Service Manual

SEP-10S
SEP-10S Plus
SEP-12S Plus
SP-12S Pro

SYRINGE INFUSION PUMP

BS037051EN-P03




aitecs

Prior to servicing this pump, read this manual and the pump's Operator's Manual carefully to fully understand the pump's functionality and to ensure safe and proper servicing.

CONTENTS

1. INTRODUCTION

♦ This SERVICE MANUAL describes how to check, troubleshoot and repair SEP-10S, SEP-10S Plus, SEP-12S Plus and SP-12S Pro syringe infusion pumps. The purpose and maintenance of the pumps are described in the appropriate OPERATOR'S MANUAL.
If when repairing your pump you have encountered problems, which you cannot solve, or the pump parameters are changed after the repair, please, in all these cases contact the manufacturer.

NOTES:

1. ***The manufacturer's authorized personnel may carry out the technical servicing of the pump only!***
2. ***Product specification is subject to change without notice.***

♦ SERVICE CONTACTS

VILTECHMEDA, 125 Kalvariju Str., 08221 Vilnius, Lithuania.
E-mail: service@aitecs.com

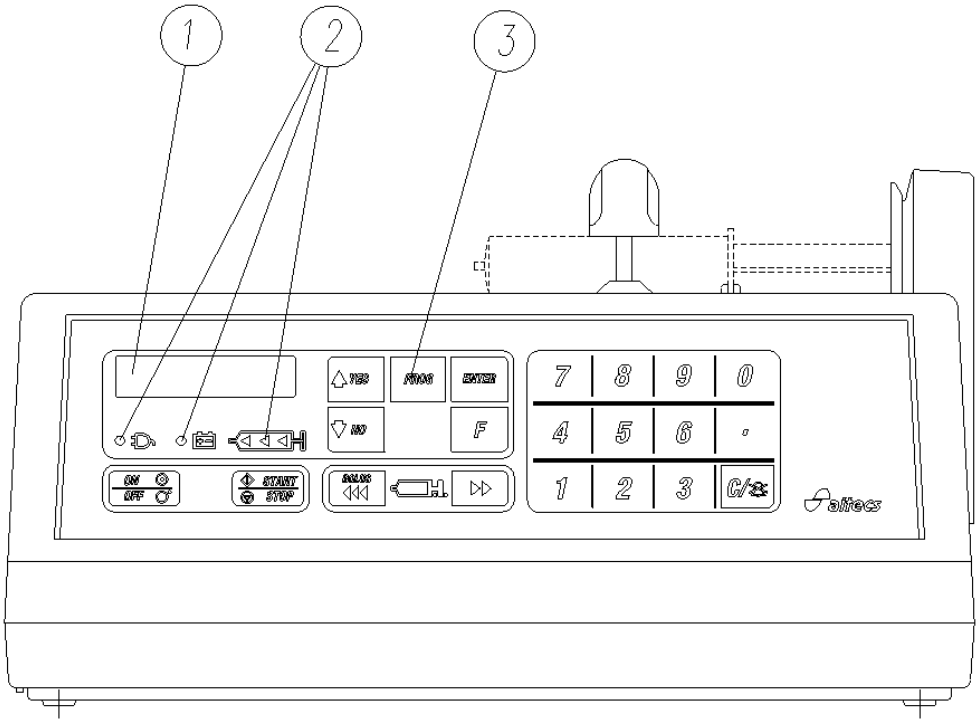
2. TECHNICAL DATA

Power supply:
220-230 VAC ±10%, 50/60 Hz, or 115 VAC ±10%, 50/60 Hz, or internal rechargeable battery.
Fuses:
T80 mA/L250 V - for 220-230 VAC
T160 mA/L250 V - for 115 VAC.
Power consumption:
10 VA (max).
Internal battery:
9.6 V 1300 mAh NiMH battery.
Battery operation:
8 h (minimum) at 5 ml/h infusion rate;
2 h (minimum) at 100 ml/h infusion rate.
Battery recharging time: 24 hours.
Classification: *Class II, CF, splash proof.*
RS232*
12 VDC supply connection*
Nurse Call connection**
Operating temperature range:
+5 to +40 °C.
Storage temperature range:
-20 to +40 °C.
Air pressure:
60 to 106 kPa.
Relative humidity:
90% max., no condensation (operation and storage).
Dimensions:
(WxHxD) 305 x 135 x 195 mm.
Weight:
2.6 kg.

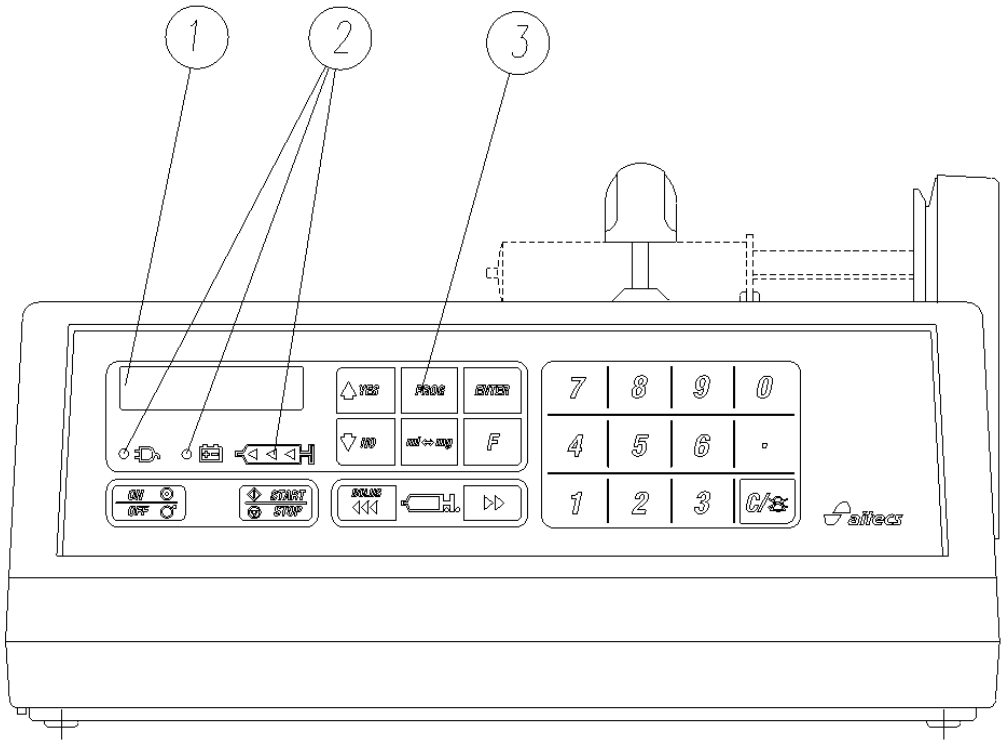
*- ***unavailable in SEP-10S, optional in SEP-10S Plus.***
- ***unavailable in SEP-10S, optional in SEP-10S Plus, SEP-12S Plus, SP-12S Pro.*

3. EXTERNAL VIEW

Fig. 1.

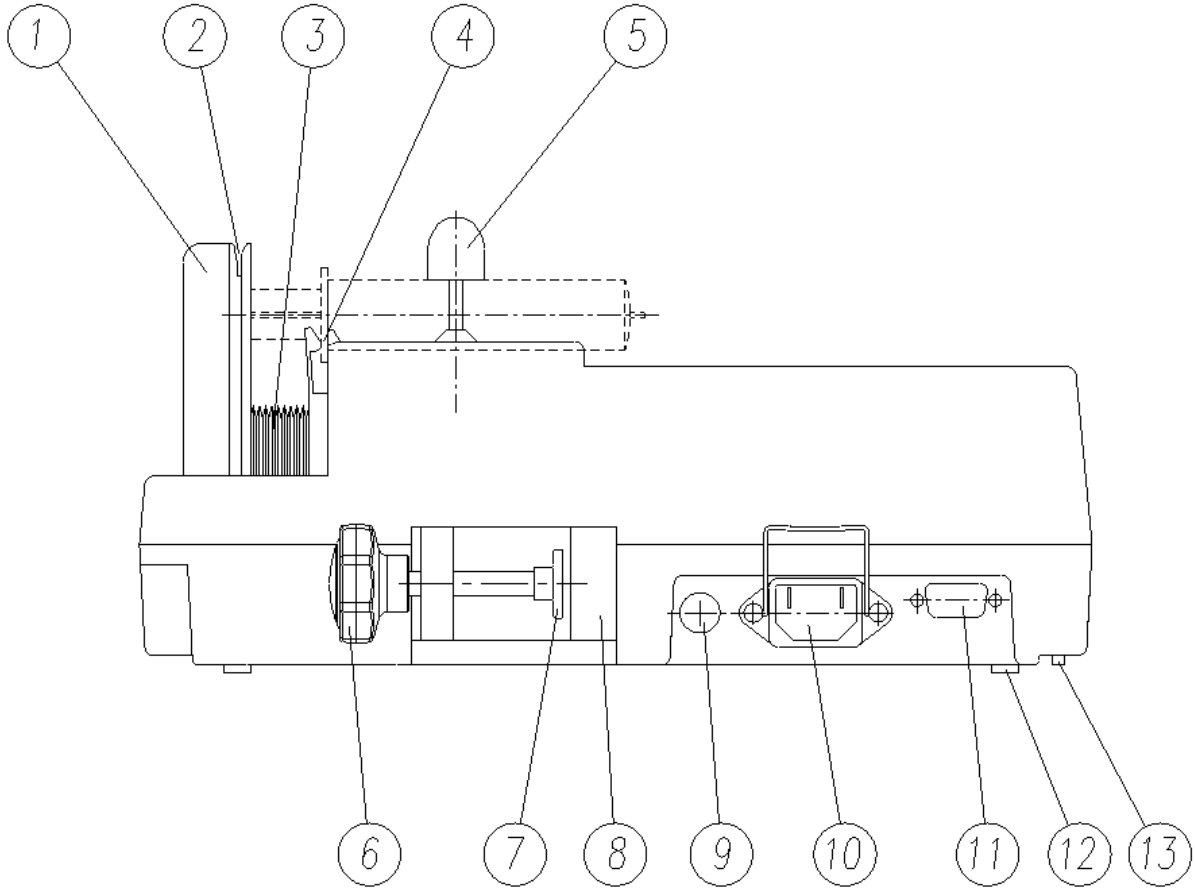


Front view of the pumps SEP-10S, SEP-10S Plus



Front view of the pumps SEP-12S Plus, SP-12S Pro
1 — display 2 — indicators 3 — keypad

Fig. 2.



Rear view of the pumps SEP-10S, SEP-10S Plus, SEP-12S Plus and SP-12S Pro

1 — syringe driver arm
2 — slot for inserting the push-button of the syringe plunger
3 — rubber bellows
4 — slot for inserting the finger grips of the syringe barrel
5 — syringe clamp
6 — cross knob
7 — plastic cap
8 — mounting pole clamp
9 — fuse holder
10 — mains inlet
*11 — MFC unit**
12 — leg
*13 — audio volume control**

* — unavailable in SEP-10S, optional in SEP-10S Plus

4. KEYPAD DESCRIPTION

	The green BATTERY LED lights when the pump is operating on battery power. Flashing if LOW BATTERY alarm condition occurs.
	The green MAINS LED lights when the pump is connected to the AC and battery is charging.
	During infusion, three yellow LEDs are sequentially flashing. If the rightmost LED is on permanently – the infusion is stopped.
	Key to switch the pump on/off; keep it pressed for several seconds in order to switch off.
	Key to start/stop the infusion.
	Key to move the syringe driver arm rapidly to the left-hand side during syringe insertion or to initiate the Bolus mode; it is also intended for air removal from the extension set after syringe insertion.
	Key to move the syringe driver arm to the right-hand side.
	Keys to scroll up/down the list of parameters and syringe brands or answer positively or negatively the dialog questions.
	Key to select dimensions of parameters when programming (only in SEP-12S Plus and SP-12S Pro).
	Key to program (modify) parameters. Pressing it once more restores previous values.
	Key to confirm the selected parameter.
	Numerical keys to enter digits of the parameter being programmed.
	Key to select additional functions or to review programmed parameters.
	Key to cancel the numerical value or the meaning of the parameter or silence the alarm signal. It deletes TOTAL INFUSED and INFUSED DOSE values and clears the numerical value on display when programming.

