Aug. 15, 1950 P. E. CHANEY ET AL 2,518,663

TUBE CALIPERING AND RECORDING MECHANISM

Filed Oct. 26, 1945 2 Sheets-Sheet 1

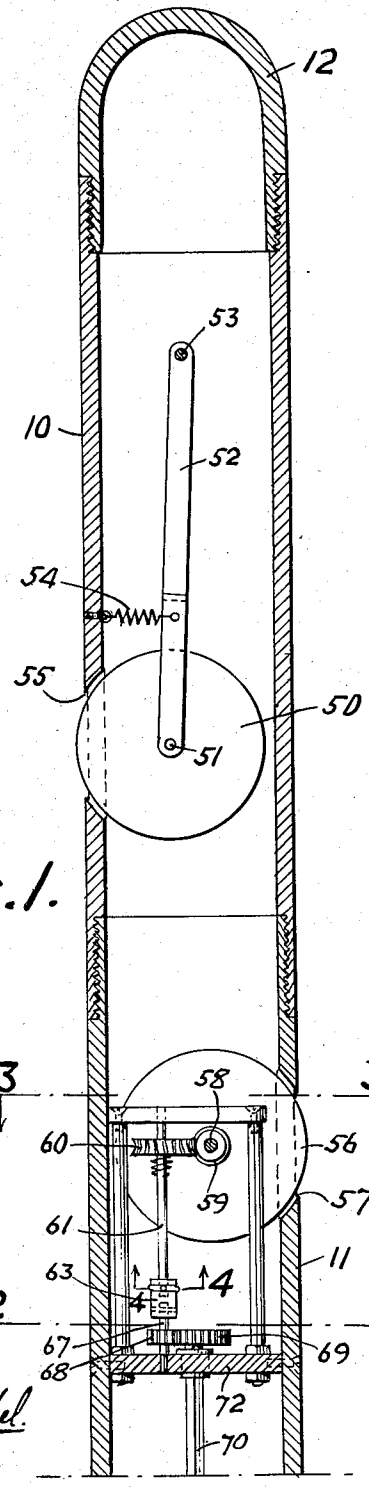


FIG. 1.

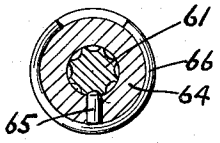


FIG. 4.

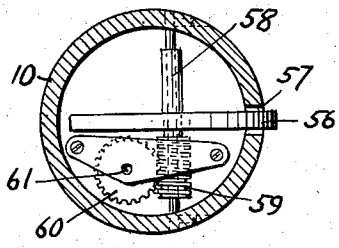


FIG. 3.

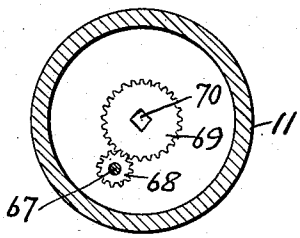


FIG. 2.

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TUBE CALIPERING AND RECORDING MECHANISM

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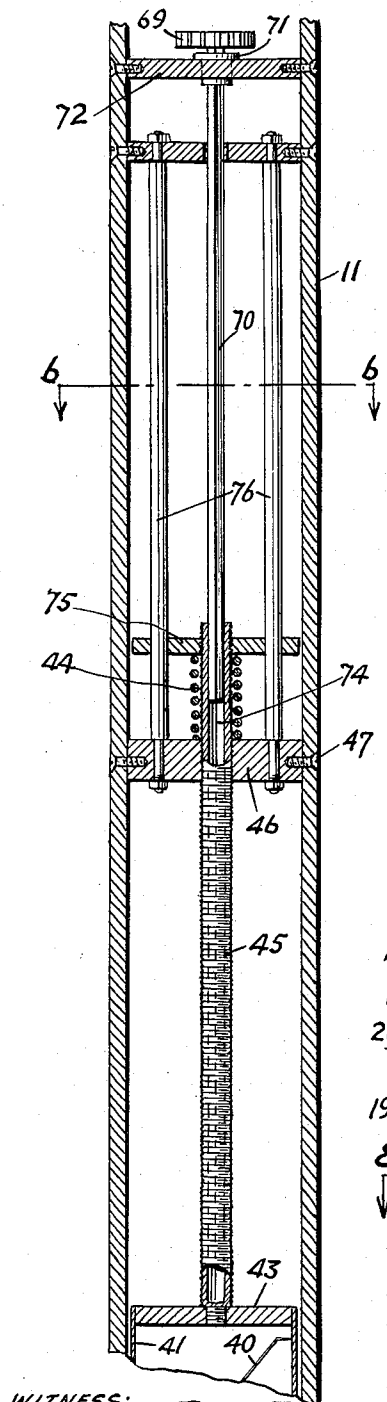


