

April 23, 1968

F. F. SEGESMAN
WELL LOGGING PAD STRUCTURE HAVING PIVOTALLY
INTERCONNECTED MEMBERS

3,379,964

Filed April 2, 1965

2 Sheets-Sheet 1

Fig. 1

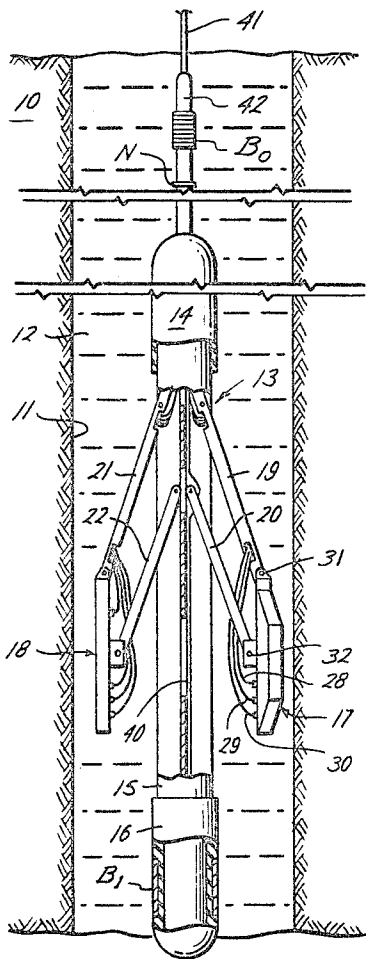
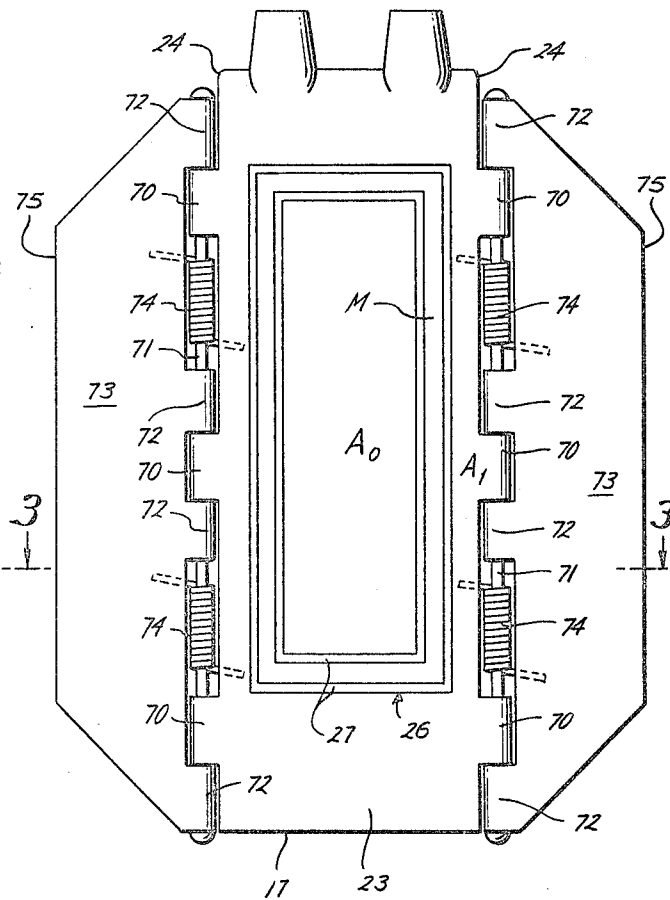


