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(71) Applicant
The Secretary of State for Defence (United Kingdom), Whitehall, London SW1A 2HB

(72) Inventors
Leonard John Bond,
Nader Saffari

(74) Agent and/or Address for Service
R. A. Miller,
Procurement Executive, Ministry of Defence, Patents 1A(4), Room 2014, 20th Floor, Empress State Building, Lillie Road, London SW6 1TR

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(58) Field of search
G1G

(54) Method of ultrasonic non-destructive testing

(57) The method uses spectral analysis of leaky Rayleigh waves to yield information relating to surface crack dimensions. The method comprises placing a transmitter transducer (20) to transmit toward an immersed test-piece (30), placing a receiver transducer (23) to receive from the test-piece, exciting the transmitter transducer to establish ultrasonic waves in the test-piece, positioning the receiver transducer at substantially the Rayleigh Critical Angle (θ) for the test-piece material with respect to the normal to the test-piece surface and recording the receiver transducer output for analysis. The receiver transducer may be on the same side of the test piece as the transmitter transducer, and the transducers may form a single transmitter/receiver transducer.

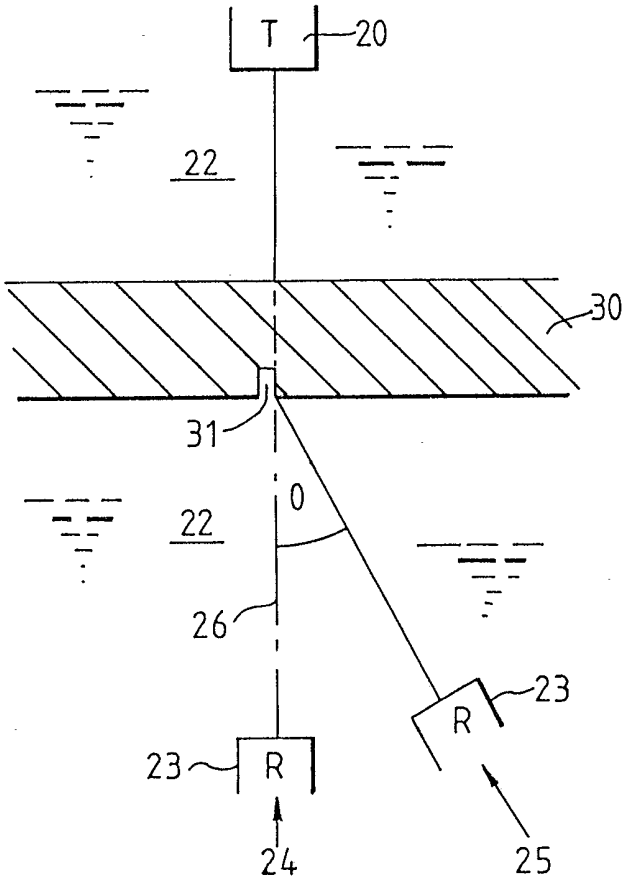


Fig. 3a.

GB 2 139 757 A

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

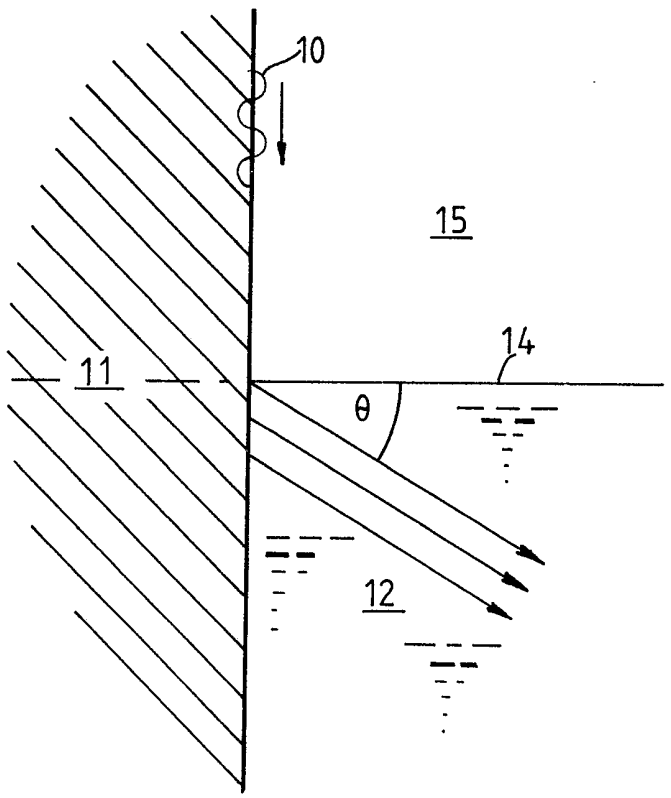


Fig. 1. (PRIOR ART)