FIG. 5.

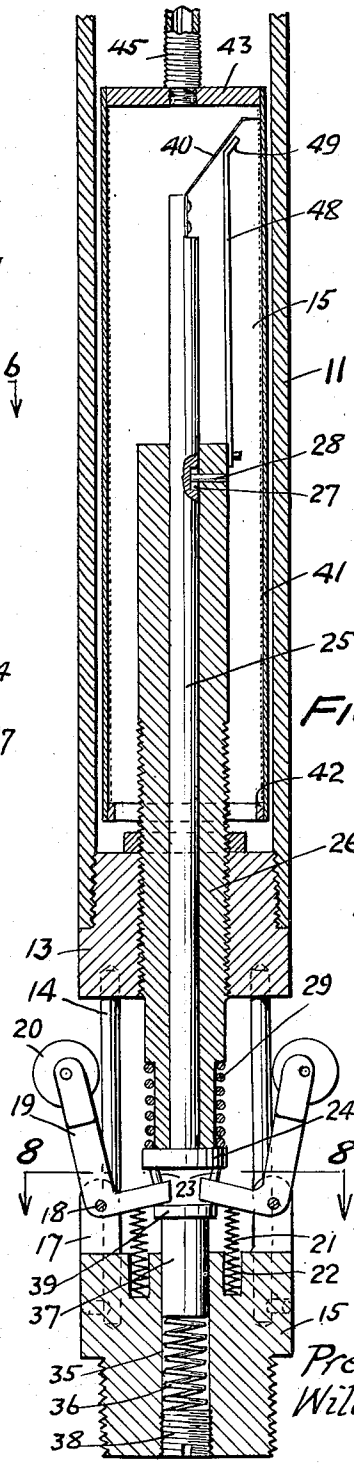


FIG. 7.

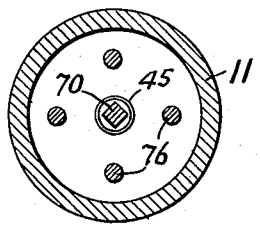


FIG. 6.

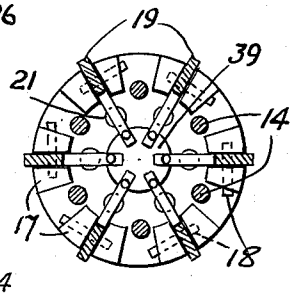


FIG. 8.

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2,518,663

TUBE CALIPERING AND RECORDING MECHANISM

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Application October 26, 1945, Serial No. 624,811

4 Claims. (Cl. 33—174)

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The present invention relates to a calipering and recording device for measuring and recording variations in the internal surface wear of pipes, tubing and the like conduits. More particularly this invention relates to a device for determining variations of internal surface configurations of extended lengths of conduits, such as oil well tubing, that may contain fluids under pressure during the recording operation.

It is a well known fact that oil and gas well tubing becomes worn and corroded after periods of use, depending upon the operating conditions to which it is submitted. Many wells produce, in addition to oil and gas, water having a high acidic content which actively attacks and corrodes the tubing resulting in the formation of pits and depressions on the internal surfaces of the tubing. In addition to corrosion, scoring and wearing of the internal surfaces of the tubing is caused by the passage of well tools through the tubing and by the presence of foreign materials in the fluid flow. The pits or depressions resulting from the scoring and corrosion of the well tubing are sometimes so severe as to reduce the wall thickness of the tubing to such an extent that it will not withstand the pressure of the fluids flowing therethrough. When such failure occurs, the tubing becomes ruptured and the fluid pressure originally confined therewithin is imposed directly upon the well casing, which may or may not be able to withstand pressures of this magnitude. To prevent such failure of the well tubing it is desirable periodically to determine the condition of the interior of the tube walls in order that replacements can be made and proper precautions taken to prevent rupture of the tubing.

