

CNC ELECTRIC DISCHARGE MACHINE

BP93p



zapbp.com.pl

Zakład Automatyki Przemysłowej B.P.

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1. GUIDELINES REGARDING USER SAFETY

- a) The precondition for the safe and efficient operation of the machine is to read this operation manual carefully and strictly follow all safety instructions contained therein.
- b) Prior to the first use of the machine, undergo appropriate training.
- c) The BP93p Electric Discharge Machine must be used, according to its purposes, exclusively.
- d) Before commencing work, make sure you are well familiar with operating the machine and its correct use.
- e) Before each maintenance and adjustment of the BP93p machine, disconnect it from power supply.
- f) Always disconnect power supply, before filling or changing water in the tank.
- g) Should water from the tank be spilled, clean it with the machine disconnected from power supply.
- h) Apply integrated spot lighting, in order to make sure your workpiece is well lit.
- i) Remove all freely moving elements from the machine, in order to make sure that it can be transported safely.
- j) Do not use the machine, if its guard is damaged.

2. INTENDED USE

The BP93p cavity type electrical discharge machine is intended to perform electron discharge machining of all types of steel, cast iron, alloys, aluminium, and other electro-conductive materials. It is used primarily to produce injection moulds, blanking dies, and when machining tools after thermal and/or chemical treatment.

The PP15 control system applied in the machine enables the following:

- a) Creating executive programs based on G- and M-codes;
 - Carrying out a drilling process: along any straight line in the machining space; along any straight line, including a rotating movement of the electrode (A-axis); along any arc, within the XY-plane; spirally, along the Z-axis;
 - Programming activation/deactivation of additional functions, when drilling, such as: vibrating motion of the electrode; orbiting around a circle; and orbiting around a square (applicable to the Z-axis only);
 - Programming selection of one of the ten available systems of working coordinates;
 - Declaring execution of n cavities in the pre-defined direction;
- b) Communicating with a PC, via RS232, Bluetooth, or an SD card;
- c) Storing up to 20 executive programs on an SD card.

3. THE UNIT INCLUDES:

Standard version:

- A mechanical frame with a co-ordinate table and a tank;
- An oscillator with programming and controlling systems;
- A petroleum tank with a set of pumps and filters;
- A petroleum level sensor.

Accessories:

- TE-1 EDM lathe,
- GO-3 rotary head,
- MD-1 Micro EDM machine,
- UR-1 and UR-2 adjustment handles,
- WS-1 and WS-2 spinning heads,
- PDT-1 and PDT-4 rotary tables.

4. TECHNICAL PARAMETERS

BP93p <i>for diamond discs</i>		
MACHINE	The area occupied by the machine	0.9m ²
	Dimensions	750x700x1900mm
	Standard tank	610x400x200mm
	Working table	235x335mm
	Travel along the XYZ-axis	250x180x180mm
	Distance between the table and spindle (min/max)	70/250mm
	Height of workpiece (max)	140 mm
	Weight of workpiece (max)	50 kg
	Weight of electrode (max)	4 kg
	Accuracy of positioning	0.02 mm
	Electric drive in axis	X, Y, Z
	Drive	Stepper motors 1.8°
	Electrode material	Cu, graphite
	Total weight (without petroleum)	330kg
TANK	Volume	160 litres
	Dielectric fluid	Petroleum, paraffin oil
	Filtering medium	Paper
OSCILLATOR	Drilling current	30A
	Electrode working voltage	250V
	Supply voltage	3x380V
	Power input	1.5kW
	Petroleum level sensor	Volumetric

5. DESIGN

The welded structure of the table supports a flagstone and the mechanical frame of the machine. Next to it, there is an oscillator cabinet with a reader. Under the table, there is a tank with a pump and filter.

5.1. MECHANICAL SECTION

This section includes:

- a table,
- a tank with pump, filter, and supply and discharge conduits for dielectric fluid,
- a mechanical frame comprised of the following components:
 - foundation (a cast-iron truss),
 - adjustable legs screwed to the foundation,
 - a trolley,
 - linear ball bearings in the X-axis that connect the foundation to the trolley,
 - linear ball bearings in the Y-axis that connect the foundation to the table,
 - a measuring power screw in the Y-axis,

- a handle with a nut for the Y-screw, screwed to the trolley,
- a measuring power screw in the X-axis,
- a handle with a nut for the X-screw, screwed to the trolley,
- a stepper motor Y,
- a stepper motor X,
- a play elimination unit in the X- and Y-axis, with a weight suspended on a tensioning cord,
- a brake in the Y-axis,
- a brake in the X-axis,
- a table with T-shaped grooves, threaded holes, and a rubber seal to connect to the tank,
- a tank with a distributor,
- distributor valves with hoses,
- overflow and discharge hole with gates,
- L-shaped frame with electric equipment and guards,
- a head comprised of the following elements:
 - a linear ball bearing in the Z-axis with a strip with an electrode holder being its integral part,
 - a bed connected to the L-shaped frame that holds a linear ball bearing,
 - a handle that holds a nut for the Z-screw, screwed to the strip,
 - a measuring power screw in the Z-axis,
 - a stepper motor Z,
 - a head guard,
- a strip with an electrode holder.

5.2. DIELECTRIC FLUID CIRCULATION

Under the table, there is a tank unit with a pump and filter. The entire unit can be pulled out to the front of the machine. The unit is connected to the machining tank by two hoses. The dielectric fluid contained in the tank is supplied through a filter paper, and then flows into the distributor located on the tank side. The distributor had three valves connected in parallel, one of which is dedicated to filling the tank, and the other two to washing out erosion product, during machining. There is an overflow and discharge hole, located on the discharge side – it enables complete discharging of the dielectric fluid, provided that an appropriate gate has been installed in the tank to keep the fluid at a desired level.

5.3. ELECTRICAL SECTION

This section includes:

- a) an oscillator cabinet with a microprocessor controller;
- b) a petroleum level and temperature sensor;
- c) electronic systems installed in the frame.

Attention!!!

Detailed schematic and assembly diagrams are available at the manufacturer's after expiration of the warranty period, if requested.

Description of operation

The synchronizer generates a rectangular travel of adjustable pulse time T and idle time t . It energises the inverter amplifier. The magnitude of current pulse in the 1-30A inverter depends on the set-point defined for the R142 potentiometer (CURRENT AMPLITUDE). The voltage level set for the potentiometer is compared to the voltage drop detected in the R191 resistor. The difference in the signal energises the T42 and T40 amplifiers, and the T44 terminal of power transistors.

Should there be a short circuit or irregular voltage drops between electrodes, the power supplied to energise the terminal is reduced. It is controlled by the following systems: T27, PO1, T29, T30, and US23. One of the electrodes is connected to the M potential (system earth). The other electrode is connected to the D110 current oscillator output and the so-called ignition spark oscillator, i.e. 250V keyed voltage, using the T192 transistor, synchronous with de-energising of the mentioned oscillator. Its operation is signalled by the lighting up of the IGNITION lamp.

The signal coming from the active electrode is supplied to the system that identifies and forms control runs of the motor, i.e.

T27, P01, R90, C36, US15	"SHORT CIRCUIT"	Retract electrode
T28, P02, R90, C37, US14	"OPERATION"	Stop electrode
T28, P02, R106, C38, US13	"SLOW DOWN"	Retract, if work efficiency has exceeded 90%

including the following signals:

US11	Periodic retracting
C ⁺	Positive rotation pulse
C ⁻	Negative rotation pulse

all of which are transferred to the reader and microprocessor controller system.

The reader is responsible for controlling displays, keypad, and meters assigned to each of the axes, as well as for energising stepper motors, according to the set program.

The signalling system collects information from a sensor that detects petroleum level and temperature at limiting switches, and from a thermistor installed on the inverter radiator. It signals erroneous statuses, by the flashing of an appropriate signal lamp. In the case of automatic working mode, the system shuts down the oscillator (T20, ST1) and generates an additional acoustic signal.

If the RC oscillator is activated, the inverter of the oscillator (US23) is shut down, while the T26 and D60 systems are also activated to generate the "OPERATION" - Stop motor signal, as well as the PK2 relay of the C100 capacitor powered by a 250V ignition resistor is also activated. In this mode, the synchroniser works for a shorter period of time, the T192 and T193 systems are activated, and the afore-mentioned inverter is deactivated. The signals that control the motor are generated in the same manner as the ones controlling the oscillator-based operation.

6. INSTALLING AND CONNECTING THE MACHINE

One must exercise extra attention and thoughtfulness, when drilling with the BP93p machine. Pay particular attention to the fire protection of both the machine and the room in which it operates, as sparks are produced that may come into direct contact with the dielectric fluid. The EDM machine must be installed in a separate room that meets the following conditions:

- Good lighting;
- Low level of noise;
- Good ventilation (it is recommended to extract the gases accumulating above the machine);
- Good fire protection (have a carbon-dioxide extinguisher available);
- Air temperature in the 15-25° C range;
- Medical protection (first aid kit);
- Fire protection: fire-fighting equipment should be placed in easily accessible places that are not exposed to hazards (as much as possible).

The machine must be positioned in such a way that there is convenient access to the main switch and all the components subject to periodic inspections. The machine must be subject

to period examination performed by a Sanitary and Epidemiological Station, in order to measure the level of electromagnetic field emission and define “hazard areas” in a given room.

Attention!!!

The warning signs compliant with PN-74/T-06260 must be located next to the entrance to the room where the machine operates. In addition, there must also be a site plan showing all locations where electromagnetic field intensity was measured.

After finishing work:

- travel by a specific value, to remove the electrode from the material (*Manual Mode [R]* -> *Travel -> By the value*),
- deactivate the main switch,
- drain petroleum,
- make sure there is no leak from the dielectric fluid tank,
- disconnect the plug from the mains,
- before leaving the room, make sure that fire extinguishers are in their proper places.

7. DESCRIPTION OF ADJUSTMENT RANGES PRESENTED ON FRONT PANELS



- 1) **CURRENT AMPLITUDE [A]** potentiometer: Variable adjustment of the discharge current amplitude, $I = \langle 1, 30 \rangle$,
- 2) **EFFECTIVENESS [%]** potentiometer: Drilling efficiency adjustment, $P = \langle 0, 100 \rangle$,
- 3) **SHORTING [%]** potentiometer: Adjustment of electrode retracting delay, resulting from short circuits or incorrect operation, $z = \langle 0, 100 \rangle$,

The knobs 2 and 3 are used to set the machine working conditions, in the automatic mode. The motor will continue lowering the electrode, until the required discharge factor has been exceeded. The motor is re-started, if the frequency of discharges is lower than the required factor, following material consumption and increasing the working gap. If the frequency of occurring short circuits is higher than the required short circuit threshold, the electrode is retracted, until short circuit is eliminated. Then, the electrode travels to the material again.

