RMT Ltd

DEVICE FOR MEASURING SEEBECK
COEFFICIENT AND ELECTRICAL
CONDUCTIVITY OF INGOTS

DX8070
USER GUIDE

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Limited Warranty

RMT Ltd warrants that the DX8070 Device, if properly installed and used, will be free from defects in material and workmanship and will substantially conform to RMT's publicly available specification for a period of one (1) year after the date that the DX8070 Device was purchased.

If the DX8070 Device, which is the subject of this Limited Warranty, fails during the warranty period for the reasons covered by this Limited Warranty, RMT, at this option, will:

REPAIR the DX8070 Device; OR

REPLACE the DX8070 Device with another DX8070 Device of the same model.

Trademark Acknowledgments

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INTRODUCTION

This User Guide is intended for studying the facility DX8070 (further the DX8070) for the incoming control of the Seebeck coefficient of ingot and disks, as well as the Seebeck coefficient and electrical conductivity of ingots of thermoelectric (TE) material based on Bi_2Te_3 taking into account the polarity (n/p) and contains all the necessary data and illustrations, sufficient for a correct operation.

The device provides measurements of the following parameters of thermoelectric (TE) modules - see the table below.

Parameter measured	Units	Designation	Values	Accuracy, %
Seebeck coefficient	mV/K	α	100…300	3
Electrical conductivity	1/(Ohm·cm)	σ	300…2000	5

Samples of the material should meet the following dimensions:

Parameter	Units	min	Max
Ingot			
Length	mm	40	110
Diameter	mm	20	25*
Disk			
Thickness	mm		30
Diameter	mm	20	25*

Note*: * - larger diameter is available on request.

For the measurements, the samples should be prepared in an appropriate way. The order of preparation will be described further.

The facility works under the control of a computer with the software installed. The commands from a computer are processed by the control block.

The device has a degree of automation, allowing to realize measurement of parameters in one cycle for ingots (along one axis) or over the section of a disk according to some law of coordinates changing at a given ambient temperature.

The facility allows performing research, acceptance, qualification, periodic and other kinds of TE material testing.

1. TECHNICAL PARAMETERS

Technical parameters of the facility are given in the table

Parameter	Designation	Units	Values
Step between the nearest points measured	d	mm	To be set
Accuracy of the probe positioning	Δx	mm	0.02
Positioning repeatability		mm	± 0.04
Summed length of the probe moving	L	мм	0…200
Voltage measured	U	mV	0.01…2
Voltage measurement accuracy		μV	±3.5
Ambient temperature measurement accuracy	T_{amb}	K	0.5
Electric current	I	A	0.5 – 5

Power supply:

- AC voltage, V - 220 +10/-15;
- Power consumption – no more than 200 W.

The equipment DX8070 is meant for laboratory measurements at the ambient temperature 25±3ºC and relative humidity up to 80%.

2. STANDARD KIT

#	Name	Note
1	Control block	PMTK 249.04.00
2	Robot with the following equipment:	
3	Measuring table	PMTK 249.05.00
4	Probe head	PMTK 249.06.00
5	Flat cable	PMTK 249.08.00
6	1kHz cable	PMTK 249.09.00
7	Computer supply cable	
8	Computer-monitor supply cable	
9	USB cable	
10	RS232 cable	

For operation, a computer with the software installed is necessary.

3. ARRANGEMENT AND OPERATION

Item designations in the figures correspond to item designations given in Section 1. "Standard Kit".

Further in the text of a designation in brackets correspond to the designations in figures.

The measuring part of the facility is a measuring table on which the sample and the probe head are established. Mutual positioning of the probe head of a sample is made by the robot.

The device control and processing of signals are carried out by the control block, by commands from a computer.


3.1. Connection Procedure

Item designations in the figures correspond to item designations given in Section 1 "Standard Kit".

Further in the text of a designation in brackets correspond to the designations in figures.

- Connect the flat cable (5) to the control block (5a) and to the probe head (5b).
- Connect the 1 kHz cable (6) to the control block (6a) and to the measuring table (6b).
- Connect the supply cable (7) to the control block.
- Connect the supply cable (8) to the control block (8a) and to the robot (8b).
- Connect the control block and computer by the cable USB (9).
- Connect the control block (10a) and the robot (10b).by the RS232 cable (10).
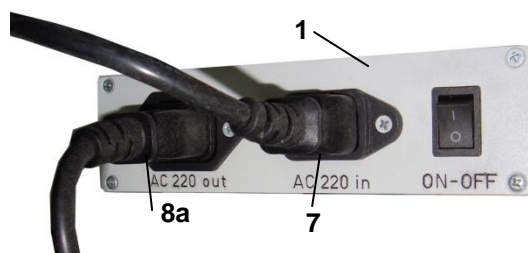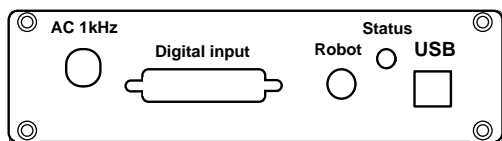
Before starting to work:

