WATSON-MARLOW

603U/R

Auto-control high-flow pump

Installation, calibration and operating instructions

Using this manual

Part 1 should be read by all users and contains essential installation information. Part 2 is for users who will operate the pump in the control mode in which it has been received. Part 3 need only be consulted when the method of control (manual, remote or auto) is to be changed, or when the pump is to be re-calibrated to respond to a different control signal.

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Part 1. Installation

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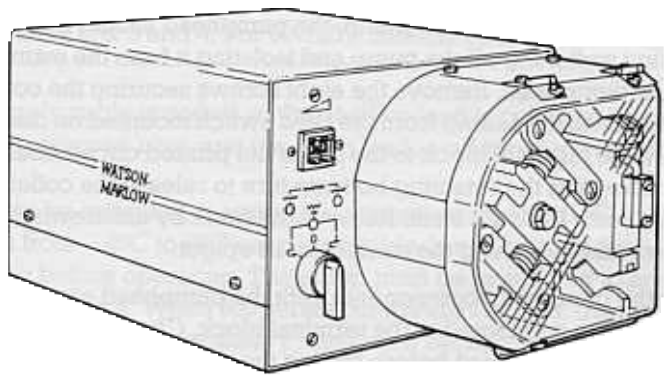
Introduction

Thank you for choosing a Watson-Marlow product. This 603U/R pump is the most sophisticated high-flow peristaltic pump available today, providing flow rates of up to 14.6 litre/min and incorporating comprehensive signal conditioning facilities. The 603U/R supersedes the 602U/R and incorporates two major enhancements over that model. First, a switch is fitted to the pumphead guard so that power to the motor is cut off when the pumphead guard is raised. Second, a digital speed control is fitted, allowing pump speed to be accurately set and reset over the range of 5 to 99 percent.

The 603U/R shares with the other Watson-Marlow auto-control pumps, the 101U/R, the 202U/AA, the 501U/R and the 701U/R, three major features. First, the mode of control, (manual, remote or automatic), may be changed by the user at any time. Second, within its auto-control mode the 603U/R may be factory or user set to respond to a wide range of both voltage and current control signals. Third, a front panel mounted light emitting diode illuminates to give warning of the input signal exceeding the maximum safe level for the programmed use. A second light emitting diode illuminates if the rotor is stalled by overloading, and the power supply to the motor is simultaneously shut off.



Two-year warranty

Watson-Marlow warrants, subject to the conditions below, through either Watson-Marlow or its authorised distributors, to repair or replace free of charge, including labour, any part of this product which fails within two years of delivery of the product to the end user. Such failure must have occured because of defect in material or workmanship and not as a result of operation of the product other than in accordance with the instructions given in this manual. Conditions of and specific exceptions to the above warranty are:

1 Consumable items such as fuses, rollers and tubing are excluded.

2 Products must be returned by pre-arrangement carriage paid to Watson-Marlow or its authorised distributor.

3 All repairs or modifications must have been made by Watson-Marlow or its authorised distributors or with the express permission of Watson-Marlow or its authorised distributors.

4 Products which have been abused, misused, or subjected to malicious or accidental damage or electrical surge are excluded.

Warranties purporting to be on behalf of Watson-Marlow made by any person, including representatives of Watson-Marlow or its distributors, which do not accord with the terms of this warranty shall not be binding upon Watson-Marlow unless expressly approved in writing by a Manager or Director of Watson-Marlow.

Quick start-up guide

1 Ensure mains electricity supply matches that marked on rear panel.

2 Load tubing into pumphead.

3 If the pump is to be manually controlled, insert the pre-linked Din plug into the rear panel socket, and check that rear panel indicates that the pump is set for manual control, Mode M1. Set running speed.

4 If the pump is to be automatically controlled, follow instructions in Part 2, Section 3, or Part 3, Section 7.

5 Turn power switch to correct direction of rotation to start pump.

6 Turn power switch to central off position to stop pump.

7 If direction of rotation is to be reversed, make two second pause in central off position before selecting other direction of rotation.

Care and maintenance

Scheduled maintenance of the 603U/R pump is not required except for the brushes which should be replaced after each one thousand hours running. If harmful liquids are spilled on to the pump, the pumphead should be removed and cleaned after first switching off the pump and isolating it from the mains. Remove any tubing in the pumphead. Remove the eight screws securing the cover and disconnect the two wires leading from the reed switch mounted on the pumphead from the terminal block to the left of the printed circuit board. Remove the rotor by unscrewing the retaining bolt one turn to release the collet, and withdrawing the rotor from the shaft. Remove the track by unscrewing the two retaining screws and detaching the track from its spigot.

After cleaning the pumphead components, refit the pumphead ensuring the leads of the reed switch are connected to the terminal block. Check for correct operation of the switched guard before putting the pump back into service.

All moving parts of the rotor should be checked from time to time for freedom of movement. Occasional lubrication of pivot points and rollers with light lubricating oil will help ensure trouble free operation. If the pump needs cleaning, use a cloth dampened with water and mild detergent. Do not use strong solvents.

Part 1: INSTALLATION

1 Check list

Please check that you have received one 603U/R pump, one unwired Din plug, one Din plug linked for use in manual mode, one pack of spare self-adhesive mode labels, plus any accessories specified in your order. A label on the rear panel indicates the control mode to which the pump has been set. If not specified on your order, the 603U/R will be set to manual mode M1.

2 Installation

Ensure that the supply voltage and frequency corresponds with that marked on the rear of the unit. If the supply voltage is outside the marked range then the tappings of the transformer must be changed.

WARNING There are dangerous voltages (at mains potential) inside the pump. Changing the tappings of the transformer requires the cover to be removed. Seek qualified advice regarding electrical hazards.

Isolate the pump from the mains supply and remove the eight screws securing the cover to gain access to the terminal block on the top chassis. For 200-250V 50/60Hz operation, link 3 and 4. For 90-130V 50/60Hz operation, link 2 and 4 and link 3 and 5.

The mains supply cable is coded so that the live lead is coloured brown, the neutral lead is coloured blue, and the earth lead is coloured green and yellow.

