MULTIFUNCTION COMPUTER METER

CX-742

USERS MANUAL

CONTENTS

1. BASIC INFORMATION

The Manual was prepared for the meters CX-731, CX-732, CX-741 and CX-742. All this meters have this same technical parameters. They have different casing and features The meters **CX-741** and **CX-742** have an additional function of dissolved oxygen measurements.
CX-731 and **CX-741** are laboratory meters in stationary casing, powered by 6V/500mA power adapter.
CX-732 and **CX-742** are portable meters in suitcase casing, they are powered by 8V/500mA power adapter, and built in accumulators, which enable about 7 hours of non-stop work in the field
Portable versions of the meters enable flow measurements of small water-courses (streams, small rivers) using the conductance method.
All programmed parameters and electrodes characteristics are stored in non-volatile EEPROM memory, what makes them independent from the power source.
The clock has an internal battery designed to provide 10 years of continuous operation without switching the meter on. The stored results of single and series measurement are kept in the memory of the meter for about 4 months and are powered by separate accumulator. **After first switching the meter on one should leave it connected with the power source for about 15 hours to charge this battery.** Periodical charging of this battery is necessary what is described in the chapter „Power, storing and conservation" page 91.
Wisibility of the displayed signs on the display is connected with the exterior light. Changing the contrast is possible in function **Prefs** menu **Misc** position „*Contrast"*.
There is possibility to remove all stored parameters and characteristics introduced by the user (The reset function). **To do this one should switch the meter off, than press the ESC key and holding the key pressed switch the meter on till the moment when the main menu will be displayed.**
This action will remove from the memory <u>all programmed parameters and characteristics and will provide the producer settings.</u>
The meter may cooperate with the automatic electrode switch APE-2, which enables multiplexed measurement of one parameter using up to 9 electrodes. The switch may be bought as an additional equipment.
In case of any damage the meter should be returned to our company where in short time we will make the warranty or after warranty repair.

2. USING THE INFORMATION

Kinds of information:
1. Usage instructions;
2. Information in the lower line of screen;
3. Information in windows displayed during the work;
4. Sound information.

To make the work easier and without using the users manual in the lower line of display, short information is.
During the work in some cases windows are displayed with additional information about errors which were made, warnings about possibility of loosing stored parameters or informing about the finished calibration.
Some information is signalised by sound signals. Every pressing of key is signalised by short beep sound and incorrect value of entered parameter by longer beep.
Change of every minute is signalised by short sound, what may be switched off in the menu CLOCK.
Lack of paper in the printer is signalised by multiple sound signal. Exceeding the programmed minimum or maximum of alarm is signalised by interrupted sound.
In case of loosing the memory (ex. after discharge of the accumulator) after switching the meter on the user is informed about that fact by double sound signal.

3. CHARACTERISTICS OF THE METER

- graphic LCD display 235 x 110 mm with back light;
- possibility of watching the result in graphic and numerical form;
- easy usage thanks to the information given in the lower line of the display;
- possibility of choosing the resolution of displayed result;
- information about the stabilisation of the result;
- possibility of selecting „time of stabilised measurement" for concrete electrode;
- automatic or manual temperature compensation;
- 8 point automatic, semiautomatic or manual calibration of the electrode;
- numerical or graphic reading of electrode characteristic;
- in conductivity meter, ion meter and thermometer possibility of changing the used unit into another with automatic conversion of the result;
- in ion measurements the meter automatically introduces the molecular weight of the examined ion.;
- separate option of titration with semiautomatic counting of the data;
- possibility of graphic compering of two titration series;
- in conductivity meter possibility of flow measurement in small water courses using the conductance method with possibility of automatic counting of the data to l/s;
- during the conductivity measurements it is possible to introduce the K constant of the cell, chosen reference temperature Tr and α coefficient;
- during the voltage measurements possibility of introducing the reference voltage Vref;
- possibility of storing 10 series of measurements 499 measurements each;
- possibility of numerical or graphic presenting of the stored measuring series on the display, printer or transferred to computer;
- automatic calibration of graphs, zoom function;
- possibility of graphic comparison of two series of measurements;
- possibility of removing chosen measurements from the whole remembered series;
- possibility of printing the stabilised results or on request;
- possibility of printing the electrode characteristic as table or graph;
- possibility of printout of the stored series in form of text or graph with automatic calibration;
- possibility of sending the stored measurement series in numerical form to the PC computer to work on the data in spreadsheet;
- output for recorder and two point alert with determination of the hysteresis and output from the relays;
- storing of all measurements series for about 4 months from switching the meter off;
- independently powered clock with calendar;
- possibility of transfer of all data and measurement series from the meter memory to the PC computer using a special cx7xx-pc.exe program. Thanks to it the information may be gathered on the HDD and if necessary after some changes send it back to the meter;
- optionally cooperation with automatic electrode switch APE-2 which enables taking multiplexed measurements with up to 9 electrodes at one time.

4. TECHNICAL DATA

MEASUREMENT	pH	Ion	Voltage	Concentr. O_2	Conductivity	Temperature
UNITS	pH	pX, M/l, g/l	mV	%, mg/l	mS, ppm	^{o}C, ^{o}F, K
RANGE	-3 ÷ 20 pH	-3 ÷ 20 pX or 0.001 µM/l ÷1 kM/l autorange	±2000 mV	200.0% or 20.00 mg/l	0 ÷ 2 S/cm or 0 ÷ 1 ppo 6 ranges autorange or manual	-200 ÷ +200 ^{o}C -328 ÷ +392 ^{o}F 73.15 ÷ 473.15 K
ACCURACY (±1 digit)	±0.001 pH	±0.002 pX	**do ±1200mV:** ± 0.1 mV **do ±2000mV:** ± 0.1% FS*	of the probe	**0÷20mS:** ±0.3 % FS* **20mS÷2S:** ±0.5% FS*	±0.2 ^{o}C
TEMP. COMPENS..	-5 ÷ 130 ^{o}C	-5 ÷ 130 ^{o}C	—	0 ÷ 40 ^{o}C	0 ÷ 50 ^{o}C	—
INPUT IMPEDANCE	10^{12} Ω	10^{12} Ω	10^{12} Ω	—	—	—
K CONSTANT of PROBE	—	—	—	—	0.1 ÷ 9. 999	—
α COEFFICIENT	—	—	—	—	0 ÷ 5 % / ^{o}C	—
FREQUENCY	—	—	—	—	64Hz, 1.2kHz	—

CALIBRATION	MULTIPOINT, UP TO 8 POINTS
ELECTRODES	STORING OF THE ELECTRODE CHARACTERISTICS 5 x 10 ELECTRODES
ALERT RELAYS	TWO POINTS: MAXIMUM, MINIMUM AND HYSTERESIS max. voltage 100V, current 1A, max. power 10VA
MEASURING SERIES	10 SERIES 499 MEASUREMENTS EACH
TITRATION	SEPARATE FOR EACH FUNCTION WITH POSSIBILITY OF GRAPHIC PRESENTING OF THE COURSE. POSSIBILITY OF COMPARING TWO TITRATION COURSES.
FLOW	FLOW MEASUREMENT IN l/s IN SMALL WATER COURSES (STREAMS, WEIRS) BY CONDUCTANCE METHOD
GRAPHS	IN TIME FUNCTION OR NUMBER OF MEASUREMENTS IN SERIES. ZOOM FUNCTION. AUTOMATIC CALIBRATION. POSSIBILITY OF COMPARING TWO GRAPHS.
OUTPUTS	CENTRONICS, RS-232: Parameters of transmission: 9600 bod, 8 bit, 1 even bit, 2 stop bit. RECORDER: pH, Ion, mV measurements: voltage measured, measurement of O_2: 1mV / 0,1% or 1 mV / 0.01 mg/l, conductivity measurement 0 ÷ 2 V, cycle temperature measurement: 1mV / 0.1 ^{o}C. RELAYS: 9 PIN
INPUTS	pH ELECTRODE, REFERENCE ELECTRODE, ION SELECTIVE ELECTRODE, OXYGEN PROBE, TEMPERATURE PROBE, CONDUCTIVITY CELL, POWER
DISPLAY	GRAPHIC LCD - 235 x 110 mm (640 x 200 points)
POWER	STABILISED POWER ADAPTER 6V 500mA (CX-732 AND CX-742: 8V 500mA) IN CX-732 AND CX-742 ADDITIONAL ACCUMULATOR 6V 2Ah (field work)
WEIGHT	X-731 and CX-741 - 2 kg, CX-732 and CX-742 - 3 kg

* FS - upper limit of the measurement range.

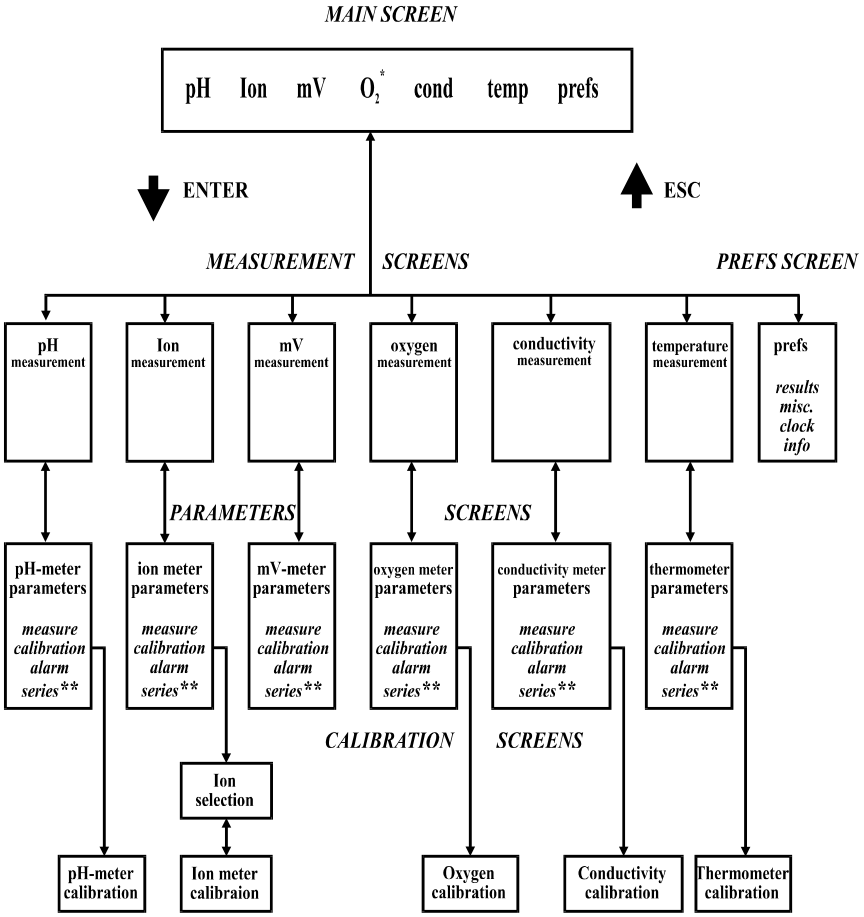
Technical data about the oxygen measurement concern only CX-741 and CX-742 meters.

NOTICE: the technical data is guaranteed after 10 minutes from switching the meter on.

5. SCREENS

In the upper part of the housing there is a LCD display, on which different function screens are displayed. The main screen displays five measuring functions and prefs (options). From this screen one may enter the measurements screens, different for different measuring functions. One may observe the value of the measurement and information about the supplementary parameters connected with the measurement. One chooses the measurement screen, or misc. screen using the ⇐ or ⇒ buttons and when the right one is chosen, by confirming it with the **ENTER** key.
From every measuring screen one may pass to the parameters screen which enables entering the controlling data. From the parameters screen one may enter the calibration screen in which the calibration of the electrodes, cells and probes is done.
Passing to the next screen is executed by pressing the ENTER key. Returning to the previous screen is executed by pressing the ESC key.
The **ENTER** or ⇓ key opens menu in misc. or parameters screen after setting the cursor on the chosen menu and pressing one of the buttons.
The parameters in menu misc. and parameters are changed with ⇐ or ⇒ keys.
Entering the values to the menu by the numerical keyboard.
The user has the possibility of choosing the measurement screen. It may be a numerical screen, which displays results as digits, or graphic which displays the result as graph completed with the actual value of the measured function displayed as digits.
After finished entering of the parameters to the opened menu on the screen of parameters, first pressing of the **ESC** key closes the menu, second pressing causes returning to the measuring screen.
Entering the calibration screen is done from the parameters screen after choosing the position „ Calibration Mode” in menu CALIBRATION. After choosing the calibration mode one should press the **ENTER**. To return to the parameters screen one should press the **ESC** key.
After switching the meter on on the screen for a while the main menu is displayed and than the meter enters the measurement mode in which it was switched off.
The description of the measurements screens is given in the following chapters.
The screens of parameters were described in detail on the page 17 and separately in description of every measurement function
The arrangement of the screens is showed on the following diagram. Detailed description of the individual screens and their operating is placed in the following chapters.

THE DIAGRAM OF THE SCREENS ARRANGEMENT

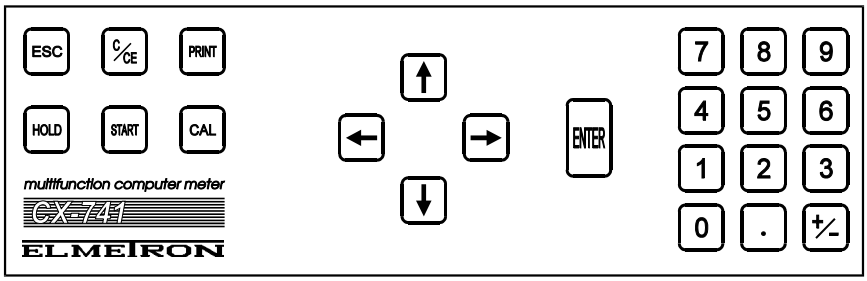


In Italics the names of menu were given

*** - menu O_2 appears only in CX-741 and CX-742**
**** - menu "Series" interchangeably with menu "Titration" or "Multiplex", in "cond" function additionally possibility of changing to "Flow".**

6. USING THE KEYBOARD

The keyboard in all described meters is identical, its view is showed on the picture 1.



Picture. 1

Below we present operations which may be carried out using the keyboard. In the detailed description of the measuring functions all necessary information concerning using the keyboard were given.
To make the work easier in the bottom line of the LCD a short information about the actual functions of keys is displayed.

ENTER

1. Passes to the next screen.
2. Opens the menu on the screen of misc or screens of parameters.
3. Confirms the entered values in the opened screen menu of prefs or measurement screens.
4. Confirms end of the calibration in one of the buffer solutions.
5. Confirms storing of the characteristic after the end of calibration.
6. Ends the titration series.

ESC (**ESC**APE)

1. Returns to the earlier screen.
2. Closes the menu in the parameters, calibration and misc screens.
3. Ends the titration series.
4. Resets the memory and enters the producer settings, by continuous holding during switching the meter on.
5. Closes the screen with the content of registers.
6. Ends the calibration.

KEYS WITH ARROWS

1. ⇐ , ⇒ - chooses the function on the screen with the main menu,
2. ⇐ , ⇒ - chooses the menu in the prefs or parameters screens,
3. ⇐ , ⇒ - changes the parameters in the chosen menu position,
4. ⇐ , ⇒ - chooses place to enter the values of the buffer solutions,
5. ⇐ , ⇒ - changes the cursor by zoom on the graphical measurement screen,
6. ⇐ , ⇒ - moves the cursor between the measurement points on the graphic measuring screen,
7. ⇐ , ⇒ - changes the electrode number in menu calibration,
8. ⇑ , ⇓ - chooses the position in menu,
9. ⇓ - opens menu in prefs or parameters screens,
10. ⇑ - closes menu in prefs or parameters screens,
11. ⇑ , ⇓ - sets the range of zoom on the graphic measurement screen.

NUMERICAL KEYBOARD

This keys are used for entering the values of parameters.

C/CE

1. Deletes the single values of buffer solutions in the place of cursor (single pressing).
2. Deletes everything from the calibration table from the cursor to the end of the table (**double pressing)**.
3. Stops the titration series.
4. Stops „freezing" of the result on the screen by the **HOLD** button.
5. Eliminates the voltage measurement with relation to reference voltage V_{ref}.
6. Deletes V_{ref} by voltage measurement.
7. Resignation from storing the electrode characteristics.
8. Deletes the contents of the register

PRINT

1. Printout of the current value of the measurement on the printer.
2. Printout of the electrode characteristic.

HOLD

1. Freezes the value on the screen, a **„hold"** sign is displayed (**C/CE** key releases).
2. Freezes the measurement for one portion in manual titration.
3. Ends automatic titration.

START

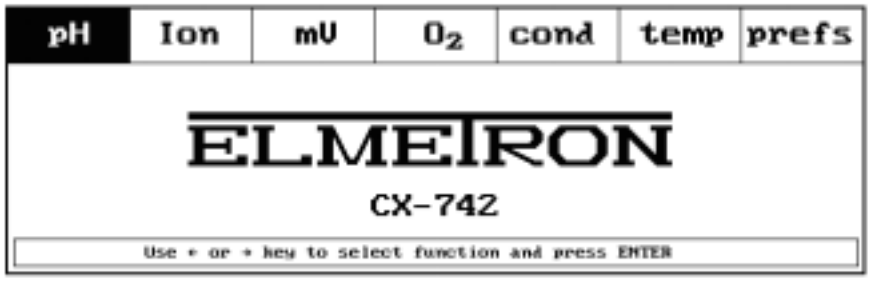
1. Starts the measurement series according to the earlier programmed data.
2. Stores the measurement result during taking the measurements manually.
3. Starts calibration on next buffer solution.
4. Starts titration.

CAL

1. Confirms end of entering the buffer solution values during calibration.
2. Confirms magnifying of the earlier chosen part of graphic screen.
3. Command of taking the V_{ref} into consideration on the measuring screen of mV.
4. Enters the V_{ref} during the voltage measurement.

7. THE SCREEN WITH THE MAIN MENU

The screen with the main menu is displayed on the picture 2.



Picture. 2

This screen has a menu which enables entering to measurement screen of the individual function or to the prefs. screen.

One may chose one of the given measuring screens:
pH-meter - **pH** symbol
ion meter - **Ion** symbol
mV meter - **mV** symbol
oxygen meter - **O_2** symbol
conductivity meter - **cond** symbol
thermometer - **temp** symbol
or
pref. screen - **prefs.** symbol

Notice: position **O_2** occurs only in the CX-741 and CX-742 meters.

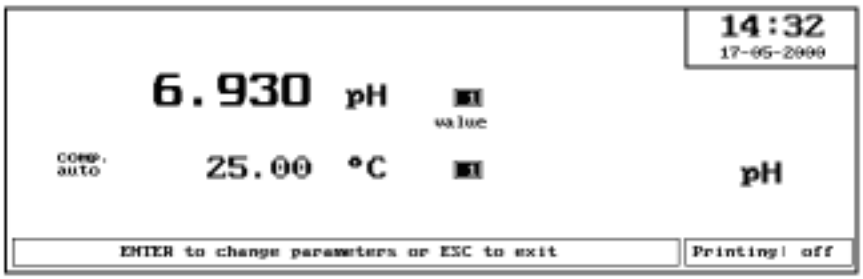
With keys ⇐ or ⇒ set the cursor on the chosen symbol and confirm with the **ENTER** key. In the **prefs** screen one may enter parameters which are common for all measuring functions.
In the bottom line of the display a short info about using the screen with the main menu is displayed.

8. THE NUMERICAL AND GRAPHIC MEASURING SCREENS

The meter has two measuring screens – graphic and numerical.
The numerical screens display the results as digits, graphic as graphs. The numerical screens display all essential information about the measurement and the entered parameters. The graphic screens don't display some information. In all function the size and arrangement of the information is identical.

8.1. The numerical measuring screens

The numerical screen is showed on the picture 3. (example of pH meter).



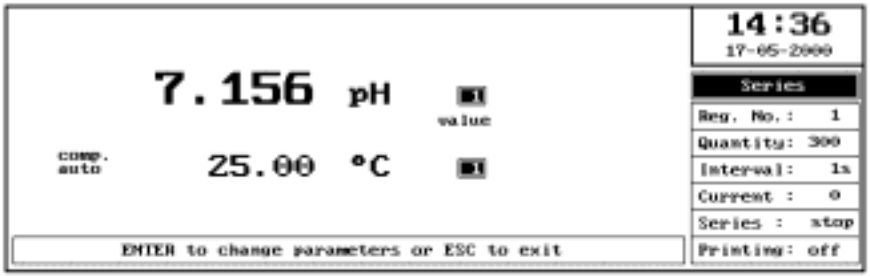
Picture. 3

The measurement result is displayed on the left side of the display. By the result a symbol of the unit is displayed, it may be determined for most of the measuring functions in the menu **Measurement**.
The temperature measurement results displayed below the result of the chosen function. By the result a symbol of the used unit is displayed (^{O} C, ^{O} F or K). The unit may be changed in menu **Measurement** on the screen of parameters in the temperature measurement function. For example here we give way of proceeding starting from the main menu.
The cursors wee described with arrows, menu names with small letters in quotation marks, names of keys with big letters and the chosen position in the menu in italics.

⇒, "temp", ENTER, ENTER, "Measure", ENTER, "*Unit*" , ⇐ or ⇒ ESC, ESC.

