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(54) A PROCESS FOR AUTOMATICALLY FOLLOWING UP READING EXPECTATION RANGES IN CONNECTION WITH ULTRASONIC TESTING

(71) We, MANNESMAN AKTIENGESELLSCHAFT, a German Body Corporate, of Mannesmannufer 2, 4 Düsseldorf 1, Federal Republic of Germany, and KARL DEUTSCH PRÜF- UND MESSGERÄTEBAU, a German Body Corporate, of Otto-Hausmann-Ring 101, 5600 Wuppertal-Elberfeld, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The invention relates to a process for automatically adjusting the looking window for the detection of ultrasonic signals by means of follow-up control, for example, for the testing of metal sheets using transmitter-receiver testing heads, the transit time between transmission pulse and first rear wall echo being measured in each testing cycle and the end of the looking window, when no flaw echo is present, being established with the aid of the transit time, the start of the looking window being measured in each testing cycle.

The "looking window" referred to above is to mean, for example, the period during which an ultrasonic receiver is enabled to receive an echo signal. A looking window, therefore, has two meanings, a broad one and a narrow one. Generally, it is just a period during which a particular signal path for electrical signals representing ultrasonic signals is open. The narrow meaning or definition relates to the fact that for and during a specific looking window specific signals are expected to the exclusion of others.

The device which establishes the basis for the looking window is a monitor, e.g. a signal monitor, digital monitor, analogue monitor or integrating monitor. In a known process, the looking window is established by such a monitor by means of test reflections derived form representative test or reference objects and once established, the looking window remains invariant during the testing operation.

One application by way of example is the testing of metal sheets, strips and tubes using test heads which transmit ultrasonic waves transversely to the surfaces of the test objects. For reasons of tolerances of the test objects as well as of the test equipment, one can test only from the front surface of the object to a little (a few mm) above the rear wall surface; thus the region near the wall surface is excluded from inspection, i.e. the looking window for flaw echoes is closed well ahead of the occurrence of the rear wall echo.

German Offenlegungsschrift 24 22 439 discloses a method for automatic adjustment of the looking window whereby echo pulses are measured and their occurrence controls the position (in time) of the looking window. This method has the disadvantage that it does not adjust to differences in thickness of a test object. Thus, rear wall echos could be interpreted as a flaw echo if the test object is thin at a particular location. On the other hand, echoes from flaws close to the rear wall may be missed for a thicker than normal location of the test object. These flaw signals are able to influence the recognition of a reference echo so that a wrong looking window is generated for subsequent measurements.

A testing of both sides of the metal sheets is often desirable and results in duplication of equipment. Also, registration and association as well as cross-checking of test data for purposes of ascertaining the true situation as to defects is quite difficult with known equipment including, for example, compensation of test head characteristics and referring to the respective rear wall echo.

It is the aim of the invention to provide a method of ultrasonically testing objects which permit testing of the object from one side only without having to exclude rear surface regions.

Accordingly the present invention provides a method of automatically adjusting looking windows in ultrasonic testing of an object for flaws by transmission thereto of ultrasonic signals and detecting echoes wherein in each test cycle at least two echo pulses from the rear wall surface of the object are detected, the method comprising:

(a) detecting the transit time of a first and second rear wall pulse during a particular cycle and forming the transit time difference;

(b) generating a first looking window for detection of flaw echoes during a cycle following the particular cycle, by providing for a beginning of the window at an instant ahead of the first rear wall echo by the transit time difference and by providing for an end of that window ahead of the first rear wall echo by a particular, relatively small amount

(c) generating a second looking window or predetermined width for detecting a first rear wall echo in the said following cycle, shortly after the end of the first window as generated;

(d) generating a third looking window of predetermined width for detecting a second rear wall echo in the said following cycle, the third looking window beginning at a delay after the end of the first window as generated, the delay being the transit time difference, so that first and second rear wall echoes can be distinguished from a flaw echo; and

(e) using the first and second rear wall echoes as actually occurring during the second and third windows as generated for the generation of the first looking window in the next following cycle as per step (b).

By contrast with prior known test procedures, also flaws in the region between minimum wall and actual wall thicknesses are reliably recognised with the method of the present invention. Furthermore, the adjustment procedures necessary with conventional methods are avoided.

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

Figure 1 is the simplified timing diagram for ultrasonic signals during one test cycle; and

Figure 2 is a function diagram explaining the automatic adjustment of looking windows in accordance with a preferred embodiment of the present invention.

A logic unit controlled by the actual wall thickness of the test element is used, which logic unit determines in each separate test cycle the reading expectation ranges for the following test cycle. Accordingly, the simplified representation of the ultrasonic signals during a test cycle is shown in Figure 1. For the looking window, it is necessary with each test cycle to establish the time between transmitter pulse 1 and first rear wall echo 2. This is effected, for example, by a digital counting process between the transmitter pulse 1 and the first rear wall echo 2. The end of the looking window 3 is equal to the difference between the time as measured above and a prescribed tolerance (e.g. 0.3 mm sound transit time in the steel).

