

Jan. 10, 1939.

F. L. WALLACE
 APPARATUS FOR INDICATING AND RECORDING CONTOURS
 OF INTERIOR SURFACES OF TUBES
 Filed Dec. 21, 1937

2,143,233

3 Sheets-Sheet 1

FIG. 1.

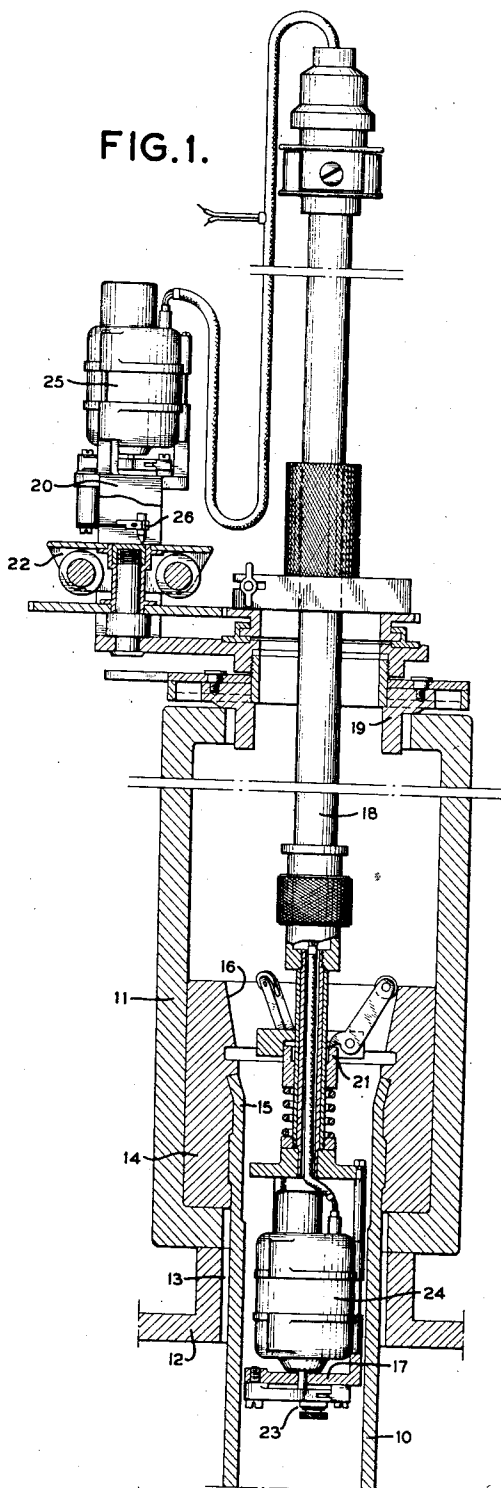


FIG. 4.

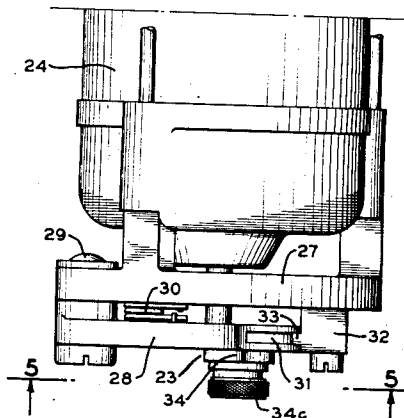
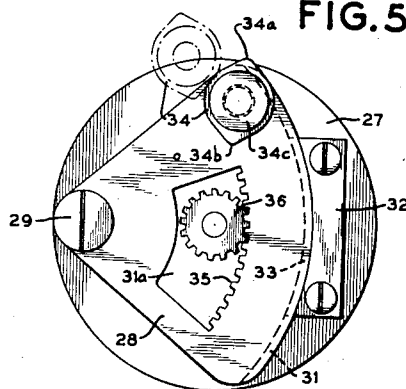


FIG. 5.



