Sept. 13, 1966 L. O. STEBBINS 3,272,000

APPARATUS USEFUL IN ULTRASONIC INSPECTION OF PIPES

Filed May 9, 1963 2 Sheets-Sheet 1

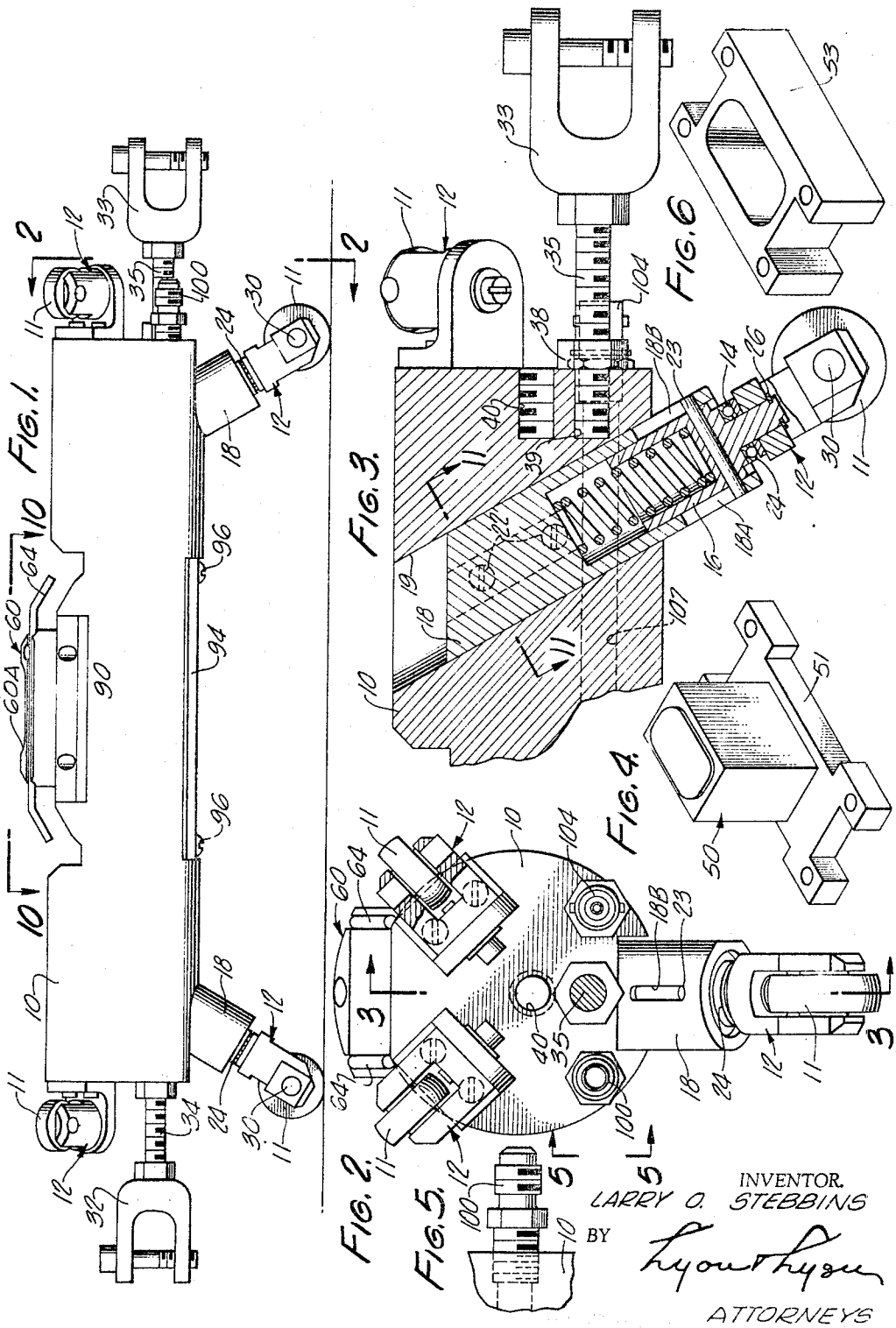

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FIG. 7.

