WATSON-MARLOW

501U

Auto-control drive module

Installation, calibration and operating instructions

INTRODUCTION

Thank you for purchasing this 501U Drive Module. It is a highly versatile unit which can be fitted with a wide range of pumpheads and operated under manual, remote or automatic control to meet your present and future requirements.

The 501U incorporates two major advances.

1 The module can be programmed at any time to respond to a wide range of both voltage and current control signals, and incorporates full mains isolation allowing earthed or un-earthed signals to be accepted.

2 Automatic protection is incorporated so that if the input signal reaches a level which would cause the motor to exceed its maximum speed, the module is shut down until the signal reaches a safe level. A front panel mounted LED indicates this signal overload condition.

The 501U and its companion models - the 202U and the 602U are probably the most sophisticated peristaltic pumps for auto-control use available today. Their in-built signal calibration facilities are unique, as too is the ease with which they may be re-calibrated to respond to different signals.

USING THIS MANUAL

This manual is divided into three parts.

PART 1 should be read by all users and contains essential ion 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 either 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.

CONTENTS

1: CHECK LIST

Please check that you have received the following items:

1 501U Drive Module. A label on the rear panel indicates the control mode in which the Drive Module has been set. If not specified on your order, the 501U will be set to Manual Mode M1.

DIN plug unwired

1 DIN plug, linked for use in Manual Mode

1 Pack of spare self-adhesive labels 'Set to Mode....'

... together with pumphead(s) and any accessories specified in your order.

Section 2: INSTALLATION

Ensure that the supply voltage and frequency corresponds with that marked on the nameplate at the rear of the unit.

The mains supply cable is colour coded in accordance with the following code:

Brown	Live
Blue	Neutra
Green/Yellow	Earth

The 501U can be operated at ambient air temperatures from -10°C to 35°C. Storage temperatures from -40°C to 70°C are permissible, but allow time for acclimatisation before operating. An operating unit should be positioned to enable a free passage of air around it. When 501 Modules are stacked the normal foot mountings will provide the necessary ventilation between units.

It is recommended that, in accordance with normal practice, signal leads be kept as short as possible: in some cases screening may be required

WARNING Dangerous voltages (at mains potential) exist inside the Drive Module. As calibration requires cover to be removed, seek qualified advice regarding electrical hazards.

Should the pump fail to operate, check the following:

That mains electricity is available at the unit.

That all fuses are intact.

That the LED is not indicating an excess signal condition.

That the pump is not stalled by incorrect fitting of tubing.

That the pumphead module is properly located and securely attached to the drive module.

That the correct DIN plug is in position - see PART 2.

CAUTION A label on the rear panel indicates for which mode of operation your 501U 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.

Section 3: SPECIFICATIONS

Nominal Maximum Rotor Speeds ..	10,50,100,170 rpm
Speed Control Ratio	20:1
Operating Voltage/Frequency ...	200-250V,50-60Hz or 90-130V,50-60Hz
Maximum Power Consumption	150VA
Normal Power Consumption	75VA
Operating Temperature ...	-10°C to 35°C
Storage Temperature	-40°C to 70°C
Relevant Standards	CEE10, IP42
Audible Noise	60dBA maximum
Dimensions	140 x 200 x 325mm
Weight	6kg

Section 4: CARE AND MAINTENANCE

Scheduled maintenance of the 501U Drive Module is not required.

From time to time the unit may need cleaning. It is recommended that a cloth dampened with a solution of water and mild detergent is used for this purpose. On no account should strong solvents be used.

Section 5: PUMPHEAD MODULES AND FLOW RATES

The table indicates typical flow rates obtained from pumpheads fitted with silicone tubing (except AA where Vinyl tubing was used) when pumping water at room temperature with negligible suction and delivery pressures. Minimum flow rates will be 5% of the figures given.

The actual flow rate for a particular application should be determined under operating conditions where the important factors are suction and delivery pressures, temperature, fluid viscosity and the tubing material.

For operating details of particular pumpheads see relevant Instruction Sheets.

PERMISSIBLE COMBINATIONS OF DRIVE MODULES AND PUMPHEADS

		PUMPHEAD Maximum channels advised				
Module	rpm	501R*	301DS1/A*	502AA	501M	501D
501U	10	1 or 2	8	2 x 16	3 x 10	5 x 10
	50	1 or 2	8	3 x 16	4 x 10	5 x 10
	100	1 or 2	5	2 x 10	2 x 10	
	170	1 or 2	3	2 x 10	1 x 10	

* Two channel use restricted to tubes of 4.8 mm bore or smaller

501R FLOW RATES (ml/min)

Drive		Tubing internal diameter (mm)						
Module	rpm	0.5	0.8	1.6	3.2	4.8	6.4	8.0
501U	10	0.4	1.3	4.2	19	39	64	96
	50	2.1	6.1	22	92	200	315	520
	100	4.2	12.4	43	186	405	635	1080
	170	7.1	21	73	320	700	1080	1820

301DS1/A FLOW RATES (ml/min)

Drive		Tubing internal diameter (mm)				
Module	rpm	1.6	3.2	4.8	6.4	8.0
501U	10	3	9	20	30	40
	50	14	45	95	140	200
	100	25	85	190	300	400
	170	42	145	320	510	680

MAXIMUM NUMBER OF 301 PUMPHEADS

The number of pumpheads which can be used is determined by the speed of the Drive Module and the type of tubing material used.The maximum number for two common tubing materials are given in the table below.

