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AUTOMATED ASSISTED-INTERPRETATION OF PHASED ARRAY ULTRASONIC TESTING INSPECTION DATA

BACKGROUND

[0001] The present disclosure relates generally to methods and systems to perform evaluation of welds. More specifically, in certain embodiments, the present disclosure relates automated assisted-interpretation of phased array ultrasonic testing data and associated methods and systems.

[0002] During the fabrication process, it may be necessary to perform non-destructive evaluation (NDE) of structural steel and pipe spool welds to determine whether the welds meet defined requirements. The industry standard NDE method for analyzing welds has been radiographic testing (RT). HSSE-related issues associated with RT and the requirement to perform radiographic testing in off hours is driving the industry to look for alternative NDE methods.

[0003] One alternative NDE method is Phased Array Ultrasonic Testing (PAUT). PAUT is used for flaw detection, defect sizing, and imaging in welds. Its advantages over RT include a lower operating cost, a lower HSSE risk, and almost zero downtime on operations. It also offers the potential to store the raw scan data for offline analysis, improved probability of defect detection, and flexibility for inspection of complex geometries. US Patent Application Publication Nos. 2015/0346164, 2015/0377707, 2014/0283611, and US 2013/0167646 describe several methods and system of evaluating welds utilizing PAUT, the entireties of which are hereby incorporated by reference.

[0004] PAUT technology is rapidly replacing RT throughout the world of NDE, however, large NDE programs require significant man power to review all the weld backlog data. Currently, weld inspectors must manually review individual sample sets of data. It is not uncommon for some inspectors to take >1 hour for 6 meters of PAUT NDT data collected.

[0005] It is desirable to develop a method and system that allows for an automatic assisted anomaly detection and a reduction of the inspection time of large weld batches.

SUMMARY

[0006] The present disclosure relates generally to methods and systems to perform evaluation of welds. More specifically, in certain embodiments, the present disclosure relates automated assisted-interpretation of phased array ultrasonic testing data and associated methods and systems.

[0007] In one embodiment, the present disclosure provides a weld evaluation system comprising: a weld, a probe, a data acquisition unit, a data filtering unit, and a display unit.

[0008] In one embodiment, the present disclosure provides a method comprising: providing a weld, scanning the weld to generate weld data, scoring the weld data to generate scored weld data, filtering the scored weld data to generate filtered weld data, and reporting the filtered weld data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A more complete and thorough understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings.

[0010] Figure 1 is an illustration of a weld evaluation system in accordance with certain embodiments of the present disclosure.

[0011] The features and advantages of the present disclosure will be readily apparent to those skilled in the art. While numerous changes may be made by those skilled in the art, such changes are within the spirit of the disclosure.

DETAILED DESCRIPTION

[0012] The description that follows includes exemplary apparatuses, methods, techniques, and/or instruction sequences that embody techniques of the inventive subject matter. However, it is understood that the described embodiments may be practiced without these specific details.

[0013] The present disclosure relates generally to methods and systems to perform evaluation of welds. More specifically, in certain embodiments, the present disclosure relates automated assisted-interpretation of phased array ultrasonic testing data and associated methods and systems.

[0014] In certain embodiments, the present disclosure describes a method and system that allows for the rapid interpretation of large data sets of PAUT weld scans. In certain

embodiments, the methods and systems discussed herein allow for the parametrization of scan welds, weld scan data, and reports into a single location that allows for the instantaneous flagging of anomalies within a weld scan. In certain embodiments, the method and system discussed herein allow for interpretations to be run on large batches of weld data and allows for the identification of flaws exceeding a set threshold indicating a potential anomaly. In certain embodiments, the methods and system discussed herein allow for more than 95%, in certain embodiments, 98% to 99%, of weld data to not be reviewed by a weld inspector.

[0015] There may be several advantages to the methods and systems described herein. In certain embodiments, the methods and systems described herein may allow for automatic assisted anomaly detection and reduces the inspection time of large weld batches from days to minutes.

