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DEVICES FOR NON-DESTRUCTIVE TESTING OF METALS, PLASTICS AND CONCRETE
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For the company's chief executive

Comparison of the systems for ultrasonic inspection of solid objects where phased antenna arrays (PA) and digitally focused antenna arrays (DFA) are used

Instruments enabling visualization of the internal structure of the solid bodies currently become more popular in non-destructive testing.

These systems as compared with traditional ultrasonic flaw detectors provide the operator with more information bearing 2-D image of cross-section of internal volume of the material: a tomogram.

Such instruments as a rule use multielement antenna arrays as transmitters and receivers of ultrasonic signals. These instruments can be divided in two groups by their operation principle:

- instruments with antenna array physically generating a scanning ultrasonic beam in the object under examination.
- instruments with virtually synthesizable focusable aperture where the antenna array senses the object under examination element-by-element with scattered ultrasound.

The ultrasonic beam in the first group of the instruments is physically formed by several adjacent elements of the antenna array electronically focused onto the definite area of the object under examination. Scanning process is provided by electronic commutation of the elements of the antenna array and variation of the focal law. The object under examination shall be repeatedly sensed with lots of ultrasonic beams with different focal laws to provide a high quality of the image. This prevents from creation of an aperture providing a high quality of the image along the whole visualisable area together with high efficiency required for automatic inspection of the objects.

Such contradiction doesn’t present in the instruments of the second group, where sensing of the object under examination is done a number of times equal to quantity of the elements contained in the antenna array. All elements of the antenna array receive the signals at each sensing at a time. A multichannel receive path is used for it. If a single channel is used, then element-by-element sensing is repeated for each nonradiating element of the antenna array, connectable by the commutator to the receive path.

Sensing and receiving of the signals by the multichannel path concurrently, as well as by the single channel successively result in a set of signals (realization of additive noise and relevant pulse-echoes) from all possible pairs of the elements of the antenna array (transmitter-receiver). Concurrent space-time procession of these realizations creates a virtual (digital) focusing of the antenna array onto each point of the visualisable area of the object under examination. The images produced by this method provide a potentially highest quality possible since besides complete focusing they posses the maximum possible signal-to-noise ratio due to coherent processing of maximum possible quantity of the realizations uncorrelated by noise that the antenna array receives.

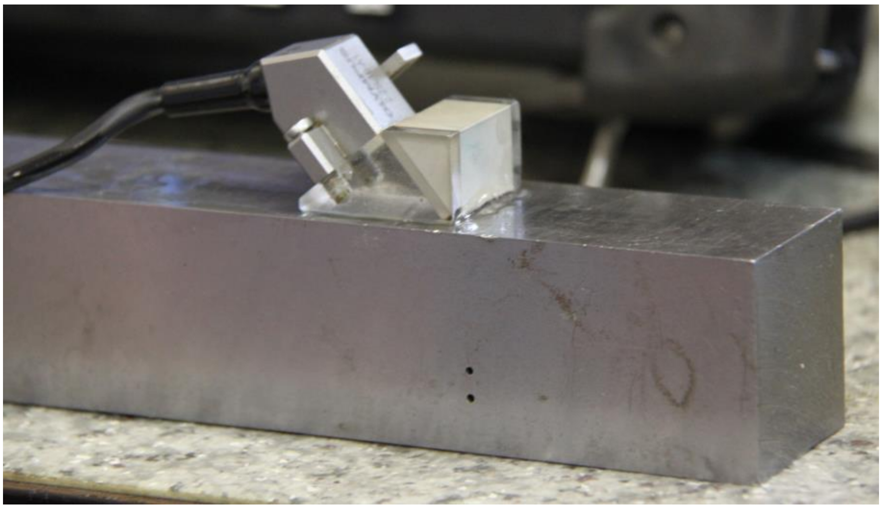
Coherent processing of the signals represents a processing of the measurement results of the physical parameters of the sound fields after their interaction with the discontinuities using the amplitude, phase, time and spatial characteristics of the fields. Phase information is not used in no coherent processing of the signals. Coherent processing of the signals provides measurement of almost actual sizes of the defects in 2D, and even in 3D image with simultaneous display of the B-, C-, D-Scans onto the screen of the flaw detector.