The 603U/R can be operated at ambient air temperatures from 0C to 37C. Storage temperatures from −40C to 65C are permissible, but allow time for acclimatisation before operating. The pump must be positioned to enable a free passage of air around it. When 600 series pumps are stacked, the normal foot mountings will provide the necessary ventilation between units. Signal leads must be kept as short as possible. In some cases screening may be required

If the pump does not operate correctly, check that power is available at the unit, that all fuses are intact, that the motor overload light emitting diode is not indicating that the pump is stalled by incorrect fitting of tubing (see section 9), that the pumphead is properly located and securely attached to the pump,that the pumphead guard is properly closed (this operates a reed switch allowing power to reach the motor), that the correct Din plug is in position (see Part 2), and that the signal overload light emitting diode is not indicating an excessive signal.

CAUTION A label on the rear panel indicates for which mode of operation your 603U/R has been set. If the unit is set in a V (voltage) mode or C (current) mode, no attempt should be made to exercise normal control through the front panel potentiometer since this may have been set as part of the auto-control calibration.

3 Specification

Motor type	Permanent magnet direct current
Maximum rotor speed	165rpm
Speed control range	5 to 99 percent
Operating voltage/frequency	200-250V 50/60Hz or 90-130V 50/60Hz
Maximum power consumption	250VA
Fuse rating	3.15A
Operating temperature range	0C to 37C
Storage temperature range	−40C to 65C
Relevant standards	CEE10, IP34
Dimensions	195 × 265 × 400mm
Weight	17kg

4 Tube loading

The 603U/R is fitted with a spring loaded twin roller pumphead designed for tubing with a nominal wall thickness of 3.2mm and bore sizes of between 4.8mm and 19.0mm. The pumphead is fixed in one position. A length of 410mm of tubing is needed for the pumphead.

WARNING Switch off the pump and isolate it from the mains supply before loading tubing. If the pump is not switched off before the pumphead guard is raised, a switch on the guard will cut off power to the motor. This switched guard is a safety back-up system and must not be used as the primary on/off switch for the pump.

Open the pumphead guard and fit one end the tube into one of the adjustable clamps. Then, whilst rotating the rotor (a spanner is provided for this purpose), feed the tube between the rollers and the track, ensuring that the tubing is not twisted or stretched. This is particularly important for the larger bore sizes of tubing. Fit the other end of the tube into the second adjustable clamp, ensuring that the tube is not slack in the pumphead. Clamp the tube firmly by turning the serrated adjustment wheel. Both clamps will grip the tube simultaneously. Remove the spanner and close the guard.

5 Adjustment of the pumphead rollers

The two spring loaded rollers compensate for tolerance variations in the wall thickness of tubing, eliminating the manual adjustment normally required by peristaltic pumps, and, in general, there should be no need for the gap setting between the rollers and track to be adjusted. Should it ever appear that the roller arms are not equally adjusted, the original factory setting of 5.2mm can easily be restored. There is an adjustment screw on each of the two roller arms. Turn each screw anti-clockwise until both rollers are just in contact with the track, and then turn each screw clockwise by five turns.

Correct and equal adjustment is important. Over-occlusion will reduce tube life. Under-occlusion will reduce pumping efficiency.

6 Flow rates

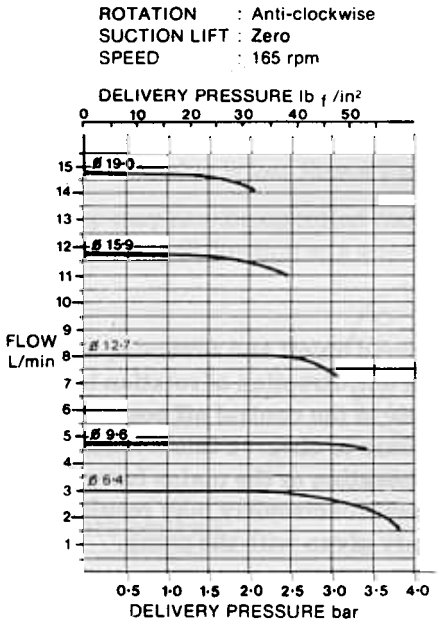
These flow rates were obtained pumping water at 20C with zero suction and delivery pressures. Where flow rate is critical it should be measured under operating conditions. The major factors affecting flow rate are suction and delivery heads, fluid viscosity and temperature.

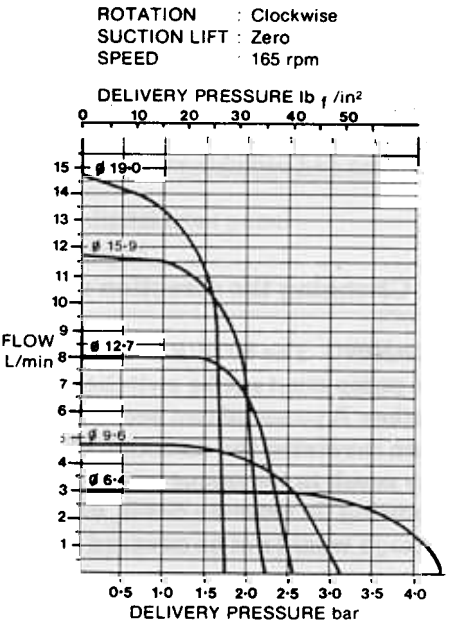
603U/R flow rates (litre/min) Minimum flows 5 percent of rates given.

Tubing internal diameter (mm)					
4.8	6.4	9.6	12.7	15.9	19.0*
1.8	2.7	4.7	8.0	11.6	

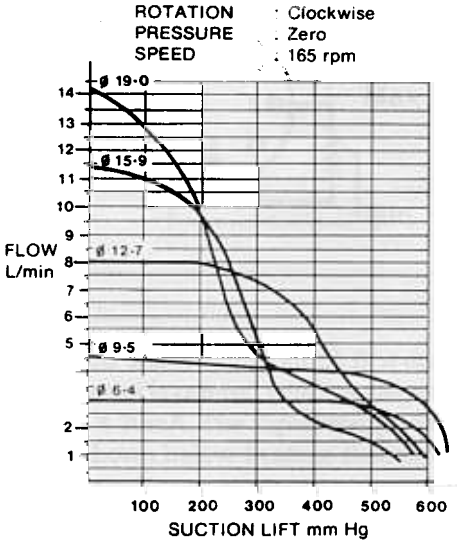
* CAUTION 19.0mm bore tubing needs care in loading to avoid kinking.