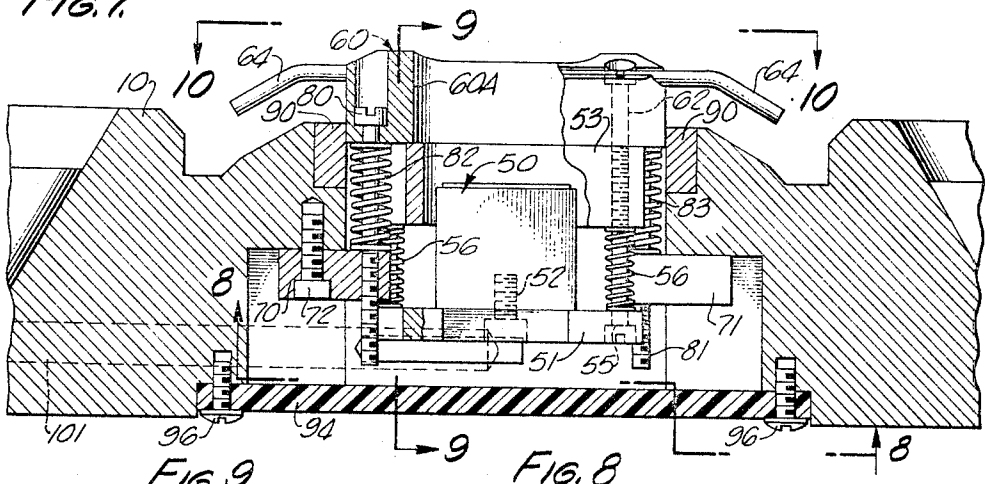


FIG. 9.

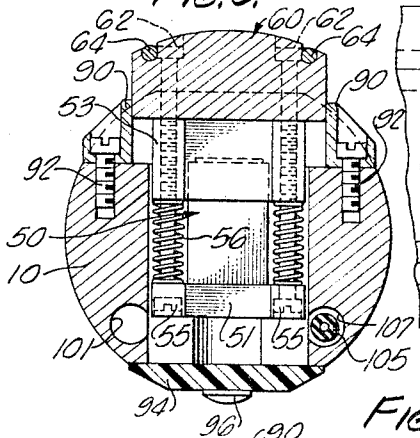


FIG. 8

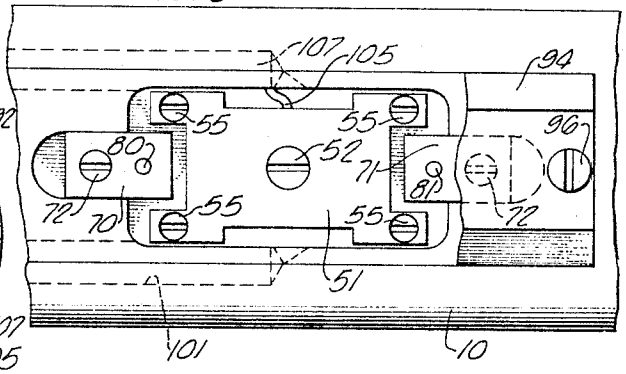


FIG. 10.

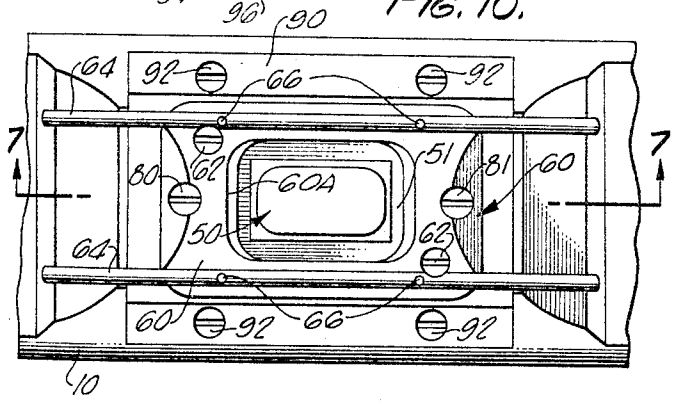
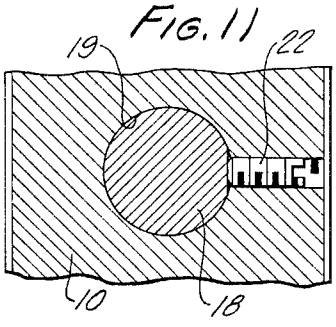


FIG. 11



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APPARATUS USEFUL IN ULTRASONIC INSPECTION OF PIPES

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8 Claims. (Cl. 73—71.5)

The present invention relates to apparatus useful in ultrasonic inspection of pipes, tubing, drill strings used in oil field installations and the like.