5. TECHNICAL DESCRIPTION

5.1. PRINCIPLE OF OPERATION

♦ The pump is intended for precise dosing of medicine at the rate programmed by the operator. The speed of syringe driver arm is set by the microcontroller, which evaluates the syringe volume and features of the syringe model. The microcontroller controls the step motor, which transfers movement to the syringe driver arm via the helical gear. The microcontroller monitors also voltage of the internal battery, mains voltage, occlusion pressure, Bolus volume and rate. Data on pump status and programming data are outputted to the alphanumeric 2x16 symbol display. Operation of the microcontroller is monitored by the special circuit (watch-dog), which unconditionally switches off the motor in case of failure of the microcontroller. In case of mains voltage failure, the pump automatically continues its operation being powered from the internal rechargeable battery and warns the operator on this by means of audible and visual signals.

5.2. ELECTRICAL SCHEMATIC DIAGRAM OF THE PUMP

5.2.1. Principle of operation

♦ The electrical schematic diagram of the pumps are presented in the Annex A, B. The interconnection diagram of the pump is presented in Annex C. Diagrams of the pump are composed of the following main parts:

- ♦ power supply;
- ♦ keypad;
- ♦ drive;
- ♦ syringe size sensor;
- ♦ electronic board B7048.

5.2.2. Power supply

♦ 220-230 VAC (or 115 VAC) voltages via the mains filter MF1 and fuse F1 is fed to the primary winding of the step-down transformer TR1. Voltage from the secondary winding of the transformer TR1 reduced to 10-11 VAC is rectified by the diode bridge D1 and capacitor C1 (11-13,5 VDC) and via the fuse F1(A2) is fed to the remaining part of the circuit. The resistor R1 sets the charging current for the rechargeable batteries GB1, GB2 which shall be in range of (70-130) mA. When the pump is powered from the internal battery, power supply current goes via the diode D2. The fuse F2(A2) protects batteries by limiting charging and load currents. There is fed a signal to the electronic board B7048 via the diode D3 and the resistor R2 informing the pump is powered from the external mains of 50/60 Hz, 220-230 VAC (or 115 VAC). The electronic board B7048 controls the buzzer Z1.

5.2.3. Keypad

♦ The keypad is composed of 21 keys (SEP-10S, SEP-10S Plus 20 keys) in form of a matrix having 7 inputs and 3 outputs. Electronic board B7048 performs scanning of the keypad and reading of information from it. The key ON/OFF controls the circuit of electronic power supply switch located on the electronic board B7048.

5.2.4. Drive

♦ The stepper motor SM1 rotates the lead screw with a nut on it converting rotating movement of the motor to linear movement of the tube. The tube supported by four guiding bearings is connected to the syringe driver arm. Marginal positions of the tube with syringe driver arm are limited by:

- ♦ limit switch S1 at the right extreme position which is actuated by the end of the tube;
- ♦ rotational optical sensor unit A3 at the left extreme position when the tube covers the raster of rotating

coupling of the optical sensor unit A3.
In case of occlusion when pressure in the syringe increases to the prohibited level, it stops movement of the syringe driver arm and at the same rotation of the stepper motor SM1.
Rotation of the stepper motor is controlled by the optical sensor unit A3 which reads a signal, reflected from the raster of rotational coupling. This signal is fed to the microcontroller U18 located on the electronic board B7048, and this signal switches on the emergency signal. There is some delay between beginning of occlusion on one hand and stepper motor SM1 stopping and emergency signal actuation on the other hand depending on infusion rate, length, thickness and elasticity of extension tube.
♦ The pre-alarm switch S2 is activated when the distance between syringe finger flange and syringe thumb rest is equal to 45 mm. When this distance is equal to 27 mm, the end switch S1 is activated, which in this case acts as the second pre-alarm switch. When the pre-alarm switch has been activated, the pump calculates distance to the end of appropriate syringe. Based on this there are calculated and activated the following warning messages:

Xmin. PREALARM!

where X < 5 min., and

SYRINGE EMPTY!

♦ In case of occlusion the stepper motor SM1 executes some number of steps back depending on syringe type. This reduced pressure in the syringe and extension tube and at the same time reduces unwanted Bolus volume injected to the patient when the cause of occlusion is removed.

5.2.5. Syringe size sensor

♦ Syringe size sensor is implemented as a sliding potentiometer R1. Depending on syringe diameter, potentiometer slider position is changed and its output voltage at the same time, which is linearly proportional to the output resistance of the potentiometer R1. This output voltage is fed to the electronic board B7048.

5.3. ELECTRICAL SCHEMATIC DIAGRAM OF ELECTRONIC BOARD B7048

♦ The electrical schematic diagram of electronic board B7048 is shown in the annex D.
It is composed of the following main parts:
- ♦ microcontroller circuit;
- ♦ display circuit;
- ♦ "watch-dog" circuit;
- ♦ stabilized power supply;
- ♦ electronic power-supply switch circuit;
- ♦ syringe size sensor signal processing circuit;
- ♦ DAC;
- ♦ pulse current stabilizers;
- ♦ switches.

5.3.1. Microcontroller circuit

♦ There is used the AT89C51ED2 microcontroller U18 having internal RAM of 256 bytes and XRAM 1792 bytes for data, internal flash memory of 64 KB, internal EEPROM of 2048 bytes and external EEPROM of 32 KB and external 32 KB time keeper SRAM U14 with clock for log.
The quartz resonator Q2 of 12,288 MHz sets clock frequency for microcontroller. The microcontroller U18 selects addresses of the SRAM U14 (lower addresses from port P0 via register U13, higher addresses from port P2 directly). The microcontroller U18 via port P0 and register U11 generates instructions for step motor control, writes information to display MD1, writes and reads information to/from SRAM U14, controls the buzzer, LEDs D26, D27, D28 "RUN". Also via port P0 and register U13, it scans the keypad.

Information from the keypad is read via register U12 to port P0.
♦ The microcontroller U8 AT89S2051 receives information from the microcontroller U18 AT89C51ED2 to its inputs P3.0 and P3.2 on step motor rotation direction, period between steps and power. The restart signal for the microcontroller U8 (pin 1) is generated by means of elements C46 and R51 in time of power switching on. When master "watch-dog" circuit is activated, a high-level signal is applied to the restart input of the microcontroller U8 interrupting its operation.

5.3.2. Display circuit

♦ Information to display MD1 (addresses and data) is written from the port P0 of microcontroller U18. The resistors R88—R91 sets current via transistor T1 5 and at that same time current for backlighting LED of display MD1. This current shall be equal to 70 ± 10 mA when backlighting is switched on and 10 ± 5 mA when backlighting is switched off. The backlighting current is controlled by the signal from microcontroller U18 via register U10. Resistor R93 defines brightness of the display MD1.

5.3.3. "Watch-dog" circuit

♦ The special "Watch-dog" circuit monitors operation of the microcontroller U18. In case of disturbances in microcontroller U18 operation, this circuit prevents functioning of the pump, stops the motor and activates audible alarm. The basis of master "Watch-dog" circuit is monostable multivibrator U5A, U5B and the trigger U3A. They compose the frequency discriminator with pass-band of 500 Hz to 2 kHz.
♦ The slave watch-dog circuit is composed of elements U17A, D25, C61, C74, R44. When for some reason the pulses cease to arrive to capacitor C61, 0.5 S later a low-level signal is generated at the output 6 of the Schmitt trigger U17A initiating actuation of the master watch-dog circuit.

5.3.4. Stabilized power supply

♦ There are used two stabilized +5VDC voltages Vcc1 and Vcc2. The voltage Vcc1 is supplied to the microcontroller U18, "Watch-dog" circuit and electronic power supply switch. When powering of the pump is switched off by means of the key ON/OFF, voltage Vcc1 goes down to 3,1 V (voltage Vcc2 becomes equal to 0 V).
The IC U1 is the voltage stabilizer. The transistor T1 is a current amplifier and the transistor T2 is a power supply switch.
Adjustable resistor R13 sets threshold for emergency signal actuation on discharge of batteries GB1, GB2 (voltage on pin 7 of the IC U1 shall go down from +5V to 0V when battery voltage drops to 9.2V).

5.3.5. Electronic power-supply switch

♦ When the pump is switched on by pressing the key ON/OFF, there is set at the same time inhibition to switch it off, i.e. the low-level signal is applied to pin 13 of the trigger U3B. This inhibition may be removed either by the microcontroller U18 having received an appropriate request or by the "watch-dog" activated. The microcontroller U18 via the input T0 receives information on depressed key ON/OFF. Then when the key ON/OFF is kept depressed for 3 sec the microcontroller U18 switches off the pump by applying high-level pulse to the pin 10 of the trigger U3B.
Electronic power-supply switch output signals control the power supply stabilizer and switch the microcontroller U18 to mode of low power consumption or to normal mode. These signals via capacitor C67 generate start (reset) pulse for microcontroller U18.

5.3.6. Syringe size sensor signal processing circuit

♦ The voltage taken from the potentiometer for syringe diameter and proportional to the syringe diameter is fed to ADC U7. Information on syringe diameter in digital form from U7 is transferred via the serial

port to the input P1.0 of the microcontroller U18.

5.3.7. DAC (digital to analog converter)

♦ The DAC is composed of resistor network, current mirror T17. Depending on the code at the port P1 of the microcontroller U8, voltage droping on resistor R28 is changing in the range 0 to 0.4 V. This voltage is fed to two (separate for each phase of the motor) sample-and-hold units for analogous signal, implemented on elements T6, C55 and T7, C57 accordingly. There are generated two independent voltages on capacitors C55, C57 being proportional to currents flowing through motor phases.

5.3.8. Pulse current stabilizers

♦ The pulse current stabilizer for the 1st phase is composed of elements U15A, T5, R56, L4, R61, R60, and that for the 2nd phase - of elements U15B, T4, R57, L5, R67, R69. Further is described operation of the pulse current stabilizer for the 1st phase only. The voltage from the capacitor C55 is fed to the inverting input 2 of the comparator U15A. The non-inverting input of the comparator receives the signal equal to voltage drop across the resistors R61, R60 and proportional to current flowing through them. When this voltage is lower than that on the capacitor C55, then transistor T5 becomes open. Then the power source VCC-NS is connected to the inductor L4 and the current through it starts to increase. When voltage drop across resistors R61, R60 exceeds voltage from the capacitor C55, the transistor T5 becomes closed and current through the reactor L4 starts to decrease. The new cycle is started, and its frequency depends on inductance of the reactor L4, phase current value and comparator hysteresis.

5.3.9. Switches

♦ Currents for both phases flow to the common conductors of motor phase coils via accumulating reactors L4 and L5. Direction of motor rotation is defined by appropriate order of current switching in both phase coils. This switching is implemented by current switches T8, T9 and T10, T13 for the 1st and the 2nd phases accordingly.