603U/Rflow rates (litre/min) against pressure at 165rpm with zero suction lift





603U/Rflow rates (litre/min) against suction lift at 165rpm with clockwise rotation and zero delivery pressure



7 Tubing range

Flow precision depends upon the accuracy and consistency of the tubing. All Watson-Marlow tubing is formulated, manufactured and quality controlled to our own specifications.

Bore mm	Marprene	Neoprene	Butyl	Silicone	Marvinal	Viton
3.2mm wall thickness						
4.8				TU155		
6.4	TU029	TU028	TU076	TU097	TU187	TU055
9.6	TU211	TU029	TU077	TU098	TU189	TU157
12.7	TU212	TU030	TU078	TU099	TU190	TU056
15.9	TU213	TU031	TU079	TU156	TU191	
19.0	TU214	TU032	TU080		TU192	TU058

8 Motor overload cut-out

If the current to the motor rises to an unsafe level, power to the motor is shut off and the motor overload light emitting diode on the front panel illuminates. This circuit mainly protects the pump from damage caused by any accidental stalling of the rotor. Running can be restored by switching the pump off, isolating it from the mains, clearing the cause of the motor overload, reconnecting the pump to the mains and switching the pump on.

9 Changing the direction of rotation

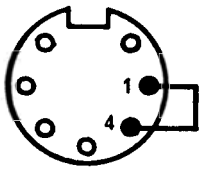
WARNING The 603U/R is fitted with a combined on/off and reversing switch. The pump must not be switched rapidly from one direction of rotation to another. A pause of two seconds must be made in the central off position when reversing the direction of rotation. Failure to observe this warning may result in the motor overload circuitry operating or the mains fuses rupturing. In extreme cases, damage to the control circuitry may result. Such damage would not be covered by the warranty given with the pump.

Part 2: ROUTINE OPERATION

1 Manual control

If the 603U/R is to be operated in manually, first ensure that the rear panel label is printed **Mode M1.** Insert the Din plug wired for manual mode into the rear panel Din socket. The pump will not operate if the wrong Din plug is used. If the pre-linked Din plug is lost, then a 7-pin Din plug should be linked as follows:

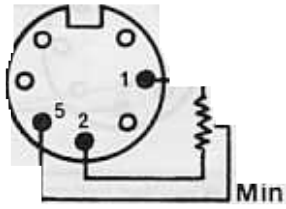
The pump may now be operated manually, and the digital front panel potentiometer will function as a speed (flow rate) control.



2 Remote control

If the 603U/R is to be operated remotely, first ensure that the self-adhesive label on the rear panel reads **Mode M2.** A remote potentiometer can now be connected to the unwired Din plug as shown below:

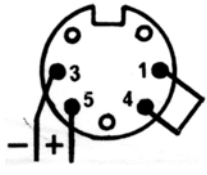
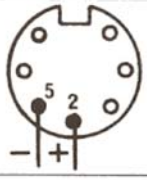
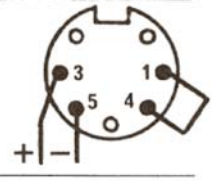
The pump may now be operated remotely over its full speed range. The remote potentiometer should have a value of 4.7 kohm to 10 kohm. A suitable potentiometer is available from Watson-Marlow as Part RV004 and the appropriate digital dial as Part DS007.



3 Auto-control

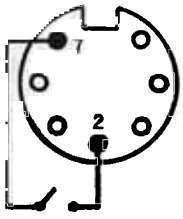
If the 603U/R is to be operated under auto-control, first ensure that the self-adhesive label on the rear panel is printed with the value of the signal you propose to use, for instance 4-20mA. The signal source should now be connected to the unwired Din plug as shown below. In some modes, pins 1 and 4 must be linked.

CAUTION Do not adjust the front panel potentiometer. In certain modes it will have been pre-set, calibrating the module to a specified input signal. The maximum voltage in to the unit must not exceed 60V. The maximum current permitted when the digital front panel potentiometer is in circuit is 20mA. When the front panel potentiometer is out of circuit, the maximum permissible current is 32mA.

Mode			Connection	Mode		Connection
	C1	C8		V7	C14	
	C2	C9		V8	C15	
	C3	C10		V9	C16	
	C4	C11		V10	C17	
	C5	C12		V11	C18	
	C6	C13		V12		
	C7					
V13	C19			V16	C24	
V14	C30			V17	C25	
V15	C21			V18	C26	
	C22				C27	
	C23				C28	

4 Remote stop

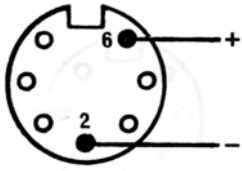
In any of the three speed control modes, (manual, remote or auto), the 603U/R may be stopped and started from a remote position. A switch should be wired across pins 2 and 7 of the Din plug. Open contacts to run, close contacts to stop.



5 Motor speed information

A 0 to 12V dc (nominal) signal which varies directly with motor speed is present across pins 6 and 2 of the Din socket. This signal may be used to monitor the motor speed. 12V is approximately equal to 165rpm. The output is load dependent but is suitable for high impedance measuring devices including all digital multimeters. If an analogue meter is to be used, choose a dc moving coil meter with 50uA full scale deflection. The output must be matched to the measuring device. Seek the advice of a qualified electronics engineer.

CAUTION If a Din plug is wired to monitor the motor speed signal, ensure that any links within the Din plug necessary for the mode for which the pump is set are made.



Part 3: RE-CALIBRATION

1 Terminology

Signal range is the change in signal level necessary to produce the required change in pumphead speed. Normally zero to maximum rated speed.

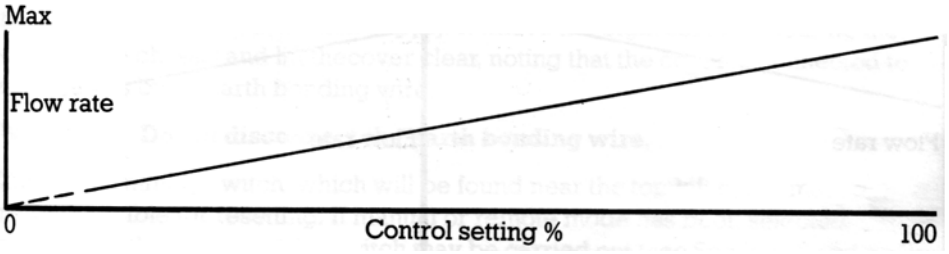
Signal offset is the signal level at which the control signal is just about to take effect. Normally the point at which the pumphead is just about to rotate.

