(12) UK Patent Application (19) GB (11) 2 124 379 A

(21) Application No **8319763**
(22) Date of filing **22 Jul 1983**
(30) Priority data
(31) **8221404**
(32) **23 Jul 1982**
(33) **United Kingdom (GB)**
(43) Application published **15 Feb 1984**
(51) INT CL³ **G01N 29/04**
(52) Domestic classification **G1G** 1A 3M 4C 7T PC **U1S** 1673 G1G
(56) Documents cited
**GBA 2105465**
**GB 1589117**
**GB 1469454**
**GB 1413755**
**GB 1357841**
(58) Field of search **G1G**
(71) Applicant
**British Steel Corporation (United Kingdom), 9 Albert Embankment, London SE1 7SN**
(72) Inventor
**Alexander Rankin Cornforth**
(74) Agent and/or Address for Service
**Fry Heath and Co., Seloduct House, Station Road, Redhill, Surrey**

# (54) Improvements in or relating to ultrasonic testing

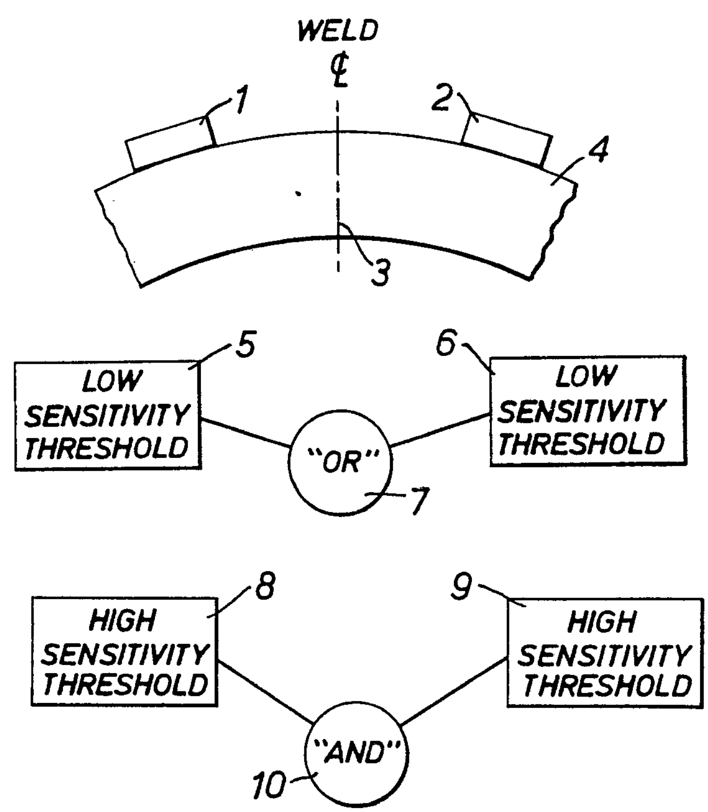
(57) A method of ultrasonic testing tubular products 4 comprises locating at least one ultrasonic transducer probe 1, 2 on each side of and directed at each other across an area of the product to be tested; transmitting ultrasonic pulses from a probe on one side of the area to be tested and detecting reflections of such pulses, indicative of defects in the product, which reach a predetermined first, lower sensitivity level 5, 6; transmitting pulses from a probe on the other side of the area and detecting reflections of such pulses, indicative of defects in the product, which reach said first level of sensitivity, and detecting reflections of pulses from the probes on both sides of the area, indicative of defects in the product, both of which reach a second higher level of sensitivity 8, 9 at or about the same time.

The method is said to improve the detection of short non-welded areas e.g. penetrators or skip-welds.

Provision is made for testing the acoustic coupling between the transducers and calibration is performed using calibration tubes with test notches.

The transducers may be mounted for rotation about the tube.

FIG.1.




GB 2 124 379 A

FIG.1.

