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(54) Title: ULTRASOUND INVESTIGATION OF JOINT INTEGRITY FOR BONDED PANELS

(57) Abstract: An ultrasound system for investigating the integrity of a bonded joint between a panel and a supporting structure, for example a vehicle glazing panel and a supporting frame, is disclosed. An ultrasonic transmitter is used to produce an ultrasonic transmission signal and a hand held, hand manipulable ultrasonic receiver is used to pick up the ultrasonic transmission signals and produce an output. The ultrasound transmission signal is modulated with a square wave form envelope in order to most effectively filter out background noise; and/or the receiver includes an adjustable gain control providing continuously variable gain over a predetermined range.

Ultrasound Investigation of Joint Integrity for Bonded Panels

The present invention relates to investigation of joint integrity for bonded panels and in particular to bonded panels such as window panes or vehicle window panels or windscreens.

In the technical field of vehicle windscreen replacement it is necessary for a replacement windscreen to be placed in register with a supporting structural opening of the vehicle, having a peripherally running bonding bead sandwiched in between the structure and the windscreen. The bonding bead is typically an adhesive material which cures in situ. A Polyurethane material is often used for the bonding material. The bonding material , in addition to its bonding function also acts as a seal to prevent moisture ingress from the exterior of the vehicle. If the bonding material integrity is compromised, for example voids or air gaps extending across the bead or if the bonding bead has been poorly applied such that spaces exist along the line of the bead, then customers return to the windscreen replacement service provider requiring a refund and/ or a repeat job. In these circumstances the customer satisfaction is poor, damaging the business and reputation of the service provider.

A prior art technique for investigation of sealing quality is disclosed in, for example US Patent 5780723. An improved technique and system for checking the integrity of a bonded joint has now been devised.

According to a first aspect, the present invention provides a system for investigating the integrity of a bonded joint between a panel and a supporting structure, the system comprising:

an ultrasonic transmitter device to produce an ultrasonic transmission signal; and,

an ultrasonic receiver device, the receiver device being hand held and manipulable; wherein:

a) the ultrasound transmission signal is modulated with a square wave form envelope; and/or

b) the receiver device includes an adjustable gain control providing continuously variable gain over a predetermined range.

The continuously variable gain enables any localised area of poor integrity bond to be rapidly and conveniently focussed in on under the control of the operator.

It is preferred that the ultrasonic receiver produces an output dependent upon the amplitude of the ultrasound signal received.

The frequency of the square wave form modulation is preferably substantially 50 per cent or lower than 50 per cent of the frequency of the ultrasonic carrier signal. In an exemplary embodiment the ultrasonic transmission frequency could be 40KHz, with the modulation frequency being 1Khz square wave. In an alternative embodiment, the the ultrasonic transmission frequency could be 100KHz, with the modulation frequency being 40 to 45Khz square wave.

The receiver beneficially processes received signals to ascertain the phase of the incoming signal to identify and lock to the correct target modulated incoming signal. A phase lock loop arrangement may be utilised to this effect. The receiver beneficially processes the targeted incoming modulated signal to measure the amplitude of the received ultrasonic transmission signal. This is beneficially compared to datum data representative of the maximum transmitter output amplitude, in order to produce an output signal. The output signal is varied dependant upon the ratio of (or difference between) the measured amplitude and the maximum representative datum.

Beneficially, the output comprises an audible output. Desirably, the audible output has an active mode when the device is being operated. In audible, active, mode a base audible output is preferably produced to indicate that the device is active, the audible output beneficially varying as the amplitude of the detected ultrasound signal increases. It is preferred that the audible signal comprises a series of sound pulses, the pulse rate increasing (or pulse interval decreasing) as the amplitude of the detected ultrasound signal increases. This provides a good

technique for feedback to the operator as they operate the gain control and scan (move) the receiver with respect to the panel.

