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Issue B

Instruction Manual

D150 Dual Gas Reactor Column

EDWARDS

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1993 1996

Caution

With respect to European Electromagnetic Compatibility (EMC) requirements for harmonics and flicker, this product should be treated as class A (industrial) as defined by EN 61326. In this context it is not intended for use in domestic buildings, or in properties directly connected to an electrical supply network which also supplies domestic buildings.

Attention

Ce produit est de type industriel (classe A), spécifié par la norme EN 61326. Pour respecter les critères européens de compatibilité électromagnétique (CEM) en matière d'harmoniques et de scintillation, veuillez noter que cet appareil ne convient pas à une utilisation en milieu domestique, ou dans des locaux directement raccordés au même réseau électrique que des bâtiments résidentiels.

Achtung!

Dies ist ein Industrieprodukt (Klasse A) entsprechend der Norm EN 61326. Beachten Sie, daß es gemäß den Anforderungen zu Oberwellen und Flimmern, die in der europäischen Richtlinie zur elektromagnetischen Verträglichkeit (EMV) festgelegt sind, weder für den Betrieb in Wohngebäuden noch in anderen Gebäuden vorgesehen ist, die an einem Stromversorgungsnetz angeschlossen sind, das auch Wohngebäude speist.

Attenzione

Questo è un prodotto di categoria industriale (Classe A) come definito dalla normativa EN 61326. Per garantire la compatibilità con i requisiti della normativa sulla Compatibilità elettromagnetica europea (EMC) per l'armonica e lo sfarfallio, si prega di tener presente che esso non è idoneo all'impiego in edifici uso abitazione o direttamente collegati a una rete di alimentazione elettrica impiegata anche per alimentazione di tali edifici.

注意

当製品は、EN 61326 により工業用 (A級)
製品として規定されています。調波やフリッカーに関する電磁環境両立性 (EMC)
要件への準拠を守るためには、ご家庭や、家庭建造物への本線網に直接接続されている地所では、
当製品を使用しないようご留意ください。

주의

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전자기적 접합성 (EMC) 지침의 요구사항을 준수하기 위해, 주거용 건물 또는 가정용
전력선에 직접 연결된 건물에서는 본 제품을 사용할 수 없습니다.

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1 INTRODUCTION

1.1 Scope and definitions

This manual provides installation, operation and maintenance instructions for the Edwards D150 Dual GRC (Gas Reactor Column), abbreviated to D150 in the rest of this manual. You must use the D150 as specified in this manual.

Read this manual before you install and operate the D150. Important safety information is highlighted as WARNING and CAUTION instructions; you must obey these instructions. The use of WARNINGS and CAUTIONS is defined below.

> WARNING
>
> Warnings are given where failure to observe the instruction could result in injury or death to people.

> CAUTION
>
> Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment and process.

The units used throughout this manual conform to the SI international system of units of measurement. Also, wherever nitrogen flow rates are specified, the term 'slm' is used to mean 'standard $l.min^{-1}$,' and the term 'slh' is used to mean 'standard $l.h^{-1}$'; these are flows of 1 $l.min^{-1}$ and 1 $l.h^{-1}$ at an ambient temperature of 0 ^{o}C and a pressure of 1013 mbar (1.013×10^{5} Pa).

1.2 Overview of the D150

1.2.1 Features of the D150

Note: The D150 is not a dust scrubber; although the D150 will trap dust in the cartridge, it cannot remove all dust from the process gases.

The D150 is designed to treat the exhaust gases from a wide range of process applications. Refer to Figure 1. The D150 has two GRC heater units (6, 5), each of which contains a replaceable cartridge. During operation, the cartridge in the 'on-line' GRC is heated and the process gases pass through the cartridge. The cartridge contains chemical reactants which convert the toxic and corrosive process gases into inert, inorganic non-toxic products which remain in the cartridge.

While one heater unit is on-line (that is, while it treats the process gases), the other heater unit can be heated ready for immediate changeover (see Section 1.2.2). After changeover, the used cartridge is isolated from the process gases and the cartridge is then automatically purged and cooled.

This design means that:

- Your process system can have 100% 'up time'; there is no need to put the process system off-line in order to change a cartridge.
- There is no need to change a cartridge while it is hot.
- Cartridge changes can be scheduled as part of your process system maintenance operations.

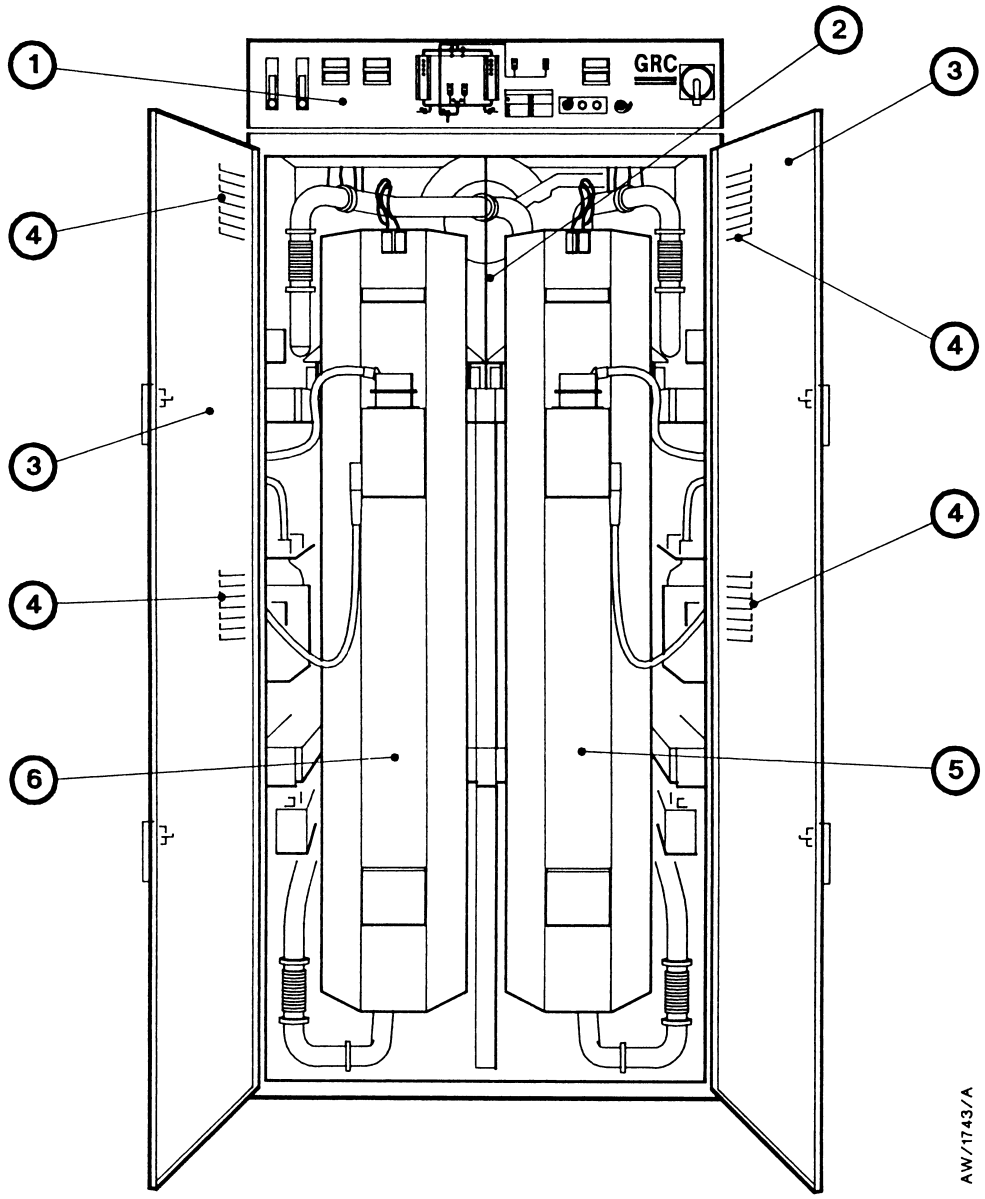
Other features of the D150 are as follows:

- The heater units (6, 5) and connecting pipelines are enclosed in a ventilated enclosure.
- The D150 has no bypass pipeline but incorporates a pump start pipeline. This pipeline enables the large transient gas flows that may occur (for example, on process system start-up) to pass through the D150 untreated. These large gas flows would otherwise cause a back-pressure in the D150 and result in pumping system shut-down due to an exhaust-pressure alarm.
- After a cartridge is changed, the new cartridge installation is automatically leak tested to ensure the integrity of the new cartridge and to protect against operator error (for example, if pipeline connections have not been made properly).
- The D150 is compact and requires a small floor area for installation: see Figures 13 and 14.
- The D150 can be supplied with end-point detectors. These sample the gas at the cartridge outlet and enable automatic GRC changeover at the appropriate process gas concentration.
- The D150 can be supplied with a Temperature Management System (TMS); a TMS is used to prevent the formation of solids in the D150 pipelines.

1.2.2 Automatic and manual GRC changeover

During operation, one of the GRCs is on-line; it is at operating temperature and treats the process gases from the pumping system. The other GRC will be in one of the following states:

- Off-line — The GRC is not available to go on-line. For example, the used cartridge in the GRC is being purged to cool it, or the used cartridge has been cooled but has not yet been changed, or no cartridge or heater unit is fitted.
- Available — A new cartridge has been installed and has been successfully leak tested. The D150 does not automatically heat up, but waits for a manual or an automatic preheat request.
- Await change — If the GRC is off-line, then the Await Change LED on the status display (see Section 1.8.2) may also be lit. This means that the used cartridge has been purged and cooled and must be changed, or a new cartridge has been installed but has failed the leak test; if a cartridge has failed the leak test, you must rectify the cause of the leak test failure.



1. Control unit
2. Guard
3. Door
4. Ventilation grill
5. Heater unit (GRC2)
6. Heater unit (GRC1)

Figure 1 - Components of the D150 (D150E/S shown)

If there is an 'available' GRC, automatic changeover is initiated by one of three events:

- There is an increase in back-pressure in the on-line GRC inlet pipelines.
- The on-line cartridge has been in use for its maximum predicted life: this is a default of 60 days (see Section 1.2.4)
- The (optional) end-point detector for the on-line GRC indicates breakthrough. Breakthrough means that the concentration of process gas in the cartridge outlet pipeline has reached the preset changeover level.

