Nov. 17, 1959 I. L. JOY 2,913,602

METHOD AND MEANS FOR TRANSMITTING ELASTIC WAVES

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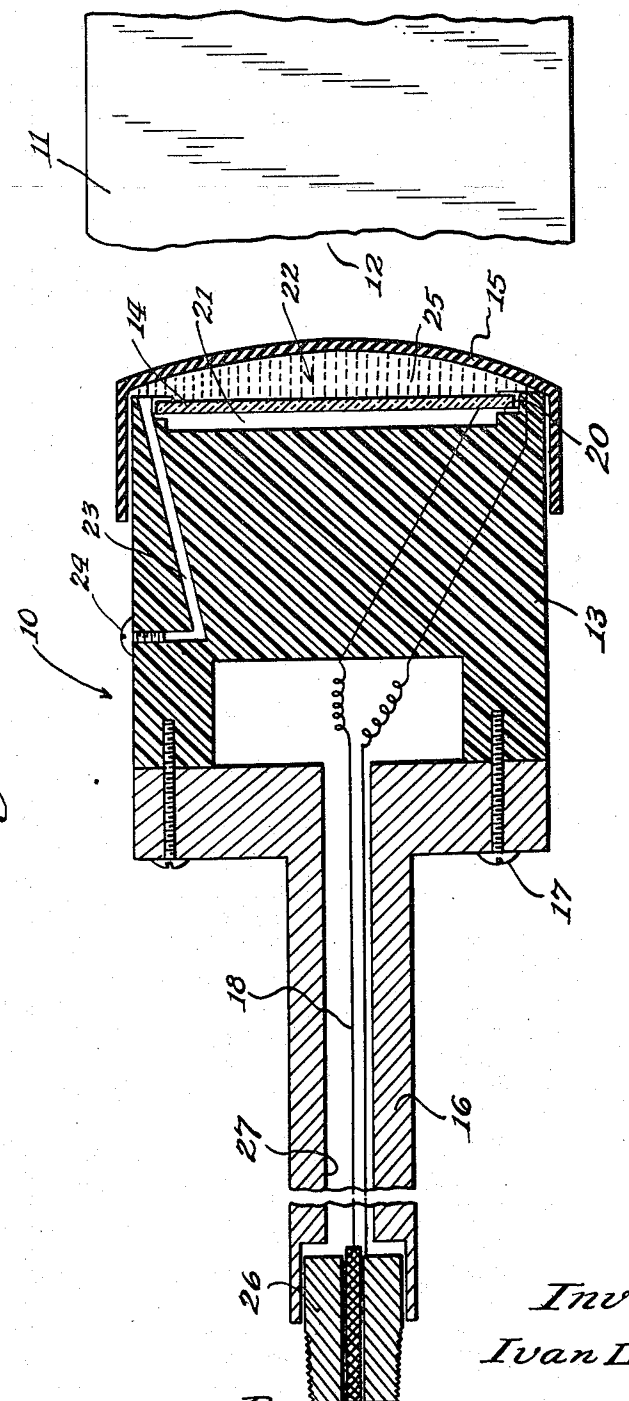

Fig. 1.

Inventor
Ivan L. Joy
By Mann, Brown and Hanemann
Attys.

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Fig. 2.