Fig. 2



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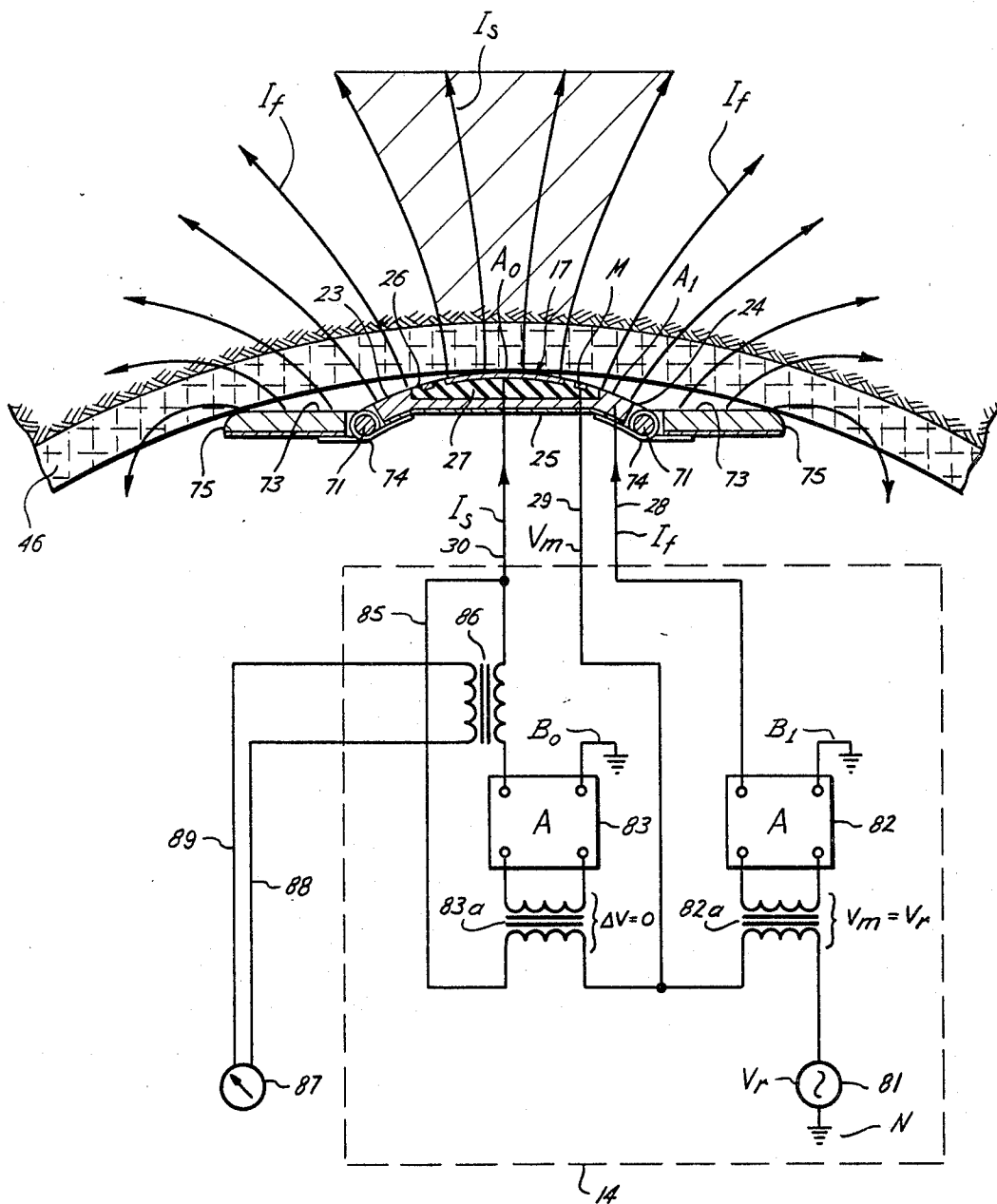


Fig. 3

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3,379,964

WELL LOGGING PAD STRUCTURE HAVING PIVOTALLY INTERCONNECTED MEMBERS

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ABSTRACT OF THE DISCLOSURE

This disclosure shows a borehole wall-engaging pad structure having earth formation exploring means which can be utilized to investigate earth formations traversed by a borehole. The pad structure comprises a central pad member and separate auxiliary pad members adjacent to the central pad members, the pad members having electrodes on the forward borehole wall-engaging faces thereof. The auxiliary pad members are hinged to the central pad member for rotation with respect thereto, and spring biased to be urged toward the borehole wall so that the pad structure, as a whole, may more nearly conform to the curvature of the borehole wall.

This invention relates to electrical apparatus for investigating subsurface earth formations traversed by a borehole and, more particularly, to apparatus for measuring the electrical resistance properties of a subsurface earth formation by means of electrodes disposed in the borehole.

One method of investigating subsurface earth formations traversed by a borehole is to move a system of pad-mounted wall-engaging electrodes through the borehole and determine the resistance presented by the earth formations to the flow of electrical current emitted from one or more of the electrodes. The electrical log obtained in this manner aids in determining the nature and lithological character of the various subsurface formations. This data is useful in the case of oil well boreholes in that it enables the presence and depth of any oil or gas bearing strata to be determined.