There is possibility to remove the displayed temperature value from the measurement screen, by setting the parameters in function **prefs.** menu **Misc**.
Information about the used kind of temperature compensation (automatic or manual) is displayed in the left bottom corner of the screen.
Information about the number of the used electrode and the used temperature probe is displayed in brackets near the symbols of units. This number may be displayed in negative (bright number on the dark background) or in positive (dark number on the bright background).

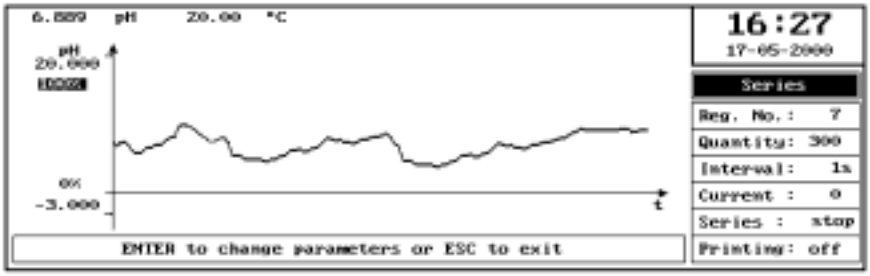
Number of electrode which is displayed in negative informs that the electrode wasn't calibrated and a linear characteristic is provided. Number of electrode which is displayed in bracket not in negative informs that the electrode was calibrated and its characteristic is stored in the memory under this number.
Calibration of the electrode is the condition of accurate measurements.
Work with the not calibrated electrode and using the characteristics introduced by the producer is always connected with additional measurement error. In pH meter, depending on the used electrode the error may be about 0.2 up to 0.5 pH. In ion meter and conductivity meter the error may be so big that that the measurement without the calibration shouldn't be done. Below the electrode number a „measurement" word is displayed. After stabilisation of the reading the word changes to „measurement stabilised". It was assumed that „measurement stabilised" means that samples which are taken about 5 times/second differ one from another not more than ±1 unit displayed in time given in position ***"measurement stabilised" in*** menu **Measurement**. It was assumed that the measurement is no longer stabilised if the following result of sampling has changed from the stabilised one more than ±1 unit.
Because the time of stabilisation practically depends on the electrode, in the parameters screens of all measuring functions in menu **Measurement** position „stabilised measurement" was placed. This position enables entering other time period than it was set by the producer for the individual measuring functions. The times given by the producer are described in description of every measuring function.
During the Ion measurements above the electrode symbol a chosen for measurement ion symbol is displayed.
In the right upper corner there is a date and time displayed. Below the clock there is a symbol of the measured function displayed. In case of activating the measurement series or choosing a titration in place of the symbol an information table is displayed.
If in menu **Measurement,** in position „Function" a „series" was chosen, it will be table which informs about the parameters of the programmed series (pic. 4). Description of measurement series programming and description of info given in the table is given in the chapter „Taking the measuring series, interpretation and transfer of results". If in menu **Measurement** in position „Function" a „titration" was chosen a table, necessary to enter required during titration data, will be displayed. Description of titration and data displayed in the table is given in the „Titration" chapter.
During work with the automatic electrode switch APE-1, in menu **Measurement** position „function" a „multiplex." should be chosen, and in menu **Multiplex.** which will be displayed in the place of the menu **Series** number of electrodes connected with the switch should be chosen. After returning to the measuring screen it will be divided into number of small screens equal to number of electrodes chosen in the menu **Multiplex.** The description is given in the chapter „multiplexing of the electrodes".
In lower left corner of the screen a bracket with word „Print" is displayed and close to it „yes" or „no" depending on the programming. This informs weather the meter will print on the printer value of every stabilised result.
Description of this function is given in the chapter „Printouts".
In the bottom line of the display short info and comments are displayed, which make using the meter easier.



Pic. 4

8.2. The graphic measuring screens

The graphic measuring screen is showed on the picture 5 (example of pH screen). On the screen the result of continuos measurement is displayed as the graph. On the vertical axis the value of the measured function is displayed and on the horizontal time.

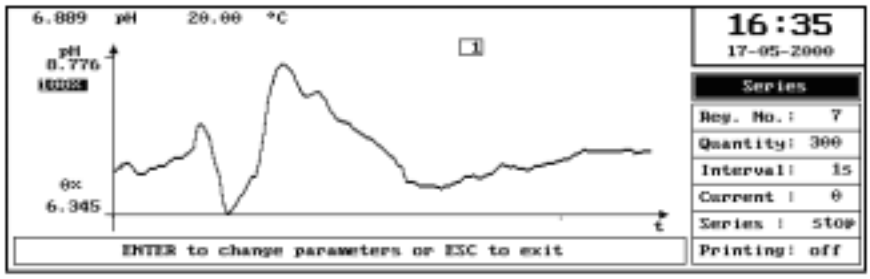


Pic. 5

After about one minute the curve of the result fills the whole screen. After this time the curve moves left, about what a marker moving on the vertical line informs.
In the upper left corner of the screen the value of the current measurement. By the measurement result information about actual temperature value is displayed (if it is not a basic measurement function). On the vertical axis full range of the measurement used for this function is showed. Kind of the unit displayed near this axis is identical with the one chosen by the user.

8.2.1. Zoom Function

On the left side of the graph brackets with the value of minimum and maximum in percents for the actual graph are displayed: 100% from top, 0% from bottom. There is possibility of magnifying part of the graph, by narrowing the range on the vertical axis (zoom function). It is based on changing the minimum and maximum value made with cursor buttons. The choice of the changed value of the range (minimum or maximum) with vertical cursor buttons.
The ⇐ button enables choosing lower and ⇒ button upper range.
Value which may be changed is marked with frame displayed in negative. Depending on the pressed button (left ⇐ or ⇒ right), negative frame will be displayed on the lower or higher value.
Range changes are done with ⇓, ⇑buttons.
Controlling of the range changes is possible thanks moving mark on the vertical axis. In the frame on the left side of the vertical axis a value of change in % is displayed. The scale is changed after pressing the **CAL** button. This activity may be repeated on newly created axis.
After bringing the cursor beyond the limit value (max. or min.), in the place of % value a ⇓ or ⇑.sign is displayed. After pressing the **CAL** button the full range from the side of arrow is displayed. For pH function sign ⇑ returns to value 20.000 pH, and sign ⇓ returns to -3.000 pH value.
Magnifying of the graph is limited only by the resolution of the meter and not of the screen. By large zoom the graph may look like not connected lines (steps). Vertical breaks between the lines correspond with the resolution of the meter for the measured value.
Entering the screen with main menu, parameters screen, other function or Prefs. Screen doesn't change the scale changes.
On the pic. 6 the graph after using the zoom function is showed.



Pic. 6

9. THE PARAMETERS SCREENS

The parameters screens are placed after the measuring screens. They may be entered from every „measuring screen" after pressing the **ENTER** button.
The parameter screen includes menu:

Measure
Calibration
Alarm

and variables:

Series, Titration, Multiplexing or **Flow.**

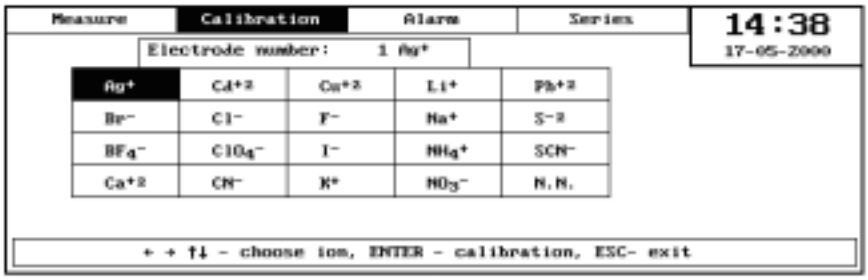
Contents of the menu **Measure and Calibration** depends on the kind of chosen measuring function.
In the menu **Measure** basic parameters connected with the measurements are being set, this are: unit, resolution, way of temperature compensation, kind of measuring screen (numerical or graphic), criterion of the "stable value", and changes of the additional features. In the **Calibration** menu the parameters connected with the electrodes or probes calibration are entered and the calibration mode is entered. In every **Measure** menu there is a position ***"Function"***, which enables, with use of the ⇐ or ⇒ buttons changing the menu **Series** to **Titration** or **Multiplex.**.
In the conductivity meter there is also possibility of choosing the **Flow** function.
The description of the menu, actions during calibration and setting the alarm function is given in chapters "Calibration", page 17 and "Alarm, relays", page 35.
Menu **Series** is described in the chapter " Taking the measuring series, interpretation and transfer of results", page 25.
Menu **Titration** and **Multiplex.** Are described in chapters "Titration" page 37 and "Multiplexing of the electrodes" page 41.
Menu **Flow was described in chapter** "Conductivity meter" on page 67.

10. CALIBRATION

The calibration consists in correcting the electrode or probe error and is essential for receiving accurate results of the measurements. This error exists even in new electrode. During exploitation the efficiency of the electrode is decreasing. For both this reasons it is essential to make the calibration, which is being done with use of buffer or sample solutions. The calibration results are stored in the meter's memory, it is possible to store 10 characteristics of the electrodes for each measuring function (except mV). Those characteristics are stored in non-volatile memory (EEPROM). Each characteristic is stored under separate "electrode number", which responds to specific electrode and during the measurement with this electrode it's number has to be entered in the **Calibration** menu. The meter enables 8 point calibration, what makes exact analysis of the electrode characteristic, in the whole range or it's part, possible. The measurements with lower accuracy requirements doesn't require calibration in all points. In pH meter and ion meter at least 2 point calibration is required. Measurements of the values on the and of measuring range require multipoint calibration with use of sample solutions close to the forecasted values of measurements.

It is important to pay attention to use the proper buffer solutions. It is not advised to use solutions which differ one from another only for about 0,1 pH, especially if they are introduced as the two last solutions. Minimal mistake during calibration with this buffer solutions (or indeterminate change of the value because of the influence of some factors ex. atmospheric ones) may falsify the result and cause bending of the calibration curve on its end what may introduce a great error or make the measurement completely impossible.
The calibration is done after entering the parameters screen of the chosen function, and choosing in the menu **Calibration** kind of the calibration. The meter enables automatic, semiautomatic and manual calibration.
During the automatic calibration the results are introduced automatically. The moment of stabilisation of the result is chosen by the meter according to the value set by the user as the stabilised result. Next the cursor moves it self to the next blank space and on the lower part of the LCD an info „Insert the electrode to the buffer solution (the value of the buffer solution is given) and press **START**".
During the semiautomatic calibration the result is stored in the meters memory after pressing the **ENTER** key. The cursor moves than to the next blank space. In the semiautomatic calibration mode gives the user the possibility to observe the result and chose the moment of stabilisation which he considers as sufficient**. Such a calibration may take longer time than automatic calibration, but it ensures higher accuracy. This kind of calibration is the safest one, because wrongly chosen time of stabilisation of the result doesn't influence the result.**
During the calibration of the ion-selective electrodes an additional screen is displayed which enables entering the symbol of measured ion (pic. 7). The accurate description is placed in chapter „Ion meter" on page 51.
In the conductivity meter the calibration is connected with the parameters of the conductivity cell, which are determined by the active area of the electrodes and the distance between them. This dependence is called „constant K". When one knows its value for the concrete electrode one may done the one point calibration without the buffer solutions. This action is described in the chapter „Screen of the conductivity meter parameters" on page 70.
One may also make a one point calibration of the cell using the buffer solution, what will enable to determine its constant K.
Constant K depends to some degree from the conductivity of the examined solution and changes along with the conductivity changes, that's why after long using of the cell or high accuracy required it is advisable to calibrate the cell using a buffer solution which value is close to the values which will be measured. 8 point calibration of the conductivity cell is possible. Such a calibration may be used to define constant K of the cell when high accuracy of measurements in different solutions is required. During this measurements the constant K will be changed automatically, depending on the measured solution. Multipoint calibration may be also used to correct results of measurements during which a poor quality electrode with non-linear characteristic is used, or the measurement is done on the end of measuring range of the electrode where the characteristics looses it's linearity.

During calibration with use of sample solutions, when introducing their value in µS/cm, mS/cm or S/cm, to the table, it is necessary to first of all **with the +/-button enter the symbol corresponding with the conductivity range and than the value.** Opposite sequence makes storing impossible. **After the calibration it is necessary to mark the electrode with the number under which it was calibrated.**



Pic. 7

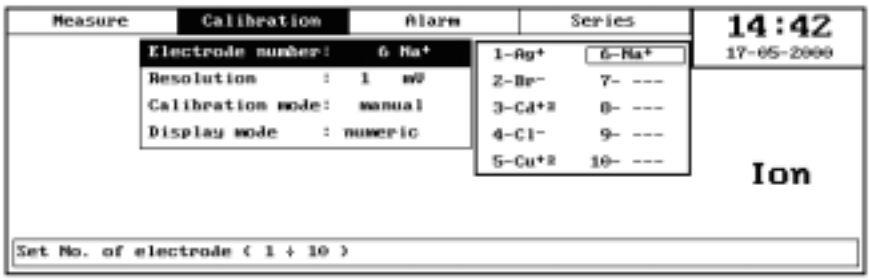
10.1. Preparation for multipoint calibration

Choose the measuring function, enter the parameters screen, choose the **Calibration** menu (pic. 8) and enter the following parameters:

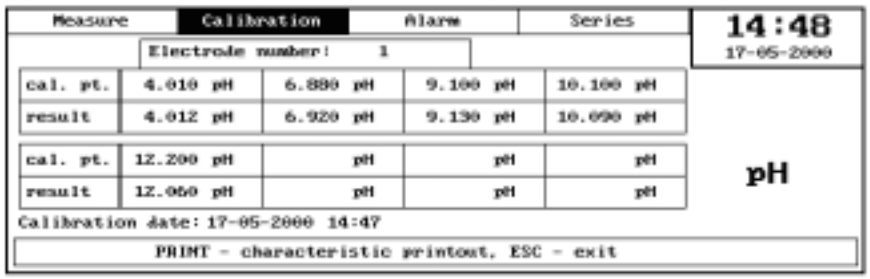
"electrode number" - with 0 ÷ 9 or ⇐ , ⇒ buttons enter the number of the electrode (0 ÷ 10). If the number is not displayed as negative, entering the new characteristic is connected with deleting the previous calibration data;

"Calibration mode" - *"auto"* (automatic), the meter automatically finishes the calibration in one solution and commands placing the electrode in the next sample solution. End of the measurement occurs when conditions set as „stable value" appear or after pressing the **ENTER** button.
"semiauto", the user decides about finishing the calibration in the given sample solution by pressing the **ENTER** button.
"manual", the user enters with the keyboard values of the sample solutions and calibration results on the basis of earlier noted calibration data of the chosen electrode. One enters the calibration screen after entering the **Calibration** menu, choosing the „calibration mode" and confirming it with the **ENTER** button.

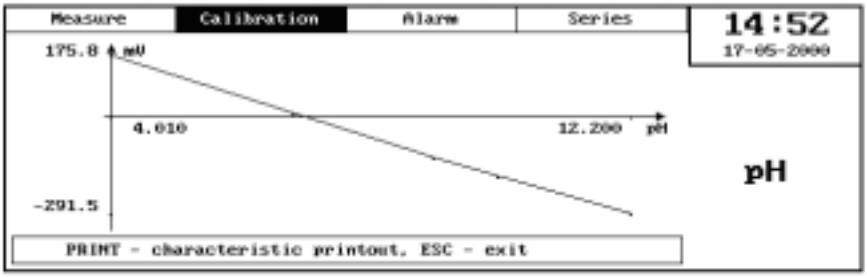
"Display mode" - *"numeric"* or *"graphic"*. This position enables displaying the earlier stored characteristics of the electrodes in numerical form (pic. 9) or in graph form (pic. 10). Changing those values is impossible.



Pic. 8



Pic. 9



Pic. 10

The Characteristic of the electrode may be printed in table or graph form. To do so in the **Calibration** menu in position ***"Readout mode"*** choose ***"numeric"*** or ***"graphic"*** and press the **PRINT** button. On the lower information strap a sign will be displayed:

"PRINTING WAIT FOR COMPLETE !"

The printout may be stopped by switching the printer off or resetting it.

Menu **Calibration** differs in different measuring functions. Details are described in the description of individual measuring functions.

10.2. The calibration screen

The calibration screen includes a table which is being filled during the calibration. This table includes 2 lines with spaces which enable calibration in maximally 8 points. In the upper row ("cal. point") with the keys the value of the sample solution is introduced. In the lower row ("result") the results of the measurement in this points are displayed. **Not calibrated electrode introduces large error to the measurement, so the results displayed in the table will differ from the values of sample solutions. During measurements with calibrated electrode those differences will be corrected by the meter.** The values of sample solutions may be introduced in freely chosen order. After introducing all required values and confirming it with the **CAL** button, the meter will automatically put them in the right order. In the conductivity meter during the calibration on sample solutions in the lower row the value of constant K of the cell will be displayed, it may change a bit depending on the sample conductivity.
In the ion meter during measurement in M/l or mg/l in the lower row the values in mV are given with conversion to 20 ^{0}C. This are values not directly connected with the real value of the sample solution.
During the manual calibration all values are introduced by the user. This way of calibration enables to introduce the known characteristic of the electrode which is not stored in the memory. The introduced values are known from the earlier made calibration. Each introduced value has to be confirmed by pressing the **ENTER** button.

10.3. The automatic calibration

For the function which has the possibility of measurement in few different units in menu **Measure** we are choosing the unit in which we are going to make the calibration. In ion meter it may be **pX**, **M/l** or **g/l**, in conductivity meter **mS/cm** or **ppm**, in thermometer **^{0}C**, **^{0}F** or **K**.
In pH meter and mV meter there is no possibility of changing the unit.
In menu **Calibration** we introduce:

"Electrode number" - choose (1÷10) with ⇐ , ⇒ buttons or numerical keys;
"Calibration mode" - *"auto"*, confirm with **ENTER** button.

The calibration screen is displayed. Depending on the unit in which the values of sample solution were given, before introducing the sample solutions values to the table on this screen it is necessary to enter the unit multiplication value, ex. in the ion meter after choosing the g/l unit in menu **Measure**, in the calibration screen one may change it to mg/l or µg/l by pressing the **+/-** buttons, and next enter the sample solution value.

The cursor may be moved with **⇐, ⇒** buttons. During entering each introduced value has to be confirmed with **ENTER** button. One pressing of the **C/CE** button removes the incorrectly introduced value, double pressing causes removing the whole line on the right side of the cursor. If the cursor is in the upper row of the table, values from all table are deleted, if the cursor is in lower row only the lower row is deleted. After deleting the whole table and pressing the **ESC** button a window is displayed with question "Will characteristic be stored? **C/CE** - no **ENTER** - yes". Confirmation with **ENTER** button causes storing the linear characteristic not connected with any electrode.

End of introducing the values of sample solutions should be confirmed with **CAL**, than the entered values will be ordered (from the lowest to highest value) and the cursor will be moved to the first place in the „result" row. On the information stripe command of immersing the electrode in the sample solution with value displayed in the first column. After immersing the electrode and temperature probe in the first sample solution press the **START** button**. First position in the „result" row is filled automatically by the meter**. After stabilisation of the result the cursor is automatically moved to the next column, under the next sample solution value. On the information strap a command about immersing the meter in the next sample solution is displayed. After rinsing the electrode with distilled water and placing it in the next solution one should start the next measurement by pressing the **START** button, in the next sample solutions act as described above. The calibration may be finished by leaving the calibration mode by pressing the **ESC** button. A window is displayed:

Will characteristic be stored ? C/CE - no ENTER – yes

Pressing the **ENTER** stores the electrode characteristic in the meter's memory.

10.4. The semiautomatic calibration

Choose the unit according to point 10.3.
In menu **Calibration** set:

"Electrode number" - *"1" ÷ "10"* with ⇐ , ⇒ buttons or numerical keys;
"Calibration" - *"semiauto"*, confirm with **ENTER** button.

The calibration screen is displayed.
The semiautomatic calibration is being made in similar way as the automatic one, the difference is only in the way of finishing the measurement. The result is being stored after pressing the **ENTER** button by the user. Than the cursor automatically moves under the next value of sample solution.

10.5. The manual calibration

Manual calibration is based on the entering the known values from earlier made calibration with use of numerical buttons. To enter the characteristic one should in the **Calibration** menu on the parameters screen choose:

"Electrode number" - *"1" ÷ "10"* with ⇐ , ⇒ buttons or numerical keys;
"Calibration" - *"manual"*, confirm with **ENTER** button.

The calibration screen is opened.
After entering the first sample solution and confirming it with the **ENTER** button the cursor goes under the entered value to enable introducing the result of measurement in this solution. In this way the whole table may be filled.

11. OPTIONS

The options screen may be entered from the screen with main menu. In the **Options** screen commands and parameters common for all functions.
The **Options** screen menu:

- **Results**
- **Misc** (Miscellaneous)
- **Clock**
- **File**

Menu **Results** is described in the chapter "Taking series of measurements, interpretation and transfer of the results" page 25. Below the rest of menus is described.

11.1. Menu Misc. (Miscellaneous)

Menu **Misc.** (pic. 11) enables for setting following parameters:

"Hardcopy" - *"vertical"* or *"horizontal"*, choosing the way of printing the results of measurement's series in graphic form.