[0016] In one embodiment, the present disclosure provides a weld evaluation system. Referring now to Figure 1, Figure 1 illustrates a weld evaluation system 1000. In certain embodiments, weld evaluation system 1000 may comprise: weld 100, probe 300, data acquisition unit 400, data filtering unit 500, and display unit 600. In certain embodiments, data acquisition unit 400, data filtering unit 500, and/or display unit 600 may each be part of a single unit. In certain embodiments, probe 300 may be in communication with data acquisition unit 400. In certain embodiments, data acquisition unit 400 may be in communication with data filtering unit 500. In certain embodiments, data filtering unit 500 may be in communication with display unit 600.

[0017] In certain embodiments, weld 100 may comprise any conventional weld use to join two materials. In certain embodiments, weld 100 may be a weld used to join piping connections or a structural steel butt weld. In certain embodiments, weld 100 may comprise first material 110, second material 120, heat affected zone 130, weld zone 140, weld material 150, and weld cap 160. In certain embodiments, first material 110 and second material 120 may comprise the same material. In other embodiments, first material 110 and second material 120 may comprise different materials.

[0018] In certain embodiments, one or more anomalies 170 may be present in weld 100. In certain embodiments, the one or more anomalies 170 may be present inside the heat affected zone 130 and/or outside the heat affected zone 130. In certain embodiments, the one or more anomalies 170 may be located inside the weld zone and/or outside the weld zone 140. In certain embodiments, the one or more weld anomalies may comprise cracks, slag inclusions, areas with lack of fusion, and/or geometric reflectors.

[0019] In certain embodiments, probe 300 and data acquisition unit 400 may be part of a phased array instrument (not illustrated in Figure 1). In certain embodiments, the phased array instrument may further comprise a probe wedge block and/or coupling fluid (not illustrated in Figure 1). In certain embodiments, the coupling fluid may be brushed or pumped.

[0020] In certain embodiments, probe 300 may comprise any probe manufactured by Olympus.

[0021] In certain embodiments, probe 300 may be capable of beaming ultrasonic energy into weld 100. In certain embodiments, probe 300 may be capable of beaming multiple beams of ultrasonic energy into weld 100. In certain embodiments, data acquisition unit 400 may be capable of sending a pulsing pattern to probe 300 which in turn may be capable of sending the wave propagation.

[0022] In certain embodiments, a portion of the ultrasonic energy beamed into weld 100 may be reflected back to data acquisition unit 400 and/or probe 300 as one or more echo signals 201. In certain embodiments, the one or more echo signals 201 may be generated when the beam of ultrasonic energy contacts the one or more anomalies 170. In certain embodiments, each anomaly 170 may generate one or more echo signals 201.

[0023] In certain embodiments, probe 300 may be capable of receiving weld data. In certain embodiments, the weld data may comprise the one or more echo signals 201. In certain embodiments, probe 300 may be capable of receiving the one or more echo signals 201. In certain embodiments, probe 300 may transmit the weld data to data acquisition unit 400. In certain embodiments, data acquisition unit 400 may be capable of measuring the relative strength of each of the one or more echo signals 201.

[0024] In certain embodiments, data acquisition unit 400 may be capable of processing the weld data to build a map of anomalies 170 in weld 100. In certain embodiments, the weld data may be displayed on an acquisition screen of data acquisition unit 400. In certain embodiments, a user may be able to determine the location of one or more anomalies 170 that generated the one or more echo signals 201 by looking at the map.