The use of the sound envelope modulation enables the ultrasonic signal from the transmitter to be identified and filtered from background noise, including background ultrasonic noise. The use of a square wave envelope provides defined front and rear end cut offs to the signal enabling ready identification. For example such a wave form envelope enables a phase lock loop to be used to achieve this in a convenient fashion. The elimination of background noise is particularly important for practical realisation of the invention because of the fact that investigation will generally be conducted in garage or workshop environments with potentially numerous other sources of ultrasound signals.

It is preferred that the receiver produces a visual output dependent upon the amplitude of the ultrasound carrier signal received. The visual signal is preferably in addition to the audible signal.

Beneficially, the gain control is used to control amplification of the received ultrasound signal. In a preferred embodiment, the adjustable gain control comprises a variable potentiometer, more preferably a rotary potentiometer.

The receiver device preferably includes a filter to isolate and lock to the correct target modulated incoming signal.

Preferably, the ultrasonic transmitter includes an ultrasound generator and modulation means for modulating the ultrasound carrier signal transmitted. Beneficially, the ultrasound carrier signal is amplitude modulated.

According to a further aspect, the invention provides a method of investigating the integrity of a bonded joint between a panel and a supporting structure, the method comprising using a system having an ultrasonic transmitter device and an ultrasonic receiver device, the receiver device being hand held and manipulable, wherein:

a) the ultrasound transmission signal is modulated with a square wave form envelope; and/or

b) the receiver device includes an adjustable gain control providing continuously variable gain over a predetermined range, the system being operated to:

initially select high level gain using the gain control and scanning the receiver device with respect to the panel until a signal is detected;

subsequently reduce the gain incrementally over its continuously variable range, whilst simultaneously moving the receiver with respect to the panel in order to ensure that a signal remains registered by the receiver device.

The system is particularly suited for investigation of the bond integrity for vehicle window panes such as windscreens. Beneficially the transmitter device is positioned internally of the vehicle and the operator is positioned externally of the vehicle. The transmitter and receiver are therefore beneficially positioned on opposed sides of the panel.

The invention will now be further described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a schematic perspective view showing a windscreen bonded to a supporting structure and the system of the invention in use;

Figure 2 is a block diagram of the transmitter of the system of Figure 1;

Figure 3 is a block diagram of the receiver of the system of Figure 1;

Figure 4 is a schematic representation of square wave form envelope modulation of the transmission ultrasound signal.

Referring to the drawings, and initially to Figure 1, there is shown a vehicle laminated windscreen 1 comprising a pair of glass sheets 2, 3 separated by an intermediate laminated plastics layer 4. Windscreen 1 is bonded to a vehicle windscreen structural frame 5 by means of an interposed polyurethane bonding bead 6 which extends around the entire periphery of the windscreen 1. The reverse face of windscreen 1 is provided with a peripheral ultraviolet barrier comprising a screen print layer 7 arranged to shield bead 6 from naturally occurring ultraviolet radiation. An external rubber seal 8 of the internal vehicle trim 9 is provided at the screen 1/frame 5 connection for weatherproofing and cosmetic reasons respectively. During windscreen replacement seal 8 and trim 9 are removed.

The bonding bead 6 also provides an important weatherproofing function and therefore the integrity of the bead 6 applied during windscreen replacement must be sound. When replacing vehicle windscreens it is frequently the case that either the bonding material bead is poorly applied or that during curing or placement of the vehicle windscreen, voids or gaps are created bridging the bonding bead. This can result in a poor integrity bond which has implications from a safety point of view and also means that the seal may not be weatherproof.

It is therefore of significant benefit to be able to check the integrity of the bond following replacement of a vehicle windscreen in position.

In accordance with the present invention, this is achieved by utilisation of an integrity testing system comprising an ultrasound transmitter 10, positioned internally of the vehicle, and a corresponding ultrasound receiver device 20 positioned externally of the vehicle.