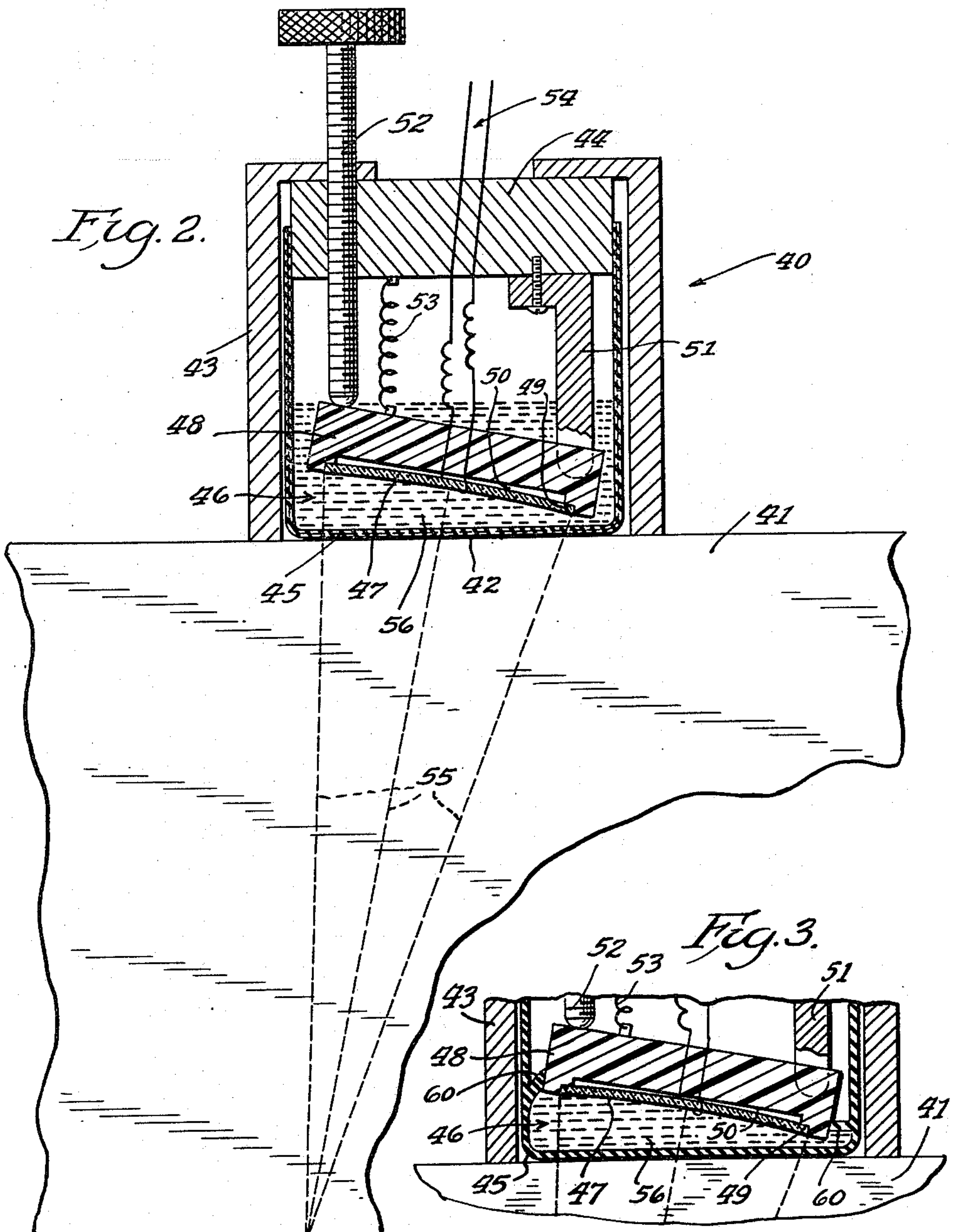

Fig. 3.

Inventor
Ivan L. Joy.

By Mann, Brown and Hansmann
Attys

2,913,602

METHOD AND MEANS FOR TRANSMITTING ELASTIC WAVES

Ivan L. Joy, Topeka, Kans.

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8 Claims. (Cl. 310—8.3)

This invention relates to a method and means for transmitting elastic waves between a transducer and a body under test and more particularly is concerned with improving the efficiency of elastic wave transmission through transducer holders that are intended for use in instances wherein there is relative movement between the transducer and the body under test.

Transducer holders of the type referred to above are characterized by a confining chamber in which the transducer is mounted for intimate contact with a suitable liquid couplant. At least a portion of the chamber wall is made of elastic wave transmitting material and this wall portion is located in the path of the elastic waves and is adapted for coupling to the entering surface of the body under test.