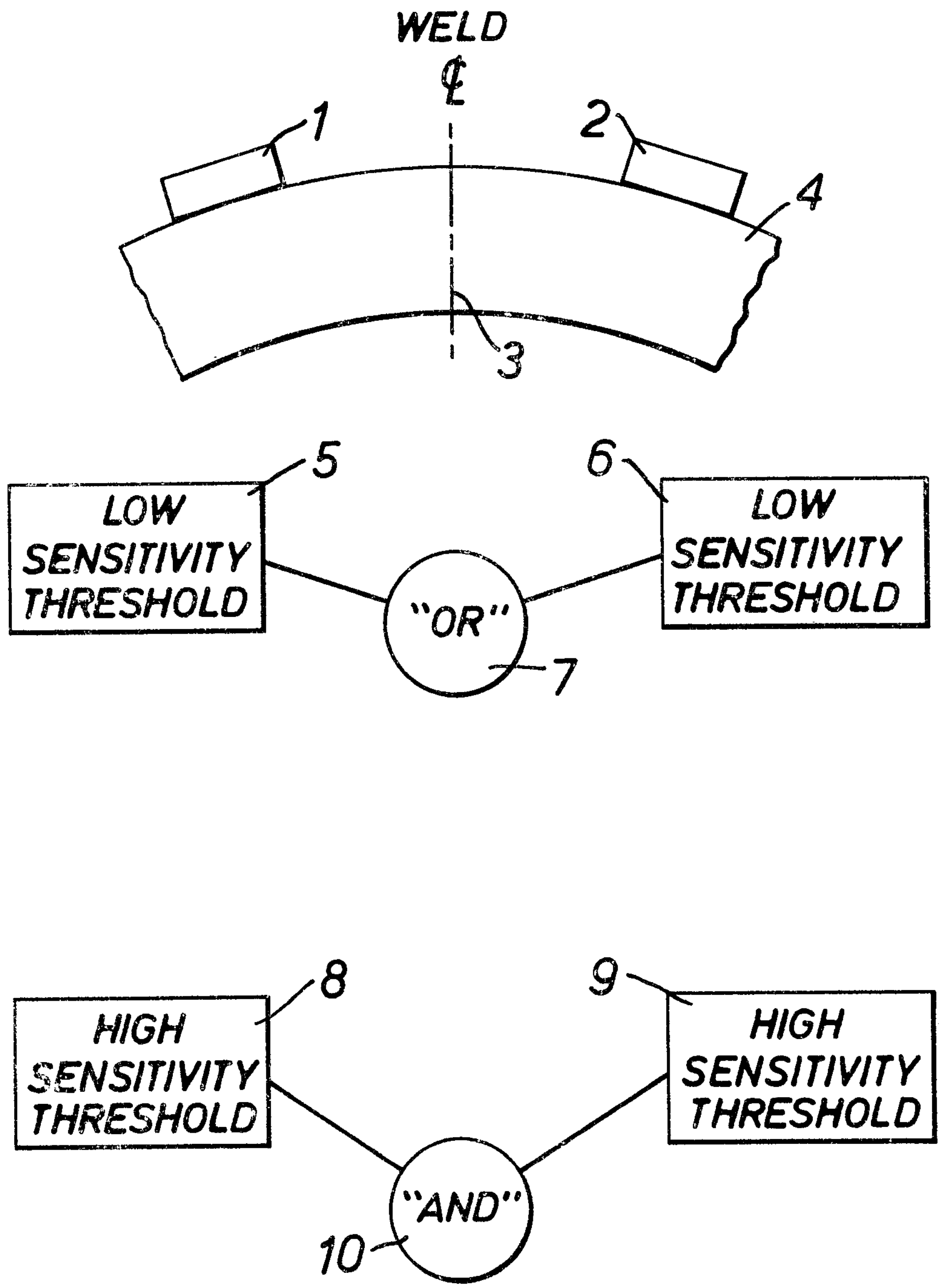