A **non-inverted response** is obtained when the pump is set to produce an increase in pumphead speed (and flow rate) when the signal level increases.

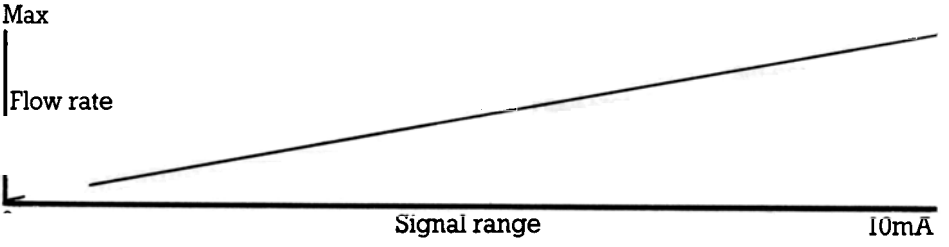
An **inverted response** is obtained when the pump is set to provide an increase in pumphead speed (and flow rate) when the signal level decreases.

2 Control capabilities

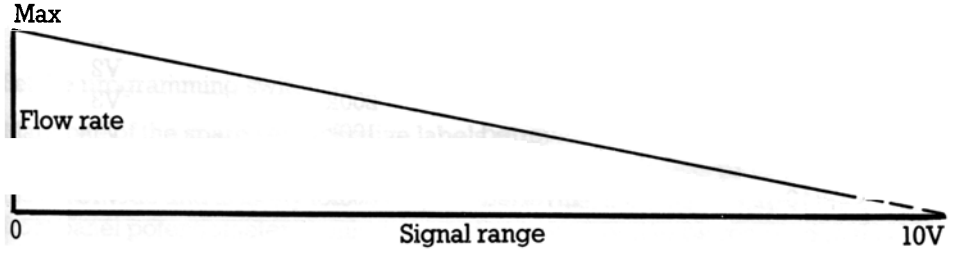
The 603U/R can be controlled manually, either from the front panel mounted potentiometer or by a remotely located potentiometer. The 603U/R has a control range of 5 to 99 percent, and the relationship between control setting and flow rates can be represented as shown below. Note that accurate control is not normally achieved below five percent of maximum flow.



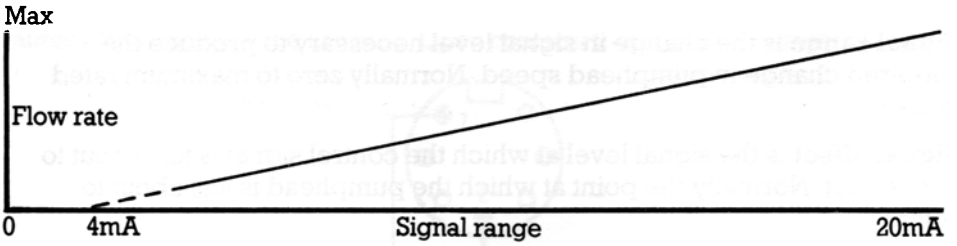
The flow rate of the 603U/R can also be controlled by any of the process control signals in common use, for instance 0-10mA as shown here.



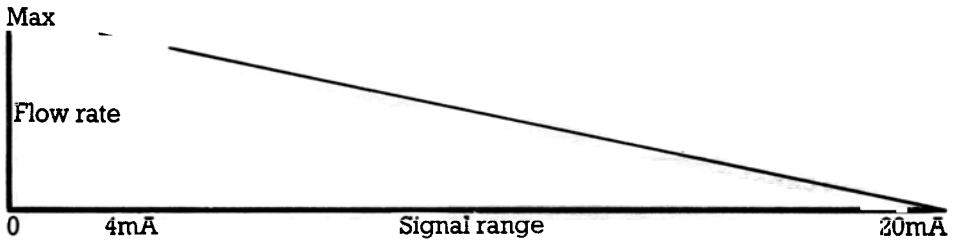
The 603U/R can also provide flow rates which are inversely proportional to the control signal as shown below, in which the input signal varies from 0V, where flow is to be at its highest to 10V, where flow is to be at its lowest.



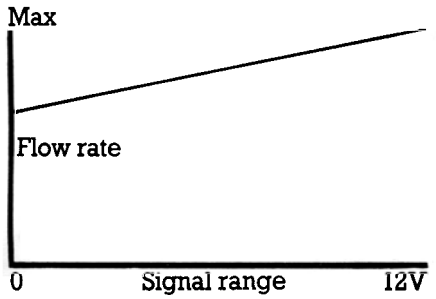
Similarly, control through a 4-20mA signal would be as shown below. Here the pump will not respond to the signal until the offset current of 4mA is exceeded. The signal range in this case is 16mA.

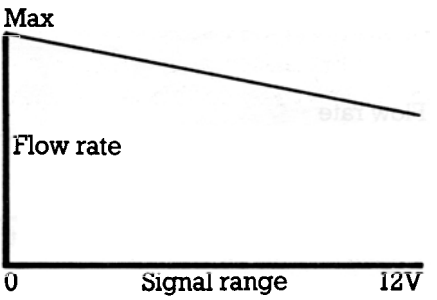


Again, the pump can be set to respond to a current signal with a signal offset and in the next illustration the signal ranges from 4mA, where flow is to be at its highest, to 20mA where flow is at its lowest.



Finally, the 603U/R can provide unusual reponses to signals as in the following examples in which the signal varies the speed of the pump over a limited speed range without bringing it to a standstill. Such responses require an unusual calibration procedure given in 8 Unusual responses.