- 4) **PERIOD** switch: on/off period retracting of electrode (during of drilling). Function parameters (time of withdrawal and time of travel) are adjusted by means of potentiometers: **WITHDRAWAL**, **RETURN WORK**,
- 5) **IMPULS [μ s]** potentiometer: Variable adjustment of pulse time, within the range of $T_i = \langle 5, 1100 \rangle$,
- 6) **BREAK [μ s]** potentiometer: Variable adjustment of idle time, within the range of $t_p = \langle 5, 100 \rangle$,
- 7) **AUT. REG. BREAK** switch: Automatic adjustment of idle time. Pressing the key set the value of idle time, according to the configuration of the "BREAK" potentiometer. Idle time is extended to 100 μ s, if incorrect operation is detected. This function is applied, if drilling is carried out in difficult conditions. It results in an increased electrode consumption,
- 8) **VALVE** switch: on/off pulse spraying of the dielectric fluid. Function:
 - is activated only if period retracting of electrode is on.
 - provides pulse spraying from the nozzle connected to the periodically switching solenoid valve (for activated periodic withdrawal, the valve is switched on at the end of the electrode departure from the material),
- 9) **PUMP** switches:
 - **PUMP1** (bistable key): on/off pump 1 (the pump won't be activated if the current oscillator is turned off),
 - **PUMP2** (bistable key): on/off pump 2 (not installed in the standard),
 - **PUMP1!** (monostable key): on/off pump 1,
- 10) **RC GENER** switch: on/off the RC relaxation oscillator. It is used when the gap is silted up, or if there is an electrode gap generated, when working with a transistor oscillator. The RC generator must be used sporadically, as it considerably increases electrode consumption,
- 11) **SMOOTHING** switch: on/off a low-current oscillator $I = \langle 1, 3, 5 \rangle$ [A]. It is used to smooth drilled surfaces (roughness $R_a < 2 \mu$ m),
- 12) **GENERATOR ON** switch: activates the current oscillator (the current oscillator won't be activated in the event of an emergency signal [see subsection 16], an open bathtub or raised working space cover),
- 13) **GENERATOR OFF** switch: deactivates the current oscillator,
- 14) **STOP ENERGY**: emergency switch,
- 15) Ignition switch with a key that activates the control,
- 16) Signal lamps
 - *Ignition*: Signals operation of the ignition system. It is lit permanently, if there are no discharges. If there are, it is dimmed, and goes out, if electrodes are shorted.
 - *Work*: Signals the occurring of the set / more than the set number of discharges in the gap, and also stopping of the drive (electrode) in the automatic mode.

- *Shorting*: Signals the occurring of a short circuit and retracting of the electrode, in the automatic mode.
- *Dielectric level*: Signals low level of dielectric.
- *Dielectric temperature*: Signals the excessive temperature of dielectric.
- *Fire extinguisher*: Signals activates the fire extinguisher GG-1,
- *Heatsink temperature*: Signals the excessive temperature of current oscillator,
- *Fire extinguisher supply*: Signals the operation of a power supply unit for the fire extinguisher GG-1,
- *Power network*: Signals the presence of 230V mains voltage,
- *No phase*: Signals lack of phase.

17) The PP15 controller

8. REMARKS CONCERNING OPERATION

- a) Prior to commencing work, level the foundation with the cast-iron table.
- b) All non-varnished metal components must be protected against corrosion (lubricated with oil).
- c) The stepper motors used as drives work in the open feedback loop circuit. If motors working in that circuit are overloaded, it may result in measuring errors.
- d) Make sure that screws are clean and lubricated, and that drives corresponding to each of the axes work properly in full scale, prior to each operation, and particularly after downtime. If any irregularities are found, lubricate screws with molybdenum grease and repeat the action described above.
- e) Results displayed in readers must be treated as rough data. If it is necessary to obtain highly accurate data, use precise measuring equipment, e.g. measurement strips.
- f) Drilling results displayed on a reader are erroneous, which results from gap enlargement (parameter S_b) and electrode wear (function $f(Z_e)$). Therefore, when setting the depth of drilling, start with the following calculation, based on characteristics:

$$\text{DIMENSION}_{\text{entered}} = \text{DIMENSION}_{\text{required}} - S_b + f(Z_e)$$
- g) Prevent petroleum from soiling and make sure that the filter is not contaminated excessively. To that end, carry out period cleaning of the tank:
 - pump out the maximum possible quantity of petroleum to a separate container,
 - dry the tank, remove the lid, and disconnect the discharge line,
 - pour out the remaining old petroleum, remove silt, and clean the tank,
 - re-install and push the tank to its original location,
 - when pouring clean or settled petroleum into the tank, make sure that the drain hole is unplugged.

Attention!!!

It is not allowed to start and operate the machine, if its guards are open, or limiting switches locked.

9. GENERAL SAFETY PRECAUTIONS

- a) Only people that underwent appropriate training in the operation of the EDM machine are allowed to work with it.
- b) The operator should wear loose clothes, without any elements that could be trapped mechanically in the machine.
- c) The workpiece must be fastened to the table – it is not allowed to machine the piece, if it is held in hand.
- d) It is absolutely required to:
 - keep the place clean and tidy!

- keep third parties away from the machine, when it is in operation.
- e) Recommendations:
 - workstation should be equipped with individual medical kits for treating injuries.
 - workstation should be located in a well-lit, quiet, and clean room, which ensures that the operator can focus on their work and do it with precision.
 - make sure that third parties do not have free access to the machine.
 - workstation can be secured with a lathing mesh (for example) to protect it against radio noise. Similarly, the mesh can be used to cover windows (thus creating the Faraday cage).
 - if the operator is exposed to electric shock, which results in their paralysis*, immediately disconnect power supply (press the STOP ENERGY button on the front panel of the oscillator, or use the CIRCUIT BREAKER switch located on the right lateral wall of the oscillator; then, provide first aid required for people exposed to electric shock.

10. FIRE INSTRUCTIONS

Fire hazard can result from the presence of the following products:

- a) Dielectric fluid – petroleum;
- b) Petroleum vapours and gaseous by-products that are derivatives of the anaerobic decomposition of the dielectric fluid. The biggest fire hazard is posed by gaseous by-products generated above the working area, as they can reach concentrations that ignite or explode easily; the same applies to the dielectric fluid, if its ignition temperature is exceeded.
- c) If the EDM machine is operated incorrectly, e.g. because the workpiece and electrode are not adequately cooled, or especially when there is air present in the working area of a drilling electrode – if it protrudes above the surface of the dielectric fluid, or it is not submerged enough.

It is absolutely forbidden to:

- a) Smoke tobacco in the vicinity of the machine;
- b) Use open fire, in the vicinity of the machine;
- c) Store rags or other materials that could work as wicks, when near the machine;
- d) Have any third parties present near the machine, if they were not trained in fire safety, regarding EDM workstations;
- e) Use the machine, if the ignition temperature of the dielectric fluid is exceeded, or if the machine works for a long time under heavy load;
- f) Use the machine, if the level and temperature sensor has not been configured properly and activated;
- g) Use the machine, if the working area is not adequately submerged (at least 3cm below the surface of the dielectric fluid);
- h) Carry out repair work or other work that may lead to damaging the tank or igniting the dielectric fluid;
- i) Modify electric or hydraulic systems, without prior consulting with ZAPbp.

Recommendations:

- a) Use a separate, well-ventilated room.
- b) Use the machine in a location that ensures safe exiting and disconnecting power supply in the room, as well as access to fire-fighting equipment, in the event of fire.
- c) It is recommended to prevent fluid from spilling over a large area, if there is a failure of the dielectric supply system. Provide a directed run-off of the fluid outside the building, or into a special tray, e.g. via a special hole.
- d) It is recommended to use an additional, automatic fire suppression system.
- e) It is also recommended to use a central fire suppression system in the room.

- f) Use a blowing system that eliminates vapours from above the tank, or a spot extractor – vapours must be directed outside the working room. The extracting system must be efficient, in order to eliminate any condensation of the dielectric fluid in conduits, or possible isolated water pools, as that can pose a fire hazard.
- g) It is absolutely forbidden to operate the machine without supervision.

Protection measures:

- a) At least two carbon-dioxide extinguishers or halide fire extinguishers within easy reach, if there is fire.
- b) A fire blanket.

Fire extinguishing procedure:

- a) Disconnect supply voltage (press the STOP ENERGY button).
- b) Eliminate flames.
- c) Use a fire extinguisher (**Attention!!!** Do not aim the stream of gas directly at the petroleum surface, as it can result in splashing of the dielectric fluid).
- d) Call external services and act adequately to the course of events.

14.INSPECTIONS AND MAINTENANCE OF THE MACHINE

The machine must undergo period inspections, carried out at an authorised service workshop of the manufacturer – every 2 years.

Responsibilities of the user:

- a) Keep the machine clean;
- b) Change filters after every 200 hours of operation;
- c) Change seals in the lids of both filter housings, as necessary;
- d) Refill petroleum systematically, up to the level marked on the tank;
- e) Clean the tank every 12 months;
- f) Prevent petroleum from spilling outside the machine and form pools; similarly, make sure there is not post-erosion silt deposited in the tank;
- g) All systems and guards must be checked, before each operation;
- h) The power network supplying the machine must be efficient (check the technical condition of connections and neutral points – PE);
- i) Report all noticed malfunctions or unexpected events to the authorised service workshop of the manufacturer.