When a borehole is drilled by the usual rotary method, the borehole is filled with mud during the drilling process. This drilling mud will penetrate laterally into the various permeable strata for a distance which depends upon the porosity of the strata. This invasion of the drilling mud into a permeable stratum causes the solid particles suspended in the drilling mud to build up in the form of a mudcake on the wall of the borehole in front of the permeable zone. The mud filtrate which actually invades the permeable zone alters the electrical resistivity properties of the earth formation immediately adjacent to the borehole wall and, not uncommonly, increase the resistivity of such portions, particularly where "fresh" muds are used. The resistivity of the mudcake which is formed on the borehole wall in such cases is usually relatively low compared with the resistivity of the flushed zone.

For the case of pad-mounted electrodes which engage the wall of the borehole, as the mudcake thickness increases, more and more of the electrode current is short-circuited back to the borehole current-return point by the relatively low resistance path formed by such mudcakes. This makes the measurement of the flushed zone resistivity and thus, any subsequent formation porosity determination more difficult because the measurement is influenced to a larger degree by the mudcake resistivity. This problem may be overcome to a large extent by using a wall-engaging electrode system of the focused type. Systems of this type are described in U.S. Patent No. 2,712,629, granted to H. G. Doll on July 5, 1955, and in U.S.

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Patent No. 3,132,298, granted to H. G. Doll and J. L. Dumanoir on May 5, 1964. In a focused system, a principal current flow emitted by one of the electrodes and used for determining or surveying the formation resistivity characteristics is constrained to a desired lateral flow pattern by a focusing current emitted by another of the electrodes adjacent thereto for opposing any tendency of the survey current to flow in an undesired direction, such as along the mudcake. Most of the survey current is thus caused to penetrate laterally into the earth formations for an appreciable distance. The problem, nevertheless, is not always an easy one. As indicated by the Doll and Dumanoir patent, more elaborate precautions are required as the environment becomes more severe or the requirements on the measurements become more demanding.

The electrode system described in the Doll and Dumanoir patent provides an improved measurement of the resistivity of the invention zone region of the earth formations even for the case of relatively thick muds. Among other things, this is accomplished by utilizing relatively large electrode surfaces on the wall-engaging pad member. It has been found, however, that in some boreholes undesired variations appear in the measurements. After considerable effort, it has been discovered that the undesired variations in these instances are caused primarily by relatively large changes or variations in the shape or contour of the borehole wall. If the cross-sectional shape of the borehole remains fairly circular and the diameter fairly constant, the results are satisfactory. If, however, a section of the borehole assumes an elliptical or other non-circular shape and if, at the same time, a fairly thick mudcake is present on the borehole wall, then the measured value will be somewhat different depending upon which side of the ellipsoid is being engaged by the electrode system.

It has been found that this undesired effect can be largely eliminated if a constant relationship can be maintained between the curvature of the borehole wall and the curvature of the wall-engaging face of the electrode system. This requires the provision of a different electrode system curvature for the different sides of the ellipse. This, however, presents further problems.

The relationship between the formation resistivity and the measurement made with an electrode system is described by the formula:

$$R = K \cdot \frac{V}{I}$$

where R is the formation resistivity, K is a proportionality constant (or calibration constant) depending upon the geometry of the electrodes including the size and shape of the individual electrodes and the distance between the electrodes, V the voltage of one of the electrodes, and I the current emitted by one of the electrodes. Either the voltage may be kept constant and the current variations measured, or the current kept constant and the voltage variations measured.

Unfortunately for the present purposes, the curvature of the electrode device is a factor in determining the K coefficient in the above formula. Consequently, changes in the electrode system curvature will tend to introduce corresponding changes into the measured values. Since these changes are independent of the formation resistivity, they are undesirable.

It is an object of the present invention, therefore, to provide new and improved apparatus for measuring the electrical resistivity properties of the subsurface earth formations adjacent to a borehole.

It is another object of the invention to provide new and improved wall-contact electrode apparatus of the focused type which provides improved focusing action under adverse borehole conditions.

It is a further object of the invention to provide a new and improved focused-type wall-contact electrode system which is less affected by variations in the radius of curvature of the borehole wall.

It is an additional object of the invention to provide a new and improved focused-type wall-contact electrode system which can adapt itself to changes in the curvature of the borehole wall without introducing excessive changes in the calibration constant of the system.

In accordance with the present invention, a pad structure for investigating earth formations traversed by a borehole comprises a first pad member having a forward face adapted to be urged against the borehole wall and having an earth formation exploring means. The apparatus further comprises a second pad member having a forward face adapted to be urged against the borehole wall and having at least a portion of an earth formation exploring means, and means pivotally interconnecting the first and second pad members. The first and second pad members may be pivotally interconnected about an axis substantially parallel with the borehole axis. The first pad member may be urged toward the borehole wall by a means connected to a support member adapted for movement through the borehole.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, the scope of the invention being pointed out in the appended claims.