		Tubing internal diameter (mm)									
DRIVE		SILICONE					PVC/TYGON				
Module	rpm	1.6	3.2	4.8	6.4	8.0	1.6	3.2	4.8	6.4	8.0
501U	10	8	6	5	4	2	3	3	3	2	0
	50	8	6	5	4	2	3	3	3	2	0
	100	5	4	4	2	1	2	2	1	0	0
	170	3	2	2	1	0	1	1	1	0	0

501M FLOW RATES (ml/min)

Drive		Tubing internal diameter (mm)						Max.
Module	rpm	1.0	1.5	2.0	2.5	3.0	4.0	Channels
501U	10	0.5	1.2	1.9	3.1	4.8	7.8	40
	50	2.6	5.8	9.6	15	24	39	40
	100	5.2	12	19	31	48	79	20
	170	8.8	20	32	52	82	134	10

501D FLOW RATES (ml/min)

Drive		Tubing internal diameter (mm)						Max.
Module	rpm	1.0	1.5	2.0	2.5	3.0	4.0	Channels
501U	10	0.3	0.6	0.9	1.2	2.0	2.8	50
	50	1.4	2.9	4.5	6.2	10	14	50

502AA FLOW RATES (ml/min)

Drive Module	rpm	Tubing internal diameter (mm) 0.127	0.190	0.250	0.380	0.520	0.630	0.700	Max. Channels
501U	10	0.005	0.012	0.028	0.048	0.08	0.11	0.15	32
	50	0.024	0.062	0.14	0.24	0.39	0.57	0.77	32
	100	0.048	0.12	0.28	0.48	0.77	1.14	1.54	32
	170	0.082	0.21	0.48	0.82	1.33	1.94	2.62	20

Drive Module	rpm	Tubing internal diameter (mm) 0.880	1.020	1.140	1.290	1.420	1.470	1.520	Max. Channels
501U	10	0.22	0.29	0.37	0.45	0.58	0.63	0.68	32
	50	1.09	1.44	1.85	2.25	2.89	3.16	3.42	32
	100	2.18	2.88	3.70	4.50	5.78	6.32	6.84	32
	170	3.71	4.90	6.29	7.65	9.83	10.7	11.6	20

Drive Module	rpm	Tubing internal diameter (mm) 1.650	1.850	2.050	2.280	2.540	2.790	Max. Channels
501U	10	0.75	0.98	1.17	1.42	1.82	2.04	32
	50	3.76	4.88	5.87	7.12	9.12	10.2	32
	100	7.52	9.76	11.7	14.2	18.2	20.4	32
	170	12.8	16.6	20.0	24.2	31.0	34.7	20

Section 6 : TUBING RANGE

1.6mm Bore Tubing

Bore mm	Material: Viton	Neoprene	Butyl	Silicone	PVC	Tygon
0.5				TU090		
0.8		TU020		TU091		
1.6	TU050	TU021	TU070	TU092	TU145	TU160
3.2	TU051	TU022	TU071	TU093	TU153	TU161
4.8	TU053	TU023	TU072	TU094	TU149	TU162
6.4	TU052	TU024	TU073	TU095	TU115	TU163
8.0	TU054	TU025	TU074	TU096		TU164

Thin Wall tubing for 501D, 501M, and Delta B

Bore mm	Stock Code	Bore mm	Stock Code	Bore mm	Stock Code
1.0	TU 100	2.0	TU 102	3.0	TU 104
1.5	TU 101	2.5	TU 103	4.0	TU 105

Accessories	Stock Code
Description	
Nipple Type P - pack of 10 for 1.0, 1.5 and 2.0 mm tubing	DE 229
Nipple Type T - pack of 10 for 2.5, 3.0 and 4.0 mm tubing	DE 209
Tube of Silicone grease	MS 4

Transmission tubing			Sleeving		
Bore mm	Wall mm	Stock Code	Bore mm	Wall mm	Stock Code
1.6	0.8	TE 020	3.2	0.8	TE 02

MANIFOLD PUMP TUBING FOR 502AA AND 501D

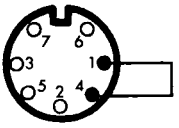
Colour Code	Bore mm	Vinyl	Silicone	Solvent Resistant	Acid Resistant
Orange/Black	0.127	TE018		TR018	
Orange/Red	0.19	TE019		TR019	
Orange/Blue	0.25	TE001		TR001	
Orange/Green	0.38	TE002		TR002	
Orange/Yellow	0.50	TE003		TR003	TV003
Orange/White	0.63	TE004	TS004	TR004	TV004
Black/Black	0.76	TE005	TS005	TR005	TV005
Orange/Orange	0.88	TE006	TS006	TR006	TV006
White/White	1.02	TE007	TS007	TR007	TV007
Red/Red	1.14	TE008	TS008	TR008	TV008
Grey/Grey	1.29	TE009	TS009	TR009	TV009
Yellow/Yellow	1.42	TE010	TS010	TR010	TV010
Translucent	1.47		TS020		
Yellow/Blue	1.52	TE011	TS011	TR011	TV011
Blue/Blue	1.65	TE012	TS012	TR012	TV012
Green/Green	1.85	TE013	TS013	TR013	TV013
Purple/Purple	2.05	TE014	TS014	TR014	TV014
Purple/Black	2.28	TE015	TS015	TR015	TV015
Purple/Orange	2.54	TE016	TS016	TR016	TV016
Purple/White	2.79	TE017	TS017	TR017	TV017

Section 1: MANUAL CONTROL

If the 501U is to be operated in the Manual Mode, first ensure that the rear panel label is printed 'MODE M1'.

