This invention relates generally to apparatus for surveying the bottom of a tank, and more particularly to improvements in apparatus for determining elevations at selected locations on the bottom of a tank for the purpose of making a contour map and thereby ascertaining the shape of the tank bottom.

It is common practice in oil refineries and chemical plants to store materials such as asphalt and the like in large diameter upright cylindrical tanks provided with flat bottoms that are supported upon concrete foundations. The areas of a tank bottom spanning the underlying foundations sag somewhat under load, making periodic inspections and surveys of the tank bottom necessary. The shape of the tank bottom is determined, and from this it is possible to determine the stresses to which the tank bottom is being subjected. The apparatus utilized in making the survey preferably operates within the tank while the tank is loaded to capacity. It should be selectively positionable for successively scanning different areas of the tank bottom, and it should be provided with means for giving a visual indication of and identifying the point on the tank bottom being scanned. Accordingly, it is a general object of the present invention to provide improved apparatus for the purpose aforesaid.

An object of the present invention is to provide such apparatus including means operable for generating electric signals indicative of the tank bottom shape.

Another object of the present invention is to provide such signal generating means comprising condenser plate means mounted upon the apparatus for movement thereby over the tank bottom in close proximity thereto for scanning the same.

Yet another object of the present invention is to provide such signal generating means comprising condenser plate means connected in electric circuit with the tank bottom and mounted upon the apparatus for movement thereby over the tank bottom in close proximity thereto for scanning the same.

Other objects and advantages of the present invention will become more fully apparent, it being understood that the present invention consists substantially in the combination, construction, location and relative arrangement of parts, all as described in detail hereinafter, as shown in the accompanying drawings and as finally pointed out in the appended claims.

In the accompanying drawings:

Figure 1 is a vertical section of apparatus constructed in accordance with and embodying the principles of the present invention;

Figure 2 is a vertical section showing a modification of the apparatus constructed in accordance with and embodying the principles of the present invention;

Figure 3 is a wiring diagram of the electric system showing, in particular, elements which may be involved in securing the desired electric signals.

Referring particularly to Figure 1, the exemplary apparatus constructed in accordance with and embodying the principles of the present invention comprises a storage tank having a bottom 110 extending horizontally, a cylindrical wall 112 extending uprightly from the tank bottom 110 and a top 114 extending horizontally. The tank bottom 110 is supported upon a concrete foundation 116 under the central area thereof and a concrete foundation 118 under the marginal area thereof.

Centrally disposed within the storage tank is a tubular shaft 120, the lower terminal portion of which is revolvably journaled in a fitting 122 anchored to the tank bottom 110. An upper end portion of the tubular shaft 120 projects through the top 114 of the tank and is revolvably journaled in a fitting 124 secured to the top 114 of the tank.

Above the foot of the tubular shaft 120 is a member, generally designated 126, an intermediate portion of which is in the form of a sleeve 128. This member 126 is fitted over the shaft 120 through the medium of the sleeve 128, being rigidly secured thereto in any suitable manner. The opposite end portions of the member 126 are in the form of sleeves 130, which respectively receive the inner end portions of a pair of frame members 132 that extend horizontally outwardly from the shaft 120 in parallel laterally spaced relation to one another. The outer end portions of the frame members 132 are received respectively by a member generally designated 134, being rigidly secured thereto by any suitable means. The shaft means 136 interconnected these frame members provide a rigid carriage member or frame structure. For supporting the outer end portion of this frame structure the member 134 is suitably fitted with a wheel 136 operating upon the tank bottom 110 and disposed close to the upright tank wall 112, over the foundation 118.

The upper terminal portion of the tubular shaft 120 has fixed thereto a bevel gear 138 meshing with a companion bevel gear 140. The latter is fixed to the output shaft of a motor and change speed unit 142 supported upon a platform 144.

Carried by the tubular shaft 120 and extending upwardly in longitudinal continuation thereof is a rod 146 to which there is attached a pointer 148. Underlying the latter is an annular dial 150, stationarily mounted in any suitable manner. The position of the pointer 148 over the dial 150 indicates the position of the rigid frame structure within the tank.