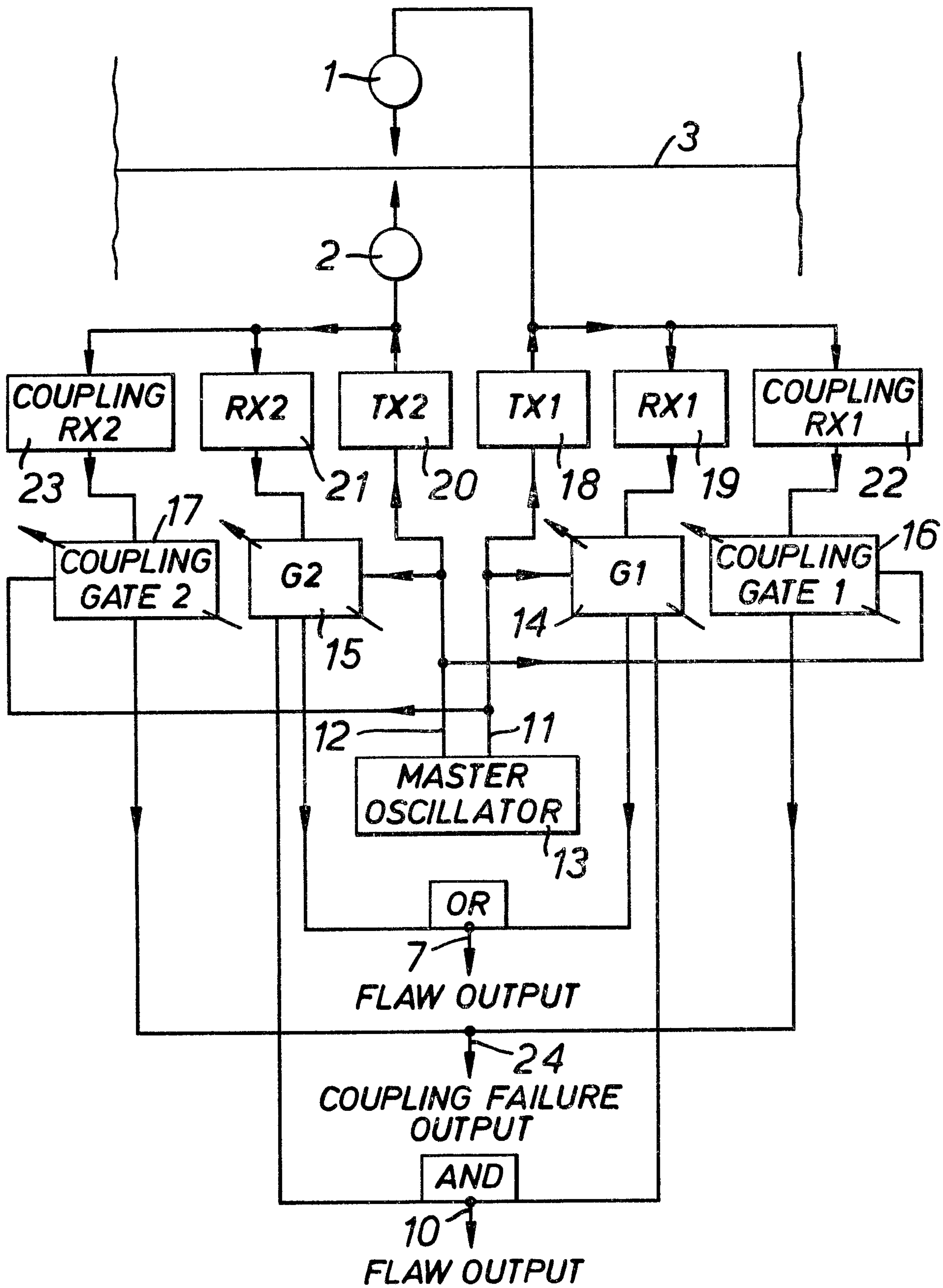