"Temperature" - *"display"* or *"no display."*, displaying or not displaying the temperature measurement results in all functions (except temp.);

"Language" - *"Polish"* or *"English"*, choosing the language in which all menus and information will be displayed;

"Stable res."- *"yes" or "no"*
"yes" – printing of every stabilised result.
"no" – function blocked.

"Contrast"

- filling of the bracket informs about the contrast level, changing with ⇐ ⇒ buttons.

"Parameters transmission " - description in the "Parameters transmission" chapter.

Pic. 11

11.2. Menu Clock

Menu **Clock** enables setting following parameters:

"Hour"
"Minute"
"Day"
"Month"
"Year"

The values are entered with numerical keys and confirmed with **ENTER** button.

11.3. Menu *Info*

Basic information about the measuring functions of the meter, technical data and company address. Scrolling the text with ⇑ ⇓ buttons.

12. TAKING SERIES OF MEASUREMENTS, INTERPRETATION AND TRANSFER OF THE RESULTS

The meter enables taking series of measurements with chosen number of measurements. (up to 499 in automatic series and 249 in manual series). The series are stored in registers. The meter has 10 registers. Before starting taking the series one has to introduce the parameters in the **Series** menu. Looking through the collected series, transferring the results to the PC or printer is supervised from the **Results** menu chosen in the Prefs. (preferences) screen.

12.1. Menu *Series*

Menu **Series** is available in each parameters screen of chosen measuring function. It is displayed interchangeably with menu **Titration** or **Multiplex.** It depends on the settings in menu **Measure** position ***Function***.
In menu **Series** (pic. 12) one may set following parameters:

"Series" - *"yes"* or *"no"*, changing with ⇐ ⇒ buttons.
"yes" activates table "Series" on the chosen measurement screen and enables starting taking series by pressing the **START** button.
"no" disactivates a series table from the measurement screen.

"Register" - number of register (1 ÷ 10), to which the series will be taken. New window with information about the registers is displayed.

"Acquisition" - *"auto"* taking series of measurements with set time interval,
"manual" taking series of measurements with different time periods. The result is stored after pressing the **START** button (max. 249 results). **After choosing the "manual" mode from the menu the positions "no. of samples" and "Interval" disappear.**

"No. of samples" - number of measurements in the series (1 ÷ 499).

"Interval" - time of breaks between storing the results (1 ÷ 999 sec).

The number values should be introduced with numerical keyboard (0 ÷ 9), and confirm them with **ENTER** button.

Pic. 12

12.2. Programming of the measuring series

To program the measuring series one has to enter the parameters screen of the chosen measuring function and next:

- if the last menu is different than **Series** open the menu **Measure** and in position Function set “Series”.
- close the **Measure** menu and open the **Series** menu (pic. 12).
- in the **Series** menu in the individual positions choose:

"Series"	- *"yes"* with ⇐ ⇒ buttons;
"Register"	- choose the register in which the results of measuring series will be taken (1 ÷ 10);
"Acquisition"	- if taking series of measurements with chosen time interval set *"auto"*. If taking series in which the results are stored manually with different time periods set *"manual"*. In that case the result is stored after each pressing of the **START** button.
"No. of measurements"	- enter the awaited number of results (1 ÷ 499) set it with use of numerical keyboard and confirm it with **ENTER** button;
"Interval"	- with numerical keyboard enter the time interval between the measurements (1 ÷ 999 s) and confirm it with **ENTER** button.

Taking the series of measurements is started by pressing the START button.
In the information window with “Series” sign the "stop" sign is replaced with “work” sign, simultaneously the current measurement number is displayed. After finishing the series a “end” sign is displayed. Starting and finishing of the series is signalised by beep sound.
The series may be stopped with the C/CE or **ENTER** buttons. In this case the number of measurements made till that moment will be stored. Continuing the stopped series is impossible. To start the programmed series from the beginning one should press the START button twice. In case of collecting the series in manual mode the result is stored after each pressing of the **START** button. In that mode it is possible to collect up to 249 results.
After finishing or stopping the series and switching the meter off results of all series are stored in the memory. All this data may be lost if the battery which ensures the data storage will be discharged.

12.3. The results of the series

The results stored in the registers may be reviewed on the screen of the meter in graphic (chart) or numerical form, print it on the printer, transfer it to the PC by the RS-232 in text or numerical form (for further work in Excel). It is also possible to compare two series of measurements on the graphic screen. During reviewing or printing of the series results in graphic form the chart is automatically calibrated to the minimal and maximal value from the series of results. There is also possibility of choosing the horizontal or vertical position of the graph on the printout. In case of using the „Transmission of the parameters" there is possibility of sending all stored data or only the chosen measurement's series (description below in „Transmission of the parameters chapter").

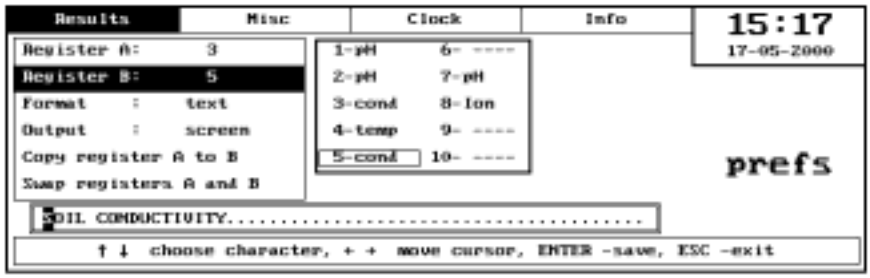
12.3.1. Menu Results

The way of getting to the **Results** menu is showed below.

Main Menu; ⇒; **Prefs. ENTER**; ⇐ ⇒; **Results**; **ENTER**

Menu **Results** enables to choose the way of interpretation of the results of measuring series stored in the registers.

Pic. 13 shows the opened **Results** menu.



Pic. 13

Menu **Results** has following positions:

"Register A" - entering the register number with numeric or ⇐ , ⇒keys;
"***Register B"*** - entering the register number with numeric or ⇐ , ⇒keys;
"***Format"*** - "*text","numeric", "graphic"*, „file" changing with ⇐ , ⇒ buttons*;*
"O***utput"*** - "screen*", "printer", "RS-232"*, changing with ⇐ , ⇒ buttons;
"Copy register ***A to B"***
"Swap ***register A and B"***

The number of the register is chosen with ⇐ , ⇒ buttons or entered with numerical keyboard and confirmed with **ENTER**. The results collected in registers additionally may be worked with, add short description, change the order or copy them from one to another register. During setting the cursor on the position ***"Register A"*** or ***"Register B"*** a chart with contents of the individual registers is displayed. In the position ***"Format"*** one has to choose the way of displaying the data stored in the register. The *"text"* form enables to display the results as numbers with time, date and short description. The *"numeric"* form enables displaying the results as numbers without text. This form enables importing this data to the Excel or other programs. The *"graphic"* form enables to display the results as charts. If the results of the series are to be observed on the meter's display in the position ***"Output"*** one should choose *"screen"*. On the screen one may look through in text and numeric form only through the results in one register introduced in the position ***"Register A"***. In that case there is no difference what is in the position ***"Register B"***. In the graphic form one may see simultaneously maximally 2 registers entered in positions ***"Register A"*** and ***"Register B"***. If the results are to be printed in the position ***"Output"*** one should choose *"printer"*. If the user wants to print a sequence of consecutive registers in positions ***"Register A"*** and ***"Register B"*** he should enter the numbers from which he wants to start and on which he wants to finish. (from – to). If the results are to be sent to a PC in position ***"Output"*** **chose** *"RS-232"***.**

Every register may have short comment. To place it one should choose the position ***"Register A"*** and enter the number of register to which we are going to add the description or comment. In the lower part of the screen a window with place for the text will be displayed. Press the **CAL** button in the lower part of the screen an information about the way of introducing the text will be displayed. With ⇐ ⇒ buttons choose the position in which we are going to place the letter and with ⇑ ⇓ buttons choose the letters or numbers. One may enter up to 126 symbols which will be displayed next to the heading as 3 rows of text Pressing the **ENTER** finishes entering of the text.

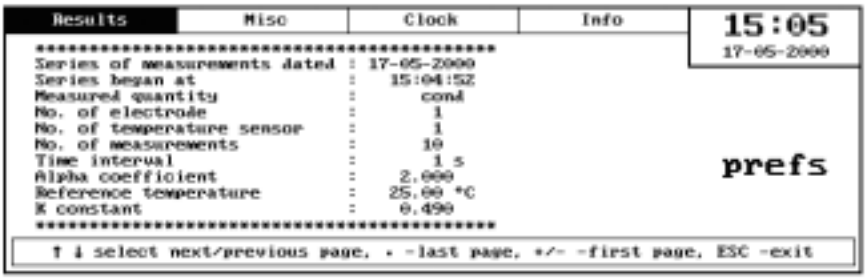
There is also possibility to change the order of the registers with use of the 2 last positions of the menu.

12.3.2. Observing the results on the screen in text form.

The text form enables to observe the results of series with the heading and comment, time and date. If some comment was added it will be displayed under the heading.
To observe the results one should:

- enter the **Prefs** screen.
- choose the **Results** menu.
- in position ***"Register A"*** enter the number of the register in which the data were stored and confirm it with ENTER.
- in position ***"Format"*** choose the *"text"*.
- in position ***"Output"*** set *"screen"* and press the **ENTER** button.

Under the heading the results of the chosen series will be displayed in order: number of the measurement, time, value of the measurement and temperature value. With buttons ⇑⇓ one may move the results up or down. This way the whole series may be observed.
Pic. 14 shows the screen with heading which is displayed above the results.



Pic. 14

There is possibility to delete initial and final results in series. In the automatically taken series after displaying the results in numeric form with ⇐ ⇒ buttons choose the number which will be a limit by removing. It is possible to remove all results **to** or **from** this number. After choosing the number press the **C/CE** button a window with question will be displayed:

Clear results number?
C/CE - to [.**n**.] ENTER - from [.**n**.]

Where **n** is the number of the measurement on which the cursor was set.
Depending on the chosen button **all results from the beginning of the series to the cursor or from cursor till the end of the series will be removed.** In manually taken series it is possible to delete single measurement on which is the cursor by pressing the **C/CE** button. Cutting out a freely chosen part of the series taken manually is possible only in the graphic format.

12.3.3. Observing the results on the screen in graphic format.

The graphic form enables observing the results of series in graph form. It is also possible to observe and compare 2 graphs simultaneously.
To observe the results in graph form one should:

- enter the menu **Prefs** and choose the menu **Results**.
- in position ***"Register A"*** enter the number of the register with series which we are interested in.
- if we would like to compare two graphs in position ***"Register B"*** enter the number with second series, if not enter 0.
- in position ***"Format"*** choose *"graphic"*.
- in position ***"Output"*** choose *"screen"* and press the **ENTER** button.

The graph of the chosen one or two series is displayed (pic. 15). On the vertical axis the values of the measured function are placed, on the horizontal axis the number of measurements in the chosen series is displayed. The scale of the graph responds to the complete range of the observed measuring function.

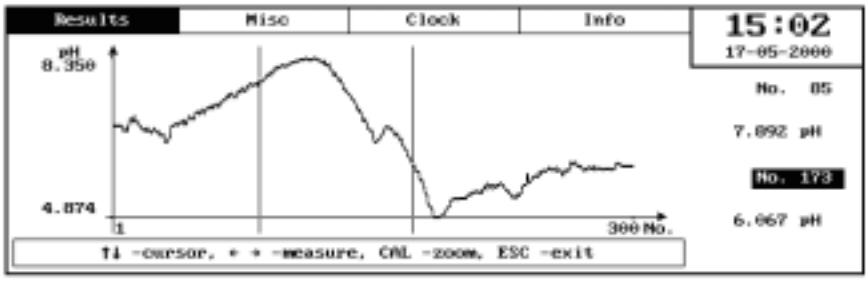
To determine a part of the graph 2 cursors are used (vertical lines taken from the vertical axis on the left side of the screen). On the beginning both cursors cover each other. The active one is chosen with ⇑ ⇓buttons, and moved with ⇐ ⇒buttons. Positions of the cursors are described in two windows on the right side of the graph. The window of the active cursor is displayed as negative. Below the window with the cursor position (number of the measurement) the result of the measurement in this place is displayed. By moving the cursor on the graph one may read the results of measurements. The cursor may be set on the freely chosen result by entering the number of the result to the active cursor window with help of numeric keyboard. After confirming it with **ENTER** the cursor will move to the chosen number and in the window the result of this measurement will be displayed. Entering number bigger than number of measurements in series is signalised by sound. To choose the part of the graph place both cursors in the chosen points and press the **CAL** button. The new graph shows the chosen part and is automatically calibrated. The vertical range of the scale corresponds with the minimal and maximal value of the observed series or chosen segment. After this change the cursor may be moved only with ⇐ ⇒ buttons. Moving the cursor in front of the first or behind the last result enables returning to the graph with all results, to this side where the cursor was moved beyond the graph. Instead of the number of the measurement a ⇐ or ⇒ symbol is displayed. Pressing the **CAL** button changes the scale of the graph. In the graphic form it is also possible to remove chosen results from the series. In the automatically taken series one may delete the results only **from the first one to the chosen** number. After displaying the results in graphic form one has to set the cursor on the number of the measurement to which the results will be deleted and press the **C/CE**, a window will be displayed:

Clear results 1 - [**n**]
C/CE - yes ESC - no

where **n** is the number of the measurement on which the cursor was set.
In the manually taken series of measurements it is possible to delete part of the series which is chosen between the cursors. After displaying the results in graphic form one has to set the cursors on the numbers of the measurements choosing a fragment which will be deleted and press the **C/CE**, a window will be displayed

Clear results from [**n1**] to [**n2**]
C/CE - yes ESC - no

where: **n1**, **n2** – numbers between which the results will be deleted.



Pic. 15

12.3.4. Printing the series of measurements gathered in the register

There is possibility of printing the series of measurements in numeric and graphic form. The correct printouts may be achieved by connecting a printer which works in EPSON standard. There is possibility of connecting the printer by Centronics or RS-232 output.

A. Printouts by *Centronics.*

Connect the printer to the Centronics output on the right side of the meter, switch the meter and printer on, enter the **Prefs** screen and than to **Results** menu and introduce:

"Register A" - enter the number of the chosen register and confirm with **ENTER**;
"Register B" - enter this same number to the second register ex.:
"Register A: 2"
"Register B: 2"
"Output" - *"printer"* and confirm with **ENTER**.

If there will be a necessity of printing the data from few registers, to the ***"Register A"*** enter the first chosen series with smaller number of the register and to the ***"Register B"*** last chosen series with greater number of the register. Ex. to print series from 3 to 7 one should enter following data:

"Register A: 3"
"Register B: 7"

Caution: the number of the register B can't be smaller then the number of the register A. In other case the transmission to the printer won't be realised.

There is also possibility of printing only part of the series in graphic form. To do so in the menu **Results** choose the ***"Register A"*** and enter the number of the register, in the position ***"Format"*** choose the *"graphic"*, in position ***"Output"*** choose the *"screen"* and press the **PRINT** button. At this moment an information: "PRINTING WAIT FOR COMPLETE".
Interrupting the printing process is possible only by switching off or resetting the printer.

B. Printing by *RS-232*.

Connect the printer with RS-232 output in the meter, turn the meter and printer on, enter the screen **Prefs** menu **Result** and enter:

"Register A" - enter the number of the chosen register and confirm with **ENTER**;
"Output" - *"RS-232"*;

The parameters of transmission: 9600 bod, 8 data bit, 1 even bit, 2 stop bit.

12.3.5. Transferring the series result to the PC

Connect the PC with the RS-232 output of the meter, turn the meter and PC on, enter the menu **Prefs** menu **Results** and enter:

"Register A" - enter the number of the chosen register and confirm it with **ENTER**;
"Output" - *"RS-232"*.

Next with DOS command: **mode COMn:9600,e,8,1** set the transmission parameters;
Enter the command **copy COMn "name of the file"** (where n = 1 ÷ 4), press ENTER on the PC and ENTER in the meter;
After finishing the transmission press the **CTRL Z** in the PC what will cause closing the file on the disc.

13. TRANSMISSION OF THE PARAMETERS

The cx7xx-pc.exe software enables **transmitting to the PC all actually stored in the meter parameters, like electrodes characteristics, all of the entered parameters in all menus and chosen series of measurements.** There is possibility of modification of this transferred parameters, storing them on the hard disc and transferring them back to the meter**. After this the meter looses the actually set data and stores those send from the PC.** This function may be useful in case of need of storing the data from registers longer than it is enabled by the battery life which support the data storing in the meter. In case of taking greater number (above 10) of the measuring series "Transmission of the parameters" enables transferring those series to the PC, storing them on the disc and taking next series. The file created on the disc includes all data about the contents of the registers in the coded form. For further use in database or in spreadsheet it is necessary to convert it to the ASCII code in the way described below. Each starting of the program loads the configuration file "phcontr.cfg" (first starting of the program creates it automatically). This is a text file which includes 3 lines:

COM1
CMOS
.cms

Its meaning is as follows:

COM1 - information through which RS connector the transmission will be realised,
CMOS - name of the sub file in the current file, where the data will be stored and read from,
.cms - extension added to the name of the file with the data.

Each of this lines may be changed ex. COM1 to COM2, with any of the editors, but the easiest is the NORTON COMMANDER, one can't use any punctuation marks.

To transfer the parameters one should:

- connect the meter with the PC by RS-232 output.
- turn the meter and the PC on and run the cx7xx-pc.exe software.
- **in the meter** enter the **Prefs**, open the menu **Misc.** choose the position *"Transmission of the parameters"* and press the **ENTER**. A window will be displayed with information: "**Wait for connection, ESC-exit"**
- **in the cx7xx-pc.exe software** enter the **Pref., open the** menu **Results** and introduce the numbers of transferred registers. If we want only to transfer the parameters in the position ***"Register B"*** one should enter the 0. The contents of the ***"Register A"*** has no meaning.
- move to the menu **File** and depending on the direction of sending the data choose the right position ***"Transmission to instrument"*** or ***"Transmission from instrument"***. After pressing the **ENTER** button on the screens of the meter and the PC an information will be displayed: "Wait for the connection", and on the screen of the device which is sending the data additionally an information strap, which will be filled together with sending the data.
- after finishing the transmission both devices return to the opened menu (meter to **Misc.** menu and the PC to **File** menu).

In case of occurring some errors in the transmission on both devices an information will be displayed:

Communication breakdown **ESC** – exit

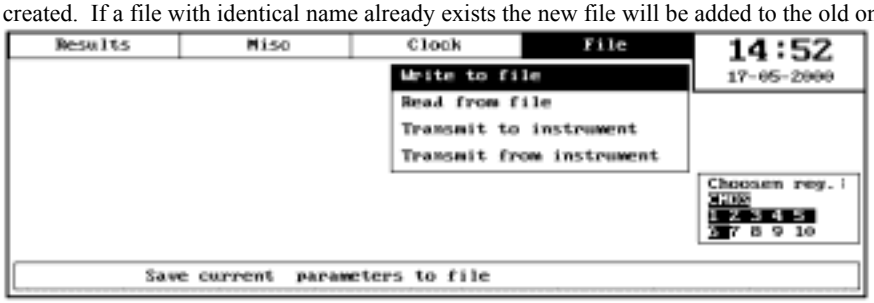
In this case it is necessary to check the connections and compatibility of the numbers RS-232 (COM1, COM2) in the PC and in the file "phcontr.cfg".

After finishing the transmission the parameters and the register's contents may be stored on the disc. To do so on the PC in the menu **Results** enter the numbers of registers which will be stored – do it according to the information given in the chapter "Taking the measuring series, interpretation and transfer of results". If we want only to send the parameters in the position ***"Register B"*** enter the 0. Next in the menu **File** choose the position ***"Write to file"***. The program will open the window with names of earlier stored files (only the files from this catalogue and with extension defined in the file will be displayed). With the cursor one can choose the existing name (a window with confirmation of requirement will be displayed) or one can enter a new name but without extension.! In case of reading the data in the menu **File** one has to open the position ***"read from the file"***.

Similarly as it is done by storing a table with names of already existing files will be displayed in the catalogue and extensions defined in the file "phcontr.cfg". In each of the lines in the table except the name of the file the date of storing and displayed as negative numbers of the registers stored with the parameters (0 corresponds with the register 10).

With cursor we choose the name and confirm it with **ENTER**. After reading the file the software returns to the opened menu **File** (pic. 16).

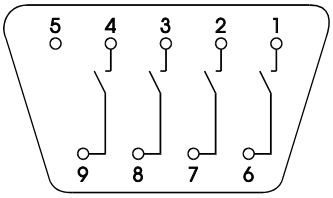
To process the contents of the freely chosen file to the ASCII code one should enter the **Results**, in position ***"Register A"*** enter the number of the processed file, in the position ***"Format"*** choose the *"numeric"* or *"text"* and in position ***"Output"*** choose the *"file and "* press the **ENTER**. A frame with question for the name of the file will be displayed. After signing in the name with the extension and confirming it with the **ENTER** a file on the disc will be created. If a file with identical name already exists the new file will be added to the old one.