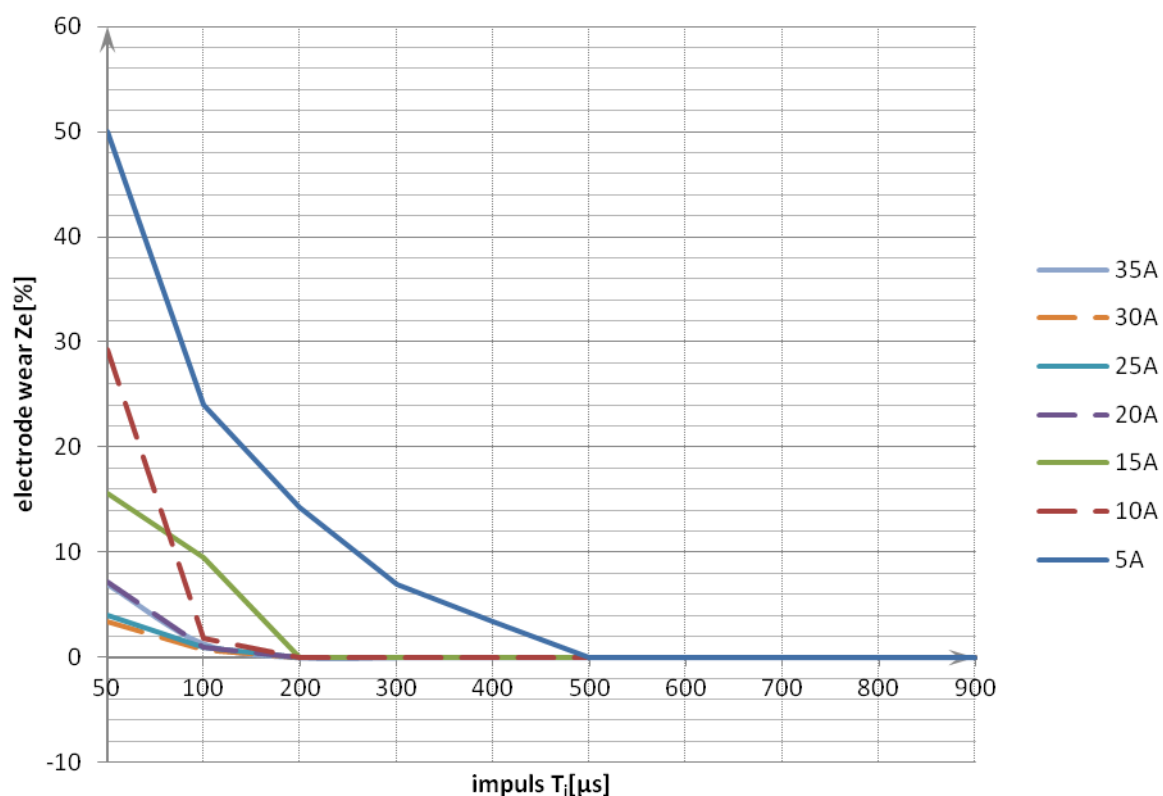
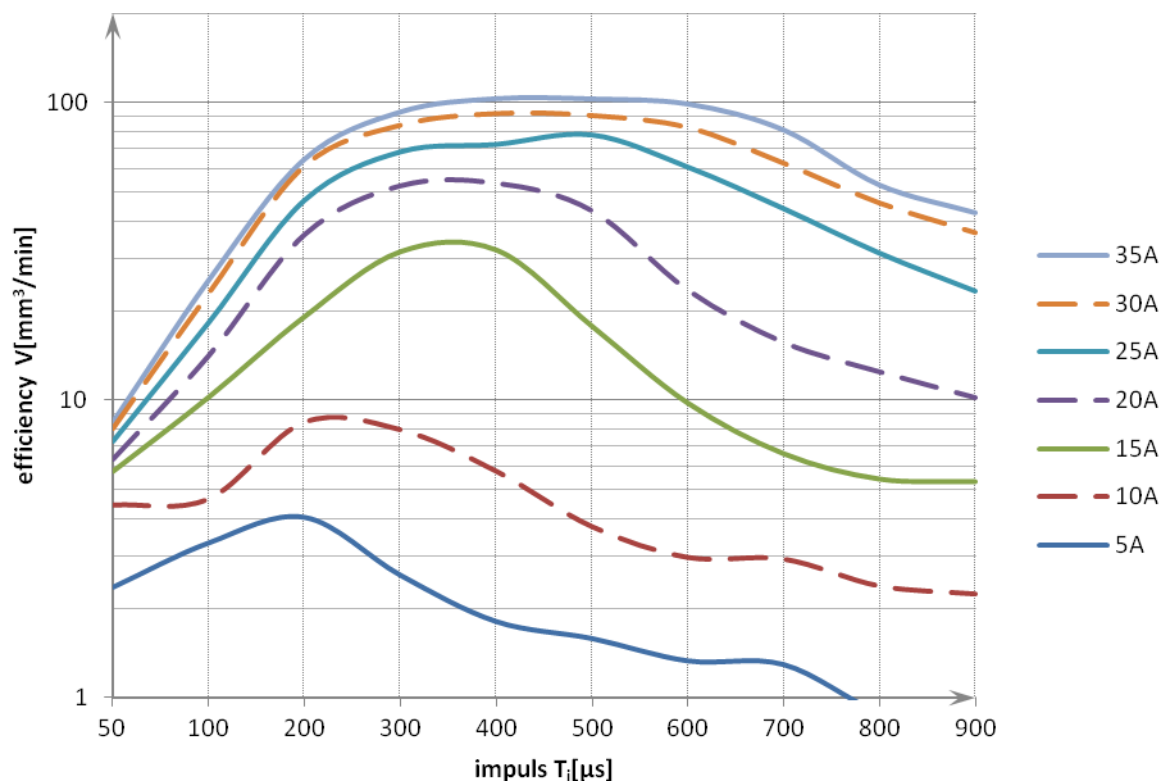
15. TECHNOLOGICAL CHARACTERISTICS

Electrode: copper M1E

Workpiece: steel

Dielectric fluid: paraffin oil

Other parameters: $t_p=50\mu s$, $P=10\%$, $z=50\%$

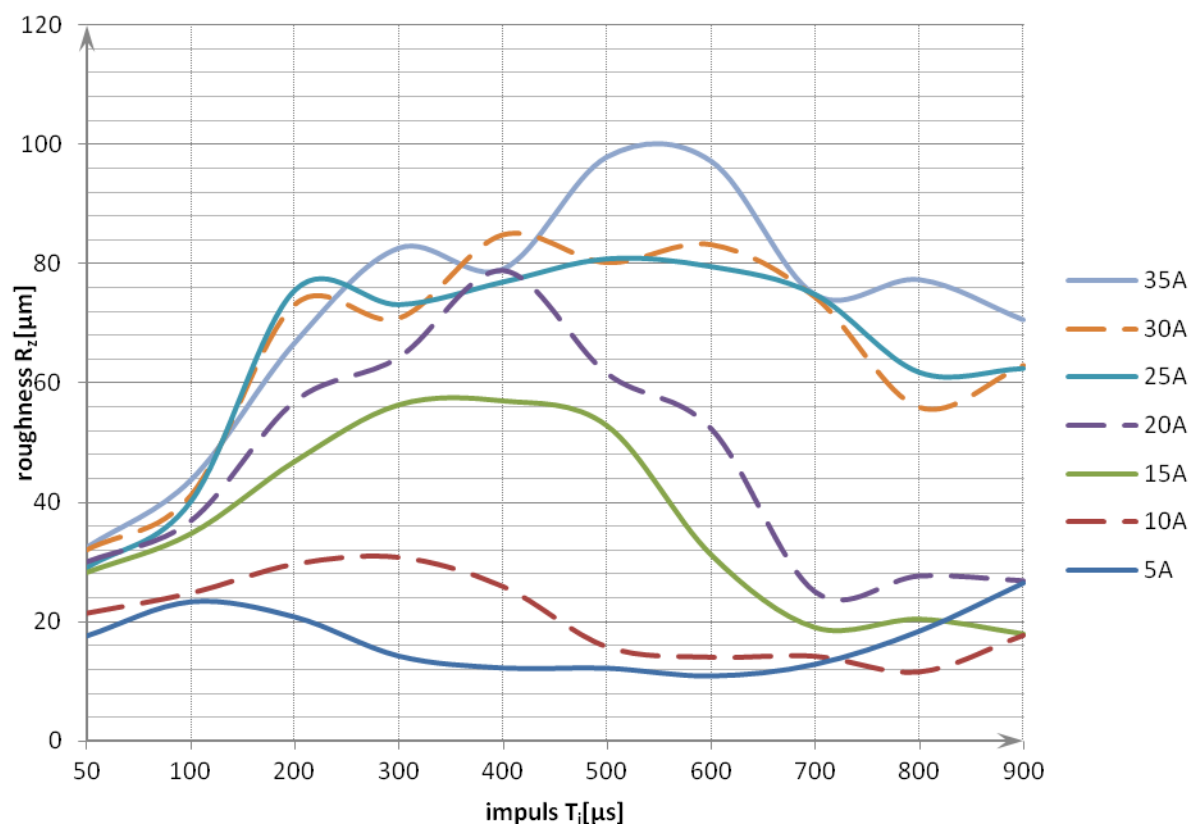
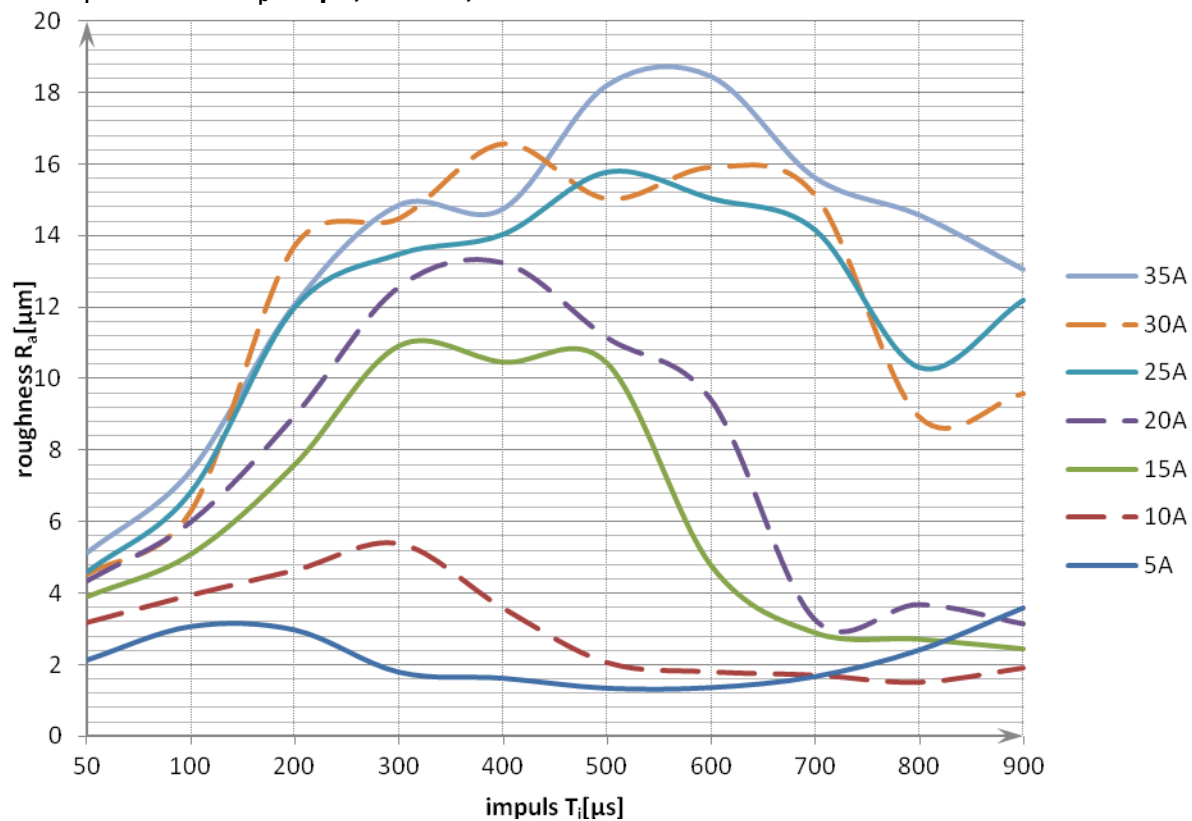


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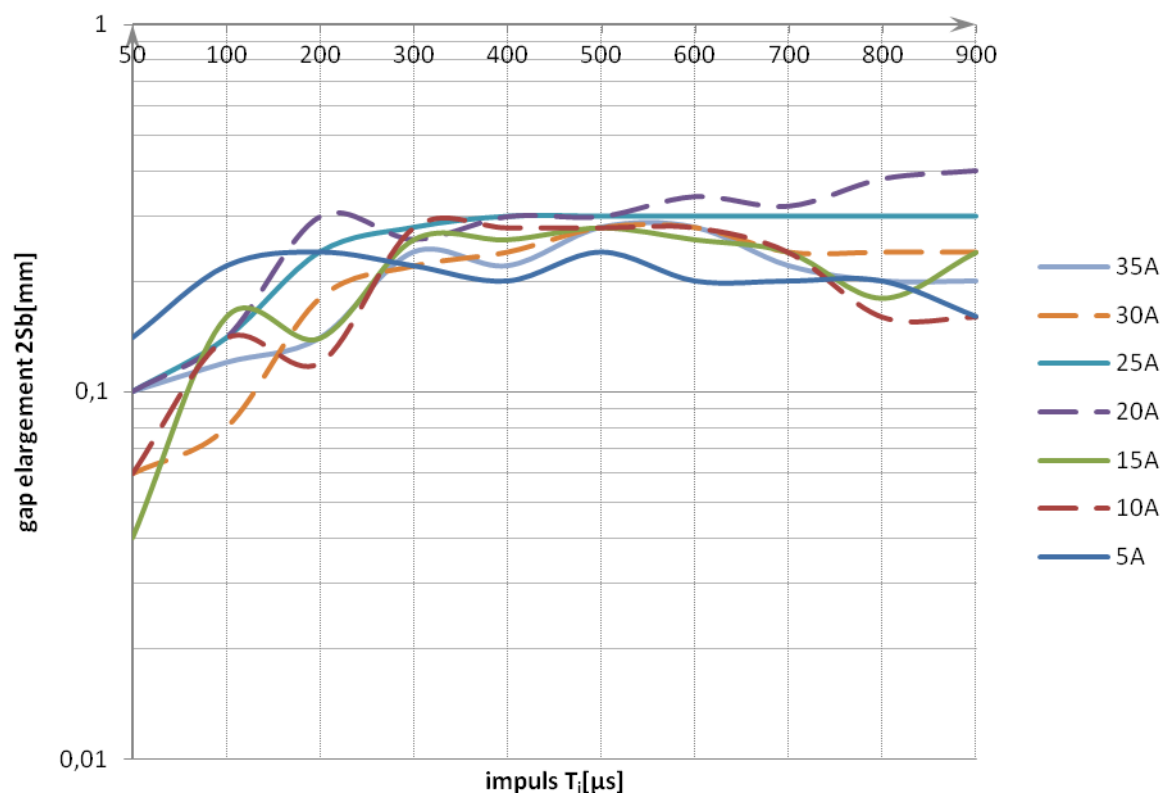