Referring to the drawings:

FIG. 1 illustrates, partly in cross-section, a representative embodiment of borehole investigating apparatus constructed in accordance with the present invention;

FIG. 2 is an enlarged elevational view of the wall-engaging face of one of the electrode pads of the FIG. 1 apparatus; and

FIG. 3 is a cross-sectional view of the electrode pad of FIG. 2 taken along the section line 3—3 thereof.

Referring to FIG. 1 of the drawings, there is shown a representative embodiment of the downhole portion of an apparatus constructed in accordance with the present invention for investigating an earth formation 10 traversed by a borehole 11, the borehole 11 being filled with a conductive fluid or drilling mud 12. This apparatus includes an elongated support member 13 adapted for movement through the borehole 11. The support member 13 includes an upper instrument housing portion 14 of a generally cylindrical shape and having a hollow fluid-tight interior for enclosing certain downhole electrical circuits to be discussed hereinafter. The support member 13 also includes intermediate frame portion 15 in the form of an iron or steel I-beam and a lower nose portion 16 of generally cylindrical shape.

Supported from the intermediate I-beam portion 15 of the support member 13 on opposite sides thereof are a pair of electrode pad members 17 and 18, each of which is adapted to be urged against the wall of the borehole 11. The pad member 17 is supported by way of support arms 19 and 20 which are pivoted to both the pad member 17 and I-beam portion 15. Similarly, the pad member 18 is supported by way of support arms 21 and 22 which are pivoted to both the pad member 18 and I-beam portion 15. A suitable actuating mechanism for extending and retracting the support arms 19 and 21 is included within the lower portion of the instrument housing section 14.

Only the electrode pad member 17 will be dealt with in the explanation of the invention. The electrode pad member 18 can include any known type of electrode system, as for example, the electrode pad shown in FIG. 2 of U.S. Patent No. 2,712,629 granted to H. G. Doll on July 5, 1955. The length of electrode pad member 17 in a direction parallel to the borehole axis is somewhat greater than the width of electrode pad member 17. Considering the electrode pad member 17, best seen in FIGS. 2 and 3, the major portion is formed by a generally rec-

tangular pad portion A_1 of solid metal construction. This A_1 portion is made of an electrically conductive material such as iron and, as such, constitutes a focusing current electrode for emitting focusing current from the various surface portions thereof. This focusing current electrode A_1 includes a surface portion 23 located on the wall-engaging face thereof and as seen in FIG. 3, there is an insulating material 25, as for example rubber, covering at least a part of the back side thereof. As seen in FIGS. 2 and 3, the A_1 electrode has a recess 26 cut into a central portion of the wall-engaging face thereof which is of a rectangular shape. The recess 26 is coated with a suitable electrical insulation material 27 such as rubber.

Looking at FIG. 2, the metal pad member 17 also includes an elongated electrode A_0 of rectangular shape located concentrically inside of the recess 26 and electrically insulated from the A_1 electrode proper by the insulation material 27. The surface portion of the A_0 electrode is thus centrally located relative to the wall-engaging portion 23 of the A_1 electrode. This exposed surface portion A_0 constitutes a survey current electrode surface for emitting survey current into the adjacent earth formations.

The metal pad member 17 further includes a potential monitor electrode M located intermediate the survey current electrode A_0 and the focusing current electrode A_1 and electrically insulated from both the survey current electrode A_0 and the focusing current electrode A_1 by the insulation material 27. This potential monitor electrode M has an exposed surface portion of the narrow width which defines a path encircling the A_0 survey current electrode.

FIG. 3 shows the electrode pad 17 pressed against a mudcake 46 on the borehole wall and electrical connections to the electrodes A_0 and A_1 by way of insulated conductors 28, 29 and 30. The mechanical details of the electrical connections to the electrodes may take the form shown in Patent No. 3,132,298, supra. In FIG. 1, it can be seen that these insulated conductors 28, 29 and 30 pass upwardly through the hollow interior of the support arm 19 to electrical circuits contained within the instrument housing portion 14. Mechanical connections of the metal pad member 17 to the support arms 19 and 20 are made by way of lug members 31 and 32 respectively. The electrical continuity of the lug members 31 and 32 is broken by means of non-conductive inserts so that these members are electrically isolated from the electrodes.