Pic. 16

14. ALARM, RELAYS

In every measuring function it is possible to set an alarm for two values minimal and maximal. Menu **Alarm** is on parameters window in al. functions. Activating the alarm for the chosen function displays a frame on the measurement screen with information "Alarm" and symbol of the function. There is also possibility to simultaneously set the alarm for the temperature. Activating the temperature alarm displays in the frame "temp" symbol.
The alarm is signalised by blinking symbols and additionally by breaking sound signal. Together with the alarm the right contacts of the relays are connected.
Parameters of the contacts: max. voltage 100V, current 1A, max. power 10VA.
Chart of the outputs to the connector below.



1, 6 - temp max
2, 7 - temp min
3, 8 - function max
4, 9 - function min
5 – not connected

The menu **Alarm** on the parameters screen is showed on the picture 17.

Pic. 17

The menu **Alarm** includes:

"Alarm"	- *"yes"* or *"no"*, switching the alarm function on or off. Changing with ⇐ ⇒buttons.
"Min"	- minimal value below which the alarm will be activated.
"Max"	- maximal value above which the alarm will be activated.
"Hist"	- hysteresis value
"Sound"	- *"yes"* or *"no"*, during the active alarm a sound is given or only the symbol of the function in which the minimal or maximal value was exceeded. Changing with ⇐ ⇒ buttons.

The values are entered with numeric keys and confirmed with **ENTER**. For function in which the measurement may be done in few units it is determined in menu **Measure** and next it is possible to set the alarm taking into consideration the multiplier of the unit, ex. after choosing in the ion meter a g/l unit the alarm may be set in mg/l or µ g/l. **The multiplier is changed with the +/- button before entering the value**.

14.1. Activating the alarm

To activate the alarm it is necessary:
- enter the parameters screen of the chosen function.
- choose the menu **Alarm**.
- set the parameters in this menu:

"Alarm"	- set *"yes"*
"Minimum"	- with **+/-** button enter the right unit (in ion meter and conductivity meter) and enter the minimal value below which the alarm should be activated;
"Maximum"	- with **+/-** button enter the right unit (in ion meter and conductivity meter) and enter the maximal value above which the alarm should be activated;
"Hysteresis"	- enter the unit (as above) and enter the value of the hysteresis;
"Sound"	- choose *"yes"* for sound signalling.

Caution: the ***Maximum*** value has to be bigger than ***Minimum***. Setting the ***Minimum*** value higher than maximum unable programming, information about this fact is displayed in a window which appears after pressing **ESC** key. In case of simultaneous setting the alarm for the temperature it should be set in the parameters screen of the temperature function in menu **Alarm** in the way described above.

The alarm is switched off after every leaving of the measuring screen of the function for which the alarm was set. After returning to the measuring screen of that function the alarm is automatically activated.

To block the alarm:
- enter the parameters screen;
- choose the **Alarm** menu;
- set ***Alarm*** - *"no"*.

15. TITRATION

The titration process is treated by the meter as specific kind of measuring series. Two kinds of titration are possible: automatic and manual. This kinds are connected with the kind of used burette.
When titrating with manual burette it is assumed that the doses of the added titrant don't have to be identical and each dose after the stabilisation of the result should be entered to the meter's memory.
When titrating with automatic burette it is assumed that there is possibility of adding constant doses of the titrant during the whole process. After finishing the titration the total volume of the added doses is entered to the meter's memory.

Before starting the titration it is necessary:

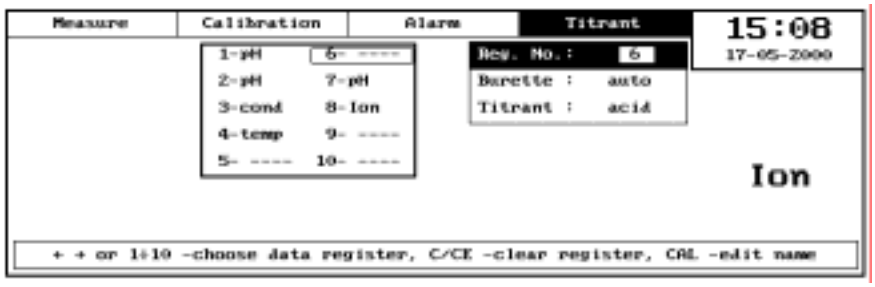
- enter the chosen measuring function screen.
- enter the parameters screen of this function and open the **Measure** menu.
- in position **"Screen"** set - *"graphic"*.
- choose the position "Function" and change "Series" to "Titration".
- close menu **Measure**.
- open menu **Titrant,** which is displayed in the place of menu **Series.** The opened menu is showed on the picture 18.
- set the parameters of menu:

  "Reg. No." - *"1"* ÷ *"10"*, enter with 0 ÷ 9 keys and confirm with **ENTER**.

  "Burette" - *"automatic"* or *"manual"*, with ⇐ ⇒ buttons choose.
  "manual" requires entering of volume of each added dose. *"auto"* the results are stored in constant time intervals: 5s for temperature; 1s for other functions.

  "Titrant" - *"base"* or *"acid"***,** choose with ⇐ ⇒ buttons.

By conductometric or calorimetric titration the choice of the titrant has no meaning.



Pic. 18

15.1. Course of titration

After setting the parameters return to the measuring screen. **It is advised to choose the graphical screen, because it's observing enables easier control of the titration course and makes defining the end of the titration much easier.**

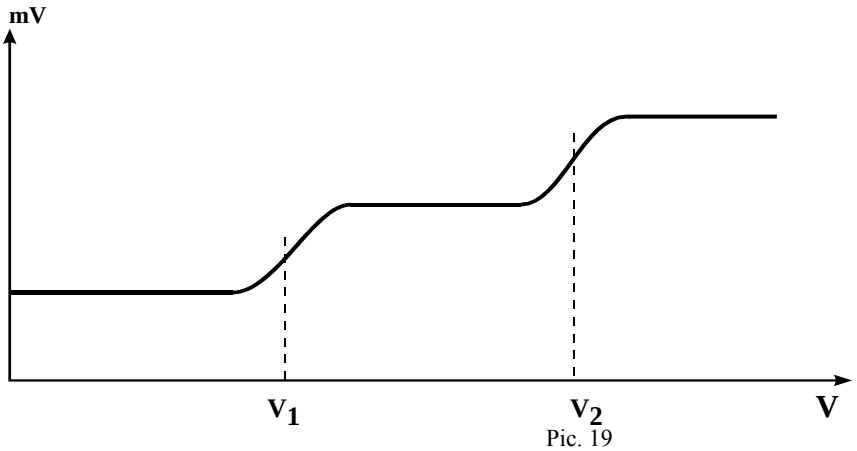
On the right side of the screen there is a table of titration. When titration with manual burette the table includes volume of the added dose and the total volume of the added titrant. By titration with use of manual burette the sequence of action is as follows:

- press the **START** button;
- start dosing the titrant by adding the defined volume;
- store the stabilised result by pressing the **HOLD** button;
- with numeric keys enter to the meter's memory the added volume (in ml) and confirm it with **ENTER** button.

After entering the volume of the dose the meter automatically goes to the next measurement. In the lower space of the table the total volume of the titrant added so fare is displayed. Titration with manual burette may be stopped by pressing the **C/CE**, **ESC** or **ENTER** buttons.

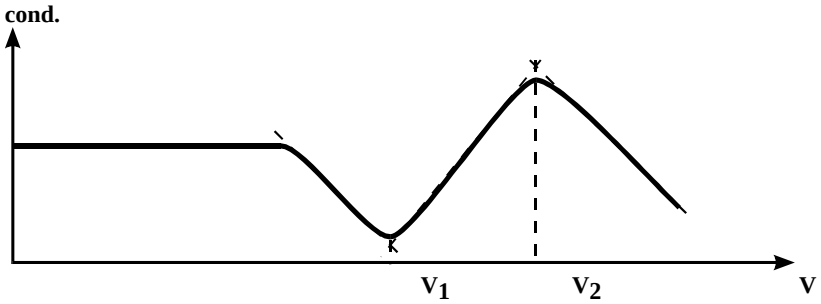
By titration with automatic burette the beginning of the process is similar like this described above. The difference is that the rest of the process is automatic. The measurements are taken regularly every 1s or every 5s by calorimetric titration. The titration, after it's finish, is stopped by pressing the **HOLD** button. After stopping it is necessary to enter the total volume of the added titrant with the numeric keyboard.

Titration with automatic burette, similarly like by titration with manual burette may be paused with **C/CE**, **ESC** or **ENTER** buttons. The difference is that pausing the automatic titration causes loosing the already taken series of measurements and in manual titration only of the last result. By potentiometric titration (screens pH, pX, mV) the values of added titrant volumes, for which the maximum of the derivative of the measured quantity with relation to volume or minimum of the derivative, depending on the chosen titrant. (Pic. 19).



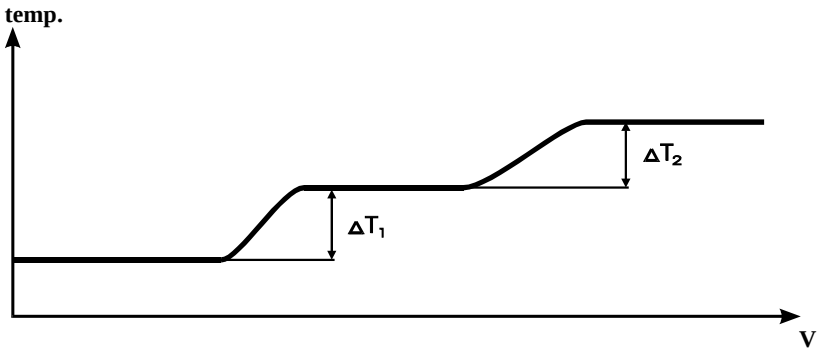
Pic. 19

By conductometric titration the values of volume, for which the change of derivative sign appeared, are determined This are the points of crossing of the straight which approximate the individual segments of the collected series graph (pic. 20).



Pic. 20

For the calorimetric titration, which is based on the measurements of temperature effects of chemical reaction, the temperature changes are determined (pic. 21). The automatic calorimetric titration differs from potentiometric and conductometric one because the whole volume of the titrant is added directly before the whole titration process and in the other two cases the titrant is added evenly during the whole process.



Pic. 21

After finishing the titration it is possible to observe the gathered results in numeric or graphic form, similarly like in normal measuring series. The way of acting is described in the "taking the measuring series, interpretation and transfer of results" chapter on page 25. **The appointed final points of titration are stored with the taken measuring series and may be observed in function “Prefs” menu “Results”. During observing the results of titration in text and numeric form with “.” button it is possible to move to the end of the series, where the final points of titration may be seen.** With +/- button it is possible to return to the beginning of the series

The results of titration are stored with chosen resolution (in menu **Measure),** and with this same resolution the final points of titration are determined. Thanks this choosing the right resolution may eliminate the unwanted points. Additionally it is possible to observe the derivative of the measured value with relation to volume. On the end of the results in numeric form additional information is placed – the total volume of the titrant is given. **For pH, pX and mV titration the following minimum and maximum values of the derivative are given. For conductometric titration following volumes are given, for which the change of the derivative sign has changed. For calorimetric titration following temperature jumps are specified.** By every specified characteristic point a number of the measurement (portion) closest to this point is given.

16. PRINTOUT

The meter was prepared for cooperation with printers working in EPSON standard. There are 4 possible kinds of the printouts:

- printout of the actual result;
- printout of every stabilised result;
- printout of series gathered in the register;
- printout of the electrode characteristic (numeric or graphic).

16.1. Printout of the actual result

To print the actual results one has to connect the printer to the Centronics connector on the right side of the meter and turn the meter and PC on. Enter the measurement screen of the function which results we want to print. Each pressing of the **PRINT** button causes printing of the result of the measured function, temperature, time and date.

16.2. Printout of the stabilised results

To print the stabilised results it is necessary to connect the printer to the Centronics output on the right side of the meter and switch the meter and printer on. Next enter the screen **Prefs** and in menu **Misc** choose *"Stable result: print"*. Enter the measurement screen of the function which results we are going to print. In the right lower corner of the screen an information will be displayed "Printing on". After each displaying of the information "value stable" the result will be printed.

16.3. Printout of series gathered in the register

Description of printing the results of measuring series was described in the chapter “Taking the measuring series, interpretation and transfer of results” on the page 25.

16.4. Printout of the electrode characteristic

It is necessary to connect the printer with the meter and switch the meter and printer on. In the **Calibration** menu in position ***"Display mode"*** choose *"numeric"* or *"graphic"* and next press the **PRINT** button.

17. MULTIPLEXING OF THE ELECTRODES

The meter enables connecting an automatic electrode switch APE-1 which enables almost simultaneous measurement of the chosen function with few electrodes. It enables making the measurements with few electrodes at one time. With every electrode a separate temperature probe may cooperate and it is switched automatically. **It is ensured by automatic temperature compensation independently for each electrode**. It is possible to connect from 2 to 9 pH or ion selective electrodes or conductivity cells and temperature probes.
In automatic temperature compensation mode 1 temperature may be used if all electrodes are working in this same temperature. In that case it should be directly connected with the "temp" connector in the meter.
During measurement with manual temperature compensation for all electrodes the temperature entered by the user is taken into consideration. Depending on the measuring function and kind of the measuring electrodes it is possible to make pH, ion selective, conductivity, voltage or temperature measurements. The electrodes should be calibrated before starting the measurements. **Together witch switching the electrodes their characteristics, entered during calibration, are switched.** The meter enables also collecting the measurements results made with few electrodes in form of series taken to following registers.

17.1. Connecting the electrodes

The electrode switch has 3 rows of connectors which are used for connecting the electrodes and probes.
The upper row is used for connecting the reference electrodes (din banana connector).
The middle row for measuring or combination electrodes (BNC-50 connector).
Lower row for temperature probes (Chinch connector).
The pairs of connectors were marked with numbers from 1 to 9.
The entered to the meter number of the electrodes connect with the switch always starting from the connectors marked 1. At least 2 electrodes may be connected and maximally 9.

17.2. Cooperation of the meter and the electrode switch

The electrode inputs during the measurement are switched from 1 to n,
where "n" is the number of the electrodes entered in the menu **Multiplex.**

During calibration switching the electrodes is stopped on the number of calibrated electrode.
The numbers of the calibrated electrodes respond to the numbers of connector on the electrode switch.

17.2.1. Calibration

To make the calibration with the use of the electrode switch one should:

- in case of using reference electrodes connect them to the upper row of connectors on the switch in the right order starting from the first one to the last one without breaks;
- connect the measuring electrodes (or combination electrodes) to the middle row of the connectors in the right order starting from the first one to the last one without breaks;
- in case of using the automatic temperature compensation connect the temperature probes to the switch in the right order;
- connect the electrode's output, temperature and "Canon" of the APE-1 switch to the meter;
- connect the 12V power adapter to the side of the APE-1
- in the meter choose the right measuring function and after entering the parameters screen in menu **Measure** position ***"Function"*** choose *"multiplex."*, press the **ESC** button, first menu on the right side of the screen will change the name to **Multiplex.**;
- enter the **Multiplex.** menu (Pic. 22);
- choose ***"No. of electrode."*** and enter the number of calibrated electrodes (2 - 9);
- In menu **Calibration** choose the number of the calibrated electrode and mode of calibration;
- according to the information in chapter "Calibration" make the calibration of electrodes.

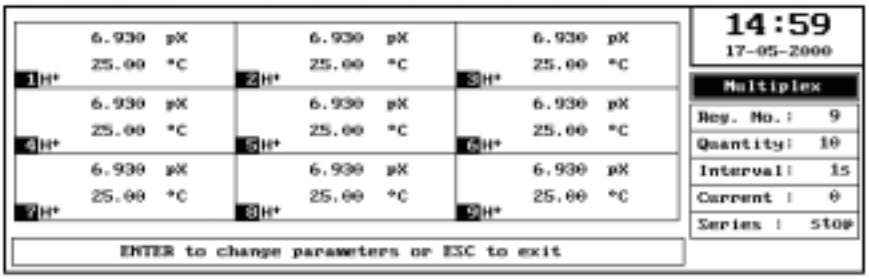
There is possibility of using the earlier entered characteristics of electrodes stored in the meter.

17.2.2. Measurement

To make the measurement or taking the series of measurements with use of the electrode switch it is necessary to:

- connect the calibrated electrodes to the switch identically like during the calibration;
- connect the electrodes and probes to the switch and "Canon" connector of the APE-1 to the meter;
- connect the 12V power adapter to the APE-1;
- choose the right measurement screen, enter the parameters screen in menu **Measure** position ***"Function"***, choose *"multiplex."*, press **ESC**, first menu on the right side of the screen will change the name to **Multiplex.**;
- enter to the menu **Multiplex.** (pic. 22);
- in position ***"Series"*** choose *"yes"* or *"no"* depending on the needs;
- in position ***"No. of electr."*** Enter the number (from 2 to 9)
- in case of taking series of measurements enter the number of measurements, time interval and mode. The results are stored in registers with numbers identical like electrode numbers. During taking series of measurements in "manual" mode, the results from all electrodes are stored in the moment of pressing the **START** button;
- enter to the measurement screen of the chosen function. On the numerical screen a number of windows will be displayed which corresponds with the number of electrodes entered in position ***"No. of electr."***. In the windows the numbers of electrodes are displayed together with the result of the measured function and temperature (pic. 23);

Pic. 22



Pic. 23

17.2.3. Notices about the measurements with the APE-1 switch

The results of the measurements transferred from the electrodes to the meter are processed by the meter in turns and not at one time, what is connected with the construction of the meter. This causes existing of following limitations:

- the time of switching from one electrode to another for pH, ion, mV and temperature is 0.6 s, what by using 9 electrodes gives time difference of 4.8 s;
- the time of switching from one cell to another for the conductivity measurement is 2.5 s, what for 9 cells gives time difference of 20 s;
- the value entered in the manual temperature compensation is taken for compensation of all measurements;
- in the multiplex. mode the HOLD button and the function of stabilised results printout is not working;
- the results on the screen may be displayed only in the numeric form (after finishing the measurement the results gathered in series may be displayed in graph form).

During the work with connected printer there is possibility of printing the results displayed at this moment on the screen. To do so press the **PRINT** button. The time and date will be printed and below the electrode number and result of the measurement.

18. pH-METER

18.1. pH measuring screens

During the pH-measurements it is possible to choose one of two kinds of measuring screens: numeric or graphic. It is changed in the pH meter parameters screen in menu **Measure**.

18.1.1. The Numeric screen

The description of the screen was given in the "The numeric and graphic measuring screens" chapter on page 13. The numeric screen is showed on the pic. 3.

18.1.2. The graphic screen

The graphic measuring screen is showed on the pic. 5 on page 15. The measurement result is showed on the screen in form of graph. On the vertical axis the whole measuring range from -3.00 to 20.00 pH is marked, and on the vertical axis time is showed. The rules of creating the graph on this screen and way of using the zoom function were given in the "The numeric and graphic measuring screens" chapter on page 13.

18.2. The pH parameters screen

The pH parameters screen includes:

- **Measurement**
- **Calibration**
- **Alarm**

and interchangeably

- **Series, Titration or Multiplex.**

Moving between the menu with ⇐ or ⇒ buttons. Opening menus with **ENTER** or ⇓ button. Closing the menu with **ESC** or ⇑ button. On the right side of the screen there is a **pH** symbol. The parameters screen was described on the page 17.

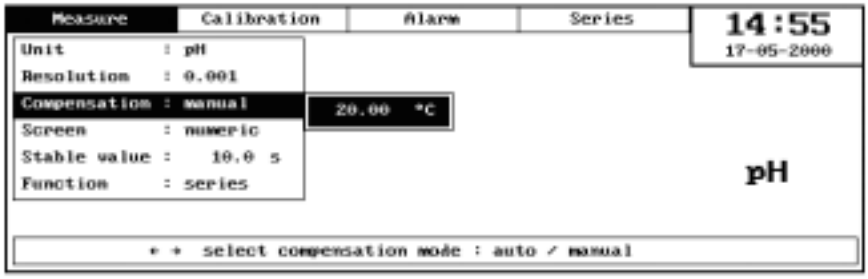
18.2.1. Menu **Measure**

The opened menu **Measure** is showed on the pic. 26.

"Unit"	- *"pH"* without possibility of change.
"Resolution"	- 0.1, 0.01, 0.001.
"Screen"	- *"graphic", "numeric"*.
"Compensation"	- *"automatic", "manual*". Changing the parameters with ⇐ or ⇒ buttons. In case of choosing the manual compensation additionally a window for entering the temperature value is displayed. This value is entered with 0 ÷ 9 buttons and confirmed with **ENTER**.

"Stable value" - enables entering a time during which the meter is checking weather the criterion of stable value was fulfilled. The factory setting is 10 s. The value is entered with numeric keys. The Stable value criterion was described on the page 14.

"Function" - *"series", "titration", "multiplex."*, is changed with ⇐ , ⇒ buttons.



Pic. 26

18.2.2. Menu Calibration

The description of the calibration is in chapter "Calibration", page 17.

18.2.3. Menu Alarm

The menu **Alarm** is described in the "Alarm, relays" chapter, page 35.

18.2.4. Menu Series, Titration, Multiplexing

This menus were described adequately on the pages 25, 37 and 41.

18.3. Preparation of the pH electrode

The electrode should be prepared to work according to the producer instructions. If the instructions weren't given please follow the steps:

1. New electrode should be put into distilled water or in saturated KCl solution for about 5 hours:
2. Before starting the measurements protecting rings (if used in this kind of electrode) should be removed. The ring placed on the junction – lower part of the electrode should be moved up along the electrode's body and the upper, which protects the KCl refilling hole, down along the body.