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16.ADDRESSES OF DEALERS

a) FILTERS

○ WE-325

Przedsiębiorstwo Produkcyjno Handlowe Motoryzacji EXMOT (A manufacturer and supplier of filters), 19-300 Ełk, ul. Przemysłowa 6B, Tel.: (87) 621-36-59, (87) 621-84-50, Fax: (87) 621-31-59, Email: exmot@exmot.pl, exmot.pl

○ L-325 or L-520

Spółdzielnia Inwalidów Two-Met (Disabled workers co-operative), 95-100 Zgierz, ul. Dąbrowskiego 13, Tel./Fax: (42) 716-31-21, Tel.: (42) 716-28-76, Email: marketing@two-met.pl, twomet@two-met.pl, www.two-met.pl

b) GLEITMO 100 MOLYBDENUM GREASE

FUCHS OIL CORPORATION (PL) Sp. z o.o., 44-101 Gliwice, ul. Kujawska 102, Tel.: (32) 401-22-00, Fax: (32) 401-22-55, Email: gliwice@fuchs-oil.pl, fuchs-oil.pl

c) COPPER AND OTHER NON-FERROUS METALS

HUTMEN S.A., 53-234 Wrocław, ul. Grabiszyńska 241, (Headquarters) Tel.: (71) 334-83-00, Fax: (71) 339-03-46, (71) 339-03-47, Email: biuro.spolki@hutmen.pl, www.hutmen.pl

HUTMET sp.j.- Retail Outlet, 53-234 Wrocław, ul. Grabiszyńska 241C, Tel.: (71) 334-86-22, (71) 339-03-00, Fax: (71) 334-86-22, Email: hutmet@wp.pl, www.hutmet.metale.pl

d) WORKING DIELECTRIC FLUID

○ EDR 3

ORLEN OIL Sp. z o.o., 31-323 Kraków, ul. Opolska 100, Tel.: (12) 665-55-35, (24) 201-03-70, fax: (12) 665-55-30, (24) 367-70-93, Email: handel@orlenoil.pl, www.orlenoil.pl

○ PARAFFIN

SOLON, 81-002 Gdynia, ul. Morska 316A, Tel./Fax: (58) 623-76-79, Email: solonsobczyk@wp.pl, www.solongdynia.za.pl

**Programmable controller for electro-erosion removal machines
manufactured by ZAPbp.**

Operator's manual.



zapbp.com.pl

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1 Control Panel

1.1 Keyboard Layout

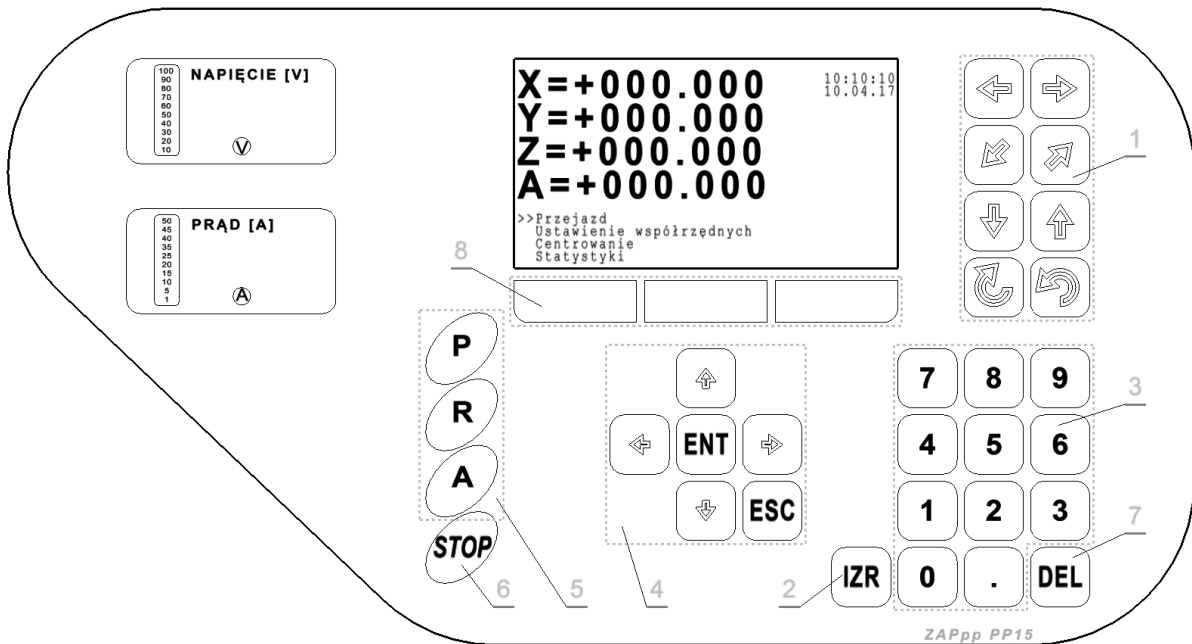


Fig. 1

The keyboard attached to the operator panel is comprised of the following elements:

- [1] A block of directional keys (they control the direction of movement and the turning movement of the working bit of the machine machine);
- [2] The Ignore Short Circuit button **[IZR]** (it is used during travelling, if it is necessary to ignore the contact between the working bit and the table; if this function is active, the following messages appears on the screen: *IZR*);
- [3] A numeric keypad;
- [4] A block of navigational keys (it is used to navigate through the controller menu);
- [5] A block of **[P]**, **[R]**, and **[A]** keys that are used to select one of the following working modes: *Programming, Manual Mode, or Automatic Mode.*
- [6] The **[STOP]** button (it is used to stop any current operation);
- [7] The **[DEL]** button (it is used to delete individual programmes);
- [8] A block of **[F1]**, **[F2]**, and **[F3]** functional keys (their current function is displayed on a LCD display, directly above each of the buttons).

1.2 Menu Layout

The menu layout has been presented on the diagram below:

Working mode	Main Menu	Sub-Menu	
Manual Mode	Travel	• By value • By step • To coordinates • Home • To characteristic points • To the beginning of program	
	Configuration of coordinates	• Operator's coordinates • A list of base coordinates • Physical coordinates	
	Alignment	Within a hole	• A hole in the XY-plane • A hole in the XZ-plane • A hole in the YZ-plane • A gap along the X-axis • A gap along the Y-axis • A gap along the Z-axis
		On the mandrel	• Rotation around the X-axis • Rotation around the Y-axis • Rotation around the Z-axis
	Statistics		
Programming	Settings	• Date/Time • Type of rotating instrument • Additional functionalities • Language	
	List of programmes		
	Transfer of program	• Bluetooth • RS232	
Automatic Working Mode			
New program			

By pressing one of the three keys that define the working mode (see Fig. 2), the User will be directed to the Main Menu dedicated to a particular working mode. The afore-mentioned operation will not be possible, if we have started declaring parameters that are necessary for a selected function, or when the controller is carrying out a selected operation (e.g. travel by a certain value).



Fig. 2

To navigate through the menu structure, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:

- [1] [**↑**] The cursor moves up to another item on a menu list;
- [2] [**↓**] The cursor moves down to another item on a menu list;
- [4] [**ENT**] It enables entering a sub-menu;
- [5] [**ESC**] It enables exiting a sub-menu.

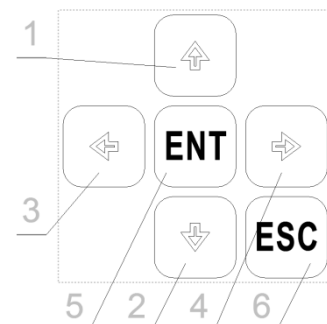


Fig. 3

2 Manual Working Mode

Initial notes:

- The machine will **only** work within the positive quadrant of the global co-ordinate system that is also referred to as a physical co-ordinate system.
- If the user attempts to travel toward negative physical coordinates, the system will generate an appropriate error message.
- The coordinates displayed on the LCD display are operator's coordinates corresponding to the datum point of a local co-ordinate system.
- The datum point of a local co-ordinate system can be adjusted, in relation to the global co-ordinate system.
- The following working ranges apply:
 - Linear coordinates:
 - Physical coordinates = <0 to 999.995>;
 - Operator's coordinates = <-999.995 to 999.995>;
 - Angular coordinates:
 - Physical coordinates = <-999°59' to 999°59'>;
 - Operator's coordinates = <-999°59' to 999°59'>.

2.1 Travel

2.1.1 Manual Travel

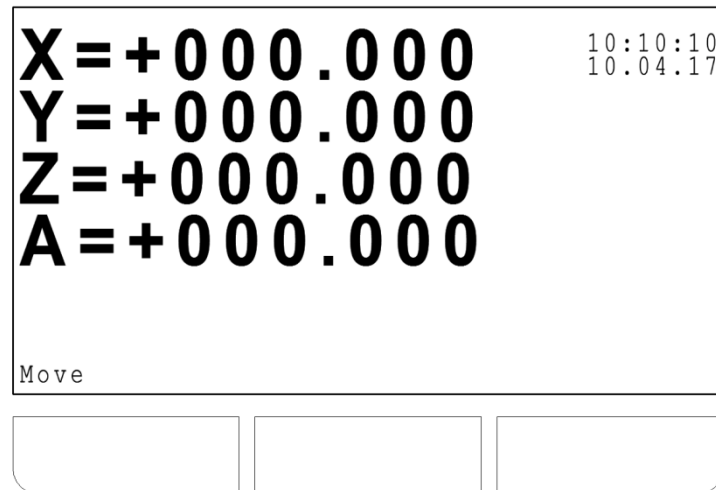
Intended use: This function is responsible for travelling the working bit of the machine in a specific direction, and according to a specific turning movement, by pressing and holding one of the keys included in the directional keypad (see Fig. 1). This function will not be available, once the user has entered a window dedicated to a selected operation (e.g. travel by a specific value).

2.1.2 Travel by a specific value

Intended use: This function is responsible for travelling the working bit of the machine by a specific value, along a single axis or many axes simultaneously.