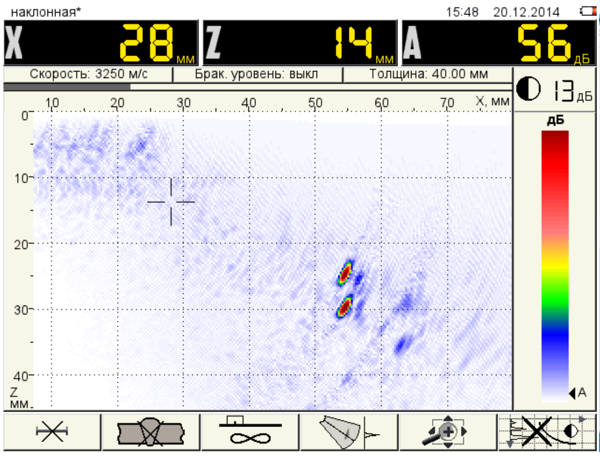
Ultrasonic flaw detectors with phased antenna arrays create a steering or line scanning ultrasonic beam in the object under examination. The phased antenna arrays are often being interpreted as ultrasonic transducers with dynamic beam steering and focusing. Such terms as “start angle of scanning”, “end angle of scanning”, “depth focusing and angle focusing” are used.

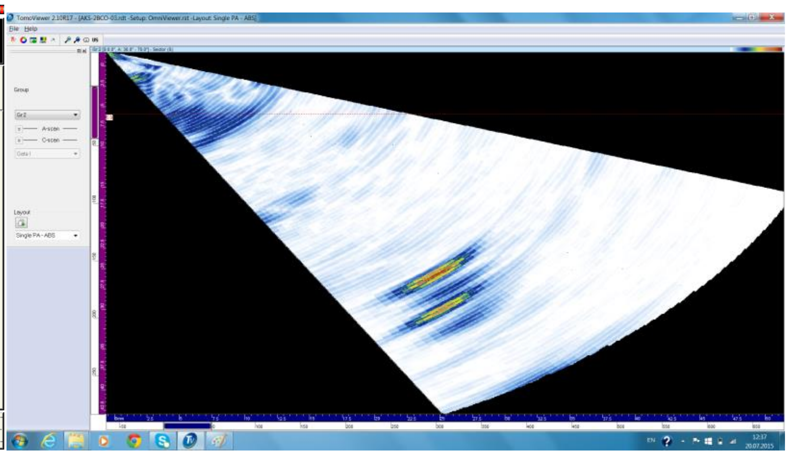
For instruments with the antenna arrays digitally (DFA) focusable onto all points of the visualisable area (cross-section) of the object under examination, terminology of the angles of probe and types of beam scanning is not acceptable, since these instruments use scattered ultrasonic irradiation, not a physically formed straight ultrasonic beam or a beam focused onto a definite depth along a single line (e.g. along the butt of the weld seam only). In DFA system scattered irradiation covers the whole area or a major part of the visualisable area; hence no scanning with “beam” is required. Focusing represents a result of digital procession of the array of the received signals.

Below you can see images of various types of the defects are received by dint of using PA and DFA devices.