WELD
1
2
4
3
5
LOW SENSITIVITY THRESHOLD
6
LOW SENSITIVITY THRESHOLD
"OR"
7
8
HIGH SENSITIVITY THRESHOLD
9
HIGH SENSITIVITY THRESHOLD
"AND"
10

FIG. 2.


1
3
2
COUPLING RX2
RX2
TX2
TX1
RX1
COUPLING RX1
23
21
20
18
19
22
17
16
COUPLING GATE 2
G2
G1
COUPLING GATE 1
14
15
12
11
MASTER OSCILLATOR
13
OR
7
FLAW OUTPUT
24
COUPLING FAILURE OUTPUT
AND
10
FLAW OUTPUT

SPECIFICATION
**Improvements in or relating to ultrasonic testing**

This invention relates to testing and more particularly relates to the testing by ultrasonic means of tubular products in which the number of ultrasonic testing transducer probes are each acoustically coupled to the surface of the product to be tested by means of a liquid such as water. In use the probes are arranged to transmit ultrasonic pulses into the product and to detect reflections or echoes of such pulses from any such defects such as flaws of internal discontinuities or inclusions in the product.

When dealing for example with longitudinal electric weld tube it is known to ultrasonically test the weld zone by means of one or more transducers on each side of the weld line in such a way as to provide full inspection coverage of the weld line from opposing directions. By inspecting from both sides the possibility of failing to detect weld imperfections is minimised, since defects which may give little response to inspection from one side are likely to give a response to inspection from the other side. This is applicable for example to non-metallic inclusion clusters adjacent to a weld line which may have been diverted or squeezed in one direction on welding.

However one particular form of defect which has been found to cause difficulty of detection at the test sensitivity levels usually used in practice is that form known as a "penetrator" or s "skip weld". This is typically a short non-welded portion along the weld line extending either partially, or in extreme cases, totally, through the thickness of the wall of the tubular product. Such skip welds can either extend from the outer surface of the wall or from the inner surface, or indeed can be wholely located within the thickness of the wall without extending to either surface approximately simultaneously.

This form of defect presents detection difficulty at the sensitivity levels usually used since it is short in length and does not present a large enough reflecting area to ensure detection. However in terms of defect importance it is of significant seriousness, particularly in certain tube applications such as oil well casing or line pipes. This form of defect is of course capable of detection at a higher test sensitivity level than is usually used, but this will inevitably lead to the detection of other relatively minor defects such as small diverted inclusions usually non-detrimental and acceptable for many steel tube applications, and will also detect dimensional variations of weld trimming and minor weld offset which are in practice quite acceptable.

It is one object of the present invention to overcome or at least substantially reduce the above mentioned problem.

According to the invention there is provided a method of ultrasonic testing tubular products comprising directing at least two ultrasonic transducer probes at the product; transmitting ultrasonic pulses from a first probe and detecting any reflections of such pulses, indicative of defects in the product, which reach a predetermined first, lower test sensitivity level; transmitting pulses from a second probe; and detecting any reflections of pulses from the first and the second probes, indicative of defects in the product, which reach a second, higher, level of test sensitivity at or about the same time or from the same location in the product.

The method according to the invention may comprise locating at least one ultrasonic transducer probe on each side of and directed at an area of the product to be tested; transmitting ultrasonic pulses from a probe on one side of the area to be tested and detecting reflections of such pulses, indicative of defects in the product, which reach a predetermined first, lower, test sensitivity level; transmitting pulses from a probe on the other side of the area and detecting reflections of such pulses, indicative of defects in the product, which reach said first level of test sensitivity, and detecting reflections of pulses from the probes on both sides of the area, indicative of defects in the product, both of which reach a second higher level of test sensitivity at or about the same time.

By means of the invention as hereinbefore defined, it is possible to carry out testing at the usual sensitivity level appropriate for the product quality required whilst at the same time utilising a higher sensitivity in such a way as to ensure a greater degree of certainty that defects of the form specified above (for example) will be detected.

