Micromanipulator 5171

Operating Manual

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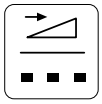
Brief description of key functions

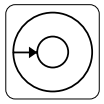
To fully understand these key functions, read through the comprehensive operating instructions first.

RESET: Initiated with the key combination DYN/STEP – CANCEL

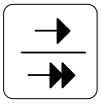
Parameter keys (yellow)



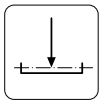
DYN/STEP
Option key for the DYN or STEP mode



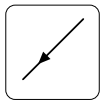
PROP
Switches to PROPortional mode



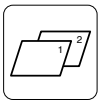
SPEED
Option key: slow/fast in the DYN mode



LIMIT
Defines the work level

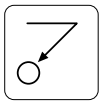


AXIAL
Axial movement on/off in DYN, STEP and PROP modes

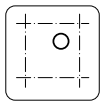


DEVICE
Option key for devices 1 and 2 (option)

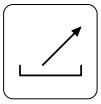
Function keys (red)



INJECT/IMPALE
Initiates the selected function



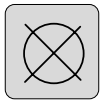
STORE/GOTO
STORE: stores coordinates;
GOTO: locates coordinates



HOME
Exits work area and later relocates exit point

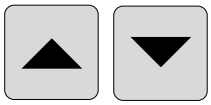
Programming keys (background color)

SAVE
Stores parameters permanently

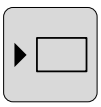


CANCEL
Aborts and deletes, inactivates the joystick

SET
Initiates a SET sequence (entry of new parameters)



Cursor keys
Change parameters in ascending and descending sequence



ENTER
Stores parameters temporarily

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1 General information

The Eppendorf Micromanipulator combines the classic advantages of a mechanical system (direct feeling for tool movement) with the advantages of a precise electromotive system.

The direct mounting of the module unit onto the tripod (left- or right-hand attachment) and the separate joystick control board prevent oscillation and vibration.
With the aid of the corresponding adapter, it is possible to mount the instrument onto all commonly available inverse microscopes.
The tool can be fitted to the module unit at any angle and in any direction.
The modular design provides enhanced flexibility.

The manipulator is suitable for all micropositioning applications, such as microinjection, electrophysiological measurements and microdissection.

- Use in microinjection

Semi-automatic injection is possible if the micromanipulator is used in conjunction with the Eppendorf Transjector 5246 or the Eppendorf Microinjector 5242. Injection movement and pressure are activated simultaneously at the push of a button. Movement takes place so quickly that, in many cases, a considerable increase in the number of cells injected can be achieved. In addition to the careful method of inserting the microcapillary axially into the cell and removing it axially without damaging the cell by wobbling the capillary by hand, this enhances the effectiveness and range of application of microinjection considerably. Furthermore, intelligent microelectronics simplify operations. To a great extent, operator errors are avoided, thus protecting both tool and preparation.

- Use in electrophysiology

The micromanipulator is also designed for carefully placing measurement electrodes on and in the cell. This is facilitated by single-step approach to the cell membrane and the impale function with variable speed. Measurements with a duration of more than 30 minutes are especially facilitated by the virtually drift-free mechanical construction of the device and joystick zero positioning which is performed automatically every 20 seconds. In addition, the joystick can be inactivated to prevent unintentional movement.
The change of pipettes frequently required for patch clamp measurements is substantially accelerated and simplified by the HOME function.

- Use in microdissection

With its ability to define work areas and to store positions, the micromanipulator allows you to carry out chromosome dissections precisely and rapidly. Adjustable tool movement speeds guarantee a minimum of loss when transporting chromosome segments.

- Expansion possibilities

The micromanipulator is also capable of assuming control of supplementary units as a second device using the same joystick. By upgrading with a second manipulator, the workplace can be used, for example, for injecting suspension cells.

2 Safety precautions and application

- Observe operating instructions!
- Only use device for application described!
- Take care when transporting the control board! Do ***not*** transport the device by holding the joystick!
- When mounting/dismounting take care to ensure that the motor modules (weight 3.5 kg) can be held safely! Failure to do so may result in injury!
- A weight of max. 500 g may be applied to the micromanipulator.
- The motor modules must not be moved against a mechanical obstacle, as this may damage the drive units.
- Before transporting the micromanipulator, the module unit is to be dismantled and, if possible, packed in its original box.
- 

  Caution when mounting tools!
  Mounting must not be performed with pressure. Glass capillaries can be damaged during mounting if they are not handled carefully. Wear eye protection to prevent the risk of injury from glass splinters.
- 

  Please ensure that all work is carried out in accordance with this manual!
  When placed upon a surface, the glass capillaries may break and glass splinters may cause injury. It is therefore essential to wear eye protection!
- Electrical connection with devices which are not expressly mentioned in this operating manual is only permitted after obtaining the prior approval of the manufacturer!

- Never point capillaries at persons!
  Capillaries can suddenly be loosened from their capillary grips under high pressure and become a missile.

- The device is to be used solely for micromanipulation in accordance with the appropriate legislative requirements!

- The responsibility for the correct functioning of the device passes onto the owner or user if the device is maintained or serviced improperly by persons not belonging to the Eppendorf service team or if used for a purpose other than that intended. Eppendorf AG is not liable for damage occurring from non-observance of these notes. Guarantee and conditions of liability of the terms of sale and delivery of Eppendorf AGare not expanded by the above notes.

3 Device description

3.1 Device components

The Eppendorf Micromanipulator consists of the following 3 components:

– Module unit

– Control board

– Power unit

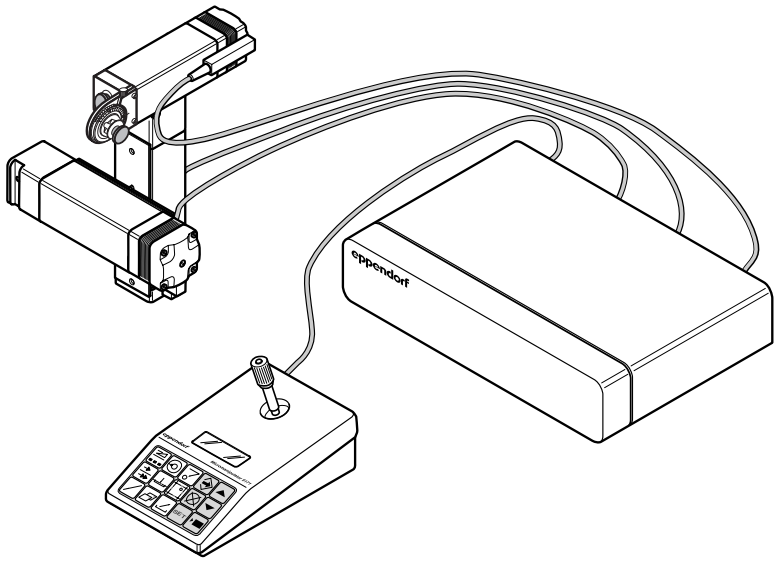


Fig. 1: Micromanipulator 5171, complete
Module unit for mounting on right-hand side

3.2 Module unit

The module unit can be mounted on all commonly used microscopes on the left or the right-hand side via an appropriate adapter.

The module unit is made up of 3 modules (X, Y, Z). Each module consists of a drive unit with stepping motor and special head piece.

The cannula holder for tool insertion is located on the X module. The angle of inclination of the cannula holder can be adjusted by up to 90°.

Tools with a diameter or a width of 4 mm and a weight of max. 500 g may be used. (e.g. capillary holder for microinjection, pipette holder and piezotranslators).

The motor position is indicated by the two markings on the guiding plate of the appropriate motor module. Figure 2 shows the center of the module. If the gap between the module housing and the motor is above the external ends of the markings, the motor can only operate in one direction (reverse).

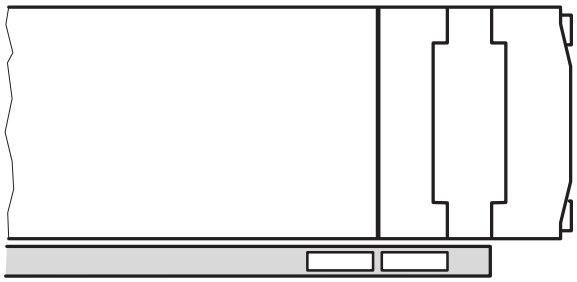


Fig. 2: Marking of motor position

3.3 Control board

The joystick with button, the keypad and the display panel are located on the control board.

3.3.1 Keypad

The keypad on the control board is subdivided into three areas:

- Parameter keys (yellow underlay)
- Action keys (red underlay)
- Programming keys (color as background)

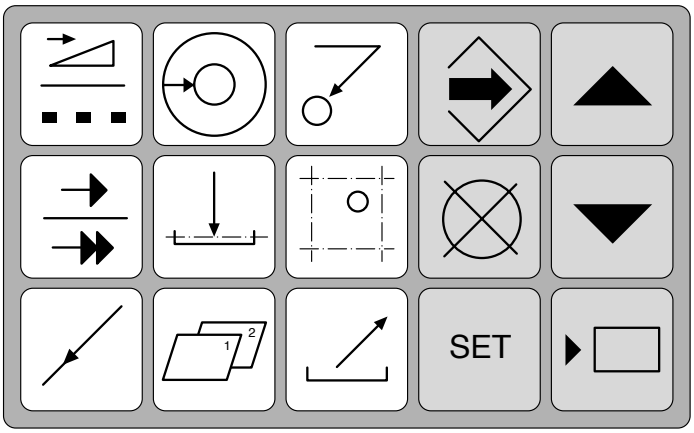
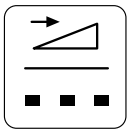


Fig. 3: Keypad

Defining, programming and amending work parameters is described in Sec. 5 "Mode of operation", beginning Page 5–1. The relevant section number is shown in brackets.

Parameter keys (yellow underlay)

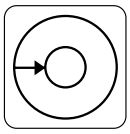


DYN/STEP (see Sec. 5.2.1.1)
Option key for DYN or STEP mode. The set parameter is displayed in field A (Fig. 4, Sec. 3.3.3).

DYN mode
Increased joystick deflection results in increased tool speed. When the joystick is released, it returns to the center position.

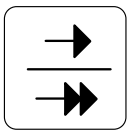
STEP mode
Single-step movement:
Joystick operation provides single-step movement on the X, Y and Z axes. Deflection of more than 0.5 s provides constant-speed movement.

RESET function
Initiated in conjunction with the CANCEL key (see Sec. 5.10).

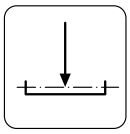


PROP (see Sec. 5.2.1.2)
Option key for PROPortional mode. Parameters are displayed in field A (Fig. 4, Sec. 3.3.3).

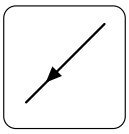
PROP mode
The tool behaves as if it were mechanically connected to the joystick; i.e. the joystick movement is proportional to tool movement.



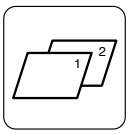
SPEED (see Sec. 5.2.4)
Option key: selects speed range (FAST/SLOW). Can only be activated in DYN mode. Display in field B (Fig. 4, Sec. 3.3.3).



LIMIT (see Sec. 5.3)
Defines the work level beyond which the tool cannot be moved. A limit can be defined in the X or Z direction. Display in field D
(Fig. 4, Sec. 3.3.3).

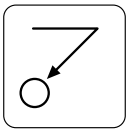


AXIAL (see Sec. 5.2.1.3)
Axial movement on/off in DYN, STEP and PROP modes.
Display in field C (Fig. 4, Sec. 3.3.3).



DEVICE (see Sec. 5.6)
Switchover between devices 1 and 2. Display in field E (Fig. 4, Sec. 3.3.3).

Function keys (red underlay)

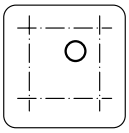


INJECT/IMPALE (see Sec. 5.4)
Initiates the selected function.

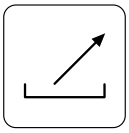
INJECT: The tool moves down to the defined work level (LIMIT) and back.

IMPALE: The tool moves only as far as the defined work level (LIMIT). Pressing the key once more returns it to the original position.

Display of the selected function in field D (Fig. 4, Sec. 3.3.3).



STORE/GOTO (see Sec. 5.7)
In the STORE function, the current tool coordinates are stored as fixed points.
In the GOTO function, the tool moves to the displayed (stored) position.
Display of the selected function in field F (Fig. 4, Sec. 3.3.3).



HOME/CLEAN (see Sec. 5.5)
The tool exits axially from the work area.

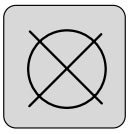
HOME: Exits up to the limit position of the X and Z motors.

CLEAN: Exits up to a previously defined level.

Pressing the key once more returns the tool exactly to the original position.

Programming keys (background color)

SAVE
Completes a SET sequence. The parameters are stored both in the main memory and permanent memory.