Calipering devices in general, which usually involve the application of electrical circuits, are now available for measuring the variations in the inside diameter of uncased well bores. However, devices of this type are not suitable for insertion in small diameter well tubing and further are not adaptable for measuring and recording variations in internal wall surface conditions of well tubing under pressure due to the practical difficulties of running a multiple strand insulated electrical cable into the hole under pressure.

With the present mechanism a thin wire can be used for dropping the device into the well tubing and by the use of conventional seal rings the inlet end of the tubing can be sealed off and the calipering operation carried on with the tubing under high pressure.

It is a principal object of this invention to

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provide a calipering device which may be lowered or dropped as a unit into a well tubing under pressure and effect a continuous recording of maximum internal surface wear of the tubing in order that the location of maximum corrosion and wear conditions existing along the entire length of the tubing can be determined.

An important object of this invention resides in the fact that the calipering and recording device is completely self-contained and mechanically operated and does not require the use of insulated electric cables or the like, it being only necessary to lower the calipering device into the well and then pull it back to obtain a complete and continuous record of the internal surfaces of the well tubing.

It is also an important object of this invention to provide a calipering device for measuring and recording the exact longitudinal position and the depth of any pit or depression on the internal surface of the well tubing.

Calipering and recording devices for determining variations in internal diameters are generally old but the results obtained with such known instruments indicate, at best, the variation in average inside diameter and so do not indicate individual depressions on the internal surfaces being examined. It is therefore an object of the present invention to provide a calipering device of the type referred to in which a plurality of feelers or indicators are employed to engage with the internal surfaces of the tubing being measured and the feelers or indicators are so connected with the recording mechanism that any one of a plurality of feelers may move into a depression on the internal surface and actuate the recording mechanism while the remainder of the feelers continue to contact the normal walls within the tubing to center the device within the tubing and thus enable, when a surface pit is encountered, a determination of the extent of each individual pit or depression encountered; and to record such determinations or measurements on a record chart.

A particular object of the invention is to provide a device or instrument that will record in simple and very readable form the depth, longitudinal extension and precise location of pits or depressions. The mechanism of the invention, accomplishing this object, is operable by wholly mechanical means in wells of any depth, whether or not under well pressure.

Applicants' device can be operated to produce a compact record depicting the precise depth and precise location of only the deepest pit in

the calipered wall surface at any given cross-section of the tube during calipering passage of the device. Such a record has never before been produced.

It is a further object of this invention to provide a calipering device of the class described, the operation of which is not affected by the presence of oil, gases and other fluids under pressure, so that it may be inserted within the tubing string of a well under pressure without the need of stuffing boxes or heavy friction loadings on the bearings of the operating members in the device, thus facilitating the operation and increasing the accuracy of the calipering and recording mechanism.

It is also an object of the invention to provide a calipering and recording device of the class described which is completely self-contained and mechanically operated, driving mechanism being provided in the device for contacting the walls of the well tubing and actuating the recording mechanism in response to the movement of the device into or out of the well tubing, the recording device being so contained as to enable a continuous record for long lengths of tubing string to be made on a minimum of record space.

An essential and unique operating characteristic of the invention is the production of a unitary record accurately depicting a precise representation of maximum calipered wear at any given cross-section of a very long string of tubing; such, for example, as thousands of feet of high pressure gas or distillate well tubing in petroleum or gas fields.

During passage of the calipering and recording instrument through such a string of tubing, each cross-section is calipered simultaneously at a plurality of points around its circumference; but only a calipered point representing maximum internal tube wall surface wear is recorded. Such recording is in the form of corresponding deviation from a normally smooth line being scribed on a record chart.