The ultrasound transmitter 10 has a carrier frequency generator 11 arranged to produce a transmission signal which is mixed by means of a mixer 12 with a structured square wave modulation envelope generated by a sound generator 13. This is shown most clearly in figure 4 with the square wave envelope 41 modulating the ultrasonic pressure wave 42. The frequency of the square wave form modulation is preferably significantly different to the

ultrasound pressure wave transmission frequency. Preferably the frequency of the square wave form modulation is substantially 50 per cent (or lower than 50 per cent) of the frequency of the ultrasonic transmission signal. In an exemplary embodiment the ultrasonic transmission frequency could be 40KHz, with the modulation frequency being 1Khz square wave. In an alternative embodiment, the the ultrasonic transmission frequency could be 100KHz, with the modulation frequency being 40 to 45Khz square wave.

The mixed signal is amplified by means of amplifier 14 and transmitted via air. The transmitter 10 is positioned in the vicinity of the windscreen periphery; seal 8 is not yet repositioned following fitting of the glass. Ultrasonic waves passing through any breach or other flaw in the bond provided by the bonding material bead 6 would pass to the exterior of the vehicle windscreen and be detected by the receiver 20. The receiver has a handle 21 to be easily manipulatable and also a continuously variable gain control 30 which will be described in further detail hereafter.

The receiver 20 includes an ultrasound detector transducer 22 which produces an output which passes through a preamplifier 23. The signal passes via gain control 30 to amplifier 24 which passes the signal onto a signal DC converter 25 where the signal is converted to a DC level. The signal level is measured by a processor 26 which adjusts the respective output via a tone generator and amplifier or the LED drive 29. The processor 26 processes received signals to ascertain the phase of the incoming signal in order to identify and lock to the correct target modulated incoming signal. A phase lock loop arrangement is utilised in order to achieve this. The processor 26 processes the targeted incoming modulated signal to measure the amplitude of the received ultrasonic transmission signal. This is beneficially compared to datum data representative of the maximum transmitter output amplitude, in order to produce an output signal. The output signal is varied dependant upon the ratio of (or difference between) the measured amplitude and the maximum representative datum.

The gain control 30 is operator adjustable continuously over a predetermined range. The gain control 30 comprises a rotary potentiometer and switch. In use, initially the operator selects maximum gain and the receiver 20 is moved about the detection zone until a signal is received. Initially this signal may be very strong and shown over a large area. The operator gradually

reduces the gain using gain control 30 whilst still moving the receiver 20 about the detection zone ensuring that a signal is still present. This process continues until the signal is only obtained at the site of the problem.

The signal output from the receiver to the operator is importantly via an audible signal. The audible output provides a continuous reminder signal that the unit is in operational mode, the audible output varying as the amplitude of the signal detected increases. Typically the audible signal will comprise a series of audible pulses or marks, the pulse repetition frequency increasing (or the interpulse duration decreasing) as the amplitude of the signal detected increases.

The feature of the gain being variable over a continuous range (rather than in step changes) is also important as this enables the operator to accurately control and focus in on the area at which the signal is strongest. The rotary potentiometer enables this continuously variable gain adjustment to be achieved.

The use of the sound envelope modulation and filtering enables the modulated ultrasonic signal from the transmitter to be identified and filtered from background noise, including background ultrasonic noise. The use of a square wave envelope provides defined front and rear end cut offs to the signal enabling ready identification. For example such a wave form envelope enables a phase lock loop to be used to achieve this in a convenient fashion. The elimination of background noise is particularly important for practical realisation of the invention because of the fact that investigation will generally be conducted in garage or workshop environments with potentially numerous extraneous sources of ultrasound signals.

The invention provides a convenient technique and system for quickly and accurately identifying any areas of poor bonding integrity for vehicle windscreen replacement. Whilst primarily described in relation to vehicle windscreen replacement, it would be readily appreciated that the technique and system can be used in other applications in which the integrity of the bond may usefully be investigated.