The DIN plug wired for Manual Mode must be inserted in the rear panel DIN socket . The Drive Module will not operate if the wrong DIN plug is used. Should the pre-linked DIN plug be mislaid, then a 7 pin DIN plug should be linked as follows.

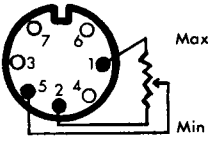
The Drive Module may now be operated and the front panel potentiometer will function as a speed (flow rate) control. The direction of rotation can be reversed from the rear panel toggle switch.



Section 2: REMOTE CONTROL

If the 501U is to be operated in the Remote Mode, 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:



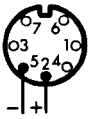
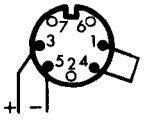
The Drive Module may now be operated remotely over its full speed range. The remote potentiometer should have a value of 4.7 to 10kohm. A suitable potentiometer is available from Watson-Marlow as Part No. RV004 and the appropriate digital dial as Part No. DS007.

A complete case mounted (80 x 80 x 85mm) ten-turn potentiometer with digital dial and 3 metre flexible cord terminated in a DIN plug is also available from Watson-Marlow as part No. 501U/P.

Section 3: AUTO-CONTROL

If the 501U 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 - eg 4-20mA.

The signal source should now be connected to the unwired DIN plug as shown below. Note that in some modes, pins 1 and 4 must be linked.

MODE	CONNECTION	MODE	CONNECTION
V1 C1 C8 V2 C2 C9 V3 C3 C10 V4 C4 C11 V5 C5 C12 V6 C6 C13 C7		V7 C14 V8 C15 V9 C16 V10 C17 V11 C18 V12	
V13 C19 V14 C30 V15 C21 C22 C23		V16 C24 V17 C25 V18 C26 C27 C28	

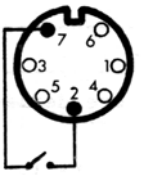
CAUTION Do not adjust the front panel potentiometer. In certain modes it will have been pre-set, calibrating the module to a specified input signal.

The maximum voltage in to the unit must not exceed 60V. The maximum current permitted when the front panel potentiometer is in circuit is 20mA. When the front panel potentiometer is out of circuit, the maximum permissible current is 32mA.

Section 4: REMOTE STOP

In any of the three speed control modes - Manual, Remote or Auto, the 501U may be stopped and started from a remote postion.

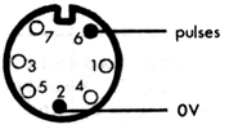
A suitable switch should be wired across pins 2 and 7 of the DIN plug. Open contacts to run, closed contacts to stop.



Section 5: TACHOMETER OUTPUT

Information from the motor tachometer, which may be used to monitor speed, is present across pins 6 and 2 of the DIN socket. Pin 6 is pulsed and Pin 2 is low. The output is in the form of 12V pulses and if this output is coupled to external instrumentation, then the resistance of the instrumentation must be 1Mohm and normally AC coupled. Failure to observe the input resistance requirement will result in loss of accurate speed control.

See Part 3, Section 7:2:2 for information on the relationship between pulse frequency and pumphead revolutions.



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PART 3 RE:C. LIBRATION
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Section 1: TERMINOLOGY

The terms used in this section are defined as follows:

Signal Range
The change in signal level necessary to produce the required change in pumphead speed - normally zero to maximum rated speed.

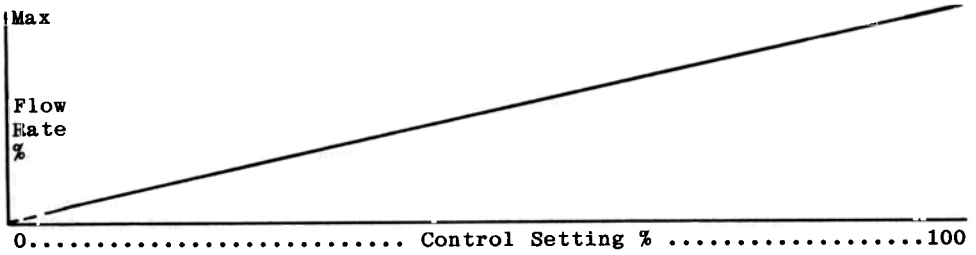
Signal Offset
The signal level at which the control signal is just about to take effect. Normally the point at which the pumphead is just about to rotate.

Non-Inverted Response
The pump is set to produce an increase in pumphead speed when the signal level increases.