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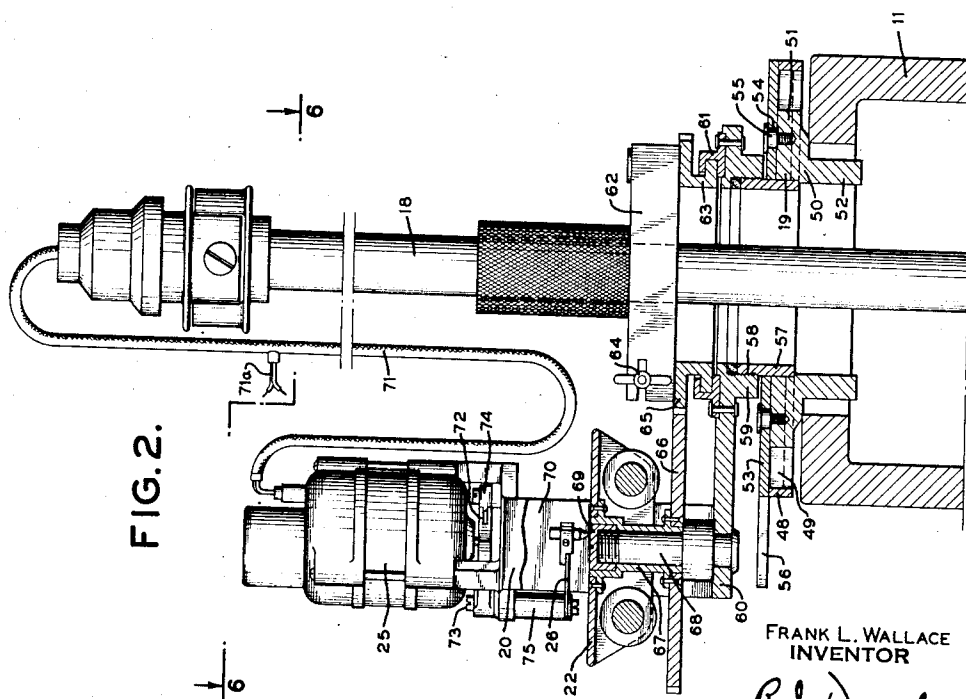
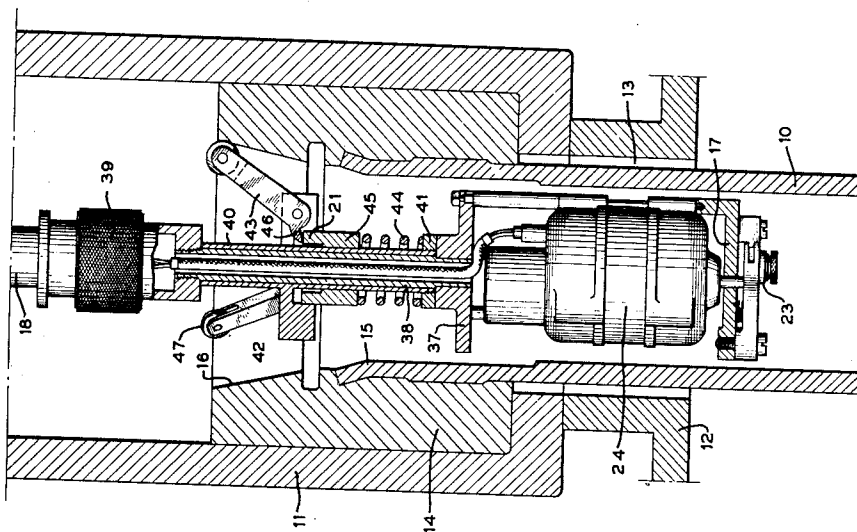
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FIG. 6.

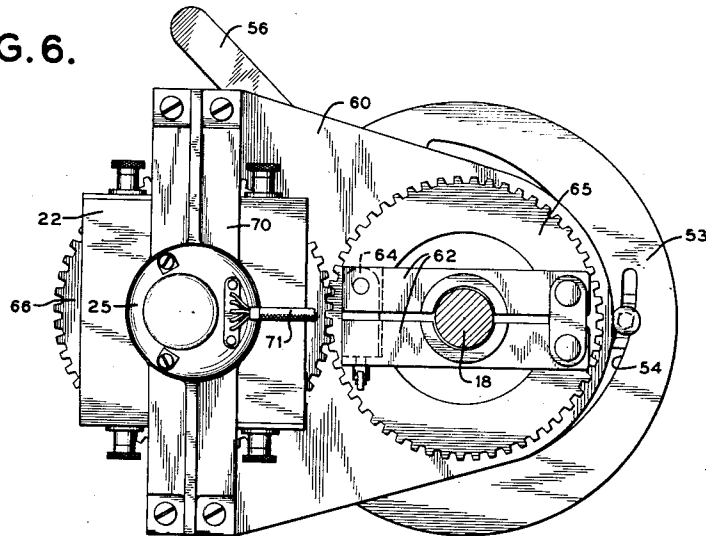


FIG. 7.