Claims:

1. A system for investigating the integrity of a bonded joint between a panel and a supporting structure, the system comprising:

an ultrasonic transmitter device to produce an ultrasonic transmission signal; and,

an ultrasonic receiver device, the receiver device being hand held and manipulable; wherein:

a) the ultrasound transmission signal is modulated with a square wave form envelope; and/or

b) the receiver device includes an adjustable gain control providing continuously variable gain over a predetermined range.

2. A system according to claim 1, wherein the ultrasonic receiver produces an output dependent upon the amplitude of the ultrasound signal received.

3. A system according to claim 2, wherein the output comprises an audible output.

4. A system according to claim 3, wherein the audible output has an active mode when the device is operable.

5. A system according to claim 4, wherein in audible active mode a base audible output is produced to indicate that the device is active, the audible output varying as the amplitude of the detected ultrasound signal increases.

6. A system according to any of claims 2 to 5, wherein the audible signal comprises a series of sound pulses, the pulse rate increasing as the amplitude of the detected ultrasound signal increases.

7. A system according to any preceding claim, wherein the receiver produces a visual output dependent upon the amplitude of the ultrasound signal received.

8. A system according to any preceding claim, wherein the square wave form modulation is at or below 50 per cent of the frequency of the ultrasonic transmission signal.

9. A system according to any preceding claim, wherein the receiver processes received signals to ascertain the phase of the incoming signal to identify and lock to the correct target modulated incoming signal.

10. A system according to claim 9, wherein a phase lock loop arrangement is used to identify and lock to the correct target modulated incoming signal.

11. A system according to any preceding claim, wherein the receiver processes the targeted incoming modulated signal to measure the amplitude of the received ultrasonic transmission signal.

12. A system according to claim 11, wherein the measured amplitude is compared to datum data representative of the maximum transmitter output amplitude, in order to produce an output signal.

13. A system according to claim 12, wherein the output signal is varied dependant upon the variance of the measured amplitude and the maximum representative datum.

14. A system according to any preceding claim, wherein the gain control is used to control amplification of the received ultrasound signal.

15. A system according to any preceding claim, wherein the adjustable gain control comprises a variable potentiometer.

16. A system according to claim 15, wherein the adjustable gain control comprises a rotary potentiometer.

17. A system according to any preceding claim, wherein the ultrasonic transmitter includes an ultrasound generator and modulation means for modulating the ultrasound signal transmitted.

18. A system according to claim 17, wherein the ultrasound transmission signal is amplitude modulated.

19. A system according to any preceding claim , wherein the modulation envelope is of audible frequency.

20. A system according to any preceding claim, wherein the receiver device includes a filter to isolate the modulated signal.

21. A method of investigating the integrity of a bonded joint between a panel and a supporting structure, the method comprising using a system having an ultrasonic transmitter device and an ultrasonic receiver device, the receiver device being hand held and manipulable, wherein:

a) the ultrasound transmission signal is modulated with a square wave form envelope; and/or

b) the receiver device includes an adjustable gain control providing continuously variable gain over a predetermined range, the system being operated to:

initially select high level gain using the gain control and scanning the receiver device with respect to the panel until a signal is detected;

subsequently reduce the gain incrementally over its continuously variable range, whilst simultaneously moving the receiver with respect to the panel in order to ensure that a signal remains registered by the receiver device.