Access path: Manual Mode [R] -> Travel -> By the value of

Screen:



Course of action:

- 1) Select a specific direction and turn during travel, by pressing an appropriate key included in the directional keypad (see Fig. 1).
 - *The entry window dedicated to the selected axis of travel will be displayed.*
- 2) Enter the required value of travel, using the numeric keypad ([DEL] – Deletes the entered character; [ESC] – Cancels the option of entering a value).
- 3) Accept the entered value, by pressing [ENT].
- 4) Declaration of movement for another axis – go back to item 1.

- 5) Activate/Deactivate the Ignore Short Circuit function by pressing the **[IZR]** button (activate this functions, if it is necessary to ignore the contact between the working bit of the machine with the table, during travelling, e.g.resulting from measuring the location of a workpiece on the table, using a sensor).
 - *If the Ignore Short Circuit function is on, the following message will appear on the screen: IZR;*
- 6) Press the **[F1]** **"Move"** button to activate the function.
 - *The machine will travel, according to the set value.*

The following keys are available, when this function is carried out:

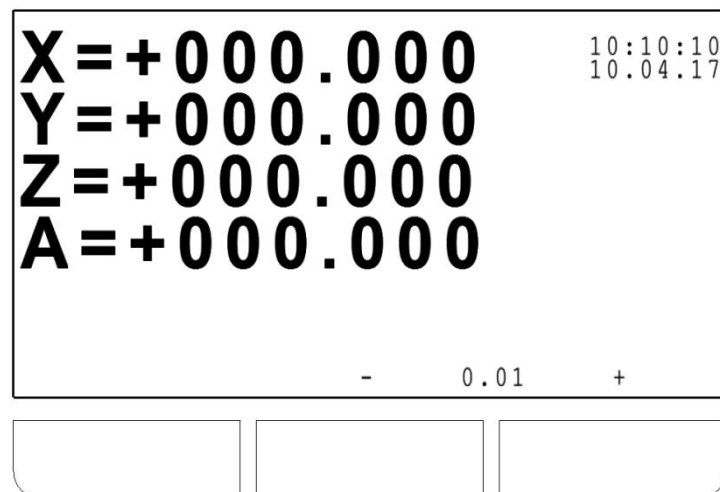
- **[STOP]**: Travel is stopped immediately. When the function is paused, the following options for further actions will appear on the screen:
 - a. **[Fx]** **"Continue"**: Travel will continue;
 - b. **[Fx]** **"Abort"**: Travel will be stopped.

2.1.3 Travel by a specific step

Intended use: This function is responsible for moving the working bit of the machine along a selected axis, according to a pre-set "step" value. The following "step" values are available: 0.01mm, 0.10mm, and 1.00mm.

Access path: Manual Mode [R] -> Travel -> By the step of

Screen:



Course of action:

- 1) Use the **[F2]** **"-"** and **[F3]** **"+"** to select a step value (the current value of step will be displayed between the "+" and "-" characters. See the Figure above).
- 2) Activate/Deactivate the Ignore Short Circuit function by pressing the **[IZR]** button (activate this functions, if it is necessary to ignore the contact between the working bit of the machine with the table, during travelling, e.g.resulting from measuring the location of a workpiece on the table, using a sensor).
 - *If the Ignore Short Circuit function is on, the following message will appear on the screen: IZR;*
- 3) Select a specific direction and turn during travel, by pressing and releasing an appropriate key included in the directional keypad (see Fig. 1).
 - *The machine will travel, according to the set step value.*

2.1.4 Travel toward specific coordinates

Intended use: This function enables moving the working bit of the machine toward specific base coordinates.

Access path: Manual Mode [R] -> Travel -> Travel to specific coordinates

Screen:

X=+000.000
Y=+000.000
Z=+000.000
A=+000.000

10:10:10
10.04.17

Move

Course of action:

- 1) Select a specific character and the axis for which we intend to declare target coordinates, by pressing an appropriate key included in the directional keypad (see Fig. 1).
 - *The entry window dedicated to the selected axis of travel will be displayed.*
- 2) Enter the required value of coordinate, using the numeric keypad ([DEL] – Deletes the entered character; [ESC] – Cancels the option of entering a value).
- 3) Accept the entered value, by pressing [ENT].
- 4) Declaration of movement for another axis – go back to item 1.
- 5) Activate/Deactivate the Ignore Short Circuit function by pressing the [IZR] button (activate this functions, if it is necessary to ignore the contact between the working bit of the machine with the table, during travelling, e.g. resulting from measuring the location of a workpiece on the table, using a sensor).
 - *If the Ignore Short Circuit function is on, the following message will appear on the screen: IZR;*
- 6) Press the [F1] “Move” button to activate the function.
 - *The machine will travel, according to the set value.*

The following keys are available, when this function is carried out:

- [STOP]: Travel is stopped immediately. When the function is paused, the following options for further actions will appear on the screen:
 - a. [Fx] “Continue”: Travel will continue;
 - b. [Fx] “Abort”: Travel will be stopped.

2.1.5 Travel Home

Intended use: This function enables moving the working bit of the machine home. Once the machine has reached all limiting switches, the physical coordinates of the machine will be reset (X=0.0; Y=0.0; Z=max height of crawl corresponding to a particular machine).

Access path: Manual Mode [R] -> Travel -> Travel to limiting switches

Course of action:

- *The machine will travel, according to the set value.*

The following keys are available, when this function is carried out:

- [STOP]: Travel is stopped immediately. When the function is paused, the following options for further actions will appear on the screen:
 - a. [Fx] “Continue”: Travel will continue;
 - b. [Fx] “Abort”: Travel will be stopped.

Attention!!!

- 1) It is recommended to carry out a travel home, when:
 - a) The machine has been activated for the first time;
 - b) The machine has been moved to a different working station;

- c) The machine has undergone repairs that required the disconnecting of the generator from the mechanical section of the machine.

Failing to perform the Home function, once any of the afore-mentioned conditions has occurred, may result in an incorrect operation of the “travel to a characteristic point” function and locking of manual travels toward the selected direction.

- 2) Before initiating travel, make sure that the Ignore Short Circuit (IZR) function is inactive.

Error messages:

- **Not all home positions have been reached:** The machine has failed to reach all home positions. This error occurs, if one of the limiting switches is damaged, or one of the cases specified in item 2.1.8 [General error messages concerning travel] has occurred.

2.1.6 Travel to characteristic points

Intended use: This function enables automatic travelling of the working bit of the machine toward a central point of the machine working space.

Access path: Manual Mode [R] -> Travel -> Travel to characteristic point

Course of action:

- *The machine will travel, according to the set value.*

The following keys are available, when this function is carried out:

- **[STOP]:** Travel is stopped immediately. When the function is paused, the following options for further actions will appear on the screen:
 - a. **[Fx] “Continue”:** Travel will continue;
 - b. **[Fx] “Abort”:** Travel will be stopped.

Attention!!!

Before initiating travel, make sure that the Ignore Short Circuit (IZR) function is inactive.

2.1.7 Travel to the beginning of program

Intended use: This function enables automatic travelling of working bit of the machine toward the datum point of a selected working program.

Access path: Manual Mode [R] -> Travel -> To the beginning of program

Course of action:

- *The machine will travel, according to the set value.*

The following keys are available, when this function is carried out:

- **[STOP]:** Travel is stopped immediately. When the function is paused, the following options for further actions will appear on the screen:
 - a. **[Fx] “Continue”:** Travel will continue;
 - b. **[Fx] “Abort”:** Travel will be stopped.

Error messages:

- If the function is inactive (the machine has not travelled to the beginning of program) and the machine has automatically returned to the main menu of the manual working mode, see item 3.3.1 [Error Messages].

Attention!!!

Before initiating travel, make sure that the Ignore Short Circuit (IZR) function is inactive.

2.1.8 General error messages regarding travels

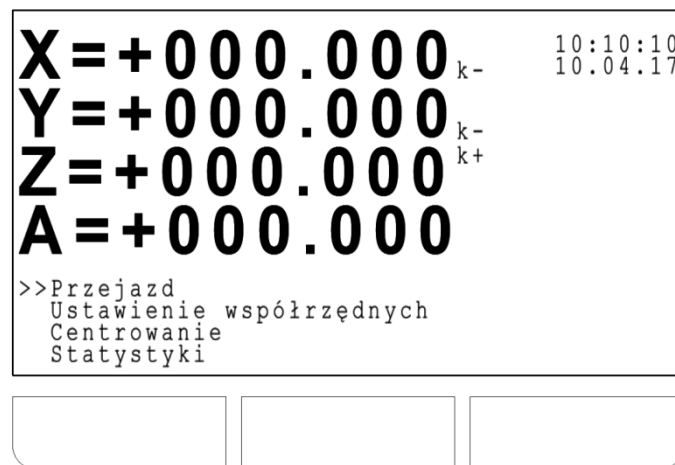
Travel can be stopped immediately, if an emergency situation occurs. Look below at a list of potential errors:

- **Short circuit:** The working bit has come into contact with the table (workpiece), during travel. It is possible to deactivate short circuit detection, by activating the Ignore Short Circuit function (the **[IZR]** key), prior to commencing travel.
- **Attempting to exceed physical or base coordinates.**

- **Stopping the process:** Travel has been paused by pressing the **[STOP]** key.
- **Critical ruler error:** The ruler does not report that it has completed travel, although the motor responsible for movement along a given axis has received a message about completion of travel. This error occurs, when:
 - a. There is a motor malfunction;
 - b. There is a motor controller malfunction;
 - c. The travelling structure produces too much resistance during movement (if that is the case, it is recommended to clean and re-lubricate the power screw).

2.1.9 Limiting switches

If the upper or lower limiting switch has been reached, it is signalled by the following message displayed on the screen: "k+" or "k-", respectively, with the value of axis coordinate corresponding to the value that triggered a limiting switch.



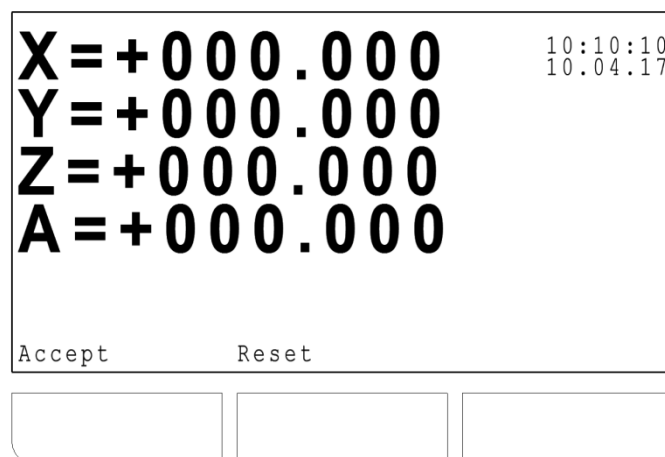
2.2 Configuration of coordinates

2.2.1 Operator's coordinates

Intended use: This function enables changing values for each of the operator's coordinates. This way, it is possible to change the datum point corresponding to a local co-ordinate system, in relation to the datum point corresponding to a global co-ordinate system.

Access path: Manual Mode [R] -> Configuration of coordinates -> Operator's coordinates

Screen:



Course of action:

- 1) Select a specific character and the axis for which we intend to declare new operator's coordinates, by pressing an appropriate key included in the directional keypad (see Fig. 1).
 - The entry window dedicated to the selected axis will be displayed.

- 2) Enter the required value of coordinate, using the numeric keypad ([DEL] – Deletes the entered character; [ESC] – Cancels the option of entering a value).
- 3) Accept the entered value, by pressing [ENT].
- 4) Declaration of coordinate for another axis – go back to item 1.
- 5) Confirm the declared coordinates, by pressing [F1] "Accept".