6. SETUP MENU

In order to access optional functions or certain parameters, keep the **START/STOP** key in pressed position and switch the pump on by pressing the **ON/OFF** key. When short beep is heard, release the **START/STOP** key, enter appropriate code with the numerical keys and confirm it by pressing the **ENTER** key.
The total list of optional functions/parameters and their access codes are presented in the Table 1:
Table 1

CODE	*NAME*	*DESCRIPTION*	*NOTE*
100	PUMP MODES		
137	SYRINGE SET		
147	DRUG SET		
157	DEFAULT DRUG SET	restoring default (manufacturer's) list of drug	
237	PARAMETERS SET	configurable functions/parameters	
257	DEFAULT PARAMETERS SET	restoring default (manufacturer's) parameters	
337	LANGUAGE SET	installation of dialog language	
537	SYRINGE SIZE CALIBRATION	to calibrate syringe size sensor	Spacers required for calibration of the pump without 5ml syringes: 1- B8640037-01 2- B8640037-02 3- B8640037-03 4- B8640027-03
			Spacers required for calibration of the pump with 5ml syringes: 0- B8640027-04 1- B8640037-01 2- B8640037-02 3- B8640037-03
547	OCCLUSION CALIBRATION	calibration of occlusion level	
637	DATE, TIME	setting of date and time	

♦ List of optional functions may be reviewed using the scroll keys. If displayed name is marked with the asterisk, it means that function is active. To activate an inactive function press the **ENTER** key, and the asterisk will appear in front of the item name.
To deactivate a function, press the **C** key. The asterisk shall disappear.
♦ To change flow rate upper limit select appropriate item, press the **PROG** key, enter the new value using the numeric keys and confirm it by pressing the **ENTER** key.
♦ To enter a new drug name open the drug list and select the drug name to be replaced by the new one. Press the **PROG** key, and enter the new drug name using keys in accordance with the table below (e.g. to enter letter Z press the 9 key four times):

Key	1	2	3	4	5	6	7	8	9	0	.	YES	NO, C
Cha-racter	1	A,B, C,2	D,E, F, 3	G,H, I, 4	J, K, L, 5	M, N, O, 6	P,Q,R, S, 7	T, U, V, 8	W, X, Y, Z, 9	%, 0, /, -	.	Space	Backspace

Confirm the new drug name by pressing the **ENTER** key.

NOTES:

1. **Entered character can be reset by means of the C or NO keys.**
2. **Old drug name can be restored by means of the PROG key until new name is confirmed.**

♦ To exit setup menu press the **START/STOP** key.
♦ To change date and time settings enter new values when appropriate demand is displayed and press the **ENTER** key to confirm them and exit setup menu.

ATTENTION !

It is recommended to minimize number of parameters, types of syringes, drug names and other functions leaving only that necessary for work. It will help to avoid errors in parameters programming and thereby decrease patient's risk.

♦ If the high occlusion level value after actions specified in section 7.5 are performed is beyond specified limits, occlusion level shall be calibrated. For this sake factual value of high occlusion level pressure obtained during testing is entered into pump. Typical value for **CORRECT END** is 60 kPa.

7. CHECKING PARAMETERS

7.1. MEANS REQUIRED FOR PARAMETERS CHECKING

♦ Prepare the following means:
♦ 50 ml BD Plastipak syringe,
♦ standard 90 cm long extension tube,
♦ stop-watch,
♦ glass test-tube with graduation (one point equal to 0.1 ml), 60 ml or more volume,
♦ pressure gauge with graduation up to 160 kPa, (accuracy 2.5%).

NOTE:
Programming infusion parameters, filling the syringe and extension tube with drug solution, inserting the syringe into the pump and starting infusion are described in the OPERATOR'S MANUAL of the pump.

7.2. CHECKING INFUSION VOLUME

♦ Take the 50 ml BD Plastipak syringe with extension tube connected to it and fill it with distilled water up to the point of 55 ml. Insert the syringe into the pump and confirm the 50 ml BD Plastipak syringe. Program the following infusion parameters:
♦ infusion rate — 100 ml/h,
♦ volume limit — 50 ml,
♦ occlusion pressure level — HIGH.
Expel the air from the extension tube. Insert the free end of the extension tube into the graduated test-tube and start the infusion. When the infusion is finished, the measured volume in the test-tube shall differ from the programmed volume not more than by ± 1 ml (± 2%).

7.3. CHECKING INFUSION RATE

♦ Take the 50 ml BD Plastipak syringe with extension tube connected to it and fill it with distilled water up to the point of 55 ml. Insert the syringe into the pump and confirm the 50 ml BD Plastipak syringe. Program the following infusion parameters:
♦ infusion time — 12 min,
♦ volume limit — 10 ml,
♦ occlusion pressure level — HIGH.
Expel the air from the extension tube. Insert the free end of the extension tube into the graduated test-tube and start the infusion. Measure infusion time by the stopwatch and record the volume in the test-tube at the end of infusion. Calculate the infusion rate. It shall be 50 ml/h ± 1 ml/h (± 2%).

7.4. CHECKING BOLUS VOLUME

♦ Take the 50 ml BD Plastipak syringe with an extension tube connected to it and fill it with distilled water up to the point 50 ml. Insert the syringe into the pump and confirm the 50 ml BD Plastipak syringe. Program the following infusion parameters:
♦ infusion rate - 50 ml/h,
♦ volume limit — 50 ml,
♦ bolus rate - 100 ml/h,
♦ bolus dose - 20 ml,
♦ occlusion pressure level — HIGH.
Expel the air from the extension tube. Insert the free end of the extension tube into the graduated test-tube

and start the infusion. Record the volume delivered into the test-tube and starts the Bolus mode. Record the volume in the test-tube at the end of the Bolus cycle. The difference of these two volumes shall be 20 ml ± 0.4 ml (± 2%).

7.5. CHECKING OCCLUSION PRESSURE

♦ Take the 50 ml BD Plastipak syringe with an extension tube connected to it and fill it with distilled water up to the point of 30 ml. Insert the syringe into the pump and confirm the 50 ml BD Plastipak syringe. Program the following infusion parameters:

- ♦ infusion rate - 50 ml/h,
- ♦ volume limit — 30 ml,
- ♦ occlusion pressure level - LOW.

Connect the pressure gauge to the free end of the extension tube. Start the infusion. As soon as the audible alarm is activated and there is displayed the message

OCCLUSION!!!

the pressure gauge shall read the pressure of (30 or 40)* kPa ± 15 kPa.
Press the key C. Reprogram the occlusion pressure to MEDIUM. Start again the infusion. As soon as the audible alarm is activated and there is displayed the message

OCCLUSION!!!

the pressure gauge shall read the pressure of (60 or 80) kPa* ± 25 kPa.
Press the key C. Reprogram the occlusion pressure to HIGH. Start again the infusion. As soon as the audible alarm is activated and there is displayed the message

OCCLUSION!!!

the pressure gauge shall read the pressure of 90 kPa* ± 30 kPa or 120 kPa* ± 35 kPa.

NOTE:
If measured values of pump parameters are out of ranges permitted, contact the Manufacturer.

* depends on the installed occlusion presure set (for SP-12S Pro only).

8. TROUBLESHOOTING

All failures are listed in the Table:

No	*SYMPTOM*	*CAUSE*	*CORRECTIVE ACTIONS*
1	Message in the display "NO MAINS!!! Check power cord" although the pump is connected to the mains (the green indicator ○ ⊐ isn't glowing).	1. External fuses are blown. 2. Faulty mains cord. 3. Faulty supply unit.	1. Check the external fuse and replace with identical one, if required. In case it blown again, consult the Manufacturer. 2. Check the mains cord and replace it, if necessary. 3. Check and replace if necessary the supply unit as described in section 9.14.
2	Short cordless work time or no cordless work at all.	1. Fuse F2 is blown in the supply unit. 2. Decreased capacity of the battery.	1. Open the pump as described in section 10.1. Check and replace the fuse with identical one. In case it is blown again, consult the Manufacturer. 2. Connect the pump to the mains for 24 hours in order to charge the internal battery. Disassemble the pump as pointed out in section 9.1. Connect the resistor of 20 Ω/10 W to the battery and measure discharge time to the moment the battery voltage drops to 8V. In case this time is shorter than 2 hours (for 1300 mAh capacity battery), replace the battery as pointed out in section 9.2.
3	Rubber bellows cracked.	Rubber ageing. Impermissible chemical substances were used for disinfecting and cleaning.	Replace the rubber bellows as described in sections 9.1 and 9.3.
4	Without syringe, the syringe driver arm doesn't move when pressing the <, >keys.	1.Faulty optical sensor unit (Fig. 6 pos. 10) or dirty raster in the coupling (Fig. 6 pos. 3).	1. Disassemble the pump as described in section 9.1 leaving the power connector P1 connected. Clean the coupling raster with a piece of soft cloth. Switch on the pump pressing the ON/OFF key. By means of an oscilloscope observe the signal at TP1 in the optical sensor unit (rotate the coupling slowly by hand). The low level of the signal shall be not more than 1.5 V and the high level - not less than 4.0 V during the full revolution of the motor. Otherwise adjust R3 potentiometer in the optical sensor unit or replace the optical sensor unit (section 9.4).
		2. Broken connecting wires to the stepper motor.	2. Disconnect the connector P1 of the step motor from the electronic board B7048 and check the wires to the step motor for continuity according to the electrical schematic diagram by means of an ohmmeter. If the wires are broken, re-solder them. Re-connect the motor connector to the electronic board B7048.
5	In the syringe insertion mode, the syringe driver arm stops with noise when it reaches its right hand side position.	Faulty end switch S1 (Fig. 6 pos. 16).	Check the end switch and replace, if required, as described in the sections 9.1 and 9.5.
6	The pump doesn't display the messages "X min. PREALARM!" and "SYRINGE EMPTY!" although the syringe is filled with more than 50% of its nominal volume.	Faulty pre-alarm switch S2 (Fig. 6 pos. 11).	Check the pre-alarm switch and replace, if required, as described in the sections 9.1 and 9.6.

No	*SYMPTOM*	*CAUSE*	*CORRECTIVE ACTIONS*
7	Although the syringe is inserted, there is displayed the message INCORRECT INSERTION!	Syringe sensor S3 is faulty	Disassemble the pump as described in the section 9.1.Replace the syringe sensor as described in the section 9.7.
8	When a syringe is inserted, a wrong syringe size is displayed, or there is a message ILLEGAL SYRINGE! CHANGE SYRINGE	Faulty syringe size sensor (Fig. 6 pos. 2).	Calibrate syringe sensor (see section 6) or replace it (if calibration was not successful) as described in the sections 9.1 and 9.11.
9	One or several keys fail to operate.	Faulty keys.	Check and replace the keypad, if required, as described in sections 9.1and 9.9.
10	Audible alarm of the pump fails to operate.	Faulty buzzer Z1 in the power supply.	Check the buzzer and replace, if required, as described in the sections 9.1 and 9.12.
11	The keypad scratched, discolored or detached.	Impermissible chemical substances were used for disinfecting and cleaning.	Replace the keypad as described in the sections 9.1 and 9.9.
12	The pump fails to operate when switched on with ON/OFF key. No message or the message "ERROR XXX" is displayed. Audible alarm is activated.	Faulty electronic board B7048.	Replace the electronic board B7048 as described in the sections 9.1 and 9.8(see also Annex E).
13	Indicator  glows, but the pump fails to operate.	Fuse F1 blown in the supply unit (Fig.4. pos.12).	Open the pump as described in section 9.1. Check the fuse and replace it with identical one, if required. Incase it is blown again, consult the Manufacturer.
14	When fixing the pump to a stand, the stand surface is damaged	The plastic cap (Fig. 4 pos. 8) of the cross knob is cracked.	Remove the cross knob of the mounting clamp rotating it counterclockwise until the cap falls down. Rotate the cross knob clockwise with the cylinder of 20mm x 20mm inserted and pressing the new cap between the cross knob screw and the cylinder until the cap seats on the screw.
15	Burned and cracked mains inlet	The mains inlet was flushed with liquid and after connection to the mains 230 VAC there has occurred short connection.	Disassemble the pump as described in the section 9.1. Replace the mains inlet unit as described in the section 9.13.

9. PUMP REPAIR

9.1. DISASSEMBLING THE PUMP

(FIG. 3, ANNEX C)

♦ The syringe driver arm shall be moved to its end right hand side extreme position.
Remove six screws (8) located of the pump base. Carefully lift the pump housing and disconnect the supply unit connector P4 (Fig. 4 pos. 14), buzzer connector P5 (Fig. 4 pos. 21), MFC unit connector P6 (Fig. 4 pos. 23) from the electronic board B7048.