In mechanical effect, the instrument records an accurate measure of only the maximum radius of a plurality of calipered radii, "felt" or "sensed" by a plurality of independently operating calipering feelers at spaced circumferential points or locations at any instant during calipering passage.

Further objects and advantages of this invention will be apparent by reference to the following specification and drawings in which:

Figure 1 is a longitudinal section of the bottom portion of the device.

Figure 2 is a transverse section on the line 2—2 of Figure 1.

Figure 3 is a transverse section on the line 3—3 of Figure 1.

Figure 4 is an enlarged transverse section on the line 4—4 of Figure 1.

Figure 5 is a longitudinal section in continuation of Figure 1 and showing the central portion of the device.

Figure 6 is a transverse section on the line 6—6 of Figure 5.

Figure 7 is a longitudinal section in continuation of Figure 5 and showing the top portion of the device, and

Figure 8 is a transverse section on the line 8—8 of Figure 7.

The calipering device of this invention is comprised of an elongated housing containing at one end, which may be considered the lower portion of the device, the driving mechanism as shown in Figure 1 for actuating the recorder operating mechanism which is mounted generally in the central portion of the housing as shown in Fig. 5 and which in turn cooperates with the stylus which is actuated by the feeler or indicator mechanisms located in the upper portion of the housing as shown in Figure 7. The device is lowered into the tubing to be examined by securing a wire line of small diameter such as a "Halliburton wire line" at its upper end and dropping the assembly into the well tubing by such well known apparatus and procedures as are used in connection with bottom hole pressure and sampling bombs. As the assembly is raised or lowered into the well tubing, the driving mechanism at the lower portion engages the tubing inner walls and by frictional contact therewith operates the mechanism for rotating a recording chart while as the feelers or indicators engage the walls the recording stylus is actuated in reciprocation to effect the record. The cooperation of the stylus actuating mechanism and recording mechanism with each other is such that a spiral or helical record from the top to the bottom of a cylindrical chart is produced and any variations in maximum internal surface wear are indicated by vertical deviations from a true spiral or helical line.

The particular association of the various mechanisms of the device is such, as will be appreciated from an understanding of the details of the invention, that the recording can be effective in either direction of movement of the device through the tubing and either end of the device may be used to drop or lower the device into the tubing.

For a more detailed understanding of the invention reference will be made to the drawings wherein a housing is shown to be made up of sections 10 and 11 which preferably are threaded together while section 10 is closed by a threaded cap member 12 and section 11 is closed by a threaded plug 13 providing in effect an enclosed chamber therebetween. Extending axially from cap member 13, as shown in Figure 7, are a plurality of studs 14 to the free ends of which is secured a support block 15 which as indicated is provided with threads for the reception of a "sinker bar" provided with a wire line to permit the assembled device to be lowered into the well tubing.

The support block 15 is provided with a plurality of bracket arms 17 to which are pivotally connected by pins 18 (Figures 7 and 8) a plurality of bell crank levers 19 each of which is positioned between two adjacent bracket arms. Rollers or indicating feelers 20 are mounted on the end of the outer arm of the bell crank levers and are adapted to engage the inner walls of the tubing to be calipered while the inner arms of the levers extend generally radially inwardly. Compression coil springs 21 have one end disposed in sockets 22 formed in support block 13 while the other end of the springs are secured to the inwardly extending short lever arms to independently urge each roller or feeler 20 outwardly to its fully extended position, as shown, in Figure 7 for constantly contacting the walls of the tubing. As depressions are encountered by the rollers 20 each of the inwardly extending short lever arms will be moved independently upwardly or downwardly in accordance with the movement of the rollers 20 and through pins 23 which are secured to the free ends of the short lever arms, a collar 24 on a stylus push rod 25

will reciprocate the push rod 25 in accordance with movements of the rollers 20.