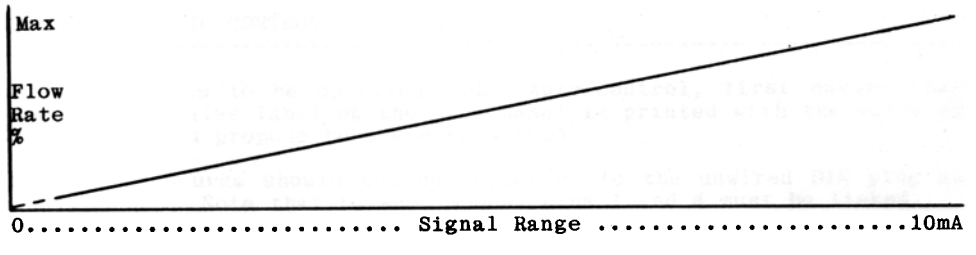
Inverted Response
The pump is set to provide an increase in speed when the signal level decreases.

Section 2: CONTROL CAPABILITIES

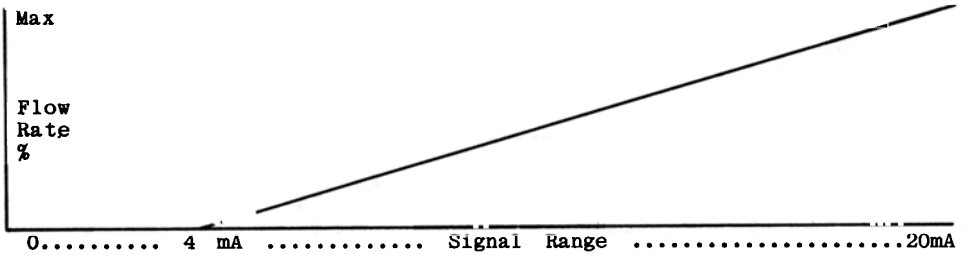
The 501U can be controlled manually, either from the front panel mounted potentiometer or by a remotely located potentiometer. The unit has a control ratio of 20:1, and the relationship between control settings and flow rates can be represented as shown below. Note that accurate control is not normally achieved below 5% of maximum flow.



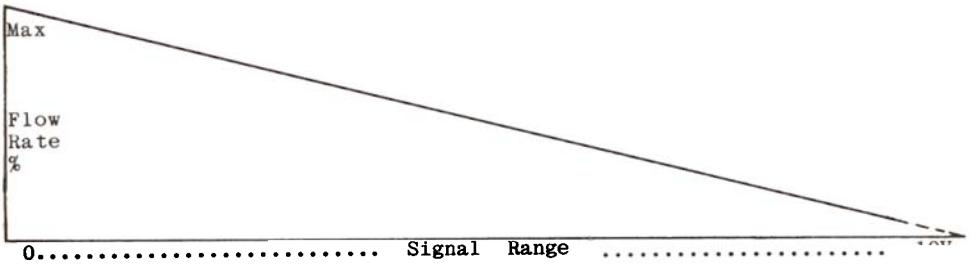
In addition, the 501U offers the facility of control of flow by virtually any of the process control signals in common use - for instance 0-10 mA as shown here:



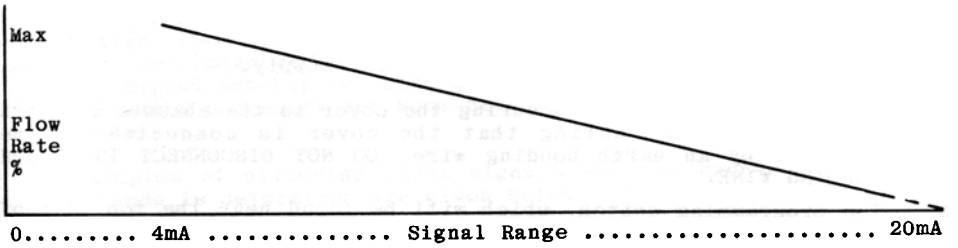
Similarly, control through a 4-20 mA signal would be as shown below. Here the pump will not respond to the signal until the OFFSET current of 4mA is exceeded. The SIGNAL RANGE in this case is 16 mA.



Furthermore the 501U will meet requirements in which the flow rate is to be inversely proportional to the control signal as shown below, in which the input signal varies from 0V, where flow is to be maximal, to 10V, where flow is to be minimal.

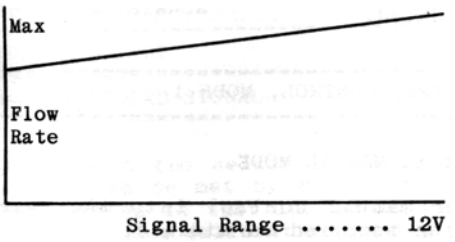


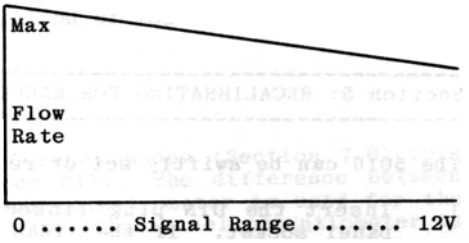
Again, the pump can be set to respond to a current signal with a SIGNAL OFFSET and in the next illustration the signal ranges from 4mA, where flow is to be at its highest, to 20mA where flow is at its lowest.



The above examples are a few of the numerous control options for which the unit can be programmed by following the instructions given in Part 3.

Additionally, the 501U has the ability to 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 which may require specialist attention. See Section 8.