As shown in FIG. 1, the downhole portion of the apparatus also includes a current return electrode B_1 located on the support member 13 close enough to the location of the pad member 17 so as to be electrically proximate thereto, but longitudinally spaced apart from the location of the pad member 17 so that no portion of this B_1 electrode is located directly behind the pad member 17. This B_1 current electrode is of generally cylindrical shape and is mounted on suitable electrical insulation material which either covers or forms the nose portion 16 of support member 13. Electrical connection to the B_1 electrode is made by way of an insulated conductor 40 which runs upwardly along the I-beam portion 15 to the instrument housing 14.

The downhole support member 13 is suspended in the borehole 11 by way of an armored multi-conductor cable 41 which extends upwardly to a suitable drum-and-winch mechanism (not shown), located at the surface of the earth for raising and lowering the support member 13. The first hundred feet or so of the cable 41 immediately above the instrument housing portion 14 is covered with a layer of electrical insulation material 42 such as rubber. Supported on this layer of insulation material 42 towards the upper end thereof are an electrically remote current return electrode B_0 and an electrically remote potential reference electrode N.

Turning now to the schematic electrical circuit diagram

portion of FIG. 3 of the drawings, the circuit portion contained within the dashline box 14 corresponds to the circuit portions that are located within the interior of the instrument housing portion 14 of FIG. 1. The circuits are constructed to maintain the potential level V_m of the monitor electrode M relatively constant with respect to a remote reference point and, at the same time, to maintain a substantially "zero" potential difference between the survey electrode A_0 and monitor electrode M to determine the formation resistivity characteristics by measuring the resulting variations in the magnitude of the survey current I_s emitted from the central A_0 electrode. Alternating current reference voltage V_r is supplied from source 81 to input transformer 82a of high current gain amplifier 82. Also supplied to the input transformer 82a of the amplifier 82 via conductor 29 is a signal representative of the potential V_m of the potential monitor electrode M. This voltage or potential signal V_m is supplied with like polarity to the side of the transformer 82a primary winding opposite from the reference voltage V_r side so that if the monitor electrode M is at a potential level equal to the reference voltage V_r , then the net input signal to the amplifier 82 is very nearly zero. If, on the other hand, the potential level V_m of the monitor electrode M differs from this V_r value, then the amplifier 82 input signal, which is in the nature of a degenerative feedback error signal, serves to adjust the amplifier output current I_f which is supplied to the A_1 electrode so as to bring the monitor voltage V_m back to the desired V_r value. Thus, the potential level of the monitor electrode M is kept substantially constant with respect to a remote reference point represented by electrode N.

In addition, the potential difference between the monitor electrode M and the A_0 survey current electrode is adjusted so as to be maintained at a value of substantially zero. To this end, the monitor electrode signal V_m is also supplied to an input transformer 83a of a high-gain amplifier 83. A signal representative of the potential level of the A_0 electrode is supplied to the opposite side of the primary winding of the input transformer 83a. This A_0 signal is supplied by way of conductors 30 and 85. Thus, if the M- A_0 potential difference is not substantially zero, then the error signal existing at the input of amplifier 83 serves to adjust the amplifier output current I_s which is supplied to the A_0 electrode by way of conductor 30 so as to establish this desired zero potential difference.

As the formation resistivity in front of the electrode pad 17 varies, differing amounts of survey current I_s will be required to maintain the M- A_0 potential difference at a zero value. The magnitude of this survey current required will be directly proportional to the electrical conductivity of the formation material. This indication is transmitted to the surface of the earth by means of a transformer 86 having a low impedance primary winding coupled in series between amplifier 83 and conductor 30 leading to the A_0 electrode. Thus, the voltage signal appearing across the secondary of transformer 86 is proportional to the I_s current flow and hence to the formation conductivity. This voltage signal is transmitted to a galvanometer unit 87 at the surface of the earth by way of cable conductors 88 and 89.

Instead of using the constant voltage circuit of FIG. 3, a constant current circuit such as shown in U.S. Patent No. 3,132,298, supra, could be used. As a further alternative, both the voltage and current may be varied and a suitable ratio circuit or device used for taking a ratio of voltage to current, or vice versa, for providing the desired output signal.