The following keys are available, when this function is carried out:

- [F2] "Reset": It enables resetting operator's coordinates.

2.2.2 A list of base coordinates

Intended use: This function enables assigning physical coordinates corresponding to the current location of the working bit of the machine to one of the G-codes within the following range: G50-G59.

Access path: Manual Mode [R] -> Configuration of coordinates -> List of base coordinates

Screen:

	X	Y	Z
G 5 0	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 1	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 2	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 3	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 4	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 5	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 6	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 7	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 8	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0
G 5 9	0 0 0 . 0 0	0 0 0 . 0 0	0 0 0 . 0 0

Accept

Course of action:

- 1) Select an axis (an appropriate G-code) to which you intend to assign the current value of a corresponding physical coordinate.
 - The selected axis is displayed with an intersection, in relation to the edge of the column.
 - To navigate through the list of base coordinates, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [1] [↑] The cursor moves up to another item on the list;
 - [2] [↓] The cursor moves down to another item on the list;
 - [3] [←] The cursor moves to the left item on the list;
 - [4] [→] The cursor moves to the right item on the list.
- 2) Assign a value to the physical coordinate, by pressing [ENT].
 - The value set for the selected coordinate will change.
- 3) Declaration of coordinate for another axis – go back to item 1.
- 4) Confirm the declared coordinates, by pressing [F1] "Accept".

2.2.3 Physical coordinates

Intended use: This function enables changing values for each of the physical coordinates. Consequently, the datum point corresponding to the global co-ordinate system is changed.

Access path: Manual Mode [R] -> Configuration of coordinates -> Physical coordinates

Screen:

X=+000.000
Y=+000.000
Z=+000.000
A=+000.000

10:10:10
10.04.17

Accept

Course of action:

- 1) Select a specific character and the axis for which we intend to declare new operator's coordinates, by pressing an appropriate key included in the directional keypad (see Fig. 1).
 - *The entry window dedicated to the selected axis will be displayed.*
- 2) Enter the required value of coordinate, using the numeric keypad ([DEL] – Deletes the entered character; [ESC] – Cancels the option of entering a value).
- 3) Accept the entered value, by pressing [ENT].
- 4) Declaration of coordinate for another axis – go back to item 1.
- 5) Confirm the declared coordinates, by pressing [F1] "Accept".

Attention!!!

If physical coordinates are modified manually, it may have a negative impact on the "Travel to Characteristic Point" function (see item 2.1.4), and lock "manual travel" in the selected direction. It is recommended to perform a single resetting of physical coordinates, using the "Travel Home" function (see item 2.1.4), if one of the conditions below has occurred:

- a) The machine has been started for the first time;
- b) The machine has been moved to a different working station;
- c) The machine has undergone repairs that required the disconnecting of the generator from the mechanical section of the machine.

2.3 Alignment

2.3.1 Within a hole

Intended use: This function enables automatic centring of the electrode within a gap or hole.

The available options of alignment include:

- A hole in the XY-plane;
- A hole in the XZ-plane;
- A hole in the YZ-plane;
- In a gap, along the X-axis;
- In a gap, along the Y-axis;
- In a gap, along the Z-axis.

Access path: Manual Mode [R] -> Alignment -> In a hole

Course of action:

- 1) Move the head in such a way that the electrode sinks in the hole.
- 2) Identify the type of alignment.
 - *When a particular type of alignment has been selected, the following symbol will precede it: ">>".*
 - *To select a particular type of alignment, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:*
 - [1] [↑] *The cursor moves up to another item on the list;*
 - [2] [↓] *The cursor moves down to another item on the list.*

- 3) Initiate alignment, by pressing **[ENT]**.

The following keys are available, when this function is carried out:

- **[STOP]**: Alignment is stopped. When the function is paused, the following options for further actions will appear on the screen:
 - a. **[Fx]** **“Continue”**: Alignment will continue;
 - b. **[Fx]** **“Abort”**: Alignment will be stopped.

2.3.2 On the mandrel

Intended use: This function enables automatic centring of the electrode, in relation to the outer outline of material, or a selected fragment of material, e.g. a mandrel.

The available options of alignment include:

- Rotation around the X-axis;

▪ X+ ↗ (rotation around the X+ axis; alignment along the Y+ axis); ▪ X+ ↖ (rotation around the X+ axis; alignment along the Y- axis); ▪ X+ ↑ (rotation around the X+ axis; alignment along the Z+ axis); ▪ X+ ↓ (rotation around the X+ axis; alignment along the Z- axis);	▪ X- ↗; ▪ X- ↖; ▪ X- ↑; ▪ X- ↓;
--	--
- Rotation around the Y-axis;

▪ X+ → (rotation around the Y+ axis; alignment along the X+ axis); ▪ X+ ← (rotation around the Y+ axis; alignment along the X- axis); ▪ X+ ↑ (rotation around the Y+ axis; alignment along the Z+ axis); ▪ X+ ↓ (rotation around the Y+ axis; alignment along the Z- axis);	▪ Y- →; ▪ Y- ←; ▪ Y- ↑; ▪ Y- ↓;
--	--
- Rotation around the Z-axis.

▪ Z+ → (rotation around the Y+ axis; alignment along the X+ axis); ▪ Z+ ← (rotation around the Y+ axis; alignment along the X- axis); ▪ Z+ ↗ (rotation around the Y+ axis; alignment along the Y+ axis); ▪ Z+ ↖ (rotation around the Y+ axis; alignment along the Y- axis);	▪ Z- →; ▪ Z- ←; ▪ Z- ↗; ▪ Z- ↖;
--	--

Access path: Manual Mode [R] -> Alignment -> On a mandrel

Course of action:

- 1) Select the level of alignment, by defining the datum point of the electrode, in relation to the workpiece (see Fig. 4).
- 2) Select the direction of rotation around the workpiece (see Fig. 4).
- 3) Define the turning point of rotation, and the direction and turning point of alignment (see Fig. 4).
 - When a particular type of alignment has been selected, the following symbol will precede it: “>>”.
 - To select a particular type of alignment, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [1] **[↑]** The cursor moves up to another item on the list;
 - [2] **[↓]** The cursor moves down to another item on the list.
- 4) Initiate alignment, by pressing **[ENT]**.

Attention!!!

You must remember that the automatic alignment on mandrel requires setting the direction and turning point of alignment in such a way that that electrode comes into contact with a workpiece, when it is moving toward that particular direction. The process of alignment is cancelled, if the electrode has moved by 50mm, after alignment was started, and there is no contact with the workpiece.

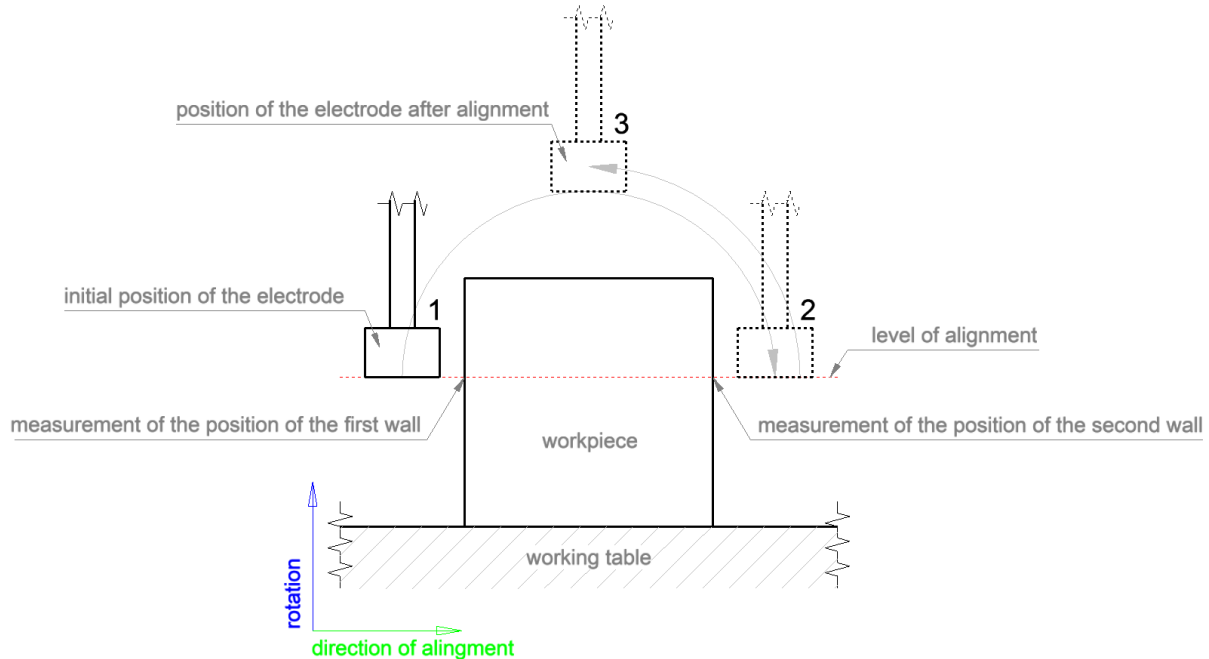


Fig. 4

The following keys are available, when this function is carried out:

- **[STOP]:** Alignment is stopped. When the function is paused, the following options for further actions will appear on the screen:
 - a. **[Fx] "Continue":** Alignment will continue;
 - b. **[Fx] "Abort":** Alignment will be stopped.

2.3.3 Error messages regarding alignment

Alignment can be stopped immediately, if an emergency situation occurs. Look below at a list of potential errors:

- **Attempting to exceed physical or base coordinates.**
- **Stopping the process:** See item 2.1.8. [General error messages regarding travels]
- **Critical ruler errors:** See item 2.1.8. [General error messages regarding travels]
- **Travel Home.**
- **Unrepairable short circuit:** When aligning, the machine detects the location of the working bit, by by period contact between the electrode and the workpiece. This error occurs, when attempting to move away from the workpiece, after detecting a short circuit, and the short circuit does not stop, when the working bit has moved away within the distance of 0.2mm from the workpiece. The error occurs when the workpiece in relation to which alignment is performed has a surface that is oxidised or covered with dirt that conducts electric current.

2.4 Statistics

Intended use: This function enables viewing archived data, regarding the completed working programmes. The collected data includes:

- Name of the program (*Program*), its date (*Date*), and time of its completion (T_{ex});
- The data is stored in a text file, on an SD card, at the following location: E:\stat.txt.

Access path: Manual Mode [R] -> Statistics

Screen:

P r o g r a m	D a t e	T e x
B 2 . T X T	3 0 . 1 2 . 1 6	0 0 : 0 0 : 0 9
B 2 . T X T	3 0 . 1 2 . 1 6	0 0 : 0 0 : 1 9
B 2 . T X T	3 0 . 1 2 . 1 6	0 0 : 0 0 : 1 0
P 0 0 2 . T X T	3 0 . 1 2 . 1 6	0 0 : 0 0 : 0 9
P 0 0 2 . T X T	3 0 . 1 2 . 1 6	0 0 : 0 0 : 1 8
P 0 0 2 . T X T	1 0 . 0 4 . 1 5	0 0 : 0 0 : 1 1

- To navigate through the list of archived data, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
- [3] [←] Return to the previous page;
- [4] [→] Go to the next page.

2.5 Settings

2.5.1 Date/Time

Intended use: This function enables setting the current date and time.