Briefly, the apparatus described herein involves an ultrasonic transducer mounted on a wheeled carriage which is adapted to be moved through a pipe, tubing or casing with spring-urged wheels and a spring-urged transducer head contacting the inner surface of such pipe for ultrasonic inspection of the same. The carriage has an electrical connector for the transducer and also a water passage therein for the introduction of water that couples the transducer to the pipe, tubing or casing being inspected.

It is therefore a general object of the present invention to provide new and useful apparatus constructed and functioning in the manner indicated above.

A specific object of the present invention is to provide apparatus of this character useful in pipes of different diameters.

Another specific object of the present invention is to provide apparatus of this character which assures good electrical coupling between the transducer and the pipe in those instances where the internal surface of the pipe has irregularities.

Another specific object of the invention is to provide apparatus of this character wherein the wheels are mounted to assure substantially straight-line tracking when and as the apparatus is moved through pipe.

Another specific object of the invention is to provide apparatus of this character using a novel transducer mounting.

Another specific object of the invention is to provide apparatus of this character which may be subjected to rough handling without damage to the transducer.

The featuures of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a view in side elevation of apparatus embodying features of the present invention.

FIGURE 2 is a view taken generally along the line 2—2 of FIGURE 1.

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 2.

FIGURE 4 is a perspective view showing the transducer used in FIGURE 1 on its mounting base.

FIGURE 5 is a view taken in the direction indicated by the arrows 5—5 in FIGURE 2.

FIGURE 6 is a perspective view showing a mounting block used in the construction of FIGURE 1.

FIGURE 7 is a sectional view taken along the line 7—7 of FIGURE 10.

FIGURE 8 is a view taken along the line 8—8 in FIGURE 7.

FIGURE 9 is a sectional view taken along the line 9—9 in FIGURE 7.

FIGURE 10 is a view taken along the line 10—10 in either FIGURE 7 or FIGURE 1.

FIGURE 11 is a view taken along the line 11—11 in FIGURE 3.

The apparatus shown in the drawings is essentially a

cylindrical carriage **10** formed from cylindrical metal stock and has three spring-urged wheels **11** at each end thereof, forming a part of the caster **12** which is spring-urged outwardly. A typical mounting for each of the casters is illustrated in FIGURE 3 wherein the caster **12** has a shaft **14** of a spring-urged tubular spring follower or seat **16** secured thereto. This spring follower **16** is slidably received within a blind bore in a circular cross-sectioned support **18**, the support **18** being secured within a bore **19** of the carriage member **10** by set screws **22** as shown also in FIGURE 11. The spring follower **16** has a pin **23** extending radially therethrough, with the ends of the pin **23** slidably cooperating with slotted portions **18A** and **18***b* in support **18** for guiding movement of the spring follower **16**. A ball-bearing thrust bearing **24** is positioned between a shouldered portion of the follower **16** and caster **12** and is retained by a snap ring **26** on the end of shaft **14**.

It will be seen from the drawings that the supporting shaft **14** for each of the casters is inclined with respect to the longitudinal axis of carriage **10**, the shaft axes each extending through the center of the axis of the cylindrical carriage member **10** and with each shaft axis offset in the direction of the adjacent end of the carriage to make an acute angle with the axis of the carriage.

It is noted also that the caster shaft **30** for each caster wheel **11** is offset in the direction of the corresponding end of carriage member **10**, i.e. the axis of shaft **14** does not pass through the axis of shaft **30** which is dispaced from the shaft axis **14** toward the adjacent end of the carriage **10**. This construction facilitates assembly of the apparatus within a pipe as well as good tracking of the carriage when and as it is being pulled or moved through the pipe.