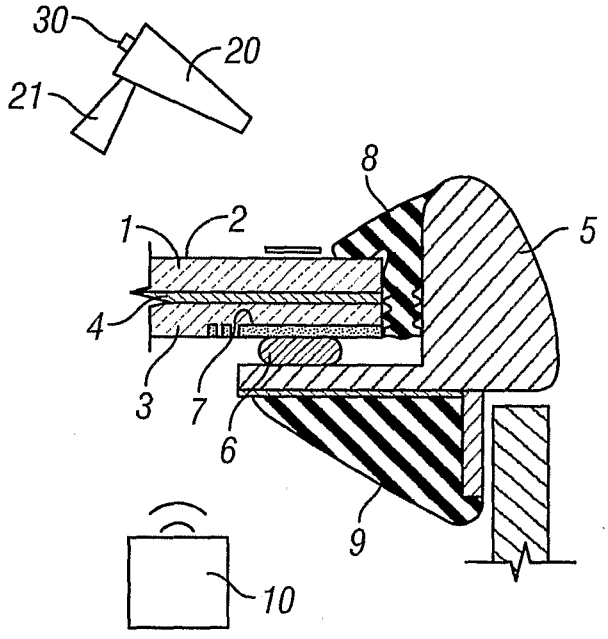
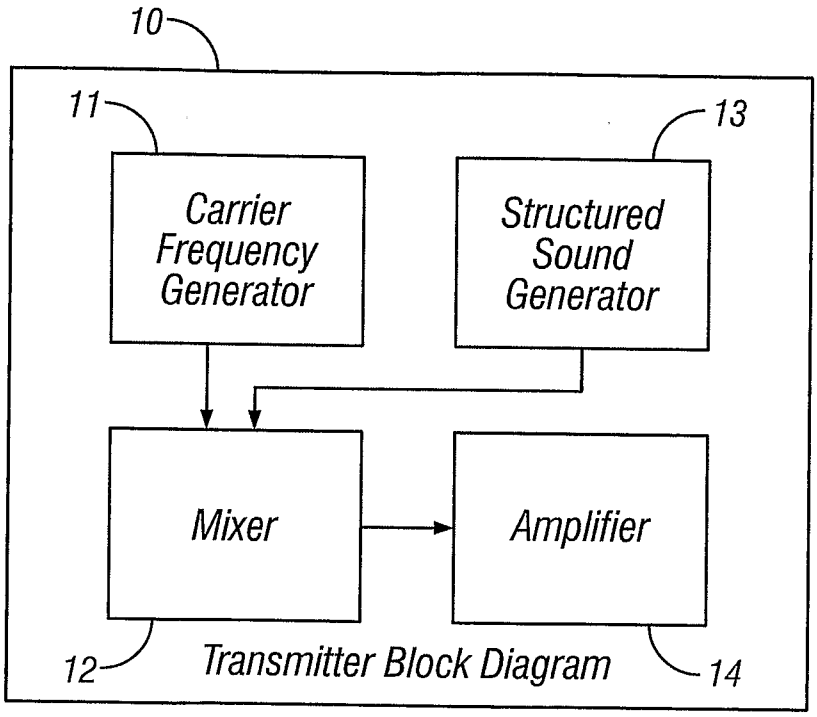