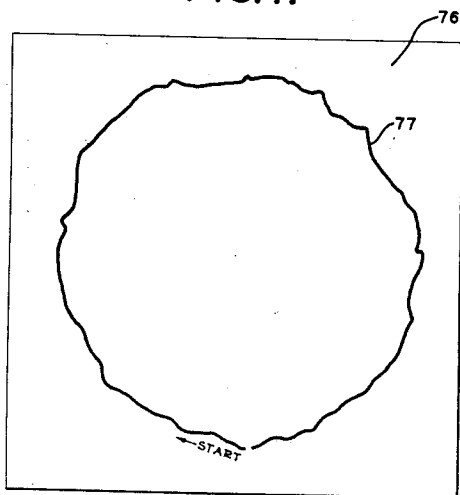
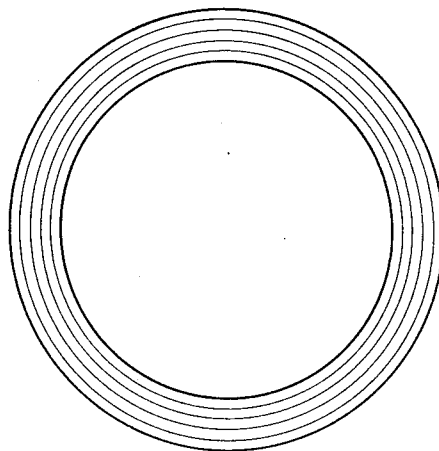


FIG. 8.



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UNITED STATES PATENT OFFICE

2,143,233

APPARATUS FOR INDICATING AND RECORD-
ING CONTOURS OF INTERIOR SURFACES
OF TUBES

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Application December 21, 1937, Serial No. 180,974

5 Claims. (Cl. 33—23)

This invention relates to apparatus for indicating and recording the contour of the interior surfaces of tubes, and concerns particularly an apparatus adapted to indicate and re-
5 produce, in cross section, the exact contour of the interior surfaces of a tube or similar article at a point located at any distance from the ends thereof. The apparatus of the invention is particularly useful for determining the contour of
10 the interior surfaces of tubes used in tube stills for cracking oil.

As is known in the oil refining art, the oil to be processed is introduced into a series of relatively long tubes suitably joined together to form a tortuous conduit of relatively great length. Throughout a substantial portion of this conduit the oil is subjected, under considerable pressure, to relatively intense heat from a furnace. Under the working conditions, with the high temperatures on one side of the tube and the pressure of the oil on the other side, together with the reacting components contained in the oil, the tubes are subjected to what is generally conceded to be relatively severe service. In practice the
20 tubes have a tendency to swell or to be pitted and eaten away at certain points due to erosion, chemical action or for other reasons. It is of course readily appreciated that the failure, under operating conditions, of a tube with the consequent releasing of the pressure and of the contained oil into the furnace is a serious matter. Accordingly, all precautions are usually exercised which are possible to avoid such an occurrence and, in this connection, the furnaces are shut
25 down periodically and the tubes examined. Heretofore the inspector has been compelled to confine his observations substantially to those tubes which could be visually inspected from the outside inasmuch as there has been no known instrument available for measuring and recording the contour of the interior surfaces of the tubes throughout their length. In this connection it is to be pointed out that the tubes are usually several
30 feet in length, in some instances extending for lengths of from 5 to 30 feet.

While I shall describe the apparatus of the invention in connection with its use for determining the contour of the interior surfaces of tubes used in tube stills for cracking oil, it will be understood that the apparatus may be used also for many other purposes.

In the oil fields the device can be used for caliper slush pump liners, as a reading can be
35 obtained which can not be obtained by hand

caliper with any reasonable expenditure of time.

The device can be used to caliper oil well liner pump barrels to determine whether they should be reworked or not. It can also be used on the
40 plunger barrel to determine what repairs are necessary.