[0025] In certain embodiments, data acquisition unit 400 may be capable of transmitting the weld data to data filtering unit 500. In certain embodiments, data filtering unit 500 may be capable of receiving a signal from data acquisition unit 400. In certain embodiments, the signal may comprise the weld data. In certain embodiments, data

filtering unit 500 may be capable of filtering the weld data to create filtered data. In certain embodiments, the filtered weld data may comprise only the one or more echo signals 201 that originated from one or more anomalies 170 located within weld. In certain embodiments, the filtered weld data may comprise only the one or more echo signals 201 that originated from one or more anomalies located within heat affected zone 130. In certain embodiments, the filtered weld data may comprise only the one or more echo signals 201 that originated from one or more anomalies located within weld zone 140.

[0026] In certain embodiments, the filtered weld data may only comprise the one or more echo signals 201 that are above a certain echo signal level threshold. In certain embodiments, the echo signal level threshold may be 20% DAC. In other embodiments, the echo signal level threshold may be 40% DAC, 35% DAC, 30% DAC, 25% DAC, 15% DAC, or 10% DAC.

[0027] In certain embodiments, data filtering unit 500 may be capable of scoring the filtered weld data or the weld data to generate scored weld data. In certain embodiments, the scored weld data may be generated utilizing an algorithm that takes into account the size of each anomaly, the proximity of each anomaly to an end cap of the weld, the proximity of each anomaly to a weld boundary, and the proximity of the anomaly to other anomalies.

[0028] In certain embodiments, the algorithm may comprise a sizing algorithm. In such embodiments, the weld data may be represented by a set of samples. Each sample may comprise an echo signal from an anomaly. Each sample may be associated with a position relative to the origin of the weld. Each position may be defined relative to the coordinate system chosen for the weld. The type of coordinate system may on the type of weld. For example, position on a linear weld on a plate or very large pipe may be quantified using Scan, Index and Depth. Scan is the distance along a weld center-line in the scanning direction from a fiducial point. Index is the distance left (negative) or right (positive) of the weld center-line, along the direction perpendicular to the scan axis in the plane of the scan face. Depth is the distance into the part along the axis perpendicular to the scan axis and the index axis.

[0029] For the purpose of sizing the samples are filtered. A low pass filter may be used because the raw PAUT sample data may suffer from aliasing (beam spacing is usually wider than the beam spread). The low pass filter may ensure a conservative reflector size estimate where aliasing produces ambiguity about the connectedness of a feature.

[0030] Each sample may be associated with an ultrasound echo amplitude. The output of the sizing algorithm may be a set of reflectors. Each reflector may represent a physical or phantom feature within the weld or surrounding materials. The sizing algorithm may partition the sample points by associating each point with a label. A subset of the labels may define reflectors. Each reflector may be associated with a non-overlapping subset of the samples. The size of each reflector may be a function of the positions associated with the reflector's samples. For example, in certain embodiments the length of a reflector may be calculated as the maximum scan coordinate minus the minimum scan coordinate of the reflector's samples. Each reflector may have a seed point. The seed point may be the reflector's sample with maximum amplitude. If several points have the same amplitude, a tie-breaking rule may be used to select a single seed point. For example, in certain embodiments, the sample that is lowest in the lexicographical ordering of the sample coordinates among the samples with maximum amplitude may be selected.

[0031] A sample may be determined to belong to a reflector if two criteria are met. First the sample must not belong to a reflector that has a higher peak amplitude. Second, the dominant path from the reflector's seed point must satisfy the path criterion. A path may be a sequence of samples between a starting point and an ending point. Each sequential pair of points must be neighbors. In general, the distance between samples must be below a threshold for the samples to be considered neighbors. For scans where samples are arranged on a regular grid, samples may be considered neighbors per grid adjacency. For example, each interior point of a rectangular volumetric grid can be considered to have 26 neighbor points. The path criterion may comprise or consist of a threshold and a transfer function. The threshold and transfer functions may be functions of the preceding points of the path. The criterion may be satisfied if for every point of the path, the value of the transfer function is less than the value of the threshold function. The dominant path from a seed point to a given point is the minimum-length path from the seed point to the given point that satisfies the path criterion and has the maximum threshold value at the given point.