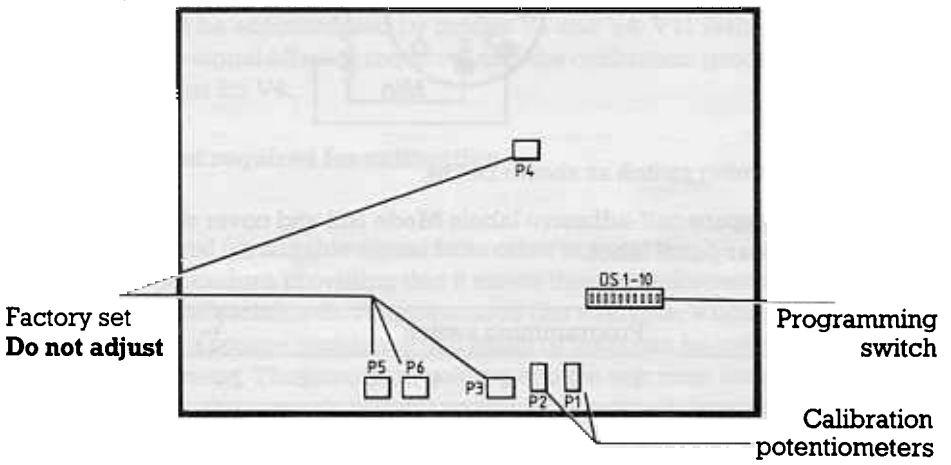


The examples shown above make reference to some control signals (0-10V, 0-12V, 0-10mA and 4-20mA) all of which are in general use. For those users not already committed to a specific control signal, the following table listing signals in common use may be helpful. The relevant technical data for each signal (to which reference is made later) has been added to aid programming.

	Signal	Sense	Input resistance	Mode
Current		Non-inverted	0.75k	C4
Signals		Non-inverted	1.2k	C5
		Non-inverted	0.75k	C13
		Inverted	0.75k	C22
		Inverted	1.2k	C23
		Inverted	1.2k	C23
Voltage	0-5V	Non-inverted	100k	V2
Signals	0-10V	Non-inverted	100k	V2
	0-12V	Non-inverted	200k	V3
	0-5V	Inverted	100k	V14
	0-10V	Inverted	100k	V14
	0-12V	Inverted	200k	V15

3 Mode selection

The required mode is selected by making the appropriate links and/or connections at the rear panel Din socket, and setting the programming switch, which is mounted internally on the printed circuit board. If an auto-control mode is selected, the pump must be calibrated by adjusting two pcb mounted potentiometers, P1 and P2, and, in most cases, adjusting the digital front panel potentiometer.



4 Access to programming switch and potentiometers

WARNING There are dangerous voltages (at mains potential) inside the pump when it is connected to a mains supply.

Isolate the pump from the mains supply. Remove the eight screws securing the cover to the chassis and lift thecover clear, noting that the cover is connected to the chasssis by an earth bonding wire.

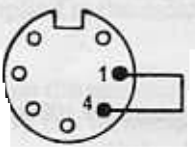
WARNING Do not disconnect the earth bonding wire.

The programming switch, which will be found near the top left of the main pcb, is now accessible for resetting. If manual or remote mode has been selected, resetting of the programmingswitch may be carried out (see Sections 5 and 6) and the cover replaced. If auto-control mode has been selected, re-connect the pump to the mains supply before commencing the calibration procedure which is detailed in 7 Recalibrating for auto speed control.

CAUTION Potentiometers P3, P4, P5, and P6 are factory set and must not be tampered with if the specified performance under manual, remote and auto signals is to be maintained, and the warranty is not to be invalidated.

5 Recalibrating for manual speed control

Insert the Din plug linked for manual control into the rear panel socket. If the linked plug supplied is mislaid, link a 7-pin Din plug as shown below.



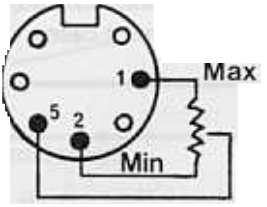
Set the programming switch as shown below.

Mark one of the spare self-adhesive labels supplied **Mode M1** and attach it to the rear panel in place of the now incorrect label. If the pump was previously set in the auto mode and is likely to be re-set in that mode, then the setting of the digital front panel potentiometer should be noted as it will need to be returned to this setting. The pcb mounted potentiometers are unaffected.

	Programming switch									
Switch position	1	2	3	4	5	6	7	8	9	10
These switches on			3	4			7	8		10

6 Recalibrating for remote speed control

A pump can be set to this mode without interfering in any way with any auto mode calibration which might exist. Wire a suitable potentiometer to the Din plug as shown below.



Set the programming switch as shown below.

Mark one of the spare self-adhesive labels **Mode M2** and cover or replace the now incorrect rear panel label.

	Programming switch									
Switch position	1	2	3	4	5	6	7	8	9	10
These switches on	1	2					7	8		

7 Recalibrating for auto speed control

7.1 Mode determination

With a given input signal response requirement for the pump, the first task is to determine which auto mode will be most suitable. First, the input signal description must be re-stated in a way which provides the information necessary for mode selection and, later,calibration of the pump.

Example 1. Signal 4-20mA. Input resistance 0.75 kohm. Flow rate required to rise as signal rises.

Sense: **Non-inverted**

Signal range: **16mA**

Input resistance: **0.75 kohm**

Signal offset: **4mA**

Maximum speed signal: **20mA**

Turning to the selection chart for current modes (section 7.8), this signal can be met by mode C13 or mode C17. The difference between these modes is that in C13 an internal potentiometer is used for the signal offset calibration, and in C17 the front panel potentiometer is used for that calibration. The choice of C13 or C17 will depend on whether you prefer signal offset calibration to be accessible or inaccessible.

Example 2. Signal 0-10V. Input resistance 100 kohm. Flow rate required to fall as signal rises

Sense: **Inverted**

Signal range: **10V**

Input resistance: **100 kohm**

Signal offset: **10V**

Maximum speed signal: **0V**

Signal offset is defined as the point at which the pump is just about to start rotating. In this case, as the signal falls to 10V, rotation will commence and the offset is thus 10V. The signal is best met by mode V14 (see selection chart for voltage modes, section 7.6), though V17 could be used. V14 is probably best since the front panel potentiometer is disabled and the calibration cannot be disturbed by adjustment of this control.

Example 3. Signal 0-5V. Input resistance 100 kohm. Flow rate required to rise as signal rises.

Sense: **Non-inverted**
Signal range: **5V**
Input resistance: **100 kohm**
Signal offset: **0V**
Maximum speed signal: **5V**

This signal can be accomodated by modes V1 and V4. V11 is the recommended mode since no signal offset is required, and the calibration procedure will be simpler than that for V4.

7.2 Equipment required for calibration

Signal source

A process signal (or suitable signal from other source) can be used in the calibration procedure providing that it meets these requirements: For voltage modes, a stable, variable dc voltage source (for example, a laboratory power supply having a source resistance of 5 kohm or less) can be used in conjunction with a dc voltmeter. The maximum voltage into the unit must not exceed 60V. For current modes, the same dc voltage source may be used, (providing it will supply the current required) in conjunction with a dc milliamp meter. The maximum current permitted when the front panel potentiometer is in circuit is 20mA. When the front panel potentiometer is out of circuit, the maximum permissible current is 32mA. In all cases, the signal output must be connected to the Din socket in accordance with the selection chart.