The principal object of the invention is to increase the efficiency of elastic wave transmission through transducer holders of the type described above.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same,

Figs. 1 and 2 are sectional views of two different transducer holders of the general class to which the present invention is applicable; and

Fig. 3 is a fragmentary sectional view showing a modification of the holder of Fig. 2.

A variety of coupling liquids are known to be effective for transmitting elastic waves between a transducer and a solid body and each exhibits its own particular advantages and disadvantages. For instance; castor oil has the property of high attenuation and hence is useful in situations wherein it is desired to avoid standing waves; silicone oil is inert and hence finds application when holders using rubber diaphragms are employed; and water is cheap and plentiful.

According to the invention, it has been found that the elastic wave transmitting ability of any of these or similar coupling liquids is importantly enhanced by mixing an appropriate quantity of metallic particles therewith. This includes such substances as white lead, powdered iron, powdered aluminum or aluminum oxide, and presumably any other powdered metallic substances.

In tests metal particles having a diameter less than one-thousandth of an inch have been employed and this appears to be the most desirable arrangement. This specific disclosure, however, is purely illustrative and is not intended to impose undue limitations upon the range of particle sizes.

In the case of any of these substances it has also been noted that standing wave problems are eliminated and while this seems anomalous in view of the increased transmission characteristics, this phenomenon is apparently due to the presence of a large number of interfaces provided by the dispersed metallic particles.

In general, the transmission characteristics of the coupling liquid mixture improve as the proportion of solid particles increases, however, such increases ultimately reduce the ability of the crystal holder to adapt itself to the surface contours of the body under test and/or to accommodate crystal movements. For the types of transducer holders discussed herein a ratio by volume of one part solid particles to two or three parts coupling liquid has been found satisfactory. Obviously the specific ratios recited are not critical and may be varied in accordance with the requirements of the particular application.

Referring now to the drawings, and particularly to Fig. 1, there is shown a transducer holder **10** that is intended for use in the ultrasonic testing of joint bars **11**, such as are used to connect adjacent rails, and other similar objects which are characterized by the fact that the surface **12** through which the ultrasound enters is of a rough and irregular contour. Only the end portion of the joint bar **11** is shown in the figure.

The transducer holder comprises a base **13** which may be made of Bakelite or some such similar insulating material, a piezoelectric crystal **14** mounted on the base, a rubber diaphragm **15** for confining coupling liquid for contact with the crystal, a handle **16** connected to the base **13** by suitable screws **17**, and a pair of wires **18** for supplying potential variations to the crystal.

The front face of the base is formed with a stepped recess that provides an annular shoulder **20** and the crystal is mounted on the base by cementing the outer marginal portions thereof to the shoulder **20**. The arrangement provides an air gap **21** behind the crystal **14** and a couplant confining chamber **22** in front of the crystal. The base is also provided with a bore **23** to facilitate filling the compartment **22** with couplant **25** and back flow is prevented by sealing the bore with a screw **24**.

The wires **18** enter the holder through a coaxial connector **26** mounted in the free end of the holder **16**, pass through an axial bore **27** formed in the handle and thence through the Bakelite base **13** for connection to the front and rear faces of the crystal. For this purpose the crystal faces are provided with suitable coatings of silver, copper, or other electrically conductive material.

In accordance with the invention the couplant **25** in chamber **22** may consist of a mixture of a coupling liquid of any chemical composition that will not be destructive of the metallic coating on the front face of the crystal **14** or to the rubber diaphragm **15** and metal particles as described above.

In testing joint bars and the like with the holder **10**, it is desirable to first clean the surface **12** through which the ultrasound is to pass and apply a suitable wetting liquid thereto. The wetting liquid may be oil or water and preferably should not be harmful to the rubber diaphragm **15**. The rubber diaphragm is preferably one-half wave length thick or a multiple thereof, this wave length being selected in relation to the speed of propagation of the ultrasound through the diaphragm.