[0032] The 6dB rule is an example path criterion that can be useful for NDT operations governed by the API RP2X standard. A path may satisfy this criterion if each point in the path is greater than or equal to 50% of the path peak amplitude and less than the seed amplitude. The path peak amplitude for a given point of the path is the most recent amplitude peak found along the path, when walking from the seed point to the given

point. The path criterion threshold function may be 50% of the path peak amplitude and the path criterion transfer function is simply the amplitude of the given sample.

[0033] For example, the following algorithm computes the path peak amplitude.

[0034] Consider the points of the path to be indexed from 0 to N. Point 0 is the seed point. The peak path amplitude for point 0 is the seed amplitude. If the amplitude of point I is less than or equal to the amplitude of point I-1, then point I is not a peak and so the peak path amplitude of point I is equal to the peak path amplitude of point I-1. Otherwise, point I is either a peak or rising towards a peak and so the peak path amplitude of point I is equal to the amplitude of point I.

[0035] The algorithm finds reflectors iteratively. Each iteration begins by selecting the maximum amplitude unlabeled sample. If the amplitude of the maximum unlabeled sample is less than the echo signal level threshold (for example 20% DAC), then the remaining samples are labeled “not a reflector” and the algorithm terminates. Otherwise the maximum unlabeled sample is the seed point of the next reflector. The next step of the iteration is to label the samples that belong to the reflector with the selected seed point. A find reflector algorithm may be used to label the samples of the reflector. The algorithm outputs the reflector using the samples labeled with the reflector’s identifier and then proceeds to begin the next iteration.

[0036] In certain embodiments, the algorithm may comprise a find reflector algorithm. The find reflector algorithm may track a list of active samples and access the label map. Each item in the list may reference a sample and the path peak amplitude. A priority queue (or heap data structure) may be used to provide an efficient implementation of the list. Initially, the seed point is pushed to the list of active samples. The algorithm may proceed iteratively until the list of active samples is empty. To begin each iteration, the active sample with maximum path peak amplitude may be selected and removed from the list. The label map may be updated with the identifier for the current reflector. Each unlabeled neighbor sample of the selected sample may be tested to see if the neighbor sample satisfies the path criterion. If so, the neighbor sample path peak amplitude may be calculated and the neighbor may be enqueued.

[0037] In certain embodiments, an individual score may be assigned to each anomaly. In certain embodiments, the score may correspond to the probability that the anomaly is a defect.

[0038] In certain embodiments, the scored weld data may comprise a map of all

anomalies 170 that have been identified as probable defects. In certain embodiments, the scored weld data may be transmitted to display unit 600. In certain embodiments, display unit 600 may be capable of displaying a map of the probable defects. In certain embodiments, an inspector may do a field inspection of each probable defect.

[0039] In one embodiment, the present disclosure provides a method comprising: providing a weld, scanning the weld to generate weld data, filtering the weld data to generate filtered weld data, scoring the filtered weld data to generate scored weld data, and reporting the scored weld data.

[0040] In certain embodiments, the weld may comprise any combination of features discussed above with respect to weld 100.

[0041] In certain embodiments, the weld may be scanned to generate weld data. In certain embodiments, the weld may be scanned utilizing a phased array instrument and/or probe. In certain embodiments, the phased array instrument may comprise any combination of features discussed above with respect to the phased array instrument. In certain embodiments, the probe may comprise any combination of features discussed above with respect to probe 300.

[0042] In certain embodiments, the weld may be scanned by beaming ultrasonic energy into the weld. In certain embodiments, one or more echo signals may be generated by beaming ultrasonic energy into the weld. In certain embodiments, the one or more echo signals may originate from one or more anomalies in the weld. In certain embodiments, the weld data may comprise the one or more echo signals generated by the one or more anomalies.