- Plug in the supply cable (7). Be sure the power source is ~220 V (50 Hz)
- Turn on the robot switch (11)
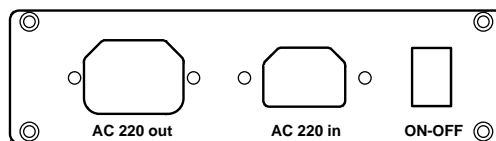- Turn the robot switch (12) to the position "RUN"
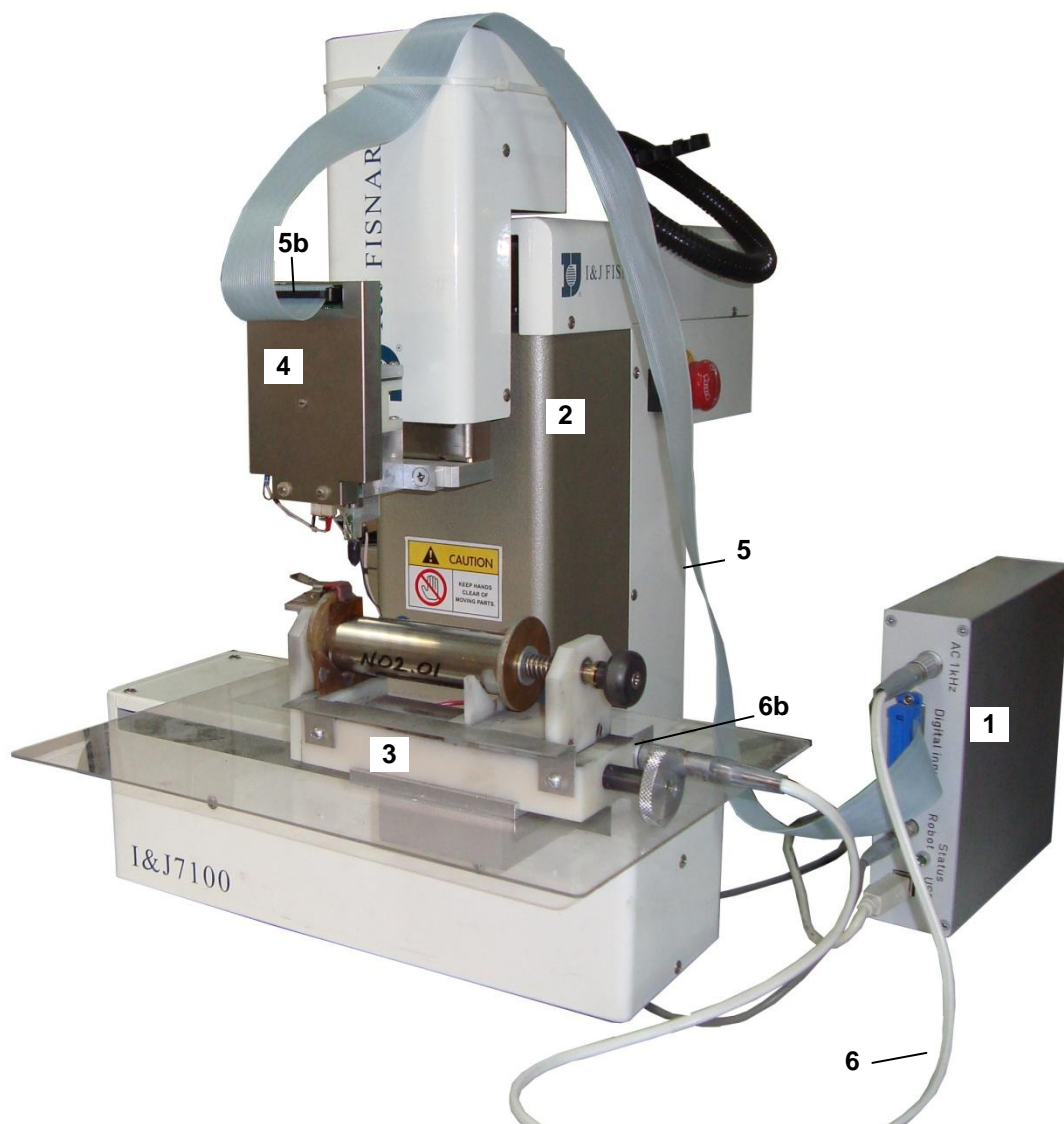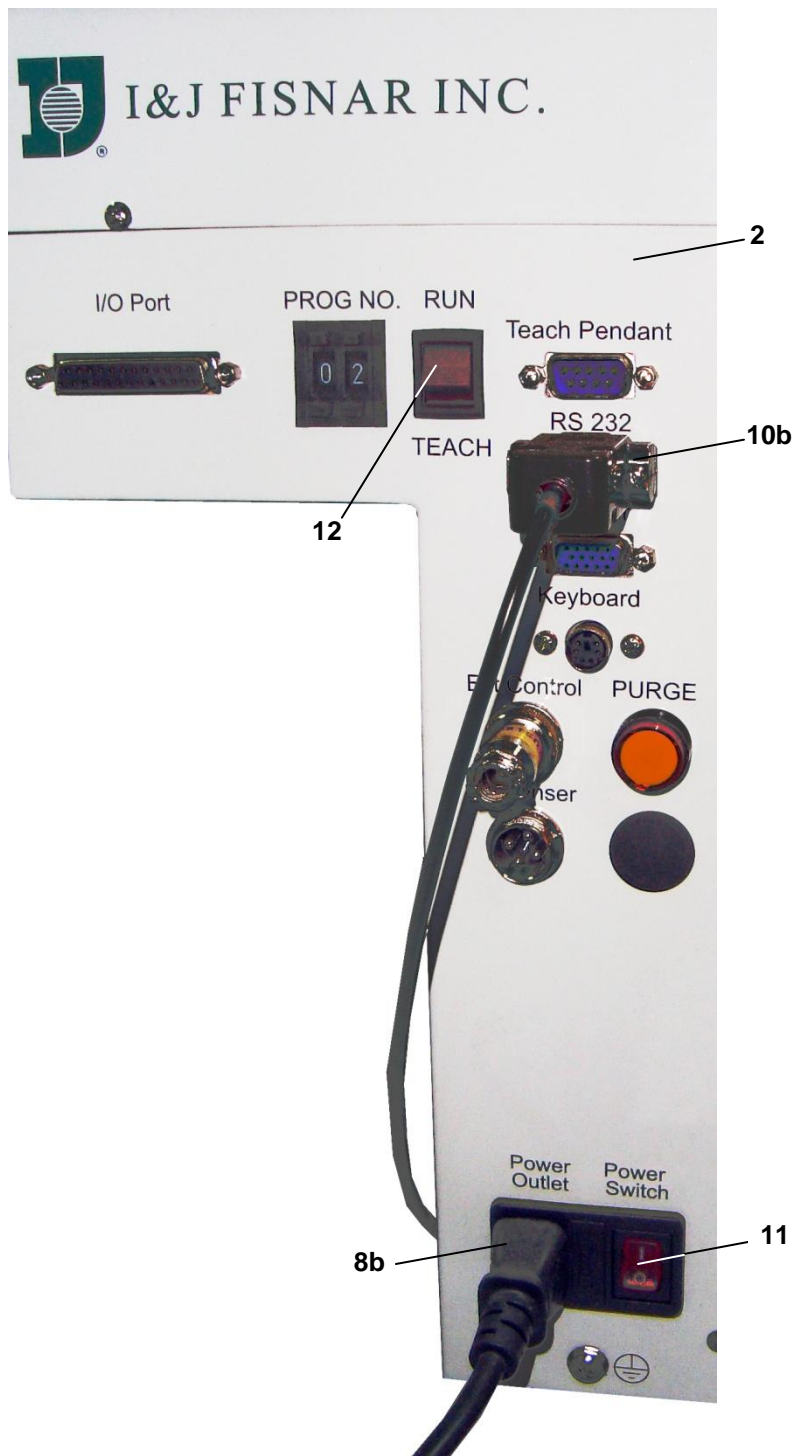
DX8070 general outlines
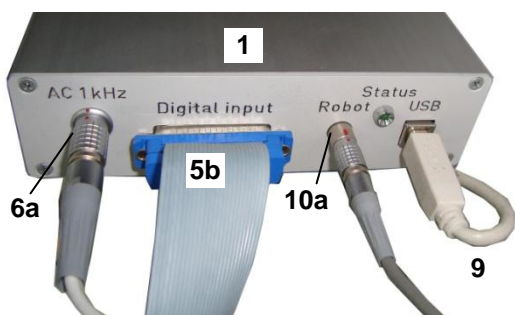
Control block front panel