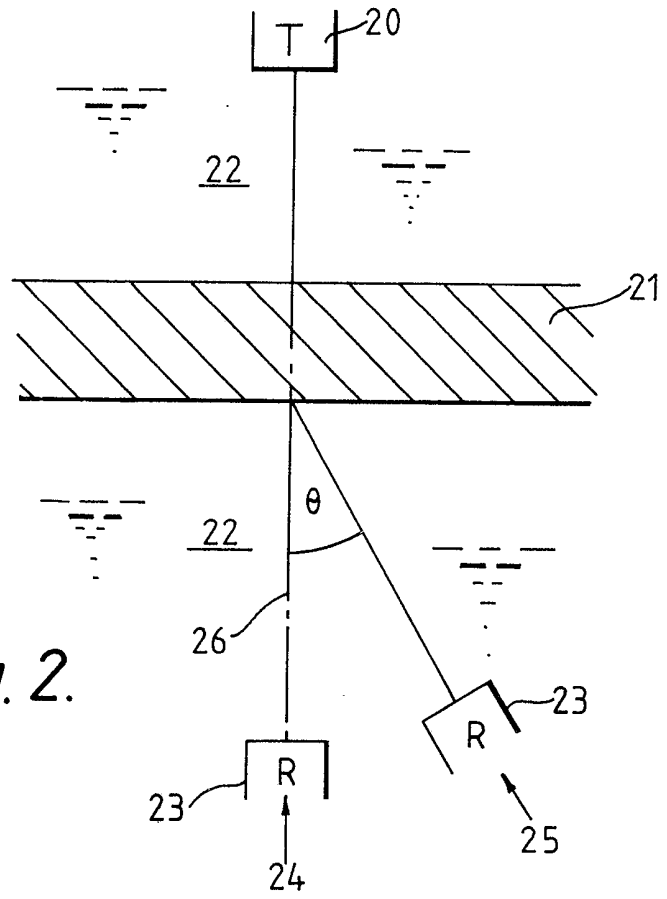


Fig. 2.

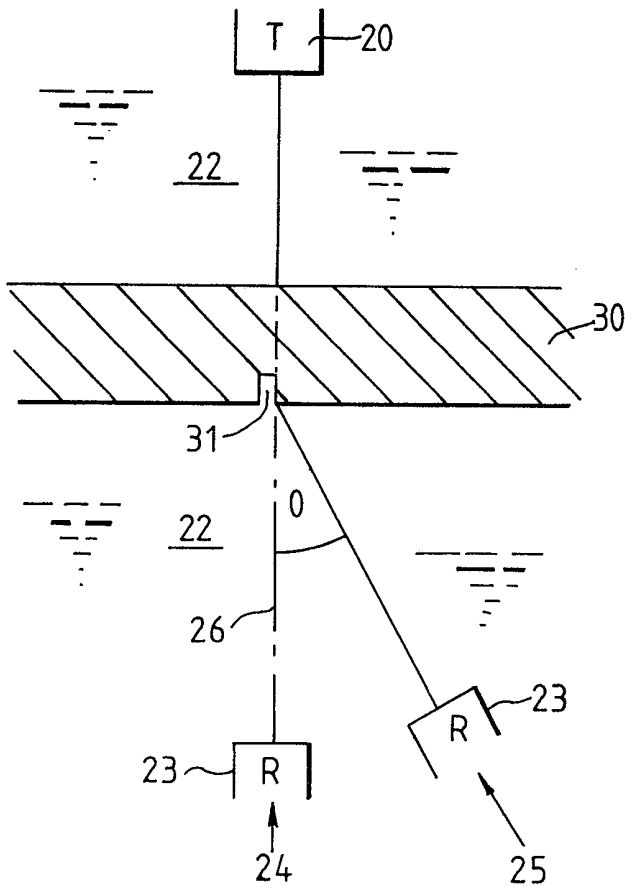


Fig. 3.a.