CANCEL
Aborts

- parameter entries
- functions
- programming steps

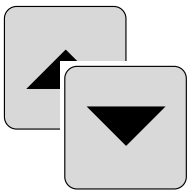
Deletes

- coordinates
- limit

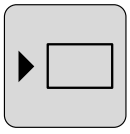
RESET function
Initiated in conjunction with the DYN/STEP key (see Sec. 5.10).

Inactivating the joystick
After approx. 10 s, a message appears in the display that the joystick has been inactivated. Before and after this message, inactivation can be aborted with CANCEL.

SET
Initiates a SET sequence (entry of new parameters). The variable parameters flash. Pressing SET once more acknowledges the default parameters, and the flashing display switches to the next parameter position.



CURSOR KEYS
Change parameters in ascending and descending sequence



ENTER
Completes a SET sequence. The parameters are stored in the main memory. The data is irretrievably lost after the unit is switched off or after a RESET.

3.3.2 Joystick

The joystick provides horizontal movement (X and Y axes) and vertical movements (Z axis). Vertical movement is initiated by rotating the joystick:
Clockwise rotation: downward movement
Counterclockwise rotation: upward movement.

Multidirectional movement (all three axes) is possible. The direction of movement along individual axes can be reversed.
A button is integrated into the joystick handle. The button function can be defined with a SET function (see Sec. 5.8).

3.3.3 LC display

The LC display consists of two levels:

– Main display level

– SET display level

Main display level

Fig. 4: Main display level

Display fields A to H are status fields; position fields X=..., Y=..., Z=... show the X, Y and Z position of the tool in mm in relation to the power-on position or the last zero position defined. An * preceding X, Y or Z indicates that the relevant axis is located in its end position.

The status field displays have the following significance:

AAAA	***Indicates the tool's mode of operation.***
DYN	Tool movement in dynamic mode.
STEP	Tool movement is divided into single steps of 160 nm.
PROP	Tool movement in proportional mode.
BBBB	***Displays the speed range in the DYN mode.***
SLOW	Tool movement in slow speed range (max. 710 mm/s).
FAST	Tool movement in rapid speed range (max. 5,680 mm/s). These displays are only possible in the dynamic mode.
CC	***Indicates AXIAL mode.***
----[1)]	Axial movement not activated.
AX	Axial movement activated.
DDD	***Indicates whether and on which plane a LIMIT is defined and whether and in which form INJECT/ IMPALE is activated.***
----[1)]	INJECT/IMPALE not activated; no LIMIT set.
LIZ	INJECT/IMPALE function not activated; LIMIT set in the Z plane.
LIX	INJECT/IMPALE function not activated; LIMIT set in the X plane.
IN	INJECT function activated; no LIMIT set.
INZ	INJECT function activated; LIMIT set in the Z plane.
INX	INJECT function activated; LIMIT set in the X plane.
IM	IMPALE function activated; no LIMIT set.
IMZ	IMPALE function activated; LIMIT set in the Z plane.
IMX	IMPALE function activated, LIMIT set in the X plane.
EEEE	***Indicates the active device.***
----[1)]	Device I active.
dev2	Device II active.

----[1)] means no entry

FFFFFFFFF	***Provides data on STORE/GOTO mode activity and stored/approached positions.***
----[1)]	STORE/GOTO function not activated.
jSTORE!mn	STORE function activated.
jkGOTOmno	GOTO function activated.
j	Denotes the number of the last approached position (in GOTO mode) or stored position (in STORE mode) for device II. If no second device is connected, field remains empty.
k	Denotes the number of the last approached or stored position for device I. If device II is active, a colon is displayed.
m	If device I is active, denotes the number of the current position; if device II is active, it denotes the number of the position to be stored or approached. This number can be changed with the cursor key (in the STORE mode to any number between 0 and 9, in the GOTO mode only to a previously defined position). If no device II is installed, the field remains empty.
n	If device I is active, denotes the number of the position which should be stored or approached next. It can be changed with the cursor key (in the STORE mode to any number between 0 and 9, in the GOTO mode only to a previously defined position). If device II is active, a colon is displayed.
o	▲ or ▼ indicates increasing or decreasing order of counting.
!	When displayed preceding mn, it indicates that a position is already stored under this number. Press the STORE/GOTO key to overwrite the value.

GGGGGGG	***Displays the function allocated to the joystick button (JB = joystick button)***
----[1)]	Function of joystick button not defined.
JB=DYN/STP	Joystick button functions as DYN/STEP key.
JB=PROP	Joystick button functions as PROP key.
JB=SPEED	Joystick button functions as SPEED key.
JB=LIMIT	Joystick button functions as LIMIT key.

----[1)] means no entry

JB=AXIAL	Joystick button functions as AXIAL key.
JB=DEVICE	Joystick button functions as DEVICE key.
JB=INJ/IMP	Joystick button functions as INJECT/IMPALE key.
JB=ST/GOTO	Joystick button functions as STORE/GOTO key.
JB=HOME	Joystick button functions as HOME/CLEAN key.

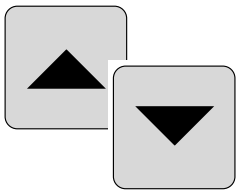
HHHHHHHH	***Displays the REMOTE mode of operation status. This mode of operation can only be switched on and off by means of an on-line computer***
----[1)]	Remote control not activated.
MONITOR	Monitor function of remote control activated.
REMOTE	Remote control activated.
HANDPOS	Remote control with manual positioning activated. (Switch off with DEVICE button at the control board.)

SET display level

This display level is activated when a SET sequence for changing and redefining functions and parameters is initiated. To move to the next line on the display, you must press SET. This display level is described in detail in Sec. 5 "Mode of operation".

3.3.4 LC display illumination

The background illumination of the LC display can be switched on or off by pressing the cursor keys simultaneously.



Key combination for switching on/off the LC display illumination

----[1)] means no entry

3.4 Power unit

The power unit contains the entire power electronics for the micro-manipulator.

The main power switch and the connecting sockets for the individual modules, the control board and the serial interface are located at the rear.

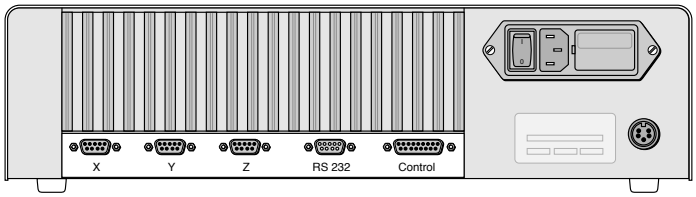


Fig. 5: Rear view

4 Installation

Before checking that the delivery package is complete and assembling the device, please read the next section carefully.

4.1 Hazards during unpacking and other important notes

- The control board must not be carried/pulled out using its joystick! The joystick is a very sensitive control element for transmitting movements in the 0.1 µm range. When transporting, always hold the housing only!
- Never place the control board upside-down onto the joystick!
- Handle the motor modules with care!
- If possible, always transport the motor modules in their original packaging!
- Always disassemble the motor modules before transporting!
- Place motor modules very carefully onto bench when assembled (do not tilt)!
- When assembled, the motors must not be at the top of the module. They must always be at the bottom or in a horizontal position!
- Following the warm-up phase (at least 30 minutes), the device is virtually drift-free.
- After the RESET function has been actuated, the joystick may only be deflected after the RESET function has ended. The end of the RESET function is accompanied by an acoustic signal or by the display returning to the operating status.
- When using the Eppendorf injection system, enter an injection time of >0.0. Failure to do so could result in an error message.

4.2 Overview and accessories

4.2.1 Overall view

The complete Micromanipulator 5171 with all device components mounted is shown in Fig. 6. In this example, right-hand sided mounting has been selected.

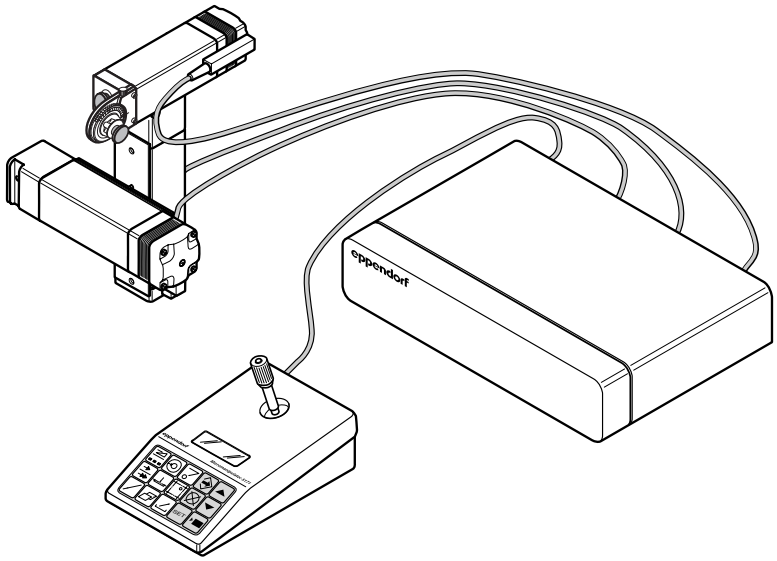
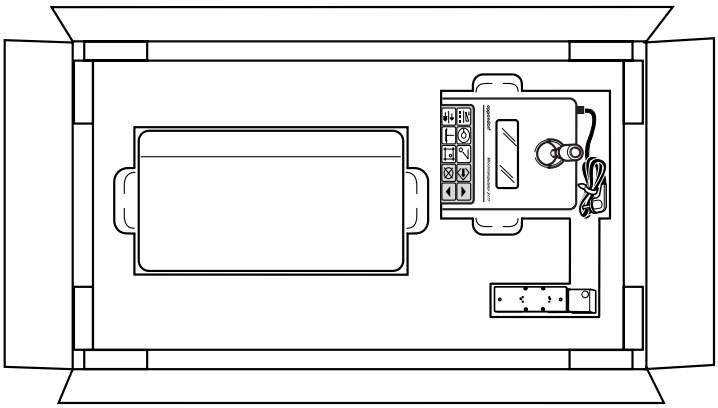


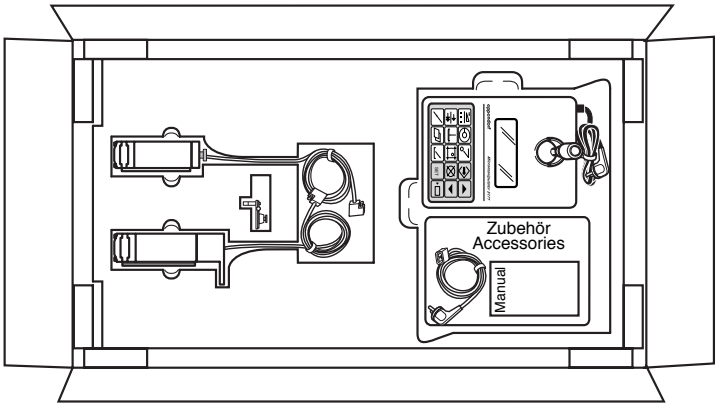
Fig. 6: Micromanipulator 5171,
Module unit for mounting on the right-hand side

4.2.2 Packaging

The packaging should be kept for transport at a later date. It has two levels. The first level contains the power unit and a motor module.



The second level contains the accessories, the operating manual, the other two modules and the control board.