[0043] In certain embodiments, scanning the weld to generate weld data may further comprise collecting the weld data. In certain embodiments, the weld data may be collected utilizing a data acquisition unit. In certain embodiments, the data acquisition unit may comprise any combination of features discussed above with respect to data acquisition unit 400. In certain embodiments, the data acquisition unit may be capable of processing the weld data to build a map of anomalies in the weld 100. In certain embodiments, the data acquisition unit may be capable of transmitting the weld data to a data filtering unit.

[0044] In certain embodiments, filtering the weld data to generate filtered weld data may comprise filtering the weld data with a data filtering unit. In certain embodiments, the data filtering unit may comprise any combination of features discussed above with respect to data filtering unit 500. In certain embodiments, filtering the weld

data to generate filtered weld data may comprise removing weld data from echo signals that originated from one or more anomalies located outside of the heat affected zone and/or weld zone. In certain embodiments, filter the weld data to generate filtered weld data may comprise removing weld data from echo signals that are below a certain echo signal level threshold. In certain embodiments, the echo signal level threshold may be 20% DAC. In other embodiments, the echo signal level threshold may be 40% DAC, 35% DAC, 30% DAC, 25% DAC, 15% DAC, or 10% DAC.

[0045] In certain embodiments, scoring the filtered weld data to generate scored weld data may comprise utilizing the data filtering unit to generate scored weld data. In certain embodiments, the scored weld data may be generated utilizing an algorithm that takes into account the size of each anomaly, the proximity of each anomaly to an end cap of the weld, the proximity of each anomaly to a weld boundary, and the proximity of the anomaly to other anomalies. In certain embodiments, the algorithm may comprise a sizing algorithm. In certain embodiments, the algorithm may comprise a find reflector algorithm. In certain embodiments, scoring the filtered weld data may comprise assigning an individual score to each anomaly. In certain embodiments, the score may correspond to the probability that the anomaly is a defect.

[0046] In certain embodiments, reporting the scored weld data may comprise providing a map of all anomalies that have been identified as probable defects. In certain embodiments, reporting the scored weld data may comprise transmitting the scored weld data to a display unit. In certain embodiments, the display unit may comprise any combination of features discussed above with respect to display unit 600. In certain embodiments, reporting the scored weld data may comprise displaying a map of the probable defects. In certain embodiments, an inspector may do a field inspection of each probable defect.

[0047] While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are illustrative and that the scope of the inventive subject matter is not limited to them. Many variations, modifications, additions and improvements are possible.

[0048] Plural instances may be provided for components, operations and/or structures described herein as a single instance. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a

single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the inventive subject matter.

What is claimed is:

1. A weld evaluation system comprising: a weld, a probe, a data acquisition unit, a data filtering unit, and a display unit.
2. The weld evaluation system of claim 1, wherein the data acquisition unit, the data filtering unit, and the display unit are each a part of a single unit.
3. The weld evaluation system of claim 1 or 2, wherein the weld comprises one or more anomalies.
4. The weld evaluation system of any one of claims 1-3, wherein the probe and the data acquisition unit are part of a phased array instrument.
5. The weld evaluation system of claim 4, wherein the phased array instrument further comprises a probe wedge block and a coupling fluid.
6. The weld evaluation system of any one of claims 1-5, wherein the probe is capable of beaming ultrasonic energy into the weld to generate one or more echo signals.
7. The weld evaluation system of claim 6, wherein the probe is capable of receiving the one or more echo signals.
8. The weld evaluation system of claim 7, wherein the data acquisition unit is capable of processing the one or more echo signals to build a map of the one or more anomalies.
9. The weld evaluation system of any one of claims 6-8, wherein the data filtering unit is capable of filtering and scoring the one or more echo signals to generate filtered and/or scored data.
10. The weld evaluation system of claim 9, wherein the display unit is capable of displaying the filtered and/or scored data.
11. A method comprising: providing a weld, scanning the weld to generate weld data, filtering the weld data to generate filtered weld data, scoring the filtered weld data to generate scored weld data, and reporting the scored weld data.
12. The method of claim 11, wherein scanning the weld to generate weld data comprises scanning the weld with the weld evaluation system of any one of claims 1-10.
13. The method of claim 11 or 12, wherein scanning the weld to generate weld data comprises generating one or more echo signals by beaming ultrasonic energy into the

weld.