1. Sample with two side drilled holes ø 1.5 mm.

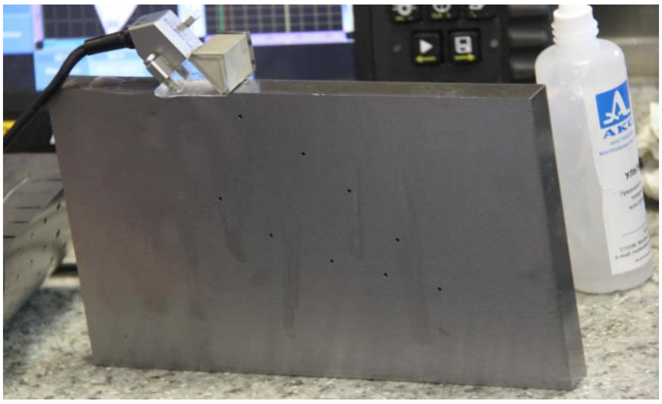


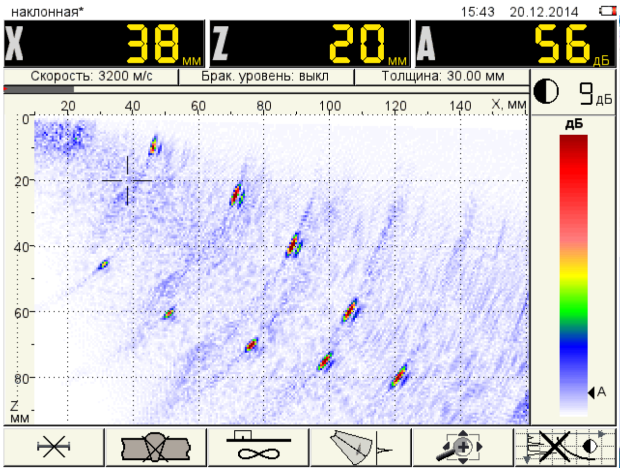




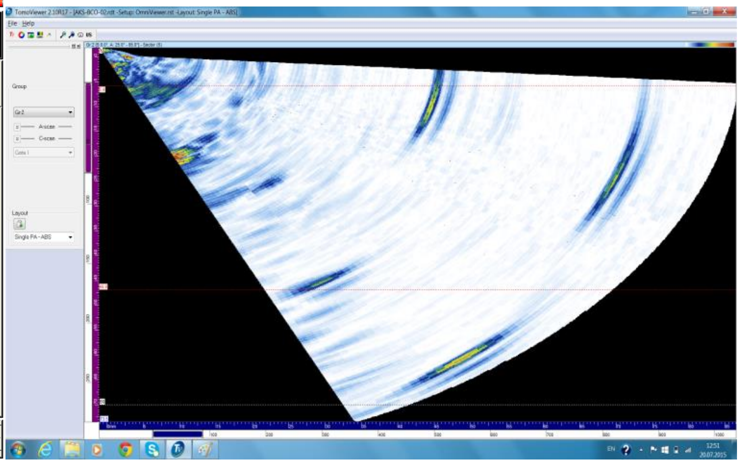
Images of the holes obtained by A1550 IntroVisor **Images of the holes obtained by OmniScan MX**

2. Sample with several side drilled holes ø 1.5 mm, which are located at different depth.



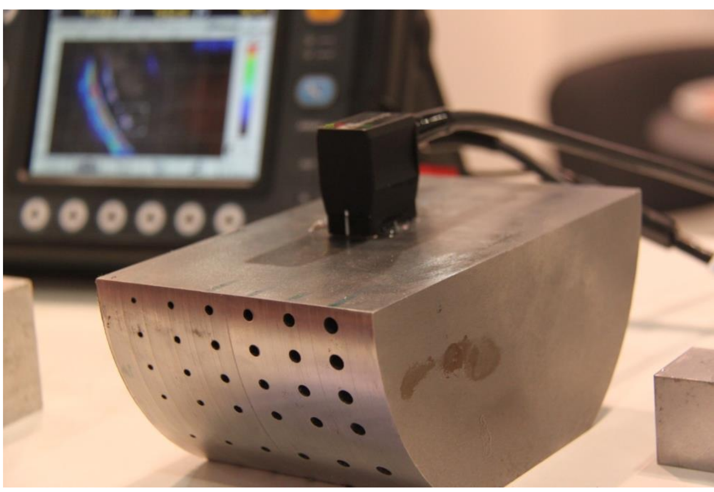


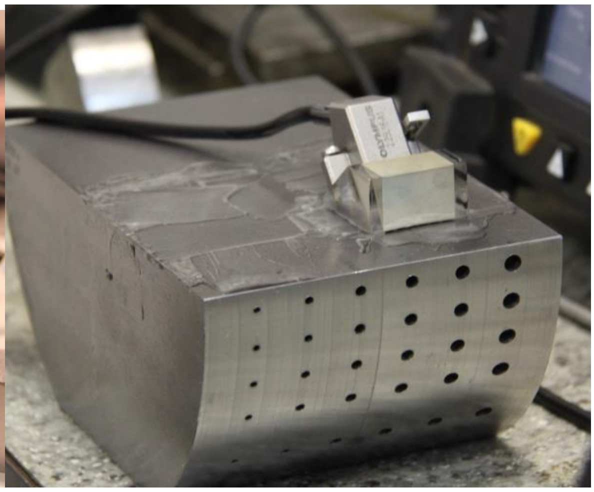
Images of the holes obtained by A1550 IntroVisor