The standard accessories consist of:

1 Operating Manual
1 Main power cable
2 Oval head screws, M3x6
1 Phillips screwdriver
1 Allen wrench, 4 mm
1 Connecting plate
4 Oval-head screws, M2x4
1 Transmission cable 5246

4.3.2 Components of the module unit

The module unit consists of the following components (Fig. 7):

1 Fastening head
2 Y module
3 Connecting plate with 4 fastening screws
4 Z module
5 Connecting head
6 Cannula holder
7 Adapter block
8 X module

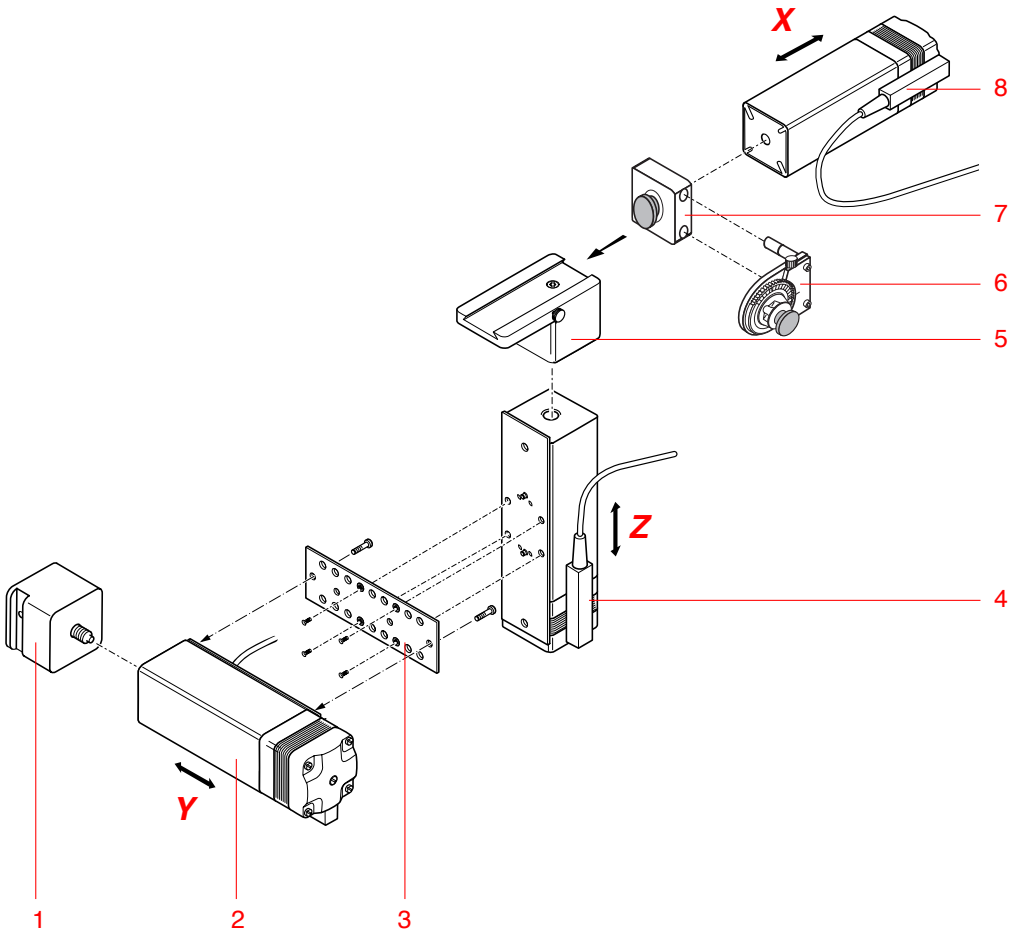


Fig. 7:

Delivery status

Z module

The Z module is connected to the Y module via the connecting plate (Fig. 11). The X module is fastened using the connecting head (Fig. 8.1).

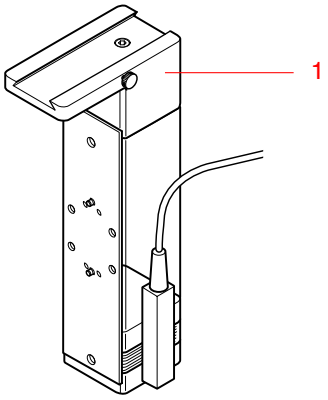


Fig. 8:

1 Connecting head

Y module

The Y module is connected to the Z module via the connecting plate (Fig. 11). The module unit is connected to microscope with the aid of the fastening head (Fig. 9.1) and the corresponding adapter.

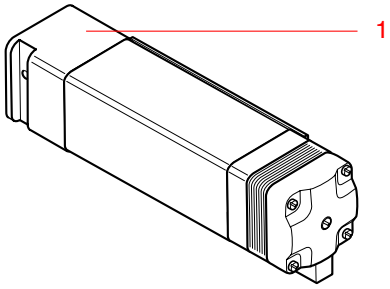


Fig. 9:

1 Fastening head

X module

The adapter block with cannula holder (Fig. 10.1) is located on the X module, on which the tool (e.g. capillary holder) can be mounted.

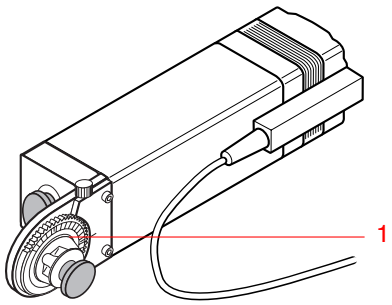


Fig. 10:

1 Adapter block
with cannula holder

Connecting plate

The Y module and the Z module are connected using the connecting plate. The connecting plate can be screwed onto either the Y module or the Z module (see mounting instructions for the corresponding microscope). The module unit must be assembled according to whether it has been mounted on the left-hand side or right-hand side of the microscope. Note that distances a and b vary in size.

Connecting plate on the Y module: Distance a is at the top.

Connecting plate on the Z module: Distance a is at the rear.

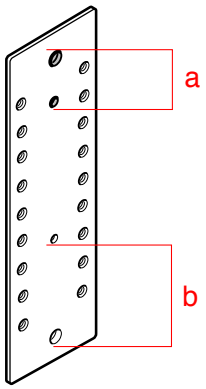


Fig. 11: Connecting plate

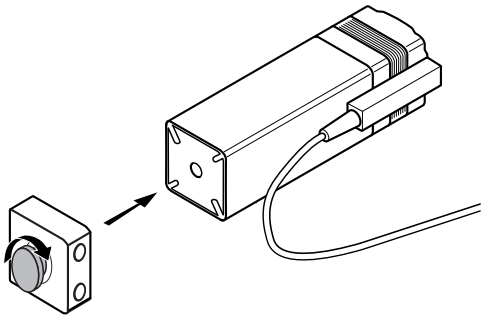
4.3 Mounting the module unit

The mounting procedures described here are intended for fastening the module unit to the most commonly used microscopes. It is assembled onto the microscope tripod via adapters which differ according to the microscope used and which must be ordered separately. If a different type of mounting is necessary, special adapters are required. See appendix C, "Examples of Application".

4.3.1 Mounting the cannula holder

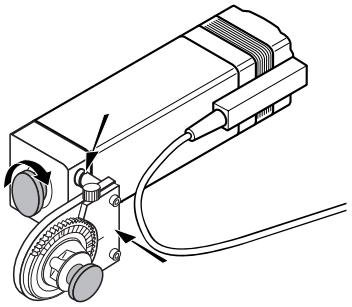
Mount the adapter block with the fastening screw as shown in the diagram.

Do not tighten the fastening screw fully.



Insert the cannula holder into the bores of the adapter block via the two metal pins. Ensure that the markings of the metal pins disappear completely into the adapter block

Tighten the fastening screw.



4.3.2 Right- and left-hand side mounting

Mounting the module unit is dependent on the microscope used as well as on the selected side of the microscope.

The exact procedure for mounting the module unit is described in the mounting instructions for the adapter used.

4.3.3 Pre-positioning

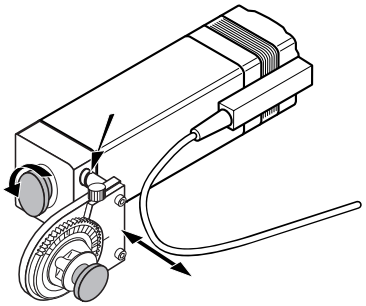
The module unit must be pre-positioned manually. The tool is then inserted. By manual shifting of the X,Y and Z modules, the tip of the tool is taken approx. 5–10 mm by eye over the center of the objective.

Z direction
By removing and moving the connecting plate on the Y module, the height of the X and Z module, and thereby the height of the tool, can be changed. Altogether, the connecting plate on the Y module can be mounted at six different levels. Ensure that the middle bores with the shorter distance (a) on the connecting plate are at the top.

Y direction
In order to shift the X and Z module in the Y direction, the connecting plate can also be mounted on the Z module. The X and Z module are positioned at one level.

Altogether, the connecting plate can be mounted on the Z module in six different positions. Distance a must be at the rear.

It is also possible to position the cannula holder in the Y direction by shifting it in the adapter block. To do so, loosen the fastening screw slightly and pull the cannula holder slightly out of the adapter block.



Do not pull the metal pins further out than the marking as the cannula holder will then no longer be connected correctly.

Retighten the fastening screw.

X direction
By loosening the setscrew (Fig. 12.2), the X module (Fig. 12.1) can be shifted. The tightening screw must then be refastened.

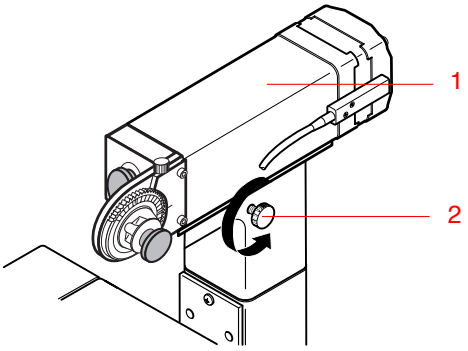


Fig. 12:

1 X module
2 Setscrew

4.4 Connecting the cables – Startup

The connections between control board, power unit and modules may only be made or interrupted when the device is switched off.

The three plugs of the Z, Y and X modules are connected in this order to the corresponding sockets on the rear panel of the power unit. The plug of the control board is also connected to the power unit.

Note: Tighten the screws on the plugs!

Before plugging in the device, compare your power supply with the electrical requirements listed on the ID plate.

If the module axes are interchanged because of the connection of the module unit to the microscope, this must be taken into consideration when the plugs are assigned to the sockets.

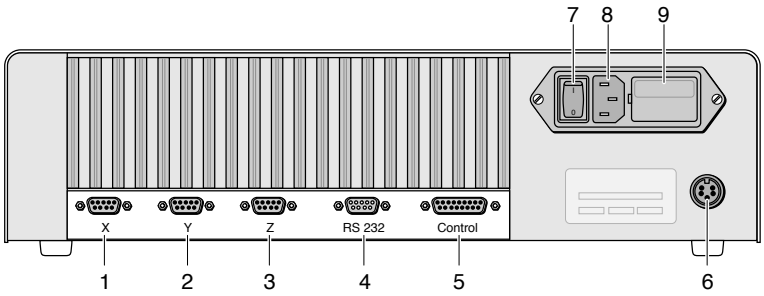


Fig. 13: Rear panel

1 Connection for X module
2 Connection for Y module
3 Connection for Z module
4 Serial interface for computer (RS 232)
5 Connection for control board
6 Connection for transmission cable 5246 or 5242
7 Main power switch
8 Main power socket
9 Fuse panel

4.4.1 Transmission cable 5246

For ideal use of the INJECT/IMPALE function (see Sec. 5.4), the micromanipulator must be connected to the Eppendorf Transjector 5246.

Connecting the cables:

You require the transmission cable 5246 and the optional foot control.

– Connect the 6-pin plug to the corresponding socket on the rear panel of the power unit.

– Connect the 5-pin to the right socket on the rear panel of the Eppendorf Transjector 5246.

– Join the connector at the short end of the transmission cable to the plug on the foot control (option).

Note: The transmission cable 5246 cannot be used to combine the Eppendorf Micromanipulator 5171 with the Eppendorf Microinjector 5242. The older transmission cable 5242 is required for this purpose.

The older transmission cable 5242 can be used, with certain restrictions, as a connection to the Transjector 5246. In this combination, only pressure control is initiated with the INJECT key of the Transjector and not injection movement. The cable is connected accordingly.

4.4.2 Connecting cable for 2nd device

If you are connecting a second device, you require a second power unit. This is programmed inside the device for operation as second device. The two power units are connected by means of the "Connecting cable device II" and plug no. 5 shown in Fig. 13. The control unit is connected with its own plug-in cable via the double-sided connector of the connecting cable to the power unit of the first device.

4.5 Inserting the tool holder

If the large fastening screw (Fig. 14.1) is loosened counterclockwise, the tool holder (4 mm diameter) can be inserted into the upper groove.

In this diagram, the tool holder is the universal capillary holder.

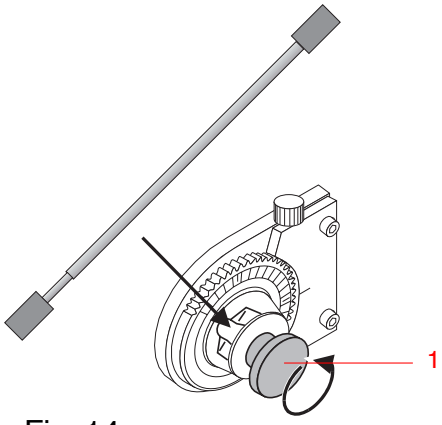
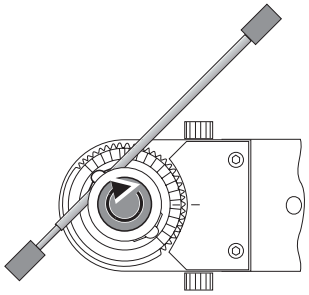
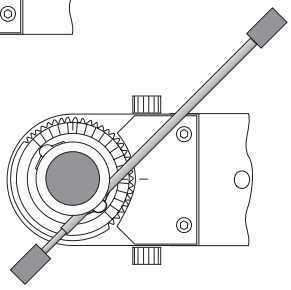


Fig. 14

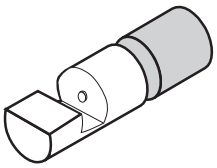
The universal capillary holder is fixed into place by retightening the fastening screw.



