitter for Borehole Caliper or in co-pending U.S. patent application No. 839,417, filed on September 11, 1959, by Marshall B. Broome and entitled Well Logging Caliper Motor Control System. The proper operation of the mechanism described in the aforementioned co-pending applications makes it absolutely mandatory that the three switches in each of the groups 48 and 49 be actuated, and this is assured by the apparatus illustrated in FIGURE 3.

Referring now to the operation of the apparatus of the invention and assuming initially the well tool illustrated in FIGURE 1 is at the bottom of the well bore so that it is desired to permit expansion of the bow spring 4, the motor 37 is energized so as to rotate its shaft 34 in a counterclockwise direction. The motor 37 continues to rotate until the leaf spring 53 jumps the stop 56 and engages the downwardly depending tab 58 and thereby actuates the switches 49. However, prior to rotation of the shaft 34 to the extent required to actuate the switches 49, the bow spring 4 may engage the wall of the well bore and if this occurs rotation of the shaft 29 discontinues, this being permitted by the slip coupling 52. The point at which the shaft 29 stops rotating is indicated by the resistance of the potentiometer 44 and this produces an indication via the electronic apparatus contained in the casing 2 of the diameter of the well bore at this point. After the motor 37 has discontinued operating, the electronic circuits in the casing 2 are energized as a result of operation of the switches 49 and the well may be hoisted to initiate measurement of the diameter of the well bore along its length. Variations in curvature of the bow spring 4 with changes in diameter of the well produce movement of the cable 9 which is reflected in rotation of the shaft 29 and therefore in rotation of the shaft 43 of the potentiometer 44. In consequence, the resistance of the potentiometer 44 is a direct measure of the diameter of the well bore and therefore provides a log of diameter of the wall versus tool depth.

When it is desired to retract the bow spring 4, the motor 37 is energized in a manner indicated in the aforementioned co-pending applications so as to produce clockwise rotation of the shaft 34. The member 33 of the coupling 32 rotates independently of the member 31 until the counterclockwise end of the slot 39 engages the pin 38 at which time clockwise rotation is also imparted to the shaft 29. Counterclockwise rotation of the shaft 29 causes counterclockwise rotation of the drum 24, resulting in retraction of the spring 23 and therefore application of the necessary force to the cable 9 to retract the bow spring 4. Limit switches 48 are set to stop the motor when the spring 4 is fully retracted.

The entire retractor assembly disposed within the housing 1 is filled with electrically non-conductive lubricating fluid and the interior of the housing 1 is pressure equalized to the ambient atmosphere by the action of a bellows 63 disposed in the left end of the housing 1 as illustrated in FIGURE 1. Also, electrical connections to the motor 37, switches 48 and 49, and to the electronic equipments carried in the housing 2 are made through pressure sealed connectors 64 and 66, respectively.

The apparatus of the present invention has thus far been described employing an electric motor to drive a gear train through a compound in order to retract the bow spring and permit expansion thereof. In accordance with another embodiment of the present invention, the apparatus may employ a hydraulic or liquid operated system in which a motor drives a pump to develop appropriate pressure within the system employed in conjunction with the apparatus of the present invention. The assembly illustrated in FIGURE 4 of the accompanying drawings there are illustrated only those elements of the system which are essential to an understanding of the hydraulic counterpart of FIGURE 1. More particularly, there is provided a casing 1 in which the system is housed, the casing 1 being connected with a casing 2 as illustrated in FIGURE 1 but not in FIGURE 4. A rod 67 is connected to a cable (not illustrated) for retracting the bow spring and allowing it to expand in the same manner that the rod 12 is connected to the cable 9 in FIGURE 1. The rod 67 is disposed in a suitable seal 68 into the interior of a cylinder 69 having a piston 71 disposed therein. The rod 67 is secured to the piston 71 and a portion of the rod intermediate the packing 68 and the piston 71 constitutes a rack gear 72 which cooperates with a pinion gear 73. The pinion gear 73 is secured to a shaft 74 of a potentiometer which is not illustrated that which is disposed within the housing portion 76 which rises semicircularly from the upper wall of the cylinder 69. The end of the piston 71 opposite to the end which is connected to the rack gear 72 is connected to a constant tension spring 77 and thus, regardless of the position of the piston 71 within the cylinder 69 a constant tension is maintained on the rod 67. It will be noted that a coiled constant tension spring is employed in this embodiment but the types of springs employed in the two embodiments of the invention are interchangeable with only slight modifications required.