Determination of rotational speeds

It is possible to use the factory calibrated signal overload light emitting diode to maximum rpm. This is done by turning the signal range potentiometer in an anti-clockwise direction until the light emitting diode illuminates. Slowly turn P2 back until the light (just) goes off, then continue for a further half turn.

Where a more accurate determination of maximum speed is required or where it is required to assess intermediate speeds, it is possible either to use a stopwatch and count the actual revolutions, or to use a revolution counter. This can be any type capable of giving the required accuracy at speeds of 170rpm or less.

7.3 Technical information concerning calibration

The internal 12V reference has a tolerance of plus or minus five percent and the figures given in the selection chart for offset are nominal. For current modes, the on-board measuring resistors R15 and R16 have a tolerance of plus or minus two percent and the signal range figures given in the selection chart are nominal. The front panel potentiometer has a tolerance of plus or minus five percent and the current values given in the selection chart are nominal.

If the input signal reaches excessive levels, the signal overload light emitting diode on the front panel will illuminate. The motor will continue to run but excessive voltage will not be applied to the motor because of the use of a limiting transformer.

The input resistance referred to on the selection charts determines the loading effect that the pump input circuitry has on the signal source. Ensure that the signal source is capable of operating correctly under this loading, which is listed for each mode in the selection charts.

7.4 Before calibration

Allow the unit to attain normal working temperature. If possible, allow it to run for one hour. If a suitable control signal is not available, set the pump to operate in the manual mode (see section 5). Set the programming switch for the required mode as specified in the selection chart. Connect signal source to the Din socket as indicated in the selection chart. Ensure that potentiometers P1 and P2 are set to approximately mid-position. Insert a length of tubing into the pumphead. Proceed to instructions relating to the selected mode out in sections 7.5 and 7.7, and note the change of control mode of the pump on the rear panel using one of the selfadhesive labels supplied.

7.5 Calibration procedure for voltage signals

V1, V2 and V3 (front panel potentiometer disabled)

1 Set source to the maximum speed signal.

2 Adjust P2 for maximum speed.

V4, V5 and V6 (front panel potentiometer disabled)

1 Set source to maximum offset and adjust P1 for zero speed.

2 Set source to maximum speed signal and adjust P2 for maximum speed.

3 Repeat 1 and 2 until interaction between adjustments is eliminated.

V7, V8 and V9 (offset adjustment from front panel potentiometer)

1 Set source to the signal offset and adjust the front panel potentiometer for zero speed.

2 Set source to maximum speed signal and adjust P2 for maximum speed.

3 Repeat 1 and 2 until interaction between adjustments is eliminated.

V10, V11 and V12 (front panel potentiometer extends offset range adjustment)

1 Set source to the signal offset
and when offset is required to be 12V or less, set potentiometer to 00 and adjust P1 for zero speed.

or when offset is required to be between 12V and 36V, turn P1 fully anti-clockwise and then adjust the front panel potentiometer for zero speed.

2 Set source to maximum speed signal and adjust P2 for maximum speed.

3 Repeat 1 and 2 until interaction between adjustments is eliminated.

V13, V14 and V15 (front panel potentiometer disabled)

1 Set source to the signal offset and adjust P1 for zero speed.

2 Set source to maximum speed signal and adjust P2 for maximum speed.

3 Repeat 1 and 2 until interaction between adjustments is eliminated.

V16, V17 and V18 (front panel potentiometer extends offset range adjustment)

1 Set source to the signal offset and when offset is required to be 12V or less, adjust the front panel potentiometer to 00 and set P1 for zero speed.

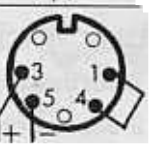
or when offset is required to be between 12V and 36V, set the front panel potentiometer to 99 and adjust P1 for zero speed.

2 Set the source to maximum speed signal and adjust P2 for maximum speed.

3 Repeat 1 and 2 until interaction between adjustments is eliminated.

7.6 Selection chart for voltage modes

Sense	Mode	Input signal range min	Input signal range max	Input signal offset min	Input signal offset max	Input resistance kohm	Programming switch These switches on 1	2	3	4	5	6	7	8	9	10	Din connections Rear view of plug
			6	**0**	**0**	**100**	**1**	**2**							**9**		
			12	**0**	**0**	**100**	**1**	**2**							**9**	**10**	
n	V3	6	24	0	0	200		2							9	10	
	V4	1.5	6	0	12	100	1				5				9		
i	V5	3	12	0	12	100	1				5				9	10	
n	**V6**	**6**	**24**	**0**	**24**	**200**					**5**				**9**	**10**	
v	**V7**	**1.5**	**6**	**0**	**12**	**100**	**1**	**2**				**6**					
e	**V8**	**3**	**12**	**0**	**12**	**100**	**1**	**2**				**6**			**9**	**10**	
r	**V9**	**6**	**24**	**0**	**12**	**200**		**2**				**6**			**9**	**10**	
t	V10	1.5	6	0	24	100	1										
e	V11	3	12	0	24	100	1				5	6			9	10	
d	V12	6	24	0	36	200					5	6			9	10	
I	V13	1.5	6	1.5	12	100	1				5				9		
n	V14	3	12	3	12	100	1				5				9	10	
v	V15	6	24	6	24	200					5				9	10	
e	V16	1.5	6	1.5	24	100	1				5		7		9		
r	V17	3	12	3	24	100	1				5		7		9	10	
t	V18	6	24	6	36	200					5		7		9	10	
e																	
d																	



7.7 Calibration procedure for current signals

C1, C2, C3, C4 and C5

1 Set the front panel potentiometer to 00.

3 Adjust P2 for maximum speed.

C6, C7, C8, C9 and C10 (front panel potentiometer extends signal range adjustment)

1 Set source to maximum speed signal.

2 Set the front panel potentiometer to 00, and then adjust P2 for maximum speed. If required speed cannot be obtained, leave P2 in maximum setting and then adjust the front panel potentiometer.

These modes are similar to C1, C2, C3, C4 and C5, but a wider choice of signal range is achieved by utilising the front panel potentiometer to provide the necessary increase in input resistance.