The universal capillary holder can be inserted into the lower groove.

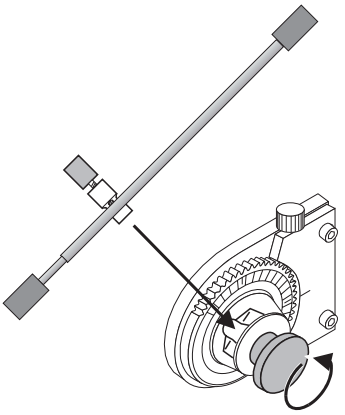


The clamping piece can be used to fix the position of the universal capillary holder following removal.

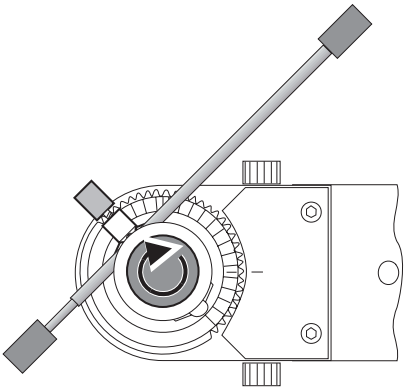


To do so, the clamping piece is fastened to the universal capillary holder as shown in the diagram.

The universal capillary holder is then inserted into the groove together with the clamping piece.



The universal capillary holder is fixed using the large fastening screw. The position is determined exactly using the clamping piece.



4.5.1 Setting the angle

The angle can be preset by turning the adjusting screw (Fig. 15.1) on the cannula holder. The angle can be read directly using the scale.

Note: When the angle is changed, the height of the universal capillary holder and the tool also changes. A downward movement may destroy the tool.

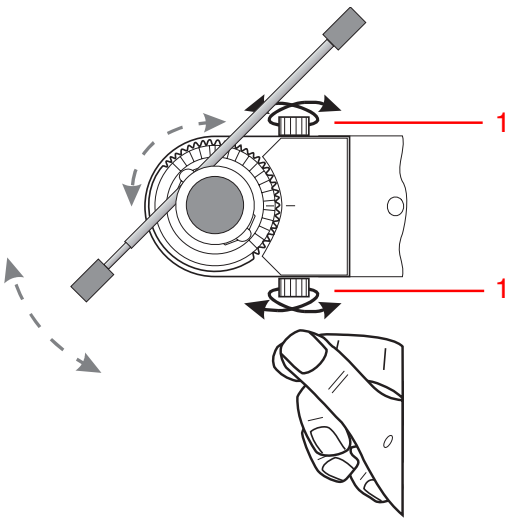


Fig. 15

5 Mode of operation

5.1 General

Switch on the device by pressing the toggle switch on the back of the unit. Then the device is in the following basic mode:

- Dynamic mode;
- Slow speed;
- No special function selected.

The current status is shown on the LC display.

If a combination of keys is not permissible, an acoustic signal is emitted. The device remains in the previously selected mode. It is possible to disable the acoustic signal (see key sequence SET-DEVICE, Sec. 5.6).

The maximum distance travelled for each of the three motors is 2.5 cm. When the end position of the X, Y or Z axes is reached, an asterisk appears in front of the corresponding position field on the display. Move the joystick in the opposite direction. If the tool cannot be moved into the optical axis/focal point, the device must be pre-positioned again (see Sec. 4.3.3).

5.2 Positioning the tool

When using the device, three modes of operation are available:

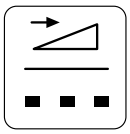
DYN mode (dynamic control)
Increased joystick deflection results in increased tool speed. When the joystick is released, it returns to the center position.

STEP mode (control in single-step mode)
Joystick operation provides single-step movement of 160 nm on the X, Y and Z axes. Joystick deflection of more than 0.5 s causes continuous tool movement.

PROP mode (proportional control)
The tool behaves as if it were mechanically connected to the joystick; i.e. the joystick movement is proportionate to tool movement. The speed of the tool is controlled by the dynamics of the joystick movement. The position of the tool at the time of switching over determines the center of the work area.

5.2.1 Defining the mode of operation

5.2.1.1 DYN/STEP



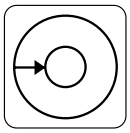
It is possible to toggle between the dynamic and STEP mode by pressing the DYN/STEP key. The active mode is displayed in field A.
The DYN mode allows the tool to travel long distances rapidly and, at the same time, to be positioned precisely. It is primarily suitable for pre-positioning the tool or working at points which are far apart.
According to joystick deflection, the speed increases progressively up to the set maximum value of 700 mm/s in the SLOW mode and 5500 mm/s in the FAST mode (FAST/SLOW = 8/1).

The STEP mode allows you to complete single steps of 160 nm. It is needed primarily for the precise positioning of the pipette for electrophysiological measurements.

Short deflection (X, Y) or rotation (Z) of the joystick initiates a single step. This is followed by a pause.
If the joystick is deflected for a longer period, the step is repeated at a constant rate as long as the joystick is deflected. The rate of repetition can be set within the speed setting (SET-SPEED) (see Sec. 5.2.4).

5.2.1.2 PROP

Precise tool control, almost as if the tool was attached to the joystick, provides precision positioning capability in the mm range. The PROP mode is particularly suitable for cells in mutually close proximity.



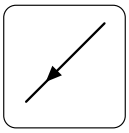
The PROP key switches over from the dynamic or STEP mode into the proportional mode.
On the X and Y axes the joystick remains in the position it was in when it was released. However, the Z adjustment (rotating the joystick) returns to the center position. Therefore, a search level is available which always remains at a constant distance from the focus level of the microscope.

When switched over to the DYN/STEP mode, the joystick returns automatically into the center position. The zero position is redefined. For this reason, the joystick must not be held tightly during switchover.

If the joystick button is used for switching over into the DYN/STEP mode, it must be released immediately after being pressed. As a reminder, an acoustic signal is during switchover and the following message appears in the display:

After three seconds, the current joystick position is defined as the zero position.

5.2.1.3 AXIAL



Simultaneous movement of the tool on the X and Z axes is defined as axial movement. The tool should be set up at a defined angle (see Sec. 4.5.1).

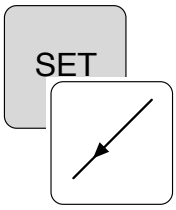
If axial movement is activated, joystick rotation triggers a combined X-Z movement.

Pressing the AXIAL key activates axial movement in DYN, STEP and PROP modes.

Clockwise rotation:
Downward diagonal movement.

Counterclockwise rotation:
Upward diagonal movement.

5.2.1.4 Angle definition



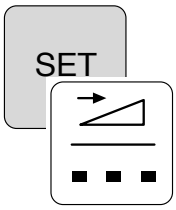
The SET-AXIAL key combination can be used to set an angle at which the tool will move in the INJECT/IMPALE, HOME, CLEAN and AXIAL functions. Starting with an flat angle of 10°, it is possible to set an angle of 90° vertical to the microscope stage). If possible, the selected angle should also be set on the cannula holder (see Sec. 4.5.1). The factory-set angle is 45°.

set angle for
INJECT AXIAL
CLEAN HOME
aa °

The field aa flashes.
Set the desired angle using the cursor keys.

The value is saved in the main memory by pressing the ENTER key and in the permanent memory by pressing the SAVE key.

5.2.2 Joystick zero position



This function redefines the central position of the joystick. It is executed automatically after any start and reset or during operation if no deflection takes place. Therefore, it must only be carried out where necessary.

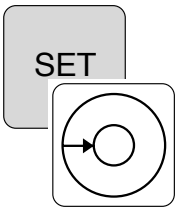
Key sequence: SET-DYN/STEP

Release the joystick.

Press the ENTER key.

The zero position for the joystick is set.

5.2.3 Radius of circular work field



Parameters can be entered for a new work field for the PROP mode. This allows the manipulator to remain within the field of view at various levels of microscope magnification. A radius of 250 mm is set in the factory.

Key sequence: SET-PROP

Move the tool with the joystick to the desired left edge of the working field.

Press the SET key again.

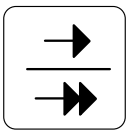
Now move the tool to the center of the work field.

Press the ENTER key.

The parameters of the defined work field are stored in the main memory. If you press the SAVE key instead of the ENTER key, the parameters are stored in the main memory and the permanent memory.

5.2.4 Tool speed

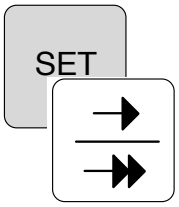
5.2.4.1 Defining the speed range



When in the DYN mode, you can change over between slow and fast using the SPEED key.
Slow is designed for fine positioning and for working with higher magnification.
"Fast" is designed for rapid positioning of the tool and thus replaces the mechanical coarse adjustment. It is also useful when working with lower magnification.

5.2.4.2 Defining the maximum speed

The keys SET-SPEED are for altering the speed parameters for DYN/STEP and PROP. The speed value is specified in µm/s.



The cursor keys are used to alter the maximum value in the SLOW speed range. Speed can be set from 5 to 700 µm/s which represents maximum joystick deflection.
In the fast speed range the maximum speed is 8 x slow speed. The current speed parameters are therefore correspondingly altered with a multiplication factor of 8.

Key sequence: SET-SPEED
Depending on the starting conditions (DYN, PROP or STEP), one of the following messages appears on the display.

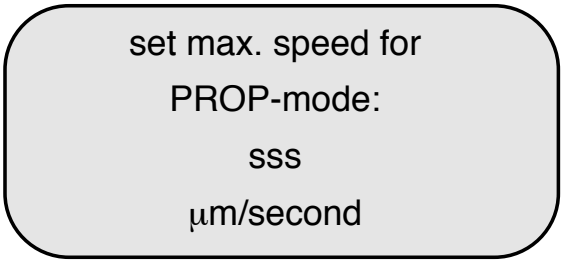
1. DYN mode selected:

set max. speed for
DYN-mode (slow):
sss
µm/second

Field sss flashes.

Set the maximum speed (slow) value using the cursor keys. This setting also changes the maximum speed (fast) by a multiplication factor of 8.
Press the ENTER key.
The parameter entered is stored in the main memory. If you press the SAVE key instead of the ENTER key, the parameter is stored in the main memory and the permanent memory.

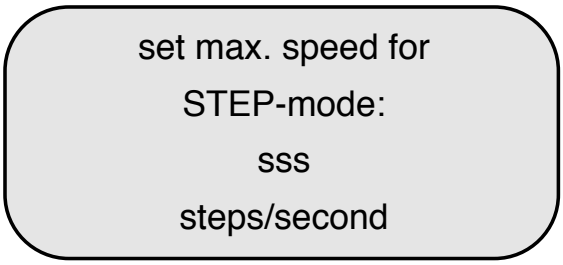
2. PROP mode selected:



Field sss flashes.

The maximum speed in the PROP mode can be changed using the cursor keys. This may be necessary for special applications. It is not necessary for normal applications as the speed of the tool is determined by the dynamics of the joystick deflection.

3. STEP mode selected:



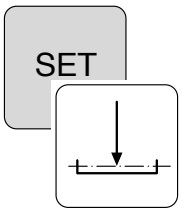
Field sss flashes.

Continue as under DYN.

Alterations in speed in the STEP mode define the step frequency for continuous joystick deflection in the range from 2 to 640 steps per second.

5.3 Work level

5.3.1 Defining the X or Z plane as work level



The work level can be set either in the X or in the Z plane. The tool cannot be moved beyond the set plane. At the same time, the work level defines the final position of tool movement for the INJECT/IMPALE function. The INJECT/IMPALE function cannot operate without a defined LIMIT.

The work level is set to avoid damage to the tool and preparation and to determine the injection depth in the case of the INJECT/IMPALE function.

The main application for the Z limit is microinjection of adherent tissue culture cells (see Fig. 17, left). An application for the X limit is the injection of suspension cells when using a holding capillary (see Fig. 17, right).

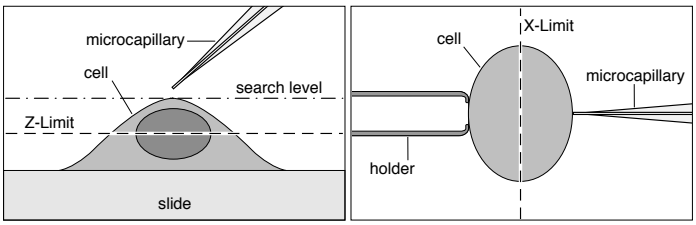


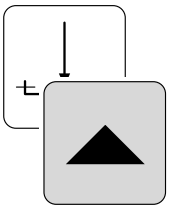
Fig. 17: Z and X limits

Key sequence: SET-LIMIT

The tool is moved into the required position. The current tool position is entered as the work level by pressing the SET and LIMIT keys. The screen displays information to facilitate definition of this tool position as the X or Z limit with the aid of the cursor keys. Storage as Z limit is offered as an option. Storing is performed with the ENTER key or SAVE key in the main memory. Any parameters stored in the memory are replaced by the new position. By pressing CANCEL, the procedure is terminated without modification and can be carried out again.