The automatic changeover sequence is as follows:

- The available GRC is heated up for five hours (this is known as preheat).
- After the five hour preheat, the on-line GRC goes off-line and the available GRC becomes the on-line GRC.
- The off-line GRC is purged with nitrogen and cooled for 24 hours.
- After the 24 hours, the off-line GRC is in the await change state .

If necessary, you can manually control the preheat and changeover sequence. Refer to Section 4.4 for the manual preheat and changeover procedure.

1.2.3 Safety features

The D150 has many safety features; these include the following:

- The two heater units and connecting pipelines are fully enclosed by the ventilated enclosure. This prevents accidental contact with hot components during normal operation.
- The doors of the enclosure (Figure 1, item 3) are interlocked so that the door of the on-line GRC cannot be opened. This means that when you change a cartridge, you cannot open the wrong door and touch the hot surfaces of the on-line GRC.
- The used cartridge is purged for 24 hours to cool it before you change it. This prevents contact with hot surfaces when you change a cartridge.
- The enclosure has a guard (Figure 1, item 2) between the GRCs. This means that when you change a cartridge, you cannot touch the hot outlet pipeline of the on-line GRC.
- While you change a cartridge, a safety interlock locks the pneumatic control circuit so that the valves cannot operate and release process gases, even if there is an electrical failure in the control unit.
- The electrical supplies to the GRCs are controlled by the control unit; when a GRC is off-line or await change, the electrical supplies to the GRC heater unit are switched off. This means that when you change a cartridge, you cannot touch high voltages components.

1.2.4 Configurability

Operation of the D150 is controlled by a PLC (programmable logic controller) in the control unit. The 'ladder logic' used to program the PLC is easy to configure. For example, you could configure the following features for your application:

- Default cartridge life: the time after which the D150 will start an automatic GRC changeover.
- Preheat time: the time between the start of preheat and automatic GRC changeover.

You will have discussed your configuration requirements with Edwards before you ordered your D150 and your D150 will be supplied configured for your application. The rest of this manual describes the default (unconfigured) D150.

1.2.5 Ordering options

The D150 can be supplied with a number of options fitted, such as:

- A TMS (Temperature Management System); the TMS maintains the inlet pipelines in the D150 at a high temperature in order to prevent the formation of solids in the pipelines. Section 1.10 describes the TMS components in more detail.
- An end-point detector fitted to each GRC. The end-point detector measures the conductivity of the gases in the outlet of the GRC cartridge to determine when a cartridge should be changed.

Refer to Section 7.6 for all of the ordering options.

1.3 Applications

The D150 is designed primarily to treat the hazardous exhaust gases from plasma etch and CVD semiconductor processes. The D150 can remove most chlorine, fluorine and bromine compounds from the exhaust gases. It can also remove silane and dopant levels of phosphine and diborane at typical process gas flows. Examples of typical process applications for which the D150 is suitable are shown in Table 1.

Process		**Exhaust gas mixture**
Metal etch		BCl_3 / Cl_2 / CHF_3 CCl_2F_2 / Cl_2 / $SiCl_4$ BCl_3 / Cl_2 / $SiCl_4$ CCl_4 / Cl_2 CCl_4 / BCl_3 / Cl_2 / SF_6
Poly etch		HCl / BCl_3 / Cl_2 HBr / Cl_2 / SF_6 HBr / SF_6 / NF_3
Trench etch		HBr / Cl_2 / SiF_4
Oxide etch		CF_4 / O_2 $C2F_6$ / O_2 / CHF_3 CF_4 / O_2 / CHF_3 / NF_3
CVD	Nitride	SiH_4 / NH_3 / CF_4 / NF_3 DCS# / NH_3
	Oxide	SiH_4 / N_2O / CF_4 TEOS* / O_3 / C_2F_6 / NF_3
	Poly	TEOS* / NF_3 SiH_4 / NF_3 SiH_4 / C_2F_6 / O_2
Gas cabinet purge lines		Halogens / hydrides

* Tetraethylorthosilicate or tetraethoxysilane
\# Dichlorosilane

Table 1 - Typical D150 process applications

The standard D150 cartridge (type C150Y) is suitable for all of the applications in Table 1, but it is **not** suitable for process applications which have high flow rates of TEOS or SiH_4, or applications which use AsH_3 or PH_3. Other cartridges are available for use in some of these applications: please consult your supplier or Edwards.

Before you use the D150, ensure that you have discussed your application with Edwards or your supplier and that you have been advised on the suitability of the D150 (and the cartridge type) for your process application.

If you wish to change your process application, complete part 1 of the GRC Application Form (form GRC1, included at the end of this manual) and send the completed form to your supplier or Edwards, who will complete part 2 of the form and return it to you.

1.4 Accessories

A number of accessories are available for the D150. You can use these accessories to optimise the operation of the D150 for your specific applications. The accessories are listed in Section 7.

Note that you must have at least one cartridge change cart available (see Section 1.11) to allow you to change cartridges.

1.5 Principle of operation

In the following sections, refer to Figure 2 which shows a schematic diagram of the D150 process system. The components in the D150 enclosure are shown in Figure 3. With the exception of the end-point isolation-valves (3, 4, 6, 7), all of the valves are pneumatically actuated and are operated under control of the PLC in the control unit.

1.5.1 Normal operation

During normal operation, one of the GRCs is on-line and treats process gases from the pumping system. When a GRC is on-line:

- The three-way pump start valve (20) directs process gases from the pumping system to flow through the D150 inlet (19) to the changeover valve (21).
- The three-way changeover valve (21) directs the process gases through the corresponding inlet pipeline (17 or 26) to the cartridge (12 or 28) in the on-line GRC. The heater unit (11 or 27) heats the cartridge.
- The treated gases flow through the corresponding GRC outlet isolation-valve (10 or 29) to the D150 outlet (5).
- The other GRC outlet isolation-valve is normally closed to isolate the GRC from the process gases, unless it is being purged during preheat or cooling (see Section 1.5.4).

1.5.2 End-point detector operation: optional

Each GRC has a cartridge end-point detector (1, 9). When a GRC is on-line, the end-point sample pump (2 or 8) pumps bubbles of gas from the corresponding GRC cartridge outlet pipeline through the fluid in the end-point detector bottle (Figure 3, item 33) and then into the enclosure (4, 7) to be extracted through the air-extraction port.

The end-point detector measures the conductivity of the fluid in the end-point detector bottle; the change in conductivity depends on the quantity of process gases which pass through the fluid. The end-point detector uses these measurements to determine the cumulative concentration of toxic process gas which passes from the outlet of the cartridge in the on-line GRC. The end-point detector outputs are connected to the control unit which determines when the automatic changeover sequence should start.

The manually operated end-point isolation-valves (3 and 6) are used to isolate the end-point detector from the GRC outlet pipelines when you refill an end-point detector bottle (see Section 5.4.4).

1.5.3 Pressure-switch operation

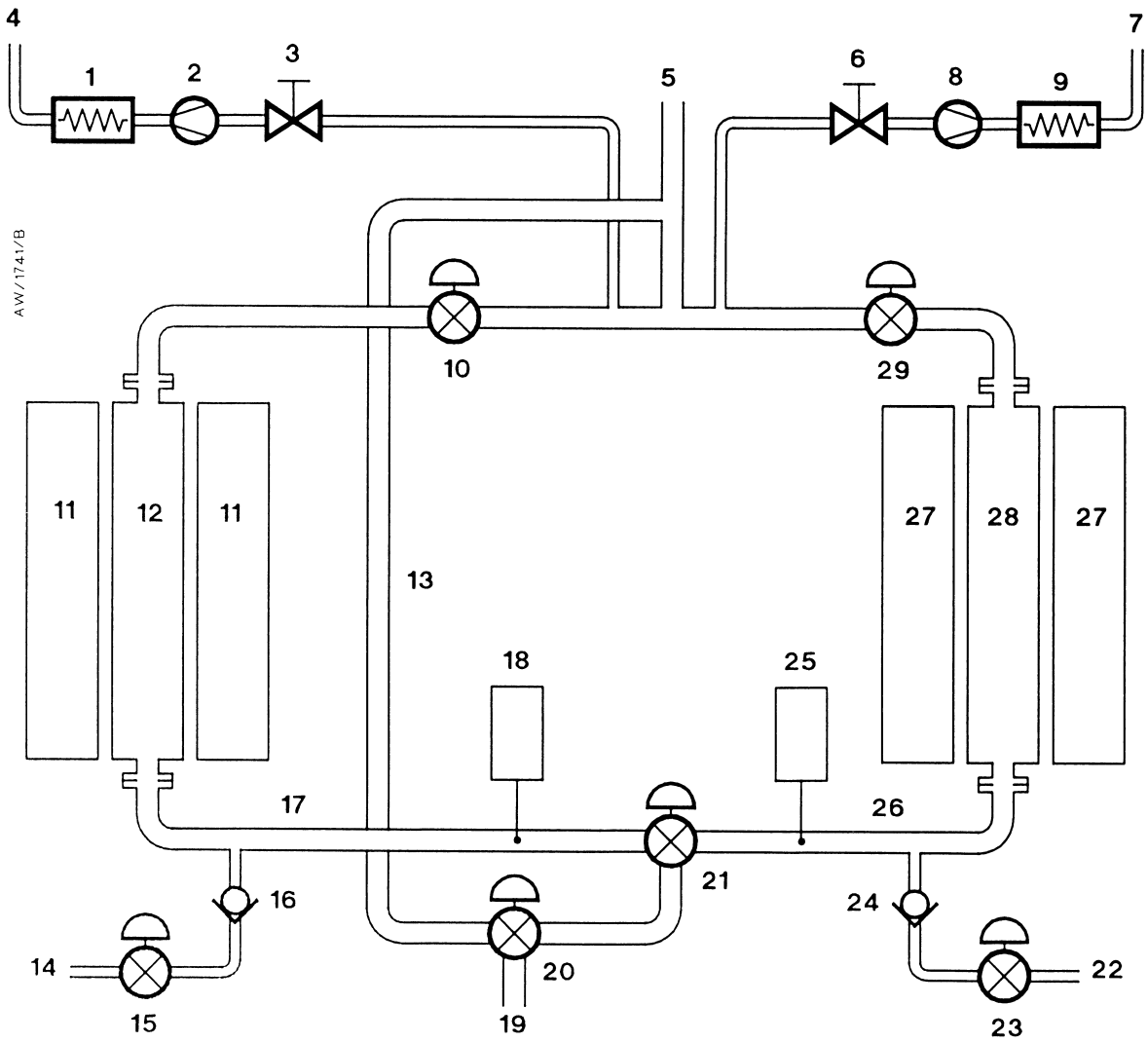
Each of the GRC inlet pipelines has a pressure-switch unit (18 or 25) which monitors the pressure in the corresponding pipeline. The pressure-switch unit has two levels of output: a warning pressure and a high pressure. When a cartridge is on-line:

- The warning pressure output causes one of the status display LEDs to go on (see Section 1.8.2); if the output has been on continuously for one minute or more, the automatic preheat sequence of the off-line GRC is started (if a new cartridge has been fitted and successfully leak tested).
- If there has been a slow rate of pressure rise, the high pressure output causes the automatic changeover sequence to start (see Section 1.2.2) if a new cartridge has been fitted to the off-line GRC and has been successfully leak tested.
- If there has been a rapid rate of pressure rise, the high pressure output causes the pump start valve to open (see Section 1.5.5).