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. All are readily accepted by a suitably programmed 501U, and the relevant technical data for each signal (to which reference is made later) has been added to facilitate programming.

	Signal	Sense	Input Resistance	Mode
Current Signals	0-10mA	Non-Inverted	0.75k	C4
	0-20mA	Non-Inverted	1.2k	C5
	4-20mA	Non-Inverted	0.75k	C13
	0-10mA	Inverted	0.75k	C22
	0-20mA	Inverted	1.2k	C23
	4-20mA	Inverted	1.2k	C23
Voltage Signals	0-5V	Non-Inverted	100k	V2
	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

Section 3: MODE SELECTION PROCEDURE

The required mode is determined by selecting the appropriate combination of:

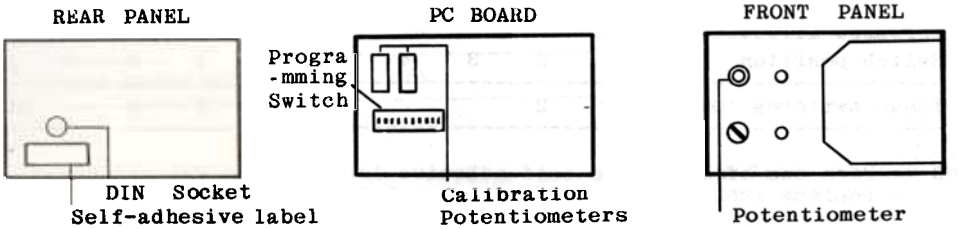
a Links and/or connections at the rear panel DIN socket, and

b Setting the PROGRAMMING SWITCH , which is mounted internally on the printed circuit board (pcb).

IF AUTO-CONTROL mode is selected, the unit must be calibrated by:

c Adjusting two pcb mounted POTENTIOMETERS, P1 AND P2, and in most cases...

Adjusting the front panel potentiometer.



Section 4: ACCESS TO PROGRAMMING SWITCH AND CALIBRATION PROCEDURE

WARNING Dangerous voltages (at mains potential) exist inside Drive Module case when it is connected to a mains supply.

1 Isolate the Drive Module from the mains supply.

2 Remove the four screws securing the cover to the chassis and lift the cover clear, noting that the cover is connected to the chasssis by an earth bonding wire. DO NOT DISCONNECT THE EARTH BONDING WIRE.

3 The programming switch, which will be found near the top left of the main pcb, is now accessible for resetting.

4 If MANUAL or REMOTE mode has been selected, resetting of the programming switch may be carried out (see Sections 5 and 6) and the cover replaced.

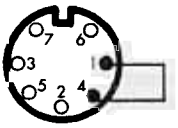
5 If an AUTO mode has been selected, re-connect the Drive Module to the mains supply before commencing calibration procedure which is detailed in Section 7.

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.

Section 5: RECALIBRATING FOR MANUAL SPEED CONTROL, MODE 1

The 501U can be swiftly set or re-set to MANUAL MODE.

1 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.



2 Set Programming Switch as shown below.

	PROGRAMMING SWITCH									
Switch position	1	2	3	4	5	6	7	8	9	10
These switches 'ON'	1	2	3	4			7	8		10

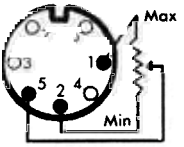
3 Mark one of the spare self-adhesive labels supplied 'Mode M1' and attach it to the rear panel in place of the now incorrect label.

If the module was previously set in the AUTO mode and is likely to be re-set in that mode, then the setting of the front panel potentiometer should be noted as it will need to be returned to this setting. The pcb mounted potentiometers are unaffected.

Section 6: RECALIBRATION FOR REMOTE SPEED CONTROL, M2

A pump can be set to this mode without interfering in any way with any AUTO mode calibration which might exist.

1 Wire a suitable potentiometer to the DIN plug as shown below.



2 Set the PROGRAMMING SWITCH as shown below.

	PROGRAMMING SWITCH									
Switch position	1	2	3	4	5	6	7	8	9	10
These switches 'ON'	1	2					7	8		10

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

NOTE Suitable potentiometers are available from Watson-Marlow - see Part 2, Section 2.

Section 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 Module.

Three examples of differing input signals and the manner in which a suitable Mode is determined are given below.

Example 1

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

SENSE	NON-INVERTED
SIGNAL RANGE	16mA
INPUT RESISTANCE	0.75kohm
SIGNAL OFFSET	4mA
MAXIMUM SPEED SIGNAL	20mA

Turning to the selection chart for Current Modes (Section 7.6),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 and C17 will depend on whether you prefer signal offset calibration to be accessible or inaccessible.

Example 2

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

SENSE	INVERTED
SIGNAL RANGE	10V
INPUT RESISTANCE	100kohm
SIGNAL OFFSET	10V
MAXIMUM SPEED SIGNAL	0V

Remember that 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, 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 100kohm. Flow rate required to rise as signal rises.

SENSE	NON-INVERTED
SIGNAL RANGE	5V
INPUT RESISTANCE	100kohm
SIGNAL OFFSET	0V
MAXIMUM SPEED SIGNAL	5V

From the Selection Chart for Voltage Modes (Section 7:6), it can be seen that this signal can be accomodated by Modes V11 and V14. V11 is the recommended Mode since no Signal Offset is required, and the calibration procedure will be simpler than that for V14.