The handle **16** of the holder is grasped and the diaphragm **15** placed against the surface **12** of the body under test and effective ultrasonic contact between the joint bar **11** and diaphragm **15** is readily obtained by applying a slight pressure. This slight pressure insures that the rubber diaphragm conforms to the irregular contours of the rough surface **12** and achieves the desired ultrasonic contact with but a minimum of coupling liquid between the diaphragm and the test part.

Since the holder **10** is applied to the testing of bodies having rough entering surfaces, it is necessary to vary the orientation of the crystal relative to the entering surface in order to select experimentally an angle of incidence such that the ultrasound will be directed through the entire length of the object under test. The rubber diaphragm responds to the slight pressures imposed and closely conforms to the contour of the entering surface at all times. These necessary changes in the contour of the rubber diaphragm as caused by the contour of the entering surface of the body under test limit the ratio of metal particles to coupling liquid that may be employed in the confining chamber **22**. Should an unduly high proportion of metal particles be employed, the ability of the rubber diaphragm to follow the contour of the test surface would ultimately be limited by the increased rigidity of the couplant mixture.

It is believed that the ability of metal particles to increase the elastic wave transmission efficiency of a coupling liquid depends in part upon the maintaining of a homogeneous mixture. In the broadest aspect of the invention, of course, the solid particles may be mixed in a coupling liquid whether the liquid is confined as in the present case or whether it is freely flowing, and in either case, will enhance the efficiency of transmission. However, in a holder wherein the coupling liquid is confined the vibrational energy of the elastic waves passing through the couplant mixture tends to maintain the particles in suspension and therefore produce a couplant medium of the highest transmission efficiency.

It has been found that the thickness of the chamber **22** in the direction of elastic wave propagation should not exceed one-quarter of an inch. When this figure is exceeded attenuation increases unduly and limits the effectiveness of the arrangement.

Fig. 2 illustrates another form of transducer holder **40** which is of the variable angle type and which is used in the testing of axles or other surfaces **41**, the entering surface **42** of which is more regular than the end surfaces of joint bars. The holder **40** consists of a metal shell **43** to which is secured a mounting block **44** on which a rubber diaphragm **45** is secured for defining therewith a confining chamber **46** in which the crystal **47** is mounted for angular movement. The crystal **47** is cemented at its outer marginal portions to an annular shoulder **49** that is provided by forming a stepped recess in the front face of a Bakelite base **48**. With this arrangement the crystal is mounted with its back face bonded by an air gap **50** and with its front face in open communication with the couplant chamber **47**.

The base **48** is mounted for angular movement and for this purpose is hinged at one end to a projectnig arm of a bracket **51** that is secured to the mounting block **45** and has its opposite end associated with a screw **52** that is threadedly received in the mounting block. In addition, the base is spring biased by a coil spring **53** and thus is urged inwardly by advancing the screw **52** and is urged inwardly by the action of the spring **53** when the screw is retracted.

The crystal is actuated by potential variations supplied over the wires **54** which pass through the mounting block **45** and through the confining chamber for contact with metallic coatings on the front and rear faces of the crystal.

In testing solid bodies with the holder **40** the metal frame **43** is normally maintained stationary relative to the entering surface of the body under test and the positioning of the screw **52** is varied to vary the angle of orientation of the crystal **47**. With this arrangement the crystal is able to scan a solid body simply by varying the angle of orientation of the crystal. Similar variable angle crystal holders find use in applications wherein it is desired to test a body with ultrasound that is transmitted at a plurality of angles of incidence in order to insure the detection of all of the flaws in the body irrespective of the plane in which they are oriented.

In this instance the crystal **47** is shown curved and this permits the beams of ultrasound **55** to be focused to facilitate the inspection of particular regions within the object and also to intensify the beam and permit the detection of smaller defects.

The couplant mixture is designated **56** and once again must have a sufficiently low proportion of solid particles as to permit the base **48** to move freely under the control of the screw **52** and bias spring **53**. Here again the passage of the ultrasonic energy through the coupling mixture maintains the solid particles in suspension within the coupling liquid and increases the efficiency of transmission.

No insulating problems have arisen from the use of metal particles in the couplant mixture. Such problems can be avoided completely, however, by partitioning the chamber **46** and as shown in the fragmentary view of Fig. 3, this may be done by connecting an auxiliary diaphragm **60** between the side walls of diaphragm **45** and the base **48**. This auxiliary diaphragm is preferably of thin rubber material and yields sufficiently to accommodate all necessary movements of the pivoted base **48**.

Another advantage of the diaphragm **60** is that it limits the confining chamber to the region through which the ultrasound must pass. This is desirable from the standpoint of controlling the ratio of the couplant mixture.

It will be noted that in the case of the holder of Fig. 1, the movement of the crystal relative to the test surface was necessitated by the roughness of this surface whereas in the case of the holder of Fig. 2, the movement of the crystal accomplished a scanning of the test part and/or permitted detection of defects regardless of their plane of orientation. There are other applications wherein the crystal moves relative to the test surface for still a different reason, such as in the testing of rail wherein the crystal moves longitudinally along the rail in order to progressively test successive portions of the rail. Changes in rail contour require movement of the crystal relative to the rail surface.

The invention also finds important application in transducer holders for the testing of rail since many of these holders also utilize confining chambers for the couplant and here again there is the particular advantage that the passage of the ultrasound through the confined coupling mixture maintains the solid particles in suspension and achieves a maximum of transmission efficiency.

It should be understood that the description of the preferred form of the invention is for the purpose of complying with section 112, title 35, of the U.S. Code and that the appended claims should be construed as broadly as the prior art will permit.

I claim:

1. In ultrasonic testing apparatus wherein elastic vibrational waves are transmitted between an electromechanical transducer and a solid body, a couplant between said transducer and body comprising a mixture of coupling liquid and metal particles.

2. In an ultrasonic system for testing a body with elastic waves by means of an electromechanical transducer wherein there is relative movement between the transducer and the body under test; a transducer holder having a confining chamber wherein said transducer is mounted in intimate contact with a couplant comprising a mixture of coupling liquid and metal particles, said chamber having an elastic wave transmitting wall portion disposed in the elastic wave path between said transducer and said body.

3. In an ultrasonic system for testing a body with elastic waves by means of an electromechanical transducer that is movable relative to the body under test; a transducer holder having a confining chamber wherein said transducer is mounted in intimate contact with a couplant comprising a mixture of coupling liquid and metal particles, said chamber having an elastic wave transmitting wall portion disposed in the elastic wave path between said transducer and said body, said wall portion being yieldable to conform to the contour of the surface of the body through which the elastic waves pass.

4. The combination with an electromechanical elastic wave generator that generates elastic wave energy for trans-

mission into a solid body through an entering surface of said body, of a holder for said generator having a confining chamber in which said generator is mounted in intimate contact with a couplant comprising a mixture of coupling liquid and metal particles, said chamber having an elastic wave transmitting wall portion disposed in the elastic wave path between said generator and said body so that elastic waves passing between said generator and said body maintain said particles in suspension in said liquid and increase the elastic wave transmission efficiency.

5. In an ultrasonic testing apparatus wherein elastic vibrational waves are transmitted between an electromechanical transducer and a solid body, a couplant between said transducer and body comprising a mixture of coupling liquid and metal particles, the ratio by volume of coupling liquid to metal particles being substantially 3 to 1, with the metal particles having a diameter on the order of one thousandth of an inch.

6. The arrangement of claim 4 wherein the ratio by

volume of coupling liquid to metal particles is substantially 3 to 1.

7. The arrangement of claim 4 wherein the ratio by volume of coupling liquid to metal particles is substantially 3 to 1, with the metal particles having a diameter on the order of one thousandth of an inch.

8. The arrangement of claim 4 wherein the elastic wave transmitting wall portion of said chamber is spaced not more than ¼" from said generator.

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