Tubular goods used in drilling, such as kellys, drill collars and drill pipe, can be checked by this device to determine whether any large amount
45 of fluid cutting has occurred either during regular drilling or during a short blow-out.

The device can be used in internal upset drill pipe, for checking up on the condition of the pipe just below the upset. No satisfactory means for doing this has been available heretofore.

In accordance with the invention the apparatus includes a detecting and transmitting device adapted to be inserted in the tube to be measured and an indicating and recording device
50 which ordinarily is situated outside the tube. The detecting device is adapted to be rotated within the tube and includes a tracing unit which is adapted to engage and trace the contour of the interior surface of the tube as the detecting device is rotated. It also includes the transmitting motor of a pair of Selsyn motors. The tracing device actuates the shaft of the motor so that the shaft is deflected slightly by any irregularities in the contour of the interior surfaces of the
55 tube.

The recording device includes the receiving or indicating motor of the pair of Selsyn motors. The Selsyn motors operate on the principle of magnetic linkage, a deflection of the rotor of one motor producing an exact deflection in the rotor of the connecting motor both as to degree and direction. Thus, any deflections in the shaft of the transmitting motor are communicated to the shaft of the receiving motor, which is correspondingly deflected. The shaft of the receiving motor actuates a pen arm and any deflections in that shaft are recorded on a chart by means of the pen arm. The chart is rotated automatically at the same speed as the detecting device is rotated, so that the record on the chart corresponds exactly to the contour of the interior surfaces of the tube being examined.

The invention will be better understood from the following description and the accompanying drawings. Referring to the drawings:

Figure 1 is a view in elevation, partly in section, of apparatus embodying this invention.

Figure 2 is a view on an enlarged scale of the

apparatus shown in the upper portion of Figure 1.

Figure 3 is a view on an enlarged scale of the apparatus shown in the lower portion of Figure 1.

Figure 4 is a view on a still larger scale of the tracing apparatus shown in the lower portion of Figure 3.

Figure 5 is a plan view taken on the line 5—5 of Figure 4.

Figure 6 is a plan view taken on the line 6—6 of Figure 2.

Figure 7 is a tracing of an actual recording showing the contour of a heating tube, which tracing was made with apparatus substantially as described herein.

Figure 8 is a chart which may be used as a guide for comparing the contour of the tube examined with that of a tube having the desired dimensions.

Referring to Figure 1, the apparatus is shown fully assembled and in position for recording the contour of the interior surfaces of a heating tube. A portion of a heating tube 10 is shown, this tube being represented as situated in a heater in which the heating tubes thereof are positioned vertically. A return bend fitting 11, which ordinarily is used for securing the end of the tube 10 to a U-bend, rests upon and is supported by a tube sheet 12. The return bend fitting 11 is provided with an insert or collar 14 in which the end of the tube 10 is secured by upsetting the tube as at 15, and which is tapered as at 16 to engage the tapered portion of a U-bend.

A detecting and transmitting unit indicated generally as at 17 is shown inserted in the tube 10, this unit being rigidly secured to a pipe 18, which in turn is supported by a clamping device 19. The clamping device 19 is secured to the upper portion of the return bend fitting 11 and will be described more in detail hereinafter. A recording device shown generally as at 20 is supported by the clamping device 19. The detecting unit 17 is additionally supported in the tube 10 by a centering device 21 which engages the walls of the tube 10 and provides a bearing for the pipe 18. The clamping device 19 permits the unit 17 and the pipe 18 to be advanced within the tube 10 so that additional examinations may be made.

The arrangement is such that the unit 17 may be rotated in the tube 10, by rotating the pipe 18 to which it is secured. A chart holder 22 is connected by means of gears to the pipe 18, so that it will be correspondingly rotated upon rotation of the pipe 18. The detecting unit 17 includes a tracing device 23 which is adapted to trace the contour of the interior surfaces of the tube 10 as the unit 17 is rotated. The unit 17 also includes the transmitting motor 24 of a pair of Selsyn motors and the tracing device 23 actuates the shaft of the motor so that said shaft is deflected or rotated slightly by any irregularities in the contour of the tube 10. The recording device 20 includes the receiving motor 25 of said pair of Selsyn motors. The stators of the two motors 24 and 25 are connected together electrically and the rotors are energized by an alternating current voltage in a manner well known to those familiar with self-synchronous motors. Any deflections in the shaft of the transmitting motor 24 are thus communicated to the shaft of the receiving motor 25 which is deflected in exactly the same way. The shaft of the receiving motor 25 actuates a pen arm 26 and any deflections in the shaft of the motor 25 are recorded

by the pen arm on a chart which is held by the chart holder 22.