Depending from longitudinally spaced portions of the rigid frame structure are a plurality of casing members 152 within each of which are housed certain elements of the electric system, as will appear hereinafter. Depending from the rigid frame structure are a plurality of insulated conductors each of which may take the form of a metallic plate 154 provided with a thin coat of an inert insulating material 156 such as Teflon. An inner group of these insulated conductors is closely associated respectively with the casing members 152, while an outer group is associated with the outermost portion of the rigid frame structure. All of the insulated conductors of both groups thereof are shown in Figure 3, but in Figure 1, to avoid confusion, while all of the insulated conductors of the inner group thereof are shown, only one of the insulated conductors of the outer group thereof is shown. All of these insulated conductors are suspended from the frame members 132 by means of hangers indicated at 158, thereby being disposed in the same horizontal plane, in close proximity to the tank bottom 110. It will be understood that the outer group of insulated conductors are all disposed directly over the concrete foundation 118.

Each plate 154 of the inner group thereof is provided with a conductor 160 extending into the associated casing 152. Each plate 154 of the outer group thereof is provided with a conductor 162 extending into one of the casings 152. A conductor 164 is connected to the top 114 of the tank, proximate the shaft 120, and...
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extends downwardly and then outwardly across the tank bottom 110 branching into each of the casings 152. Extending downwardly freely into the tubular shaft 120 are coaxial cables 20, 20' and 20". These cables pass freely through the wall of the shaft 120 and 166 and continue outwardly each into one of the casing members 152, as shown.

The electric system hereinafter may take the form of an electric system disclosed in the copending application of Elbert Nell Shawhan, Serial No. 449,437, filed August 12, 1954, which copending application describes, in connection with Figures 1, 2 and 3 of the drawing, an electric system comprising expansion joints, detecting and measuring circuits. Referring particularly to Figure 3 of the instant application, showing the signal generating circuit, it will be noted that the same numerals have been utilized, where applicable, as in the aforesaid copending application. It should be observed that all of the signal generating apparatus, except the condenser plates 154, is housed within the casing members 152, and that the tank is grounded. Reference may be had to the copending application aforesaid for the disclosure of details of construction and operation of the electric system not hereinbefore.

Each plate 154 of the inner group thereof is disposed over a tank bottom area that is subject to sagging under load. The plate serves as one of the plates of a test capacitor C1, while the underlying area of the tank bottom 110 serves as the other plate of the test capacitor C1. Each plate 154 of the outer group thereof is disposed over an area of the tank bottom 110 that cannot sag, i.e., as noted hereinbefore, an area adjacent the cylindrical tank wall 112, over the foundation 118. The plate serves as one of the plates of a reference capacitor C0, while the underlying area of the tank bottom 110 serves as the other plate of the reference capacitor C0. It will be appreciated that the capacitance at a given plate 154 will depend upon the vertical spacing between that plate 154 and the tank bottom area immediately thereabovetherein, in consequence of which the several capacitances C1 may be different from one another and from the reference capacitance C0, which latter is the same at each plate 154 of the outer group thereof.

Operation of the electric system as described in the copending application aforesaid, the differences between the several capacitances C1 and the reference capacitance C0 may be measured with a high degree of accuracy thereby to obtain an indication of the shape of the tank bottom thereon in either direction. For shifting the casing member 152, a cable section 200 is secured by one end thereof to the casing member and trained under a pulley 202 depending from the frame structure, project back the tank bottom shape at each of said positions, the operator may draw a contour map of the tank bottom and determine the degree to which it has sagged under load and the stresses to which it is being subjected under load.

Now referring to Figure 2, the exemplary modified apparatus constructed in accordance with and embodying the principles of the present invention is similar in construction and operation to that already described, except as indicated hereinbefore. Wherefore applicable, the same numerals have been applied to corresponding parts of the two exemplary embodiments.