After the work level has been successfully defined, the tool is returned to the search level above the cell.

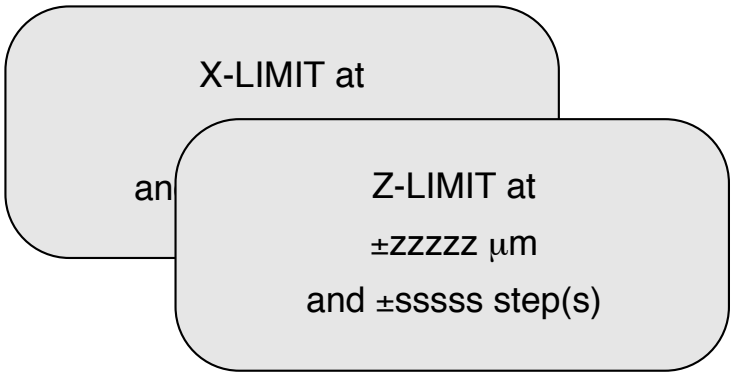
5.3.2 Fine correction of work level



or

Uneven surfaces (especially when working with plastic petri dishes), and even various kinds of cell morphology call for correction to the work level from time to time. To avoid the extensive work involved in redefining the limit each time as described above, the limit plane can be easily readjusted with the cursor keys in single steps of 160 nm. This can be carried out from the current position and is not effective until the next time INJECT/IMPALE is activated.

Key sequence: LIMIT-CURSOR KEYS

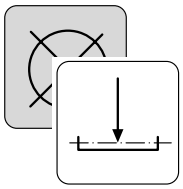


The limit level is stored internally in microsteps. To be able to compare this with the displayed coordinates, it is converted into mm and displayed in the ± xxxxx or ± zzzzz field. ± sssss displays the deviation of the exact value from the mm parameter in microsteps. When changing the limit level with the cursor keys, at first only the ± sssss field is changed. When the cursor key is released, the µm parameter and the deviation in microsteps are recalculated and displayed.

To be able to check the correction carried out, the tool can be moved without pressing ENTER or SAVE to store, and INJECT/IMPALE activated. The parameters set on the main work level are valid. No other function, e.g. DEVICE II, HOME/CLEAN, STORE/GOTO can be triggered without returning to the main display.

Pressing the ENTER key or SAVE key acknowledges the corrected limit level, stores it in the main memory and returns to the main display.

5.3.3 Deleting the current work level



To set a completely new LIMIT or to be able to continue working without LIMITS, the current work level can be deleted and, if required, reprogrammed as described above.

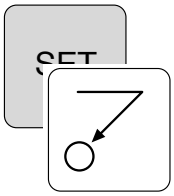
Key sequence: CANCEL-LIMIT

5.4 Injection process

The injection process is defined using the INJECT/IMPALE key.

This function is designed to initiate tool movement down to the set LIMIT (IMPALE) or down and back up (INJECT).

5.4.1 Defining INJECT/IMPALE and setting the required parameters



You can decide whether to operate in the INJECT or IMPALE mode. In addition to this, the direct vertical (with set Z limit) or horizontal (with set X limit) movement of the tool to the defined work level (AXIAL off) can be switched to an axial movement by simultaneous X and Z movement of the tool (AXIAL on, only working with set Z limit). Also the speed of the INJECT/IMPALE-movement can be pre-programmed up to a maximum value of 700 mm/s. For correct axial movement, the angle which has been set on the cannula holder (see Sec. 4.5.1) should be the same as the defined angle (see Sec. 5.2.1.4). SYNC is used to determine whether the connected microinjector should begin building up injection pressure when the injection movement begins (Immediate) or when LIMIT has been reached.

Key sequence: SET-INJECT/IMPALE

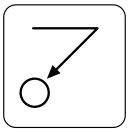
The following is displayed

You can use the cursor keys to activate INJECT (INJ on/ IMP off), IMPALE (INJ off/IMP on) or inactivate both functions (INJ off/IMP off).

Pressing the SET key advances you to the next line; the selected parameters flash.

This parameter can be changed using the cursor keys. Pressing the ENTER key stores the parameter entered in the main memory. If the SAVE key is pressed instead of the ENTER key, the parameter is stored in the main memory and in the permanent memory.

5.4.2 Initiating the INJECT/IMPALE function



By pressing the key INJECT/IMPALE, the movement selected is carried out using the defined parameters. The movement takes place on the X or Z axis up to the defined limit plane.

If the INJECT function is selected, the tool returns to the original position after completing the motion. The INJECT function with defined Z limit is used primarily for injecting adherent cells.

If the IMPALE function is selected, the tool stops at the LIMIT plane and does not return to the original position until the INJECT/IMPALE key is pressed again. This function is used primarily in electrophysiology for intracellular measurements.

If no LIMIT is defined, pressing the INJECT/IMPALE key has no effect.

If a Z limit is set and the AXIAL function selected, movement takes place in the axial direction due to the simultaneous X and Z movement. This facilitates particularly careful injection methods.

Fig. 18 shows a schematic injection with set Z LIMIT and activated AXIAL function.

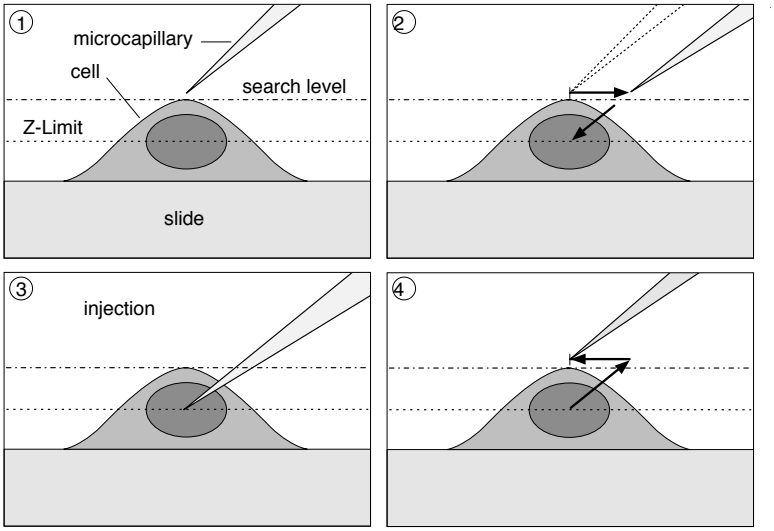


Fig. 18: INJECT function

1 Original position, capillary in search level.
2 The manipulator travels in the X direction.
3 The capillary pierces the cell in axial direction down to the Z limit.
4 After ending an injection, the capillary returns to the original position.

Fig. 18.1:
Beginning of the pressure build-up with the Microinjector in SYNC = IMMEDIATE
Fig. 18.3:
Beginning of the pressure build-up with the Microinjector in SYNC = LIMIT

This procedure takes place automatically.

The initiation of the INJECT/IMPALE function does not require using the INJECT/IMPALE key. As an alternative, the sequence can be initiated by the Transjector 5246 or by foot/hand control. However, the IMPALE function cannot be initiated via the Transjector 5246 or the foot/hand control.

As another alternative, you can use the joystick button to initiate (see Sec. 5.8).

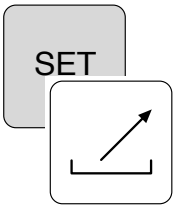
To aid manual injection, it is possible to move to the microinjector by pressing the INJECT key or by activating the joystick key. To do so, the function must be switched off (INJECT off, IMPALE off). When the INJECT key is pressed, the pressure build-up of the microinjector begins at the point where the capillary is located.

5.5 Cleaning and changing the tool

The CLEAN/HOME key enables you to clean the tool of particles adhering to it rapidly and easily; if necessary, you can also change the tool.

This function is designed to remove the tool quickly from the work area and return it accurately to its original position.

5.5.1 Defining the CLEAN/HOME function and the relevant parameters



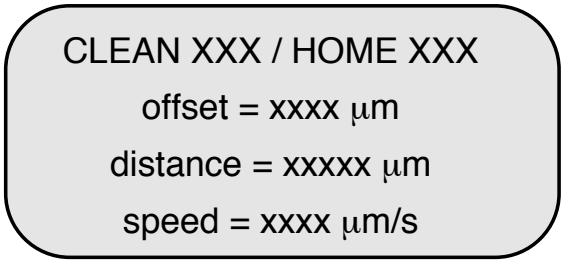
You have the option of complete movement of the tool to the end positions of the X and Z motors (HOME) or a limited axial movement up to a defined end position (CLEAN). Axial movement takes place under the defined angle (see Sec. 5.2.1.4).

The HOME function facilitates rapid and careful tool change. In order to prevent damage to the tool when it returns to the work position, you can preprogram a safety clearance (OFFSET).

The CLEAN function makes it possible to remove cell particles and similar matter which accumulates on the tool tip. For this purpose, the tool is removed axially from the medium by a defined distance (DISTANCE) and the particles are wiped off during passage through the boundary liquid/air. The tool returns to the original position.

Key sequence: SET-HOME/CLEAN

The following is displayed:



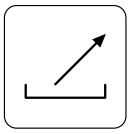
The cursor keys define CLEAN/HOME as follows:
CLEAN off / HOME off
CLEAN on / HOME off
CLEAN off / HOME on
CLEAN on / HOME on

Pressing the SET key advances you to the next line, where you can define the parameters for the safety clearance on the HOME function (OFFSET), the distance to be used for the CLEAN function (DISTANCE) and the speed of tool movement used on these functions (SPEED).

Press the SET key again and change the next parameter.

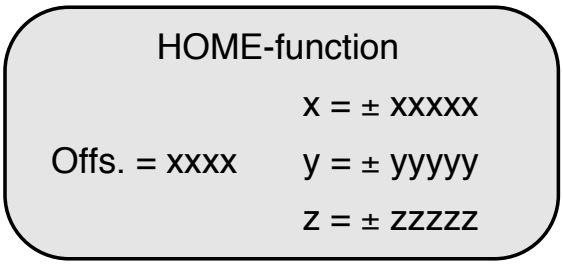
Pressing ENTER stores the parameters entered in the main memory. If the SAVE key is pressed instead of the ENTER key, the parameter is stored in the main memory and in the permanent memory.

5.5.2 Initiating the CLEAN/HOME function



The CLEAN/HOME key is used to activate one of the two functions to remove the tool from the work level. If both functions are active (CLEAN ON / HOME ON), short pressing of this key activates the CLEAN movement for the preprogrammed DISTANCE, pressing the key longer activates the HOME movement into the X/Z end position. If both functions are inactivated, key operations are without effect. If you wish to initiate a CLEAN movement, you must have preprogrammed a DISTANCE. Otherwise, the tool remains immobile.

After pressing the CLEAN/HOME key, the following is displayed if the HOME function is activated:



x, y and z indicate the location of the tool position in the CLEAN/HOME position. The last value used is displayed as OFFSET. In case you forgot to enter the correct OFFSET prior to activating the HOME function, you can now do so by using the cursor keys before returning the tool to the work position. This value cannot, however, be stored. Tool movement control with the joystick is not possible in the CLEAN/HOME position.

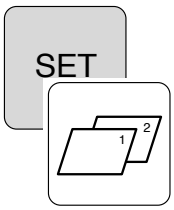
Pressing the CLEAN/HOME key again returns the tool to the previous work position (CLEAN) or to a position that corresponds to the previous work level plus the set value for OFFSET (HOME).

In the CLEAN/HOME position no other keys can be activated. Exceptions to this are the CANCEL key, which terminates the procedure and enables tool return via joystick control, and the DEVICE key, which enables switchover from this position to the second device (if installed). In the second device, you have unlimited use of all functions. After switching over to device I, the CLEAN/HOME key is pressed to initiate return to the work position as described above.

5.6 Working with a second device

An additional device can be connected to the Micromanipulator 5171 and accessed by the same control board. For this purpose, a second power unit[1)] is required, which is connected to the first one with a connector cable (see Sec. 4.8.2). The following can be connected as a second device: a second Micromanipulator 5171, a motorized Zeiss slide holder or a motorized microscope stage for electrophysiology.

5.6.1 Defining the basic parameters for on-line devices



Key sequence: SET-DEVICE

After pressing the SET and DEVICE keys, you can define the on-line devices, their microsteps and the direction of the axes, and set the current coordinates to ZERO. In addition, you can switch the acoustic alarm for disabled key combinations on or off.

All stored marks and limits are erased if the type of device is redefined or the coordinate display set to ZERO.