When a new cartridge has been installed and is being leak tested (see Section 1.5.4), the pressure-switch unit is used to monitor the pressure drop in the cartridge and pipelines to determine whether the cartridge passes or fails the leak test.

Each pressure-switch unit has a nitrogen purge pipe (Figure 3, item 37). The nitrogen purge flow helps prevent blockage of the pipeline to the pressure-switch by deposits from the process gases. If a blockage occurs, the pressure of the nitrogen purge supply will cause the pressure-switch to operate as described above.

An electrical connector (Figure 3, item 41) on each pressure-switch unit connects the outputs of the unit to the control unit.



1. End-point detector (GRC1)
2. End-point sample pump (GRC1)
3. End-point inlet isolation-valve (GRC1)
4. End-point outlet (GRC1)*
5. D150 outlet
6. End-point inlet isolation-valve (GRC2)
7. End-point outlet (GRC2)*
8. End-point sample pump (GRC2)
9. End-point detector (GRC2)
10. Outlet isolation-valve (GRC1)
11. Heater unit (GRC1)
12. Cartridge (GRC1)
13. Pump start pipeline
14. Nitrogen supply (GRC1)
15. Nitrogen purge valve (GRC1)
16. Check-valve (GRC1)
17. Cartridge inlet pipeline (GRC1)
18. Pressure-switch unit (GRC1)
19. D150 inlet
20. Pump start valve
21. Changeover valve
22. Nitrogen supply (GRC2)
23. Nitrogen purge valve (GRC2)
24. Check-valve (GRC2)
25. Pressure-switch unit (GRC2)
26. Cartridge inlet pipeline (GRC2)
27. Heater unit (GRC2)
28. Cartridge (GRC2)
29. Outlet isolation-valve (GRC2)

* To the enclosure air-extraction port

Figure 2 - Schematic diagram of the D150 process system

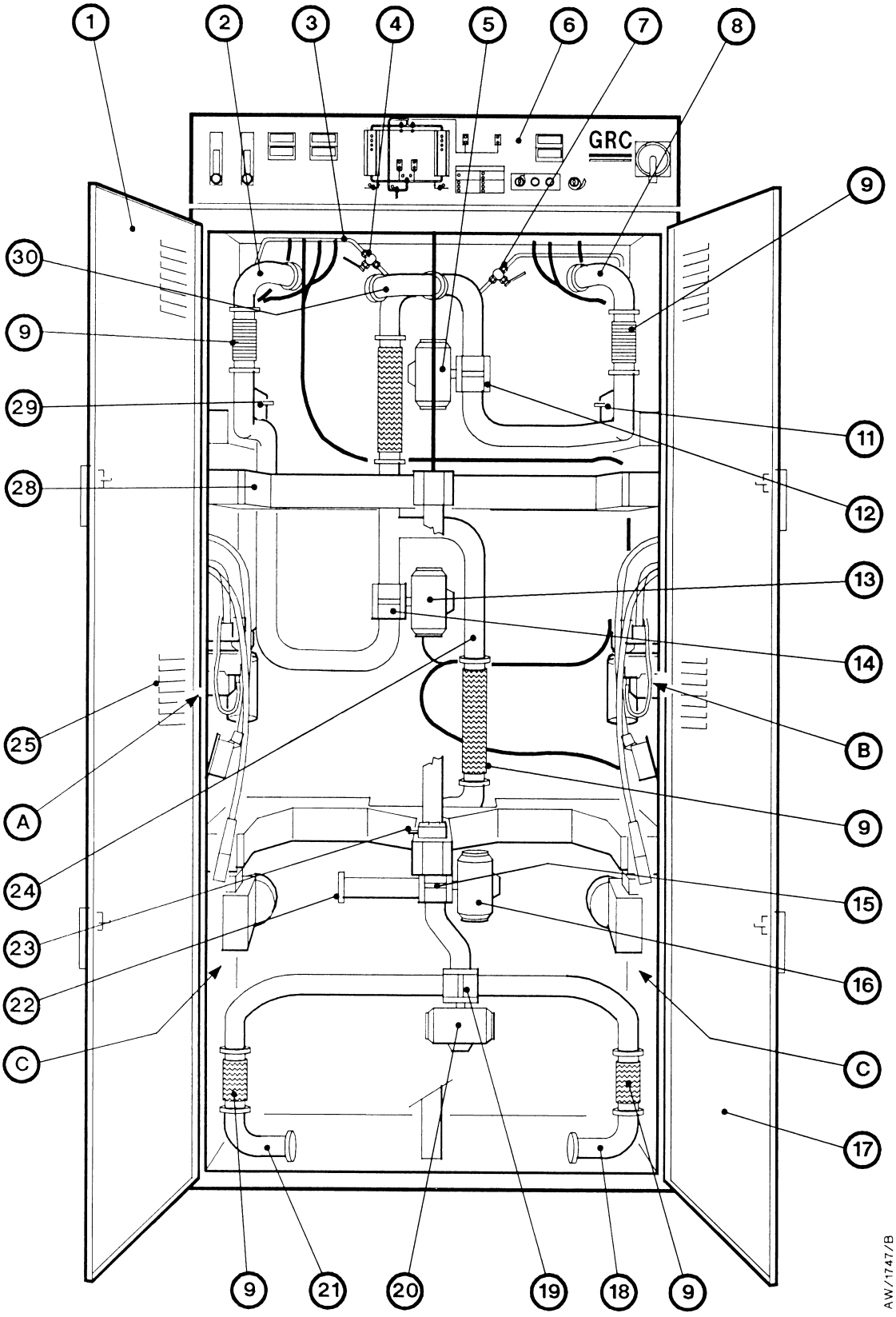
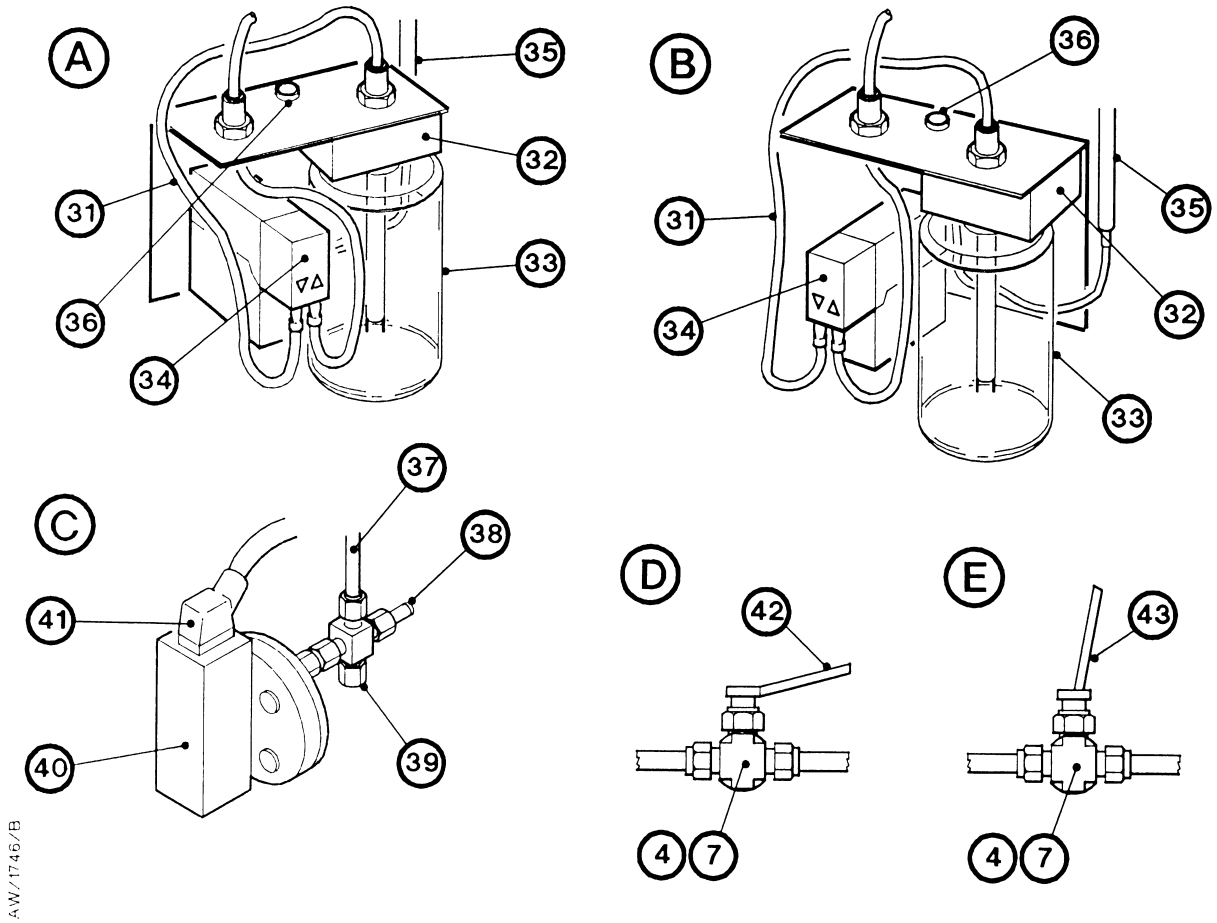


Figure 3 - D150 enclosure (D150E / S shown): sheet 1 of 2



1. Enclosure door (left)
2. Cartridge outlet pipeline (GRC1)
3. End-point outlet pipe (GRC1)
4. End-point isolation-valve (GRC1)
5. Pneumatic actuator
6. Control unit
7. End-point isolation-valve (GRC2)
8. Cartridge outlet pipeline
9. Flexible bellows
10. Not used
11. Heater solenoid-catch (GRC2)
12. Outlet isolation-valve (GRC2)
13. Pneumatic actuator
14. Outlet isolation-valve (GRC1)
15. Start-up valve
16. Pneumatic actuator
17. Enclosure door (right)
18. Cartridge inlet pipeline (GRC2)
19. GRC isolation-valve
20. Pneumatic actuator
21. Cartridge inlet pipeline (GRC1)
22. D150 inlet pipeline
23. Door lock
24. Pump start pipeline
25. Ventilation grill
26. Not used
27. Not used
28. Heater unit support rail
29. Heater solenoid-catch (GRC1)
30. D150 outlet
31. End-point inlet pipe
32. End-point electronics box
33. End-point detector bottle
34. End-point sample pump
35. End-point outlet pipe
36. Pump test button
37. Pressure-switch purge supply pipe
38. Pipe to cartridge inlet pipeline
39. Pressure gauge connector
40. Dual pressure-switch unit
41. Pressure-switch unit connector
42. End-point isolation-valve handle (closed)
43. End-point isolation-valve handle (open)

Figure 3 - D150 enclosure (D150E / S shown): sheet 2 of 2

1.5.4 Nitrogen purge valve operation and leak testing

Refer to Figure 2. When a GRC is on-line, the corresponding nitrogen purge valve (15 or 23) is closed.