C11, C12 and C13

1 Set the front panel potentiometer to 00.

2 Set source to the signal offset and adjust P1 for zero speed.

3 Set source to the maximum speed signal and adjust P2 for maximum speed.

4 Repeat 2 and 3 until interaction between adjustments is eliminated.

C14, C15, C16, C17 and C18 (offset adjustment from front panel potentiometer)

1 Set source to the signal offset and adjust the front panel potentiometer for zero speed.

2 Set source to the maximum speed signal and adjust P2 for maximum speed.

3 Repeat 1 and 2 until interaction between adjustments is eliminated.

C19, C20, C21, C22 and C23

1 Set the front panel potentiometer to 00.

2 Set source to the signal offset and adjust P1 for zero speed.

3 Set source to the maximum speed signal and adjust P2 for maximum speed.

4 Repeat 2 and 3 until interaction between adjustments is eliminated.

NOTE The combination of the signal range and the offset must not be less than zero (eg 2.7 offset with 10 signal range equals minus 7.3. This is not acceptable).

C24, C25, C26, C27 and C28 (offset adjustment from front panel potentiometer)

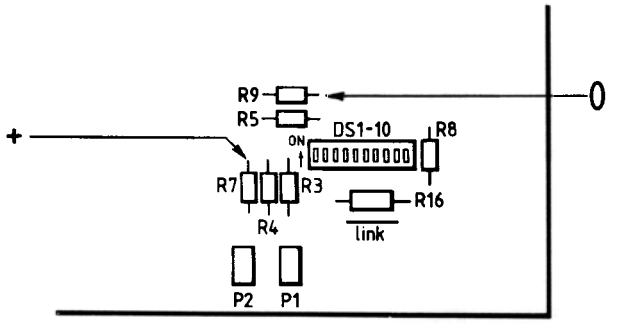
1 For modes C24 and C25 adjust P1 to a voltage of + 5.7V. For modes C26, C27 and C28 adjust P1 to a voltage of + 11.5V. (See illustration below for measuring points).

2 Set source to the signal offset and adjust front panel potentiometer for zero speed.

3 Set source to maximum speed signal and adjust P2 for maximum speed.

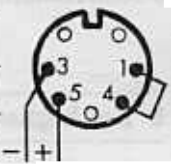
4 Repeat 2 and 3 until interaction between adjustments is eliminated.

NOTE Slight readjustment of P1 may be necessary to achieve zero speed.



7.8 Selection chart for current modes

Sense	Mode	Input signal range min	Input signal range max	Input signal offset min	Input signal offset max	Input resistance kohm	Programming switch These switches on 1	2	3	4	5	6	7	8	9	10	Din connections Rear view of plug
	C1	**1.4**	**5**	**0**	**0**	**1.2**	**1**	**2**	**3**						**9**		
	C2	**2.2**	**8**	**0**	**0**	**0.75**	**1**	**2**		**4**					**9**		
			10	**0**	**0**	**1.2**	**1**	**2**	**3**						**9**	**10**	
N	C4	4.4			0	0.75	1	2		4							
o	C5	5.2	20	0	0	1.2		2	3						9	10	
n	C6	0.3	5	0	0	6.2-1.2	1	2	3						9		
-	C7	0.3	8	0	0	5.75-0.75	1	2		4							
n	C8	0.5	10	0	0	6.2-1.2	1	2	3						9	10	
v	C9	0.5	16	0		5.75-0.75	1	2		4					9	10	
e																	
	C10	**1.0**	**20**	**0**	**0**	**6.2-1.2**		**2**	**3**						**9**	**10**	
	C11	**1.4**	**5**	**0**	**10**	**1.2**	**1**		**3**		**5**				**9**		
e	C12	2.7	10	0	10	1.2	1		3		5				9	10	
d	C13	4.4	16	0	16	0.75	1			4	5				9	10	
	C14	1.4	5	0	10	1.2	1	2	3			6			9		
	C15	2.2	8	0	16	0.75	1	2		4		6			9		
	C16	2.7	10	0	10	1.2	1	2	3			6			9	10	
	C17	4.4	16	0	16	0.75	1	2		4		6			9	10	
				0	10	1.2		2	3						9	10	
	C19	**1.4**	**5**	**1.4**	**5**	**1.2**	**1**		**3**		**5**				**9**		
I	**C20**	**2.2**	**8**	**2.2**	**8**	**0.75**	**1**			**4**	**5**				**9**		
n	**C21**	**2.7**	**10**	**2.7**	**10**	**1.2**	**1**		**3**		**5**				**9**	**10**	
v	**C22**	**4.4**	**16**	**4.4**	**16**	**0.75**	**1**			**4**	**5**						
e	C23	5.2	20	5.2	20	1.2			3		5				9	10	
r	C34	1.4	5	5	15	1.2	1		3		5		7		9		
t	**C25**	**2.2**	**8**	**8**	**24**	**0.75**	**1**			**4**	**5**		**7**		**9**		
e	**C26**	**2.7**	**10**	**10**	**20**	**1.2**	**1**		**3**		**5**		**7**		**9**	**10**	
d	**C27**	**4.4**	**16**	**16**	**32**	**0.75**	**1**			**4**	**5**		**7**		**9**	**10**	
	C28	5.2		20	30	1.2			3		5				9	10	



8 Unusual responses

The final two graphs in Part 2 illustrate the use of speed offset where the pump is set to run at some minimum speed regardless of signal level. Full range deflection of the signal will then vary the speed of the pump over the remainder of the speed range. This is perhaps best illustrated by the following example:

Signal 0-10mA. Input resistance 0.75 kohm. Flow rate to rise with signal but output to vary over only fifty to one hundred percent.

Sense: **Non-inverted**
Signal range: **10mA**
Input resistance: **0.75 kohm**
Signal offset: **0mA**
Maximum speed signal: **10mA**

Modes C13 and C17 are suitable because they cater for 0-10mA and 0.75 kohm input resistance and have offset adjustment. Modes C4 and C9 are unsuitable because although they will handle the signals they do not have an offset adjustment. Potentiometer P1 can be used to give, in this case, speed offset instead of signal offset. The choice between C13 and C17 depends upon whether external adjustment (through the front panel potentiometer) of the calibration control is required.