The direction of operation for each axis can be inverted. On the Z axis, inversion results in a reversal of normal and axial movement!

After pressing the SET and DEVICE keys, the following is displayed

zero coordinates: nnn
x=rxrxrx disp=ppp
y=ryryry audio=aaa
z=rzrzrz devd:type=t

When called, nnn flashes.

[1)] Only use the power unit supplied with DEVICE II. Otherwise, please contact our service team.

The cursor keys are used to change the parameters; SET is used to select the next parameter. The flashing display jumps to rxrxrx and so forth. If the flashing parameters are already correct, you can use SET to jump directly to the next line. Pressing ENTER or SAVE stores all displayed parameters and returns to the main display. Pressing CANCEL terminates the procedure without changes.

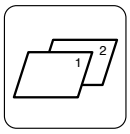
The display and position fields have the following significance

nnn	the current X, Y and Z coordinates can be set to ZERO
no	current coordinates remain intact
yes	current coordinates are set to ZERO; all valid limits and marks are erased.
rxrxrx	defines direction on the X axis
ryryry	defines direction on the Y axis
rzrzrz	defines direction on the Z axis
normal	is defined in such a way that, provided the micromanipulator is mounted in a vertical position on the right-hand side, joystick movement coincides with tool movement; joystick rotation clockwise moves the tool downwards; if turned counterclockwise, the tool moves upwards.
invert	reverses movement in X, Y or Z direction. If the AXIAL function is activated, the axial movement is also reversed on the Z axis. ***Caution:*** If the Z axis is inverted, please check that the movements of the Z axis correspond to the correct movements of the joystick. If this is not the case, the Z axis must be inverted again. Failure to do so can damage the capillary or object as well as the module when the HOME function is initiated.
ppp	indicates whether the positions are shown in the main display
on	positions are displayed
off	positions are not displayed
aaa	indicates whether the acoustic alarm is switched on
on	acoustic alarm on
off	acoustic alarm off

t indicates which device is defined as device I or II; the various microsteps on the different devices are taken into consideration and automatically converted into correct mm data.

	Device	Step size	Action radius
0	Micromanipulator 5171	157 nm/step	25 mm
1	Motorized Zeiss slide holder	940 nm/step	100 mm
2	Motorized microscope stages, for XY or XYZ movement	78 nm/step	25 mm
3	Motorized mini axes, single or combined, optional (for other devices)	100 nm/step	25 mm

5.6.2 Changing over to an additional on-line device as DEVICE II



The DEVICE key is used to access either device I or II. If device I is active, nothing special is displayed; if device II is active, a 2 is displayed.

5.7 Storing and relocating marks

The STORE/GOTO function can be used to store and later relocate up to hundred marks.

The STORE function is capable of storing the current tool coordinates as fixed positions.

In the GOTO function, the tool moves to the position indicated (stored).

Using a manipulator, you can store up to ten marks. The current memory location is shown in the display. Use the cursor keys to select another memory location.

When using a second manipulator, Device II, e.g., a motorized XY stage, ten marks of Device I can be stored in each memory location of the second manipulator, Device II, i.e., altogether 100 marks.

After storing the ten positions for Device I, switch back to Device II with the DEVICE key. Select the next memory location for Device II and then after switching back to Device I with DEVICE, another ten marks can be stored for Device 1. With this procedure, up to 100 marks can be stored.

5.7.1 Defining STORE/GOTO and the desired parameters

You can define whether a position should be stored (STORE) or moved to (GOTO). You can also define the speed parameters and axial distance of the GOTO movement. If an axial distance is defined, the tool will retract axially (45°) from the original position. The tool will then travel axially (at 45°) from the previous work level to its destination. This avoids, for example, any obstructions lying in the path between the two points.

Key sequence: SET-STORE/GOTO

The following is displayed:

STORE xxx / GOTO xxx
ax.dist. = xxx µm
Speed = xxxx µm/s

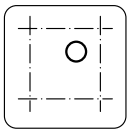
The flashing parameters can be set with the cursor keys. You can activate either STORE (STORE on / GOTO off), GOTO (STORE off / GOTO on) or inactivate both functions (STORE off / GOTO off). If the function is switched off, it prevents inadvertent overwriting or location of positions.

Press the SET key to access the next line. The changeable parameter flashes.

Press the ENTER key. The parameter entered is stored in the main memory. If you press the SAVE key instead of the ENTER key, the parameter is stored in the main memory and the permanent memory.

It is necessary to switch over frequently between STORE and GOTO. Therefore, after calling SET STORE/GOTO, the system presents the mode of operation opposite to the mode the device was currently in. This can then immediately be activated by pressing the ENTER key.
The other modes of operation can be selected sequentially using the cursor keys.

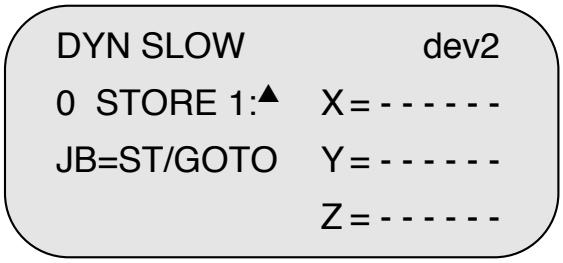
5.7.2 Storing and locating coordinates



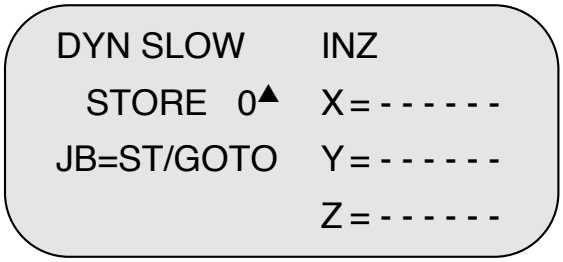
If you press the STORE/GOTO key and the STORE function is activated, the current tool position coordinates are stored as a fixed point in the memory location displayed.
If the GOTO function is activated, the tool moves towards the displayed (stored) position.

The GOTO-position, which should be reached as the next, can be defined with the cursor keys in an ascending/ descending order. In the GOTO mode, only the set marks (allocated memory space) are displayed (see Sec. 3.1.2.3).

When working, e.g., with a motorized slide holder as a second device, the following display appears after pressing the DEVICE and STORE keys:



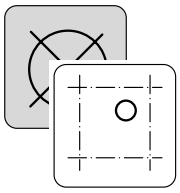
In this case, the line "0 STORE 1:▲ X= " means that mark "0", i.e., the visible detail from Device II is stored. By switching over to Device I with the DEVICE key, ten marks can be stored for Device I:



In this case, the line " STORE 0▲ X= " means that mark "0", i.e., the mark of the micromanipulator, Device I, can be stored by pressing the STORE key. If ten marks have been stored, mark "0" is filled with an "!" to indicate that this position has already been stored and will be overwritten if storage is repeated.

The GOTO function is activated for Device I and Device II via the key combination SET STORE/GOTO. The detail to be processed is selected with the GOTO function. By switching over to Device I with the DEVICE key, the stored positions can be located by pressing the GOTO key. If no mark from Device I is stored for a memory location of Device II, "x" appears in the display for Device I.

5.7.3 Deleting stored coordinates



Key sequence: CANCEL-STORE/GOTO

The following screen display appears:

Clear one mark
Clear all marks
(press cancel to abort)

Select using the cursor keys whether you wish to erase all or only one mark. Pressing the ENTER key completes the procedure if "Clear all marks" was selected and all marks are deleted. If only one mark is to be erased, the following screen is displayed after pressing ENTER.

Clear mark ##
press ▼/▲ to select
ENTER to confirm
CANCEL to abort

The last valid location mark is presented for erasure.

You can use the cursor keys to select a different stored mark. Press ENTER to erase the selected mark and complete the procedure.

5.8 Assignment of the joystick button

It is also possible to initiate every function represented by the six parameter keys and the three function keys using the joystick button. In this case, the function shown in the display adjacent to "JB=" is executed as if the corresponding key had been pressed on the keypad.

Key sequence: SET-JOYSTICK BUTTON

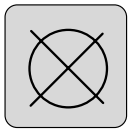
The current assignment flashes in the display. Now press the key on the keypad for that function you wish to assign to the joystick button. The name of the key replaces the previous allocation text in the display. Press the ENTER key to program the joystick button assignment.

If you press the SAVE key instead of the ENTER key, the joystick button assignment is also stored in the permanent memory.

The joystick button assignment can also be completely deleted. Press CANCEL and the joystick button. The corresponding field in the display is now empty. If you wish, this setting can be permanently stored by SET-joystick button – SAVE.

5.9 Inactivation of the joystick

During electrophysiological measurements, possible danger to the measurement by unintentional movement of the joystick can be prevented by inactivating the joystick.



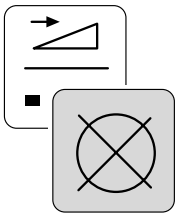
To inactivate the joystick, press the CANCEL key. The following message appears in the display after approx. 10 seconds

JOYSTICK INACTIVATED

TO CONTINUE:
PRESS ANY KEY . .

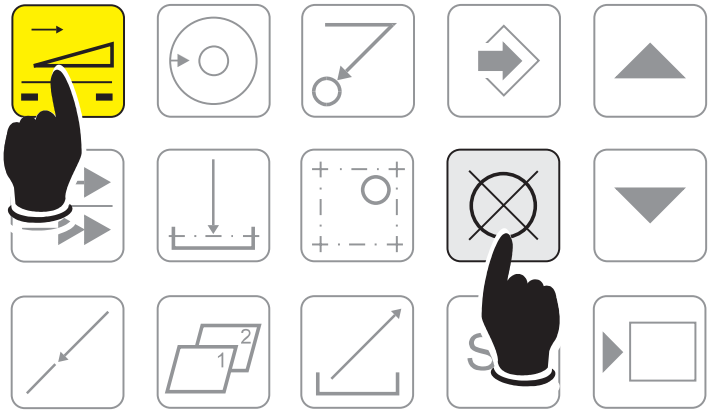
Inactivation can be aborted at any time even before this message has been displayed by repressing the CANCEL key. Inactivation can be aborted after this message has been displayed by pressing any key.

5.10 Initiating the RESET function



With the key combination DYN/STEP – CANCEL, the device is reset to the basic mode, i.e, power on is simulated without the device being switched off and on again

To initiate the RESET function, hold down the DYN/STEP key and then press the CANCEL key in order that the pressure on both keys is transmitted simultaneously.



General reset

With the key combination DYN/STEP – CANCEL, all parameters of the device can also be reset to their factory default values.

In order to achieve this with the key combination DYN/STEP – CANCEL described above, the CANCEL key is pressed and held down.

The DYN/STEP key is then released first so that the CANCEL key is held down longer. Resetting to the factory default values is confirmed by a second acoustic alarm.

6 Care and maintenance

6.1 Cleaning

Before cleaning the micromanipulator, disconnect the plug.

Ensure that no fluids enter into the manipulator in order to avoid short-circuits in the electrical installation as well as corrosion.

Wipe painted parts and aluminum surfaces using a cloth and mild detergent and then with a dry cloth.

Warning: Do not use any corrosive, solvent or abrasive detergents or polishes.

6.2 Disinfection

Clean the micromanipulator before disinfecting.

Wipe every part of the micromanipulator, including accessories and connector cables, with disinfectant.

Spray disinfection is not advisable, as disinfectants can enter into the micromanipulator.

The disinfection method used must comply with current disinfection regulations and guidelines.

6.3 Maintenance

Regular maintenance is not required.
The dealer is responsible for warranty and service.

7 Technical data

Voltage/Frequency:	100/115/127/230 V ± 10 %, 50–60 Hz		
Set voltage:	See identification plate Modifications can only be performed by the service team.		
Fuses:			
For 230 V–250 V:	time-lag 0.4 A – 5x20 mm (2 fuses)		
For 100 V–127 V:	time-lag 0.8 A – 5x20 mm (2 fuses)		
Power consumption:	66 W		
Overvoltage category:	II		
Contamination level:	I		
Contamination level:	2		
Ambient temperature:	max. 40 °C		
Ambient relative humidity:	max. 80 %		
Weight:	Module unit:		3.5 kg
	Control board:		2.5 kg
	Power unit:		5.5 kg
Dimensions of power unit:	Width:		385 mm
	Depth:		210 mm
	Height:		95 mm
Vertical travel:	Manual:		depends on mounting
	Motor:		25 mm
Horizontal travel:	X axis:	manual:	65 mm
		motor:	25 mm
	Y axis:	manual:	depends on mounting
		motor:	25 mm
	Angle of inclination:		0–90° to microscope stage
Resolution per microstep:	157 nm		
Max. tool travel speed:	6,398 µm/s		

The device is CE-approved and has UL and CSA authorization (cUL: E 158089)

Technical specifications subject to change!