When a GRC first goes off-line, the corresponding nitrogen purge valve is opened and nitrogen is passed through the cartridge for 24 hours to purge and cool it; the corresponding GRC outlet isolation-valve (10, 29) is open during the purge. After 24 hours, the nitrogen purge valve and the GRC outlet isolation-valve are closed.

After you fit a new cartridge, the D150 automatically starts to leak test the cartridge and the GRC inlet and outlet pipelines. The leak test sequence is as follows:

- With the GRC outlet isolation-valve (10 or 29) closed, the nitrogen purge valve is opened and the nitrogen supply is allowed to pressurise the cartridge and pipelines.
- The nitrogen purge valve is then closed. The pressure-switch unit for the GRC (18 or 25) monitors the pressure fall in the cartridge and pipeline for 70 seconds to determine if it is leak tight.
- After the leak test, the GRC outlet isolation-valve (10 or 29) is momentarily opened to release the pressure in the cartridge and pipelines.

A check-valve in the nitrogen pipeline (16, 24) prevents the flow of process gas back into the pipeline.

1.5.5 Pump start valve operation

Note: The pump start valve will only open if there is a sudden pressure surge in the D150 pipelines. A gradual rise (for example, as the result of the rise of back-pressure in a cartridge), will cause the automatic changeover sequence to start (refer to Section 1.2.2) if there is a new cartridge in the off-line GRC and it has been successfully leak tested; if the second GRC is not 'available' (that is, has not successfully been leak tested), the pump start valve will open.

When no GRC is on-line (that is, no heater unit and cartridge have been fitted, connected to the control unit and been successfully leak tested), the pump start valve (20) is open and allows the process gases from the pumping system to pass through the pump start pipeline (13) directly to the D150 outlet (5). Both GRC outlet isolation- valves (10, 29) are closed to isolate the process gases from the GRC outlet pipelines.

During normal operation (that is, when a GRC is on-line), the pump start valve is closed (see Section 1.5.1). If the pressure-switch unit indicates there is a sudden pressure surge in the pipeline (to above 3.5 psig, 1.2 bar absolute, 1.2×10^5 Pa):

- The pump start valve (20) opens to release the pressure (through the pump start pipeline (13) and to the D150 outlet (5)). After ten seconds, the pump start valve closes.
- If the pressure has fallen to below 3.5 psig (1.2 bar absolute, 1.2×10^5 Pa), the on-line GRC will then resume treatment of the process gases.
- If the pressure is still above 3.5 psig (1.2 bar absolute, 1.2×10^5 Pa), this sequence is repeated.

1.6 GRC heater unit and cartridge

The two GRC heater units (Figure 1, items 6 and 5) are identical. Each GRC heater unit rests on two roller carriages in the enclosure (see Figure 21) so that you can easily move the unit onto the cartridge change cart to change a used cartridge (see Section 5.4).

Refer to Figure 4. During operation, the cartridge is maintained at operational temperature by the heaters (4, 6) in the upper and lower zones of the heater unit (7).

A thermal fuse at the top of the heater unit protects the heater unit and the cartridge from over-temperature damage.

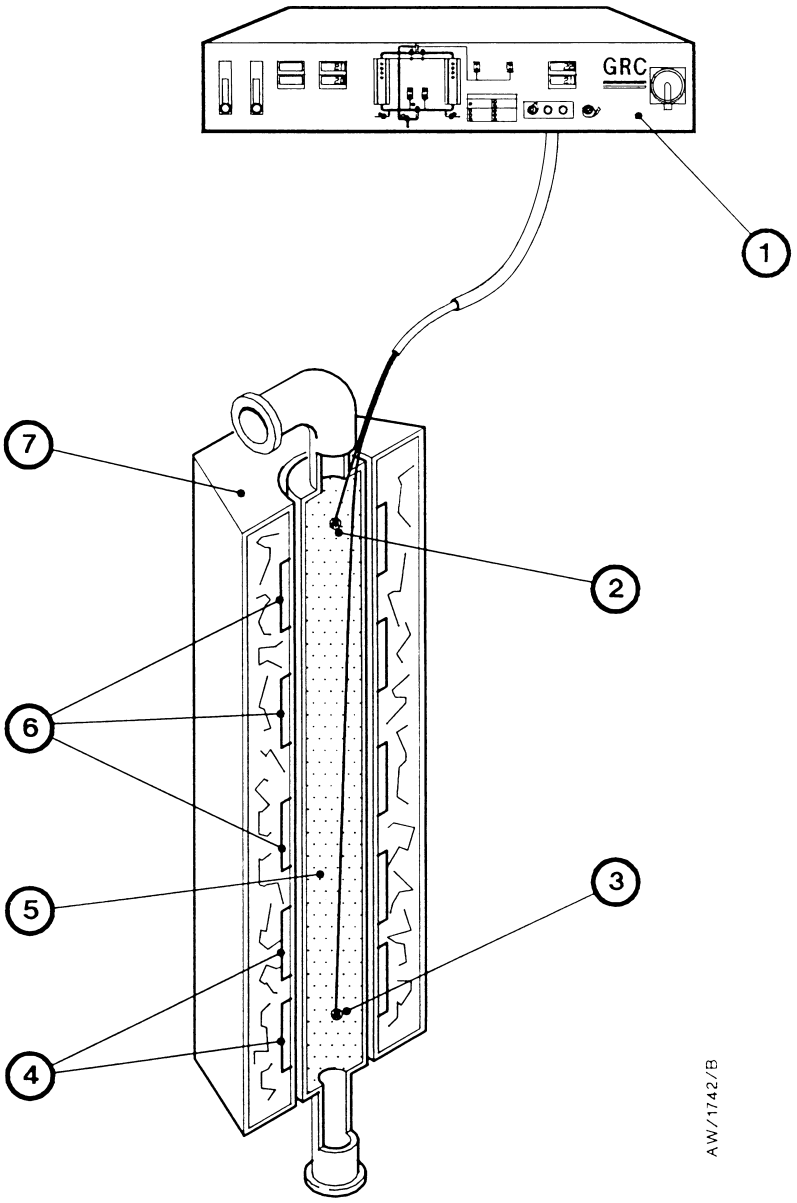
The cartridge has two thermocouples which are connected to the cartridge temperature controllers; one thermocouple (2) is in the upper zone of the cartridge, the other thermocouple (3) is in the lower zone. The outputs of these thermocouples are used by the cartridge temperature controllers to maintain the cartridge at the correct operating temperature (see Section 1.8.3).

Electrical connectors (Figure 19, items 2, 3, 8 and 9) on the heater units allow the units to be connected to the control unit.

1.7 Control unit connections

The top panel of the control unit (shown in Figure 16) has the following connectors:

- Electrical supply cable-gland (11) — To connect the electrical supply to the D150.
- Nitrogen supply connector (10) — To connect the nitrogen supply to the D150.
- Compressed-air supply connector (9) — To connect the compressed-air supply to the D150.
- Remote input connector (8) — The D150 can be configured to use the signals input on the remote input connector to automatically control the operation of the D150 (that is, to select preheat, change over, and so on): refer to Section 3.15.
- Remote alarm connector (7) — The signals output on the remote alarm connector can be used by your process or control equipment to control indicators or to automatically shut down the pumping system: refer to Section 3.14.



1. Control unit (D150E/S shown)
2. Thermocouple (upper)
3. Thermocouple (lower)
4. Lower heaters
5. Cartridge
6. Upper heaters
7. Heater unit

Figure 4 - Cartridge and heater unit (not to scale)