14. The method of any one of claims 11-13, wherein filtering the weld data comprises removing any echo signals from the weld data that originate from any anomalies located outside of a weld zone.

15. The method of any one of claims 11-14, wherein filtering the weld data comprises removing any echo signals from the weld data that are below a certain echo signal level threshold.

16. The method of any one of claims 11-15, wherein the filtered weld data consists of echo signals that are generated from anomalies located in the weld zone and are below a certain echo signal level threshold.

17. The method of any one of claims 11-16, wherein scoring the filtered weld data comprises utilizing an algorithm that takes into account the size of each anomaly, the proximity of each anomaly to an end cap, the proximity of each anomaly to a weld boundary, and the proximity of the anomaly to other anomalies to score the filtered weld data.

18. The method of any one of claims 11-17, wherein scoring the filtered weld data comprises assigning an individual score to each anomaly.

19. The method of any one of claims 11-18, wherein reporting the scored weld data comprises generating a map of all anomalies that have been identified as probable defects.

20. The method of claim 17, further comprises performing a field inspection of each probably defect.

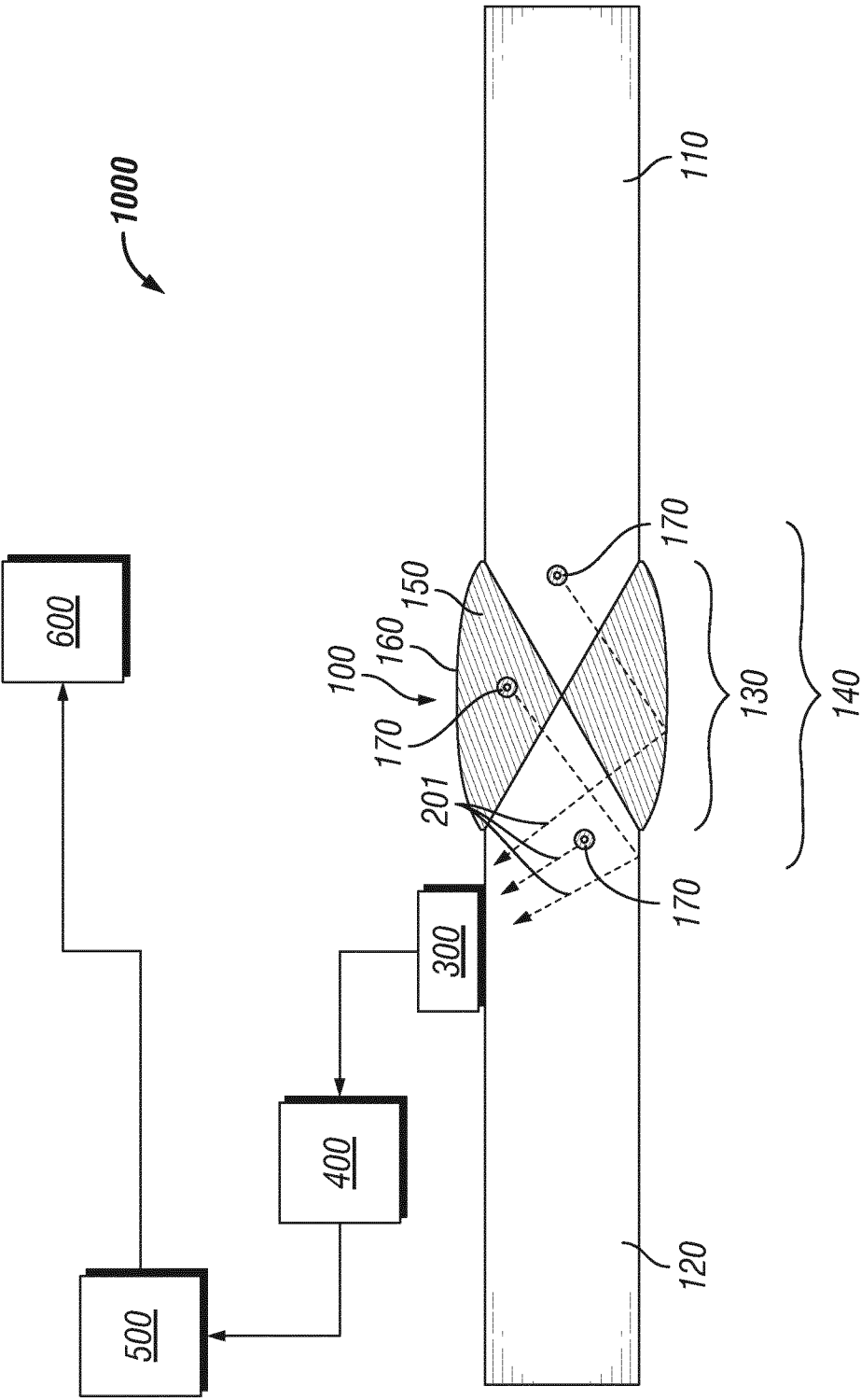


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/053499

A. CLASSIFICATION OF SUBJECT MATTER		
INV. G01N29/04	G01N29/06	G01N29/11 G01N29/26 G01N29/44
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) G01N		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/023610 A1 (UME IFEANYI CHARLES [US] ET AL) 3 February 2011 (2011-02-03)	1-13,