We believe that with respect to the particular kind of form of defect we are concerned with in longitudinally welded tube the probability of detection at the highest test sensitivity simultaneously from each side is high, whilst the probability of detection of other, non-significant defects such as small diverted inclusions or internal bead residues simultaneously from both sides at high test sensitivity is relatively low. We therefore believe that the form of testing hereinbefore defined is of such selectivity as to be of considerable value in locating defects of the form specified, although other faults of a somewhat different nature may of course also be detected.

More than one probe may be located on each side of the area to be tested.

In order that the invention may be more readily understood one embodiment thereof will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a schematic representation of the basic operation of one embodiment of steel tube weld line tester according to the invention; and

Figure 2 is a block diagram illustrating control and operational circuitry applicable to the arrangement of Figure 1.

As can be seen from the drawing two ultrasonic probes 1 and 2 are located directly opposite one another and approximately equidistant from the weld line 3 of a steel tube 4. The probes are arranged for alternate actuation of defect testing and cross-coupling testing. The defect testing is carried out at two sensitivity levels, one involving the normal lower sensitivity threshold for defect indicative signal output, and the second at a higher sensitivity threshold. Probe outputs operating through a low sensitivity threshold as shown at 5 and 6 are connected to a logical 'OR' gate 7 that is to say that when either probe finds an imperfection giving a signal response equal to or greater than that of the lower sensitivity threshold level it will trigger an alarm or defect indicative signal.

The probe outputs operating through a high sensitivity threshold as shown at 8 and 9 are connected to a logical 'AND' gate 10 where it is required that both probes detect a defect giving a signal response equal to or greater than that of the higher threshold level to give a trigger alarm condition or direct indicative signal.

It follows logically that a combination of one probe indicating a lower sensitivity threshold defect and the other indicating a higher sensitivity threshold will also provide a defect indicative signal output.

As can be seen from Figure 2 signals emitted from the outputs 11 and 12 of a master oscillator 13 are used to generate, after necessary time delays, test time gates 14 and 15 and coupling gates 16 and 17 to determine the presence of a defect of a coupling failure condition respectively. The electronic system associated with each probe is identical, each system being operated alternatively by means of signals from the master oscillator 13. Each of the gates are variable in duration and in time relation to the trigger pulses.

The operation is as follows:—

The master oscillator 13 signals a transmitter 18 to excite probe 1 so that probe 1 transmits an ultrasonic pulse into the tube wall. If a defect is present a proportion of the pulse incident on the weld line 3 will be reflected back to probe 1, the reflected signal then being amplified by a receiver 19 before being passed to gate 14. If the amplified signal attains the low sensitivity threshold level it is passed, via 'OR' gate 7, as a defect output signal. If the amplified signal attains the high sensitivity threshold level it is passed to 'AND' gate 10.

In the next cycle of operation probe 2 is excited via a transmitter 20 and the weld line is examined from probe 2 side, reflected pulses are amplified by a receiver 21 and passed to gate 15. If the amplified signal attains the low sensitivity threshold level it is passed, via 'OR' gate 7 as a defect output signal. If the amplified signal attains a high sensitivity threshold it is passed to 'AND' gate 10. If in successive cycles 14 and 15 both pass signals to 'AND' gate 10, then a defect indicative signal is generated at its output.

It is to be noted that the apparatus includes provision for monitoring accoustic coupling with the tube 4 being tested. Thus signals are transmitted between probes 1 and 2 during each cycle and received and gated at 22 and 16 and 23 and 17 respectively to feed a coupling indicative output 24.

We have found that testing longitudinal weld steel tube with an appropriate lower sensitivity level is that identified as "N10" whilst the higher sensitivity level is that identified as "N5", these being standard sensitivity levels as defined in American Petroleum Institute Specifications 5A and 5L for example and essentially comprise a sensitivity adequate to detect a parallel sided rectangular notch of a minimum length of 50 mm and a maximum width of 1 mm extending 10% and 5% respectively of the thickness of the tube wall being tested. Other relevant % depths could be selected. As alternatives for example the similar API sensitivity levels identified as "V5" and "V10" or "B5" can be used.