Another necessary measurement value is the actual wall thickness. It is established by measuring the time between the first rear wall echo 2 and a second rear wall echo 6.

The start of the looking window 3 in a test cycle is established by the difference in the previous test cycle of the transit time between transmitter pulse 1 and the first rear wall echo 2 and the transit time between the first rear wall echo 2 and the second rear wall echo 6.

By the establishment of the start of the looking window 3 in each test cycle, each variation in fluid coupler path between test head and test object is taken into account during the testing. Furthermore, from the measured transit times in one test cycle are calculated the values for the rear wall echo looking windows 4 and 5 in the next test cycle.

The meaning of the references in Figure 2 is as follows:

9 Commencement of test
10 Assumption of provisional looking windows 3, 4 and 5
11 Signal in looking window?
12 Rear wall echo present?
13 Transit time measurements
14 Formation of new looking windows
15 End of flaw range <minimum wall thickness?
16 End of flaw looking window = minimum wall thickness
17 Signal in looking window?
18 Flaw within minimum wall thickness?
19 Blocking of the looking window setting for 1 test cycle
20 Rear wall echo present?
21 Blocking of the looking window setting for 1 test cycle

22 Transit time rear wall echo = transit time flaw

Figure 2 shows the sequence of steps of a preferred method according to the present invention. With the commencement of a testing operation 9, provisional looking windows are presumed, either by assumption of the known minimum wall thickness or by a logical linking (not more fully described) of the directly measured transit times between transmitter pulse 1, first rear wall echo 2 and second rear wall echo 6.

The looking window 3 is defined in Figure 2 as flaw expectation range and the looking window 4 is defined as rear wall echo range. An interrogation procedure is effected via a logic decision 11 as to whether there is a signal in the flaw looking window 3 within the first test cycle. If a flaw 7 (second flaw echo 8) exists, the reading expectation ranges are not changed in the following test cycle. Another logical decision 12 is produced through the presence of the first rear wall echo. As long as there is no rear wall echo, once again the looking windows are not altered. It is only when the conditions of there being no signal in the flaw looking window with a simultaneously present first rear wall echo are fulfilled in a test cycle that transit time measurements 13 are carried out between the first and second rear wall echoes and between the transmitted pulse and the first rear wall echo. On the basis of the established transit times, new values are calculated for the looking windows at 14. An additional decision is reached at 15 through the end of the flaw looking window. If the end of the flaw looking window is smaller than the prescribed minimum wall thickness of the test object, the end of the flaw looking window is set as being equal to the prescribed minimum wall thickness at 16.

The following test cycle commences with a decision at 17 resulting from the presence of a signal within the flaw looking window. If no signal is present, it is checked at 20 whether the rear wall echo is there. If a rear wall echo is present, then once again the transit time measurement 13 are effected in order to establish the looking windows for the following test cycle. If there were no rear wall echo present within the decision at 20, the testing in the following test cycle is carried out with the unchanged looking windows. The looking window setting is blocked at 21 for the following test cycle. When there is a signal in the flaw looking window 17, another decision is reached; it is checked whether the signal was within the minimum wall thickness of the test object 18. If the signal were within the minimum wall thickness, the automatic looking window setting for the following test cycle is blocked (19). If the signal were outside the minimum wall thickness, the transit time of this signal is set as being equal to the transit time of the rear wall echo (22).

After the transit time of the "rear wall echo" has been established in this way at 22, the new values for the start and the end of the looking windows of the rear wall echoes (14) are directly calculated for the following test cycle without using the measurement values of the transit time measurement at 13. The reason for the decision (18) is that both a flaw and also the rear wall are able to produce a signal in the flaw looking window with the narrow looking window setting.

For the evaluation and interpretation of the results of the testing procedure, it is necessary to fulfill an additional criterion, i.e. it is necessary for each test cycle to compare the transit time of the first rear wall echo with that of the preceding test cycle; an evaluation of the rear wall echo as a flaw can, for example, be effected when a prescribed transit time difference is suddenly exceeded or not reached.

As a result of the method being employed in accordance with the invention, it is guaranteed in advantageous manner that, for example, flaws within the minimum wall thickness and extending obliquely into the test object may also with certainty be recognised as flaws.

The process may be employed in arrangements of "hardware" or "software" type.