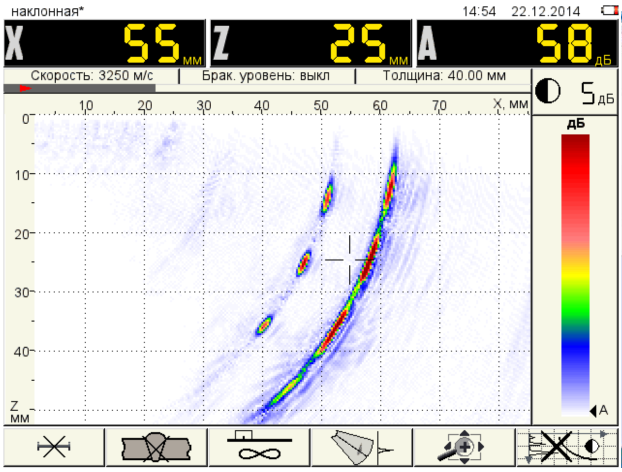


Images of the holes obtained by OmniScan MX

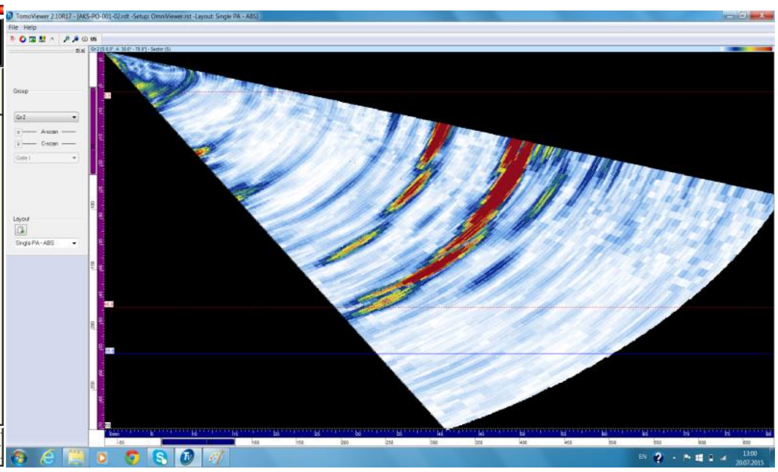
3. Sample with several flat bottom holes ø 5.0 mm, 4.2 mm, 3.6 mm, 3.0 mm, 2.3 mm, 1.8 mm.