In the modified form of the invention, a single casing member 152 is mounted, by means not shown, upon the rigid frame structure for shifting movement longitudinally thereof in either direction. The casing member 152, being then extended upwardly with the cable section 200 freely through the guide brackets 206 and the tank top 114. It will be apparent that the casing member 152 may be positioned as desired along the length of the frame structure by manipulation of the cable sections 200 and 208.

One plate 154 is mounted, as by a member indicated at 214, for movement with the casing member 152, and the conductor 160 extends from this plate into the casing member 152. The conductor 162 extends from the other plate 154 freely through a tubular standard 216 that is mounted upon the frame structure for movement therewith, extends to a second standard 218 that is mounted upon the casing member 152 for movement therewith, and then freely therefrom and into the casing member 152. The conductor 164 extends from the top 114 of the tank to the standard 218, and then freely therefrom and into the casing member 152. The coaxial cable 20 passes freely through the wall of the shaft 204 at 220, from whence it extends to the standard 216, freely therefrom and into the casing member 152.

The electric system for this modified form of the invention may be essentially the same as that hereinbefore as being suitable for the form of the invention illustrated in Figure 1. However, only one sensing or signal generating circuit is utilized. The cable sections 200 and 208 may be manipulated to selectively shift the casing member 152 and the plate 154 and standard 218 mounted upon the member 152 as a unit longitudinally of the frame structure, sufficient slack being provided in the conductors 162, 164 and the coaxial cable 20 to accommodate this movement. The plate 154 mounted upon the casing member 152 and the underwater tank bottom area serve as the plate of the test capacitor C1, while the other plate 154 and the underlying tank bottom area serve as the plates of the reference capacitor C0. The shape of the tank bottom 112 at the location being scanned may be determined by repeatedly operating the electric system, the casing member 152 being in a predetermined different position for each operation.

Further details of the construction and operation of this modified form of the invention are omitted as being unnecessary for a full understanding of the present invention. It will be understood, of course, that the present invention as hereinbefore described and as shown in the accompanying drawings is susceptible of various changes and modifications which may be made from time to time without departing from the general principles or real
spirit of the invention. For example, while, in the form of the invention illustrated in Figure 1, three casing members 152 are shown more or fewer than three could be utilized. In addition, while the reference condensers are shown mounted on the outer end of the frame structure, they could be mounted proximate the center of the tank, over the foundation 116. Furthermore, it may be impossible because of temperature or other reasons to have that part of the electric system shown and described as being housed in the casing 152 in the tank. In this event, the part of the electric system aforesaid may be housed outside of the tank, for example, on the top 114. Still further, while in the exemplary embodiments of the apparatus shown and described scanning is effected through the medium of electrical capacity, scanning may be effected through the medium of other means. For example, sound waves, mechanical or electrical contact feelers or inductance could be utilized.

What is claimed is:

1. In combination, a tank having a horizontally extending bottom rigidly supported in only a portion of its total area and subject to sagging in the unsupported portion of its area; at least one electrode disposed in superposed spaced relation to the tank bottom in the unsupported portion of its area, means connecting said tank bottom and said electrode in electrical circuit thereby to make said electrode one plate of a test condenser and said tank bottom the other plate of said test condenser, another electrode disposed in superposed spaced relation to the tank bottom in the supported portion of its area, means connecting said tank bottom and said other electrode in electrical circuit thereby to make said other electrode one plate of a reference condenser and said tank bottom the other plate of said reference condenser, means connected in circuit with said test and reference condensers for indicating the difference between the capacitance of said test condenser and the capacitance of said reference condenser, and means for moving said one electrode over the unsupported portion of said tank bottom successively to predetermined different positions for scanning the same.

2. The combination defined in claim 1, including also a plurality of electrodes similar to said one electrode and each forming with said tank bottom a respective test condenser; the moving means including a horizontally extending elongated carriage member upon which the plurality of electrodes are fixedly mounted, in longitudinally spaced relation to one another.

3. The combination defined in claim 1, wherein the moving means includes a horizontally extending elongated carriage member upon which said one electrode is mounted so as to be selectively positionable along the length of said carriage member.

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