1.8 Control unit controls and displays

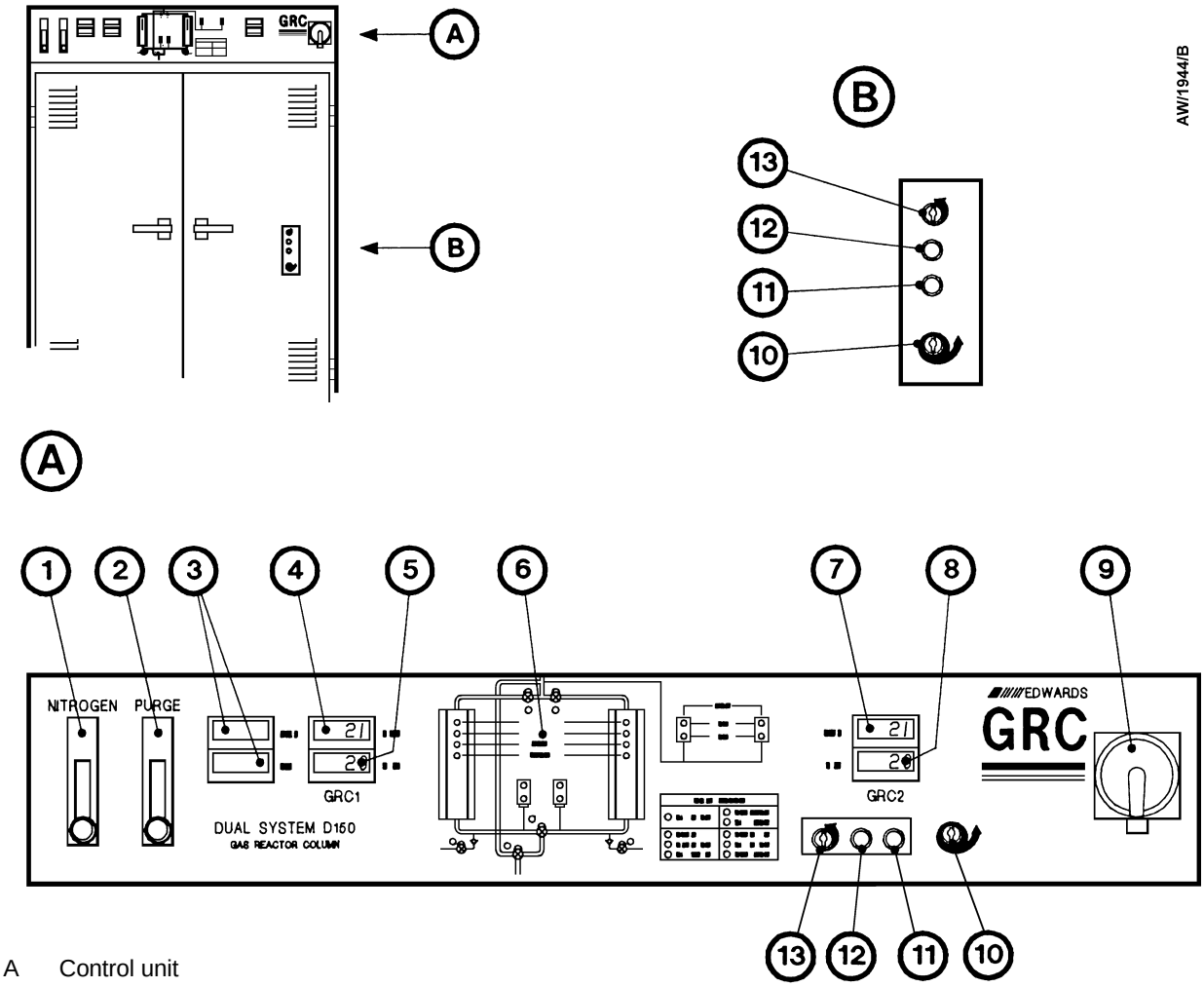
1.8.1 Introduction

Refer to Figure 5. The controls and displays on the D150 are described below. Note that the D150E/S does not have a lower control panel, and all of the controls and displays are on the control unit, as shown in detail A; on the D150J, the buttons and keys (10 to 13) are not on the control unit, but are on the lower control panel (see detail B).

Electrical supply isolator (9)	Use this to switch the D150 on and off.
GRC1 cartridge temperature controllers (4, 5)	Use these to control the operation of the GRC1 heaters; refer to Section 1.8.3.
GRC2 cartridge temperature controllers (7, 8)	Use these to control the operation of the GRC2 heaters; refer to Section 1.8.3.
Status display (6)	This is a schematic display of the D150 process system. LEDs on the display indicate the status of the D150 and also indicate faults.
Off-line purge flowmeter and flow-control valve (1)	Use these to monitor and control the flow rate of nitrogen when an off-line cartridge is purged or when a newly fitted cartridge is leak tested: refer to Section 5.4.8.
Pressure-switch purge flow-meter and flow-control valve (2)	Use these to monitor and control the flow rate of nitrogen to the pressure-switch units.
Button lock key (13)	Use this key to lock and unlock the control buttons (12, 11) on the control unit. When the key is in the lock (anticlockwise) position, the control buttons on the control unit have no effect.
Preheat start button (12)	Use this button to manually start to preheat a cartridge: refer to Section 4.4.
Changeover button (11)	Use this button to manually select changeover; that is, to make the available GRC the on-line GRC: refer to Section 4.4.
Safety interlock key (10)	Use this key to isolate the compressed air supply when you remove a heater unit from the enclosure to change a cartridge. While the compressed air supply is isolated, none of the pneumatically-actuated valves can operate (that is, change from open to closed, or from closed to open), so the process gases will remain isolated from the heater unit which you will remove.
TMS temperature controllers (3): optional	Use these to control the operation of the optional TMS heaters: refer to Section 1.10.

Refer to Figure 16. The inside of the control unit has the following controls:

GRC1 heater controller (12)	Use this to control the operation of the GRC1 heaters: refer to Section 1.8.4.
GRC2 heater controller (6)	Use this to control the operation of the GRC2 heaters: refer to Section 1.8.4.



A Control unit
B Lower control panel

1. Off-line purge flow-meter and flow control valve
2. Pressure-switch purge flow-meter and flow control valve
3. TMS temperature controllers*
4. Upper cartridge temperature controller (GRC1)
5. Lower cartridge temperature controller (GRC1)
6. Status display
7. Upper cartridge temperature controller (GRC2)
8. Lower cartridge temperature controller (GRC2)
9. Electrical supply isolator
10. Safety interlock key
11. Changeover button
12. Preheat start button
13. Button lock key

* Only fitted if you have ordered the TMS with your D150

Figure 5 - Control panel

1.8.2 Status display

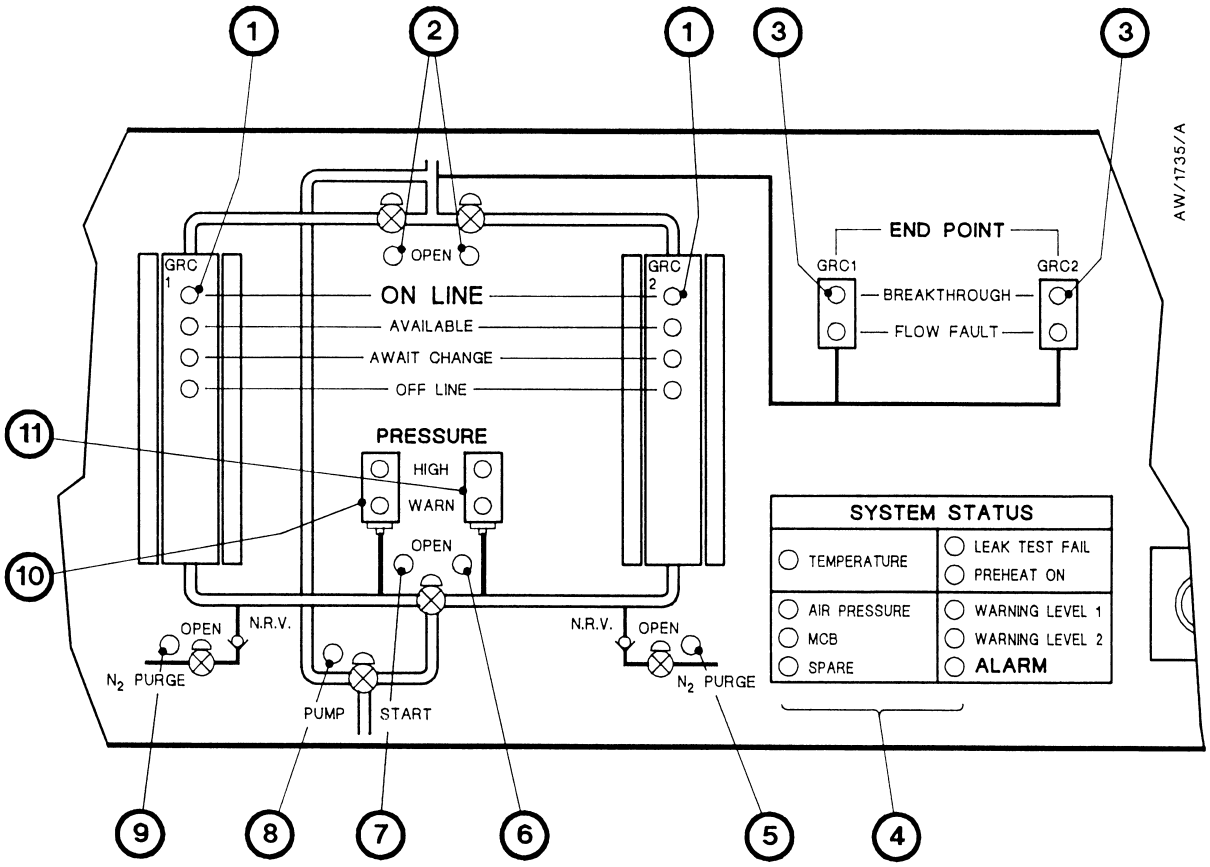
The status display is shown in Figure 6. The display has red and green LEDs (see Table 2). In normal operation, only green LEDs should be on; a red LED on indicates that there is a fault or that operator action is required. For a full description of fault finding and operator actions required when a red alarm LED goes on, refer to Section 5.11.

Figure 6 key	LEDs Name	Meaning
1	On-line	This green LED is on when the corresponding GRC is on-line: see Section 1.2.2.
1	Available	This green LED is on when the corresponding GRC is available to be preheated: see Section 1.2.2. If required, you can manually select changeover to make this GRC on-line.
1	Await change	This red LED is on when the cartridge in the corresponding GRC must be changed: see Section 1.2.2.
1	Off-line	This red LED is on when the corresponding GRC is off-line: see Section 1.2.2.
2	Outlet isolation-valve open	This green LED is on when the corresponding GRC outlet isolation-valve is open.
3	Breakthrough	This red LED is on when the corresponding end-point detector has identified that the cartridge has reached the end of its useful life. The LED may also be on if the end-point detector is disconnected from the control unit.
3	Flow fault	This red LED is on when the corresponding end-point detector does not work correctly; that is, that the corresponding end-point sample pump is not operating or the manual isolation-valves are closed or the sample pipeline is blocked.
4	Temperature	This red LED is on when there is a temperature fault; that is, the temperature of the corresponding cartridge is outside the correct operating temperature range.
4	Air pressure	This red LED is on when the pressure of the compressed air supply is too low or when the safety interlock key is in the cartridge change position.
4	MCB	This red LED is on when the electrical circuit breaker has switched off the GRC heaters due to an electrical overload.
4	Spare	This red LED is spare and can be used to display other system status information.
4	Leak test fail	This amber LED flashes during the leak test of a newly fitted cartridge. The LED will go permanently on if the leak test fails.

Table 2 - Status display LEDs

Figure 6 key	LEDs Name	Meaning
4	Preheat on	This amber LED is on when the available cartridge is being preheated.
4	Warning level 1	This red LED goes on when there is a warning level 1 condition: see Section 4.6.
4	Warning level 2	This red LED goes on when there is a warning level 2 condition: see Section 4.6.
4	Alarm	This red LED goes on when there is an alarm condition; that is, the pump start valve is open and process gases are not treated by the D150: see Section 4.6.
5, 9	Nitrogen purge valve open	This green LED is on when the corresponding GRC nitrogen purge valve is open; that is, the cartridge is being purged or leak tested.
6, 7	Changeover valve	One of these green LEDs is on when the changeover valve directs the process gases to the corresponding GRC.
8	Pump start	This red LED is on when the pump start valve is open; that is, process gases are not treated by a GRC cartridge but are directed directly to the D150 outlet.
10, 11	High pressure	These red LEDs go on if the corresponding pressure-switch detects a high pressure level in the on-line GRC: see Section 1.5.2.
10, 11	Warn pressure	These amber LEDs go on if the corresponding pressure-switch detects a warning pressure level in the on-line GRC: see Section 1.5.2.