The stylus push rod 25 is journaled in an elongated bushing 26 which is threaded for adjustment lengthwise of the housing 11 and is prevented from rotating but permitted limited axial movement by a pin 28 and cooperating slot 27. The bushing 26 is threaded through the plug 13 and has one end positioned exteriorly of the plug 13 having a weak coil spring 29 which normally urges the collar 24 of the push rod 25 into engagement with the pins 23. Thus movement of the feelers 20 causes a corresponding axial movement of the stylus push rod 25. In Figure 7 the feelers 20 are in their extended position and the push rod 25 and collar 24 are at their limit of movement. It will be understood of course that when the feelers 20 are retracted the spring 29 will urge the collar 24 and push rod 25 away from the end of bushing 26.

The supporting block 15 is provided with an axial bore 35 in which is mounted a compression spring 36 and a plunger member 37 held in place by a set screw 38. The plunger 37 is provided with a collar 39 which engages all of the inwardly extending lever arms of the bell crank levers 19 and through the coil spring 36 the rollers 20 are each urged outwardly equi-distantly in engagement with the interior walls of the tubing. The arrangement of springs 21 as above discussed permits each of the rollers 20 to move independently and the stylus push rod 25 will be axially moved a distance corresponding to the greatest outward movement of any one of the feelers 20 while the spring 36 functions to center the calipering device within the tubing. This is an important feature of the invention since it provides for an indication of each individual depression in the internal surface of the tubing being examined and provides for its transmission to the stylus push rod even though the majority of the feeler members are at that time sensing the average diameter of the tubing.

A recording stylus 40 is fixed to the lower end of the stylus push rod 25 and is adapted to cooperate with a recording chart cylinder 41 to effect a record. The recording cylinder shown in Figure 7 is provided with end wall 43 and receives a recording chart (shown in dotted lines) which is provided with a spring ring 42 at its lower end and which has on its surface a suitable oil and water resistant material of the type disclosed in our co-pending application for Cylindrical Recording Chart Construction, Serial No. 624,814, filed of even date herewith. The threaded shaft 45 is fixed centrally to end wall 43 and is threaded through a partition 46 which is secured at 47 to the housing 11 so that rotation of the threaded shaft 45 will cause both a rotary and axial movement of the recording chart 41 with respect to the stylus 40 in order to effect a spiral or helical record corresponding in pitch to the pitch of the threads on the threaded shaft when the stylus is in contact with the moving chart.

Attached to the end of the stylus push rod bushing 26 nearest the stylus end as shown is an arm 48 having its free end bent at 49 and positioned adjacent the stylus 40 so that upon maximum inward movement of the feelers 20 causing an equivalent upward axial movement of the stylus push rod 25, the stylus 40 and the bent portion 49 of the arm 48 will contact and the stylus will be moved away from the inner surface of the recording chart. This arrangement permits the recording chart to be inserted or removed without contacting the stylus by merely

urging the outer arms of the bell crank lever 19 inwardly to allow the push rod 25 to rise the distance permitted by the length of slot 27 in the shaft 25.

For an explanation of the manner in which the recording chart is actuated, reference is had to driving mechanism shown in Figures 1–6 of the drawings. Adjacent the closed end of the housing 10, an idler wheel 50 is pivotally mounted at 51 to an arm 52 which in turn is pivoted at 53 to the housing 10. A spring 54, which may be a coil spring or any other suitable resilient means, normally urges the idler wheel 50 outwardly through a slot 55 sufficiently to contact the inner walls of tubing to be calipered. A frictionally driven wheel 56 extends through an opening 57 sufficiently to contact the inner wall of the tubing diagonally opposite to that of idler wheel 50 and is maintained in frictional contact with the inner wall of the tubing. Thus movement of the calipering device through the tubing which is being calipered will cause a rotation of the friction driven wheel 56.