The carriage **10** may be pulled through the pipe using a rope or wire cable attached to clevises **32** and **33** on opposite ends of the carriage **10**, such clevises **32** and **33** each having a corresponding threaded shank **34** and **35** threaded into corresponding walls of carriage **10** as typified in FIGURE 3. These shanks **34** and **35** may be threaded into tapped holes **50** having their axes coincident with the axis of carriage member **10** or, alternatively, such shanks **34** and **35** may be threaded into bore holes **39** which have their axes offset with respect to the longitudinal axis of the cylindrical carriage member **10**, as shown in FIGURE 3. When the shanks **34** and **35** are secured in their corresponding tapped holes **40**, the carriage **10** is moved without turning about its axis; and when such shanks **34** and **35** are threaded in their corresponding offset taped holes **39**, the carriage **10**, during its longitudinal movement, rotates also about its axis for spirally scanning the interior surface of the pipe. If desired, the clevises **32** and **33** may be swivelly mounted on their corresponding shanks **34** and **35**. To assure such spiral movement of the carriage **10**, the caster supports **18** are adjustably positioned, using set screws **22**, such that different wheel shafts **30**, in each set of three wheels, are progressively spaced in the direction of adjacent ends such that a plane passing through the axes of the three shafts of a set makes an acute angle with respect to the longitudinal axis of the cylindrical carriage **10**.

The cylindrical carriage **10** is centrally apertured and formed to receive the transducer **50** (FIGURE 4) of conventional construction comprising a crystal suitably mounted in a housing. The transducer unit **50** is mounted on a base member **51** and assembled on the carriage **10** in the manner now described in connection with FIGURES 7–10. A screw **52** secures the crystal unit **50** to its base member **51** which, in turn, is resiliently mounted on a mounting block **53** (FIGURE 6) using four mounting bolts **55**, each of which passes through

a corresponding coil compression spring **56** and is threaded in the mounting block **53**, each of such springs **56** being compressed between the base plate **51** and mounting block **53**, and the mounting block **53**, in turn, being resiliently supported using the following construction.

The mounting block **53** has secured thereto a pipe wall engaging member **60** using two bolts **62** which are threaded into the support block **53** and which, as shown in FIGURE 10, serve also to retain a pair of bent rods **64** in outer grooved portions of the member **60**, such rods **64** serving as skids and being also retained in such grooved portions by pins **66**.

The mounting block **53**, thus secured to the pipe-engaging member **60**, is resiliently mounted on a pair of support members **70** and **71** (FIGURES 7 and 8) which are retained in internal slotted portions of the carriage **10** by bolts **72**. For this purpose each of a pair of bolts **80** and **81** pass through a corresponding coil compression spring **82**, **83** and is threaded in a corresponding one of the blocks **70**, **71**, the coil compression springs **82** and **83** being compressed between the member **60**, on the one hand, and correspondingly between the support blocks **70** and **71**.

Thus, using this construction, the pipe wall engaging member **60** and support block **53**, mounted as a unit, are resiliently mounted on the carriage **10**, and, in turn, the transducer **50** is resiliently mounted on the mounting block **53**. In other words, the crystal or transducer unit **50** is shock-mounted on the support member **53** which, in turn, is resiliently mounted on the carriage **10**. The wall contact member **60** is guided in its movement by a rectangular apertured guide member **90** which is secured to the carriage member **10** by bolts **92** (FIGURE 9).

One side of the centrally apertured carriage **10** has a water-tight cover member **94** of transparent material secured by fastening bolts **96**.

Water is introduced into the interior of the carriage **10** through a suitable fitting **100** (FIGURE 1) which is in communication with the channel **107** (FIGURES 3, 9 and 7) leading to that space within which the crystal **50** is mounted. The crystal **50** is electrically connected to an electrical coaxial fitting **104** (FIGURE 2) through a coaxial cable **105** (FIGURES 9 and 8), the cable **105** extending through a channel **107** in member **10**.

The member **60** has its outer face contoured generally to fit against the inner circular wall of the pipe under investigation, but water leakage may occur between member **60** and the pipe since it is contemplated that water under pressure is supplied to the fitting **100** so that at all times there is a solid water column between the transducer **50** and the inner wall of the pipe whereby a good ultrasonic coupling exists at all times between the transducer **50** and such interior wall of the pipe which is encompassed by the generally rectangular apertured portion **60A** (FIGURE 10) of the contoured member **60**.

It is thus contemplated that when and as the carriage **10** is either positioned or moved within a pipe under investigation, the transducer **50** is electrically connected to conventional electronic equipment for analyzing energy periodically reflected from the pipe with such energy being transferred through a solid water column between the pipe and transducer **50** with the transducer **50** serving not only as a transmitting crystal but also as an echo receiving crystal.