FIG. 1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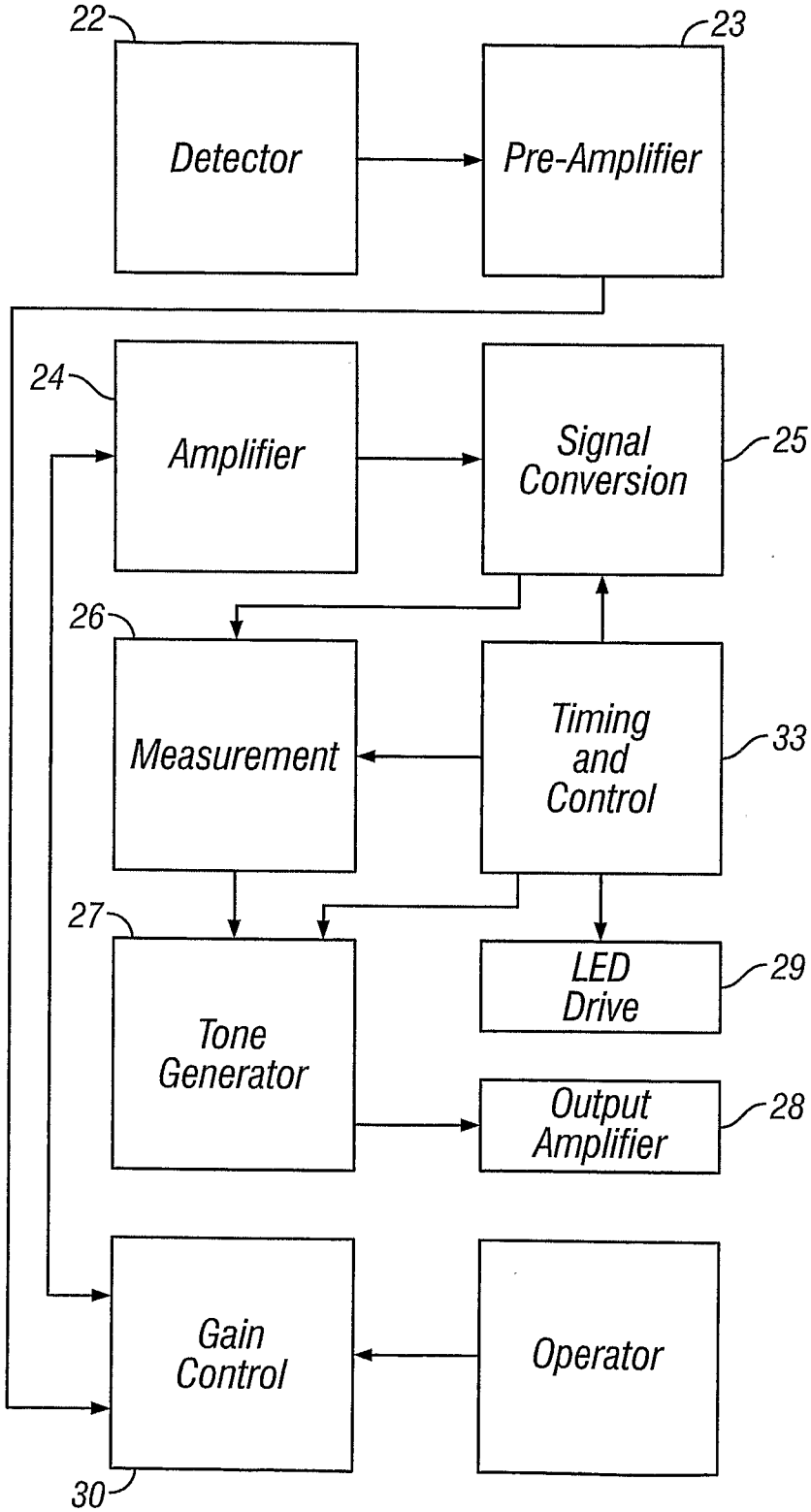
11
13
Carrier Frequency Generator
Structured Sound Generator
Mixer
Amplifier
12
Transmitter Block Diagram
14

FIG. 2



Receiver Block Diagram

FIG. 3

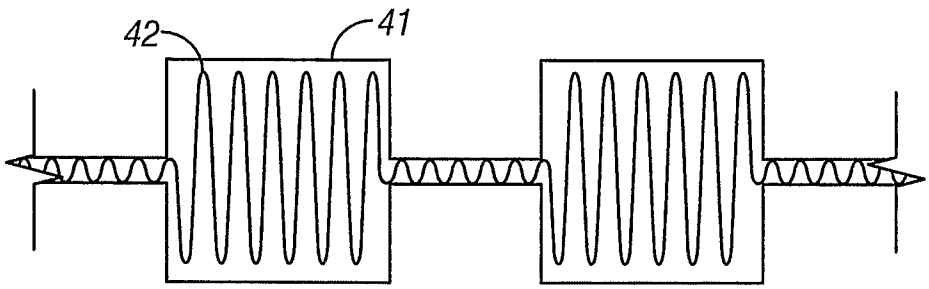


FIG. 4