Equipment Required for Calibration

7:2:1 Signal Source

A process signal (or suitable signal from other source) can be used in the calibration procedure providing that it meets the requirements set out below.

For Voltage Modes, a stable, variable DC voltage source (e.g laboratory power supply having a source resistance of 5kohm or less) can be 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 the manner shown in the Selection Chart.

7:2:2 Determination of rotational speeds

It is possible to use the factory calibrated Signal Overload LED facility to achieve setting of maximum rpm. This is carried out as follows:

Adjust signal range potentiometer P2 for maximum rpm, turning it in an anti-clockwise direction until the LED 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, any of the following methods can be used:

At lower speeds it is possible to use a stopwatch and count the actual revolutions.

Revolution Counter. This can be any type capable of giving the required accuracy at speeds of 170rpm or less.

3 Frequency counter. Frequency information from the internal tachometer is available at pin 6 of the DIN socket in the form of positive 12V pulses, referenced to zero volts at pin 2. When this output is coupled to external instrumentation (eg frequency counter), the input impedance must be 1Mohm and normally AC coupled, otherwise loading will affect the control circuit. The relative relationship between rated speed and frequency is given below, as well as the division factor for calculating intermediate speeds.

Drive Module nominal rpm	170	100	50	10
Nominal frequency (Hz) at 100%	2400	2400	2400	1200
Division factor	14	24	48	120

Minimum rpm. For this setting, greater accuracy can be obtained by observing the internal tachometer disc. Adjust P1 until the disc revolves slowly, then turn it back until the disc just stops.

7:3 Technical Information concerning Calibration

The internal 12V reference has a tolerance of ±5%, and the figures given in the Selection Chart for Offset are nominal.

2 Current Modes only: The on-board measuring resistors R15 and R16 have a tolerance of ±2% and the Signal Range figures given in the Selection Chart are nominal. The front panel potentiometer has a tolerance of ±5% and the current values given in the Selection Chart are nominal.

3 Should the input signal attain excessive levels during calibration or subsequently, a protection circuit will stop the motor and illuminate the Signal Overload LED. The motor will restart when the signal returns to a safe level. It is important to note that this circuit only gives protection when the incoming signal is appropriate to the mode for which the programming switch has been set.

4 Tolerances of the mechanical limit stops of the front panel potentiometer may lead to ambiguity in the maximum readout on the digital dial. The dial is factory set to 000 when turned fully anti-clockwise. However, when turned fully clockwise the dial can indicate greater than 999, normally between 000 and 008. It is convenient to adopt 999 as 'maximum'.

5 Those less familiar with the term 'Input Resistance' referred to on the Selection Charts, will need to appreciate that this determines the 'loading effect' that the Drive Module 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 Calibrating Any Unit...

Allow the unit to attain normal working temperature - if practicable allowing it to run for one hour. If a suitable control signal is not available, convert the unit to operate in the Manual Mode (Section 5).

Set the Programming Switches for the required Mode as specified in the Selection Chart.

Connect Signal Source to the DIN socket as indicated in the Selection Chart.

4 Ensure that Potentiometers P1 and P2 are set to approximately mid-position.

5 Insert a length of tubing into the pumphead.

Now proceed to instructions relating to the selected mode as set out in Section 7:5 and 7:7 remembering that the change of Control Mode of the Drive Module should be recorded on the rear panel using one of the self-adhesive labels supplied.

7:5 Calibration procedure for Voltage Signals

V1,V2 and V3 (front panel potentiometer disabled)

1 Set signal source to the maximum speed signal.
2 Adjust P2 for maximum speed.

V4,V5 and V6 (front panel potentiometer disabled)

1 Set signal source to the maximum offset and adjust P1 for zero speed.
2 Set signal 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 for front panel potentiometer)

1 Set signal source to the signal offset and adjust the front panel potentiometer for zero speed.
2 Set signal 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 signal source to the signal
and (a) when offset is required to be 12V or less, set top panel potentiometer fully anti-clockwise and adjust P1 for zero speed.
or (b) when offset is required to be between 12V and 36V, adjust P1 fully anti-clockwise and then adjust the front panel potentiometer for zero speed.

2 Set signal 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 signal source to maximum speed signal and adjust P2 for maximum speed.
3 Repeat 1 and 2 until interaction between adjustments is eliminated.

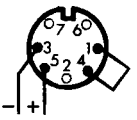
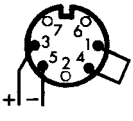
V16,V17 and V18 (front panel potentiometer extends offset range adjustment)

Set signal source to the signal offset

and (a) When offset is required to be 12V or less, adjust the front panel potentiometer fully anti-clockwise and adjust P1 for zero speed.
or (b) when offset is required to be between 12V and 36V, adjust the front panel potentiometer to fully clock wise postion and adjust P1 for zero speed.

Set the signal source to maximum speed signal and adjust P2 for maximum speed.
Repeat 1 and 2 until interaction between adjustments is eliminated.

7:6 SELECTION CHART Voltage (V) Modes

SENSE	MODE	INPUT SIGNAL RANGE min	max	OFFSET min	max	INPUT RESISTANCE K ohm	PROGRAMMING SWITCH These switches 'ON' 1	2	3	4	5	6	7	8	9	10	DIN CONNECTIONS Rear view of plug
N	V1	1.5	6	0	0	100	1	2							9		
O	V2	3	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			9		
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				5	6			9		
E	V11	3	12	0	24	100	1				5	6			9	10	
D	V12	6	24	0	36	200					5	6			9	10	
	V13	1.5	6	1.5	12	100	1				5				9		
I																	
N	V14	3	12	3	12	100	1				5				9	10	
V																	
E	V15	6	24	6	24	200					5				9	10	
R																	
T	V16	1.5	6	1.5	24	100	1				5		7		9		
E																	
D	V17	3	12	3	24	100	1				5		7		9	10	
	V18	6	24	6	36	200					5		7		9	10	

7:7 Calibration Procedure for Current Signals

C1,C2,C4 and C5

1 Set the front panel potentiometer fully anti-clockwise.
2 Set the signal source to maximum speed signal.
3 Adjust P2 for maximum speed.

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

1 Set signal source to maximum speed signal.
2 Set the front panel potentiometer fully anti-clockwise, 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 fully anti-clockwise.
2 Set signal source to the signal offset and adjust P1 for zero speed.
3 Set signal 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 signal source to the signal offset and adjust the front panel potentiometer for zero speed.
2 Set signal 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

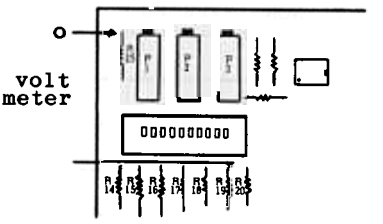
1 Set the front panel potentiometer fully anti-clockwise.
2 Set signal source to the signal offset and adjust P1 for zero speed.
3 Set signal source to the maximum speed signal and adjust P2 for maximum speed.
4 Repeat 2 and 3 until interaction between adjustments is eliminated.

NOTE The combination of the signal range and the offset must not be less than zero (e.g. 2.7 offset with 10 signal range = 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 signal source to the signal offset and adjust front panel potentiometer for zero speed.
3 Set signal 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 Current (C) mA Modes

SENSE	MODE	INPUT SIGNAL RANGE min	INPUT SIGNAL RANGE max	OFFSET min	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		
	C3	2.7	10	0	0	1.2	1	2	3						9	10	
N	C4	4.4	16	0	0	0.75	1	2		4					9	10	
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					9		
I	C8	0.5	10	0	0	6.2-1.2	1	2	3						9	10	
N	C9	0.5	16	0	0	5.75-0.75	1	2		4					9	10	
V	C10	1.0	20	0	0	6.2-1.2		2	3						9	10	
E	C11	1.4	5	0	10	1.2	1		3		5				9		
R	C12	2.7	10	0	10	1.2	1		3		5				9	10	
T	C13	4.4	16	0	16	0.75	1			4	5				9	10	
E	C14	1.4	5	0	10	1.2	1	2	3			6			9		
D	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	
	C18	5.2	20	0	10	1.2		2	3			6			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				9	10	
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	20	30	1.2			3		5		7		9	10	

Section 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 0.75kohm. Flow rate to rise with signal but output to vary over only 50 to 100%.

SENSE	NON-INVERTED
SIGNAL RANGE	10mA
INPUT RESISTANCE	0.75kohm
SIGNAL OFFSET	0 mA
MAXIMUM SPEED SIGNAL	10mA

Turning to the Selection Chart for Current Signals, Modes C13 and C17 are suitable because they cater for 0-10mA and 0.75kohm 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 is determined by whether external adjustment (through the front panel potentiometer) of the calibration control is required.

Calibrating the module is carried out as follows:

1 Carefully follow the access instructions given in Section 4

2 Set the Programming Switch and connect the signal to the unwired DIN plug as shown in the Selection Chart, Mode C13.

3 Set the front panel potentiometer fully anti-clockwise (000).

4 Set the signal source to 0mA and adjust P1 for the required minimum speed (ie 50% of maximum in this example).

5 Set the signal source to 10mA and adjust P2 for the required maximum speed (ie 100% in this example).

The pump will now operate as required in response to the 0-10mA control signal.

Section 9: FOR HIGHEST ACCURACY OF OPERATION

1 Use a Drive Module with the most appropriate maximum speed.

The 501U is available with maximum speeds of 10,50,100, and 170rpm and has a control ratio of 20:1. Clearly if a unit is expected to operate satisfactorily between 6 and 20rpm, the 170rpm unit would not be ideal.

2 Effect of pumphead load when calibrating.

The instructions call for a pumphead and tubing to be fitted prior to calibration. Improved accuracy will be achieved when calibrating if the pump is fitted with the tubing which it is intended to use. It is not normally necessary for the tubing to contain fluid during calibration, but where large bore tubing and significant delivery pressures are being used, doing so will offer increased accuracy.

3 Setting at zero flow rate condition.

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 5% speed.

It may therefore be beneficial to set Signal Offset to give 5% of maximum speed. Thus in the second example given in Part 2 where 0 to 10mA is shown controlling the flow rate from zero to maximum, adjust the unit so that 0.5mA corresponds to 5% of maximum speed.

It must be recognised that this may result in the pump stopping before zero or continuing to rotate very slowly at zero.

Section 10: SPARE MODE SELECTION GRIDS

These spare grids are provided so that control signals which may be used with a 501U may be stated in a way which will provide the information necessary for Mode Selection and, later, calibration of the Module. Finally, the Mode number and the DIN plug connection can be noted as a permanent record.

SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

MAXIMUM SPEED SIGNAL

SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

MAXIMUM SPEED SIGNAL

SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

MAXIMUM SPEED SIGNAL

SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

MAXIMUM SPEED SIGNAL

SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

MAXIMUM SPEED SIGNAL

SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

MAXIMUM SPEED SIGNAL

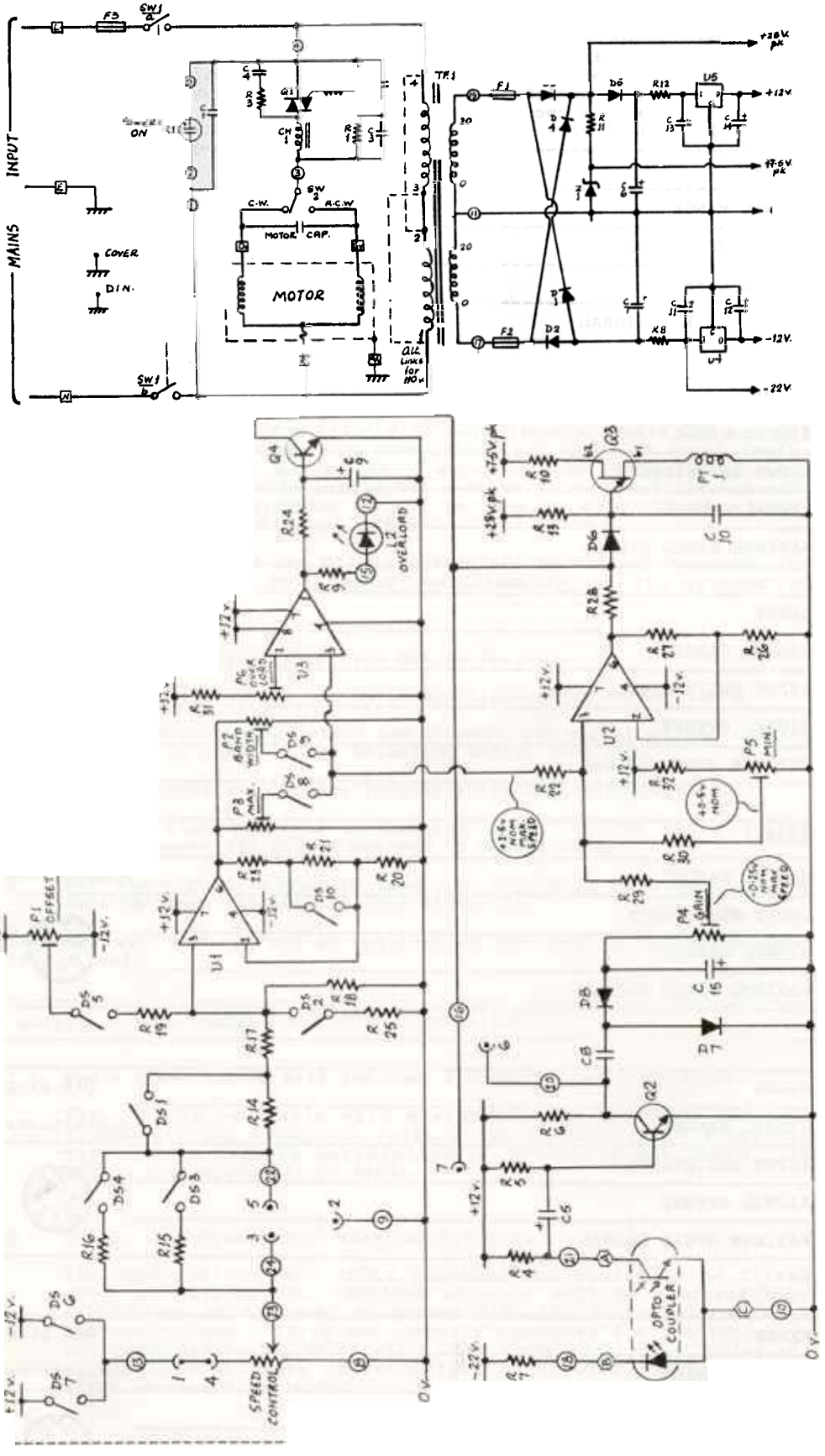
SENSE — DIN plug connections

SIGNAL RANGE

INPUT RESISTANCE

SIGNAL OFFSET

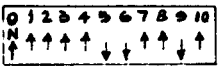
MAXIMUM SPEED SIGNAL



KEY:

- □ ~ TERMINAL BLOCK CONNECTIONS
- ○ ~ PLUG IN P.C.B. "
- ⬡ ~ TACHO P.C.B. "
- ⊙ ~ DIN (7way) "
- ⏚ ~ EARTH BONDING SCREW "

DS1 ~ 10 PROGRAMMING SWITCH



MANUAL ~ NON. INV.
INT. POTENTIOMETER
DIN PLUG 1+4 LINKED