9.2. REPLACING INTERNAL BATTERY

(FIG. 4, ANNEX C)

♦ Disassemble the pump according to section 9.1. Remove screws (18) fastening the battery cover (19). Disconnect connectors P13, P14 (17) from the supply unit. Install new batteries and reconnect connectors P13, P14 (17). Fix the battery cover with screws (18) and reassemble the pump in the reverse order to section 10.1.

9.3. REPLACING RUBBER BELLOWS

(FIG. 5)

♦ Remove screw (7) and cover (9). Disconnected the flexible cable (Fig. 3, pos. 7) from the connector (Fig. 3, pos. 4). Remove three screws (10) fastening the plate (8) to the tube (3) and remove the plate. Remove screws (6). Remove the rubber bellows (4) and the syringe holder (5) from the tube (3). The new rubber bellows (4) is inserted with its narrower end towards the notch on the tube (3). Spread the silicon sealer on the housing-side of the syringe holder (5) and install the syringe holder (5) in such a way as to clamp the end of the rubber bellows (4) between the syringe holder (5) and the housing (1). Replace the screws (6). Replace and fasten the plate (8) to the end of the tube (3) with screws (10) clamping the end of the rubber bellows (4). Connect the flexible cable (Fig. 3, pos. 7) to the connector (Fig. 3, pos. 4). Fasten the cover (9) with the screw (7).

9.4. REPLACING OPTICAL SENSOR UNIT

(FIG. 6)

♦ Disassemble the pump according to the section 9.1. Remove the screws (8) and then remove the optical sensor unit (10). Note the order of conductor connection and unsolder them. Re-solder the conductors to the new optical sensor unit (10) in the same order. Fasten the optical sensor unit (10) by means of the screws (8) and washers (9) so as to maintain the distance between the optical sensor unit (10) and the coupling (3) equal to 4 ± 0.1 mm. Reassemble the pump in reverse order to the section 9.1.

9.5. REPLACING END SWITCH S1

(FIG. 6)

♦ Disassemble the pump according to the section 9.1. Unsolder two conductors from the end switch (16). Remove the screws (15) and then remove the end switch (16). Fasten the end switch (16) by means of the screws (15), washer (14), plate (12) and stopper (13) in such a position as to be activated when the distance between the housing surface supporting finger flanges of the syringe and the syringe driver arm surface supporting thumb rest of the syringe is equal to 27 mm. Re-solder the conductors to the same terminals. Pull insulation tubes onto the soldering places. Reassemble the pump in reverse order to the section 9.1.

9.6. REPLACING PRE-ALARM SWITCH S2

(FIG. 6)

♦ Disassemble the pump according to the section 9.1. Unsolder two conductors from the pre-alarm switch (11). Replace the pre-alarm switch (11) similar as end switch (see 9.5). Re-solder the conductors to the same terminals. Pull insulation tubes onto the soldering places. Fasten the pre-alarm switch (11) in such a position as to be activated when the distance between the housing surface supporting finger flanges of the syringe and the syringe driver arm surface supporting thumb rest of the syringe is equal to 45 mm. Reassemble the pump in reverse order to the section 9.1.

9.7. REPLACING SYRINGE SENSOR S3

(FIG. 3)

♦ Remove the screw (7) and the cover (9) (see Fig.5). Disconnect the flexible cable (7) from the connector (4). Remove the syringe sensor (3) with its connector (4). Glue the new syringe sensor (3) with its connector (4) on the same place at the same depth. Connect the flexible cable (7) to the connector (4). Fasten the cover (9) with the screw (7) (see Fig.5).

9.8. REPLACING ELECTRONIC BOARD B7048

(FIG. 6, ANNEX C, E)

♦ Disassemble the pump according to the section 9.1. Remove four screws (18). Disconnect step motor connector P1 from electronic board B7048 (17). Disconnect syringe sensor connector P2, sensors connector P3, MFC unit connector P6, syringe size sensor connector P8 and keypad connector J1 from the electronic board B7048 (17) and carefully take out the electronic board B7048 (17). Install the new electronic board B7048 (17), reconnect all connectors in reverse order. Reinstall four screws (18). Reassemble the pump in reverse order to the section 9.1. Perform syringe size calibration (see Chapter 6)

9.9. REPLACING KEYPAD

(FIG. 3)

♦ Disassemble the pump according to the section 9.1. Detach the old keypad (1). Disconnect keypad (1) connector from the electronic board B7048 (2). Glue the new keypad (1) taking openings for the display and for LEDs as a reference. Glue from the left to the right pressing the keypad (1) with a piece of soft clothes. Reconnect keypad (1) connector to the electronic board B7048 (2). Reassemble the pump in reverse order to the section 9.1.

9.10. REPLACING MICROCONTROLLER

(ANNEX E)

♦ Disassemble the pump according to the section 9.1. Note the orientation of the key on the body of microcontroller U18 on the electronic board B7048. By means of the special tool lift carefully the microcontroller U18 out from its socket on the electronic board B7048. Insert the microcontroller into the socket on the electronic board B7048 so as to have the same orientation of the key of its body as it was on the old microcontroller. Reassemble the pump in reverse order to the section 9.1.

9.11. REPLACING SYRINGE SIZE SENSOR

(FIG. 6)

♦ Disassemble the pump according to the section 9.1. Remove the screw (6) and remove the syringe clamp (5) (see Fig. 3). Disconnect the syringe size sensor (2) connector P8 from electronic board B7048 (17). Remove two screws (1) and lift the syringe size sensor (2). Install the new syringe size sensor (2) and fasten by means of two screws (1). For pumps with 5 ml syringes install the new syringe sensor (2) via four washers (1) (see Fig.5) and fasten by means of two screws (1). Connect syringe size sensor (2) connector P8 to electronic board B7048 (17). Reassemble the pump in reverse order to the section 9.1. Perform syringe size calibration (see Chapter 6)

9.12. REPLACING BUZZER UNIT

(FIG. 4)

♦ Disassemble the pump according to the section 9.1. Detach buzzer unit (22) (potentiometer and buzzer) from the housing. Glue the new buzzer unit to the housing in the same location. Glue potentiometer using thermo glue. Reassemble the pump in reverse order to the section 9.1.

9.13. REPLACING MAINS INLET UNIT

(FIG. 4)

♦ Disassemble the pump according to the section 9.1. Cut the tie (13). Disconnect mains inlet unit connector (6) from supply unit (11). Pull off fuse unit (7) wires from mains inlet unit connector (6). Remove two screws (5) and remove the mains inlet unit (3). Fasten the new mains inlet unit (3) by means

of the screws (5) via plate (4). Plug in fuse unit (7) wires in the mains inlet unit connector (6). Connect mains inlet unit connector (6) to supply unit (11). Fix mains inlet unit (3) wires with tie (13). Re-assemble the pump in reverse order to section 9.1.

9.14. REPLACING SUPPLY UNIT

(FIG. 4)

♦ Disassemble the pump according to the section 9.1. Disconnect battery connectors P13, P14 (17) and mains inlet unit connector (6) from supply unit (11). Remove five screws (10). Cut the tie (13). Remove the supply unit (11). Install the new supply unit (11) and reinstall five screws (10). Connect mains inlet unit connector (6) and battery connectors P13, P14 (17) to supply unit (11). Fix the supply unit cable with tie (13). Re-assemble the pump in reverse order to section 9.1.

9.15. REPLACING MULTIFUNCTIONAL CONNECTOR (MFC) UNIT

(FIG. 4)

♦ Disassemble the pump according to the section 9.1. Cut the tie (13). Remove the MFC unit screws (26) and carefully withdraw the MFC unit (1). Fit the new MFC unit (1) via plate (2) and secure via film (25) with the screws (26). Fix the MFC unit with tie (13). Re-assemble the pump in reverse order to section 9.1.

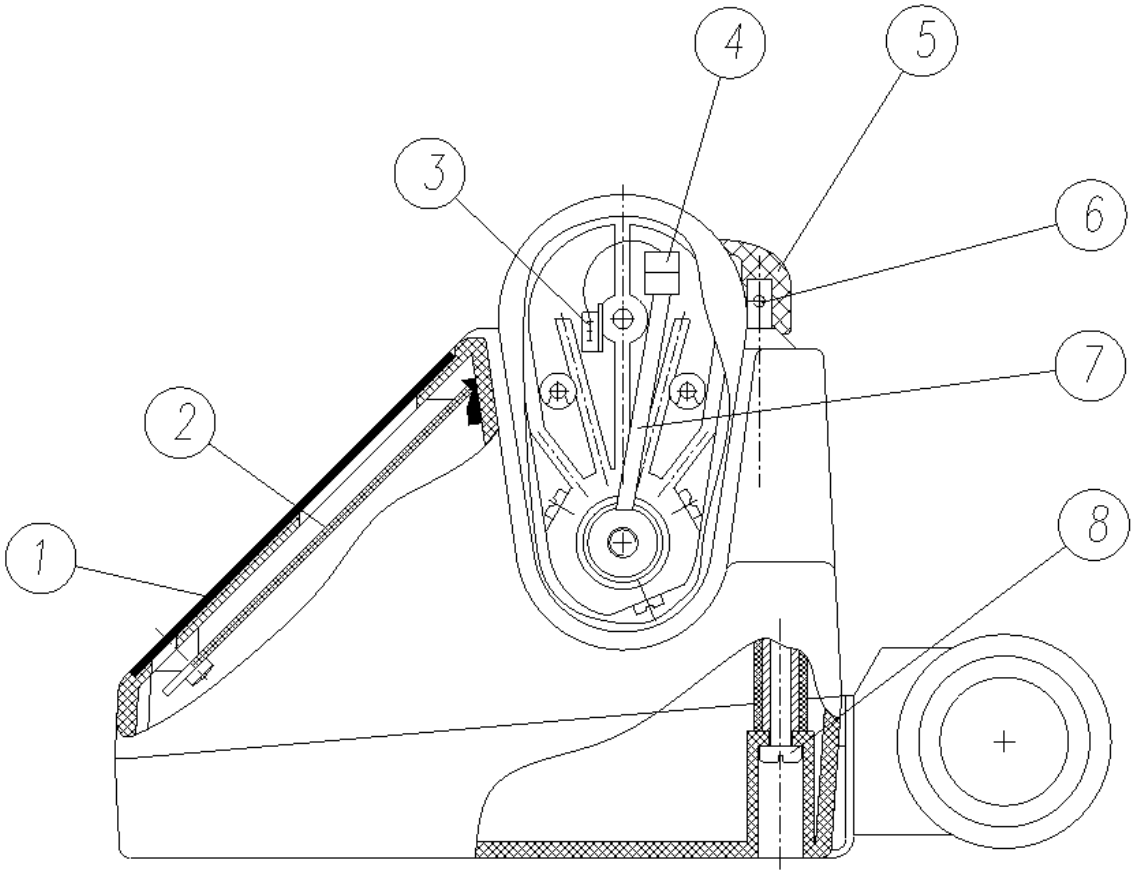


Fig. 3
1. Keypad
2. Electronic board B7048 (B3087048)
3. Syringe sensor S3 (B6660016)*
4. Connector *
5. Syringe clamp (B8127012)
6. Screw M2,5x12 DIN 966
7. Flexible cable *
8. Screws M4x14 - 4pcs., M4x50 - 2pcs. DIN 7985