Access path: Manual Mode [R] -> Settings -> Date/Time

Course of action:

- 1) Select and set the date/time component.
 - If a particular component is underlined (the cursor appears under it), it indicates that the component has been selected.
 - To change date/time, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [1] [↑] The value is modified by +1;
 - [2] [↓] The value is modified by -1;
 - [3] [←] The cursor moves to the element on the left;
 - [4] [→] The cursor moves to the element on the right.
- 2) Confirm the declared date/time, by pressing [F1] "Accept".

2.5.2 Type of rotating instrument

Intended use: This function enables selecting the currently applied rotating instrument. Each of the instruments available for selection features a different gear ratio applicable to the engine shaft (driving shaft) and the working shaft (driven shaft), which means that the machine must receive preliminary data, concerning the type of instrument it will work with. The "A" axis is responsible for the rotary movement of the aforementioned instruments.

The following options can be selected:

- Rotary head (GO-...);
- Rotary table (PDT-...);
- Lathe (TE-...).

Access path: Manual Mode [R] -> Settings -> Type of rotating instrument

Screen:

```
Rotating instruments:
>>Rotary head (GO-...)
v  Rotary table (PDT-...)
   Lathe (TE-...)
```

Load

Course of action:

- 1) Select a rotating instrument.
 - *When a particular type of rotating instrument has been selected, the following symbol will precede it: ">>".*
 - *To select a particular type of instrument, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:*
 - [3] [↑] The cursor moves up to another item on the list;*
 - [4] [↓] The cursor moves down to another item on the list.*
- 2) Confirm the declared instrument, by pressing [F1] "Load".
 - *When a particular type of instrument has been loaded, the following symbol will precede it: "v".*

2.5.3 Language

Intended use: This function enables selecting a language of the user interface.

The following options can be selected:

- Polish (PL);
- English (EN).

Access path: Manual Mode [R] -> Settings -> Language

Course of action: See item 2.4.2 [Type of rotating instrument].

2.5.4 Additional functionalities

Intended use: This function enables activating/deactivating the optional working attributes.

The following additional working attributes are available:

- Rulers.

Access path: Manual Mode [R] -> Settings -> Additional functionalities

Screen:

Additional functionalities:	
>>Rulers	---
Activate	Deactivate

Course of action:

- 1) Select a working attribute.
 - When the particular attribute has been selected, the following symbol will precede it: ">>".
 - To select a particular attribute, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [1] [↑] The cursor moves up to another item on the list;
 - [2] [↓] The cursor moves down to another item on the list.
- 2) Press [F1] "Activate" to activate the particular attribute.
 - When the particular attribute has been activated, the following symbol will follow it: "v".
- 3) Press [F2] "Deactivate" to deactivate the particular attribute.
 - When the particular attribute has been deactivated, the following symbol will follow it: "---".

3 Programming Mode

3.1 List of programmes

Intended use: This function enables viewing and deleting programmes, as well as selecting one of them to be carried out in the automatic mode. It is only possible to store up to 20 programmes on an SD card. Text files with programmes are stored on an SD card, in the following directory: E:\Gc\.

Access path: Programming [P] -> List of programmes

Screen:

List of programmes:	
>>P001.TXT	0601B
vTEST.TXT	1600B
TEST2.TXT	0245B
Load	

Course of action:

- 1) Select a program.
 - When a particular program has been selected, the following symbol will precede it: ">>".
 - To select a particular program, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [1] [↑] The cursor moves up to another item on the list;
 - [2] [↓] The cursor moves down to another item on the list.
- 2) Choose one from the following options:
 - a. Interpret and load a program as the default one to be carried out in the automatic mode, by pressing **[F1]** "Load".
 - When a particular program has been loaded, the following symbol will precede it: "v". If the program has been written incorrectly, a message informing about problems with interpretation will be displayed.
 - b. Delete the program by pressing **[DEL]**,
 - c. View the program by pressing **[ENT]**.
 - A command listing will be displayed.
- To view a particular program, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [3] [←] Return to the previous page;
 - [4] [→] Go to the next page.

3.2 Transfer of program

Intended use: This function enables receiving a text file transferred for a PC. There are two methods of data transfer: via RS232 or Bluetooth.

Access path: Programming [P] -> Transfer program -> RS232/Bluetooth

Screen:

RS232

Baud rate: 9600 bps

Data bits: 8b

Stop bits: 1b

Parity: No

Flow control: No

Enter the name of file:

R_ ABC

ABC/123 Accept

Course of action:

- 1) Enter the name of file. The name can have up to 8 characters. You can enter characters in the following ranges: <A; Z> and <0; 9>.
 - a. The range of entered characters (<A; Z> or <0;9>) can be defined with the following key: **[F1]** "ABC/123"
- To enter a particular name, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:
 - [1] [↑] If the range is <0;9>, the value will be modified by +1. If the range is <A; Z>, the next letter in the alphabet is displayed.

- [2] [$\downarrow$] If the range is <0;9>, the value will be modified by -1. If the range is <A; Z>, the previous letter in the alphabet is displayed.
- [3] [$\leftarrow$] The cursor moves to the previous item of the entered name.
- [4] [$\rightarrow$] The cursor moves to the successive item of the entered name.

- 3) Accept the name by pressing: **[F2] "Accept"**.
 - The display will show the following message: "Machine waiting for data".
- 4) Send the program for a computer, making sure that you have pre-set appropriate parameters of transmission: Baud rate=9600bps, Data bits=8b, Stop bit=1, Parity=No, Flow control=No.
 - If transfer is successful, the user will be redirected to: Programming [P] -> List of programmes

3.3 New program

Intended use: This function enables saving the new program.

Access path: Programming [P] -> New program

Course of action:

- 1) Enter the name of file. The name can have up to 8 characters. You can enter characters in the following ranges: <A; Z> and <0; 9>.
 - a. The range of entered characters (<A; Z> or <0;9>) can be defined with the following key: **[F1] "ABC/123"**
 - To enter a particular name, use the block of navigational keys (see Fig. 3). See below to learn about the operations assigned to each of the keys:

[1] [$\uparrow$] If the range is <0;9>, the value will be modified by +1. If the range is <A; Z>, the next letter in the alphabet is displayed.

[2] [$\downarrow$] If the range is <0;9>, the value will be modified by -1. If the range is <A; Z>, the previous letter in the alphabet is displayed.

[3] [$\leftarrow$] The cursor moves to the previous item of the entered name.

[4] [$\rightarrow$] The cursor moves to the successive item of the entered name.
- 2) Accept the name by pressing: **[F2] "Accept"**.
- 3) Save the program.
 - a. Select the type of code: **[F2] "G-code"**, **[F3] "M-code"**.
 - b. Enter the required value of code, using the numeric keypad (**[DEL]** – Deletes the entered character; **[ESC]** – Cancels the option of entering a value).
 - c. Accept the entered value, by pressing **[ENT]**.
 - If a particular G-code requires defining its parameters to work correctly, a list of elements accompanied with default values will be displayed on the screen. However, if a particular G-code requires no parameters, and we intend to:
 - continue writing the program, go back to item **a**;
 - finish writing the program, press **[F1] "Save"**.
 - d. Provide correct values in the list of parameters.
 - i. Open the window dedicated to entering values corresponding to a given parameter (a list of keys that call windows dedicated to entering each individual parameter is shown in Table 3.1).
 - ii. Enter the required value, using the numeric keypad (**[DEL]** – Deletes the entered character; **[ESC]** – Cancels the option of entering a value).
 - iii. Accept the entered value, by pressing **[ENT]**.
 - e. If you want to declare another G-code: go back to item **a**, or finish writing the program by pressing **[F1] "Save"**.
 - If the operation is successful, the user will be redirected to: Programming [P] -> List of programmes

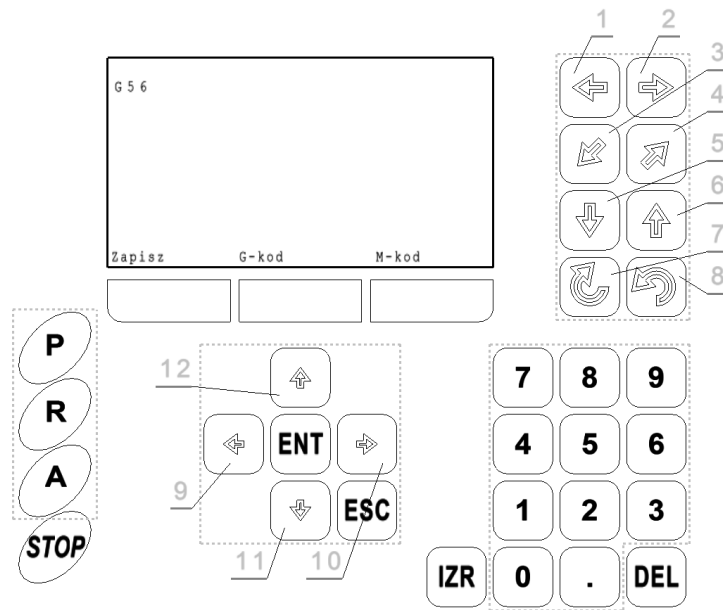


Fig. 5

Table 3.1. A list of keys that call windows dedicated to entering each individual parameter.

G-code	Parameter: a key that opens the entry window (see Fig. 5)				
G00/G01	X- : [1]	Y- : [3]	Z- : [5]	A- : [7]	
	X+ : [2]	Y+ : [4]	Z+ : [6]	A+ : [8]	
G02/G03	X- : [1]	Y- : [3]	Z- : [5]	I- : [9]	J- : [11]
	X+ : [2]	Y+ : [4]	Z+ : [6]	I+ : [10]	J+ : [12]
G81	L: [1] or [2]				
G85/G86	L: [1] or [2]	S- : [3]	D : [5] or [6]		
		S+ : [4]			

3.4 Error messages

Problems with program interpretation:

- **No G50-G59 parameters;**
- **No %...% markers;**
- **No free space in FLASH memory;**
- **Problems with reading start coordinates of program;**
- **No program has been selected:** No program to be carried out in the automatic mode has been selected (information about selecting a program – see item 3.1. [List of programmes])

Problems with an SD card:

- **No SD card:** The card is not present physically in its slot.
- **Problems with SD card:** Problems with reading the SD card;
- **No files on the SD card;**
- **Too many programs have been stored:** The user attempted to store a 21st program on the SD card (the maximum number is 20).

3.5 The principles of writing a program, using G- and M-codes

The basic notes regarding writing a program that will be interpreted by machines with the PP15 controller, manufactured by ZAPbp:

- Each program must be enclosed within the “%...%” markers.
- Program interpretation starts from the location of G50/G59 (selection of a working co-ordinate system).

- Each block (line) in the program must start with a G- or M-code. None of the data entered before a G- or M-code will be interpreted.
- Incorrect parameters for a given G-code will not be interpreted.
- If a parameter appears twice in a given block (e.g. G00 X2.0 X3.00), it will have the value of the last entry (in this case, "X" will have the value of X=3.0).
- It is not possible to add comments to the file that contains a stored program.