As seen in FIGS. 2 and 3 of the drawings, the pad member 17 also includes auxiliary pad members 73 flexibly attached to each side of the main body portion of pad 17. In FIG. 2 of the drawings, looking at either auxiliary pad member 73, it can be seen that each auxiliary pad member is rotatably connected to the main body portion of pad member 17. This connection is provided by a cylindrical pin member 71 and mating circular hinge members

70 and 72. Circular hinge member 70 is solidly connected to the main body portion of electrode pad member 17 in such a manner that circular hinge member 70 and the main body portion of electrode pad member 17 are non-flexible and non-rotatable with respect to each other. Circular hinge member 72 is solidly connected to auxiliary pad member 73 in such a manner that circular hinge member 72 and auxiliary pad member 73 are non-flexible and non-rotatable with respect to each other. Circular hinge members 70 and 72 are provided with cylindrical passageways which are adapted to receive the cylindrical pin member 71 in such a manner that either of circular hinge members 70 and 72 or both will be rotatable with respect to cylindrical pin member 71. This is accomplished by making the inside diameter of the passageway in the corresponding hinge member greater than the outside diameter of the pin member 71. Thus, it can be seen that auxiliary pad member 73 is rotatable with respect to the main body portion of pad member 17.

Spring 74 is wound around pin member 71 with the ends of spring 74 protruding outwardly along the backs of both the main body portion of pad member 17 and auxiliary pad member 73, so that the auxiliary pad member 73 will be continually pressed toward the inner surface of the borehole wall as shown in FIG. 3 of the drawings. The auxiliary pad members 73 on both sides of the main body portion of pad member 17 are connected in the same identical manner. Cylindrical pin member 71 and circular hinge members 70 and 72 are constructed of a suitable electrically conductive material so that there is an electrically conductive connection of low electrical resistance between auxiliary electrode pad members 73 and the main body portion of pad member 17. To facilitate movement of the borehole investigating apparatus downward through the borehole to the bottom of the borehole so as to begin logging, the pad member 17 could be disposed near the wall of the borehole to keep the auxiliary pad member 73 in an outwardly extending position for logging the borehole, or suitable projections could be placed on the hinge members 70 and 72 to stop rotational movement of the auxiliary pad member 73 at a specified angular position.

The focusing action of the invention can be seen in FIG. 3 of the drawings and is indicated by current flow lines I_s and I_f . Survey current electrode A_0 emits survey current I_s into the earth structure surrounding the borehole, which current diverges back to the current return electrode B_1 . This divergence of the survey current I_s back to the current return electrode B_1 becomes more severe where the mudcake 46 along the borehole wall is thick, in which case some of the survey current I_s will tend to flow through mudcake 46 to current return electrode B_1 . The focusing current I_f emitted from the focusing electrode A_1 directs the survey current I_s further into the earth structure surrounding the borehole. In other words, focusing current I_f sets up a potential gradient concentrically surrounding survey current I_s which maintains survey current I_s in a longitudinal flow away from the borehole, as shown in FIG. 3. Thus, the focused electrode system provides an improved measurement of resistivity of the invaded zone even where the mudcake is very thick.

The addition of adjustable auxiliary pad members 73 to the two sides of the main body portion of electrode pad 17, as shown in FIGS. 2 and 3 provides more accurate resistivity measurements under severe operating conditions, especially where the radius of curvature of the borehole may differ from the radius of curvature of the electrode pad. This is accomplished both by increasing the circumferential extent of the focusing electrode on the pad member 17 and by constructing the pad member 17 so that the entire electrode pad will more nearly conform to the curvature of the borehole wall. Thus, as seen in FIG. 3, the ends of the auxiliary pad members 73, shown at 75 in FIGS. 2 and 3, are pressed against the borehole wall at points circumferentially extended from

the edge of main pad member 17, shown at 24 in FIGS. 2 and 3, by a rather substantial distance. This, then, extends the focusing current electrode outwardly to keep the survey current from quickly diverging back to the borehole wall to be returned to the current-return electrode B₁.

Without the auxiliary pad members 73, the survey current I_s would extend laterally outwardly into the ground from survey electrode A₀, the focusing current from electrode A₁ causing the survey current to extend further into the ground than would be the case if there were no focusing current electrode. But, the focusing current near the edge 24 of electrode A₁ would diverge rapidly back into the borehole because of the absence of auxiliary pad members 73. This divergence would be especially acute where the mudcake is of appreciable thickness and the radius of curvature of pad 17 is less than the radius of curvature of the borehole, as shown in FIG. 3. Thus, as the focusing current diverges rapidly, so also does the survey current diverge rapidly.