Removing the lower ring is essential, in other case the electrode won't measure.

Upper ring should be removed during measurements of high temperature solutions or to protect the junction during measurements in solutions with deposits or oils;

3. during measurements in laboratory it is advisable to use an electrode holder;
4. after every measurement the electrode should be washed in distilled water;
5. excess of liquid on the electrode should be removed by gentle touching the glass with a tissue paper;
6. after work the electrode should be stored in one of the above given solutions. The protecting rings should be moved on the junction and upper hole;

7. in case of long breaks between the measurements the electrode should be stored, after drying, in the packaging;
8. after taking the electrode of the package the eventual deposit should be removed using water;
before using the electrode it should be placed in distilled water for about 2 hours;
9. if the construction of the electrode enables refilling the electrolyte, it should be controlled and refilled periodically by the upper hole in the electrode's body (usually as the electrolyte a KCl solution is used).

CAUTION: storing of the electrode in distilled water shortens it's life time and may cause shifting of the zero point.

18.4. pH measurement

Before starting the pH measurement it is necessary to introduce the necessary parameters of the measurement, to do it one should enter the parameters screen, choose the resolution, kind of measuring screen, way of temperature compensation and eventually time for the "Stable result". In menu **Calibration** it is necessary to choose the number which corresponds with the electrode which we are going to use. The electrode (or measuring and reference electrodes) should be connected to the **pH** and **GND** connectors. The electrode should be prepared to work according to it's producer information and calibrated (chapter "Calibration", page 17). If the calibration wasn't done during the measurement a standard characteristic of the electrode is provided. For not calibrated electrode following data is assumed: 7 pH = 0 mV and the slope of the characteristic is 100% what equals 58,13 mV/pH. During work with automatic temperature compensation it is necessary to connect the temperature probe to the connector marked with **temp** symbol. If using a calibrated probe it's number should be introduced on the temperature parameters screen in menu **Calibration**. For not calibrated probe every "empty" number may be chosen (in negative).
To make the measurement it is necessary to:

- enter the pH measuring screen;
- immerse the electrode in the measured solution, the electrode can't touch the bottom and walls of the vessel;
- in case of automatic temperature compensation simultaneously the temperature probe should be immersed;
- during measurements with manual temperature compensation it is necessary to check weather the temperature entered in menu **Measure** is this same as measured with the thermometer;
- after stabilisation of the reading read the result.

Caution: during pH measurement the conductivity cell has to be disconnected from the meter or taken out from the measured solution (in which the pH electrode is immersed).

Lowering the resolution in the menu **Measure** enables shortening the stabilisation time. The longest time is during measurement with 0.001 pH resolution.

18.5. Notices about the temperature compensation and interpretation of pH measurement results

The meter has a manual and automatic temperature compensation, what enables eliminating errors which result from changes of the electrode characteristics under the influence of temperature changes. To explain the role of the temperature compensation it is important to remind that pH meter is an mV meter which displays voltage counted to pH unit. In constant temperature for one pH unit a constant mV value is changed. In temperature of 20 ^{0}C it is 58,168 mV. The value of mV on one pH unit **changes together with the temperature,** what is taken into consideration in the formula for "k coefficient" of the pH electrode.

k=0.198422 T

Taking this change into consideration during measurement is called temperature compensation, which is connected with change of the electrode efficiency and not with the change of the measured solution caused by temperature change.

Changes of the pH values of some solutions with the temperature are very small and others big ex. pure water.

When comparing solutions, which change their values together with the temperature change, it should be done in this same temperature.

Sometimes it happens that results of measurement in this same solution in stable temperature are different. When analysing such a situation it is important to take following factors into consideration:

- differences may occur because of poor quality electrode;
- The result was treated as stabilised to fast (medium class electrode needs about 40 seconds to full stabilisation);
- the measured solution may not be homogeneous and lack of magnetic stirrer doesn't allow for obtaining similar results;
- During measurements in sewage some chemical reactions, which change the result, may occur;

Very small differences may be caused by the meters accuracy.

If after making a two point calibration in pH buffers 7.00 pH and 4.00 pH (acidic conditions), the results are checked in 9.00 pH (alkali conditions), in some cases the result may be 8.90 pH or 9.10 pH. This may occur when the electrode has unsymmetrical characteristic. Making a 3 point calibration with alkali, neutral and acidic buffers may prevent from such errors. Sometimes the measurement results are unstable, the quality of the electrode has the crucial influence. **In most cases the reason for slow drifting of the result, it's unstability or prolonging the time of stabilisation is the clogged junction, broken electrode or contaminated membrane.**

Often it happens when wrong kind of electrode was chosen for the kind of measured solution.

Leaving the electrode for few hours in the distilled water or placing it in water with detergent may eliminate this symptoms, especially if the measurements were done in solutions with deposits, fats or oils.

The electrode which for a long time wasn't used may have the junction clogged by KCl crystals, what may be removed by placing the electrode in distilled water. Heavily contaminated electrode may be cleaned in chloroform and deposits of iron in 2N HCl. The electrode life may be prolonged by storing it in KCl solution. Depending on the kind of measured solution or substance proper kind of electrode should be chosen. They differ one from another with shape, membranes look, kind of junction and body. Electrodes for heavily polluted sewage is different than this for clean water or for meats or soil. It should fulfil the following conditions:

it must be easy to wash, so an electrode with plastic unremoveable housing shouldn't be used. Deposits, fats and chemical compound will precipitate on the junction what will disable the measurement or falsify the results;

shape of the membrane should enable easy washing. For measurements in sewage the best shape of membrane is a cylinder shape;

junction in the electrode for sewage has more holes what enables easy flow of the electrolyte and makes clogging difficult;

during measurement of sewage or liquids with deposits with electrode which shape enables refilling of the electrolyte the hole for refilling should be opened to use the difference of pressures to clean the junction.

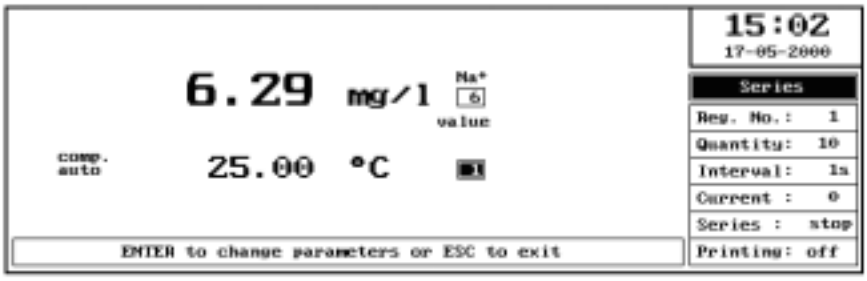
19. ION METER

19.1. Ion meter measuring screens

The measurement may be done in pX , M/l or g/l units.
The meter enables automatic conversion of the measurement result made in one unit to other unit. It has also an "autorange" function which enables during the measurements automatic change, from 0.001 mM/l to 1 kM/l, or after automatic conversion of this range by the molecular weight in µg/l mg/l or g/l.
During ion measurements it is possible to choose one of two available measuring screens: numeric or graphic. The change is done in the parameters screen of ion meter in the menu **Measure.**

19.1.1. Numeric screen.

The numeric screen of the ion meter is showed on the pic. 27. Description of this screen is in the "The numeric and graphic measuring screens", page 13. The differences are given below.



Pic. 27

The result of the measurement is on the left side of the screen. Next to the result a symbol of the unit in which the measurement is done is displayed (pX, Mol/l or mg/l). Next to the symbol the number of the electrode is displayed.
Above the electrode number the symbol of the measured ion is displayed, it depends on the kind of used electrode. It is introduced during the calibration.
For the not calibrated electrode a linear characteristic is applied and atomic weight of the hydrogen (H^+). The unit is changed in the parameters screen of ion meter in the menu **Measure**.
Below the clock an **Ion** symbol is displayed.

19.1.2. Graphic screen

On the graphic screen the measurement result is showed form of a graph. On the vertical axis the value in pX, M/l or mg/l is marked (whole measuring range) and on the vertical axis time is showed. Next to the numeric result of ion measurement the temperature is displayed. There is possibility of magnifying the graph with use of zoom function. The rules of creating the graph on this screen and way of using the zoom function were given in the "The numeric and graphic measuring screens" chapter on page 13.

19.2. The ion meter parameters screen

The ion meter parameters screen may be entered from the measuring screen by pressing the **ENTER** button. It includes following menu:

- **Measurement**
- **Calibration**
- **Alarm**

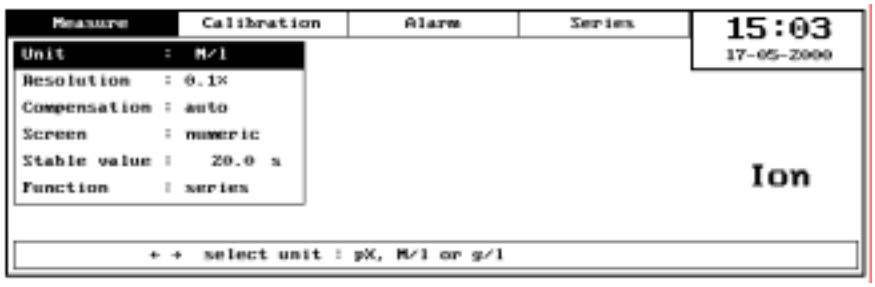
and interchangeably

- **Series, Titration or Multiplex.**

Moving between the menu with ⇐ or ⇒ buttons. Opening menus with **ENTER** or ⇓ button. Closing the menu with **ESC** or ⇑ button. On the right side of the screen there is a **Ion** symbol.

19.2.1.Measurement menu

The opened menu **Measure** is showed on the picture 28.



Pic. 28

18.2.1. Menu Measure

The opened menu **Measure** includes:

"Unit"	- *"pX", "M/l", "mg/l"*
"Resolution"	- 0.1, 0.01, 0.001 for pX and "0,1%" for M/l and mg/l.
"Screen"	- *"graphic", "numeric"*.
"Compensation"	- *"automatic", "manual*". Changing the parameters with ⇐ or ⇒ buttons. In case of choosing the manual compensation additionally a window for entering the temperature value is displayed. This value is entered with 0 ÷ 9 buttons and confirmed with **ENTER**.
"Stable value"	- enables entering a time during which the meter is checking weather the criterion of stable value was fulfilled. The factory setting is 5 s. The value is entered with numeric keys. The Stable value criterion was described on the page 14.
"Function"	- *"series", "titration", "multiplex."*, is changed with ⇐ , ⇒ buttons.

19.2.2. Menu Calibration

Below we are shortly describing the way of calibration function in the ion meter, because it is a bit different than in other functions. If in the menu **Measure** the user chooses the *"M/l"* or *"g/l"* unit in the menu **Calibration** an additional position appears - ***"Resolution"***. This parameter is applied only during calibration, which in that case is made in mV. One may choose 0.1 mV or 1 mV. By electrodes which have poorer quality faster stabilisation of the result is if the 1 mV resolution was chosen. The rest of the positions in menu are similar like in other measuring functions.

After setting the parameters in menu **Calibration** and confirming them with **ENTER**, an additional table with ion symbols which correspond to the most often used kinds of ion selective electrodes is displayed. With cursor one has to choose the ion which corresponds with the used electrode and confirm it with **ENTER**. To the meters memory the molecular weight of the chosen ion is introduced. The values taken during all conversions are showed in the table below:

Ion	weight	Ion	weight
Ag^{+}	107.870	I^{-}	126.904
Br^{-}	79.909	K^{+}	39.102
BF^{-}_{4}	155.902	Li^{+}	6.939
Ca^{2+}	40.080	Na^{+}	22.990
Cd^{2+}	112.400	NH_4	18.039
Cl^{-}	35.453	NO_3^{-}	62.005
ClO_4^{-}	99.450	Pb^{2+}	207.190
CN^{-}	26.018	S^{2-}	32.064
Cu^{2+}	63.540	SCN^{-}	58.082
F^{-}	18.998		

If the table does not include the ion which is going to be measured one should choose the *"NN"* position and confirm it with **ENTER**. A table is opened, one has to introduce the molecular weight of the new ion and below it's valency. If the measurement will be made only in the M/l or pX units entering the molecular weight is not necessary. This value is showed by the meter as 1.00. It is very important to remember that in this case receiving the result in mg/l won't be possible and after setting this unit the displayed result will be accidental. The right conversion of the result will be possible only by changing the unit from pX to mM/l or vice versa. **During measurements of ions which are not in the table entering the value of the measured ion is essential.**
After confirming the chosen ion with **ENTER** a calibration table is opened (description in chapter "Calibration"). Additionally next to the electrode number a symbol of the chosen ion is displayed. In the upper row of the table the values of the sample solutions are entered. Before entering, with +/- buttons set the unit multiplier according to the unit set in the menu **Measure**. During the calibration in pX, in the lower row of the table a conventional values of pX are displayed, this values are created by the meter to determine a characteristic of the electrode. During calibration in M/l or mg/l also a conventional values in mV counted to 20°C are displayed, on their basis the meter introduces automatically a correction to the electrode error. The calibration should be started by entering the sample solution values. Each value should be confirmed with **ENTER**. After pressing the **CAL** button the sample solutions are put in order from the least concentrated to the most concentrated. Next actions during calibration are described in the "Calibration" chapter.

19.2.3 Menu Alarm

The menu **Alarm** is described in the "Alarm, relays" chapter, page 35.
To enter the values of limits in chosen unit, first choose the unit with +/- units and next enter the numeric value of the minimum and maximum limits In case of measurements in M/l or mg/l the hysteresis is entered in % with relation to the entered value.

19.2.4. Menu Series, Titration, Multiplexing

This menus were described adequately on the pages 25, 37 and 41.

19.3. Few notices about the ion measurements

The ion metric measurements are the most difficult measurements which may be made with our meter. The decisive influence on the final result has the quality of the electrode and theoretical background necessary for this type of measurement. The electrode producers usually include a detailed description how their products should be used and information about the factors which influence the result. The knowledge of the characteristic (curve) of electrode, even in general shape given by the producer enables defining a range of the sample solutions, their number and concentration.
The ion selective electrode changes it's potential depending on the concentration (activity) of the individual ions in the solution. The main rule of the measurement is based on the linear dependence of the electrode potential from the logarithm of ion activity in the solution and is expressed by Nernst's equation:

$$E = Eo + 2.303\ RT/nF \log (ai)$$

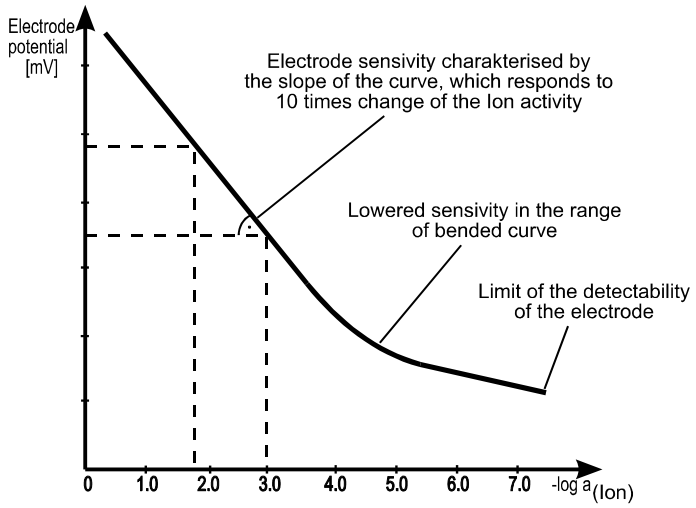
where:
- E - Electro Motoric Force of the measuring cell which consists of the ion selective and reference electrode in the measured solution (V)
- Eo - normal ion selective electrode potential, depends mainly on the internal electrolyte activity of the ion selective electrode and kind of reference electrode (V),
- ai - activity of the measured ion,
- n - valency of the measured ion,
- R - gas constant (8.31 J / K mol),
- T - temperature in K,
- F - Faraday's constant (96487 As/val)

The measurement of ion activity is based on measuring of the potential of ion selective electrode in relation with the reference electrode. In most cases this electrodes are in separate housings. The reference electrode should have an appropriate external electrolyte. It has a construction which enables replacing the electrolyte to the right one for the specific ion selective electrode. It enables using a one reference electrode with few ion selective electrodes. The electrode producers give information what electrolyte should be used depending on the measured ions. The most often electrolytes are given in the table 1. The ion selective electrodes differ one from another with their characteristics. The typical shape of the characteristic of the ion selective electrode is showed on the picture 29.

Table 1

Measured ion	External electrolyte
F^-, Cl^-, Br^-, J^-, S^{2-}, CN^-, Ag^+, Cu^{2+}, Cd^{2+}	1.0 M KNO_3
Ca^{2+}	1.0 M KNO_3 or 0.1 M KCl
NH_3	1.0 M KNO_3 or 0.1 M CH_3COOLi
K^+, Li^+	0.1 M NH_4NO_3
Na^+	0.1 M NH4NO3 or 0.1 M CH3 COOLi
NO_3^-	Saturated K_2SO_4

The best results may be achieved when the measurements are done in ranges that correspond with the linear parts of the characteristic. The essential electrode calibration on the sample solutions in that case may be done with larger difference of concentration of this solutions. The measurements made in ranges where the characteristic bends require choosing the sample solution which differ very little, because this lowers the electrode error. The measurements which are done in the ranges which correspond with lower part of the characteristic will have bigger and bigger errors, because of the lowering of electrode sensitivity. For the two valency ions the electrode sensitivity is twice lower than for single valency ions. Presence of other ions may have influence on the measurement result. The ions which interfere the electrode are given by it's producer, that's why by accurate measurements knowledge of the ion composition in the measured solution is important and it is necessary to act according to the producer's information.



Pic. 29

Preparation of the measured solution has a great influence on the final result. The fundamental meaning by the measurements of high concentration solutions has the phenomenon of ion activity changes together with change of their concentration, what may be described with the formula:

$$ai = fi * ci$$

where: ai - „i" ion activity in the solution,
fi - „i" ion activity coefficient,
ci - „i" ion concentration in the solution in mol/l or g/l.

Stabilisation of the ion activity in the high concentration solutions is the condition of proper measurement. Adding the stabilising factor, recommended by the electrode producer, enables linearisation of the electrode characteristic for this concentrations, increases it's sensitivity and enables for stable measurements.
Ageing of the electrode has an influence on the lowering the electrode sensitivity, prolonging the reaction time, shrinking the measuring range and increasing of the membrane resistivity. High temperatures lower the range of the electrode and shorten it's life. It is very important to turn attention to the electrode producer's recommendations concerned with influence of some solutions to the condition and life of the membrane.
Accuracy of behaviour, right preparation of the sample solutions and cleanness of the electrode's membrane are the basic conditions of accurate measurements. Contamination of the membrane, even invisible for eyes, may completely make measuring impossible or prolong the result stabilisation time. Lack of the result stabilisation in most cases is connected with the electrode and not with the meter. Accurate cleaning of the electrode's membrane in electrodes made of plastic consists in rubbing the electrode with a felt laid on flat surface. By strong contamination it is possible to use a rubbing paste. After finishing the cleaning the electrode should be washed in distilled water.

Notices about the ion selective electrodes calibration

The ion selective electrodes have to be calibrated. By accurate measurements calibration before every measuring series is advised. Below we present few general advises connected with some characteristics of the electrodes, sample solutions choice and influence of some factors on the measurement. Acquainting with this information before the calibration may help by increasing the accuracy of the measurements.

The meter enables 8 point calibration of the electrode. Minimal calibration points number is 2. High quality of sample solutions is required. It is not necessary to use sample solutions with strictly defined values, but because of the not linear characteristic of most of the electrodes the values of sample solutions should be close to the predicted value of the measured solutions. The ratio of the prepared solutions shouldn't exceed 1:100. Usually in practice by 2 point calibration the prepared sample solutions have 1:10 ratio and by 3 point calibration 1:10:100. It is advised to prepare the sample solutions and measured solutions in this same volume. Differences in volume may have some influence on the result. The most accurate results are achieved in this same temperature in which the calibration was done.

Significant influence on the ion selective measurements has the pH value. During accurate measurements the pH value of the measured solution should be identical with pH value of sample solutions. For each electrode a pH range is given in which it is working properly. Sometimes troubles with measurement may be caused by air in the reference electrode's membrane. Shaking the electrode usually removes this bubbles. During measurement and calibration often light unscrewing of the body with external electrolyte to remove this bubbles. New reference electrodes may be protected with silicone paste. After removing the protective ring the paste should be removed with clean piece of cloth.

The stabilisation time of the measurement result depends on the concentration of the solution. Low concentration requires longer stabilisation time. The calibration is done starting from the solution with the lowest concentration and than in those with larger concentration. So the first sample solution requires much longer stabilisation time than the last one. Very often to activate the membrane before the calibration an initial measurement of distilled water is done using the mV function. Such a measurement may last long but it is not required to wait for the full stabilisation of the result. Next, still using the mV function the most concentrated solution should be measured. After this actions the electrode should be accurately washed and the calibration may be started using the ion meter function and the right for this function calibration screen. The best results are achieved in temperature close to 20°C.