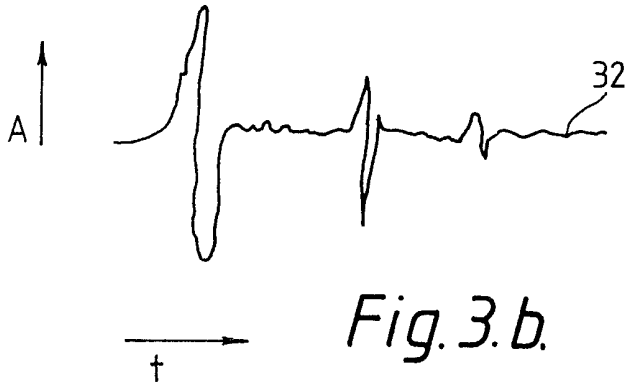


Fig. 3.b.

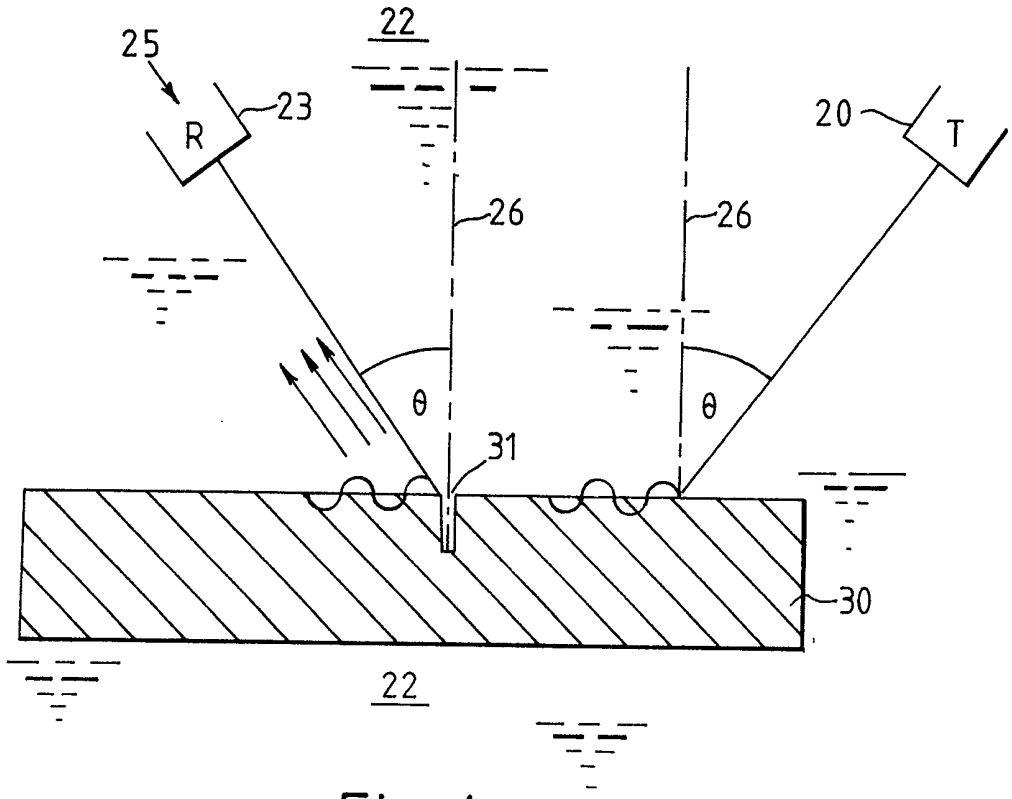


Fig. 4.

