Underwater ultrasonic pipeline measurement apparatus “SKARUCH-UW1”

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8-channel ultrasonic measurement apparatus (UMA) “SKARUCH-UW1” is designed for scanning detection of flaws in welded joints and the base metal of underwater pipelines sections Ø508…1420 × 7…40 mm with diving depth up to 60 m.

Scope of the apparatus (figure 1):

1. Underwater system:
   - Electronic 8-channel unit (flaw detector - thickness meter) **(1)**;
   - Remote monitor **(2)**;
   - Multicomponent acoustic unit with embedded data cable **(4)**;
   - Mechanical device with a travel sensor **(3)**.
2. Connecting control and power cable **(7)**.
3. Power and computer connection unit **(6)**.
4. Computer **(5)**.

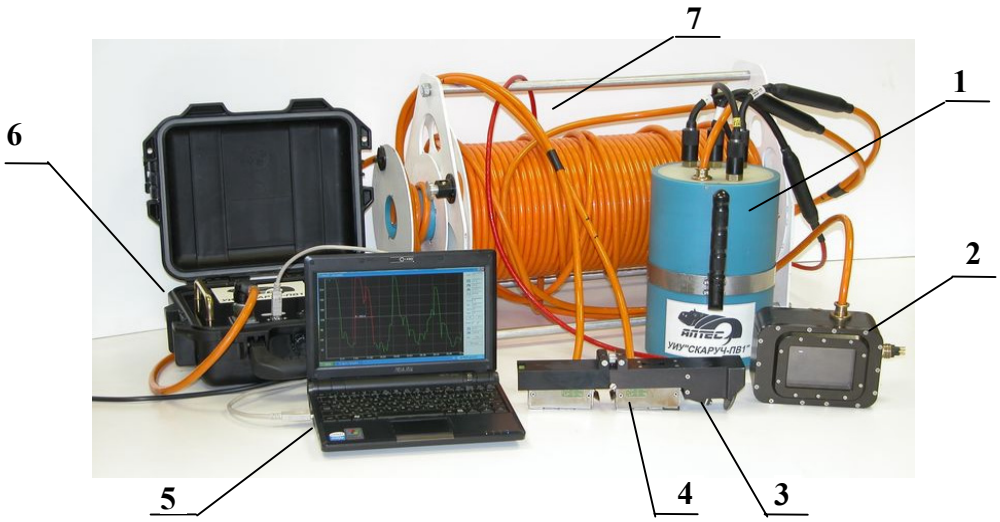

Figure 1. Scope of apparatus.

Electronic 8-channel unit (flaw detector – thickness meter) (**1**) excites the piezoelectric transducers located in acoustic units, receives measurement data and transfers it to the computer for processing. The unit has the following dimensions: diameter Ø163 mm, length 240 mm, weight 4 kg (in the air). The casing of the electronic unit is made of “polyamide-6”. The casing has terminals for connecting multicomponent acoustic init (AU), travel sensor (TS), remote monitor and connecting control and power cable (length 100 m).

The remote monitor **(2)** displays measurement data under water. Monitor dimensions: 150×102×80 mm, weight 1.8 kg. The casing material is “polyamide-6”, cover material is aluminum, and the sight glass is made of Plexiglas (thickness 10 mm). TFT monitor with resolution 320x240 pixels is installed inside the casing. The casing has connectors for manual piezoelectric transducers.

Connecting control and power cable (CCPC) **(7)** – carrying, underwater with longitudinal sealing. Length – 100 m, diameter – 10 mm. Cable limit load: 300 kgf. CCPC is wound on transformer reel with the following dimensions: 550×300×350 mm; weight 16 kg.

Power and computer connection unit features a USB-port for computer connection, power terminal (220 V) and control and power cable connector. The unit is enclosed in the watertight plastic casing. Weight: 3.8 kg, dimensions: 300×120×250 mm.

Acoustic multicomponent unit (**4**) with embedded cable generates ultrasonic waves 2.5…5 MHz into the test item and receives the reflected or transformed waves from the flaws of the welded joint. The acoustic unit is connected to the mechanical device (**3**) which the operator scans along the test item under water. The travel sensor (TS) located in the mechanical device measures the travel distance of the acoustic unit underwater from the starting position (test point) and registers the coordinates of detected flaws.

The units and the mechanical devices feature stainless steel springs which ensure constant and reliable contact of ultrasonic transducers of the acoustic unit with the surface of the test item.

Each unit features several measuring transducers (1, 2, 3, 4 and 5, 6, 7, 8, see figure 2) and acoustic contact tracking transducers (9, 10, see figure 2).

Application of large input angle and wide radiation diagrams is the features of acoustic units. This ensures uniform sensitivity along the section and the width of the welded joint. Operation in automatic mode involves automatic tracking of the acoustic contact (AC) level by generating transverse waves into the metal under test with the help of inclined acoustic contact transducer and reception of the waves and measurement of the signal amplitude using reflecting-shadowing scheme by other measurement transducers located inside each acoustic unit.

AC level tracking and correction of the received signal parameters based on the change of AC level ensure reliable testing of changes in the tested item surface.

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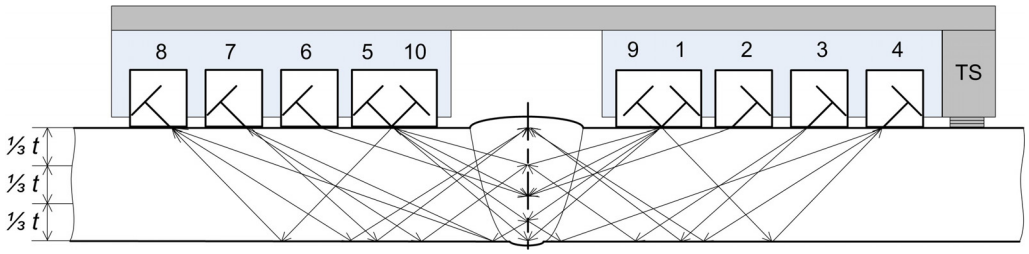

Figure 2. Testing scheme for butt joints with thickness.

The apparatus operates in the 16-stroke mode (figure 3). Every stroke implements a preset testing scheme. Each stroke has the following parameters preset according to the requirements of the current regulatory document: the gate location and duration (subject to the thickness tested and the distance to the seam); amplitude thresholds for registration of a flaw and determination of its dimensions by section. On each millimeter of the scanned distance, amplitudes are registered by the electronic unit in all the 16 strokes, which are thereupon transferred to the computer for further processing.

Stroke	Transmitter	Receiver	Scheme and method of ultrasonic measurement (USM)	Tested section
0	3	1	P-C, ECHO - reflecting	Bottom, Middle
1	7	5	P-C, ECHO - reflecting	Bottom, Middle
2	2	1	P-C, ECHO - reflecting	Bottom, Middle
3	6	5	P-C, ECHO - reflecting	Bottom, Middle
4	1	5	P-C, Reflecting-shadowing	Bottom, Middle
5	5	1	P-C, Reflecting-shadowing	Bottom, Middle
6	1	1	Combined, ECHO - method	Bottom, Middle
7	5	5	Combined, ECHO - method	Bottom, Middle
8	3	3	Combined, ECHO - method	Top, Middle
9	7	7	Combined, ECHO - method	Top, Middle
10	3	4	P-C, ECHO - reflecting	Top, Middle
11	7	8	P-C, ECHO - reflecting	Top, Middle
12	8	10	P-C, ECHO - reflecting	AC control
13	7	10	P-C, ECHO - reflecting	AC control
14	9	4	P-C, Reflecting-shadowing	AC control
15	9	3	P-C, Reflecting-shadowing	AC control

Figure 3. Stroke measurement scheme.

On each millimeter of butt joint scanning is performed simultaneously from both sides of the seam and with the operator moving the mechanical device with an acoustic unit - of the entire section under test. The scan rate is up to 1 m/min.

The gating system and microprocessor-based processing of the signals received from each transducer make it possible to identify the type of defect (volume, plane, volume-plane) based on the preset algorithms and determine the flaw parameters through comparing all signals received from it and determination of the maximum amplitudes in a stroke cycle (for the echo-methods) and minimum amplitudes (for the reflecting-shadowing methods) on each millimeter of the scanned distance (figure 4).

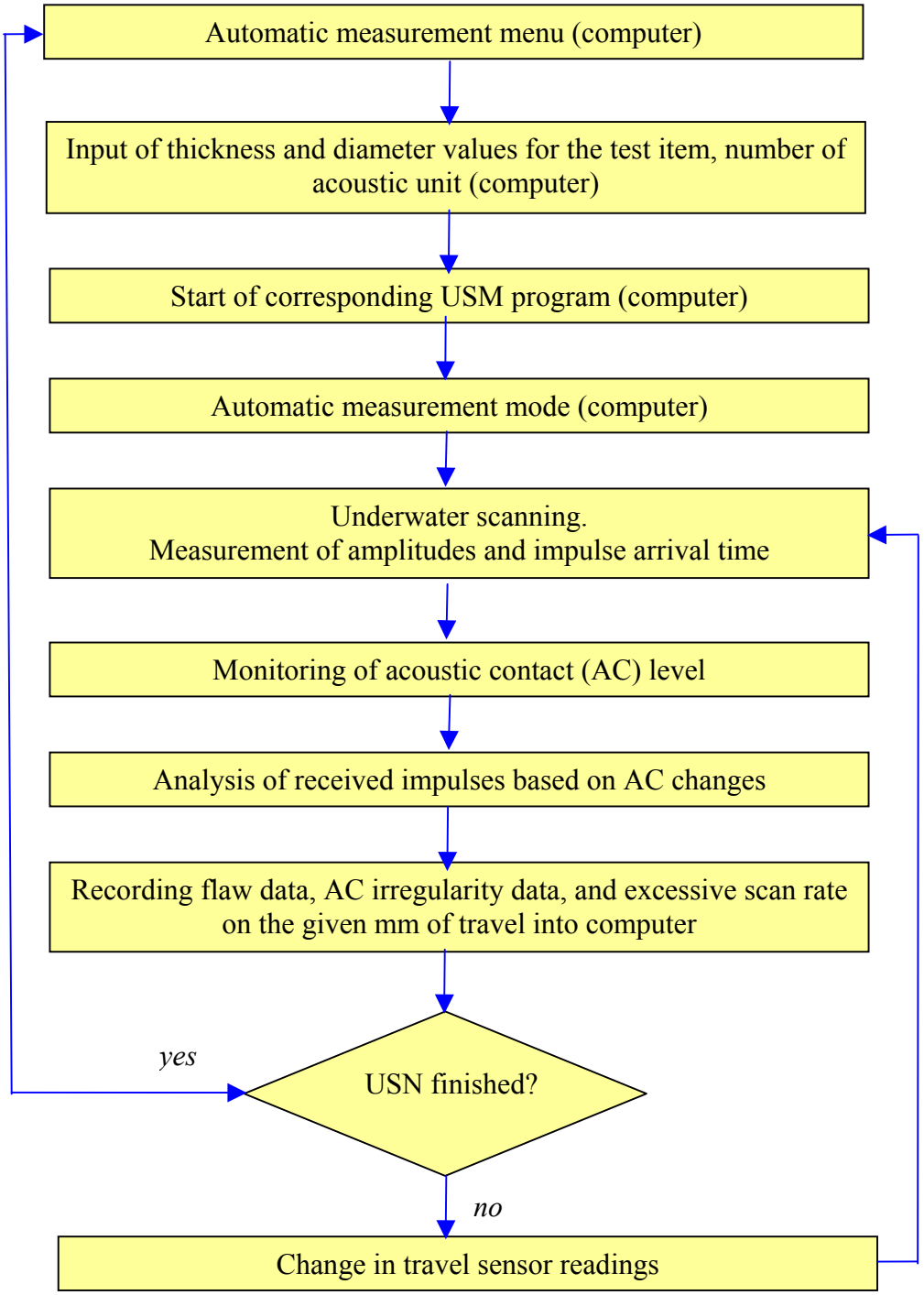

Figure 4. USM algorithm flow chart.

The test results are displayed on the screen of the computer in real-time mode (figure 5) and also on the underwater remote monitor. If required, the test results can be printed out with a printer connected to the computer. The quality of the entire welding joint is assessed according to the regulatory documents.

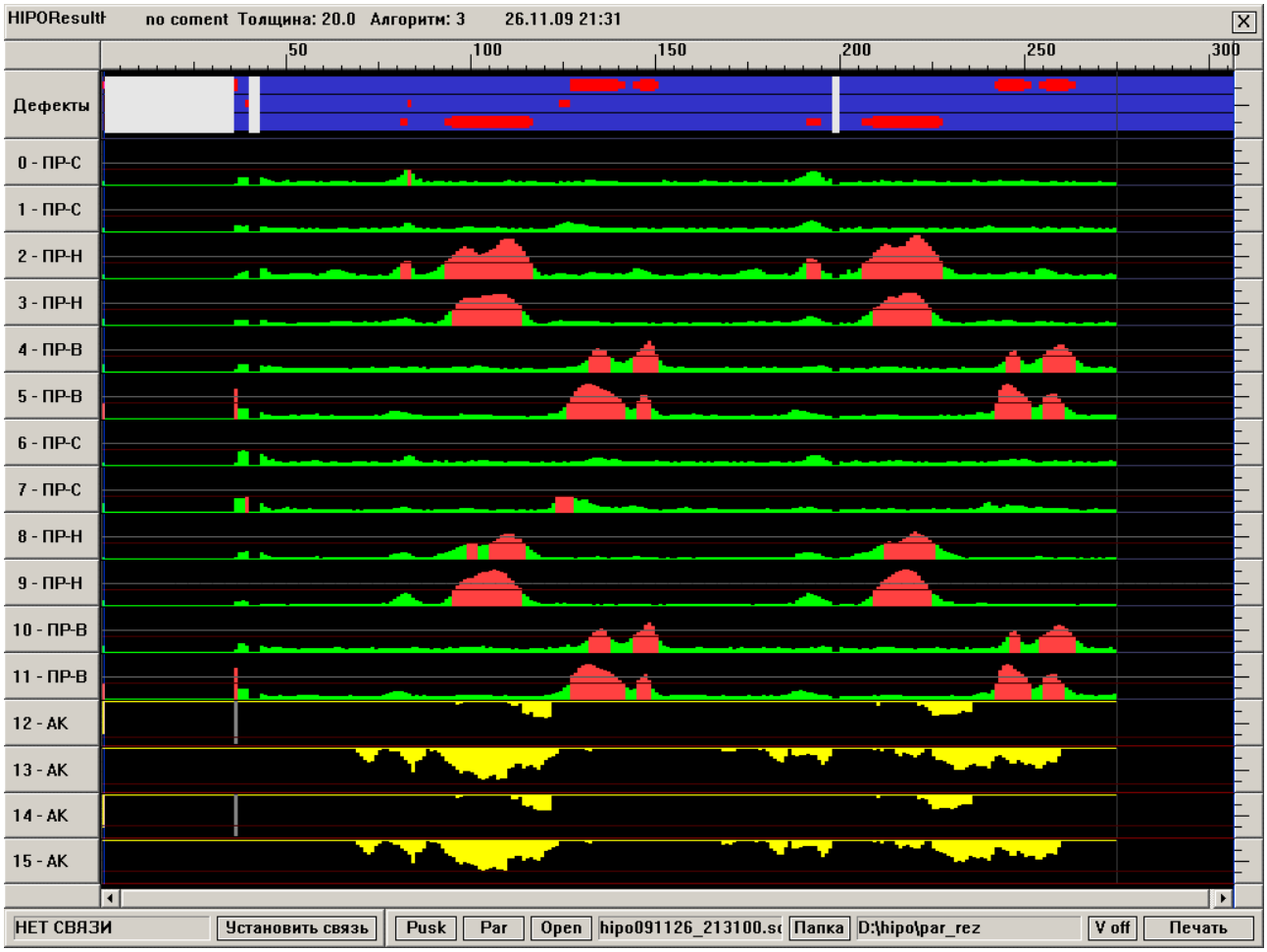

Figure 5. Results of inspecting.

The apparatus also makes it possible to perform thickness metering and flaw detection in the tested base metal through scanning with acoustic units.

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