Control block back panel

Robot connection panel

3.2. Samples Preparation

3.2.1. Ingots Preparation

- Check the face surfaces of an ingot. If they do not satisfy to the conditions of perpendicularity of 1 degree and flatness of 0.1 mm, it is necessary to make a treatment of the face surfaces.
- Sand-paper places of connection of electrodes
    a. Sample face surfaces
    b. Cylinder generatrix along which the measurements will be carried out
    c. Contact area of the top electrode
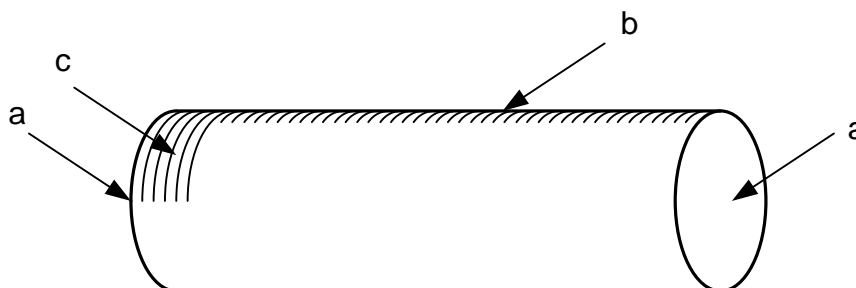
- Wash the sample with a soap in the water
- Treat the sample by a clean gasoline
- Treat the sample by ethanol
- Wipe copper contacts of the measuring table and those of the probe by ethanol
- Place the sample on a clean surface and keep it 2 hours at room temperature.

3.2.2. Disks Preparation

- Check the face surfaces of a disk. If they do not satisfy to the conditions of flatness of 0.1 mm, it is necessary to make a treatment of the face surfaces.
- Sand-paper the face surfaces
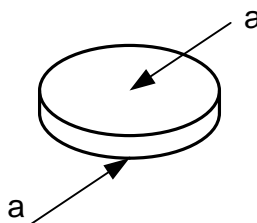
- Wash the sample with a soap in the water
- Treat the sample by a clean gasoline
- Treat the sample by ethanol
- Wipe copper contacts of the measuring table and those of the probe by ethanol
- Place the sample on a clean surface and keep it 2 hours at room temperature.

3.2.3. Ingot Installation for the Measurement

Not to stain the sample, put on the gloves.

Place the sample on a measuring table according to the figure below, having made the following actions.
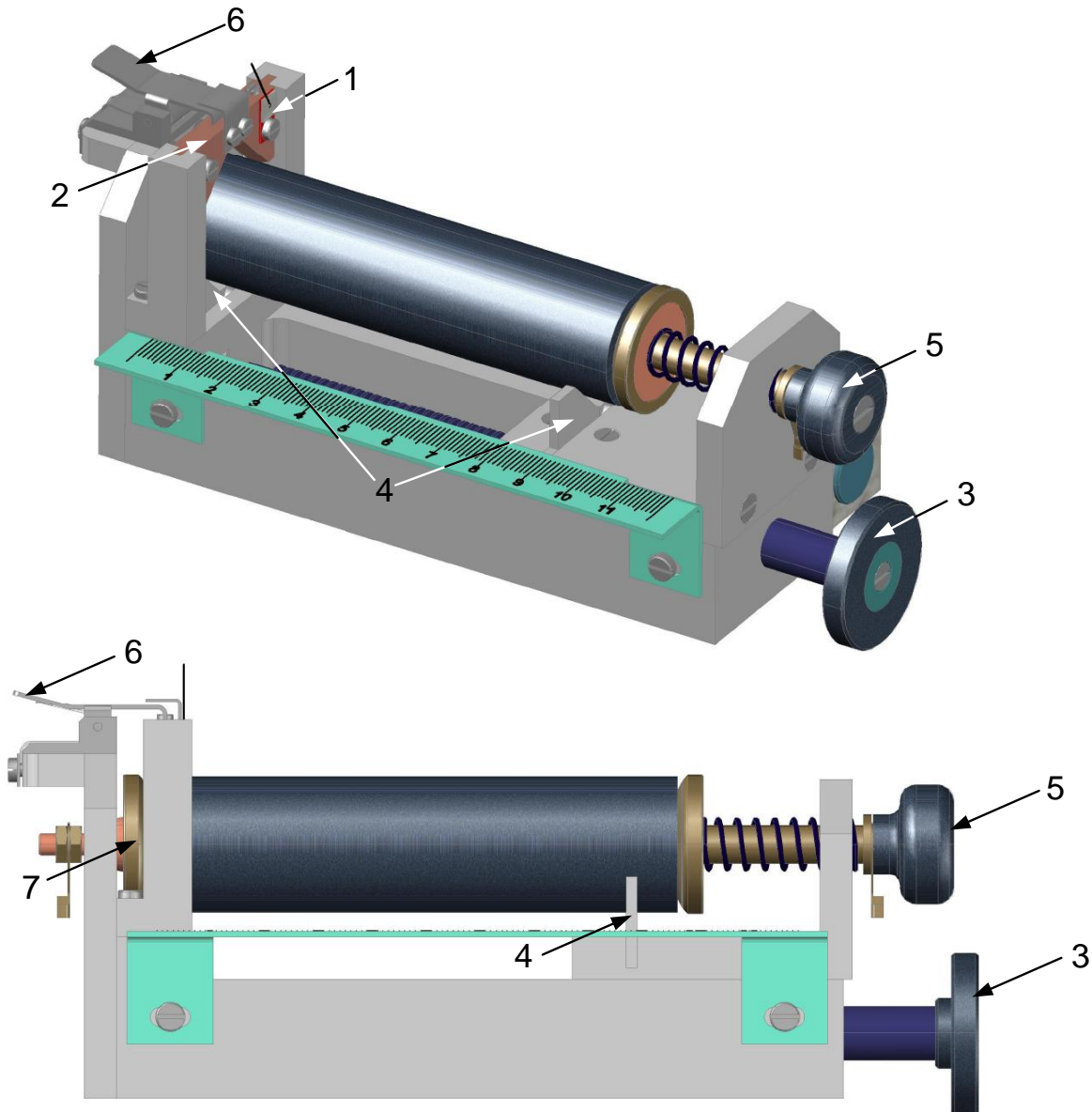
- Screw the panel of the thermocouple of the "cold end" 1 onto the top measuring electrode 2 of the measuring table

- Rotating the handle of screw 3, move apart the supporting disks 4 to the distance slightly less than the ingot length

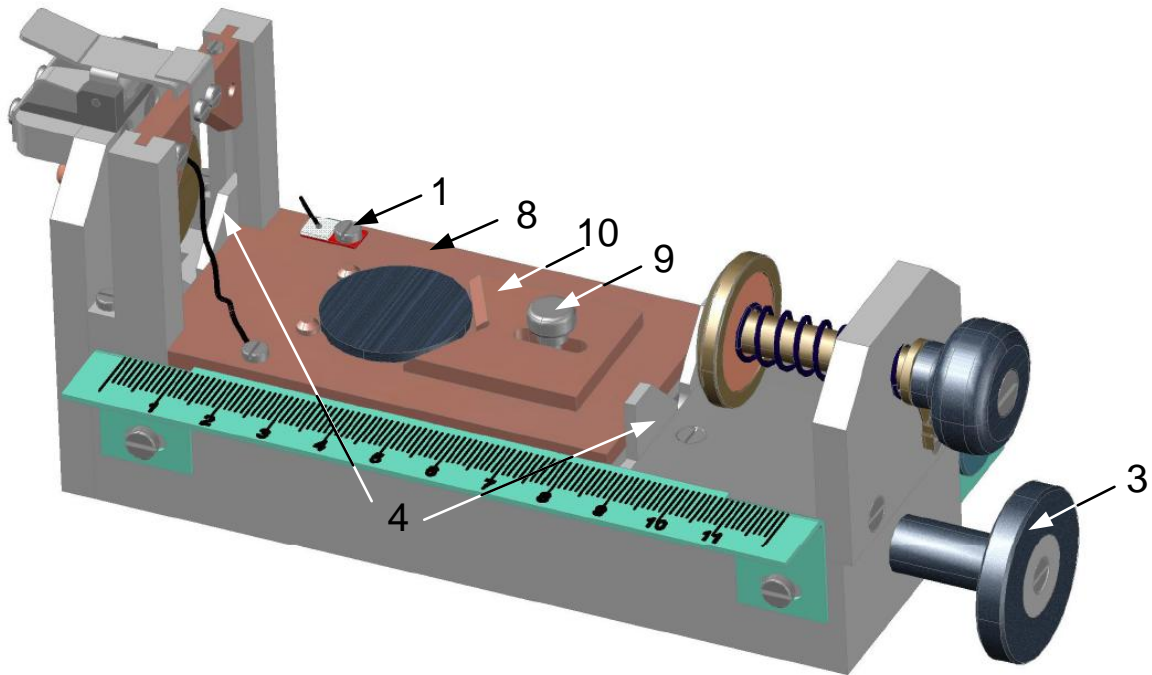- Rotating the handle of screw 5, move apart the leading electrodes to the distance slightly less than the ingot length.

- Press the clip arm 6

- Insert the ingot, leaning it against the supporting disks 4. The orientation of the ingot should be such that the cleaned zones corresponded to the places of connection of the electrodes.

- Press the ingot tightly to the left leading electrode 7

- Let off the arm of clip 6, fix the ingot and be visually be sure that there is a contact of the top electrode 2 and of the ingot

- Rotating the handle of screw 5, press the right leading electrode to the ingot tightly

Installation of a sample should provide a good electric contact of the sample all-over the plane of the leading electrodes, as well as both good thermal and electric contact with the top measuring electrode.

3.2.4. Disk Installation for the Measurement

Not to stain the sample, put on the gloves.

Place the sample on a measuring table according to the figure below, having made the following actions.

- Rotating the handle of screw 3, move apart the supporting disks 4 to the distance slightly less than the plate length for the disk measurement 8

- Insert the plate for the disk measurement 8 into the measuring table

- Rotating the handle of screw 3 move up the supporting plates 4 and fix the disks measuring plate 8

- Screw the panel of the thermocouple of the "cold end" 1 onto the disk measuring plate 8

- Weaken the fixing screw 9 and remove holder 10 to the right

- Establish the disk by pressing it tightly to plate 8 and leaning it against two supporting ledges of the plate for disk measurement

- Fix the disk by holder 10 by moving it firmly to the left and turn tightly fixing screw 9

Installation of a sample should provide a good thermal and electric contact with plate 8.

4. MEASURING PROCEDURE AND METHODS OF CALCULATIONS

- Prepare the sample and mount it onto the measuring table as shown in Section 3.2. Measure the dimensions of the sample.

- Turn on the control block and perform the measurements according to the calculations – see Section 4.1 and by the software – see Section 5.

4.1. Measurement of the Seebeck Coefficient

The method can be figured out with the help of the following scheme.

$$U_1 = \alpha_k (T_1 - T_2); \quad (1)$$

$$U_2 = \alpha_s (T_1 - T_2); \quad (2)$$
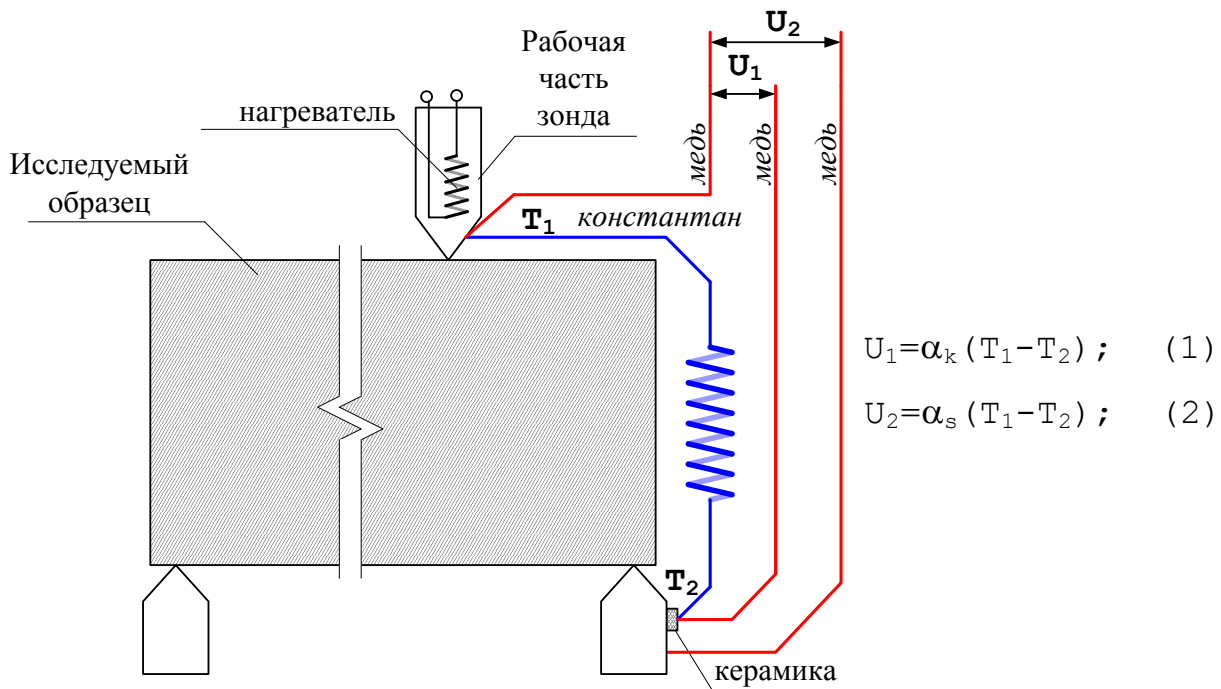
There is a heated double probe consisting of a constantan part and a copper part.

The voltage on the constantan probe is given by:

$$U_1 = \alpha_K (T_1 - T_2), \tag{1}$$

where α_k is the constantan Seebeck coefficient referred to copper.

The voltage on a sample is voltage on the copper probe U_2:

$$U_2 = \alpha_s (T_1 - T_2), \tag{2}$$

where α_s is the sample Seebeck coefficient referred to copper, T_1 is the sample temperature close to the probe end, T_2 is the base temperature in relation to which the temperature is measured.

From Eqs. (1) and (2) the sample Seebeck coefficient referred to copper is equal to:

$$\alpha_s = \frac{U_{Cu} \alpha_k}{U_k}, \tag{3}$$

4.2. Measurement of Electrical Conductivity

Electrical conductivity is measured by the voltage *U (x) at AC* electric current *I* as illustrated below.
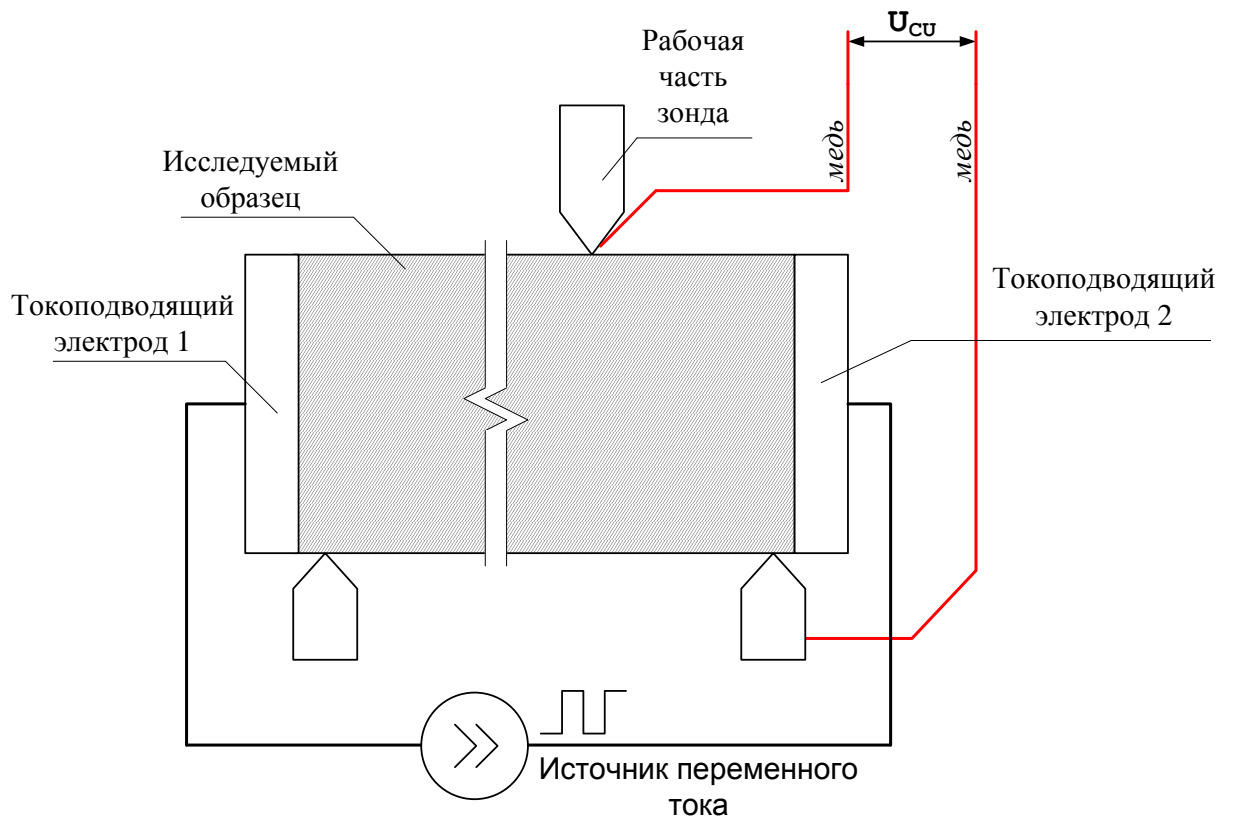
The value is calculated as:

$$\sigma(x) = \frac{I\Delta x}{s\left[U(x) - U(x - \Delta x)\right]} \,, \tag{4}$$

where *Δx* is a distance between two nearest points, *I* is the sample current, *s* is the sample cross-section, *U(x)* is a potential difference between points *x* and *0*.

5. SOFTWARE DX8070

5.1. System Requirements and Software Installation

Important!!! It is necessary to install the software "DX8080 Application" before the connection of the device "DX8070" to a computer.

For a successful installation of the software, the computer should meet the following requirements:

- Processor – Intel Pentium, frequency 1.5 GHz or AMD Athlon and higher

- 512 Mb RAM

- Operating system Windows 2000/XP/VISTA

- 50 Mb of free space

- CD-ROM

If you install the software from the CD (it is supposed that the option of automatic loading is on) "Autorun"), press the button "DX8070 Application Setup". If you downloaded the software from the site (http://www.rmtltd.ru), run the file "<PATH>\Dx8070Setup.exe" and follow the instructions, where <PATH> is the path to the file-setup.


5.2. How to Start Measuring

1. Turn on the device by the switch "ON-OFF".
2. Wait for the sound signal of the robot initialization ending.
3. Switch on the computer and start the program of controlling the device "DX8070". The software is started in a usual way, by a double-click of the mouse on the appropriate tag. After it, the software will try to define (determine) necessary devices for work. In case of a successful detection, the window with devices found will appear on the screen. It is necessary to choose one of the lists and to press button "Ok" for ccontinuation.
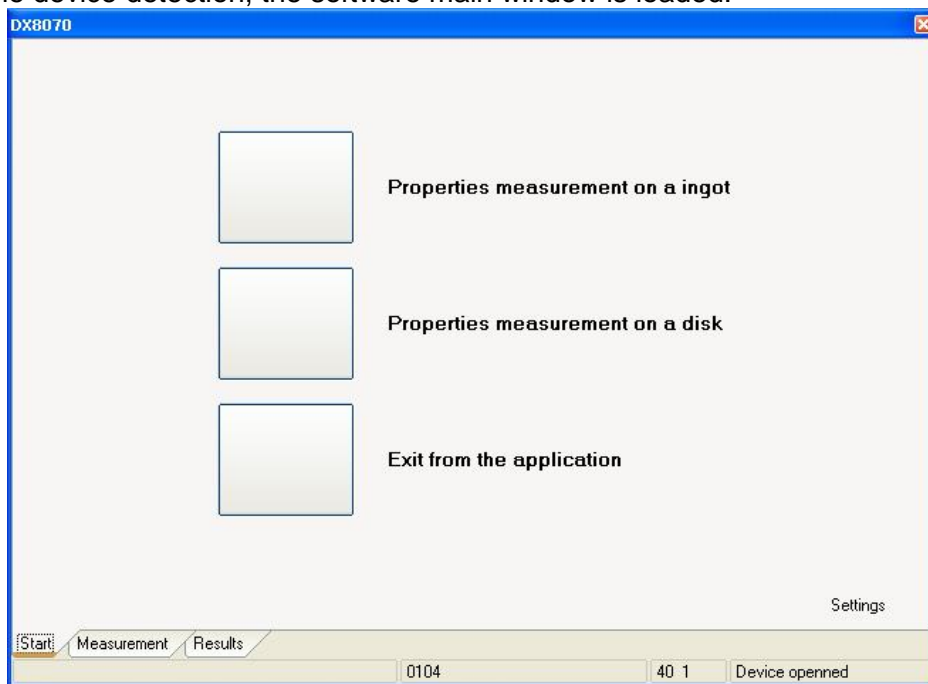
In case of an unsuccessful connection, the message will appear:
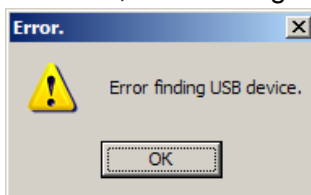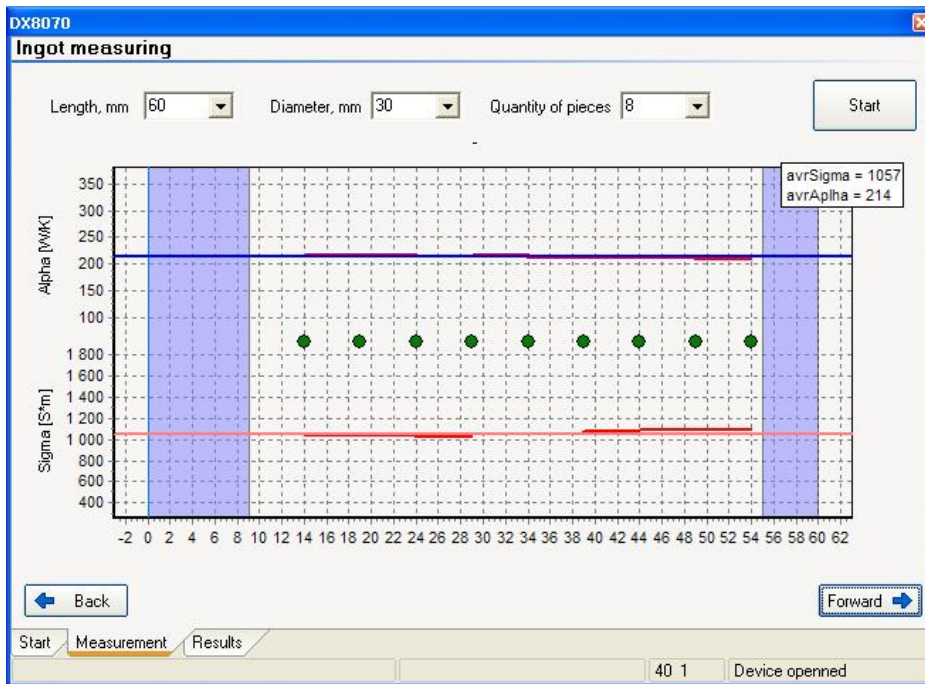

5.3. Main Window

After the device detection, the software main window is loaded:

The main window has a simple interface and allows proceeding quickly to necessary measurements on an ingot or on a disk. For this purpose, it is enough to press a mouse on the appropriate button.
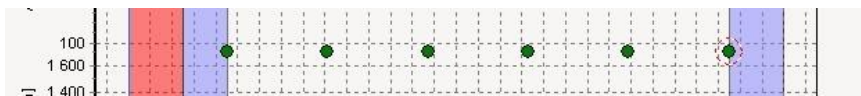
5.3.1. *Measurement of Ingot Properties*

Fill the ingot parameters in the fields "Diameter", "Length" and "Step".

A number of points to measure is set by a number of elements. The more the number of elements, the smaller the step between points. It is not recommended to set the number of elements more than 8. An approximate arrangement of points is given on the plot below.

For beginning to measure, we press button "start". Measurement on an ingot includes two independent processes: the measurement of electrical conductivity (Sigma) and that of the Seebeck coefficient (Alpha). After the measurements are over, the dependences of Alpha and Sigma versus the coordinate will be plotted, and the average values will be shown.

For the detailed information on properties of the material in a measured point, it is necessary to put the mouse cursor on a point needed. Within a small time the information will be shown in a separate window.
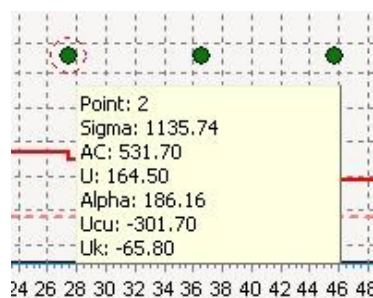
The following parameters are given in this window:
- Point number

- Sigma value
- AC current
- Copper wire voltage (for sigma)
- Alpha value
- Constantan wire voltage (for alpha)
- Copper wire voltage (for alpha)

In case of a bad contact between the sample and electrodes, the results can be incorrect. Such a situation is displayed on the diagram by strong fluctuations from the average value. If so, it is recommended to correct the contact and to repeat measurements. The examples of results of measurements with bad and good contact are given in the following figures.
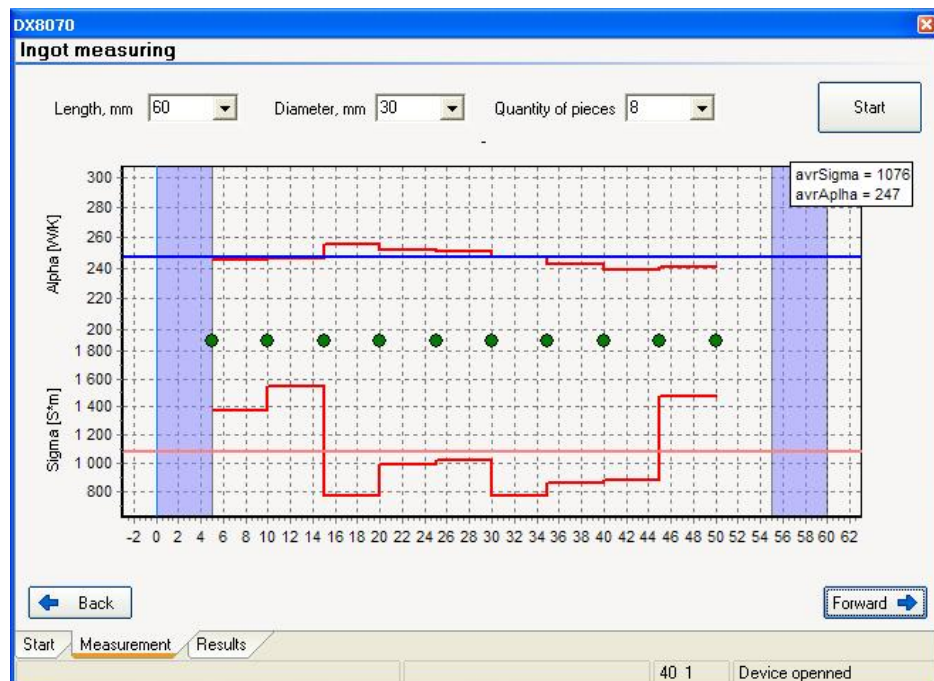
Bad contact measurements
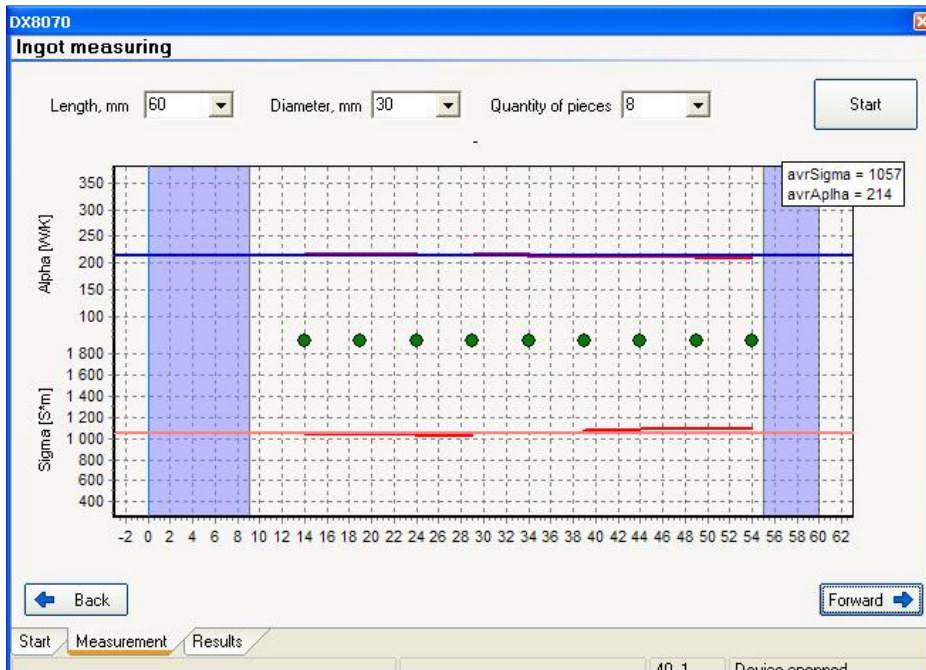
Good contact measurements

5.3.2. Measurement of Disk Properties

Fix the disk on the measuring table, as recommended.

Measure the disk diameter and write into the corresponding field of the software.

It is only the Seebeck coefficient that can be measured in this mode. To start the measuring procedure, press the button "Start".
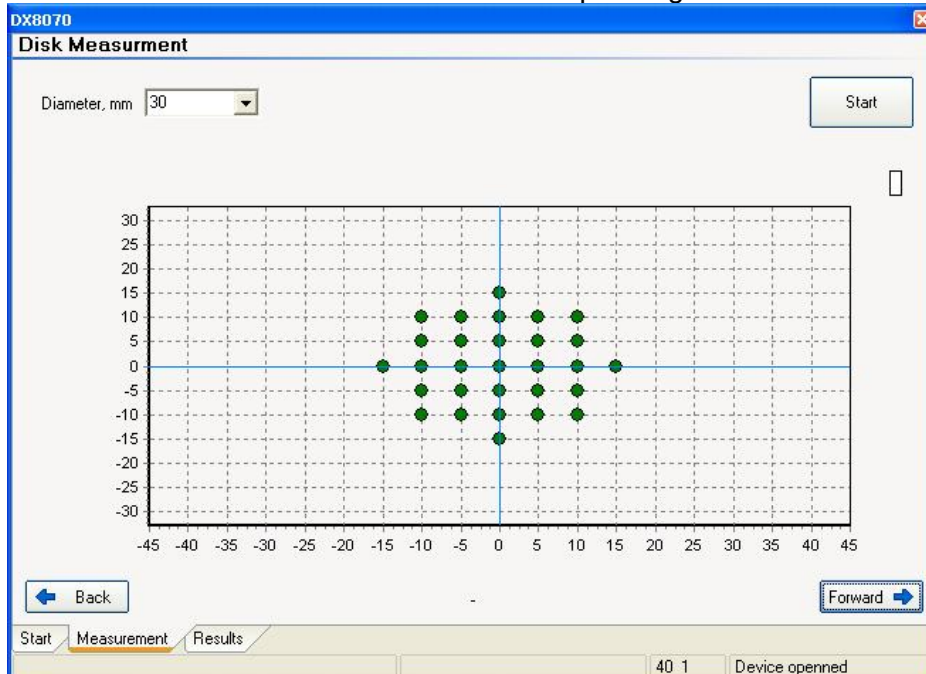
5.3.3. Results Window

In this window the summary information on measurements is given. To open the log of the test results, it is necessary to press button "further" after the end of measurements.

DX8070						☒

Sample measurement result

Print   Open   Save

Passport of the ingot

Supplier name	Date of delivery	Diameter, mm	Length, mm	Weight, g	Material type

Type	Tm(Tr), C	Sigma, Ohm^-1*cm	Alpha, uV/K	A2S	Date	Operator

Parameters list

Step from begin	Type of conduction	Sigma, Ohm^-1*cm^-1	Alpha, uV/K	A2S

⬅ Back   Forward ➡

Start / Measurement / Results /

	0104		40 1	Device openned

The test log offers the following services:

- Results storage
- Earlier results loading
- Results printing

All the actions are done by an appropriate button choice.

6. SECURITY MEASURES

- At operation, maintenance service and checking it is necessary to observe requirements of the Russian Standard "GOST 12.3.019-80", "Service regulations of consumers' electronic devices" and "Rules of a labor safety at operation of consumers' electronic devices", or to apply similar documents of your country.

- The voltage on the contacts of the device at operation is up to 250 V, which is dangerous to human life. Any connections to the device and its maintenance service are only to be done at power switched off.

- Moisture on contacts and internal elements of the device are not allowed. The usage of the device in aggressive environments in the atmosphere of acids, alkalis, oils, etc. is forbidden.

- The connection, adjustment and servicing of the device should only be performed by the qualified experts who have studied this document.

7. MAINTENANCE SERVICE

Service of the operational device consists of the technical inspection.

At the maintenance service of the device observe the security measures - see section 6 SECURITY MEASURES.

Technical inspection of the device should be carried out not rarer than once in three months and includes the following operations:

- Cleaning of the device housing of dust, dirt and extraneous subjects;

- Cables checking;

- Checking of reliability of inter-block connections.

The malfunctions found at the technical inspection should be removed immediately.

Checking of metrological characteristics of the device should be done not rarer than once in 3 years.

If necessary, make the adjustment of the device. It means the operations providing restoration of its metrological characteristics in case of their change during a long operation.

Important!!! Necessity of the adjustment is determined by results of the device checking only by the qualified experts of the metrological services carrying out this checking.

8. POSSIBLE MALFUNCTIONS AND WAYS OF THEIR ELIMINATION

Possible malfunctions and ways of their elimination are given in the table below.

Appearance	Possible reason	Way of elimination
The program could not contact the control block	Faulty USB cable Necessary drivers are not installed	Malfunction reason elimination
Temperature value is not true	Breakage of a circuit of one of thermal resistances	Malfunction reason elimination

Note. If a malfunction or a reason is not specified in the table, it is necessary to deliver the device for repair.