However, with auxiliary electrode pads 73, even when the radius of curvature of the electrode pad 17 is less than that of the borehole, there is not a great divergence of the survey current I_s. Even though the end 24 of the main body portion of electrode pad 17 is spaced apart from the surface of the borehole wall, the edge 75 of auxiliary electrode pad 73 is touching the borehole wall. Thus, the amount of divergence of focusing current I_f from point 24 is reduced. Therefore, because the divergence of the focusing current I_f is reduced, the divergence of the survey current I_s is also reduced since the focusing current I_f is keeping the survey current I_s from diverging too much. Thus, the accuracy of the resistivity or conductivity readings will be improved when using auxiliary pad members 73. Some improvement will also be realized in the case where the radius of curvature of the borehole wall coincides with the radius of curvature of the electrode pad because of the added potential gradient from the current emitted by auxiliary electrode pads 73.

When the physical configuration of the electrode device is varied, the proportionality constant K of the device will vary. With the novel form of construction shown in FIGS. 2 and 3, it has been found that variations in K are relatively small. It has been further found that if the back side of the main body portion of pad member 17 and auxiliary pad members 73 are coated with insulating or non-conductive material, the variation of the proportionality constant K will be practically insignificant, over a wide range of positions for the angle of auxiliary pad members 73 with respect to the main body portion of pad member 17. Thus, when the back of auxiliary pad members 73 and the main body portion of pad member 17 are insulated, a single value of K can be utilized in determining the resistivity or conductivity of the adjoining earth over a wide range of radii of curvature of the borehole. This insulating material on the back of pad member 17 is designated as 25 in FIG. 3.

While there has been described what is at present considered to be a preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, intended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A pad structure for investigating earth formations traversed by a borehole comprising:
 - a first pad member having a forward face adapted to be urged against a borehole wall and having an earth formation exploring means;
 - a second pad member adjacent to said first pad member having a forward face adapted to be urged against a borehole wall and having at least a portion of an earth formation exploring means; and
 - means pivotally interconnecting said first and second pad members to pivot about a substantially fixed axis

relative to the pad members which axis is substantially parallel with the borehole axis so that the pad structure as a whole may more nearly conform to the curvature of a borehole wall.

2. A pad structure for investigating earth formations traversed by a borehole comprising:
 - a first pad member having a forward face adapted to be urged against a borehole wall and having an earth formation exploring means;
 - a second pad member adjacent to said first pad member having a forward face adapted to be urged against a borehole wall and having at least a portion of an earth formation exploring means; and
 - hinging means pivotally interconnecting said first and second members to pivot about a substantially fixed axis relative to the pad members which axis is substantially parallel with the borehole axis so that the pad structure as a whole may more nearly conform to the curvature of a borehole wall.
3. A pad structure for investigating earth formations traversed by a borehole comprising:
 - a first pad member having a forward face adapted to be urged against a borehole wall and having an earth formation exploring means;
 - a second pad member adjacent to one side of said first pad member having a forward face adapted to be urged against a borehole wall and having at least a portion of an earth formation exploring means;
 - a third pad member adjacent to the other side of said first pad member having a forward face adapted to be urged against a borehole wall and having at least a portion of an earth formation exploring means; and
 - means pivotally interconnecting said first pad member with said second and third pad members to move about axes substantially parallel to a borehole wall.
4. A pad structure for investigating earth formations traversed by a borehole comprising:
 - a first pad member having a forward face adapted to be urged against a borehole wall and having an earth formation exploring means;
 - a second pad member adjacent to said first pad member having a forward face adapted to be urged against a borehole wall and having at least a portion of an earth formation exploring means;
 - means pivotally interconnecting said first and second pad members; and
 - means for biasing the second pad member to rotate with respect to the first pad member so that the pad structure as a whole may more nearly conform to the curvature of the borehole wall.
5. Apparatus for investigating earth formations traversed by a borehole comprising:
 - a central support member adapted for movement through the borehole;
 - a first pad member having an earth formation exploring means;
 - means connected to the central support member for urging the first pad member against the wall of the borehole;
 - a second pad member adjacent to said first pad member having at least a portion of an earth formation exploring means; and
 - means pivotally interconnecting said first and second members to move about an axis substantially parallel to the central support member.
6. Apparatus for investigating earth formations traversed by a borehole comprising:
 - a support member adapted for movement through the borehole;
 - a first pad member having an earth formation exploring means;
 - means connected to the support member for urging the first pad member against the wall of the borehole;
 - a second pad member adjacent to one side of said first member having at least a portion of an earth formation exploring means;