During such movement of the apparatus, the apparatus conforms to the particular internal dimensions of the pipe and in such case there is a permissive movement of the head **60** to allow it to conform generally with such changing dimensions. The springs **82** and **83**, which urge the head **60** against the inner wall of the pipe at all times, are stronger than the springs **56** that serve to shock-mount the transducer unit **50**.

While the particular embodiments of the present invention have been shown and described, it will be obvious

to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. Apparatus for the inspection of metal pipe wherein a transducer is mounted to transmit energy pulses into the pipe and to receive resulting echo signals therefrom, the combination comprising, a generally cylindrical body which is radially apertured at a central portion thereof to provide a central apertured portion, three casters on each end of said body, means slidably mounting each of said three casters near each end of said body, each of said casters having a pipe-engaging wheel rotatable about its wheel axis, each of said casters having a supporting shaft which is slidably mounted on said body and about the axis of which said wheel may be oriented, individual spring means acting between said body and a corresponding one of said shafts and urging said wheels outwardly, the axis of each shaft and the corresponding wheel axis being at right angles and being displaced in nonintersecting relationship, the axis of each shaft making an acute angle with the longitudinal axis of said body, means mounted on opposite ends of said body for exerting a pulling force on said body whereby said body may be pulled through a pipe with said spring-urged wheels engaging and rotating on the inner surface of said pipe, a transducer, an apertured pipe-engaging member providing an open window for said transducer, first resilient means, means incorporating said first resilient means and resiliently mounting said pipe-engaging member on said body, second resilient means, means incorporating said second resilient means and resiliently mounting said transducer means on said pipe-engaging member, said first resilient means being stronger and exerting a greater force than said second resilient means, water conduit means in communication with said central apertured portion for conducting water to said transducer and through said open window to an interior surface of the pipe.

2. Apparatus of the character described for the inspection of metal pipe wherein a transducer is mounted to transmit energy pulses into the pipe and to receive echo signals therefrom, the combination comprising, an elongate body which is apertured at a region intermediate its ends to provide an apertured portion, pipe-engaging wheels mounted on said body, individual spring means acting between said body and each wheel urging the same into contact with the interior wall of the pipe, a transducer within said apertured portion, a pipe-engaging member, means resiliently mounting said member on said body, means mounting said transducer on said member, said member being shaped to provide a window for the transducer, and water conduit means in said body communicating with said apertured portion for the flow of water to said apertured portion, to said transducer and through said window.

3. Apparatus for the inspection of metal pipe wherein a transducer is mounted to transmit energy pulses into the pipe and to receive resulting echo signals therefrom, the combination comprising, an elongate body which is apertured at a region intermediate its ends to provide an apertured portion, wheels on said body, each of said wheels having an axle and an axle support, individual means resiliently supporting each of said axle supports on said body, a transducer in said apertured portion, a pipe-engaging member, means resiliently mounting said member on said body for resiliently pressing said member against the interior wall of said pipe, said member being perforate to provide a window for the transducer, and means mounting said transducer on said member, and water conduit means in said body for conveying water to said apertured portion, to said transducer and through said window.

4. Apparatus as set forth in claim 3 in which said wheels are each part of a caster in which the wheel may turn on said axle support for orientation of the wheel.

5. Apparatus as set forth in claim 4 in which the axes of a wheel axle and the corresponding axle support are at right angles to each other and are displaced from each other in nonintersecting relationship.

6. Apparatus as set forth in claim 3 in which the means mounting said transducer on said member is resilient to allow movement between said transducer and said member.

7. Apparatus as set forth in claim 3 in which said apertured portion extends transversely through said body and is closed at one of its ends by a removable sealing plate.

8. Apparatus of the character described for the inspection of pipe wherein a transducer is mounted to transmit energy pulses into the pipe and to receive echo signals therefrom, the combination of, an elongated body for traveling through said pipe, said body including mounting means to provide a support portion, means mounted on said body for being maintained in moving contact with the interior wall of the pipe when said body is inside said pipe, a transducer disposed in said support portion, a

pipe-engaging member, means resiliently mounting said member on said body adjacent said interior wall of said pipe, said member being shaped to provide a window for the transducer, means mouning said transducer on said member for coupling said transducer to said window, and, water conduit means in said body communicating with said window for the flow of water through said window to couple said transducer to said interior wall.

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