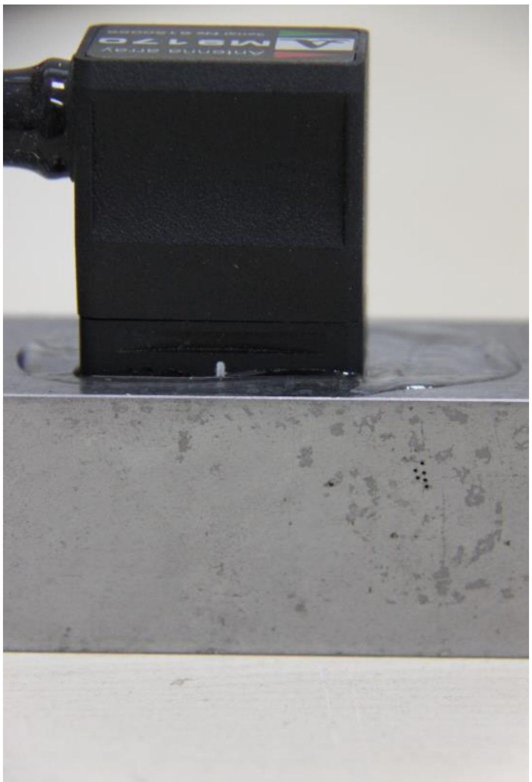


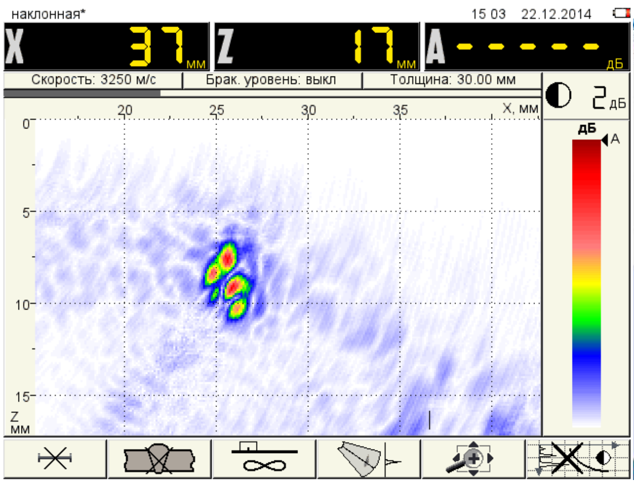


Images of the holes obtained by A1550 IntroVisor

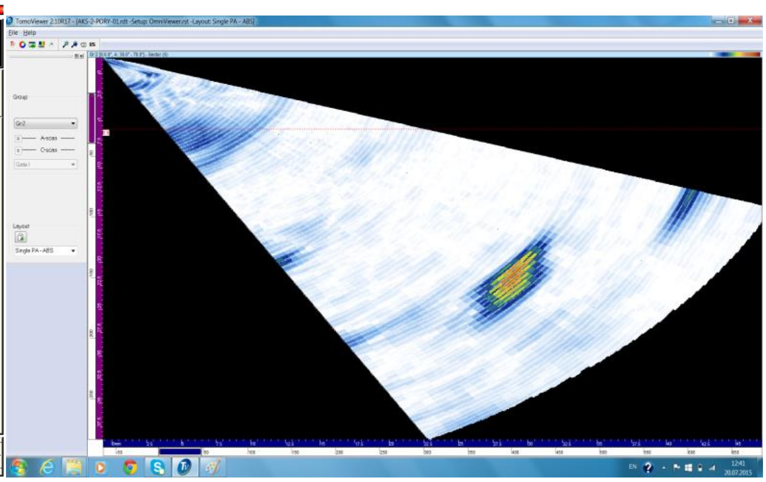

Images of the holes obtained by OmniScan MX

4. Sample with chain pores ø 0.5 мм.

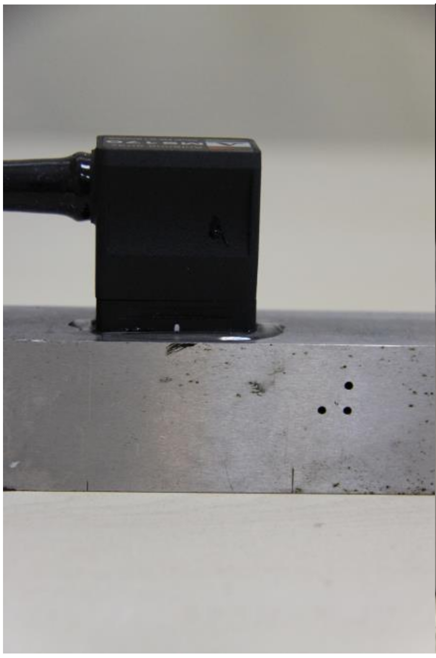


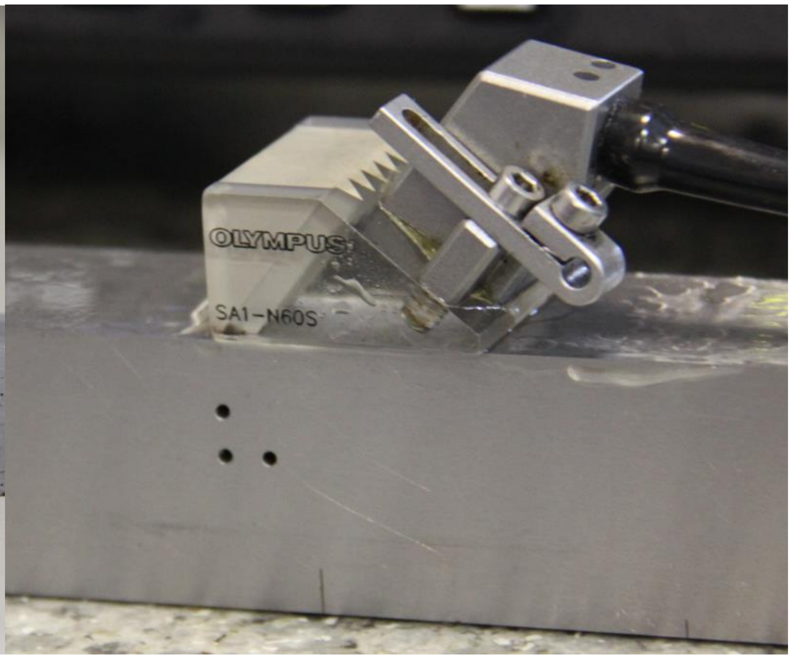


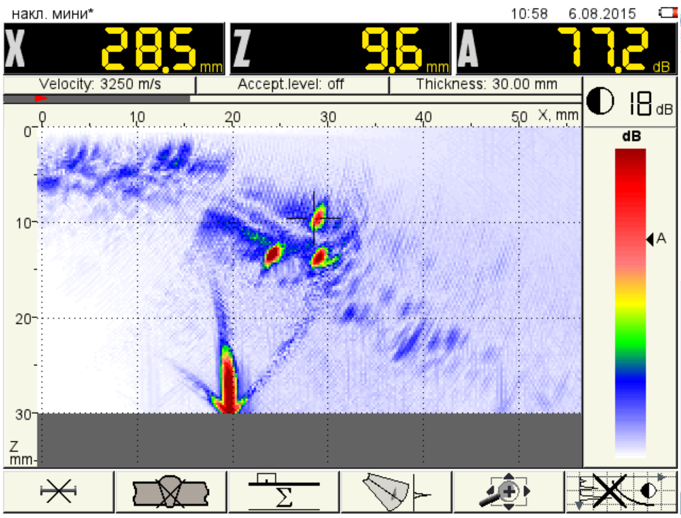
Images of the holes obtained by A1550 IntroVisor

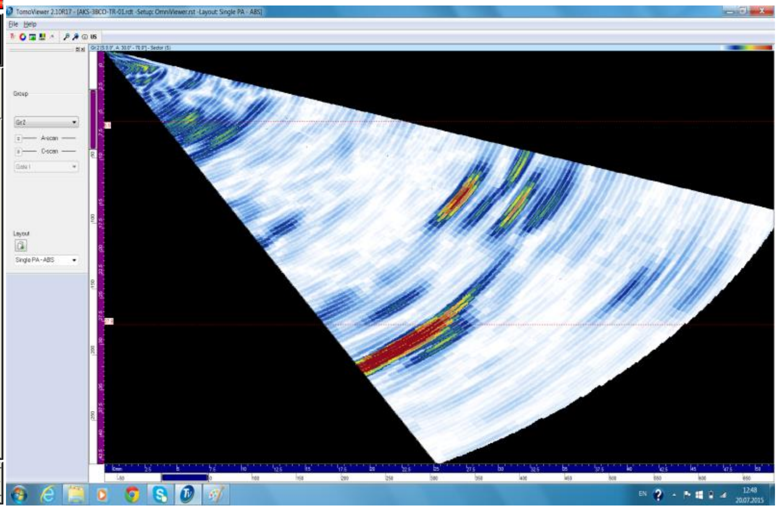

Images of the holes obtained by OmniScan MX

5. Sample with three side drilled holes ø 1.5 мм and crack with a height of 10 mm.









Images of the holes and crack obtained by A1550 IntroVisor

Images of the holes and crack obtained by OmniScan MX

SUMMARY

1. Method of the digitally focused antenna arrays (DFA), due to focusing of the aperture of the antenna array into each point of the visualisable cross-section of the object under examination, provides the highest possible quality of the image potentially, as well as high resolution capability, signal-to-noise ratio, detectability of the flaws throughout the whole depth and width of the object under examination (weld seams), thus providing environment for high efficiency during automated ultrasonic inspection.
2. Instruments with phased antenna arrays do not provide high quality of the image along the whole visualisable area of the object under examination. They provide high quality near a narrow focus band only (e.g. for constant length). Hence, ability to improve efficiency of the automated inspection of the objects is limited. The phased antenna arrays have a less good resolution capability outside this area. At that a high resolution capability is provided along a single line only on which a phased antenna array is focused.
3. Instruments with digitally focused antenna arrays (DFA), allow reconstruction of the images by means of different processing algorithms of the obtained data. Hence the user can select different types of the discontinuities (bulk defects, planar flaw (vertically-oriented flaws and plain surfaces, mirroring the ultrasound)).

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