* — *unavailable in SEP-10S*

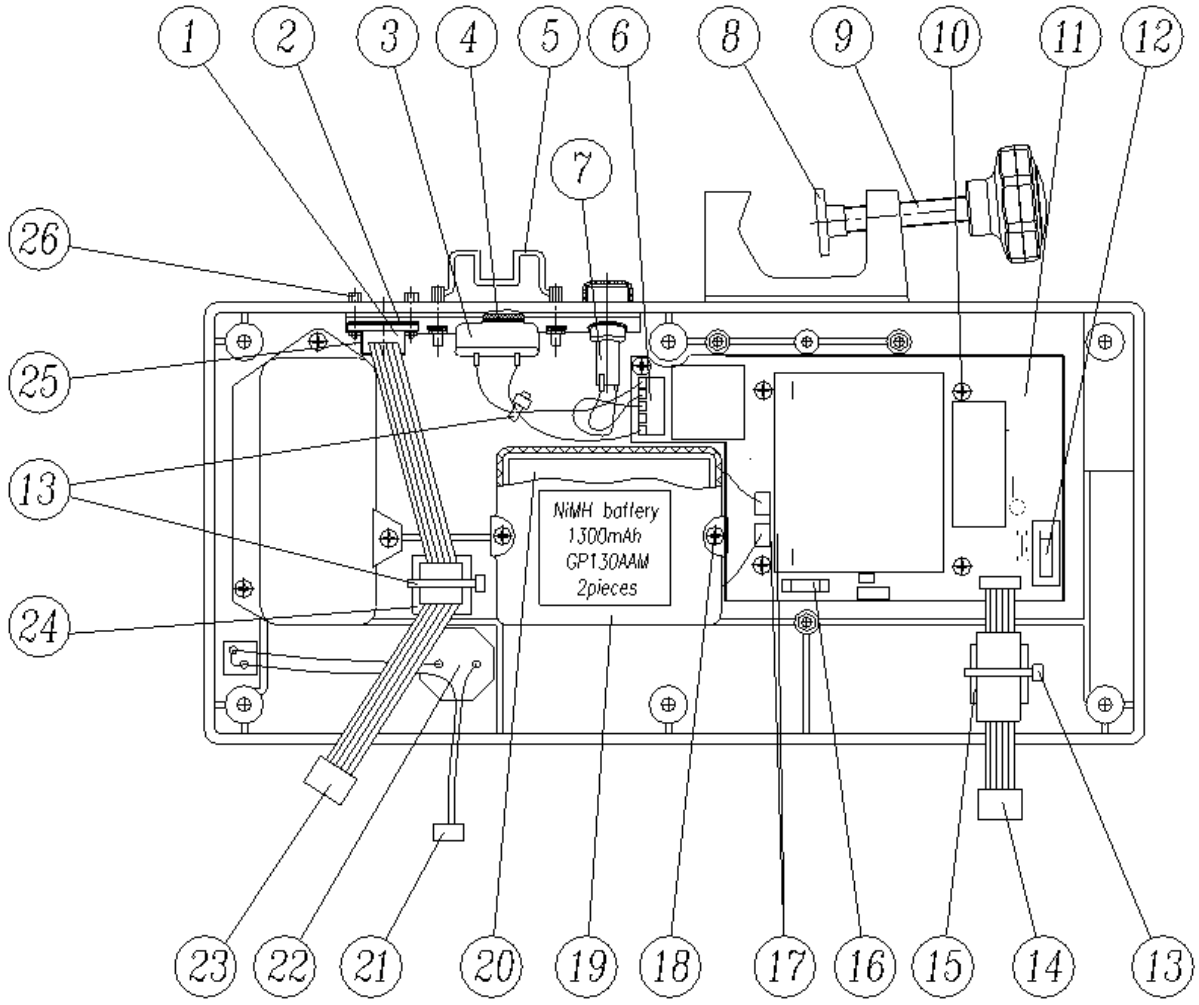


Fig. 4

1. MFC unit (B6680049)*
2. Plate (B8600370)
3. Mains inlet unit (B6680048)
4. Plate (B8600371)
5. Retaining clips with screw kit (B6200002)
6. Mains inlet unit connector
7. Fuse unit (B6720011)
8. Plastic cap (B8123009)
9. Cross knob (B6340007)
10. Screws Ø 3x6,5 ISO 7049
11. Supply unit (B6340017)
12. Fuse T1A (V5501020)
13. Tie (L5555020)
14. Supply unit connector
15. Holder (L5555030)
16. Battery fuse T1A (V5501020)
17. Battery connectors
18. Screws Ø 3x10 ISO 7049
19. Cover (B8703010)
20. Battery (B6640007)
21. Buzzer connector
22. Buzzer unit (B6710005) - with volume control*
    Buzzer unit (B6710006)- without volume control
23. MFC unit connector
24. Holder (L5555031)
25. Oracal film (48x13) mm (B8625005)
26. Screw kit (B8914031)

*- *unavailable in SEP-10S, optional in SEP-10S Plus*

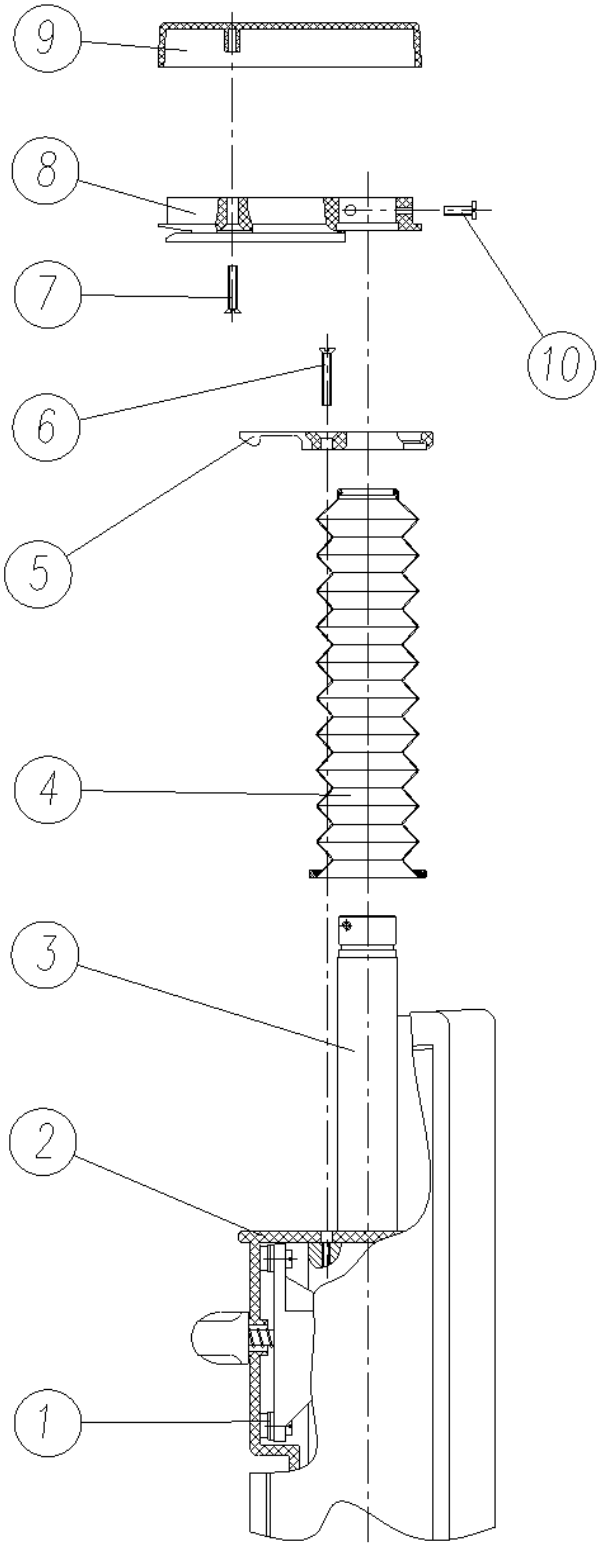


Fig. 5

1. Washers (B1002043)- only with 5 ml syringes
2. Housing
3. Tube
4. Rubber bellows (B8703002-01)
5. Syringe holder (B8126028-01)
6. Plastic screws M3x16 (B1000132)
7. Screw Ø 2,9x12 (B1000221)
8. Plate (B6600004)- without 5 ml syringes
   Plate (B6600008)- with 5 ml syringes
9. Cover (B8703014)
10. Screws M3x8 DIN 84

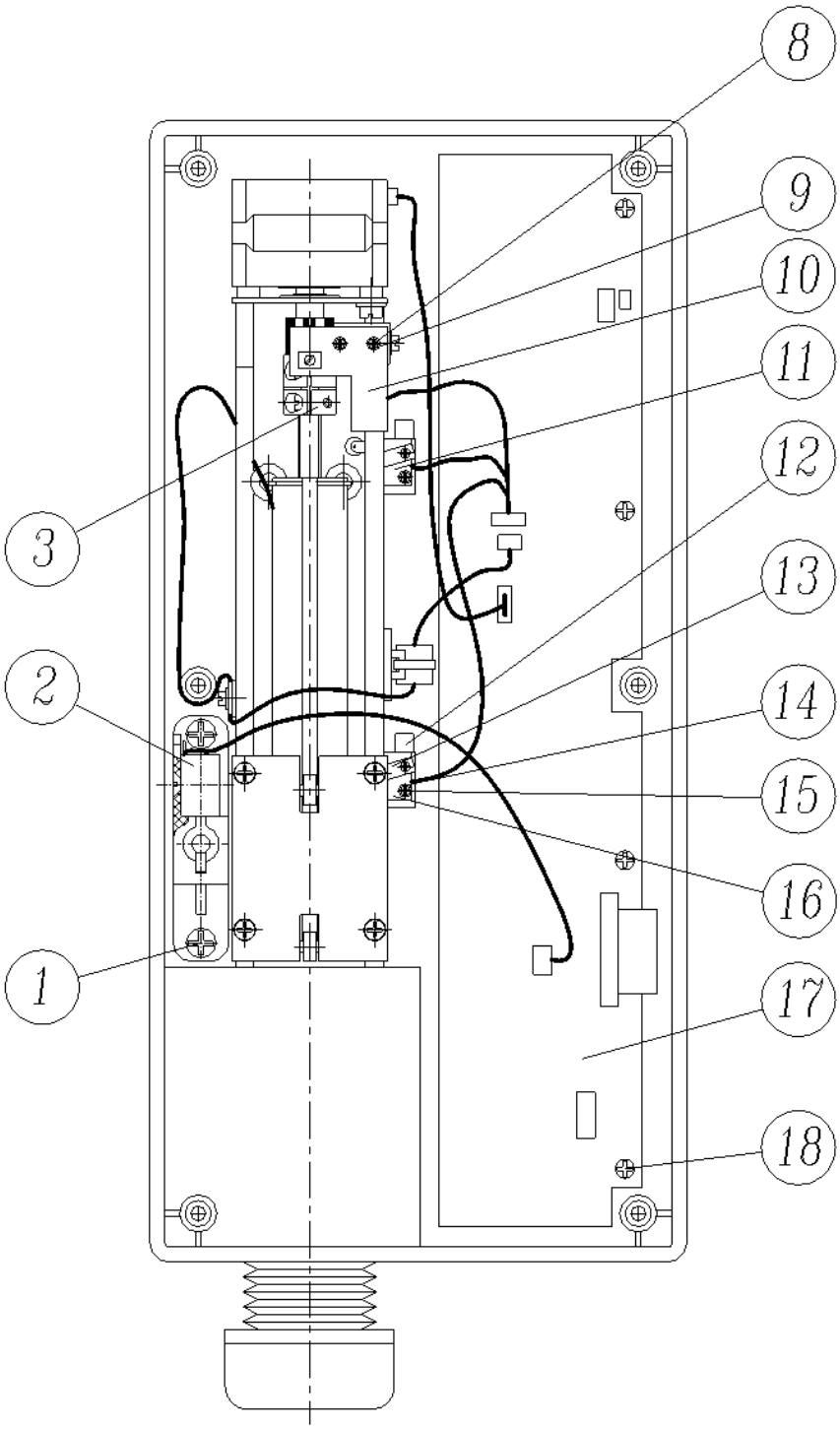
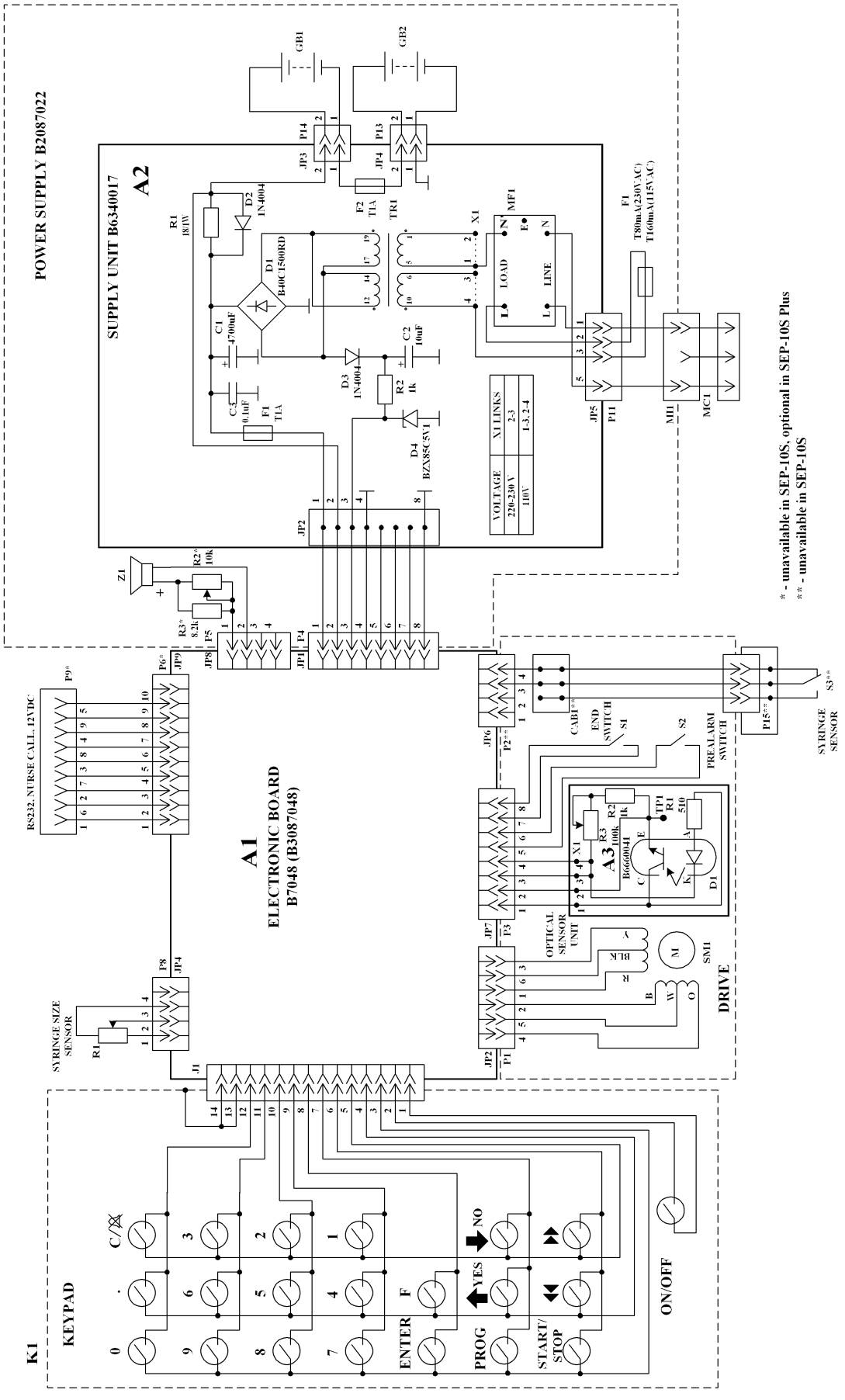