Referring to Figures 4 and 5, a bracket 27, which is rigidly secured to the lower end of the transmitting motor 24, supports the tracing device 23. The latter device includes a tracing arm 28 which is secured to the bracket 27 by means of a pin 29, the pin 29 forming a pivot about which the tracing arm 28 may be rotated. A spring 30 shown in Figure 4 attached to the bracket 27 and arm 28 forces the tracing arm outwardly, or upwardly as viewed in Figure 5, against the walls of the tube 10. The tracing arm 28 is shown as generally triangular in shape and the side thereof opposite the pin 29 is preferably curved and provided with a groove 31. A slot 31a is also formed in the arm 28. A guide 32 is rigidly secured to the bracket 27, this guide having a curved side adjacent the tracing arm 28, and being provided with a tongue 33 which engages the groove 31 in the tracing arm 28. The guide 32 thus assists in supporting the tracing arm 28 during rotation thereof. A contact member 34, which is adapted to engage the walls of the tube 10, is secured to one edge or corner of the tracing arm 28. The contact member 34 is shown as a small plate pivotally mounted on the arm 28 and having two points 34a and 34b. In case one point becomes worn, the plate can be turned by means of a thumb nut 34c so as to bring the other point into proper position. A gear segment 35 is secured to or formed on the tracing arm 28 on the side of the slot 31a opposite the pin 29. The gear segment 35 engages a pinion gear 36 which is secured to the shaft of the transmitting motor 24 and which projects into the slot 31a.

In operation, the detecting and transmitting unit 17, including the transmitting motor 24 and the tracing device 23, are slowly rotated by hand through 360 degrees in the tube 10. The point 34a on the tracing arm 28 follows the contour of the interior surfaces of the tube during the rotation of the unit 17. Since the gear segment 35, which is secured to the tracing arm 28, engages the pinion gear 36, the shaft of the transmitting motor 24 which is secured to the pinion gear 36 is thereby deflected slightly according to any irregularities in the contour of the tube 10.

Referring now to Figure 3, a ring-shaped member or bracket 37 is rigidly secured to the upper side of the transmitting motor 24, this bracket being rigidly secured also to a pipe 38 which is an extension of the pipe 18. The pipe 38 is relatively short and is connected to the pipe 18 by a pipe coupling 39.

The centering device 21 includes a sleeve 40 which surrounds the pipe 38. The sleeve 40 is threaded at the lower end thereof to receive a collar and, as shown in the drawings, the collar 41 abuts the ring-shaped bracket 37. The sleeve 40 is provided with an annular extension 42, and slots are formed in this extension adapted to receive the ends of a plurality of fingers 43 which are spaced radially about the member 42 and pivoted upon pins which are disposed horizontally in said slots.

A spring 44 surrounds the sleeve 40 and is retained by the collar 41 and exerts pressure against a collar 45 which likewise surrounds the sleeve 40 but is longitudinally movable thereon. The collar 45 engages cams 46 which form a part of the fingers 43, thereby forcing said fingers outwardly against the walls of the tube 10. The fingers 43 are provided with rollers 47 which

engage the walls of the tube 10, these fingers thus serving to maintain the detecting device centered in the tube, the contour of which is to be recorded.

Referring to Figures 2 and 6, the clamping device 19 includes a lower disc-shaped member 48 in which a plurality of radially disposed channels 49 are formed. The channels 49 are adapted to receive clamping dogs 50. The clamping dogs are provided with shoulders 51 which engage the walls of the channels 49 so that said dogs are slidable in said channels, and depending portions 52 which are adapted to engage the upper portion of the return bend fitting 11 when said dogs are expanded outwardly in said channels. The clamping device 19 also includes an upper disc-shaped member 53, this member being provided with curved slots 54 adapted to receive pins 55 secured to the clamping dogs 50. Upon rotation of the disc-shaped member 53 the slots 54 expand the dogs 50 outwardly in the channels 49, into engagement with the upper portion of the return bend fitting 11. The disc-shaped member 53 is provided with a handle 56 which may be used for rotating it.