8 Ordering information

Order no.	
5171 000.019	Micromanipulator 5171 115/230 V/50....60 Hz
	Delivery package: 1 Micromanipulator 5171 1 Tool 1 Power Cable
5246 621.006	1 Transmission Cable 5246 1 Operating Manual
	An adapter (non-standard) is also required
5171 096.008	Power unit 5171, consisting of power unit and control board for programming and controlling the Micromanipulator 5171 and other compatible stepper motor axes
5171 000.027	Micromanipulator 5171, Device II, for two-sided manipulation with Micromanipulator 5171 installed, complete with second power and module unit
	Installation
	An adapter (non-standard) is required for mounting onto the microscope
	Adapter for direct mounting of the Micro-manipulator 5171 on the microscope
5171 035.009	Adapter for Leica DMIRB (E)
5171 051.004	Adapter for Leica DMIL
5171 027.006	Adapter for Nikon Diaphot 300/200 and Nikon Eclipse TE 300/200
5171 054.003	Adapter for Nikon Diaphot / Diaphot TMD
5171 063.002	Adapter for Nikon TMS
5171 048.003	Adapter for Olympus IX50/IX70
5171 055.000	Adapter for Olympus IMT-2
5171 053.007	Adapter for Olympus CK-2, CK-40
5171 042.005	Adapter for Zeiss Axiovert 100/135/135M/S100
5171 058.009	Adapter for Zeiss Axiovert 10/35
5171 046.000	Adapter for Zeiss Axiovert 25

8 Ordering information

	Adapter for mounting the Micromanipulator 5171 on the microscope using the fastening clamp
5171 045.004	Anchoring clamp
5170 081.007	Adapter for Leitz Labovert, Fluovert, DMIL
5171 095.001	Adapter for Olympus IMT-2 SVR(L), SFR(L), CK-2

Accessories (not standard)

5242 952.008	20 Femtotips®
5242 957.000	20 Femtotips® II
5242 956.003	200 Microloaders
5242 009.012	Filling stand for Femtotips®
4910 000.018	Eppendorf Reference pipette, variable, 0.5 to 10 µl
3110 000.021	Eppendorf Research pipette, variable, 0.5 to 10 µl
5211 058.007	Foot control for microinjection
5176 190.002	Universal capillary holder for accommodating Femtotips®, Femtotips® II or capillary grip heads
5176 210.003	Grip head 0 for universal capillary holder for microcapillaries with an outer diameter of 1.0 to 1.1 mm
5176 212.006	Grip head 1 for universal capillary holder for microcapillaries with an outer diameter of 1.2 to 1.3 mm
5176 214.009	Grip head 2 for universal capillary holder for microcapillaries with an outer diameter of 1.4 to 1.5 mm
5176 207.002	Grip head 3 for universal capillary holder for microcapillaries with an outer diameter of 0.7 to 0.8 mm
5176 196.000	O-ring set for grip heads 0–3 with extraction tool
5176 195.004	Service kit for grip head and capillary holder, consisting of O-ring set, adapter for Femtotip® and clamping piece
5171 613.002	Cable "RS 232" for external connection to PC

Prices for microscopes, microscope accessories, additional adapters, video cameras and monitors available on request.

8 Ordering information

	Microinjection
5246 000.010	Transjector 5246 basic, fully programmable microinjector with integrated pressure supply and two separate pressure outputs
5246 000.028	Transjector 5246 plus, same as Transjector 5246 basic, but with programmable hold function
5176 000.025	CellTram Oil, manual piston pump for transferring cells (sperm, ES cells) with capillary holder for capillaries with an outer diameter of 1 mm
5176 000.017	CellTram Air, manual piston pump for holding cells (e.g. oocytes) with capillary holder for capillaries with an outer diameter of 1 mm
	CELLocate Glass coverslips with integrated microgrid for relocating cells in light and electron microscopy, individually sealed, with log pad
5245 952.009	Grid size 175 µm, sterile, set of 80
5245 962.004	Grid size 55 µm, sterile, set of 80
	Accessories for electrophysiology
5173 071.002	Holder for preamplifier HEKA EPC 7 / EPC 9 as well as AXON CV-4 and HS-2
	Prices for pipette holders, patch clamp towers, Faraday cages, etc. available on request.

Appendix A

Short instructions

Notes on microinjection using the INJECT function

By combining the micromanipulator with the Eppendorf Transjector 5246 or Microinjector 5242, microinjection in culture cells can be carried out easily. We recommend the following procedure:

– Set parameters on manipulator and transjector or microinjector.

– Define injection level.

– Carry out trial injection.

– Correct parameters and height of injection level (if required).

– Carry out further injections.

1. Set parameters at manipulator and transjector or microinjector

– Set "Automatic" on the transjector or microinjector.

– Set injection time for test purposes to 0.5 s.

The following parameters have to be set for startup or if alterations are made to values stored with SAVE:

– Set the cannula holder of the manipulator in accordance with the defined angle.

– Switch on INJECT function with SET-INJECT/IMPALE.

– In the same SET-INJECT/IMPALE sequence, set the speed to the medium value (300 mm/s). ("Axial" in the last line should be "on".)

2. Select injection level

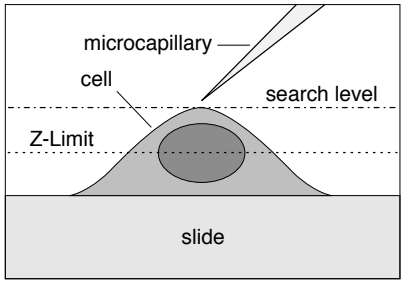
– Focus the microscope on any cell.

– Rotate the joystick to lower the capillary until the tip produces a sharply defined image next to the cell.

– Press the SET-LIMIT keys. Now the "injection level" is set.

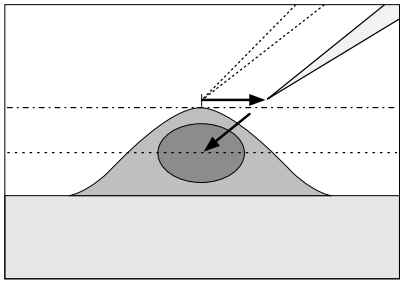
– Rotate the joystick counterclockwise to position the capillary at a safe distance above the cells = "search level".

3. Trial injection



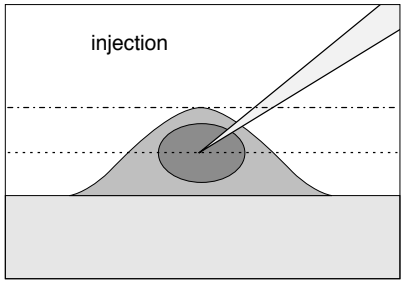
a) Position the capillary above the cell (search level)

Press the INJECT key

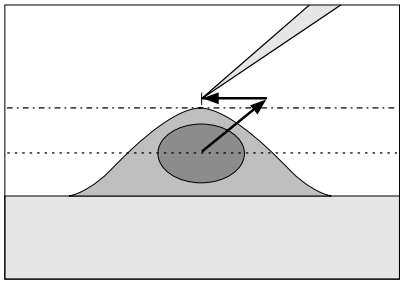


The next phases run automatically:

b) The manipulator travels in X direction



c) The capillary pierces the cell in axial direction up to the Z limit.



d) After injection is completed the capillary returns to the search level

4. Correct parameters and height of injection level (if required)

- Correct the injection level using LIMIT and the cursor keys. Capillary movement and injection are possible without pressing ENTER or SAVE.
- Correct the injection pressure and time on the Transjector 5246 or Microinjector 5242.

5. Further injections

- Proceed further as for trial injections.
- In case of change in image field, if necessary, adjust the injection level using LIMIT and the cursor keys.

Notes:

For reproducible injections and a high number of injections, we recommend our Eppendorf Femtotips, pulled ready-to-use capillaries for microinjection (see Sec. 8, Ordering information).

Always enter the injection time at the Transjector 5246 or Microinjector 5242. If this is not carried out, the INJECT function is not executed.

In the manual mode of the Transjector 5246, injection is initiated and executed by pressing and holding down the INJECT key or the joystick button, the foot control of the microinjector and the INJECT key of the Transjector.

In the "Manual" mode on the Microinjector 5242, the INJECT function is initiated by pressing the foot control. The capillary remains in the cell until the injection is terminated by pressing the foot control. The capillary then returns to the final position. The injection time is measured by the Microinjector 5242 and, after the injection has been completed, displayed there. This setting enables you to determine the injection time measured for the respective cells. This time can then be used for the "Automatic" mode.

If an injector is connected, the setting INJECT/IMPALE is without significance.

Appendix B

Description of the serial interface RS 232

1 Introduction

The Micromanipulator comprises of a computer interface which allows for an almost complete control of the device by an external computer. Especially it is possible

- to input space coordinates for each device connected and relocate these coordinates with a preselected speed
- to transmit the coordinates of the current position to the external computer
- to use all keyboard functions provided by the manipulator via 'K'-commands from the external computer. The computer to be connected must comply with the regulations of EN 60950 or UL 1950.

2 Connecting Computer and Manipulator

Control board and module unit are connected to the power unit. The serial interface cable of the computer is connected to the male 9-pin sub D plug at the rear panel of the power unit. If there is more than one device, the interface cable is connected to device I.

The 9-pin sub D plug is wired as in IBM AT Computers or compatible. There are only pin 2 (RxD), pin 3 (TxD), and pin 5 (GND) connected.

3 Transmission Parameters

The external computer must be set to the following parameters:

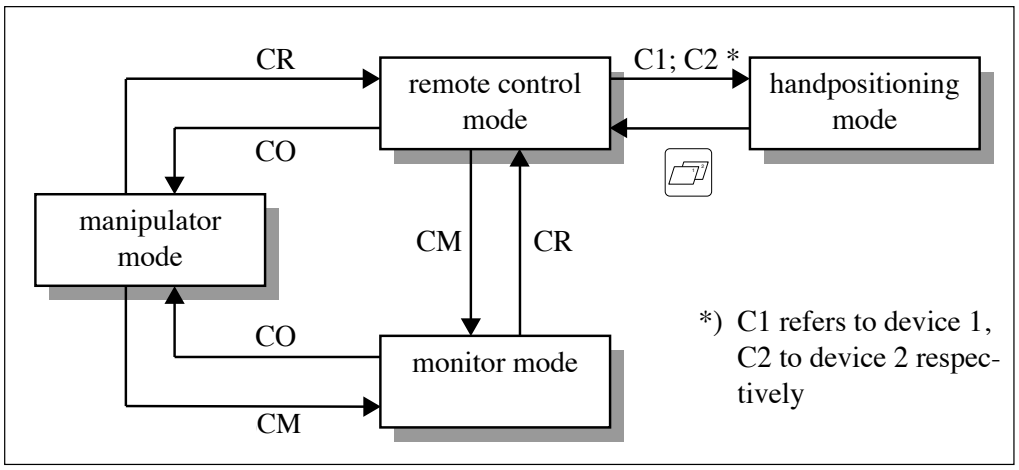
baud:	9,600
start bit:	1
data bits:	7
stop bit:	1

Only ASCII characters are transmitted. Therefore, any terminal emulation program is sufficient for data exchange between manipulator and external computer.

4 Modes of Operation

If a computer is hooked up to the manipulator there are four possible modes of operation.

To switch from one mode to another a command starting with the character "C" must be transmitted to the manipulator.
Exception: In the handpositioning mode, control is returned to the computer by pressing the device key on the control board.



4.1 Manipulator Mode (Remote Control off)

This is the default mode in which the manipulator completely ignores the hooked up computer. All control board functions are fully accessible. The manipulator mode is automatically invoked when the device is switched on.

To leave the manipulator mode a "C"-command from the computer is required ("CR" switches to remote mode; "CM" switches to monitor mode).

4.2 Remote Control Mode

Keyboard, joystick-button, and joystick operation are locked in this mode. The manipulator can be operated by "K"-commands or "M"-commands (refer to 5. Control Commands and Anwers).

The command "CO" (switch to manipulator mode) or "CM" (switch to monitor mode) causes the manipulator to leave the remote control mode. "C1" or "C2" (switch to handpositioning mode of device I or device II respectively) temporarily switch to handpositioning mode.

4.3 Handpositioning Mode

This mode allows for manual fine corrections within automated procedures. After invoking this mode with "C1" (for device I) or "C2" (for device II) in remote control mode all functions of the control board including keyboard and joystick are unlocked temporarily. The only exception is that the device key returns control to the computer, it does not cause the manipulator to switch from device I to device II or vice versa.

The handpositioning mode cannot be terminated by the external computer. This is only achieved by pressing the device key on the control baord. This causes the manipulator to send the character "R" to the computer and to return to the remote control mode.

4.4 Monitor Mode

In the monitor mode the manipulator operates like in the manipulator mode: all functions are accessible and the remote control is switched off. Communication with the computer is unidirectional. Every 250 milliseconds the number of the active device and its current coordinates are transmitted to the external computer.