- a third pad member adjacent to the other side of said first pad member and having at least a portion of an earth formation exploring means;
- hinging means pivotally interconnecting said first pad member with said second and third pad members; and means for biasing the second pad member to rotate with respect to the first pad member so that the pad structure as a whole may more nearly conform to the curvature of the borehole wall.
7. A pad structure for investigating earth formations traversed by a borehole comprising:
- a first pad member having a forward face adapted to be urged against a borehole wall;
 - a first electrode comprising at least a portion of said forward face;
 - a second pad member adjacent to said first pad member having a forward face adapted to be urged against a borehole wall;
 - at least a portion of a second electrode comprising at least a portion of said forward face of said second pad member; and
 - means pivotally interconnecting said first and second pad members to pivot about an axis substantially parallel with the borehole axis so that the pad structure as a whole may more nearly conform to the curvature of a borehole wall.
8. A pad structure for investigating earth formations traversed by a borehole comprising:
- a first pad member having a forward face adapted to be urged against a borehole wall;
 - a first electrode comprising at least a portion of said forward face, the opposite nonwall engaging face of said first pad member comprising an electrically nonconductive surface;
 - a second pad member adjacent to said first pad member having a forward face adapted to be urged against a borehole wall;
 - at least a portion of a second electrode comprising at least a portion of said forward face of said second pad member, the opposite nonwall engaging face of said second pad member comprising an electrically nonconductive surface; and
 - means pivotally interconnecting said first and second pad members to pivot about an axis substantially parallel with the borehole axis.
9. A pad structure for investigating earth formations traversed by a borehole comprising:
- a first pad member having a forward face adapted to be urged against a borehole wall;
 - a first electrode comprising at least a portion of said forward face;
 - second pad members adjacent to said first member having forward faces adapted to be urged against a borehole wall;
 - at least a portion of a second electrode comprising at least a portion of said forward faces of said second pad members;
 - hinging means pivotally interconnecting said first pad member with said second pad members; and
 - means for biasing the second pad members to rotate with respect to the first pad member so that the pad structure as a whole may more nearly conform to the curvature of a borehole wall.
10. Apparatus for investigating earth formations traversed by a borehole comprising:
- a support member adapted for movement through the borehole;
 - a first pad member having a forward face adapted to be urged against a borehole wall;
 - a first electrode comprising at least a portion of said forward face;
 - means connected to said support member for urging the first pad member against a borehole wall;
 - a second pad member adjacent to said first pad member

- having a forward face adapted to be urged against a borehole wall;
 - at least a portion of a second electrode comprising at least a portion of said forward face of said second member;
 - means pivotally interconnecting said first and second pad members; and
 - means for biasing the second pad member to rotate with respect to the first pad member so that the pad structure as a whole may more nearly conform to the curvature of a borehole wall.
11. Apparatus for investigating earth formations traversed by a borehole comprising:
- a support member adapted for movement through the borehole;
 - a first pad member having a forward face adapted to be urged against a borehole wall;
 - a first electrode comprising at least a portion of said forward face;
 - means connected to said support member for urging the first pad member against a borehole wall;
 - a second pad member adjacent to said first member having a forward face adapted to be urged against a borehole wall;
 - at least a portion of a second electrode comprising at least a portion of said forward face of said second member;
 - means pivotally interconnecting said first and second pad members to pivot about an axis substantially parallel with the support member;
 - circuit means for energizing the first electrode for emitting survey current into the adjoining earth formations;
 - circuit means for energizing the second electrode for emitting focusing current into the adjoining earth formations for confining the survey current from said first electrode to a desired flow pattern; and
 - circuit means for detecting an electrical parameter of the emitted survey current for providing an indication of an earth formation characteristic.
12. Apparatus for investigating earth formations traversed by a borehole comprising:
- a support member adapted for movement through the borehole;
 - a first pad member having a forward face adapted to be urged against a borehole wall;
 - a first electrode comprising at least a portion of said forward face;
 - a second electrode defining a path around the first electrode but electrically insulated therefrom;
 - a third electrode defining a path around the second electrode and electrically insulated from the first and second electrodes;
 - means connected to said support member for urging said first pad member against a borehole wall;
 - a second pad member adjacent to said first member having an electrically conductive forward face;
 - means pivotally interconnecting said first and second members and providing an electrically conductive connection between the conductive forward face of said second pad member and said third electrode; and
 - means for biasing the second pad member to rotate with respect to the first pad member so that the pad structure as a whole may more nearly conform to the curvature of a borehole wall.

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