WHAT WE CLAIM IS:-

1. A method of automatically adjusting looking windows in ultrasonic testing of an object for flaws by transmission thereto of ultrasonic signals and detecting echoes wherein in each test cycle, at least two echo pulses from the rear wall surface of the object are detected, the method comprising:

(a) detecting the transit time of a first and second rear wall pulse during a particular cycle and forming the transit time difference;

(b) generating a first looking window for detection of flaw echoes during a cycle following the particular cycle, by providing for a beginning of the window at an instant ahead of the first rear wall echo by the transit time difference and by providing for an end of that window ahead of the first rear wall echo by a particular, relatively small amount;

(c) generating a second looking window of predetermined width for detecting a first rear wall echo in the said following cycle, shortly after the end of the first window as generated;

(d) generating a third looking window of predetermined width for detecting a second rear wall echo in the said following cycle, the third looking window beginning at a delay after the end of the first window as generated, the delay being the transit time

difference so that first and second rear wall echoes can be distinguished from a flaw echo; and

(e) using the first and second rear wall echoes as actually occurring during the second and third windows as generated, for the generation of the first looking window in the next following cycle as per step (b).

2. A method as claimed in Claim 1, wherein the beginning of the first window is delayed by a corrective constant period to eliminate surface echoes.

3. A method as claimed in Claim 1, including the step of repeating a test cycle in response to a flaw echo detected in the first window, thereby generating a first window whose end is phase shifted as compared with the first window in which the flaw echo was detected.

4. A method of automatically adjusting looking windows in ultrasonic testing of an object substantially as herein described with reference to the accompanying drawings.

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1579651 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1

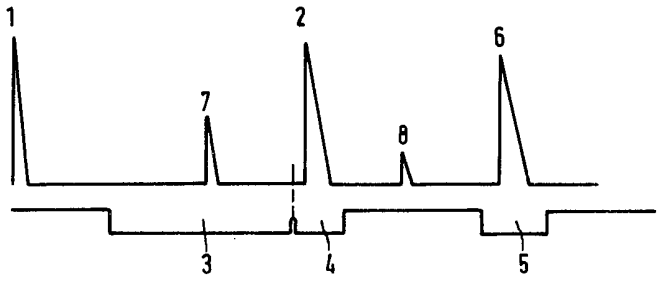
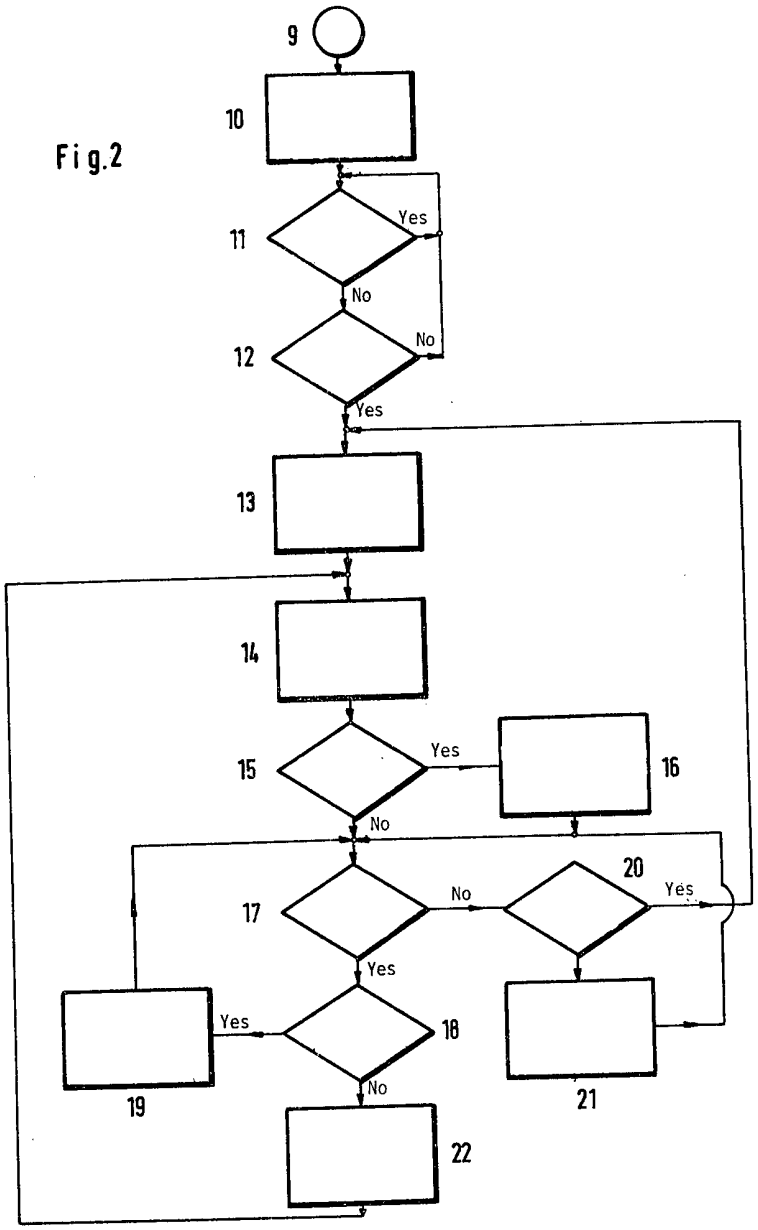


Fig.2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