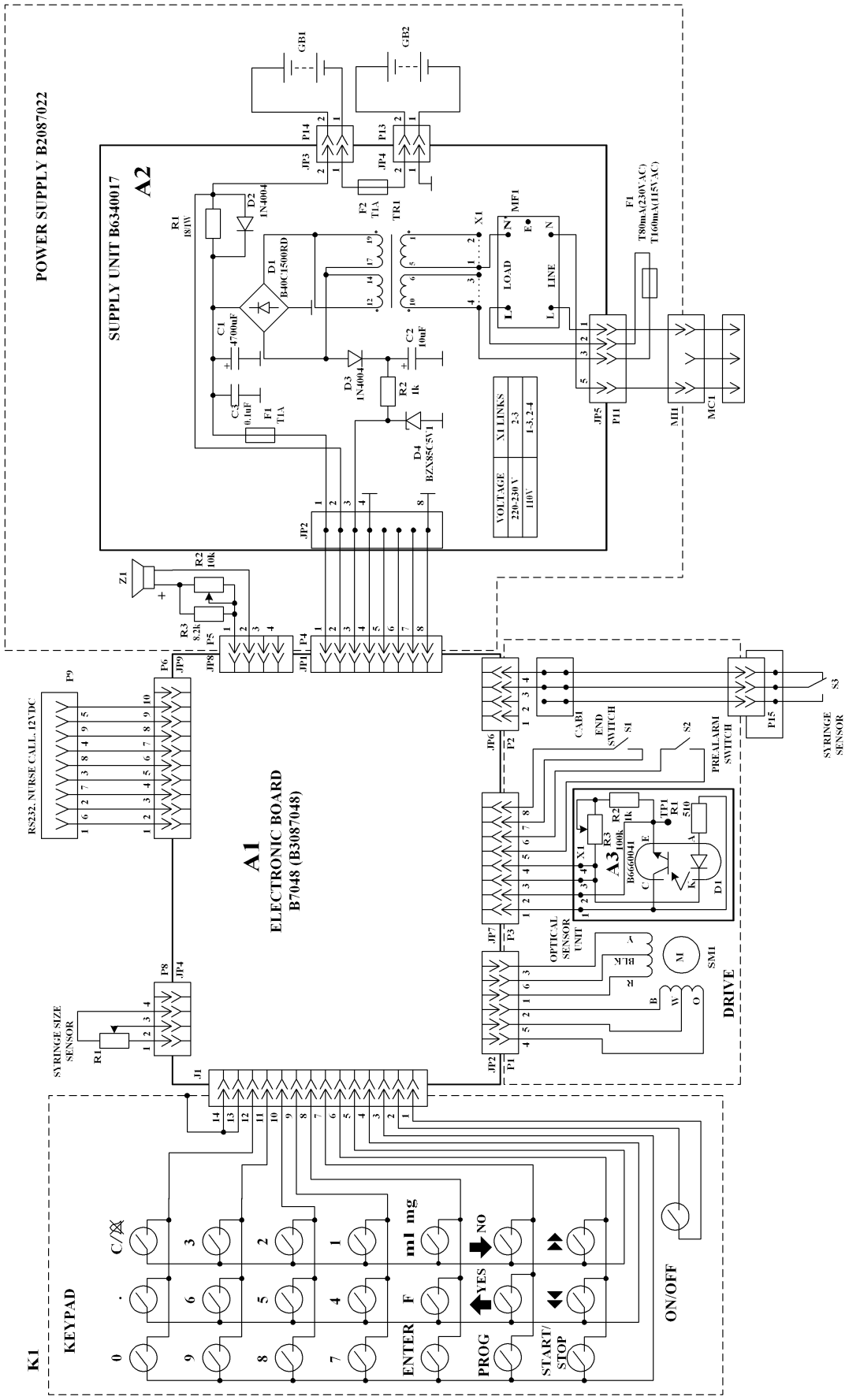
Fig. 6

1. Screws M4x8 DIN 7985
2. Syringe size sensor (B6210003-03)
3. Coupling
8. Screws M2x6 DIN 7985
9. Washers Ø 2,2 DIN 125
10. Optical sensor unit (B6660041)
11. Prealarm switch S2 (V5500900)
12. Plate (B8600063)
13. Stopper (B8090016)
14. Washer Ø 2,2 DIN 125
15. Screws M2x10 DIN 7985
16. End switch S1 (V5500900)
17. Electronic board B7048 (B3087048)
18. Screws Ø 3x6,5 ISO 7049

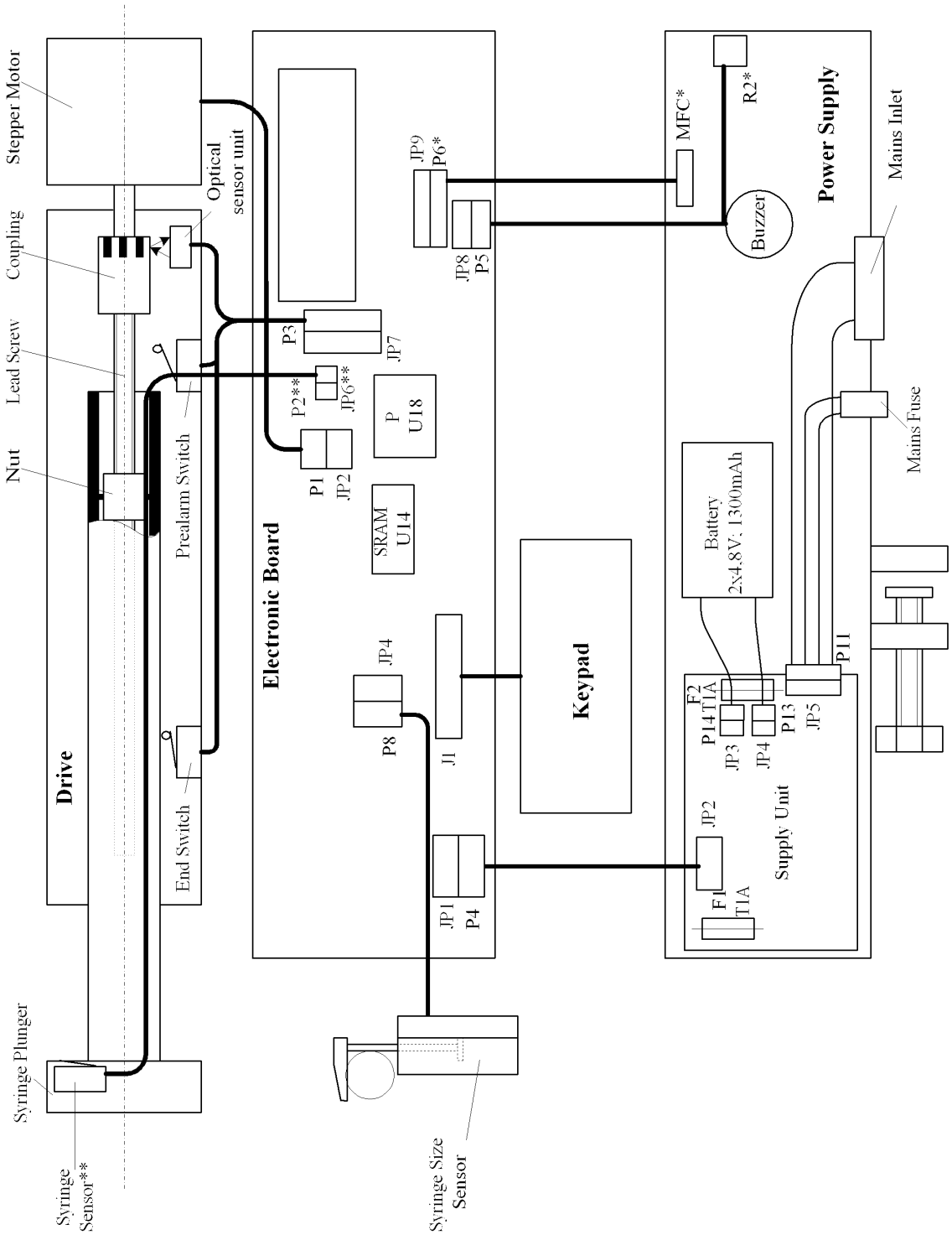
ANNEX A ELECTRICAL SCHEMATIC DIAGRAM OF THE PUMPS SEP-10S, SEP-10S Plus