As shown in Figures 1 and 3 of the drawings, the wheel 56 is mounted on a shaft 58 to which is connected at one end a worm 59 which meshes with the worm gear 60 secured at one end of the vertical shaft 61 shown in Figure 1. If desired any suitable form of ratchet mechanism (not shown) may be interposed in the connection between the worm gear 60 and the shaft 61 to cause the shaft to be driven in one direction only in response to either an upward or a downward movement only of the calipering device through the well tubing. At its other end the shaft 61 is provided with an overload release assembly 63 shown in detail at Figure 4. The assembly is comprised of indentations at the end of shaft member 61 which are enclosed by a collar member 64, having a pin 65, extending radially through the collar 64 for cooperating with the indentations and a spring ring 66, is provided for normally urging the pin into one of the indentations. The overload release member 63 functions to permit the shaft 61 and friction driven wheel 56 to rotate even though the recording cylinder may be jammed or has reached its limit of movement without causing an injury to the device.

A vertical shaft 67 is associated with the overload release assembly 63 and has a pinion gear 68 mounted thereon to mesh with a spur gear 69 secured to the end of a vertical square shaped drive shaft 70. The drive shaft 70 is journaled at 71 (Figure 5) through a strut or cross arm 72 secured to the walls of the housing 11. The square shaft 70 extends into a similarly shaped opening 74 in the threaded shaft 45 so that a splined connection is made therebetween which imparts rotation from the shaft 70 to the threaded shaft 45 while permitting a telescoping movement of the two shafts relative to each other. Plate member or nut 75 is threadably connected to shaft 45 and guide rods 76 extend through apertures therein in order to maintain the moving parts in alignment. A spring 44 is provided between plate member 75 and partition 46 and functions to prevent backlash in the threaded connection between shaft 45 and the partition 46. This arrangement it will be seen permits the chart to rotate and simultaneously therewith to move axially of the housing 11.

The operation of the well tubing calipering device of this invention should now be readily understood. It will be noted particularly that the entire device can be used in the presence of oil or other liquid under pressure without affecting

its operation. The mechanism is attached to a wire line and lowered by any suitable means into the well tubing to be examined. Upon entering the tubing, the wheels 50 and 56 contact the tubing walls and are caused to rotate and rotation of the wheel 56 will cause a rotation of shaft 70 which in turn causes a rotation of the recording cylinder 41 together with an axial movement of the record cylinder corresponding to the threads on the threaded shaft 45. Thus a spiral or helical record is produced on a suitable oil and water resistant recording surface of the recording cylinder 41 by the cooperation of the stylus 40. The stylus 40 is also moved axially in accordance with the outward movement of the plurality of feeler or indicator members 20 which are maintained in contact with the tubing walls by the springs 21 and 36. The connections between the feeler or indicator members 20 and the stylus push rod 25 and stylus 40 are such that the stylus is axially moved an amount to correspond with the greatest outward movement of any one of the plurality of feeler or indicator members which it will be observed are movable independently of each other.

Thus the spiral or helical line obtained on the recording surface will be broken by angular deviations corresponding to axial movement of the stylus which in turn is in accordance with a change in maximum calipered internal wear of the tubing being examined.

Since the complete calipering and recording device is designed particularly for calipering deep oil and gas wells as of 10 to 15 thousand feet in depth, the mechanism which actuates the stylus is arranged to produce on the record an indication of each tube length that has been calipered. This is done by taking advantage of the fact that the tubes are usually joined by outside couplings and hence a space which is equal to the thickness of the tubes will be encountered at intervals corresponding to the tubing couplings. Preferably, however, bushing 26 is adjusted so as to limit the maximum outward travel of the feelers 20 to correspond to a selected known diameter which is less than the internal diameter of the tubing couplings. Thus at each tubing coupling an angular deviation of the recorded line corresponding in amplitude to the aforesaid selected known diameter will result. By comparing other smaller deviations with this known maximum deviation, the depth of other surface irregularities may be determined.

When the lead of the threaded shaft 45 and its speed of rotation are known it is an easy matter to calculate from the record obtained the exact position of any unsafe conditions which may be found to exist in the tubing. Further, with a known amount of leverage between the feeler members and the stylus, it is possible to calculate from the record the actual depth of a depression on the inner surfaces of the tubing wall or the change in diameter.

In our co-pending application for Driving and Recording Mechanism for Calipering Device, Serial No. 624,813, filed of even date herewith, certain features of the present invention and improvements thereon are disclosed and claimed. It is to be understood that details of mechanisms disclosed in these applications may be utilized with the present apparatus.