Y	abstract; figure 1	18-20
	paragraphs [0023] - [0030], [0039] - [0040], [0059] - [0092]; figures 1, 5, 6, 7-12	14-17
X	DUNLOP I ET AL: "AUTOMATED PARAMETER EXTRACTION FOR ULTRASONIC FLAW ANALYSIS", IEE PROCEEDINGS: SCIENCE, MEASUREMENT AND TECHNOLOGY, IEE, STEVENAGE, HERTS, GB, vol. 144, no. 2, 1 March 1997 (1997-03-01), pages 93-99, XP000693145, ISSN: 1350-2344, DOI: 10.1049/IP-SMT:19970857	1, 2, 4, 5, 11, 14-16, 20
Y	abstract	14-17
	the whole document	
	- / - -	
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 9 May 2018		Date of mailing of the international search report 22/05/2018
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Meltaus, Johanna

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2018/053499

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 3 647610 B2 (JAPAN STEEL & TUBE CONSTR) 18 May 2005 (2005-05-18)	1,2,4,5, 11,20
Y	paragraphs [0012] - [0016], [0027], [0039]; figures 1, 2 -----	17
Y	GURVICH A K ET AL: "STATEMENT OF THE PROBLEM OF WORKING OUT ALGORITHMS FOR IDENTIFYING FLAWS IN WELDED JOINTS ON THE BASIS OF DATA OF ULTRASONIC QUALITY CONTROL", SOVIET JOURNAL OF NONDESTRUCTIVE TESTING, CONSULTANTS BUREAU, NEW YORK, NY, US, vol. 16, no. 3, 1 March 1980 (1980-03-01), pages 151-158, XP001330686, ISSN: 0038-5492 abstract; figure 1 page 151 - page 153; figure 1; tables 1, 2 -----	17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/053499

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011023610 A1	03-02-2011	JP 5587700 B2	10-09-2014
		JP 2011033627 A	17-02-2011
		US 2011023610 A1	03-02-2011

JP 3647610 B2	18-05-2005	JP 3647610 B2	18-05-2005
		JP H1082766 A	31-03-1998