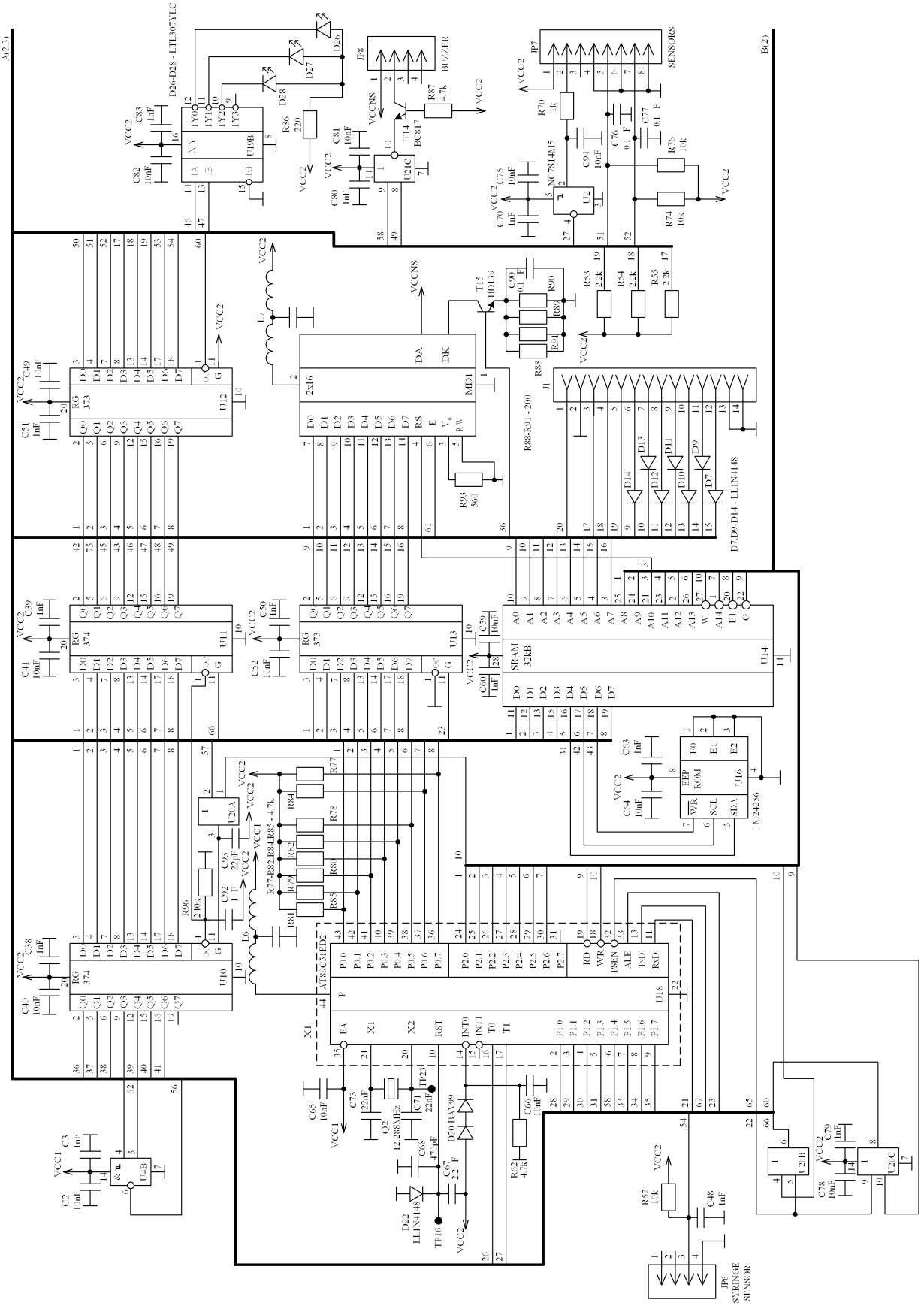
ANNEX B ELECTRICAL SCHEMATIC DIAGRAM OF THE PUMPS SP-12S Pro, SEP-12S Plus



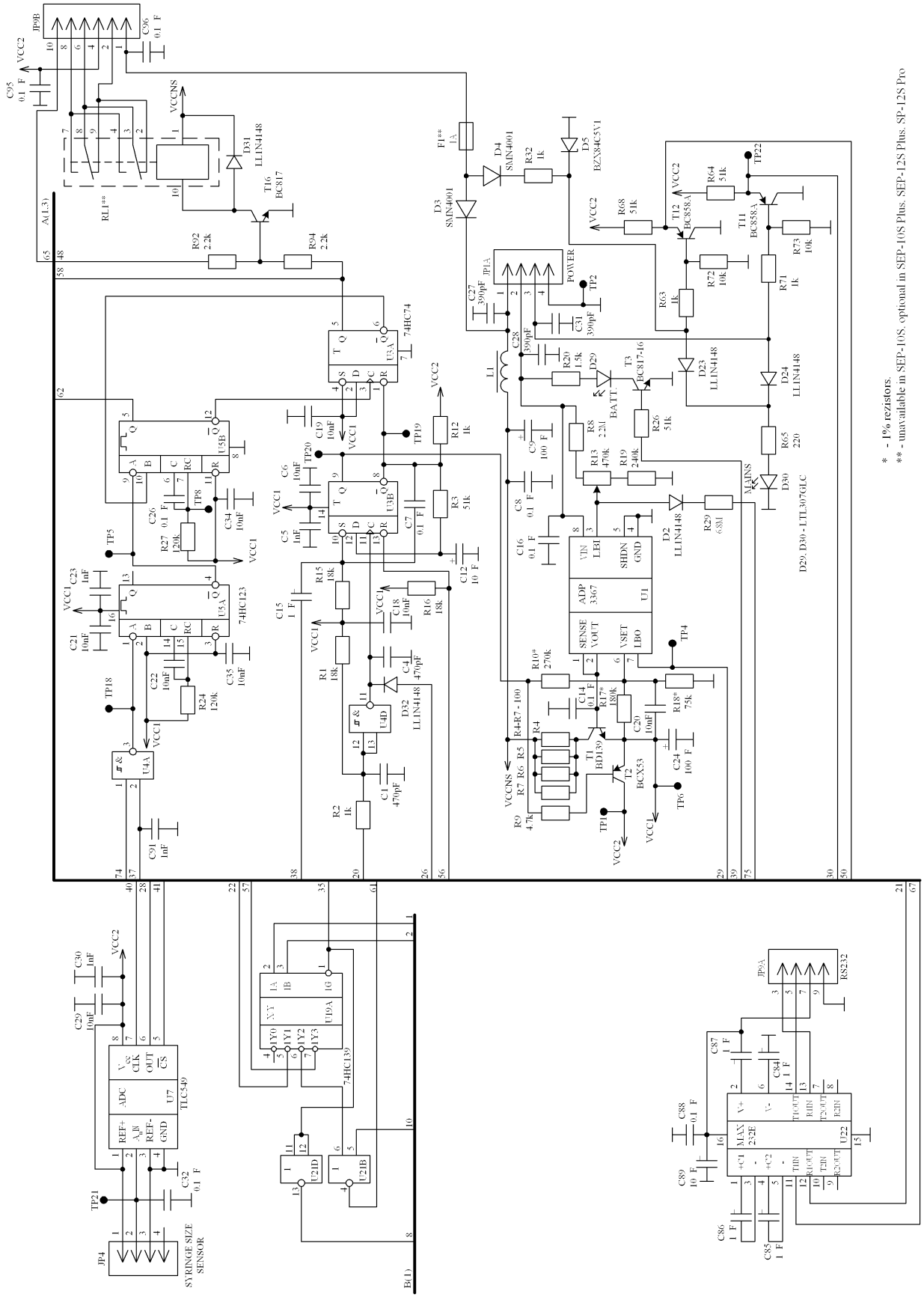
ANNEX C INTERCONNECTION DIAGRAM OF THE PUMPS