Table 2 - Status display LEDs (continued)



1. Cartridge status LEDs
2. Outlet isolation-valve LED
3. End-point detector status LEDs
4. System status LEDs
5. Purge valve LED (GRC2)
6. Inlet valve LED (GRC2)
7. Inlet valve LED (GRC1)
8. Pump start LED
9. Purge valve LED (GRC1)
10. Pressure status LEDs (GRC1)
11. Pressure status LEDs (GRC2)

Figure 6 - Control panel status display

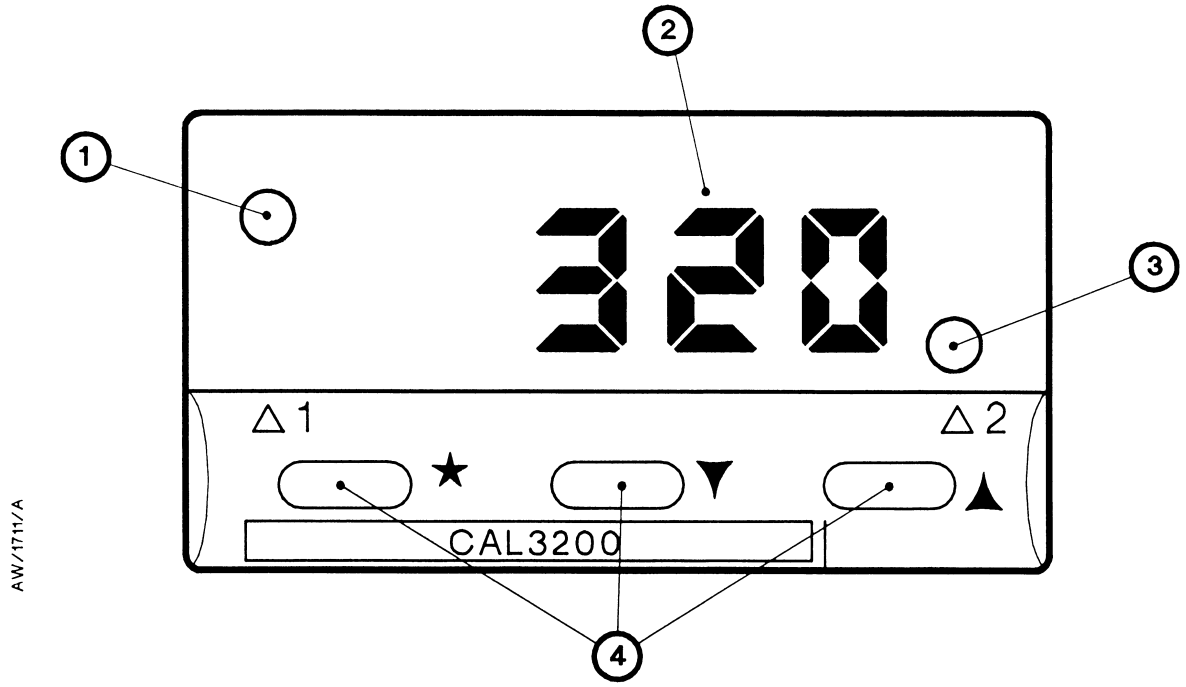
1.8.3 Cartridge temperature controllers

Each of the two GRCs has two cartridge temperature controllers. One of the two cartridge temperature controllers is shown in Figure 7. The two controllers for each GRC monitor the outputs of the upper and lower cartridge thermocouples to determine the temperature of the cartridge and to switch the heaters on and off to maintain the cartridge in the GRC at the required temperature. The green heater LED(1) goes on when power is supplied to the cartridge heaters.

The cartridge temperature (in ^{o}C) is shown on the controller (2).

The GRC is supplied with set-points in the temperature controllers preset for your application. If the temperature of the cartridge is too far above or below the preset set-point, the red alarm LED on the appropriate controller (3) goes on. If necessary, you can adjust the temperature set-point: refer to Section 5.8.

The controller will also display error messages (for example, if it is disconnected from the thermocouples): refer to Section 5.10.



1. Heater LED
2. Temperature indicator
3. Temperature alarm LED
4. Control buttons

Figure 7 - Cartridge temperature controller

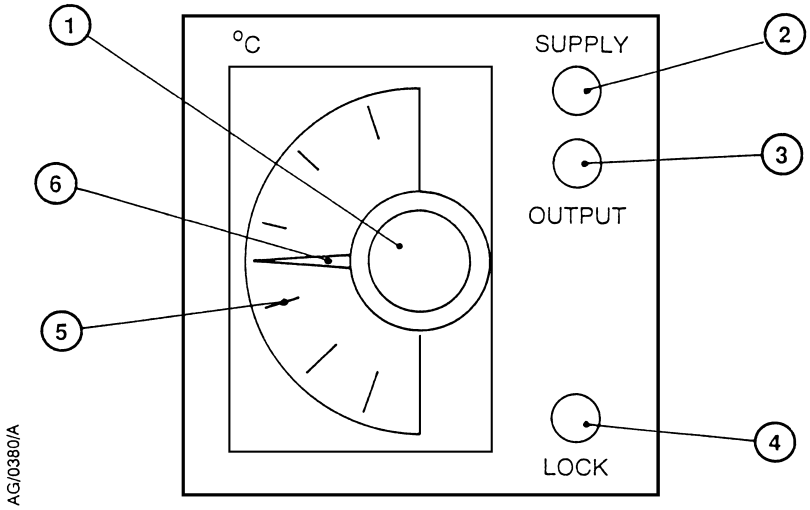
1.8.4 Heater controllers

Inside the control unit (see Figure 16) are two identical heater controllers, one for each GRC. One of the heater controllers is shown in Figure 8.

The heater controllers operate as safety devices to switch off the heaters to prevent over-temperature damage to the heater unit and cartridge.

The required maximum operating temperature is shown by the pointer (6) on the temperature display (5). A red LED on the controller (2) goes on when the electrical supply to the controller is on; a green LED (3) goes on when the heaters are on. When the heater output LED (3) is off, the heaters are switched off.

The GRC is supplied with the heater controllers preset to the correct temperature for your application. If necessary, you can adjust the temperature: refer to Section 5.9.



1. Temperature adjuster
2. Electrical supply LED (red)
3. Heater output LED (green)
4. Lock
5. Temperature scale
6. Pointer

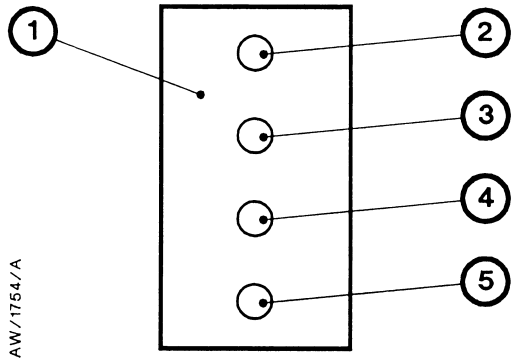
Figure 8 - Heater controller

1.9 End-point detector indicators and controls: optional

The end-point detector electronics boxes in the D150 enclosure (Figure 3, items 32) have four indicator LEDs: refer to Figure 9. These LEDs identify the status of the end-point detector, as shown below:

- Sample pump LED (2) — This LED is on when the sample pump operates.
- Flow fault LED (3) — This LED is on when the end-point detector does not sample the cartridge exhaust gases correctly. When this LED is on, the corresponding flow fault LED on the control unit status display will also be on.
- Breakthrough LED (4) — This LED is on when breakthrough is indicated. When this LED is on, the corresponding breakthrough LED on the control unit status display will also be on.
- Power LED (5) — This LED is on when the electrical supply to the end-point electronics box is on.

The end-point detector box also has a pump test button (Figure 3, item 36). When the corresponding GRC is off-line, press this button to test for correct operation of the end-point sample pump.



1. End-point detector electronics box
2. Sample pump LED
3. Flow fault LED
4. Breakthrough LED
5. Power LED

Figure 9 - End-point detector LEDs: optional

1.10 TMS (Temperature Management System): optional

Note: The following section describes the TMS components which are fitted in the D150 enclosure if you have ordered the D150 with a TMS. You must also fit TMS components to the pipeline between the pumping system outlet and the D150 inlet: see Section 3.16.

If you have ordered the D150 with a TMS, the D150 will be supplied with the TMS components fitted in the D150 enclosure. These components are described below:

Heaters and thermocouples

Pipe heaters are fitted to the pipelines between the D150 inlet and the two GRC cartridge inlets, as shown in Figure 11, detail A. A thermocouple is fitted to teach of the cartridge inlet pipelines, under the pipe heaters.

Insulation jackets

Pipe and elbow insulation jackets are fitted to the pipelines between the D150 inlet and the two GRC cartridge inlets, as shown in Figure 11, detail B.