An upwardly extending nipple 57 is secured to the disc-shaped member 48, this nipple being threaded at 58 to receive a collar 59. A horizontal extension 60, which is used to support the recording device 20, is secured to the collar 59. A ring-shaped bearing member 61, which is used to support the pipe 18 so that it may be rotated, also is secured to the collar 59.

A pair of clamping members 62, shown more clearly in Figure 6, which may be quickly fastened around the pipe 18 and easily disengaged therefrom, are used to support the pipe 18 so that said pipe may be advanced into the tube 10. The clamping members 62 are pivoted at one side to bolts which secure them to an annular member 63. The member 63 is adapted to be rotated in the bearing member 61 and a hinged bolt 64 is used to fasten the clamping members 62 around the pipe 18.

A gear 65 is secured to or formed on the annular member 63. The gear 65 is used, together with a second gear 66 which is secured to the chart holder 22, to rotate said chart holder when the pipe 18 is rotated. The chart holder 22 and the gear 66 are secured to opposite ends of a sleeve 67, this sleeve 67 surrounding and adapted to be rotated upon a vertical pin 68. The pin 68 is secured to the horizontal extension 60 and has a shoulder which provides a bearing for the lower end of the sleeve 67. The pin 68 is threaded to receive a nut 69 which secures the sleeve 67 against removal from said pin.

A bracket 70 which is in the form of an inverted U and which straddles the chart holder 22 is supported upon extension 60 and in turn supports the recording unit 20. The recording unit 20 is in many respects similar to the detecting and transmitting unit 17, above described. The receiving motor 25 is supported directly upon the bracket 70 and is connected to the transmitting motor 24 by a flexible cable 71 which passes through the pipe 18. A branch 71a of the cable 71 may be connected to a suitable source of alternating current to energize the rotor windings of the motors 24 and 25. The receiving motor 25 is provided at the lower end thereof with a pinion gear (not shown) which is similar to the pinion gear 36 of the detecting unit. The pinion gear engages a gear segment which is

similar to the gear segment 35 of the detecting unit, thereby actuating a member 72 which corresponds to the tracing arm 28 of the detecting and transmitting device. The member 72 is rigidly secured to a pin 73, and travels in a guide 74, the guide being secured to the bracket 70. The pin 73 extends downwardly through a bearing 75 which is formed in the bracket 70 and is rigidly secured at its lower end to the pen arm 26.

It is believed that the operation of the apparatus will be clear from the foregoing description. However, in summarizing, the detecting and transmitting unit 17 is placed in the tube, the inner contour of which is to be recorded, and the clamping device 19 is adjusted so that the tracing arm 28 will be at the proper distance from the end of the tube. A blank chart such as is shown at 76 in Figure 7 is secured to the chart holder 22 and the pen arm 26 adjusted to make contact with the chart. The unit 17 is then rotated slowly by turning the pipe 18 through 360 degrees. The tracer point 34a will follow the interior surface of the tube and through the arm 28 and the gearing 35 and 36 will cause the rotor of the motor 24 to be deflected or rotated slightly in accordance with any irregularities in the contour of the tube surface being examined. Due to the magnetic linkage between the motors 24 and 25, the pen arm 26 will move on the chart at the same time and to the same extent as the tracer arm 28 is moved. Because of the gearing connection 65 and 66 the chart holder 22 will revolve simultaneously with the detecting unit and the tracing 77 of the pen on the chart will therefore coincide exactly with the interior surface of the tube being examined.

Figure 7 represents an actual tracing showing the cross-section of a tube which has undergone spotty corrosion. The chart 76 on which the section of the tube calipered is recorded may be made of transparent paper, thus making it possible to superimpose the contour 77 of the tube on the master chart for that particular size tube such as is shown in Figure 8, thus by comparison the extent of pitting or corrosion of the interior tube surface will be clearly indicated.

As has been stated hereinbefore, it is to be understood that this apparatus is not limited to use in examining the interior surfaces of still tubes. The interiors of various kinds of holes may be readily studied in a similar manner since it is merely necessary to clamp the shaft supporting the detecting and transmitting unit in proper position within the hole to be examined.