The interior of the cylinder 69 communicates through a passage 78 and check valve 88 to a pump 79 driven via a shaft 80 from a gear reduction unit 81 by a motor 82. The pump 79 obtains oil for developing a pressure within the cylinder 69 from an oil reservoir 83 which may comprise the entire inner volume of the casing and may be connected to the passage 78 via a solenoid operated valve 84 and a pressure relief valve 86. Pressure in the cylinder 69 is relieved by operation of the solenoid operated relief valve 84. In operation, when it is desired to permit the bow spring to expand to the extent permitted by the diameter of the well, the solenoid operated valve 84 is opened in order to relieve pressure in the chamber 78 and therefore in the cylinder 69. Pressure is equalized through vent 85. In consequence, the piston 71 is free to move within the cylinder 69 and is pulled to the right as viewed in FIGURE 4 until the bow spring contacts the wall of the well in the region under investigation and further outward movement of the bow spring and therefore movement of the rod 67 and piston 71 is prevented. A constant tension is kept on the rod 67, and the cable to which it is attached, by the constant tension spring 77 which operates in the same manner as the constant tension spring of FIGURE 1. It is apparent that the force maintained by the spring 77 on the rod 67 causes the rod 67 to move precisely in accordance with movement of the bow spring and since the motion of the rod is imparted to the potentiometer disposed within the housing 76 through the rack and pinion 72, 73, all movements of the bow spring are converted to electrical signals indicative thereof.

When it is desired to retract the bow spring, the motor 82 is energized and the pump 79 is rotated until sufficient pressure is developed within the chamber 78 and the cylinder 69 to force the piston 71 all the way to the left as
viewed in FIGURE 4 in which position, the bow spring has been completely retracted.

In this embodiment of the invention the fluid body constitutes the requisite lost motion mechanism between the motor or pump and the piston 71. Specifically when the pressure in the cylinder 69 is relieved, the piston 71 may move with the rod 67 without affecting the motor 82 or pump 79 because when the bow spring is being retracted the piston 71 may engage the left end of cylinder 69 before the motor and pump stop operation.

In both embodiments of the present invention, there is provided a mechanism which permits the selective retraction of the bow spring of a caliper tool for well logging which caliper tool may be utilized independently or in conjunction with other electronic instruments for making suitable measurements relative to the well and surrounding strata. The mechanism is such that a bow spring for measuring the diameter of the well may be selectively retracted or expanded and when expanded permits measurement of variations in diameter by means of a caliper exerting a force on the sides of the well. The apparatus is relatively simple and rugged and where it is necessary to operate a plurality of switches simultaneously, this problem has been met by a simple and rugged mechanism which is capable of accepting the shock and environmental conditions encountered in well logging.

The apparatus has been illustrated as employing only a single caliper arm but it is to be understood that multiple arms may be controlled. In the second embodiment of the invention three cylinder and piston arrangements controlled by a single motor and pump may be employed. In the first embodiment, the shaft 34 would have a gear for driving three separate gears. The three gears would drive constant tension springs through three different lost motion couplings, and otherwise the systems would be identical.

While I have described and illustrated two specific embodiments of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims. This invention finds application in other instances where well tools are equipped with biased arms urged against the well wall as the tool is being raised. For example, centralizing or decentralizing members, usually springs, may be used to urge the tool into a particular desired position with respect to the well wall. In some instances it is necessary that the tool be urged against the well wall, and in other instances it is necessary that the instrument be located in the center of the well. In these additional instances it is desirable that the arms be retractable for insertion of the tool into the well and lowering it therein, and this invention may be used therefor.

What I claim is:

1. A well tool including apparatus for retracting at least one outwardly biased arm comprising a housing, at least one arm secured to and urged outwardly from said housing, a cable attached to said arm, said cable retracting said arm upon movement of said cable in a predetermined direction, a motor, a means for coupling said cable to said motor to move said cable in said predetermined direction under the force provided to urge said arm outwardly from said housing, and spring means connected to said cable for continuously maintaining tension therein.

2. A well surveying tool comprising a housing, an arm secured to and urged upwardly from said housing, a cable attached to said arm, said cable retracting said caliper arm upon movement of said cable in a predetermined direction, a strip spring of the type which is biased to coil itself tightly upon itself in layers thus producing tension in the uncoiled part, said uncoiled part being connected to said cable and the coiled part thereof being rotatably mounted on said housing, a motor, and drive means for applying a force upon rotation of said motor in a first direction, said drive means comprising a lost motion coupling permitting limited relative movement of said motor and said cable.

3. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, a caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm, said cable retracting said caliper arm upon movement of said cable in a predetermined direction, a strip spring of the type which is biased to coil itself tightly upon itself in layers thus producing tension in the uncoiled part, said uncoiled part being connected to said cable and the coiled part thereof being rotatably mounted on said housing, a motor, and drive means for applying a force upon rotation of said cable to move said cable in said predetermined direction, said drive means including means for selectively removing said force from said spring to permit movement of said cable oppositely of said predetermined direction, and a lost motion coupling permitting limited relative movement of said motor and said cable.