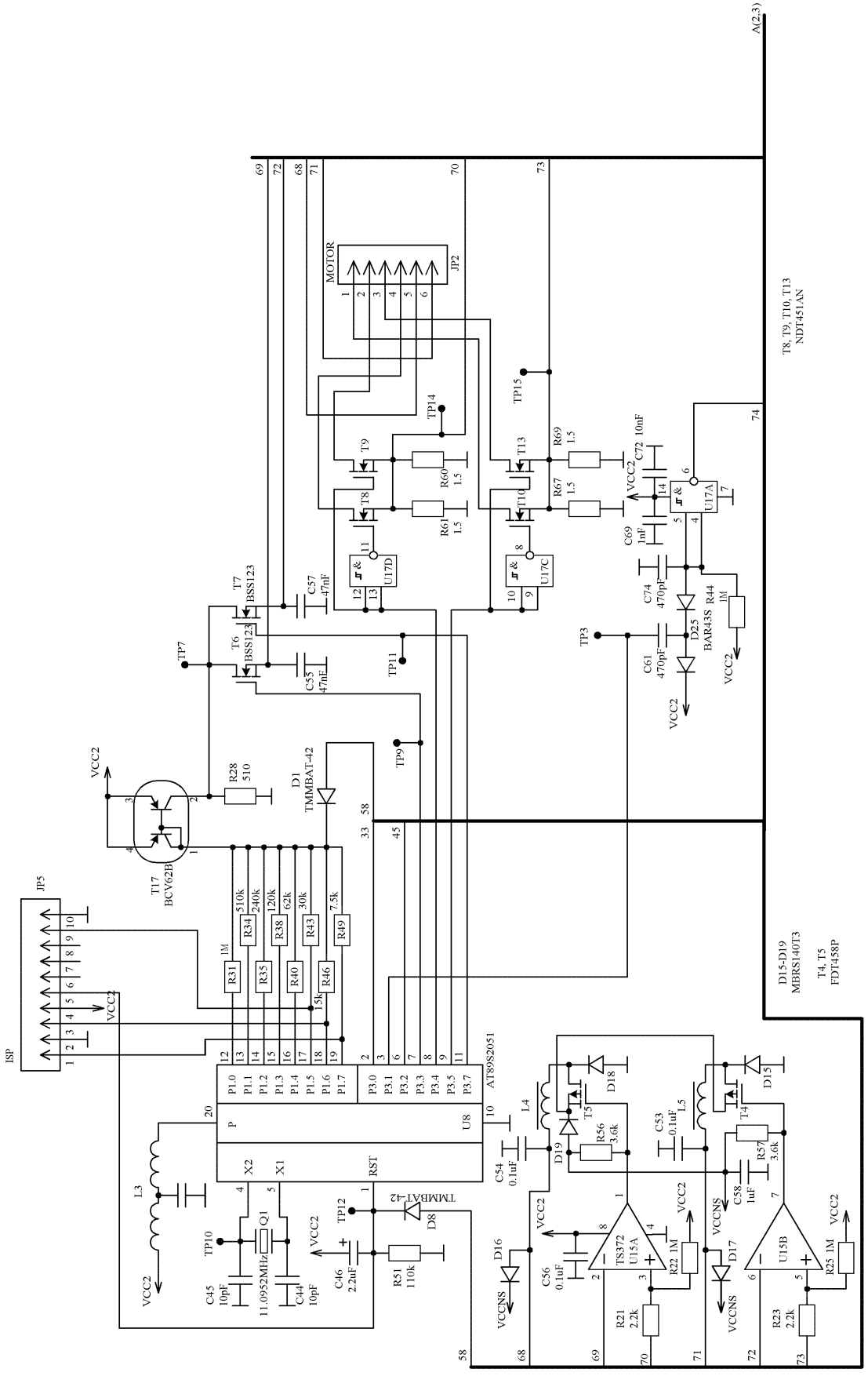
ANNEX D ELECTRICAL SCHEMATIC DIAGRAM OF ELECTRONIC BOARD B7048



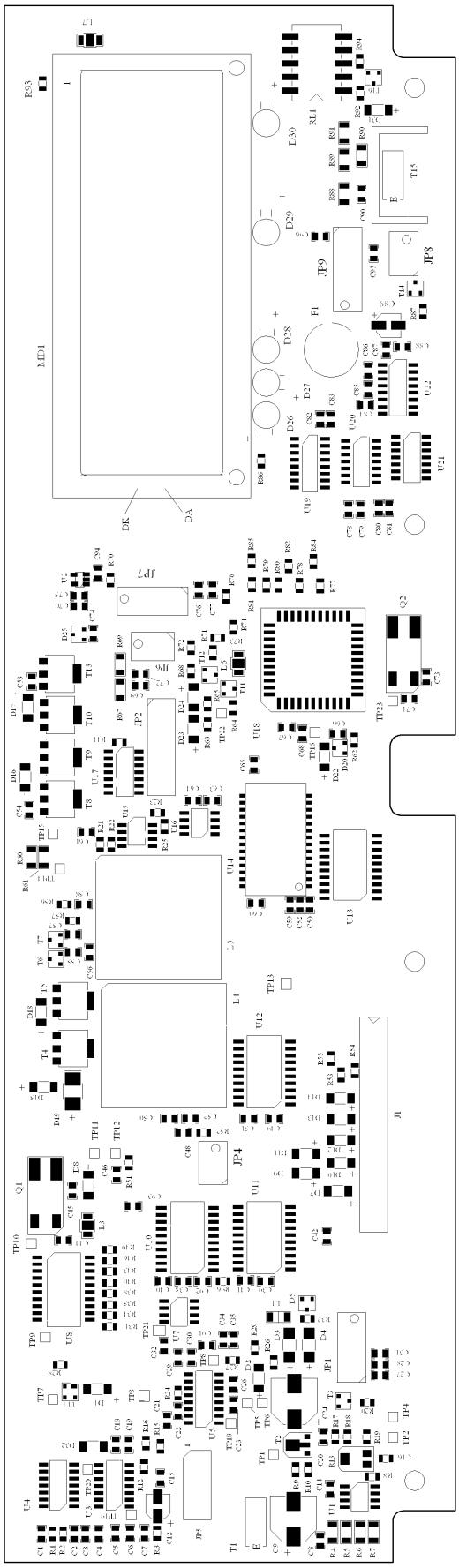
ANNEX D ELECTRICAL SCHEMATIC DIAGRAM OF ELECTRONIC BOARD B7048 (continue)



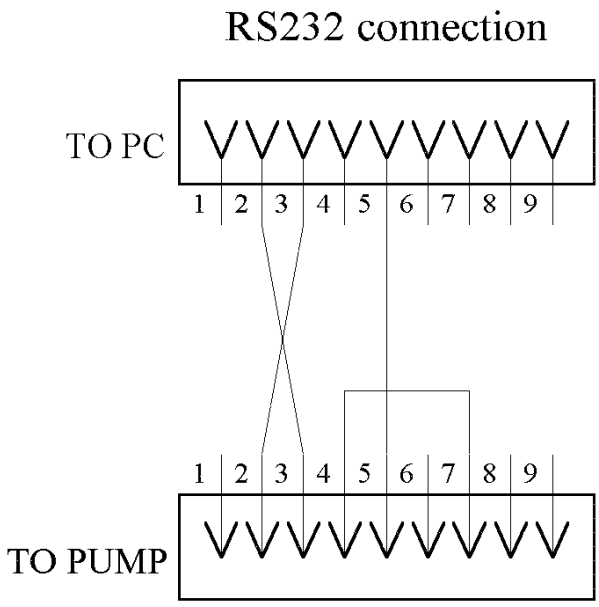
ANNEX D ELECTRICAL SCHEMATIC DIAGRAM OF ELECTRONIC BOARD B7048 (continue)

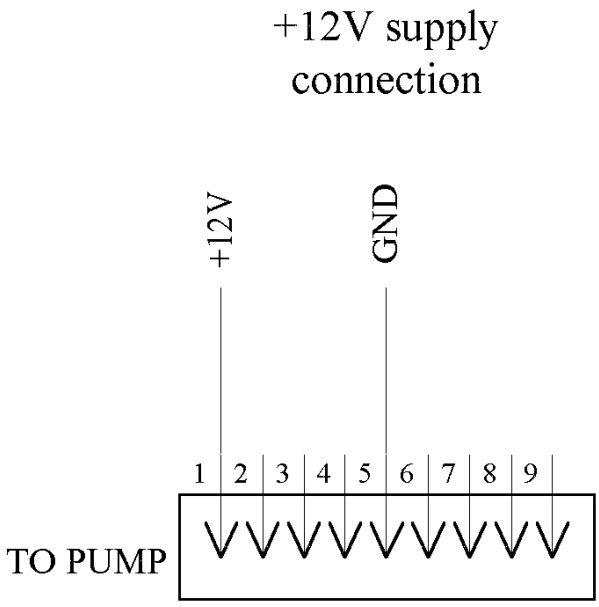


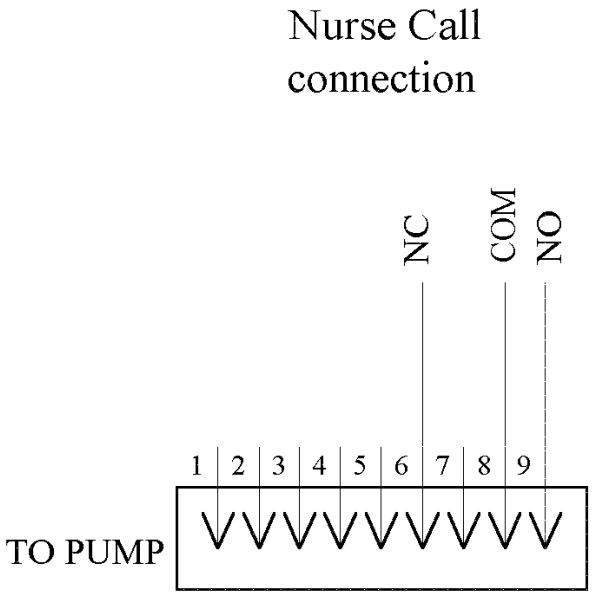
ANNEX E ASSEMBLY DRAWING OF ELECTRONIC BOARD B7048



ANNEX F DRAWING OF CABLES FOR MULTIFUNCTIONAL CONNECTOR (MFC)*







Connection data:
Ground (GND)
Normally Closed (NC)
Common (COM)
Normally Open (NO)

** — unavailable in SEP-10S, optional in SEP-10S Plus*

NOTE:
Use standard D Type - 9 pin connectors.

ANNEX G DESCRIPTION OF ERRORS

All errors are listed in the Table:

Error	*DESCRIPTION*	*CORRECTIVE ACTIONS*
ERROR 1	Cannot read data from external EEPROM	Recycle power
ERROR 2	Cannot write data to internal EEPROM	Configure Setup menu repeatedly (see Chapter 6)
ERROR 4	Occlusion coeff. settings failed	Calibrate occlusion level (see Chapter 6)
ERROR 5	Language setting failed	Select language (see Chapter 6)
ERROR 6	Incorrect program CRC	Consult the manufacturer
ERROR 7	Syringe size sensor calibration failed	Calibrate syringe size sensor (see Chapter 6)
ERROR 8	Date and time setting failed	Set date and time (see Chapter 6)
ERROR 9	Drug set failed	Restore default drug set (see Chapter 6)
ERROR 11	Incorrect external EEPROM CRC	Consult the manufacturer
ERROR 13	Watchdog activated	Consult the manufacturer
ERROR 16	Data of current syringe failed	Recycle power
ERROR 17	SRAM test failed	Recycle power
ERROR 18	Incorrect program CRC (fast test)	Consult the manufacturer
ERROR 19	Incorrect Bootloader CRC	Consult the manufacturer

NOTE:
When eliminated fault repeats consult the manufacturer.

ANNEX H PREVENTIVE MAINTENANCE CHECKLIST

Serial number…….

Service Manual section	Parameter	Value
7.2	Infusion volume accuracy	%
7.3	Infusion rate accuracy	%
7.4	Bolus volume accuracy	%
7.5	Occlusion pressure accuracy: Low Med High	kPa kPa kPa
Operator's Manual section	Alarm signal	Comment
7	NO MAINS!!! Check power cord	
7	LOW BATTERY	
7	VERY LOW BATTERY	
7	OCCLUSION!!!	
7	OCCLUSION or END	
7	SYRINGE EMPTY!	
7	Stop X.X ml KOR X.X ml/h	
7	END OF INFUSION! KOR X.X ml/h	
7	SYRINGE EMPTY! KOR X.X ml/h	
7	ATTENTION! 2 min INACTIVE	
7	STANDBY TIME ELAPSED	
7	X min. PREALARM!	
7	ILLEGAL SYRINGE! Change SYRINGE!	
7	CLAMP OPENED!	
7	PLUNGER NOT FITTED !*	

Pump owner/ward .....……..
Tests performed by (name, surname, signature) .....……...
Tests performed (date) .....…….....

*- *unavailable in SEP-10S*

ANNEX I COMPONENT LIST

Description	*Code*
Battery	B6640007
Rubber bellows	B8703002-01
Optical sensor unit	B6660041
End S1 and prealarm S2 switch	V5500900
Syringe sensor S3	B6660016
Electronic board B7048	B3087048
Keypad	V6675040 (for SEP-10S) V6675033 (for SEP-10S Plus) V6675042 (for SEP-12S Plus) V6675034 (for SP-12S Pro)
Microcontroller U18	B6270010
Syringe size sensor	B6210003-03
Buzzer unit Z1	B6710005 (with volume control) B6710006 (without volume control)
Mains inlet unit	B6680048
Supply unit	B6340017
Fuse T80 mA F1	V5501002 (for 230 VAC mains)
Fuse T160 mA F1	V5501000 (for 115 VAC mains)
Fuse T1A F1, F2(A2)	V5501020
Plastic cap	B8123009
Cross knob	B6370007
Mains cable	V5570010 (European style)
Syringe clamp	B8127012
Plate	B6600004 (without 5 ml syringes)
Plate	B6600008 (with 5 ml syringes)
Syringe holder	B8126028-01

ANNEX J ACCESSORIES

Part number	*Description*	*Note*
B6190048	Set of spacers	For syringe size sensor calibration

ANNEX K COMMUNICATION PROTOCOL TECHNICAL DESCRIPTION

♦ Communication protocol is used for downloading "Event Log" from the syringe pump in response to commands from a computer.
♦ The protocol uses a variation of the HDLC format for data transfer. Following format is used to transfer commands from computer to the syringe pump:

BYTES	CODE	DESCRIPTION
1	0xC0	Flag
1	0x02	-
1	0x13	Control
1	0x00	Status (reserved)
1	—	Command code (see below)
1	0x00	-
2	—	CRC
1	0xC1	Flag

♦ Following commands are used for downloading "Event Log" from syringe pump to computer:

CODE	DESCRIPTION
0x01	Send Model and SN
0x30	Send Event Log Size
0x31	Send (repeat) frame
0x32	Send next frame
0x33	Quit

♦ Following format is used for transferring data from syringe pump to computer:

BYTES	CODE	DESCRIPTION
1	0xC0	Flag
1	0x03	—
1	0x13	Control
1	0x00	Status (reserved)
1	-	Code of command from PC pump is responding to
1	0x00	—
45	-	Data (5 events)
2	—	CRC
1	0xC1	Flag

♦ Technical specification of the RS232 Interface is shown in the 1 table
1 table

RS 232 Specification	
Connector	9-pin D-Socket
TX	Pin 3
RX	Pin 2
Baud rate	9600 baud
Bit format	1 start, 8 data, no parity, 1 stop
Character format	Binary/ASCII (see below)
Ground	Pin 5

NOTE:
ASCII is used to transfer information regarding pump model in response to command "Send Model and SN"

♦ Cable connections scheme is shown in 2 table

2 table

PC	**Pump**
Pin 3 (Tx)	Pin 2 (Rx)
Pin 2 (Rx)	Pin 3 (Tx)
Pin 5 (Ground)	Pin 5 (GND)
Pin 4 Nc	Pin 4, Pin 7 (Jumper)
Pin 7 Nc	