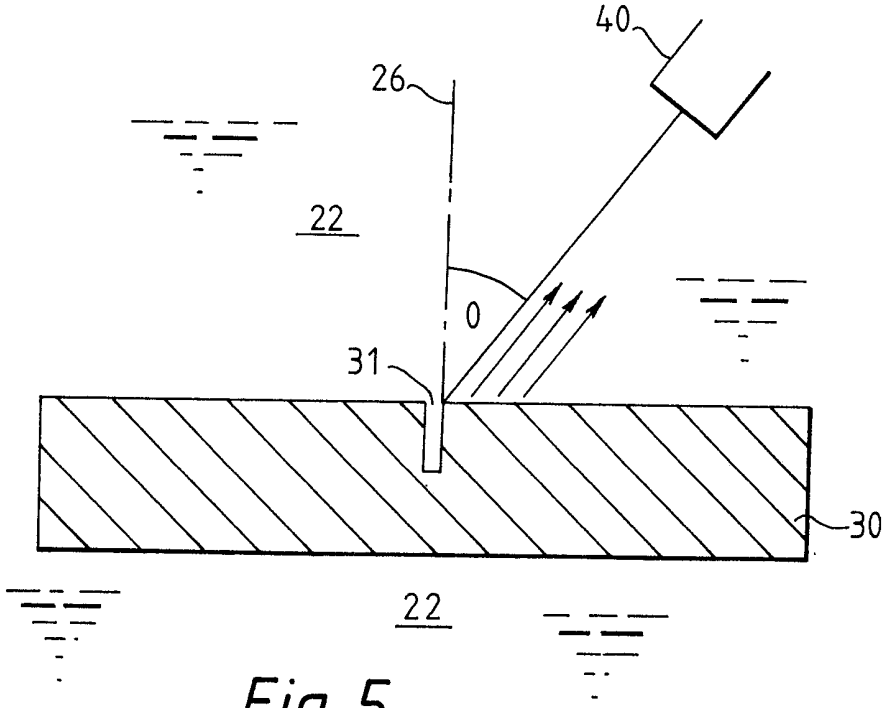


Fig. 5.

SPECIFICATION

Method of ultrasonic non-destructive testing

The present invention relates to a method of ultrasonic non-destructive testing, and in particular to ultrasonic non-destructive testing by immersion.

In ultrasonic non-destructive testing (UNDT) vibration within a test-piece is established and measured either by transducers in direct contact with the test-piece, or by transducers coupled to the test-piece by an intervening medium. A medium with good coupling characteristic is desirable, water is often used, the test-piece being immersed in the medium for testing purposes. This latter technique is often referred to as immersion testing, and it is to immersion testing that the present invention relates.

It is known that mode conversion occurs at an immersion interface. For example, if an aluminium test-piece is partially immersed in water and a Rayleigh wave established in the sample propagating towards the water boundary, mode conversion will occur at the air/water interface, resulting in compression wave propagation within the fluid. This phenomenon is sometimes referred to as a leaky Rayleigh Wave, and the propagation in the fluid occurs at some particular angle with respect to the boundary, known as the Rayleigh Critical Angle.

Mode converted, diffracted and some reflected and refracted waves have in the past been considered to be essentially noise or loss mechanisms which take energy from and cause interference with the main signal which it is desired to receive and analyse. In the present invention it is the intentional excitation of leaky Rayleigh waves by defects and the analysis thereof which form the testing methods.

According to the present invention a method for the non-destructive testing of a test-piece includes the steps of placing a transmitter transducer to transmit toward an immersed test-piece, placing a receiver transducer to receive from the test-piece, exciting the transmitter transducer to establish ultrasonic waves in the test-piece, positioning the receiver transducer at substantially the Rayleigh Critical Angle for the test-piece material with respect to the normal to the test-piece surface and recording the receiver transducer output for analysis.

In some embodiments of the invention a combined transmitter/receiver (transceiver) transducer may be employed the signals being in the pulse-echo configuration and the reflected leaky Rayleigh waves being recorded for analysis.

According to a feature of the invention the receiver transducer output is analysed by computer means.

It has been found that the method of the invention is particularly suitable for the testing of components having small surface or near surface defects where conventional time domain analysis of the signals cannot be used.

No reception due to Leaky Rayleigh Wave generation is to be expected with a perfect test-piece. Such reception at the receiver transducer indicates likely presence of a near surface or surface breaking defect, and the recording may be analysed to characterise the defect. Such analysis of the recorded signals will be by spectroscopic techniques as these techniques will yield information which may be used to dimension the defect.

In order that the potential of the invention and the means of putting it into effect may be better understood, some tests will now be described by way of example only with reference to the accompanying diagrammatic drawings of which:

Figure 1 represents a known arrangement to demonstrate the phenomenon of a Leaky Rayleigh Wave,

Figure 2 shows an arrangement for an ultrasonic non-destructive test in accordance with the present invention,

Figure 3 indicates typical test results using a defective test-piece.