4. A well surveying tool for measuring the internal diameter of a well bore comprising a housing; a caliper arm secured to and urged outwardly from said housing; a cable attached to said caliper arm, said cable retracting said caliper arm upon movement of said cable in a predetermined direction; a constant tension spring of the type which is biased to coil itself tightly; upon itself to produce constant tension in the uncoiled part, said uncoiled part being connected to said cable and the coiled part thereof being rotatably mounted on said housing, a motor; drive means for applying a force upon rotation of said motor in a first direction from said motor to the coiled part of said constant tension spring to wind up said uncoiled part whereby to move said cable in said predetermined direction, said drive means including means for selectively removing said force from said constant tension spring to permit movement of said cable oppositely of said predetermined direction, said drive means comprising a lost motion coupling permitting relative movement of said motor and said cable; and means for measuring the movement of said cable as indicative of the outward displacement of said arm.

5. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, at least one caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm, said cable retracting said caliper arm upon movement of said cable in a predetermined direction, a motor, a means for coupling said cable to said motor to move said cable in said predetermined direction in response to rotation of said motor, said means for coupling selectively permitting movement of said cable oppositely to said predetermined direction under the force provided to urge said caliper arm outwardly from said housing, means for measuring the movement of said cable along said predetermined direction, and spring means connected to said cable for maintaining a constant tension therein.

6. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, a caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm, said cable retracting said caliper arm upon movement of said cable in a predetermined direction, a constant tension spring connected to said cable, a motor, drive means for applying a force from said motor to said constant tension spring to move said cable in said predetermined direction, and means for releasing said force on said spring to permit said cable to move oppositely of said predetermined direction, said drive means comprising a lost motion coupling permitting relative movements of said motor and said cable.
7. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, a caliper arm secured to said housing and urged outwardly from said housing, a cable attached to said caliper arm, a cable retreating said caliper arm upon movement of said cable in a predetermined direction, a constant tension spring connected to said cable, a motor, and drive means for applying a force upon rotation of said motor in a first direction from said motor to said constant tension spring to move said cable in said predetermined direction, said drive means including means for selectively removing said force from said constant tension spring to permit movement of said cable oppositely of said predetermined direction, said drive means comprising a lost motion coupling permitting relative movement of said motor and said cable.

8. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, a caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm, said cable retracting said caliper arm upon movement of said cable in a predetermined direction, a spring connected to said cable, a reversible motor, and drive means for applying a force upon rotation of said motor in a first direction from said motor to said spring to move said cable in said predetermined direction, said drive means comprising means for selectively removing said force from said spring to permit movement of said cable oppositely of said predetermined direction, said drive means comprising a lost motion coupling permitting relative movement of said motor and said cable, a limit switch mechanism for limiting rotation of said motor in both of said directions, said limit switch mechanism being responsive to rotation of said motor only.

9. The combination in accordance with claim 8 wherein said limit switch mechanism comprises a shaft coupled between said motor and said lost motion coupling, a resilient arm coupled to said shaft for rotation thereby, a stop member disposed in the path of rotation of one end of said resilient arm and positioned such that upon said arm engaging said stop and the development of a predetermined spring force therein, said arm moves over said stop, a pivoted plate having one side disposed in the path of movement of said resilient arm over said stop and at least one switch operating mechanism disposed in the path of movement of said pivoted plate.

10. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, at least one caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm to retract it toward said housing upon movement of said cable in a predetermined direction, a motor, and drive means for positively moving said cable in said predetermined direction in response to rotation of said motor in a first direction and for permitting movement of said cable in a direction oppositely of said predetermined direction in response to rotation of said motor in a second direction, said drive means including a lost motion coupling between said motor and said cable, a measuring apparatus for measuring the movement of said cable, and a spring coupled to said cable for continuously maintaining tension therein.

11. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, at least one caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm to retract it toward said housing upon movement of said cable in a predetermined direction, a cylinder, a piston slidable in said cylinder, means connecting said cable to said piston, means for developing a pressure in said cylinder to move said piston so as to move said cable in said predetermined direction, means for selectively reducing the pressure in said cylinder, a spring connected to said piston for continuously maintaining tension on said cable, and means for measuring movement of said cable.

12. A well surveying tool for measuring the internal diameter of a well bore comprising a housing, at least one caliper arm secured to and urged outwardly from said housing, a cable attached to said caliper arm to retract it toward said housing upon movement of said cable in a predetermined direction, a cylinder, a piston slidable in said cylinder, means connecting said cable to said piston, a motor driving pump for producing a pressure in said cylinder to move said piston and said cable in said predetermined direction, a selectively actuable relief valve for reducing pressure in said cylinder, a spring connected to said piston for maintaining a constant tension on said cable, and means for measuring movement of said cable.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,058,227

October 16, 1962

William A. Camp

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 53, strike out "are"; column 7, line 43, for "apparatus" read -- apparatus --; line 47, after "well" insert -- tool --; line 56, for "wall" read -- well --;
column 9, line 70, for "upwardly" read -- outwardly --;
column 10, line 33, for "tightly; upon" read -- tightly
upon --; line 44, for "permitted" read -- permitting --.

Signed and sealed this 7th day of May 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents