March 31, 1959 P. E. CHANEY ET AL 2,879,604

TUBE CALIPERING APPARATUS

Filed Jan. 17, 1956 3 Sheets-Sheet 1

Fig. 1

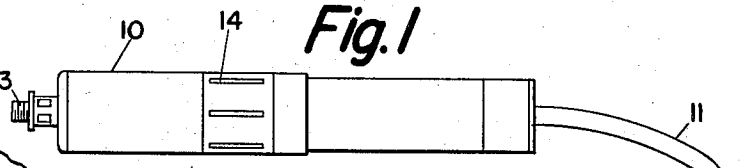


Fig. 2

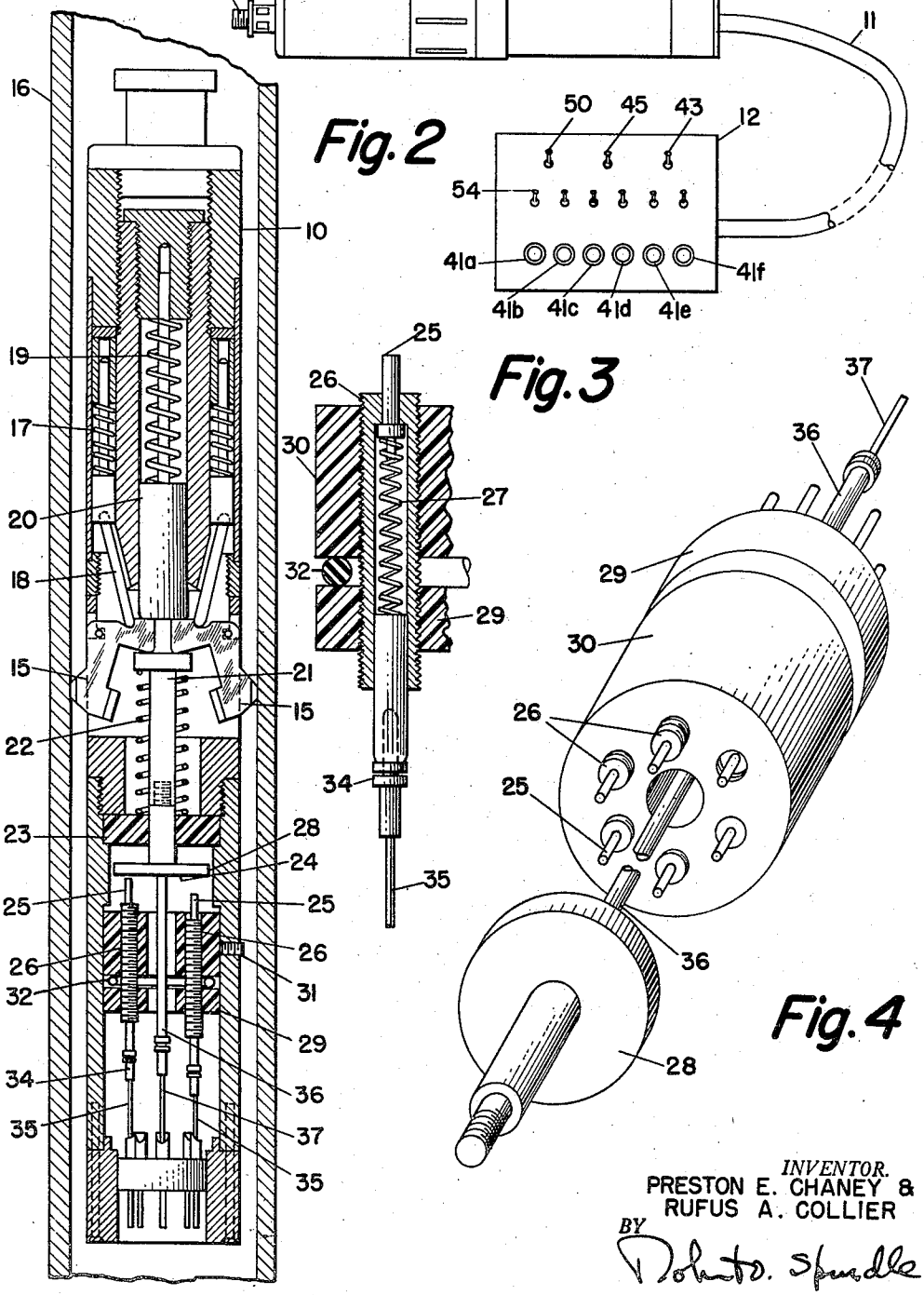


Fig. 3

Fig. 4

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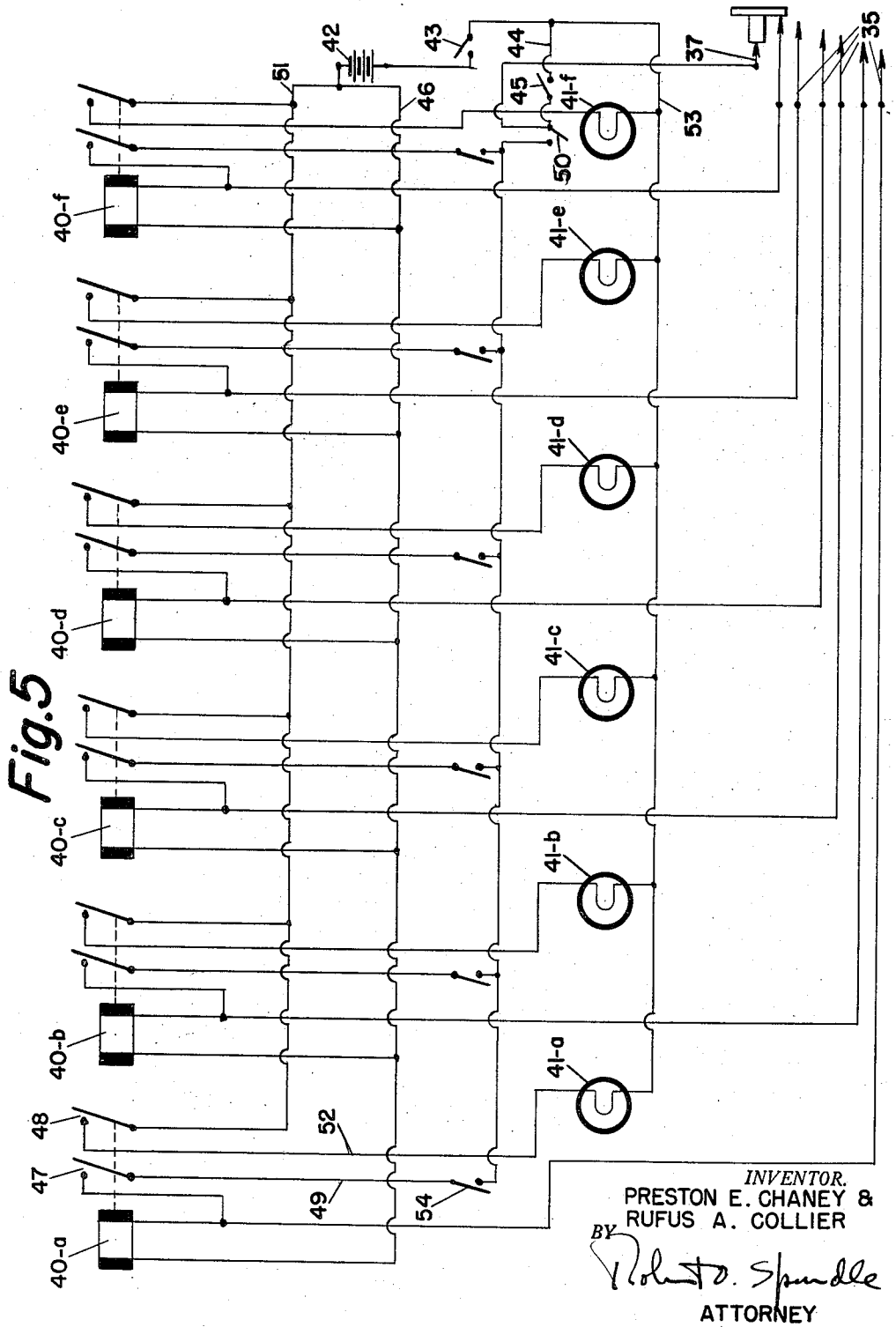


Fig. 5

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Fig. 6

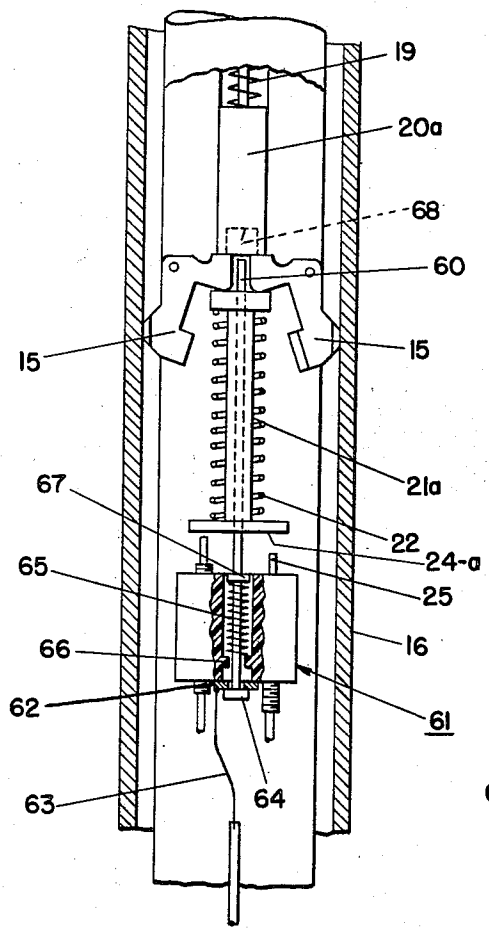
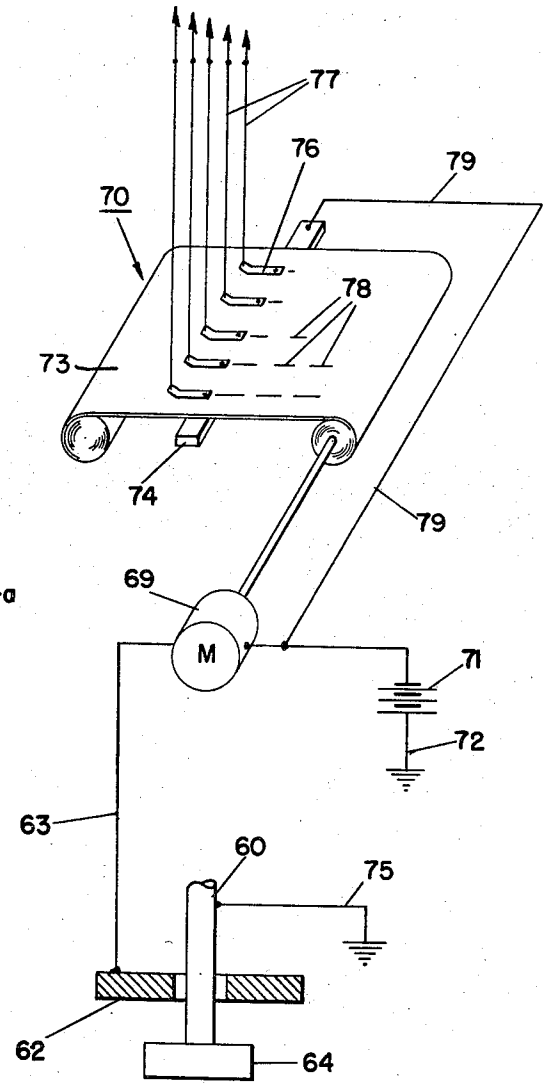


Fig. 7



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TUBE CALIPERING APPARATUS

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Application January 17, 1956, Serial No. 559,616

7 Claims. (Cl. 33—178)

This invention relates to a tubing caliper and more particularly to calipering apparatus for determining deviations in the internal radius of tubing.

Tube calipering apparatus provided by the present invention is adapted particularly for use in inspecting and grading oil field tubing, but it is also useful for calipering other tubular goods such as pipe still tubes, heat exchanger tubes and the like.

In oil field use well tubing is often subjected to corrosive conditions, with the corrosion generally occurring in the form of pitting of the inner surface of the tubing. Also, scoring and wearing of the internal tube surfaces may occur due to the passage of well tools through the tubing and erosion by solid matter in the well fluids. When the tubing is pulled from a well, it is common practice to inspect the joints on the pipe rack and grade the tubing according to the depth and degree of corrosion or wear that has occurred. What the tube joints are subsequently used for depends upon how they are graded or classified.

The most common practice in examining oil field tubing for the purpose of grading it heretofore has involved the use of a device which is drawn through the tubing on the rack and which permits a visual inspection of the internal surfaces. This method has the drawback that it fails to provide any real measurement of the ranges of pit depth in the tubing. Based upon the visual inspection the operator merely guesses at the depths of pitting observed and then grades the tubing according to his opinion as to the severity of corrosion. Generally a substantial safety factor is applied, with the result that tube joints which might well be classified as of a relatively good grade instead are classified as of lower quality. Tubing thus misgraded will have a lower value than it properly should, with resultant loss to the well owner. For example, tubing actually of a grade suitable for use as low pressure piping may be given the lowest quality classification so that it will have the low value of scrap metal.

The present invention provides calipering apparatus which determines the depth of tube corrosion or scoring within various predetermined ranges as desired and which thus eliminates guessing by the operator in the inspection and grading of tubing. The invention is more fully described in conjunction with the accompanying drawings in which:

Fig. 1 shows the general arrangement of one form of apparatus including the calipering tool and an electrically operated indicator;

Fig. 2 is a sectional view showing an embodiment of the calipering tool positioned within a tube;

Fig. 3 is a detailed view, partly in section, showing

one of the contact members which is positioned within the calipering tool for making an electrical contact when a pit of predetermined depth is encountered in the tubing;

Fig. 4 is a perspective view of the contact member assembly showing the arrangement of the several contact members;

Fig. 5 is a wiring diagram showing the wiring arrangement within the indicator illustrated in Fig. 1;

Fig. 6 is a sectional view of another embodiment of the calipering tool; and

Fig. 7 is a schematic illustration of the wiring arrangement for an automatic recorder adapted particularly for use with caliper embodiment shown in Fig. 6.

Referring to the drawings, Fig. 1 shows the calipering tool 10 connected by an electric cable 11 to the indicator box 12. The calipering tool 10 has a threaded member 13 at one end for connection with a rod or wire line so that the tool can be pushed or pulled through the tubing which is to be calipered. The housing of the calipering tool has a series of circumferentially spaced slots 14 through which calipering fingers or feelers 15, shown in Fig. 2, extend outwardly for contact with the wall of tubing 16. Feelers 15 are urged outwardly independently of each other by individual compression springs 17 which act on the feelers through feeler rods 18 which rest in a slotted portion on the inner arms of the feelers. A centering spring 19 is provided to aid in maintaining the caliper centered within tubing 16. Spring 19 acts through centering plunger 20 to push against the inner arms of all the feelers 15 when there are no deviations from the normal tube wall radius. An actuator rod 21 is positioned longitudinally within the caliper adjacent the inner arms of the feelers and is slidable in guide member 23. The actuator rod normally is urged against the feelers by means of spring 22. This spring is weaker than each of the individual feeler springs 17 against which it is opposed, so that any one of the feeler springs is capable of moving the corresponding feeler and the actuator rod 21 against the action of spring 22 when such feeler encounters a pit or depression in the wall of the tubing.

The feeler head portion of the calipering tool described above operates according to the same principle as the caliper disclosed in Chaney et al. Patent No. 2,518,663. As the caliper is passed through the tubing, the feelers press against the tube wall and operate independently of each other, each feeler moving outwardly when its feeler point encounters a pit or depression in the tube wall. The actuating rod 21 reciprocates longitudinally within the caliper in response to the greatest outward feeler movement. Hence, the distance of movement of actuating rod 21 in opposition to spring 22 is determined at any instance by the feeler which has moved outwardly the farthest.

In the lower portion of the caliper as shown in Fig. 2, there is provided mechanism which is differentially actuatable in accordance with movement of the actuator rod 21 to effect closure of individual electrical circuits in sequence at predetermined distances of movement of the actuator rod. The lower end of actuator rod 21 carries an enlarged portion 28 which provides a contact surface 24 that can move into contact sequentially with several spring loaded contact members 25 which form parts of the individual electrical circuits. Each of these contact members protrudes through an aperture in the end of a threaded cylindrical contact member holder 26, as shown

in Fig. 3, which carries a spring 27 that urges the contact member in the direction of the contact surface 24. The holders 26 are carried in a body member which is formed of two sections 29 and 30 separated by an O-ring 32, the assembly being held in place within the housing of the caliper by means of set screw 31. The body member sections 29 and 30 are made of a suitable non-conducting material such as Bakelite. The holders are screwed into the assembly while O-ring 32 is maintained under compression, so that tension will be maintained on the threads thus helping to keep the holders 26 fixed in the positions desired. The holders are screwed to different depths into the assembly as best shown by Figure 4, so that the contact points will normally be spaced from the contact surface 24 at different predetermined distances. Accordingly, when the contact surface 24 moves toward the contact members 25 in response to outward movement of feelers 15, it will first contact only the nearest member 25 and thereafter contact the others in sequence if there is sufficient outward feeler movement.

The end of each holder 26 opposite the contact member end is provided with a socket for receiving an electrical connector 34 which carries an insulated lead wire 35 that passes through cable 11 to the indicator 12. The springs 27 serve as conductors between the connector 34 and the contact members 25. The other portion of the electrical circuit formed when a contact member is contacted by the surface 24 comprises a rod 36 attached to the member 28 and longitudinally movable with it and an insulated wire 37 which leads through cable 11 to the indicator 12 and which is common to all of the circuits. With this arrangement an electrical circuit is formed upon contact of the surface 24 with each of the contact members 25, so that an indication of each contact and hence of the depth of tubing penetration within predetermined ranges can be obtained by detection of the current flow in the circuits. As shown in Fig. 4, six contact members having differential predetermined spacings from contact surface 24 are provided so as to form six electrical circuits and permit the detection of pitting depth within six different ranges. It is to be understood, however, that the apparatus may be constructed with any other number of contact members to provide whatever number of indications of pit depths that may be desired.

Fig. 5 is a wiring diagram showing a particularly suitable arrangement for detecting the current flows resulting upon contact of the surface 24 with one or more of the contact members 25. The wires 35 from the calipering tool 10 lead to separate relays, indicated in Fig. 5 as 40–*a*, 40–*b*, 40–*c*, 40–*d*, 40–*e*, and 40–*f*. The circuits each include a light, indicated as 41–*a*, 41–*b*, 41–*c*, 41–*d*, 41–*e*, and 41–*f*. A battery 42 which is connected to common lead wire 37 through switch 43, line 44 and reset switch 45, supplies direct current, suitably at about 12 volts, to each of the circuits. The other side of the battery is connected to each of the relays through line 46. Each of the relays includes two switches, as indicated for relay 40–*a* by numerals 47 and 48. Switch 47 is connected to battery 42 through line 49, switches 54, 50 and 45, line 44 and switch 43, while relay switch 48 is in circuit with light 41–*a* and battery 42, such circuit including lines 51, 52 and 53. Similar circuits are provided for each of the other relays.

Assuming that relay 40–*a* is the one which is in the circuit that includes the contact member 25 which is positioned nearest the contact surface 24, it will be the one that is first activated by outward movement of the feelers. When contact occurs thus closing the circuit, relay 40–*a* will be energized causing closure of switches 47 and 48. Closoure of the switch 48 causes the signal lamp 41–*a* to be energized, thus indicating to the operator that a pit of a certain predetermined depth range has been encountered in the tubing. Closure of the relay switch 47 applies a holding voltage to relay 40–*a* so that it will continue to hold switch 48 closed and maintain the signal lamp 41–*a* lighted. This feature permits the operator to determine whether or not a pit of the predetermined depth range has been encountered by looking at the indicator 12 after the caliper has reached the end of a calipering run so that constant attention need not be directed to the indicator during the calipering operation.

In like manner, when a pit of the next predetermined depth range is encountered, relay 40–*b* will be energized and signal lamp 41–*b* will be lighted and maintained lit for inspection at the end of the calipering run. A still greater depth of pitting will cause relay 40–*c* to be energized and signal lamp 41–*c* to become lighted, and so on. Thus at the end of the run but before the feelers 14 have passed beyond the end of the tubing, the operator can observe the indicator 12, determine what the deepest range of pit depth is in the tubing and grade it accordingly. The holding voltage applied to relay 40–*a* will remain operative until released by means of switch 54, switch 50 or switch 45. Observation of the indicator 12 should be made, however, before the feelers 14 have passed beyond the end of the tubing; otherwise, all of the signal lamps will become lighted due to outward movement of the feelers as the caliper tool is withdrawn from the tubing and hence an erroneous indication of internal tube condition may be obtained.

In some cases it is desirable to know the number of pits of a given depth range in a length of tubing. The wiring arrangement of Fig. 5 permits this to be determined. In such case, as soon as the signal lamp in question flashes on, the operator opens the corresponding switch 54 for a moment. This releases the lock-in action of the relay and de-energizes the signal lamp. By counting the number of times a lamp flashes on during a calipering run, the operator knows the number of pits contained by the tubing which have a depth of the range in question.

Switch 50 normally is maintained closed and can be used to release the holding voltage on all relays simultaneously. Switch 45 can be used to release the voltage in the circuits leading to the calipering tool 10. Switch 43 can be employed to release all voltage within the system.

When six contact members are utilized as illustrated in the drawings, the following are particularly suitable spacings between the contact members and the contact surface 24 for grading oil field tubing: 0.025", 0.050", 0.075", 0.100", 0.125", and 0.150". With this arrangement any pits of a depth between 0.025" and 0.050" will cause the first signal lamp to be lighted, and any between 0.050" and 0.075" will light the second lamp, and so on. This permits the tubing to be graded with accuracy and without the operator having to depend on guesswork as done in practice heretofore.

The caliper embodiment illustrated by Fig. 6, includes an additional feature which avoids any necessity for making observations just before the feelers 15 pass from the end of the tube being calipered. This feature is particularly useful in combination with an automatic electrical recorder as illustrated schematically in Fig. 7.

The caliper shown in Fig. 6 is generally similar to the caliper illustrated and described in conjunction with Fig. 2, and it likewise includes individual spring pressed feelers 15 which operate in the same manner as previously described. In this case the common actuator 21–*a*, which provides a contact surface 24–*a* at the end opposite the feelers, has an axially bored aperture through which rod 60 is slidably positioned. This rod extends through a contact holder assembly 61 having a construction generally similar to the assembly illustrated in Fig. 4, but additionally having affixed thereto a metal ring 62 which is connected to an insulated lead wire 63. The lower end of rod 60 has an enlarged portion 64 adapted to contact ring 62 and function as a switch. A com-

pression spring 65 positioned around rod 60 presses against a ring 66 affixed within the assembly 61 and it pushes against a shoulder 67 carried by rod 60 so as normally to maintain switch 64 closed when the caliper is inside a length of tubing. A centering plunger 20–*a* which is pressed against the inner arms of feelers 15 by spring 19, has a recessed end portion 68 spaced a predetermined distance from the end of rod 60. This distance is slightly greater than the widest spacing between the contact surface 24–*a* and contact members 25. This makes certain that contact between the surface 24–*a* and all of the contact members 25 can be made before the recessed surface 68 could abut against the end of rod 60 and thereby cause the rod to open switch 64.

Referring now to Fig. 7, switch 64 is shown schematically in open position and rod 60 is diagrammatically depicted as being grounded by means of line 75. Such grounding conveniently is effected through the calipering tool which is in contact with the tubing being calipered. Ring. contact member 62 for switch 64 is connected through line 63 to a motor 69 which drives the automatic recorder indicated generally at 70. Motor 69 is operated by means of battery 71 which is grounded by means of line 72. Recorder 70 is provided with a roll of electric-sensitive paper 73 which rides over bus bar 74 when the motor 69 is in operation. The bus bar is connected to battery 71 through line 79. A series of electrical contacts or styluses 76, which are positioned on the electrically sensitive paper 73 opposite bus bar 74, are connected by means of lead wires 77 each to one of the contact points 25 in the calipering tool. Five sets of such styluses and connecting lines are illustrated in Fig. 7. Whenever contact is made between a contact point 25 and contact surface 24–*a*, an electrical circuit is completed through the corresponding electrical stylus 76 and bus bar 74. This causes a mark on the electrosensitive paper 73, such as indicated at 78, the length of which is proportionate to the time that the circuit remains closed. Hence, the markings on the electrosensitive paper reflect feeler movement corresponding to various ranges of pit depth as predetermined by the normal spacings between contact surface 24–*a* and the contact points 25.

With the apparatus illustrated in Figs. 6 and 7, the position of switch 64 and hence the operation of chart drive motor 69 are controlled by the feelers. When the feelers 15 are inside the tubing being calipered, the centering plunger 20–*a* is maintained as shown in Fig. 6, so that the recessed surface 68 can not come into contact with the end of rod 60. Accordingly, switch 64 will remain closed during this time and the chart drive motor will operate during the calipering run through the tubing. Movement of individual feelers into pits will not affect the movement of the chart but will determine the markings produced thereon. Before the feelers enter the tubing, however, or as they emerge from the tubing, they all will extend outwardly by action of their individual springs far beyond the normal tube wall radius. This will permit the recessed surface 68 of the centering plunger 20–*a* to push rod 60 and thus open switch 64. Hence, the chart will begin being driven only when the feelers enter the tubing and the chart operation will cease immediately when the feelers emerge therefrom. Thus, by merely passing the calipering tool through the tubing, the operator will automatically obtain a permanent record from which the number of pits of the various depth ranges selected can readily be determined.

We claim:

1. An internal tube wall calipering device comprising a housing, a plurality of independently movable feelers carried by said housing at circumferentially spaced locations, an actuating member common to all of said feelers and mounted in the housing for reciprocal movement therein in response to outward feeler movement, a plurality of longitudinally slidable contact members, resilient means for urging each of said contact members toward said actuating member, means for maintaining said contact members normally at predetermined differential distances from said actuating member when the feelers are in contact with the normal tube wall surface, and means for indicating contact between each contact member and the actuating member.

2. An internal tube wall calipering device comprising a housing, a plurality of independently movable feelers carried by said housing at circumferentially spaced locations, an actuating member common to all of said feelers and mounted in the housing for reciprocal movement therein in response to outward feeler movement, a plurality of longitudinally slidable contact members, resilient means for urging each of said contact members toward said actuating member, means for maintaining said contact members normally at predetermined differential distances from said actuating member when the feelers are in contact with the normal tube wall surface, means forming an electrical circuit for each contact member upon contact with the actuating member, and means for separately detecting a current flow in each electrical circuit, whereby deviations from the normal tube radius within predetermined differing ranges are indicated by the detection of current flows in the corresponding circuits.

3. An internal tube wall calipering device comprising a housing, a plurality of independently movable feelers carried by the housing, actuating means common to all said feelers and responsive to outward movement thereof, a plurality of means differentially actuatable in common by said actuating means to indicate different predetermined outward movement of feelers, and means for preventing the indication of such movement whenever all feelers move outwardly a predetermined distance beyond their normal calipering position.

4. An internal tube wall calipering device comprising a housing, a plurality of independently movable feelers carried by the housing, means for individually urging said feelers outwardly of the housing, an actuating member common to all of said feelers and mounted in the housing for reciprocal movement therein in response to outward feeler movement, means for forming a plurality of electrical circuits including switches differentially actuatable to closed position by said common actuating member in response to different predetermined movement of said feelers, means for detecting current flow in each electrical circuit, and means for preventing the detection of current flow in the electrical circuits whenever all feelers move outwardly a predetermined distance beyond their normal calipering position.

5. An internal tube wall calipering device comprising a housing, a plurality of independently movable feelers carried by the housing, means for individually urging said feelers outwardly of the housing, an actuating member common to all of said feelers and mounted in the housing for reciprocal movement therein in response to outward feeler movement, means for forming a plurality of electrical circuits including switches differentially actuatable to closed position by said common actuating member in response to different predetermined movements of said feelers, a motor, a recorder driven by said motor and responsive to current flow in each electrical circuit for making individual indicating records thereof, and means for stopping the driving of said motor whenever all feelers move outwardly a predetermined distance beyond their normal calipering position.

6. An internal tube wall calipering device comprising a plurality of independently movable feelers, actuating means common to all said feelers and responsive to movement thereof, means providing a plurality of independent electrical circuits differentially actuatable in common by said actuating means, separate indicating means for each of said circuits for indicating different prede-

termined movements of said feelers, and means for preventing the indication of such movement whenever all feelers move outwardly a predetermined distance beyond their normal calipering position.

7. An internal tube wall calipering device comprising a plurality of independently movable feelers, actuating means common to all said feelers and responsive to movement thereof, a plurality of means differentially actuatable in common by said actuating means to indicate different predetermined movements of feelers, and means for preventing the indication of such movement whenever all feelers move outwardly a predetermined distance beyond their normal calipering position.

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