The command "CO" (switch to manipulator mode) or the command "CR" (switch to remote control mode) terminate the monitor mode.

5 Control Commands and Answers/Messages

Commands and Answers start with an identification character. This character is followed by an appropriate number of parameters. The command or answer/message respectively ends with a carriage return (CR) or with carriage return/line feed (CR LF).

Identification characters can be:

– Commands (computer to manipulator)
  "C" mode selection
  "K" triggering keyboard functions
  "M" move commands

– Answers or messages (manipulator to computer)
  "A" answers to “M”-commands
  "D" position message in monitor mode
  "E" error messages
  "R" return control to computer after being in handpositioning mode

Any CR or LF not belonging to a command are ignored by the manipulator. Spaces or tabs as delimiters between parameters are optional. If a character is not allowed the manipulator will send a question mark to the computer and the character will be ignored.
In the following text, parameter in [ ] are optional. However, if two optional parameters are enclosed by { } like { [a] [b] } at least one of these parameters must be sent.

5.1 "C"-(Control-) Commands

Commands starting with the identification character "C" select the mode of operation of the manipulator.

"C"-commands are not answered by the manipulator but the current status appears in the control board display. However, if "C" is followed by a wrong parameter, or the manipulator is busy in, for instance, an inject function and therefore is unable to perform the mode change, an errror message is returned.

5.1.1 Change to Manipulator Mode

Command syntax: "CO" CR [LF] or
"C0" CR [LF]

This command terminates the monitor mode or the remote control mode.

5.1.2 Change to Remote Control Mode

Command: "CR" CR [LF]

This command terminates the monitor mode or the manipulator mode.

Remote control cannot be switched on while the manipulator is busy in a HOME function, in a INJECT/IMPALE function or in a GOTO function. Also any SET sequence or any CANCEL sequence must be terminated before switching to remote control. Attempts to do this will cause the manipulator to send an error message.

5.1.3 Change to Handpositioning Mode

Command syntax: "C1" CR [LF] Allows for handpositioning of Device I
or "C2" CR [LF] Allows for handpositioning of Device II

These commands cause the manipulator to temporarily leave remote control mode.
Pressing the DEVICE key on the control board brings the manipulator back to remote control mode

5.1.4 Change to Monitor Mode

Command syntax: "CM" CR [LF]

This command terminates the remote control mode or the manipulator mode.

5.2 "K"-(Key-) Commands

Commands starting with the identification character "K" cause the manipulator to act as if a key on the control board was pressed. This means that the manually set parameters like limit or speed are used for the resulting operation.

"K"-commands are only recognized in remote control mode.

Command syntax: 'K'key ['/' fkt] CR [LF]

Parameter:

key = "l" corresponds to key "DYN/STEP"
key = "2" corresponds to key "▲"
key = "3" corresponds to key "CANCEL"
key = "4" corresponds to key "HOME"
key = "5" corresponds to key "PROP"
key = "6" corresponds to key "SPEED"
key = "7" corresponds to key "▼"
key = "8" corresponds to key "SET"
key = "9" corresponds to key "INJECT/IMPALE"
key = "10" corresponds to key "LIMIT"
key = "11" corresponds to key "AXIAL"
key = "12" corresponds to key "ENTER"
key = "13" corresponds to key "SAVE"
key = "14" corresponds to key "STORE/GOTO"
key = "15" corresponds to key "DEVICE"
key = "16" corresponds to key Joystick button
key = "17" corresponds to key Foot control
fct = key operation
fct = "l" corresponds to key down
fct = "0" corresponds to key up

– If the parameter is omitted the key down code and the key up code will be sent consecutively within a short time interval (This resembles a short pressing of the respective key).

"K"-commands are normally not answered by the manipulator. Only incorrect parameters will produce an error message.

5.3 "M"-(Move-) Commands

Commands starting with the identification character "M" are used to

- cause either device I or device II to move from one position to another with a preselected speed
- get the current position of either device I or device II.

It is important to note that movements triggered by the "M"-command are independent from manually set parameters on the control board. For instance, if there is a limit set it will be ignored by the "M"-command. The only exception are directions of movement in the three axes which are determined in the SET DEVICE sequence. The coordinates used resemble those in the display.

"M"-commands are only recognized in remote control mode.

If incorrect parameters are transmitted, an error code will be returned and the command will not be performed.

Each "M"-command is answered by the manipulator after the function has been performed. The answer contains information about the new position and the states of the end position switches. Before reception of this answer no new "M"-command must be sent.

Command syntax:

'M' dev ['X'{[px] ['/'vx]}] ['Y'{[py] ['/'vy]}]
['Z'{[pz] ['/'vz]}] CR[LF]

Parameters: dev = "1" (device I), dev = "2" (device II)

px (py,pz) = X (Y, Z) coordinate in μm
(positive or negative integer, ASCII), max. 30,000

vx (vy,vz) = X (Y, Z) speed in μm per second
(positve integer, ASCII), max. 5,680

- If a coordinate is omitted the current position of this coordinate remains unchanged. There will be no movement in this axis. If speed is omitted the previously set speed for this axis will be used. Note that this speed is zero after reset.
- If all parameters but dev are omitted only the current position will be returned. The manipulator does not move.

Answer syntax:

'A' dev' 'ex 'X='px ' 'ey 'Y='py' 'ez 'Z=' pz CR LF
Data block length: 40 characters

Parameters: dev = "1" (device I) dev = "2" (device II)

px (py,pz) = X (Y, Z) coordinate in μm,
Six characters including sign, right-justified.

ex (ey,ez) = "*"axis is in end position, one character
Three spaces in front of ex (ey,ez)

ex (ey,ez) = "" axis is not in end position,

Examples for "M"-comands:

– What is the current position of device II
m 2 CR

– Go to position X = 1234; Y (no move); Z = -987 X speed is 234 μm/s;
Z speed as selected previously:
M1 x1234 /234 Z-987 CR

Example for "M"-answers:

A	1				*	X	=	-	1	0	3	6	5					Y	=					-	5					Z	=		2	2	5	4	1	CR	LF

Direction of movement:

Reset or "zero coordinates" in the SET DEVICE sequence determine the zero position of the coordinates. Provided that all three axes in the SET DEVICE screen are set to normal and the module unit of the manipulator is mounted to the right side of the microscope then
positive X coordinates are at the right-hand side of the zero position
positive Y coordinates are distal of the zero position
positive Z coordinates are above the zero position

negative X coordinates are at the left-hand side of the zero position
negative Y coordinates are proximal of the zero position negative Z-coordinates are below the zero position

6 Messages

Besides the answers to the "M"-command there are three kinds of messages sent by the manipulator:

- "D"- (Position-) message
- "R"- (Return control) message
- "E#"- (Error-) messages

6.1 "D"-(Position-) Message

In the monitor mode the manipulator sends the current position to the computer approximately every 250 milliseconds. Except for the identification character the syntax is identical to the answer to the "M"-command.

'Message syntax:

'D' dev ['X' { [px] [' / ' vx] }] [' Y ' {[py] [' / ' vy] }] [' Z ' { [pz] [' / ' vz]}] CR LF

6.2 "R"-(Return control) Message

When the handpositioning mode is terminated by pressing the device key on the control board the manipulator sends the "R"-message to the computer.

Message syntax:

"R" CR LF

6.3 "E#"-(Error-) Messages

Message syntax:
'E#' ec CR LF
Parameter: ec = error code.

with
- ec = "1": parity error
- ec = "2": parameter error
- ec = "3": not enough parameters
- ec = "4": missing identification character
- ec = "5": not in remote control mode: command not disposable
- ec = "6": internal transmission error (e.g. power unit is set to wrong device #)
- ec = "7": previous task is still active (e.g. "M" command is not yet answered)
- ec = "8": manipulator in handpositioning mode: command not disposable
- ec = "9": "CR"-command not disposable. The manipulator returns this code within a not yet terminated function or SET-sequence or a CANCEL-sequence

An additional kind of error message can occur after an "M"-command

Message syntax:

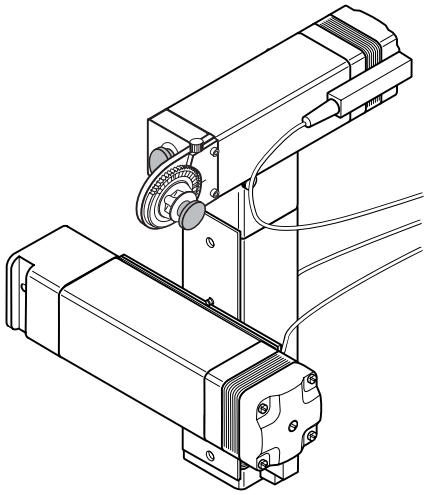
'E#' axyz CR LF

- a = "?": non recognizable character in command string including device #
- a = "0": command string ok
- x (y,z) = "0": parameter string ok
- x (y,z) = "1": non recognizable character in parameter string
- x (y,z) = "2": coordinates too large or too small
- x (y,z) = "3": speed too high or too low
- x (y,z) = "4": value for position expected
- x (y,z) = "5": value for speed expected

Appendix C

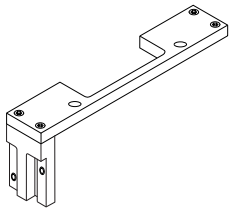
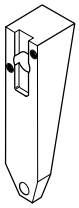
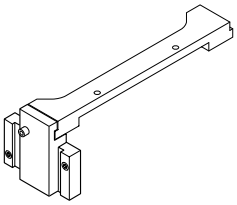
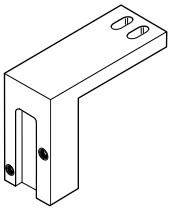
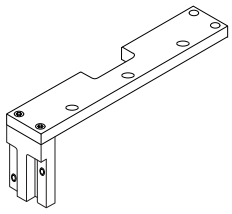
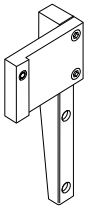
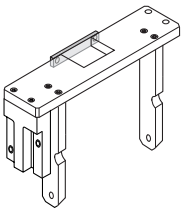
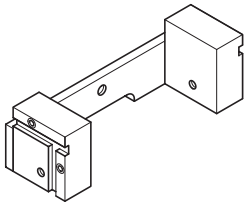
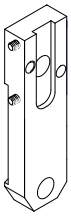
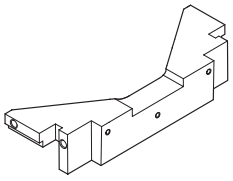
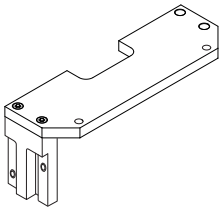
Examples of application

Mounting on the Y module
(in accordance with Sec. 4.3)



Appendix C

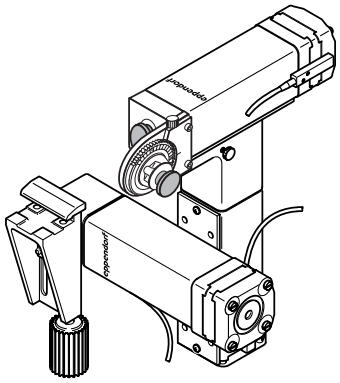
Connection for the microscope via the adapter

Leica	*Zeiss*	*Nikon*	*Olympus*
DMIRB / DMIRBE	***Axiovert 100 / 135***	***Diaphot 200/300 / Eclipse TE 300/200***	***IX 50 / IX 70***
			
Order no. 5171 035.009	Order no. 5171 042.005	Order no. 5171 027.006	Order no. 5171 048.003
DMIL	***Axiovert 25***	***Diaphot / Diaphot TMD***	***IMT-2***
			
Order no. 5171 051.004	Order no. 5171 046.000	Order no. 5171 054.003	Order no. 5171 055.000
	Axiovert 10 / 35	***TMS***	***CK-2***
			
	Order no. 5171 058.009	Order no. 5171 063.002	Order no. 5171 053.007

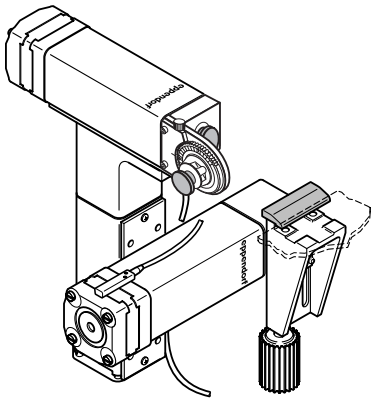
Appendix C

Further assembly possibilities
Connection to all microscopes whose microscope tables or other components allow fastening with a clamp.
(Anchoring clamp: Order no. 5171 045.004)

Right-hand sided assembly,
e.g. on the microscope table



Left-hand sided assembly,
e.g. on the microscope table



Appendix D – Index

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