3.5.1 G-codes (preparatory functions)

Table 3.2. A list of the available G-codes – Preparatory functions

G00	linear interpolation at fast feed (under construction)
G01	linear interpolation at slow feed
G02	circular interpolation clockwise
G03	circular interpolation counter-clockwise
G50/G59	selection of a base co-ordinate system

3.5.1.1 G00/G01 Linear interpolation at slow feed

X - movement command for the X-axis (endpoint X coordinates)

Y - movement command for the Y-axis (endpoint Y coordinates)

Z - movement command for the Z-axis (endpoint Z coordinates)

A - movement command for the A-axis (endpoint A coordinates)

A program that carries out drilling to the depth of 2mm:

Absolute:

%

G56

G90

G00 X0 Y0 Z0 A0

G01 Z-2.0

G01 Z0.0

%

Incremental:

%

G56

G00 X0 Y0 Z0 A0

G01 Z-2.0

G01 Z+2.0

%

3.5.1.2 G02 Circular interpolation clockwise

X - movement command for the X-axis (endpoint X coordinates)

Y - movement command for the Y-axis (endpoint Y coordinates)

Z - movement command for the Z-axis (endpoint Z coordinates)

I - distance along the X-axis toward the centre of wheel

J - distance along the Y-axis toward the centre of wheel

Presented below is a program that carries out an arc at the inclination angle of 130° and 5mm radius:

Absolute:

%

G56

G90

G00 X0 Y0 Z0 A0

G00 X1.79 Y3.83 Z0 A0

G02 X10.0 Y0.0 I3.21 J-3.83

%

Incremental:

%

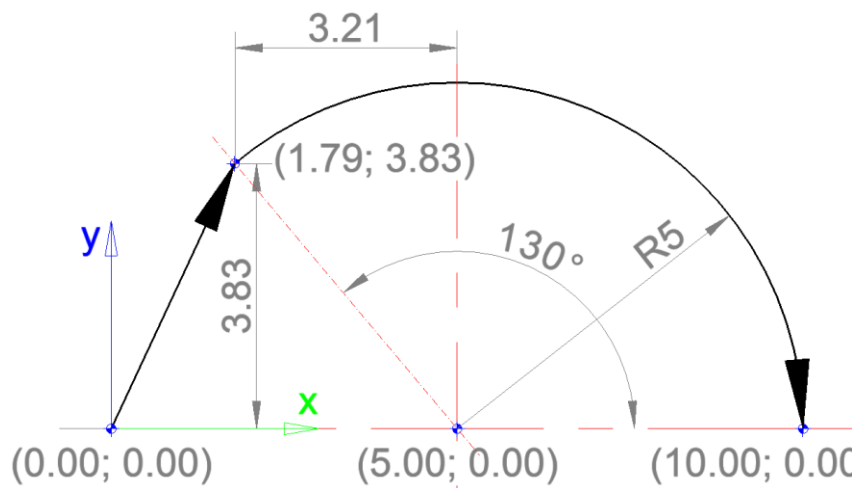
G56

G00 X0 Y0 Z0 A0

G00 X1.79 Y3.83 Z0 A0

G02 X8.21 Y-3.83 I3.21 J-3.83

%



3.5.1.3 G03 Circular interpolation counter-clockwise

X - movement command for the X-axis (endpoint X coordinates)

Y - movement command for the Y-axis (endpoint Y coordinates)

Z - movement command for the Z-axis (endpoint Z coordinates)

I - distance along the X-axis toward the centre of wheel

J - distance along the Y-axis toward the centre of wheel

Presented below is a program that carries out an arc at the inclination angle of 230° and 5mm radius:

Absolute:

%

G56

G90

G00 X0 Y0 Z0 A0

G00 X1.79 Y3.83 Z0 A0

G03 X10.0 Y0.0 I3.21 J-3.83

%

Incremental:

%

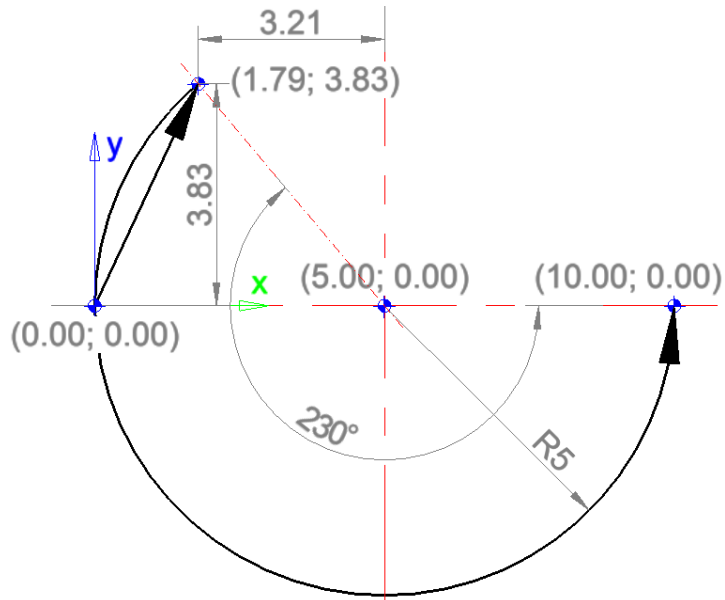
G56

G00 X0 Y0 Z0 A0

G00 X1.79 Y3.83 Z0 A0

G03 X8.21 Y-3.83 I3.21 J-3.83

%



3.5.2 G-codes (standard cycles)

Table 3.3. A list of the available G-codes – Standard cycles

G80	cancelling standard cycle
G81	carrying out a series of cavities
G85	orbiting around a circle
G86	orbiting around a square
G90	absolute coordinates in an active local co-ordinate system.
G91*	incremental coordinates (path) from the current location of the tool axis.

* - Set by default.

3.5.2.1 G81 Standard cycle to carry out a series of cavities

L – The number of repetitions

The data entered in-between the G81-G80 markers is always interpreted incrementally.

Presented below is a program that carries out 5 cavities:

%

G56

G00 X0 Y0 Z0 A0

G81 L5

G00 Z-2.0

G00 Z2.0

G00 X5.0

G80

%

3.5.2.2 G85 Standard cycle of orbiting around a circle

L – The number of convolutions

S – Stroke

D – Diameter of orbiting

Presented below is a program that carries out a orbit of 5mm in diameter, machined to the depth of 8mm:

%

G56

G00 X0 Y0 Z0 A0

G85 L8 S1 D5

%

3.5.2.3 G86 Standard cycle of orbiting around a square

L – The number of convolutions

S – Stroke

D – The length of an orbit side

Presented below is a program that carries out a orbit with a 5mm-long side, machined to the depth of 8mm:

%

G56

G00 X0 Y0 Z0 A0

G85 L8 S1 D5

%

3.5.2.4 G90/G91 Modifying the method of interpreting data (absolute/incremental)

Presented below are programs that carry out drilling to the depth of 2mm:

Absolute (G90):

G56

G90

G00 X0 Y0 Z0 A0

G01 Z-2.0

G01 Z0.0

Incremental (G91):

G56

G91

G00 X0 Y0 Z0 A0

G01 Z-2.0

G01 Z+2.0

3.5.3 M-Codes

Table 3.4. A list of the available M-codes

M33	activation of burning detection
M34	deactivation of burning detection
M35	activation of vibrations
M36	deactivation of vibrations
M37	activation of the “Extended Automatic Working Mode”
M38	deactivation of the “Extended Automatic Working Mode”

Presented below is a program that carries out drilling to the depth of 2mm, including activating additional functions and changing parameters:

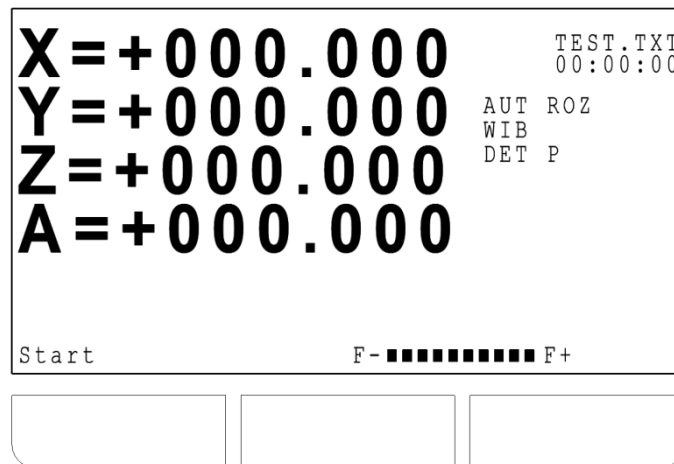
```
%
G56
G90
G00 X0 Y0 Z0 A0
G92 a20 T200 t20 P1 z4 W1000 D3000 F9
G01 Z-1.9
G92 a5 T180 t18 P1 z4 F9
M35
G01 Z-2.0
G01 Z0
%
```

4 Automatic Working Mode

Intended use: This function carries out the travel of the working bit, according to a pre-defined path of movement stored in the working program. When the machine is in operation, the name of the current program in progress and the time elapsed from the beginning of drilling are displayed in the top right corner of the screen (if the process is stopped, time is not counted).

Access path: Automatic Working Mode [A]

Screen:



Course of action:

- 1) Start PUMP1, PUMP2, PUMP3, GENERATOR.
- 2) Start the automatic working mode, by pressing: **[F1] "Start"**.
 - *If the operation is successful, the following messages will be displayed on the screen: "Operation completed successfully."*

The following keys are available, when this function is carried out:

- **[STOP]:** Work is stopped. When the function is paused, GENERATOR is activated and the following options for further actions will appear on the screen:
 - a. **[Fx] "Continue":** Work will continue;
 - b. **[Fx] "Abort":** Work will be stopped.
- **[A]:** Activation/Deactivation of the "Extended Working Mode" function (if already active, the following message will be displayed: *AUT ROZ*). If the function is activated, the following error will be ignored: "Error when returning to the beginning of segment";
- **[3]:** Activation/Deactivation of the Burning Detection function (if already active, the following message will be displayed: *DET P*).
- **[4]:** Activation/Deactivation of the Electrode Vibration function (if already active, the following message will be displayed: *WIB*);
- **[F2] "F-"; [F3] "F+":** Reducing/Increasing the speed of moving the working bit of the machine along the pre-set path of travel.

Error messages:

- If there are errors, regarding program interpretation of access to an SD card, see item 3.3.1 [Error Messages].
- **Attempting to exceed physical or base coordinates.**
- **Stopping the process:** See item 2.1.8. [General error messages regarding travels],
- **Critical ruler errors:** See item 2.1.8. [General error messages regarding travels],
- **Error when returning to the beginning of program:** A burn occurred and the working bit of the machine has returned to the beginning of the program currently in progress.
- **Error when returning to the beginning of segment:** A burn occurred and the working bit of the machine has returned to the beginning of the current segment of the program.
- **Excessive temperature in radiator, temperature or level of kerosene.**
- **Burn:** A burn has been detected.
- **The starting level of coordinate Z has been exceeded by 5mm. :** When drilling, the working bit of the machine has exceeded the starting point of the program by 5mm.
- **Travel Home.**

5 A pattern of preparatory procedures, before commencing a EDM process

- 1) Go to the “Manual Working Mode” and position the electrode in relation to a workpiece.
- 2) Travel the machine to the workpiece.
- 3) Travel away from the workpiece, according to a pre-defined value.
- 4) Reset the operator's coordinates: see item 2.2.1. [Operator's coordinates]
- 5) Set the appropriate physical coordinates (adjusted to the G-code applied in the working program): see item 2.2.2. [A list of base coordinates]
- 6) Go to “Programming” and load the program you intend to use: see item 3.1. [List of programmes]
- 7) Go to the “Automatic Working Mode” and start drilling: see item 4 [The “Automatic Working Mode”].