Distribution units

The D150 enclosure is fitted with three TMS distribution units (refer to Figure 10) connected to the TMS temperature controllers in the control unit:

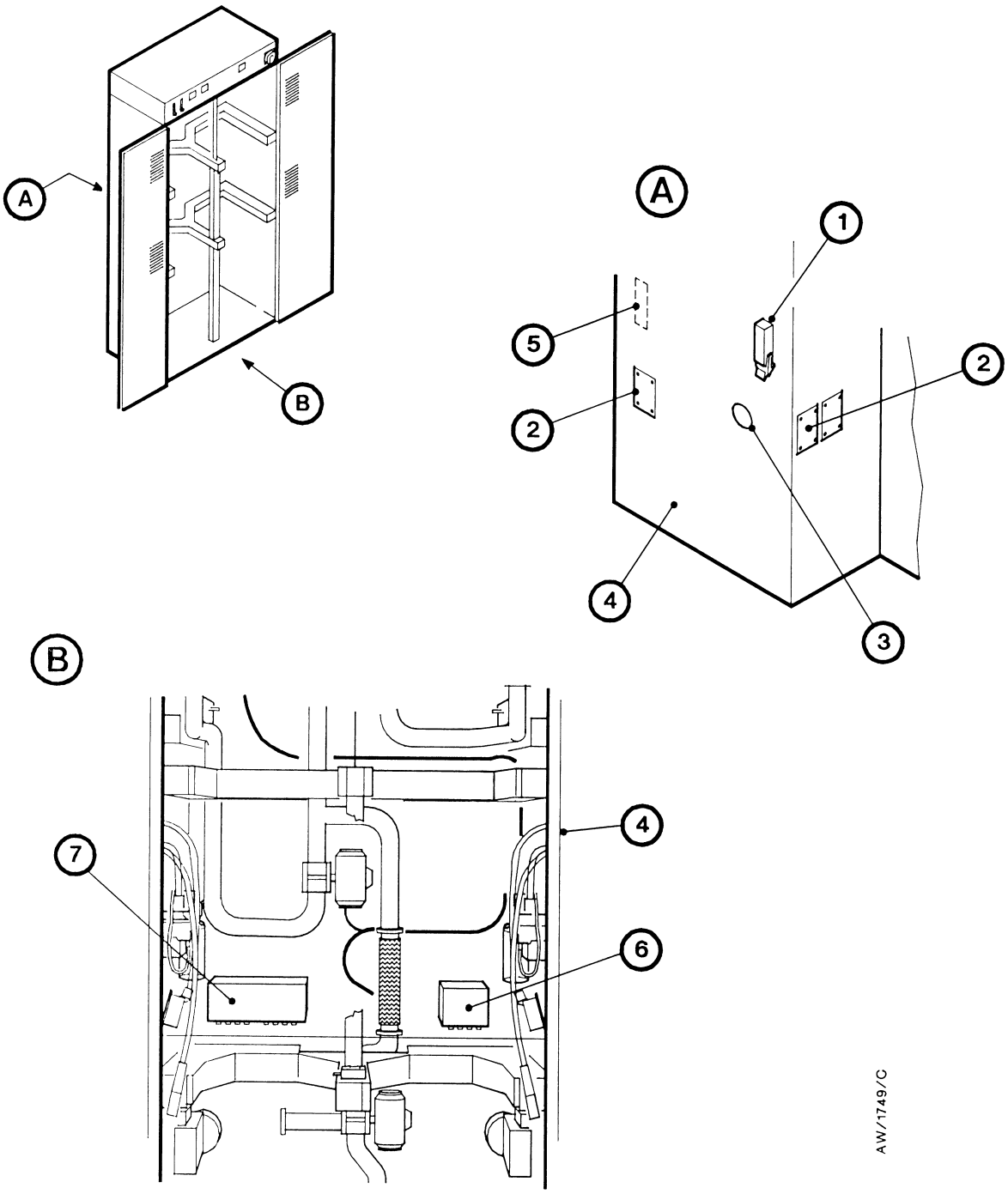
- One distribution unit (6) provides the electrical supplies for the pipe heaters fitted to the GRC2 inlet pipeline and is connected to the thermocouple on the pipeline.
- One distribution unit (8) provides the electrical supplies for the pipe heaters fitted to the GRC1 inlet pipeline and is connected to the thermocouple on the pipeline.
- The third distribution unit (7) provides the electrical supplies for the pipe heaters on the D150 inlet and the electrical supplies for the pipe heaters that you will install on the pipeline between the pumping system exhaust and the D150 inlet.

TMS temperature controllers

Two TMS temperature controllers in the control unit (Figure 5, item 3) monitor the thermocouples and switch the pipe heaters on and off to maintain the pipelines at the required temperature:

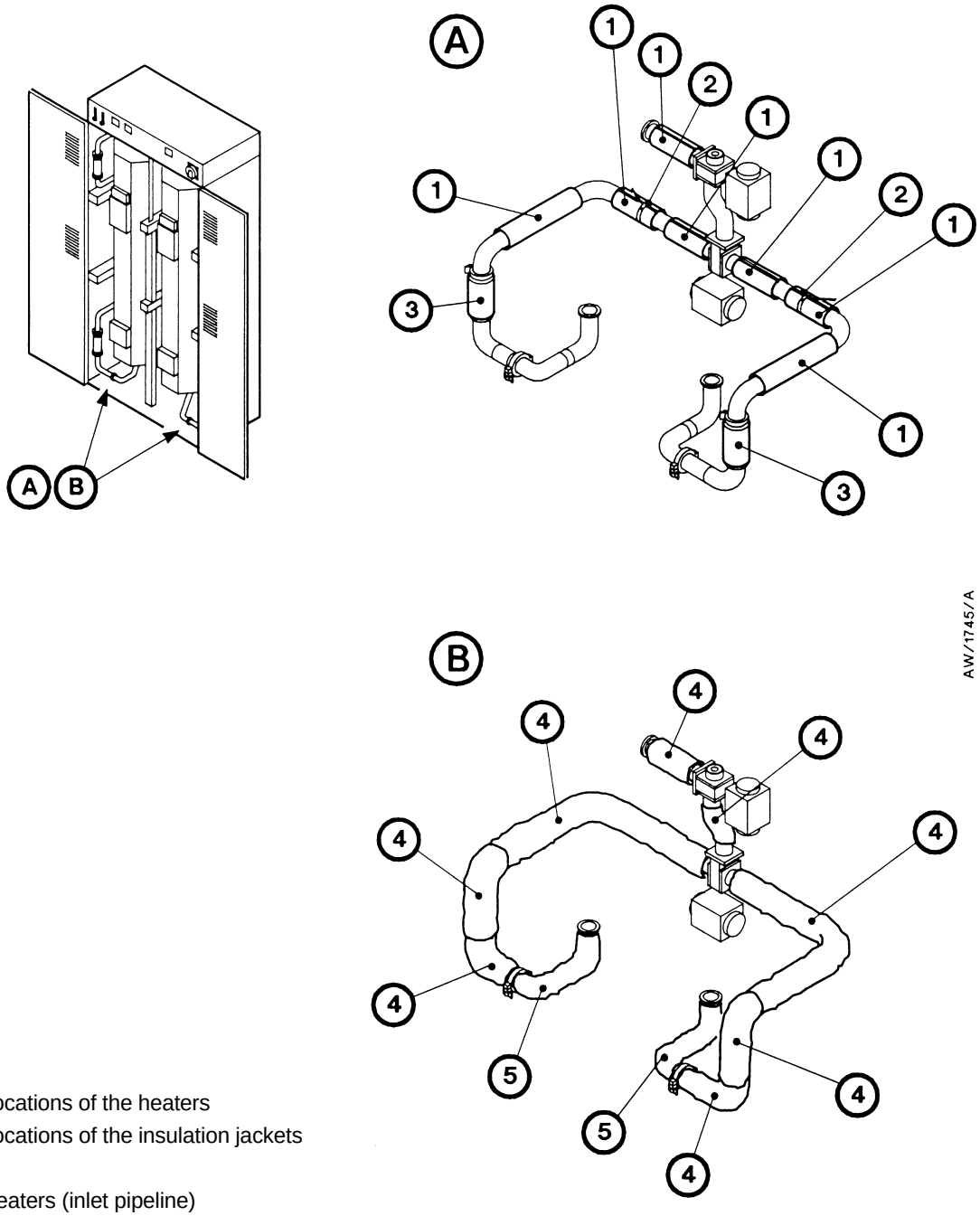
- The upper controller controls the temperature of the D150 inlet and the temperature of the pipeline between the pumping system outlet and the D150 inlet. When you install the D150, you must fit the necessary TMS components to this pipeline: see Section 3.16.
- The lower controller controls the temperature of the pipeline between the D150 inlet and the on-line GRC cartridge inlet.

Operation of the controls on the TMS temperature controllers is identical to the operation of the GRC cartridge temperature controllers: refer to Section 1.8.3.



1. TMS connector
2. Blanking plate over alternative D150 inlet leadthrough hole
3. D150 inlet leadthrough hole
4. Enclosure
5. Alternative TMS connector position
6. Distribution unit: GRC2 inlet pipeline heaters
7. Distribution unit: pumping system outlet and D150 inlet pipeline heaters
8. Distribution unit: GRC1 inlet pipeline heaters

Figure 10 - TMS distribution units and electrical connector: optional



A Locations of the heaters
B Locations of the insulation jackets

1. Heaters (inlet pipeline)
2. Thermocouples (under heaters)
3. Heaters (flexible bellows)
4. D150 inlet pipe insulation jackets
5. Cartridge inlet insulation jackets

Figure 11 - TMS heaters and insulation jackets: optional

1.11 Cartridge change cart

You must have at least one cartridge change cart to allow you to change cartridges; refer to Section 7 for the Item Number of the cartridge change cart.

Refer to Figure 12. The cartridge change cart allows you to remove a heater unit from the D150 enclosure, to replace a used cartridge in the heater unit with a new cartridge and to refit the heater unit in the D150 enclosure:

- The cart is used in the upright position (detail A) to remove a heater unit from the enclosure, to move it to the area where you will change the used cartridge and, after you have replaced a cartridge, to refit the heater unit in the enclosure.
- The cart is turned to the horizontal position (detail B) to remove the used cartridge from the heater unit and to fit the new cartridge in the heater unit.

The base of the cart has castors (4) so that you can move the cart. Two of the castors have brakes to secure the cart in its required location.

A catch (3) on the lower frame of the cart secures the upper frame (on which the heater unit rests) in its vertical or horizontal position. When you turn the cart into the horizontal position (as in detail B), the safety legs (5) automatically drop into place to support the upper frame of the cart.

The catch (2) on the upper frame secures the heater unit in place on the cart. The roller (1) supports the end of a cartridge when you fit a new cartridge in the heater unit.

Alignment blocks (6) on the upper frame allow you to correctly orient the new cartridge in the heater unit, so that the cartridge outlet elbow aligns with the GRC1 or GRC2 outlet pipeline in the D150 enclosure.