Whilst the invention has been particularly described hereinabove in relation to weld line inspection and testing, it is equally applicable in association with rotary ultrasonic testing of tubular products for example. In such arrangement two sets of probes disposed may be mounted for rotation in sequence one behind the other around the product.

It will be appreciated that calibration of apparatus carrying out the invention is of considerable importance. This can be done conventionally in relation to e.g. Standard N5 and N10 internal and external notches and with respect to the apparatus particularly described hereinabove may be carried out as follows:—

The circumferential position of each probe about the calibration tube is adjusted to achieve an approximate balance between, for example, N10 internal and external notches. Each probe output sensitivity is adjusted such that both outputs trigger on the appropriate minimum threshold response from the notches.

Without altering the relative probe positions the threshold level on each probe output is adjusted such that each channel triggers from the minimum threshold response from both N5 notches.

Again without altering the relative probe positions and the sensitivity control the threshold level of a coupling monitoring signal threshold level monitor gate is adjusted on each output such that a drop of e.g. 10 dB in the probe to probe cross-coupled signal operates the coupling failure alarm.

CLAIMS

1. A method of ultrasonic testing tubular products comprising directing at least 2 ultrasonic transducer probes at the product; transmitting ultrasonic pulses from a first probe and detecting any reflections of such pulses, indicative of defects in the product, which reach a predetermined first, lower, test sensitivity level; transmitting pulses from a second probe; and detecting any reflections of pulses, from the first and the second probes, indicative of defects in the product, which reach a second, higher, level of test sensitivity at or about the same time or from the same location in the product.

2. A method as claimed in Claim 1 comprising locating at least one ultrasonic transducer probe

on each side of and directed at an area of the product to be tested; transmitting ultrasonic pulses from a probe on one side of the area to be tested and detecting only reflections of such pulses, indicative of defects in the product, which reach a predetermined first, lower, test sensitivity level; transmitting pulses from a probe on the other side of the area and detecting any reflections of such pulses, indicative of defects in the product, which reach said first level of test sensitivity; and detecting any reflections of pulses from the probes on both sides of the area, indicative of defects in the product, which reach a second, higher, level of test sensitivity at or about the same time or from the same location in the area.

3. A method as claimed in Claim 1 or 2 wherein detection of ultrasonic pulse reflections by a probe at the first, lower, signal sensitivity enables the initiation of a first non-acceptable defect signal or alarm, and detection of ultrasonic pulse reflections by both probes at the second, higher, test sensitivity enables the initiation of second non-acceptable defect signal or alarm.

4. A method as claimed in Claim 3 wherein non-acceptable defect signal initiation at the lower test sensitivity is by means of an electronic OR gate and non-acceptable defect signal initiation at the higher test sensitivity is by means of an electronic AND gate.

5. A method as claimed in any one of the preceding claims wherein the lower or the higher test sensitivity level is established by means of a standard calibration procedure, and the higher or the lower sensitivity level respectively is established directly from the calibrated lower or higher sensitivity level.

6. A method as claimed in any one of the preceding claims wherein the lower test sensitivity level is N10 and/or the higher test sensitivity level is N5 is hereinbefore defined.

7. A method as claimed in any one of the preceding claims wherein two probes are provided, one on each side of the area to be tested, and are actuated alternately for defect testing and for cross-coupling testing.

8. A method as claimed in any one of the preceding claims utilised in weld line testing of welded tubes.

9. Apparatus for carrying out the method claimed in any one of the preceding claims.

10. A method of ultrasonic testing tubular products substantially as hereinbefore described with reference to the accompanying drawing.

11. Apparatus for ultrasonic testing tubular products substantially as shown in and as hereinbefore described with reference to the accompanying drawing.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1984. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.