19.4. Ion selective measurement

The measuring and reference electrodes should be connected with **mV/pX** and **GND** connectors. Before starting the ion selective measurements it is necessary to introduce the essential parameters: enter the parameters screen, choose the unit resolution and kind of measuring screen. It is necessary to choose depending on the measured ions the measuring and reference electrodes. Changing the resolution in menu **Measure** enables shortening the stabilisation time. When using electrode of worse quality during the measurements in pX the lower resolution 0.1 pX is advised, for measurements in mg/l and mM/l the resolution has factory settings.
In menu **Calibration** the electrode number, which we are going to work with, should be chosen. **The electrodes should be prepared for work and calibrated.** If the electrode was earlier calibrated, on the measurement screen above the electrode number an ion symbol will be displayed which we are going to measure. If work with new electrode is started or high accuracy is required the calibration should be done.
Ion measurements and storing of the results are done in mV (linear scale) with temperature influence taken into consideration. After choosing the unit *"M/l"* or *"g/l"* the results in mV are calculated and displayed in mM/l or mg/l (logarithmic scale).
During accurate measurements it is advised to make the calibration and the measurements in this same temperature. The meter may be set to manual temperature compensation and the temperature of the measured solution may be brought to the temperature of sample solutions. It is also possible to choose the automatic temperature compensation obeying the above given rules.
The following actions should be done:

- connect the temperature probe to the **temp** connector and ion selective electrode to BNC connector marked with **mV/pX** and the reference electrode to the **GND** connector..
- insert the probe and electrodes to the measured solution.
- bring the temperature of the measured solution to the temperature in which the electrode was calibrated.
- start the measurement and after stabilisation read the result.

To observe the continuous changes of the measured function it is necessary to use the graphical measuring screen. Replacing the electrode requires changing it's number in menu **Calibration** or calibrating the electrode.

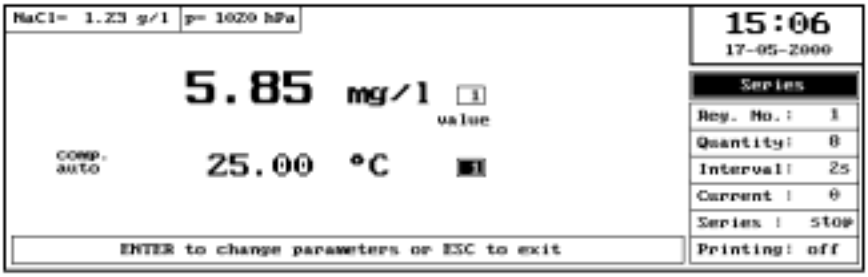
20. OXYGEN METER
(CX-741 and CX-742)

20.1. Oxygen meter measuring screens

During the dissolved oxygen concentration measurements it is possible to choose one of two kinds of measuring screens: numeric or graphic. It is changed in the oxygen meter parameters screen in menu **Measure**.

20.1.1. The Numeric screen

The description of the screen was given in the "The numeric and graphic measuring screens" chapter on page 13. The numeric screen is showed on the pic. 30.



Pic.30

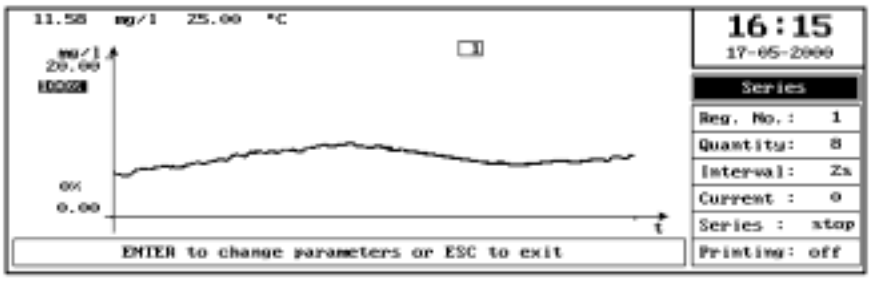
In the upper left corner of the screen two small information windows are displayed, in which the following information is given:

NaCl - salinity value
p - air pressure value

Values of this parameters are introduced on the oxygen meter parameters screen. The description is given in the chapters 20.5 and 20.6.

20.1.2. The graphic screen

The graphic measuring screen of the oxygen meter is showed on the pic. 31. The result of the measurement is displayed in graph form. On the vertical axis the range of measurement is given 0 ÷ 200.0 % or 0 ÷20.00 mg/l. During using this screen it is possible to change the range given on the vertical axis following the information given in chapter 8.2.1 „Zoom function".



Pic. 31

20.2. The dissolved oxygen meter parameters screen

The oxygen parameters screen is entered from the oxygen measuring screen after pressing the **ENTER** button. The parameters screen includes:

- **Measurement**
- **Calibration**
- **Alarm**

and interchangeably

- **Series or Multiplex.**

Moving between the menu with ⇐ or ⇒ buttons. Opening menus with **ENTER** or ⇓ button. Closing the menu with **ESC** or ⇑ button. On the right side of the screen there is a **O_2** symbol.

20.2.1. Menu Measure

The opened menu **Measure** is showed on the pic. 32.

Pic. 32

The menu includes:

"Unit" - *"%"* „mg/l"

"Resolution" - "1%", "0.1%" for % and , "0.1", "0.01" for mg/l

"Screen" - *"graphic", "numeric"*.

"Compensation" - *"automatic", "manual*".
Changing the parameters with ⇐ or ⇒ buttons. In case of choosing the manual compensation the temperature value is entered with 0 ÷ 9 buttons and confirmed with **ENTER**.

"Stable value" - enables entering a time during which the meter is checking weather the criterion of stable value was fulfilled. The factory setting is 15 s. The value is entered with numeric keys. The Stable value criterion was described on the page 14.

"Function" - *"series", "multiplex."*, changed with ⇐ , ⇒ buttons.

20.2.2. Menu Calibration

The menu **Calibration** of the oxygen meter is showed on the picture 33.

The menu includes:

"Electrode number" - *"1"* ÷ "10"

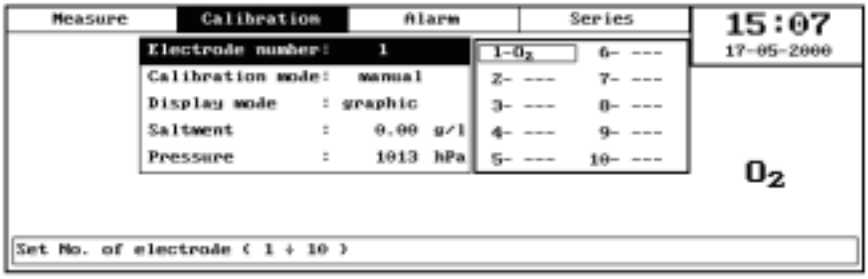
"Calibration mode" - "auto", "semiauto" and "manual"

"Display mode" - *"graphic", "numeric"*.
Changing with ⇐ or ⇒ buttons

"Saltment" - salinity value of the measured solution taken into consideration during conversion of the result from % oxygen saturation to mg/l.

"Pressure" - Air pressure value taken into consideration during conversion of the result from % oxygen saturation to mg/l.

Values of both this parameters are introduced with numeric keyboard and confirmed with **ENTER** button.



Pic. 33

Salinity value of the measured solution.
The factory setting is 0 g/l. It may be determined by conductivity measurement and reading the value in g/l from the table 2. The value of salinity may be changed in the range 0 ÷ 50 g/l.

Air pressure value.
The air pressure has an influence on the solubility of the oxygen in water. The factory settings are 1013 hPa. In case of large differences it is necessary to introduce the actual pressure value.

20.2.3 Menu Alarm

The menu **Alarm** is described in the "Alarm, relays" chapter, page 35.

20.2.4. Menu Series, Titration, Multiplexing

This menus were described adequately on the pages 25, 37 and 41.

Menu Alarm

Menu **Alarm** was described in "Alarm, relays" chapter page 34.

20.2.4. Menu Series, Multiplex.

Those menu are described on pages: 25 and 40.

20.3. Basic information about the dissolved oxygen measurement

The measurement of dissolved oxygen in water solutions is performed using an oxygen sensor. The basic element of the sensor is a Teflon semi-permeable membrane, which enables the penetration of oxygen contained in the measured solution, into the electrolyte – inside of the sensor. The sensor creates a cell, which voltage depends on the oxygen content in the electrolyte. The meter enables measurement in % of oxygen saturation and **mg/l**. The calculation of the mg/l value is based on the saturation measurement in % and the temperature measurement. When requiring high accuracy during mg/l measurements, the values of salinity and atmospheric pressure must be additionally introduced. The saturation measurement in % does not depend on these factors. **The quality of the oxygen sensor has a decisive effect on the measurement accuracy. The troubles arising during the measurements are caused mainly (98%) by the sensor, yet not by the device. In many cases the troubles result from lack of basic maintenance of the sensor from the user's side.** It must be remembered, that during the measurement the sensor takes oxygen from the environment of the membrane. **The sensor's manufacturers recommend in their instructions the minimal flow-rate of the tested water, assuring a stable result.** If that requirement is not complied **the result will regularly decrease.** During measurements in stagnant solutions the flow can be partly simulated by keeping the sensor in motion with a suitable speed. In laboratory conditions, i.e. performing the measurements in a vessel, the flow can be forced with a magnetic stirrer. Although it must be kept in mind that when measuring low O_2 saturation intensive stirring can cause an increase of oxygen content in the tested solution.

Taking water samples and transferring them to the laboratory can alter the O_2 concentration in the samples. The best results can be achieved **only in conditions, which are recommended by the manufacturer of the sensor in the operation manual.** Long-lasting storing of the sensor without performing of measurements (above 1 month) requires removing of the electrolyte. After this period the container must be filled with a fresh electrolyte and the sensor stored in distilled water for about 24 hours. A correct measurement is determined by the good condition of the membrane. The membrane must be free of any cracks (appearing of electrolyte-drops or white spots when dry). Before the measurement the electrode should be activated by storing in distilled water for about 15 minutes. Strongly polluted wastewater causes after some time clogging of the membrane. This is revealed by the impossibility of calibrating of the device at 100% oxygen content (the calibration range becomes too narrow). In both cases the membrane should be replaced according to the manufacturer's instructions. When replacing the membrane and replenishing the electrolyte it is important to pay attention weather there are no air bubbles in the container beneath of the membrane, because otherwise the measurements will be false. In that case the twisting of the sensor should be repeated after refilling the electrolyte. In order to obtain a stable result there must be some awaiting time before making the reading. According to the sensor's manufacturers that is about 1-1,5 min, depending on the thickness of the membrane. The accuracy of the measurement is connected with the temperatures of calibration and measurement. The greater the difference of these temperatures, the greater the measurement error. The used sensors require a two-point calibration in a zero O_2 saturated solution and an optional solution (most often a 100% - saturated one). Clean water contains about 60 ÷ 80% oxygen. Waste water and chemical solutions are in general less saturated with oxygen but liquids with forced aeration are much more saturated. When performing accurate measurements the sensor's manufacturers recommend carrying out calibration just before the measurement since after some time the sensor's parameters are changing. Even the best oxygen sensors have so called drift about ±1%/24 h.

20.4. The oxygen sensor

The meter may co-operate with galvanic oxygen sensor. Conventionally it co-operates with the sensor made by ELSENT with accuracy of ±1%, if the measurement is done in this same temperature as the calibration. The accuracy of measurement decreases together with growing of the difference between the temperature of calibration and temperature of measurement. It is <3% when the difference is ±5°C and 5% when the difference is ±10°C. **In case of using another sensor the device requires its adaptation by the manufacturer.**
It must be remembered that the membrane of the sensor should be replaced if it is mechanically damaged or if the device cannot be calibrated. The necessary procedures are given in the instruction of the probe's manufacturer.
Before starting the work please read carefully the information given in chapter 20.3.

20.5. Salinity influence compensation

Salinity of the solution decreases the oxygen solubility in water and requires taking into consideration during measurements in mg/l. **1 g/l change of salinity changes the oxygen saturation for about 5%.** The easiest way of determining the salinity is measuring the conductivity and checking the salinity in the table 2 below. The table 2 gives the real dependence between the salinity and conductivity counted in NaCl. The value of salinity and pressure is introduced according to chapter 20.2.2. The meter enables entering the salinity value in g/l and counts the change of oxygen saturation in mg/l.

Measurement in % does not require introducing the salinity value.

mS/cm	g/l	mS/cm	g/l	mS/cm	g/l
1	0.49	28	16.87	55	34.34
2	1.00	29	17.52	56	34.99
3	1.52	30	18.17	57	35.64
4	2.08	31	18.82	58	36.28
5	2.63	32	19.46	59	36.93
6	3.19	33	20.11	60	37.58
7	3.74	34	20.76	61	38.23
8	4.29	35	21.41	62	38.87
9	4.85	36	22.05	63	39.52
10	5.40	37	22.70	64	40.17
11	6.00	38	23.35	65	40.81
12	6.61	39	23.99	66	41.46
13	7.21	40	24.64	67	42.11
14	7.83	41	25.29	68	42.75
15	8.45	42	25.93	69	43.40
16	9.07	43	26.58	70	44.05
17	9.70	44	27.23	71	44.70
18	10.35	45	27.87	72	45.34
19	11.01	46	28.52	73	45.99
20	11.66	47	29.17	74	46.64
21	12.31	48	29.82	75	47.28
22	12.96	49	30.46	76	47.93
23	13.61	50	31.11	77	48.58
24	14.26	51	31.76	78	49.22
25	14.91	52	32.40	79	49.87
26	15.56	53	33.05	80	50.63
27	16.22	54	33.70		

Table 2. Determining the salinity in g/l NaCl on the basis of conductivity in mS/cm (in temperature $25^{O}C$).

20.6. Air pressure influence compensation

The value of oxygen saturated in water determined in mg/l depends directly on the atmospheric pressure value, this means that 10% pressure change causes oxygen saturation change for 10%. If the air pressure greatly differs from the 1013 hPa this change should be introduced to the meter and this influence will be automatically counted during measurements in **mg/l**.
During measurement in % the entered pressure value has no influence on the result.

20.7. Calibration of the oxygen probe

In order to eliminate the measurement error arising from the individual characteristic of the sensor a calibration of the device should be carried out. This procedure should be performed always before operation with a new sensor, after replacing the membrane or for special requirements concerning the measurement accuracy. The probes have a so-called "signal drift" associated with the interval between the calibration and measurement. A longer interval decreases the measurement accuracy. The calibration is also recommended if the temperature of the tested solution differs greatly from the temperature in which the probe was calibrated, because then an additional error arises. **In this case calibration solutions should be used, which temperature is almost the same as the predicted temperature of the tested solutions.**
If it is impossible to calibrate the device, the membrane of the sensor must be replaced according to the manufacturer's instruction. This situation usually takes place if the membrane is strongly polluted or ruptured (sometimes almost invisible). After replacing the membrane the sensor should be conditioned in water for 24 hours.
The used oxygen sensors require one or two point calibration in standard solutions. During two point calibration a solution **with 0% oxygen saturation** is used (solution of Na_2SO_3) and second with **100% oxygen saturation**. It can be prepared by aeration of water for more than ten minutes. When using this solution it should flow or be stirred. The method of preparing both solutions is described in detail in the users manual for the oxygen sensor. A simplified calibration for 100% O_2 saturation can be carried out in the air, without immersing the sensor in water. **Before that the membrane must be wetted with water for several minutes.**
It is assumed that the O_2 content in the air correspondents to 100%- saturation, what enables a simplified calibration to be carried out.
The one point calibration is done only in the solution with 100% oxygen saturation.

20.8. Oxygen concentration measurement

Before starting the oxygen concentration measurement the meter should be prepared for work and the oxygen sensor calibrated. As mentioned the measurement in % saturation does not require additional measurements associated with the temperature, salinity and atmospheric pressure. **Although the measurement in mg/l, used more frequently, depends on those factors.**

This influence is corrected automatically by the device, taking into the consideration the temperature value measured by the sensor or in case of manual compensation value entered by the user.
The oxygen sensor is equipped with an additional system compensating the temperature influence on the membrane. Because of the limited accuracy of this compensation the highest accuracy can be achieved by calibrating the sensor at the same temperature at which the measurement will be carried out. **The measurement error increases with the increase of the difference between the calibration and measurement temperatures and results from characteristic features of the sensor but not from the device.** For the applied sensor (ELSENT) this error is about < 3% at a $\pm 5^0$C temperature difference and increases to 5% at a $\pm 10^0$C temperature difference.
If a higher accuracy is required the interval from the last calibration must be additionally taken into consideration (signal drift). If the salinity of the tested solution is very small, the measurement can be started without entering it's value. **However accurate measurements should be preceded by the determination of the salt content in the tested solution and introducing the air pressure value.**.

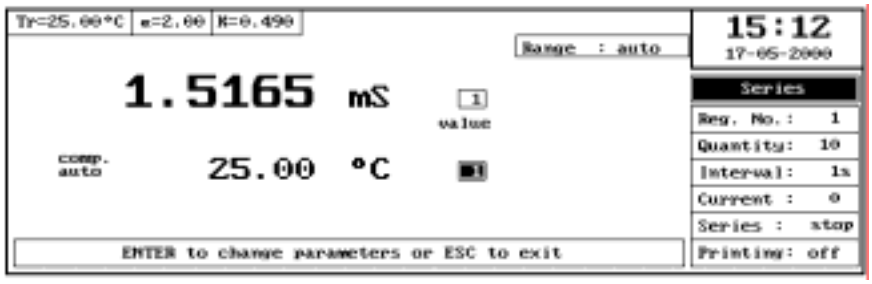
21. CONDUCTIVITY METER

21.1. The conductivity meter measuring screens

In the conductivity measuring function similarly like in other measuring functions it is possible to choose one of two kinds of measuring screens: numeric or graphic. It is changed in the pH meter parameters screen in menu **Measure**.

21.1.1. The Numeric screen

The numeric conductivity measuring screen is showed on the pic. 34. The description is in "The numeric and graphic measuring screens" chapter on page 13. Differences are listed below.



Pic. 34

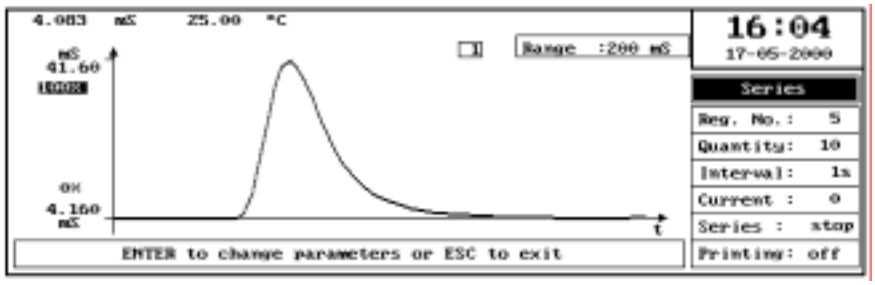
In the upper left part of the screen small information windows are displayed. In this windows following information is displayed:

- T_r - reference temperature;
- α - temperature compensation coefficient;
- K - constant K of the conductivity cell.

Value of this parameters are entered on the conductivity meter parameters screen. The description is given in the "conductivity measurement" on page 71.

21.1.2. The graphic screen

The graphic measuring screen is showed on the pic. 35. The measurement result is showed on the screen in form of a graph. On the vertical axis the whole measuring range from 0 to 2 S or 0 ppm to 1 ppo. is marked. During using this screen it is possible to change the range on the vertical axis according to the chapter 8.2.1. "Zoom function".



Pic. 35

21.2. The conductivity meter parameters screen

The conductivity parameters screen includes:

- **Measurement**
- **Calibration**
- **Alarm**

and interchangeably

- **Series, Titration, Multiplex. or Flow**

Moving between the menu with ⇐ or ⇒ buttons. Opening menus with **ENTER** or ⇓ button. Closing the menu with **ESC** or ⇑ button. On the right side of the screen there is a **cond** symbol.

21.2.1. Menu Measure

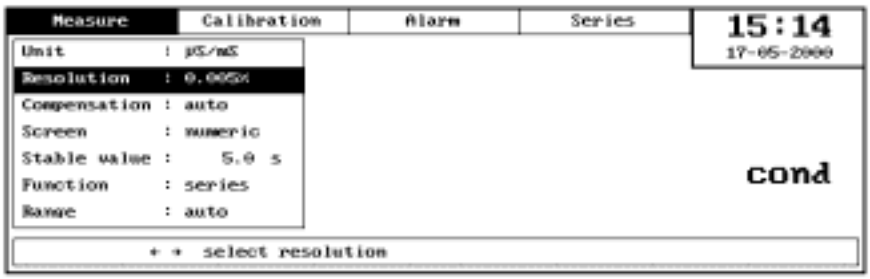
The opened menu **Measure** is showed on the pic. 36.

"Unit"	- *"µS/mS"*, *"ppm/ppo"*, change of the conductivity units to concentration units
"Resolution"	- "0.05%", "0.005%".
"Screen"	- *"graphic"*, *"numeric"*.
"Compensation"	- *"automatic"*, *"manual*". Changing the parameters with ⇐ or ⇒ buttons. In case of choosing the manual compensation additionally a window for entering the temperature value is displayed. This value is entered with 0 ÷ 9 buttons and confirmed with **ENTER**.
"Stable value"	- enables entering a time during which the meter is checking weather the criterion of stable value was fulfilled. The factory setting is 5 s. The value is entered with numeric keys. The Stable value criterion was described on the page 14.
"Function"	- *"series"*, *"titration"*, *"multiplex."*, "flow" is changed with ⇐ , ⇒ buttons.