To calibrate the pump, follow the access instructions given in section 4, set the programming switch and connect the signal to the unwired Din plug as shown in the selection chart for mode C13, set the front panel potentiometer to 00, set the source to 0mA and adjust P1 for the required minimum speed (50 percent of maximum in this example). Set the source to 10mA and adjust P2 for the required maximum speed. The pump will now operate as required in response to the 0-10mA control signal.

9 For highest accuracy of operation

It is always best for a pumphead and tubing to be fitted prior to calibration, but it is not normally necessary for the tubing to contain fluid during calibration. Where large bore tubing and significant delivery pressures are being used, doing so will help increase accuracy.

It is generally assumed in this manual that signal offset coincides with zero speed (and hence zero flow rate). In practice, the control range of the pump is finite, and no accurate control is available between 0 and five percent speed. It may therefore be beneficial to set signal offset to give five percent speed. Thus,in the second example in Part 3, section 2, where a 0 to 10mA is used, adjust the unit so that 0.5mA corresponds to five percent of maximum speed. This may result in the pump stopping before zero or continuing to rotate very slowly at zero.

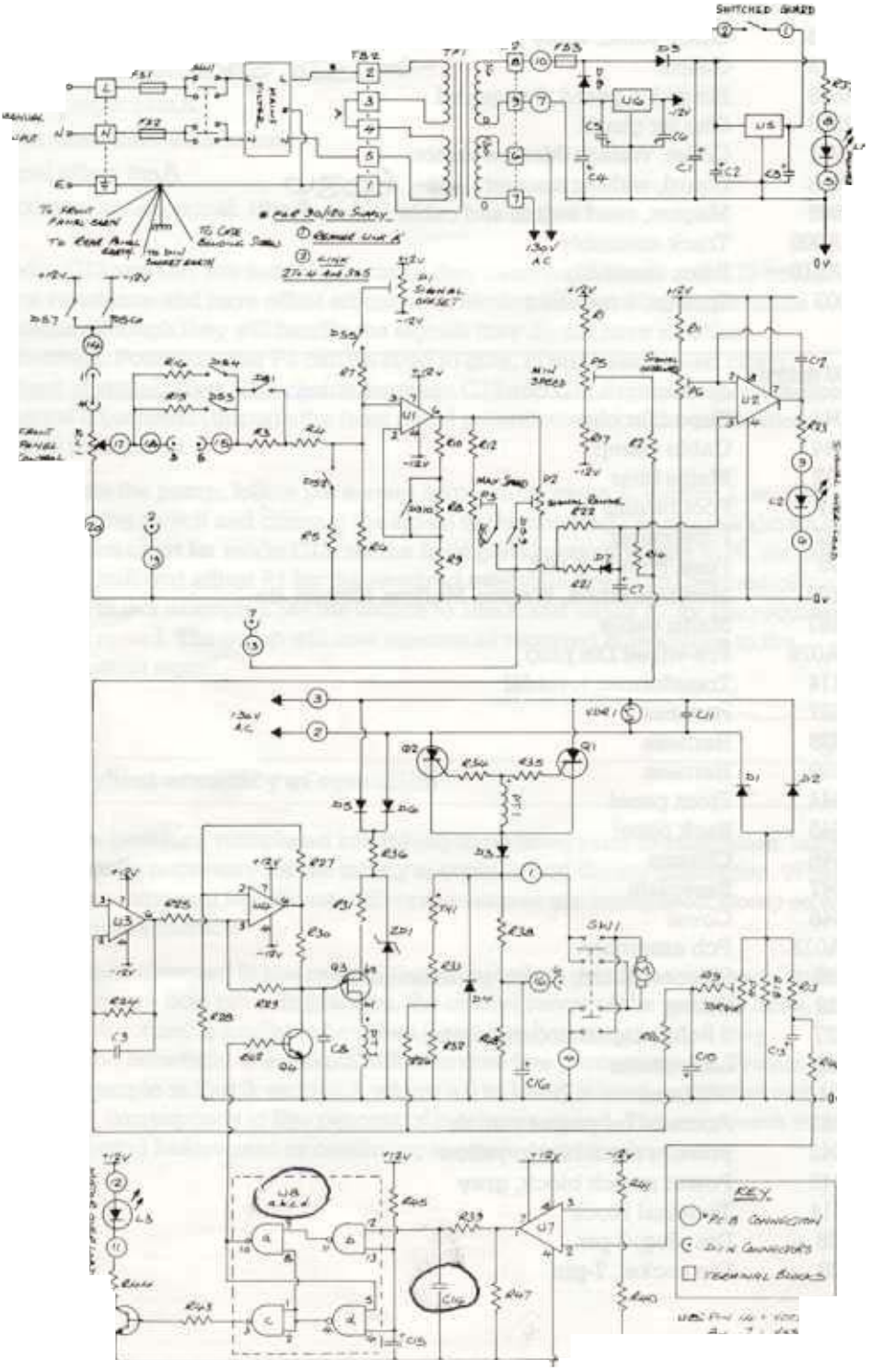
10 Spares

603R pumphead

MR571	Main tube roller, 2 required
MR572	Follower roller, 2 required
MR573	Spindle, main tube roller
MR574	Spindle, guide roller
MR575	Guide roller, white plastic
MR578	Guard → 6013/R VAC
MR579	Hinge for guard, 2 required
MR586	Clip for guard
MR601	Collet, Watson-Marlow motor
MR603	Guard, without magnet ← 603U
MR605	Magnet, reed switch and cable
MRA009	Track assembly
MRA010	Rotor assembly
SG003	Springs, 4 required

603U drive

CX041	Capacitor clip
CX044	Cable clamp
FA002	Mains filter
FB001	Foot rubber
FH007	Fuseholder
FS006	Fuse, type T, 3.15A
MG123	Motor/gearbox, Watson-Marlow, 165rpm, dc
MN197	Mains cable
MNA076	Pre-wired Din plug
MR614	Transformer, toroidal
MR627	Harness
MR628	Harness
MR629	Harness
MR644	Front panel
MR645	Back panel
MR646	Chassis
MR647	Baseplate
MR648	Cover
MRA013	Pcb assembly
OS005	Silicone guard, digital potentiometer
OS012	O ring
RV027	5 kohm digital potentiometer
SD002	LED, green
SD031	LED, red
SW041	Actuator for power switch
SW042	Power switch block, yellow
SW043	Power switch block, grey
TM014	Terminal block
UP008	Din plug, 7-pin
US008	Din socket, 7-pin


SWITCHED BOARD
KEY