Having described our invention, what we claim and desire to protect by Letters Patent is:

1. In an internal tube wall calipering and recording device adapted to be passaged through an extended length of tubing the combination comprising an elongated housing, recording means including a recorder member and a single stylus member mounted in said housing, a plurality of independently movable feelers spaced circumferentially of said housing and adapted for independent lateral movement between said housing and the tube wall being calipered, mechanical actuating means for said recording means common to all of said feelers and mounted in said housing for reciprocal movement therein, means for resiliently urging said common actuating means in one direction, and a plurality of movement transmitting means, one for each of said feelers, operable independently of each other to transmit outward movement of said feelers to said common actuating means, each movement transmitting means including means for constantly and independently urging the corresponding feeler outwardly of said housing and for simultaneously urging its movement transmitting means in opposition to, and with a force greater than, said first-mentioned urging means, whereby said common actuating means is movable in response to any of said feelers but is moved to an extent corresponding to and controlled by only the greatest outward feeler movement at any instance during a calipering passage.

2. In an internal tube wall calipering and recording device adapted to be passaged through an extended length of tubing the combination comprising an elongated housing, recording means including a recorder member and a single stylus member mounted in said housing, a plurality of independently movable feelers spaced circumferentially of said housing and adapted for independent lateral movement between said housing and the tube wall being calipered, mechanical actuating means for said recording means common to all of said feelers and mounted in said housing for reciprocal movement therein, means for resiliently urging said common actuating means in one direction, and a plurality of movement transmitting means, one for each of said feelers, operable independently of each other to transmit outward movement of said feelers to said common actuating means, each movement transmitting means including means for constantly and independently urging the corresponding feeler outwardly of said housing and for simultaneously urging its movement transmitting means toward pressure contact with said common actuating means in opposition to, and with a pressure force greater than, the first-mentioned urging means; whereby said common actuating means is movable in response to any of said feelers but is moved to an extent corresponding to and controlled by only the greatest outward feeler movement at any instance during a calipering passage.

3. In an internal tube wall calipering and recording device adapted to be passaged through an extended length of tubing the combination comprising an elongated housing, recording means including a recorder member and a single stylus member mounted in said housing, a plurality of independently movable feelers spaced circumferentially of said housing and adapted for independent lateral movement between said housing and the tube wall being calipered, mechanical actuating means for said recording means common to all of said feelers and mounted in said housing for reciprocal movement therein, means for resiliently urging said common actuating means in one direction, and a plurality of

movement transmitting means, one for each of said feelers, operable independently of each other to transmit outward movement of said feelers to said common actuating means, each movement transmitting means including a resilient element for constantly and independently urging the corresponding feeler outwardly of said housing and for simultaneously urging its movement transmitting means toward pressure contact with said common actuating means in yieldable opposition to, and with a pressure force greater than, the first-mentioned urging means; whereby said common actuating means is movable in response to any of said feelers but is moved to an extent corresponding to and controlled by only the greatest outward feeler movement at any instance during a calipering passage.

4. In an internal tube wall calipering and recording device adapted to be passaged through an extended length of tubing the combination comprising an elongated housing, recording means including a recorder member and a single stylus member mounted in said housing, a plurality of independently movable calipering means carried by said housing at circumferentially spaced locations and adapted for independent lateral movement between said housing and the tube wall being calipered, mechanical actuating means for said recording means common to all of said calipering means and mounted in said housing for reciprocal movement therein, means for resiliently urging said common actuating means in one direction, said calipering means each having a feeler part movable outwardly of said housing toward continuous contact with adjacent tube wall portions during a calipering passage and a part movable with such feeler part and extending inwardly of said housing toward abutment with said common actuating means, said calipering means each also including means for constantly and independently urging the corresponding feeler part outwardly of said housing and for simultaneously urging the corresponding inwardly extending part toward abutment with said common actuating means in opposition to, and with a pressure force greater than, said first-mentioned urging means.

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