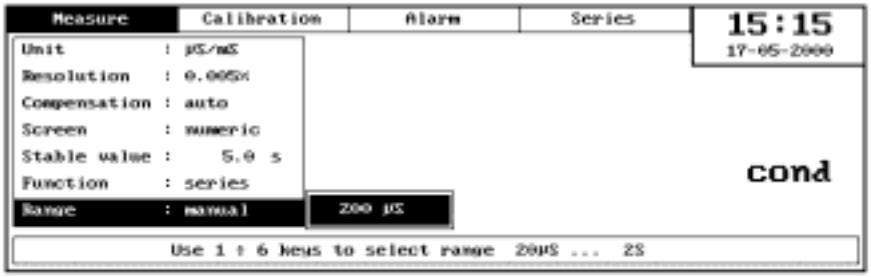
"Range" - *"auto", "manual"*, way of changing the ranges.
"auto": the ranges are changed automatically from the lower to higher after reaching a value above 19999, and from higher to lower after reaching a value below 1800.
"manual": the ranges are changed manually by entering with the keys the range number.

Range number	Range
1	0 ÷ 20 µS/cm
2	0 ÷ 200 µS/cm
3	0 ÷ 2 mS/cm
4	0 ÷ 20 mS/cm
5	0 ÷ 200 mS/cm
6	0 ÷ 2 S/cm

Pic. 37 shows menu **Measure** with opened position ***"Range"***.
Pic. 37 shows menu **Measure** with opened position ***"Range"***.



Pic. 37



21.2.2. Menu Calibration

The opened menu **Calibration** is showed on the pic**.** 38.

The menu includes:

"electrode number"	- *"1" ÷ "10"*;
"Calibration"	- *"auto"*, *"semiauto"*, *"manual"*, *"const K"*;
"Screen"	- *"numeric"* or *"graphic"*; change with ⇐ , ⇒ buttons.
"Reference Temp."	- reference temperature T_r to which the result of measurement with temperature compensation is counted.
"Temper. coef. α"	- temperature coefficient α in % / ^{O}C enables automatic counting of the result by temperature change.

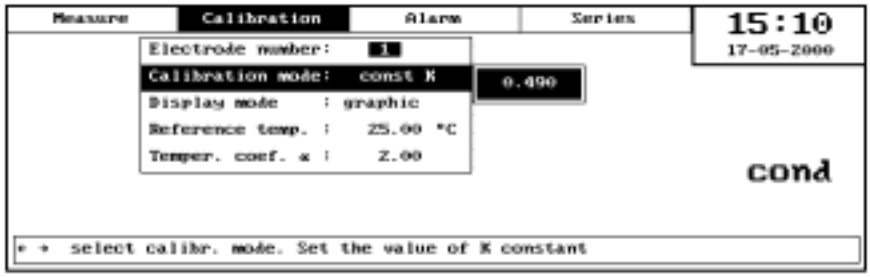
Values of both coefficients are introduced with numeric keyboard and confirmed with **ENTER** button.

Reference temperature T_r.

The T_r value was set to 25 °C. It may be changed in the range 0 ÷ 50 °C. During measurement in temperature equal to the T_r temperature the measurement is done without the temperature compensation. Value of the reference temperature depends on the data which concern conductivity of different compounds, which are given in connection with measurement temperature.

The temperature coefficient α.

The temperature coefficient α given in % / ^{O}C enables conductivity measurements with temperature compensation. It informs how the value of the solution is changing when the temperature has changed for 1 °C. The meter enables introducing the coefficient in range 0 ÷ 5 % / ^{O}C (pic. 38). The factory settings of this coefficient are 2 % / ^{O}C. More detailed description in “Conductivity measurement” chapter page 71.



Pic. 38

In practice very often the simplified way of conductivity cell calibration is used. This is the introducing of the constant K of the cell (pic. 34). This constant is given by the electrode producers or it may be determined on the basis of calibration with sample solution. Value of the constant K is introduced with the numeric keyboard in the menu **Calibration**, position ***"Calibration mode"***, confirming with **ENTER** button. The range of the constant K in this meter is 0.1 ÷ 9.999. Calibration with use of sample solution was described in the chapter "Calibration" page 17.

21.2.3. Menu Alarm

The menu **Alarm** is described in the "Alarm, relays" chapter, page 35. To enter the values of the limits in the chosen unit first it is necessary to choose the unit with +/- button and next enter the numeric value of the limit.

21.2.4. Menu Series, Titration, Multiplex. and Flow

The first three menus are described adequately on the pages 25, 37 and 41.
Menu **Flow** is described on the page 77.

21.3. The conductivity measurement

The meter enables conductivity measurement in μS / cm, mS / cm, S / cm. It is also possible to choose the concentration units ppm, ppt, ppo. The conversion is made to NaCl where 2mS / cm ~ 1g NaCl / l.
The meter enables measurement in 6 automatically changed ranges.
For conductivity this are:
0 ÷ 20 μS / cm ÷ 200 μS / cm ÷ 2mS / cm ÷ 20 mS / cm ÷ 200 mS / cm ÷ 2 S / cm.
For concentration this are:
0 ÷ 10 ppm ÷ 100 ppm ÷ 1 ppt÷10 ppt ÷ 100 ppt ÷ 1 ppo.
To increase the accuracy of the measurements two measuring frequencies were used 64 Hz and 1200 Hz. The conductivity of the solutions is changing together with the temperature. To enable comparing the results made in different temperatures the temperature compensation is used. **The temperature compensation in conductivity meter takes changes of the solution conductivity into consideration and not the changes of the electrode characteristics.** Knowledge of changes of the solution with the temperature changes is required.
During measurements with temperature compensation the result is counted automatically to the reference temperature T_r. The T_r value is automatically set to 25°C, as the most often taken into consideration, it may be changed in range 0 ÷ 50 ^{o}C. If the measurement should be done without the temperature compensation it should be done in temperature equal to T_r or introduce the coefficient α = 0 % / °C. For NaCl in temperature close to 25 °C the α = 2 % / °C. There are solutions in which the change of the conductivity together with the temperature change is more or less than 2 % / °C, ex. for 10 % HCL it is 1.56, 50 %; H_2SO_4 - 1.93, 30 % HNO_3 - 30 % / ^{o}C. The influence of temperature change to the conductivity change is different for different solutions.

The most accurate measurement is measurement made in constant temperature equal to 25 ^{0}C .

In practice the α coefficient may be determined with simplification that on the value of this coefficient greater influence has the temperature change than changes in the composition of the salts and their concentration (what shows the data in table 5).

To determine the coefficient one should:

1. Take the solution, which conductivity will be measured in temperatures different than 25 ^{0}C
2. Bring the solution in the lab to 25 ^{0}C and measure it's conductivity (**G_{25}**).
3. Change the temperature of the solution **Tx** to other value ex. 20 ^{0}C.
4. Turn the meter to manual temperature compensation by disconnecting the temperature probe from the meter.
5. Enter with the keyboard temperature value 25 ^{0}C.
6. Again measure the conductivity of the solution (ex. in 20 ^{O}C) This value will be different than in 25 ^{0}C (**G_{xT}**).
7. Determine the α coefficient using the formula:

$$\alpha = \text{오류!}$$

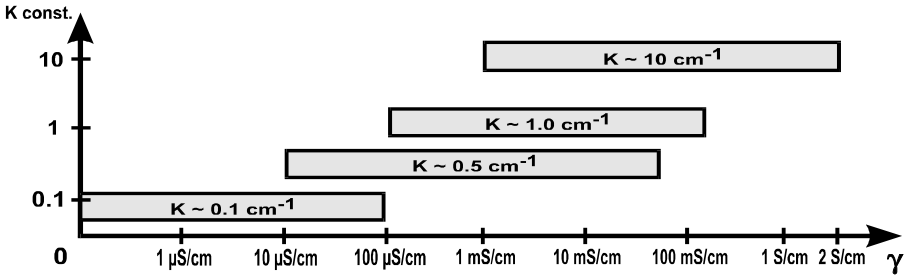
where: **T_x** - value of the changed temperature in ^{0}C
G_{25} - conductivity measured in 25 ^{0}C.
G_{Tx} - conductivity measured in temperature **T_x**

This same should be done reducing the temperature to ex. 15, 10 and 5 ^{O}C, taking down the counted values of α coefficient. This same may be done raising the temperature of the sample.

During measurements in temperatures different than 25 ^{0}C, before starting measurement, it is necessary to introduce the received α coefficient for the existing temperature

21.3.1. Making the measurements

Before starting measurement it is necessary to introduce the necessary measuring parameters, to do so it is necessary to enter the parameters screen, choose the unit, resolution, kind of measuring screen and way of temperature compensation. Introduce the reference temperature T_r and α coefficient according to the description in point "Screen of the conductivity meter parameters". The conductivity measuring range in **CX-700** series meters is 0 – 1999 mS/cm. The meter co-operates with conductivity cells with constant K = 0.010 ÷ 9.999 cm^{-1} and BNC-50 connector. Depending on the required measuring range it is necessary to choose the right cell with constant K which enables receiving correct results, to choose it one may use the chart on the next page. Beyond the range the cell looses it's linearity and the results have greater error.



Accurate measurements in the whole range are possible with use of 3 different conductivity cells.
The cell with constant K ≈ 0,1 cm $^{-1}$ should be used for measurements of ultra pure and redistilled water.

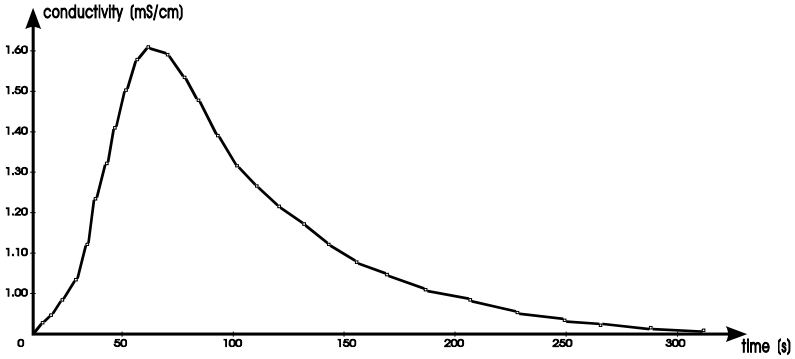
The conductivity cell should be connected with the BNC-50 connector marked with **cond** symbol. The cell should be calibrated (according to "Calibration" chapter, page 17 and 70) In case of measurement with automatic temperature compensation the probe should be connected with the **temp** connector.
To make the measurement it is necessary to:

- open the measuring screen of the conductivity meter;
- immerse the cell in the solution – don't touch the walls and bottom of the vessel;
- in case of automatic temperature compensation immerse also the temperature probe.
- In case of manual temperature compensation it is necessary to check on the measuring screen weather the introduced temperature in menu **Measure** corresponds with the temperature measured with thermometer.
- after stabilisation read the result.

During work with cell it is important to pay attention weather there are no air bubbles in the cell. To receive stable results it is recommended to store the cell for few hours before the measurement in water, especially this is required in case of distilled water measurements.
The conductivity probe maintenance mainly consists of accurate washing the inside of the measuring cell with distilled water. **It is forbidden** to clean the platinum electrodes mechanically.
The conductivity probe with broken measuring cell can't be used for further measurements because the constant K is greatly changed, the result is unstable and the influence of placing the cell in measuring vessel greatly changes the result.
During measurement without temperature compensation the temperature of the measured solution should be brought to the reference temperature 25°C. To enable continuous observation of the conductivity changes it is advised to use the graphic measuring screen. The resolution choice in menu **Measure** enables shortening the result stabilisation time. The longest time is during measurement with resolution 0,005%.

21.4. Flow measurement with conductometric method

The meter has a function of flow measurement of small water courses with conductometric method. The portable versions CX-732 and CX-742 enable using this function during work in the field. The conductometric method is characterised by simplicity of making and high accuracy confirmed in different field conditions. Significant shortening of the measurement time in comparison with traditional methods is an additional trump. The meter ensures high precision of the measurement and full automatisation in collecting the data and calculations. The conductometric measurement method is very useful specially for courses with not stabilised bed, small depth, overgrown with vegetation or with significant turbulence. In all this places traditional methods of measurement encounter some difficulties and the received results are burdened with large errors. This method may be used in small courses with very slow flow and in mountain streams with very fast current. It enables also measurements of spring efficiency etc. The width of shallow courses may be up to 4m with depth up to 0,5m. The correct results may be achieved by flow values from about 0,05 l/s to 20000 l/s. The accuracy depends on the exterior conditions.
The theoretical basics of this method were worked out in the 1920's and now days thanks the development of the conductivity measuring methods it is used more widely. The theoretical basics were created by: Barbagelata (1926), Aastad, Sognen (1928, 1954). Making the measurement requires preparing a concentrated electrolyte solution called a **„original solution"**, diluted electrolyte solution prepared on the basis of the original solution called a **„derivative solution"** and sample of water taken from the measured course. The original solution is a solution of table salt. The derivative solution is made of part of the original solution diluted with water to known specific concentration. The original solution is poured into the measured water course, the derivative solution is used only during the calibration which is necessary for obtaining the final result.
After pouring the original solution to the water course a change of conductivity value is noticed and stored by the meter in the measuring series form. An example of a curve which shows the conductivity changes after pouring the original solution may be seen on the picture 39.



Pic. 39

The next thing is the calibration with the derivative solution. This action is based on adding strictly specified portions of this solution to the water sample taken from the stream. After making the above mentioned actions it is possible to make the calculations of flow in l/s. The calculation is done automatically on the basis of the conductivity measurement of the course and calibration, after entering the right data from the menu. The meter enables accurate measurement of the conductivity and precise taking of measurement series into memory with short time intervals, what is the basic condition of the correct flow calculations. The received curves may be stored in the memory (identical like series) or sent to the PC or printer.

Below are formulas from the literature given, on their basis the meter calculates the flow.

1. Formula for calculation of relative concentration of the original solution in the sample of water taken from the course during calibration.

where: RC - relative concentration of the original solution
V_{RW} - volume of the derivative solution added to the sample of water added to water from the course during calibration
RC_{RW} - relative concentration of the derivative solution
V_K - volume of the water sample used for calibration

$$RC = \frac{V_{RW} * RC_{RW}}{V_k + V_{RW}}$$

2. Formula for flow calculation:

where: Q - flow
V_P - volume of the original solution poured into the course

$$Q = \frac{V_p}{\int_{t_0}^{t_n} RC_t * dt}$$

21.5.1. Preparation of the solutions

1. Prepare the **original solution** by diluting the table salt (NaCl) in distilled water or other (even the water from the course may be used). Knowledge of this solution concentration isn't necessary, usually solution with about 20% concentration is used it is made by adding 200 g NaCl to 1 dcm^3 of water. **In practice for work in the field a 5l container of water with 1 kg diluted salt is taken.** About 50 cm^3 (from 25 to 75 cm^3) of the original solution for each dcm^3 of the forecasted flow is needed.

2. Prepare the **derivative solution** by diluting the original solution with water. Diluting with distilled water enables using the calibration solution for few flow measurements made from different positions with use of this same original solution.

It is necessary to accurately define the **relative concentration** of the derivative solution, assuming that the relative concentration of the added thinner = 0 and the original solution = 1.
It is possible to prepare the derivative solution with 10 %, or 20% concentration.
Usually a solution with 20% concentration is made by adding to 400 cm^3 of water 100 cm^3 original solution.
Next following actions are made: preparation of the meter, measurement, calibration and flow calculation.

21.5.2. Preparation of the meter

Before the planned work in the field it is important to remember about charging the batteries. To the **cond** and **temp** connectors connect the conductivity cell and temperature probe. For making work easier it is advised to place the sensors, especially in case of measuring wide courses, on a jib. During the measurement the cell should be hold horizontally to the bottom in opposite direction then the water flow direction. The water has to fill the measuring cell and flow out through the holes. That's why a cell with bell shaped cell should be used.
Turn the meter on with **OFF/ON** switch and act according to point 21.5.3.

21.5.3. Practical information about making the flow measurement

The measurement has to be done by two people, one is pouring the original solution to the measured course and the second one is making the measurement. The time of making the measurement is from 3 to 10 minutes and depends on the experience. On the straight part of the river bed, the best would be with strong turbulence, it is necessary to choose the place of pouring the original solution. The next thing is choosing the place of measurement. The easiest way of doing it is pouring a dye and determine the place where it was completely mixed with water. The measuring position should be in about 2 to 3 times larger distance. One of the persons should prepare the meter, enter the parameters and place the cell and probe in the course. The second one in the earlier marked place should pour the original solution to the water. It is important to pour all solution at one time and possibly in one place, that's why a container (bucket) with wide hole should be used and not a bottle. The measurement should be observed on the graphic screen, what will make the analysis of changes easier. After pouring the original solution to the course the person which is making the measurement should start taking a series by pressing the **START** button in the moment when the conductivity starts changing. From this moment the results are stored in the memory, on their basis the meter will determine a measuring curve. Earlier starting of the series graph will be flat and **before starting the flow determining** it will be necessary to delete the unnecessary measurements to avoid errors. Taking the series should be stopped when the value will be close to this before the measurement. **The shape of the curve of conductivity measurements results informs weather the measurement was made in the correct way. The correct curve is characterised by very quick grow of the value to the maximum and next slow falling to the level from beginning** (pic. 39)**.** If the curve differs significantly from this pattern it is necessary to repeat the measurement witch changed volume of the original solution.

Way of action during the measurement was described below:

1. Choose the conductivity meter function and enter the parameters screen.
2. Open the menu **Measure** and in position ***"Function"*** choose *"flow"*. In position ***"Range"*** choose *"manual"* and with numeric buttons 1 ÷ 6 choose the range right for the forecasted conductivity value, usually it is 0 ÷ 2 mS. After closing the menu **Measure** on the upper stripe a **Flow** menu will be displayed.
3. Open the **Flow** menu in position ***"Measurement reg."*** With numeric buttons enter the register number to which the results of measuring series will be taken. The chosen register is marked with a frame in the information window
4. In the position ***"Mode"*** with ⇐ , ⇒buttons choose *"measure"***.**
5. In the position ***"Original volume"*** with numeric buttons enter volume of the original solution poured to the water course.
6. in position ***"Interval"*** with numeric buttons set the time interval between measurements 1 ÷ 5s. Usually 2s are set.
7. Enter the graphic measuring screen of the conductivity meter.

8. Immerse the conductivity cell and temperature probe in the water course. During the measurement the cell should be hold horizontally to the bottom in opposite direction then the water flow direction. The water has to fill the measuring cell and flow out through the holes on it's end**.** If measurements in wide courses are made use a jib.
9. Pour the original solution to the course, press the **START** button. Taking of the measuring series will start.
10. After passing the maximum of conductivity value and it's lowering to value about 20% higher than this before pouring the original solution one may finish taking the series by pressing the **ESC** or **ENTER** button. After displaying a window "Finish series ?" press **ENTER.** The meter will store the curve of the flow in the earlier chosen register.
11. Enter the main screen, choose **Prefs** and in menu **Result** choose the register to which the series was taken. In position ***"Screen"*** choose *"graphic"*, and in position ***"Output"*** choose *"screen"*. Analyse the curve shape and it's parameters. The maximal value should be about 2 – 3 times larger than value before pouring. The shape should be close to the pattern showed on the pic. 39. If those two parameters are very different the measurement should be repeated and the volume of the original solution should be increased or lowered.

21.5.4. Calibration

Prepare a vessel and pipette, if possible automatic (one portion). **From the measured course take to the clean vessel a sample of water – about 0,5 to 1 dcm^3 volume.** It can't be contaminated with the solution poured into the course. The temperature of the sample should be close to the real temperature of the water in the course. If the environment temperature may cause quick change of the sample temperature the vessel during further actions should be kept in course from which it was taken. Using the pipette add portions of the derivative solution. For 20% original solution and derivative solution with 0.1 concentration and the measured sample of water from the course 1 dcm^3, it is necessary to add 0.5, 1 or 2 cm^3· Of the derivative solution. **In practice to 0.5 l of water from the course add portions of 1 cm^3 20% derivative solution.**. Carefully stir the sample after each adding of the portion than store the measurement result in the meter's memory acting according to below given order. **It is necessary to add at least 5 to 7 portions of the derivative solution and finish when the received result will be close to the maximal value received during the flow measurement.** The larger will be the number of added portions the more accurate will be the calibration. The added portions have to be identical (Volume).

Way of action during calibration:

1. Choose the conductivity meter function and enter the parameters screen.
2. In menu **Measure**, position ***"Function"***, with ⇐ , ⇒ buttons choose *"flow"*. After closing this menu on upper stripe a new position will be displayed **Flow.**
3. Open the **Flow** menu, in position ***"Reference re."*** With numeric buttons enter the register number, in which the results of calibration will be gathered. The chosen register is showed in bracket in information window.
4. In position ***"Mode"*** with ⇐ , ⇒ buttons choose *"calibration"*.