Figure 4 shows an alternative arrangement of transducers for an ultrasonic non-destructive test in accordance with the present invention,

Figure 5 shows a transceiver arranged for an ultrasonic non-destructive test in accordance with the present invention.

In the following descriptions of the figures similar components have been given common identification numbers.

Referring now to Figure 1. It is known that if a Rayleigh Wave 10 is set up in the surface of a solid 11 partially immersed in a fluid 12, then mode conversion will occur at boundary 14 between air 15 and fluid 12. A compressive wave will propagate through the fluid 12 at an angle θ. This phenomenon is known as a Leaky Rayleigh Wave, and the angle θ as the Rayleigh Critical Angle. For an aluminium alloy test-piece partially immersed in water the critical angle is approximately 30°.

Referring now to Figure 2. In a test performed in accordance with the present invention an emission transducer 20 is placed to one side of a test-piece 21 immersed in a fluid 22. A receiver transducer 23 is placed on an opposite side of test-piece 21 at a position 24 along a straight transmission path 26. As would be expected, when the transmitter transducer 20 is energised, reception occurs at receiver transducer 23 due to compression wave through transmission across the test-piece 21. Transducer 23 was now moved through an angle θ to position 25, at which no reception was recorded. The test was performed with broadband transducers operated at centre frequencies in the range 1 to 10 MHz. The test-piece was aluminium alloy plate immersed in water and the angle through which the receiver transducer 23 was moved to reach position 25 was approximately 30°, being the Rayleigh Critical Angle for aluminium immersed in water.

Referring now to Figure 3. The test described above was repeated with a fresh specimen 30 (Figure 3a) having a surface breaking crack defect at a point 31 aligned to be on straight transmission path 26. This time reception occurs at position 25 when the transmitter 20 is energised. The form of output of the receiver 23 at position 25 may be represented as a trace 32 of amplitude (A) against time (t) (Figure 3b). The trace indicates reception of a compression wave generated by a Leaky Rayleigh Wave. The multiple peaks can be identified as being

due to reverberation of the compression wave within the sample 30.

If the spectrum of the recorded signal is analysed, it may be seen that it has been modulated due to the interference of separate pulses arriving from different features of the crack, for example, the bottom 270° corner and the top 90° corner. The locations of the modulation peaks and their periodicity can thus be releated to the depth dimension of the defect.

If more than one receiver is employed information about the angle of the crack to the surface may be extracted. Also as the incidence of compression waves on a crack results in a radiation field which can be related to surface breaking length, it is expected that this information will be transferred to the Leaky Rayleigh Waves.

Figure 4 shows the arrangement of the transmitter transducer 20 and the receiver transducer 23 both positioned on the same side of the test-piece 30 and wherein the transmitted signal is recorded. Since the depth of penetration of the surface waves is frequency dependent those wavelengths less than the defect depth dimension will be severely impeded in their passage past the defect. Therefore, analysis of the received signal spectrum will show marked differences, such as for example, a high frequency (short wavelength) cut off point when compared to the transmitted pulse. Through the deconvolution of the received signal spectrum by the incident spectrum these differences are enhanced and may thus be used for estimating the defect depth.

It will be appreciated that much information about the condition of a sample may be built up by multiple measurements performed in accordance with the present invention.

Figure 5 shows the arrangement of a transceiver 40 used in a pulsed signal mode to transmit and then receive a signal.

Signal analysis may be carried out by conventional computing techniques known in the art.

It will also be appreciated that the method will employ apparatus to facilitate the scanning of a test-piece by the transducers in the handling and manipulation thereof.

CLAIMS

1. A method for the non-destructive testing of a test-piece includes the steps of placing a transmitter transducer to transmit toward an immersed test-piece, placing a receiver transducer to receive from the test-piece, exciting the transmitter transducer to establish ultrasonic waves in the test-piece, positioning the receiver transducer at substantially the Rayleigh Critical Angle for the test-piece material with respect to the normal to the test-piece surface and recording the receiver transducer output for analysis.

2. A method according to claim 1 and wherein the transmitter transducer and receiver transducer are combined into a transceiver transducer.

3. A method substantially as hereinbefore described with reference to the accompanying specification any one of Figures 3, 4 or 5 of the drawings.

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