Obviously many modifications and variations of the invention may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated by the appended claims.

I claim:

1. An apparatus for indicating the contour of the interior surface of a tube, comprising a detecting unit adapted to be positioned and rotated within the tube, said detecting unit including one of a pair of electrical self-synchronous motors, a tracer arm connected to the rotor shaft of said motor and adapted to engage and follow the interior surface of said tube as the motor is rotated in the tube, an indicating unit including the second of a pair of self-synchronous motors, said second motor being rigidly mounted exteriorly of said tube, and an indicating arm secured to the rotor of said second motor, said pair of motors

being electrically interconnected so that as said detecting device is rotated within the tube, deflection of said tracer arm will produce corresponding deflections of said indicating arm.

5 2. An apparatus for indicating the contour of the interior surface of a tube, comprising a detecting unit adapted to be positioned and rotated within the tube, said detecting unit including one of a pair of electrical self-synchronous motors,
10 a tracer arm connected to the rotor shaft of said motor and adapted to contact with and follow the interior surface of said tube as the motor is rotated in the tube, an indicating unit including the second of the pair of self-synchronous motors, said
15 second motor being rigidly mounted exteriorly of said tube, a chart holder having a chart affixed thereto, gearing between said chart holder and said detecting unit for rotating said chart holder in synchronism with the rotation of said detecting unit, a pen arm secured to the rotor of said
20 second motor and in contact with said chart, said pair of motors being electrically interconnected so that as said detecting device is rotated within the tube, deflection of said tracer arm will produce corresponding deflections of said pen arm so
25 as to trace on said chart the interior contour of said tube.

3. An apparatus for indicating the contour of the interior surface of a tube, comprising a detecting and transmitting unit adapted to be positioned and rotated within the tube, said detecting and transmitting unit comprising one of a pair of electrical self-synchronous motors, a pipe member secured to said motor and adapted to support said motor in operative position within
35 the tube, means for clamping said pipe member to said tube so that the pipe and motor may be rotated with respect to said tube, means cooperating with said clamping means for maintaining said pipe and motor concentric with respect to
40 said tube, a tracer arm connected to the rotor shaft of said motor and adapted to engage and follow the interior surface of said tube as the motor is rotated in the tube, an indicating unit including the second of a pair of self-synchronous
45 motors and an indicating arm secured to the rotor of said second motor, said pair of motors being electrically interconnected so that as said detecting and transmitting device is rotated within the tube, deflection of said tracer arm will produce
50

corresponding deflections of said indicating arm.

4. An apparatus for indicating the contour of the interior surface of a tube comprising a pair of electrical self-synchronous motors, electrical connections between said motors so that as the rotor of one motor is rotated, the rotor of the other motor will be correspondingly rotated, a tracer arm secured to the rotor of the first motor and an indicating arm secured to the rotor of the second motor, means for supporting said first motor within and concentrically of the tube with said tracer arm engaging the interior surface of the tube, and means for rotating said first motor within the tube while said tracer arm follows the interior contour of the tube, the arrangement being such that as said first motor is rotated movements of said tracer arm caused by irregularities of the interior surface of the tube will cause deflections of the rotor of said first motor and said rotor deflections will cause corresponding deflections of the rotor and indicating arm of the second motor.

5. An apparatus for indicating the contour of the interior surface of a tube comprising a pair of electrical self-synchronous motors, electrical connections between said motors so that as the rotor of one motor is rotated, the rotor of the other motor will be correspondingly rotated, a tracer arm secured to the rotor of the first motor and an indicating arm secured to the rotor of the second motor, means for supporting said first motor within and concentrically of the tube with said tracer arm engaging the interior surface of the tube, and means for rotating said first motor within the tube while said tracer arm follows the interior contour of the tube, means for rigidly supporting said second motor exteriorly of said tube, a marking device secured to said indicating arm, a chart holder having a chart affixed thereto and adapted to be contacted by said marking device, gearing between said chart holder and the supporting means for the first motor so that said chart holder and chart will be rotated in synchronism with said first motor whereby movements of said tracer arm caused by irregularities in the inner surface of said tube will be transmitted to the indicating arm of said second motor to cause said marking device to trace on said chart the interior contour of said tube.

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