5. In position ***"Sample volume"*** with numeric keys enter the volume of the sample taken from the course.
6. In position ***"Secondary conc."*** With numeric keys enter the relative concentration of the derivative sample added to the sample taken from the water course.
7. Enter the graphic measuring screen of the conductivity meter, this will make the observation much easier.
8. Connect the cell and temperature probe with the meter and immerse it in the vessel with water taken from the course.
9. Measure the conductivity of the sample after stabilisation of the result press **START** button. In this moment the conductance of the sample was stored.
10. With pipette add first portion of the derivative solution and observe the value on the screen.
11 After stabilisation on higher level press **HOLD** and enter with numeric keyboard the volume of added portion.
12 Add next portions and act like in point 10.
13. Stop adding when the conductivity result will be close to maximal value measured during the course measurement. In the table **"Flow"** under the "Total volume" the total volume of the added portions will be displayed.
14 After finishing the calibration press **ESC** or **ENTER** and after displaying the window with question "Stop calibration of the sample ?" press **ENTER**. The meter will store the calibration curve in the earlier chosen register.
15. choose "Prefs", menu **Results** and enter the numbers of registers with measurement and calibration. Set ***"Format"*** *"graphic"*, ***"Output"*** *"screen"*. On the screen properly scaled graphs of the measurement and calibration will be displayed. It is possible to check weather the final point of the calibration graph is close to the maximal value of the course flow measurement. The zoom function may be used only on flow graph.

21.5.5. Calculating the flow

Before starting the calculation it is necessary to check weather the shape of the measurement curve is similar to this showed on the picture 35 and especially weather the curve is rising from the beginning of the graph. If not it is necessary to enter the „Prefs" menu **Result** and in the way described in chapter "The graphic measuring screens" delete the flat beginning of the graph.

To calculate the flow it is necessary to:

1. From the main screen choose the **Cond** function and enter the parameters screen.
2. If one flow measurement and one calibration was made choose menu **Flow**, position *"Calculation of flow"* and press the **ENTER** button. On the screen a result in l/s will be displayed. If few measuring series were made and were stored in separate registers before starting the calculation it is necessary to choose the number of register for which the flow should be calculated and the number of calibration curve.

21.5.6. Errors

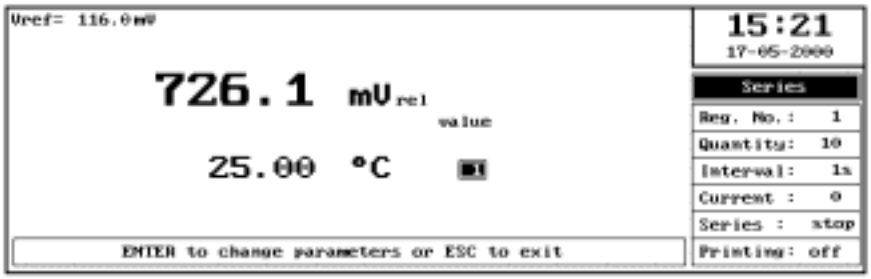
In water flows with very large turbulence air bubbles occur, they may cause an error to occur, this bubbles are staying on the electrodes in conductivity cell. In this case it is necessary to check the conductivity cell and in case of big troubles repeat the measurement. Immersing the cell for a short moment in a water with detergent (washing up liquid) and than washing it in distilled water will greatly decrease this problem. An additional error may occur in case of periodical changes of the conductivity during the measurement (piping away some contaminants). Not always the poured solution is accurately mixed with the water in this course, usually it is connected with slow flow or to small or to large volume of the poured original solution. In this case it is necessary to change the volume of the poured solution. In case of greater accuracy requirements it is possible to repeat the measurement few times in this same place and pouring this same volume of the original solution and measuring the conductivity on different depths. If the results differ a mean value should be counted. As a result of temperature change in the measured course an additional error may occur. It may be eliminated by using the automatic temperature compensation and introducing the right α coefficient. The pipettes and vessels are calibrated for distilled water. Because of other density and sticky of salt solutions a measurement error may occur. According to literature during field measurements this kind of errors may be omitted.

22. mV METER

22.1. mV measuring screens

22.1.1. The Numeric screen

The numeric mV measuring screen is showed on the pic. 40. The description is in “The numeric and graphic measuring screens” chapter on page 13. Differences are listed below.

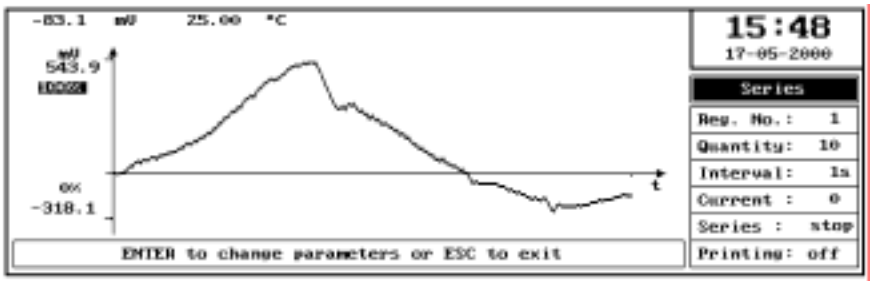


Pic. 40

The results of mV measurement are displayed on the left side of the screen. Next to the result a unit symbol is displayed: **mV**. There is possibility of relative measurements in relation with reference voltage. The description of entering the reference voltage is given in the chapter ”Voltage measurement” page 83. In case of taking the V_{ref} into consideration next to the result and unit symbol **mV**, a "**rel**" (relative) symbol is displayed.

22.1.2. The graphic screen

The graphic measuring screen is showed on the pic. 41. The measurement result is showed on the screen in form of graph. On the vertical axis the whole measuring range ±1999 mV is marked, and on the vertical axis time is showed. The rules of creating the graph on this screen and way of using the zoom function were given in the “The numeric and graphic measuring screens” chapter on page 13.



Pic. 41

22.2. The mV meter parameters screen

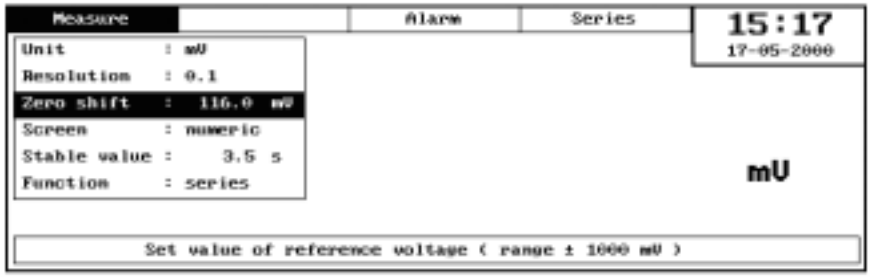
The mV meter parameters screen (pic.42) includes:

- **Measurement**
- **Alarm**

and interchangeably

- **Series, Titration or Multiplex.**

Moving between the menu with ⇐ or ⇒ buttons. Opening menus with **ENTER** or ⇓ button. Closing the menu with **ESC** or ⇑ button. On the right side of the screen there is a **mV** symbol.



Pic. 42

22.2.1. Menu Measure

The opened menu **Measure** includes:

"Unit"	-	„mV" no possibility of change
"Resolution"	-	"0.1", "1".
"Screen"	-	*"graphic", "numeric"*.
"Zero shift"	-	the reference voltage V_{ref} in the range ±1000 mV. The measurement result will be displayed in relation with V_{ref} voltage.
"Compensation"	-	*"automatic", "manual*". Changing the parameters with ⇐ or ⇒ buttons. In case of choosing the manual compensation additionally a window for entering the temperature value is displayed. This value is entered with 0 ÷ 9 buttons and confirmed with **ENTER**.
"Stable value"	-	enables entering a time during which the meter is checking weather the criterion of stable value was fulfilled. The factory setting is 5 s. The value is entered with numeric keys. The Stable value criterion was described on the page 14.
"Function"	-	*"series", "titration", "multiplex."*

The values are entered with numeric keyboard. Description of the ways of introducing the V_{ref} is given below in the point "Voltage measurement".

22.2.2. Menu Alarm

The menu **Alarm** is described in the "Alarm, relays" chapter, page 35.

22.2.3. Menu Series, Titration, Multiplexing

This menus were described adequately on the pages 25, 37 and 41.

22.3. Voltage measurement

Before starting the voltage measurement it is necessary to enter the parameters screen set the resolution, kind of measuring screen and eventually enter the reference voltage V_{ref} in menu **Measure**, position ***"Zero shift"***.
If during the measurement a **CAL** button will be pressed in the upper left corner of the measuring screen a "V_{ref} =..." sign will be displayed and the reference temperature entered in the menu **Measure** and the displayed result will be the difference between the measured value and V_{ref}. Return to the normal measuring mode by pressing the **C/CE** button. If during the measurement a **HOLD** button will be pressed and next the **CAL** button than in the upper left corner of the screen a "V_{ref} =" and value of the holded result is displayed. The result of the measurement is the difference between currently measured value and the V_{ref} (the holded value) and the measurement is back active. In both cases next to the **mV** symbol a **rel** symbol is displayed. On the graphical screen the V_{ref} voltage is not taken into consideration.

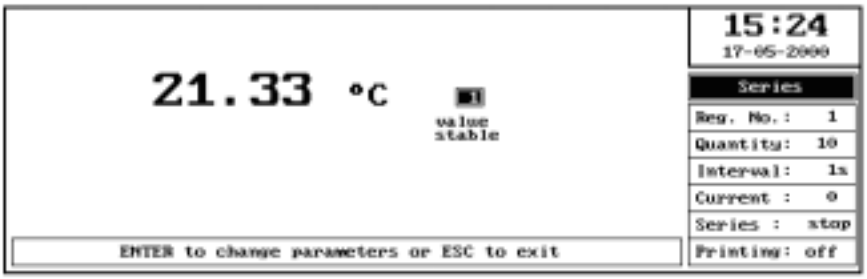
To measure the voltage one should:
- connect to the meter the Redox electrode
- open the measuring screen of the m meter;
- read the result after the stabilisation.

23. THERMOMETER

23.1. Measuring screens of thermometer

23.1.1. 22.1.1. The Numeric screen

The numeric temperature measuring screen is showed on the pic. 43. The description is in “The numeric and graphic measuring screens” chapter on page 13. Differences are listed below.

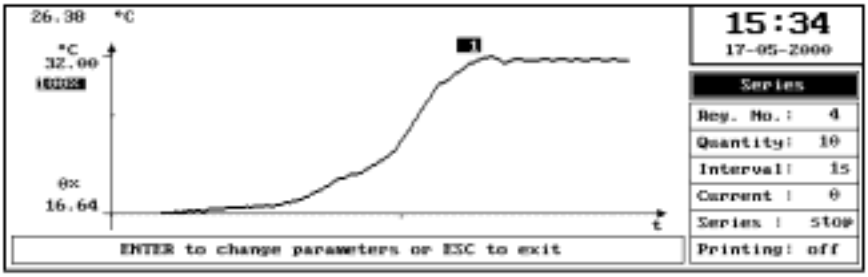


Pic. 43

The results of temperature measurement are displayed on the left side of the screen. Next to the result a unit symbol is displayed: **°C, °F or K**. The unit is changed on the parameters screen menu **Measure.** Together with the change all calculations are made on the newly introduced unit. Similarly in the menu **Alarm** the entered parameters are automatically changed. Below the clock a **temp** symbol is displayed or table of measuring series or titration.

23.1.2. The graphic screen

The graphic measuring screen is showed on the pic. 44. The measurement result is showed on the screen in form of graph. On the vertical axis the whole measuring range ±200 °C is marked, and on the vertical axis time is showed. The rules of creating the graph on this screen and way of using the zoom function were given in the “The numeric and graphic measuring screens” chapter on page 13.



Pic. 44

23.2. The thermometer parameters screen

The thermometer parameters screen includes:

- **Measurement**
- **Calibration**
- **Alarm**

and interchangeably

- **Series, Titration or Multiplex.**

Moving between the menu with ⇐ or ⇒ buttons. Opening menus with **ENTER** or ⇓ button. Closing the menu with **ESC** or ⇑ button. On the right side of the screen there is a **temp** symbol.

23.2.1. The opened menu **Measure** includes(pic. 45):

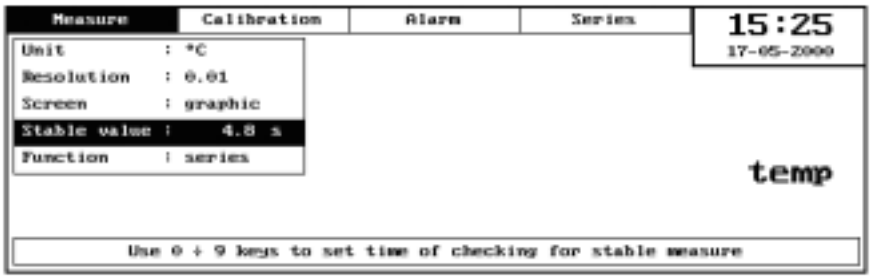
"Unit"	- *"°C"*, *"°F"*, *"K* change with ⇐ , ⇒ buttons.
"Resolution"	- *"0.01"*, *"0.1"*, *"1"* change with ⇐ , ⇒ buttons
"Stable value"	- enables entering a time during which the meter is checking weather the criterion of stable value was fulfilled. The factory setting is 4,8 s. The value is entered with numeric keys. The Stable value criterion was described on the page 14.
"Function"	- *"series", "titration", "multiplex."* change with ⇐ , ⇒ buttons

23.2.2. Menu Calibration

The **Calibration** menu and way of acting is described in the "Calibration", page 17, on the basis of pH meter. Menu of the thermometer is identical except the unit. In thermometer there is possibility of one point calibration to compensate the zero shift of the temperature sensor. The way of determining and introduction of it's value to the meter's memory is described below.

23.2.3. Menu Alarm

The menu **Alarm** is described in the "Alarm, relays" chapter, page 35.



Pic. 45

***23.2.4. Menu* Series, Titration and Multiplex.**

The menus are described adequately on the pages 25, 37 and 41.

23.3. Determining the zero shift of the temperature probe

For determining the zero shift of the temperature probe a mixture of distilled water with ice is used as temperature sample. To determine one should:

- prepare the mixture of distilled water with crushed ice (if possible in thermos flask);
- immerse the temperature probe in the prepared solution, continuously stir it;
- enter the parameters screen, menu **Calibration** and in position "cal. point" enter 0 °C;
- next act like during multipoint calibration.

The zero shift may be determined in any temperature by measuring temperature with a model thermometer and entering „cal. point" value of the measured temperature. Knowing the zero shift value it is possible to introduce it manually in the manual calibration mode as one point characteristic. In the „cal. point" bracket enter the value of model temperature and in the bracket „result" the temperature measured with not calibrated probe.

23.4. Temperature measurement

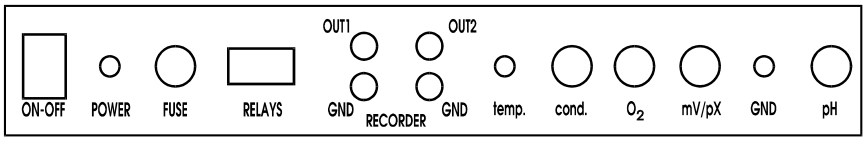
Before the temperature measurement connect the temperature probe with the chinch connector marked with **temp** symbol. Next enter the parameters screen and choose the unit, resolution and kind of measuring screen.

Way of acting during temperature measurement:

- connect the temperature probe.
- enter the temperature measuring screen or the chosen measuring screen on which the temperature will be observed.
- immerse the probe in the measured solution at least 3 cm deep.
- read the result after it's stabilisation

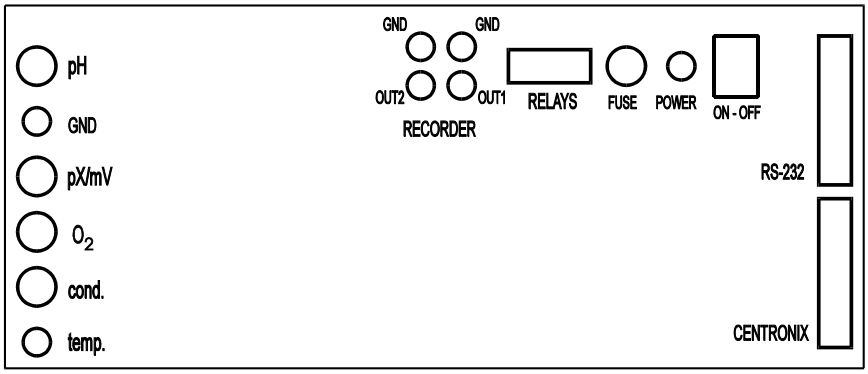
24. CONNECTING THE ELECTRODES, PROBES AND PERIPHERAL EQUIPMENT

The back side of the meters CX-731 and CX-741 with the connectors is showed on the picture 46. The connectors of meters CX-732 and CX-742 are showed on the picture 47.



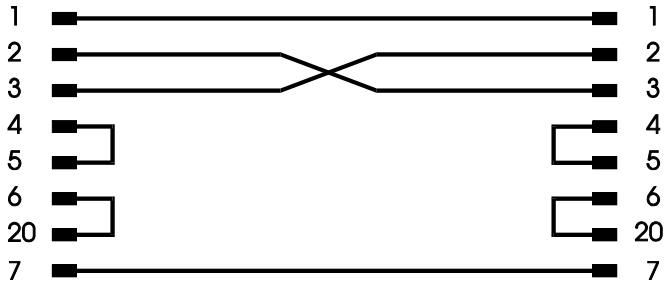
Pic. 46

1. ON-OFF - switching the meter on and off,
2. POWER - power adapter socket,
3. FUSE - fuse 500 mA,
4. RELAYS - 9 pin connector – relays output,
5. RECORDER - 4 laboratory terminals for connecting with recorder (OUT1, OUT2, GND, GND),
6. temp. - temperature probe connector,
7. cond. - BNC-50 connector for conductivity cell,
8. GND - socket for ion reference electrode,
9. mV/pX - BNC-50 connector for ion measuring electrode or end for voltage measurement,
10. GND - pH reference electrode connector,
11. pH - BNC-50 connector for combined pH electrode or measuring pH electrode,
12. CENTRONICS - printer slot,
13. RS-232 - slot for connecting the PC or printer.



Pic. 47

The meter is prepared for work with electrodes and cells equipped with BNC-50 plug and with temperature sensor equipped with Chinch plug.
The Centronics connector enables connecting the printer. The meter is prepared for work with printers in EPSON standard.
The RS-232 connector enables connecting the printer or data transmission to the PC Below please find enclosed a scheme of the connections of the RS-232 output in the meter with the PC.



Pic. 48

The meter has 4 connectors for connecting with recorder.
For pair of connectors OUT1 and GND an analogue signal of the temperature measurement (1 mV/0.1 ^{O}C) is sent.
For pair of connectors OUT2 and GND an analogue signal of the measurement of the rest of the functions is sent with value:

- for pH, pX and repeated the measured voltage;
- for conductivity meter the voltage is changing serially from 0 to 2V on each of the ranges. Information about the range change isn't supplied..

The PC, Printer or recorder should be connected when the meter is switched off. During changing the electrodes and probes switching the meter off isn't necessary.

25. POWER, STORING, CONSERVATION

The meter is powered with stabilised external power adapter.:
CX-731 and CX-741 - 6V/500mA,
CX-732 and CX-742 - 8V/500mA.
The portable has an internal rechargeable batteries 6V/2Ah.
All stored characteristics and parameters are stored in the EEPROM type memory, which doesn't require power. The clock has own battery which work time is about 10 years without switching the meter on..
The memory of the stored series of measurements is kept by special battery which enables keeping all this data for 4 months without charging. The automatic electrode switch gas own external power adapter (12V).

25.1. Charging the batteries

25.1.1. The battery supporting the registers memory

The registers memory is supported by 3,6V battery. Charging during the work with power adapter. The battery is protected against overcharging. In case of long breaks between measurements it is advised to switch the meter once for 2 moths for about 8 hours to charge the battery.
Connecting the power adapter without switching the meter on won't charge the battery.

25.1.2. Batteries which power the meter.

The fully charged batteries enable about 7h of continuous work (6V / 2Ah). Discharging is signalised by LOBAT sign in the place of clock. After few minutes from displaying this symbol the meter may stop working. Total discharging of the battery ensures it's best charging and longer operating. If the batteries weren't fully discharged it is advised to leave the meter switched on till total discharging of the batteries.
This batteries are charged by connecting the power adapter without switching the meter on. The time of charging is about 24h. If the meter is switched on the batteries are charged much slower.

25.2. Storing and conservation

The meter is not fully waterproof, that's why it's flooding may cause serious damages. The meter should be stored in a dry place not to close to heat sources. When pressing the keys it is forbidden to use sharp instruments ex. end of the pen. From time to time one may use a damp cloth and than wipe it dry. If the housing is dirty it may be cleaned with cloth with warm water and detergent.

W A R R A N T Y

The "ELMETRON" company ensures a 12 months warranty for the multifunction meter CX-731, CX-732, CX-741, CX-742* number:

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In case of damage the producer will repair the meter within 14 days from the day of delivery.
The warranty doesn't cover the damages caused by usage not in conformity with the users manual, flooding, using wrong power adapter, mechanical damages and damages caused by repairs made by unauthorised persons.

The pH electrode, conductivity cell, oxygen sensor have one year warranty of the producer.

NOTICE: Before sending the meter to us please contact the firm by phone or email.
When sending the meter, the used electrode, conductivity cell, oxygen sensor, temperature probe and power adapter and warranty with date of purchase should be also included.

Date of production.....
Date of sale.....
Date of warranty expiry.....

* cross out the unnecessary

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