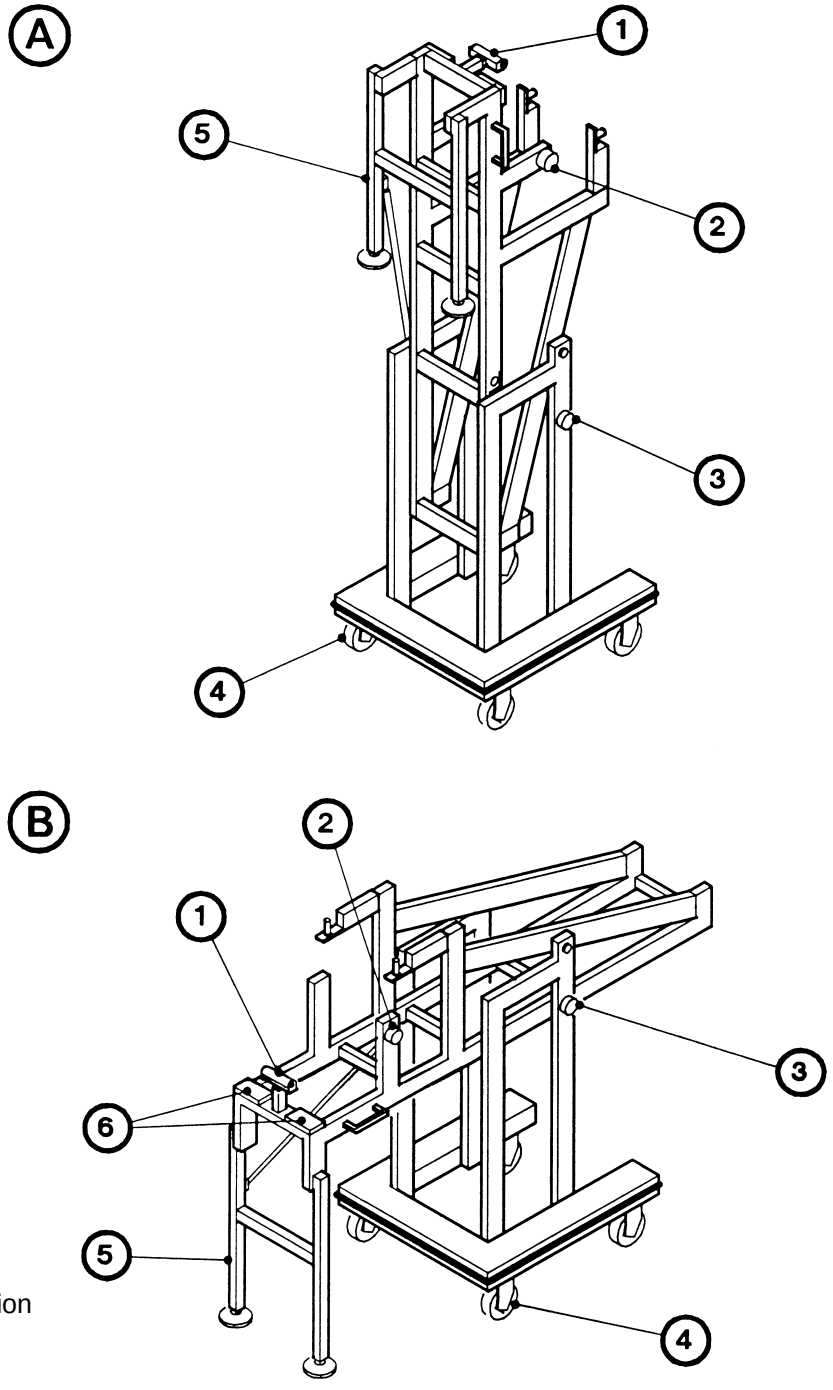
For full instructions on the use of the cart, refer to Section 5.4.

1.12 Electrical supply and compressed air supply failure

If the electrical supply and / or compressed air supply to the D150 fails:

- The D150 will remain in the same operating condition as it was before the supply failure; that is, none of the valve positions will change.
- If the electrical supply has failed, the on-line GRC will continue to effectively treat the process gases for at least half an hour, due to the thermal inertia of the D150.

However, note that the D150 cannot detect or respond to a blockage in the exhaust-extraction pipeline or a pressure rise in the D150 pipelines during an electrical supply or compressed air supply failure. You must therefore install suitable safety devices in your system: refer to Section 3.2.



A In upright position
B In horizontal position

1. Roller
2. Heater unit catch
3. Cart frame catch
4. Castors
5. Safety legs
6. Alignment blocks

Figure 12 - Cartridge change cart

2 TECHNICAL DATA

Note: Unless otherwise specified, technical data in the following sections is applicable to both GRC heater units.

2.1 Operating conditions and performance

Total process gas flow rate	
Minimum	5 slm
Maximum	60 slm
Time to warm up to operating temperature	approximately 5 hours
Cartridge capacity	Halogen equivalent to 2000-2500 litres of chlorine
Operating environment	Suitable for indoor use only
Operating ambient temperature range	5 to 40 ^{o}C
Operating ambient humidity range	30 to 95% RH, non condensing
Minimum air-extraction flow rate	500 m^3h^{-1}

2.2 Mechanical data

Dimensions	See Figures 13 and 14
Mass	
D150 enclosure (without heater units and cartridges)	180 kg
Heater unit (without cartridge)	62 kg
C150Y cartridge (unused)	40 kg
Total (D150 enclosure with two heater units and two cartridges)	384 kg

2.3 Electrical data

Note: The average operating power depends on the gas flow through the cartridge of the on-line GRC.

Average operating power (at operating temperature)	0.7 to 1 kW (see Note above)
Voltage and frequency	200 V a.c. 50/60 Hz or 208 V a.c. 60 Hz or 380/415 V a.c. 50 Hz
Number of phases	
200-208 V supply	3 phases and earth (ground)
380-415 V supply	3 phases and neutral and earth (ground)
Maximum current rating per phase	
200/208 V supply	Fuse to 25 A
380/415 V supply	Fuse to 16 A

Remote input †	
Number of signals	1
Signal type	External switched voltage
Remote alarm outputs	
Number of signals	3
Signal type	Volt-free switched contacts
Fuse ratings	
FS1	1 A
FS2	1 A
FS3	50 mA
FS4	4 A
FS5*	4 A
FS6*	4 A
FS7*	250 mA
FS8*	10 A
Thermal fuse fail temperatures	
Heater unit	184 ^{o}C
Enclosure	91 ^{o}C

2.4 Gas supplies

Note: Your nitrogen and compressed air supplies must be clean and dry.

Compressed air supply pressure	4 to 5 bar gauge, 5 to 6 bar absolute, 4×10^5 to 6×10^5 Pa, 72.5 to 87 psi
Nitrogen supply pressure	1.5 to 2 bar gauge, 2.5 to 3 bar absolute, 2.5×10^5 to 3×10^5 Pa, 36.25 to 43.5 psi
Pressure-switch purge flow rate	100 $l.h^{-1}$
Cartridge purge flow rate	0.6 to 0.75 m^3h^{-1}#

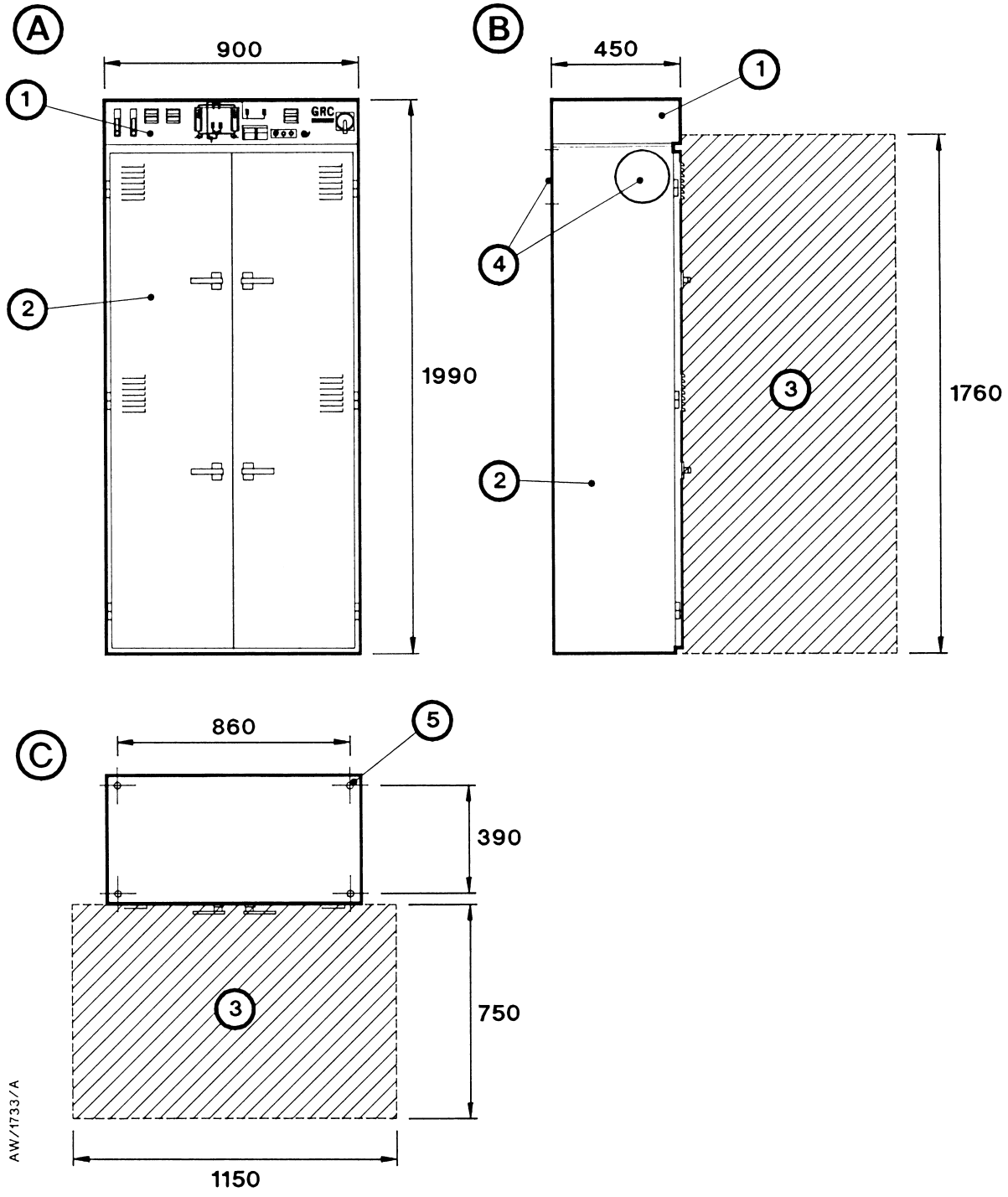
2.5 End-point detector: optional

Type	Acid gas content analyser
Sensitivity	100 ppm hours (cumulative)
Fluid	
Type	Deionised or demineralised water
Conductivity	0.2 to 5.0 $\mu S.cm^{-1}$
Bottle fluid charge	450 ml

† The D150 must be configured to use the remote inputs: refer to Section 1.2.5.

* Only applicable if you have a TMS fitted to your D150.

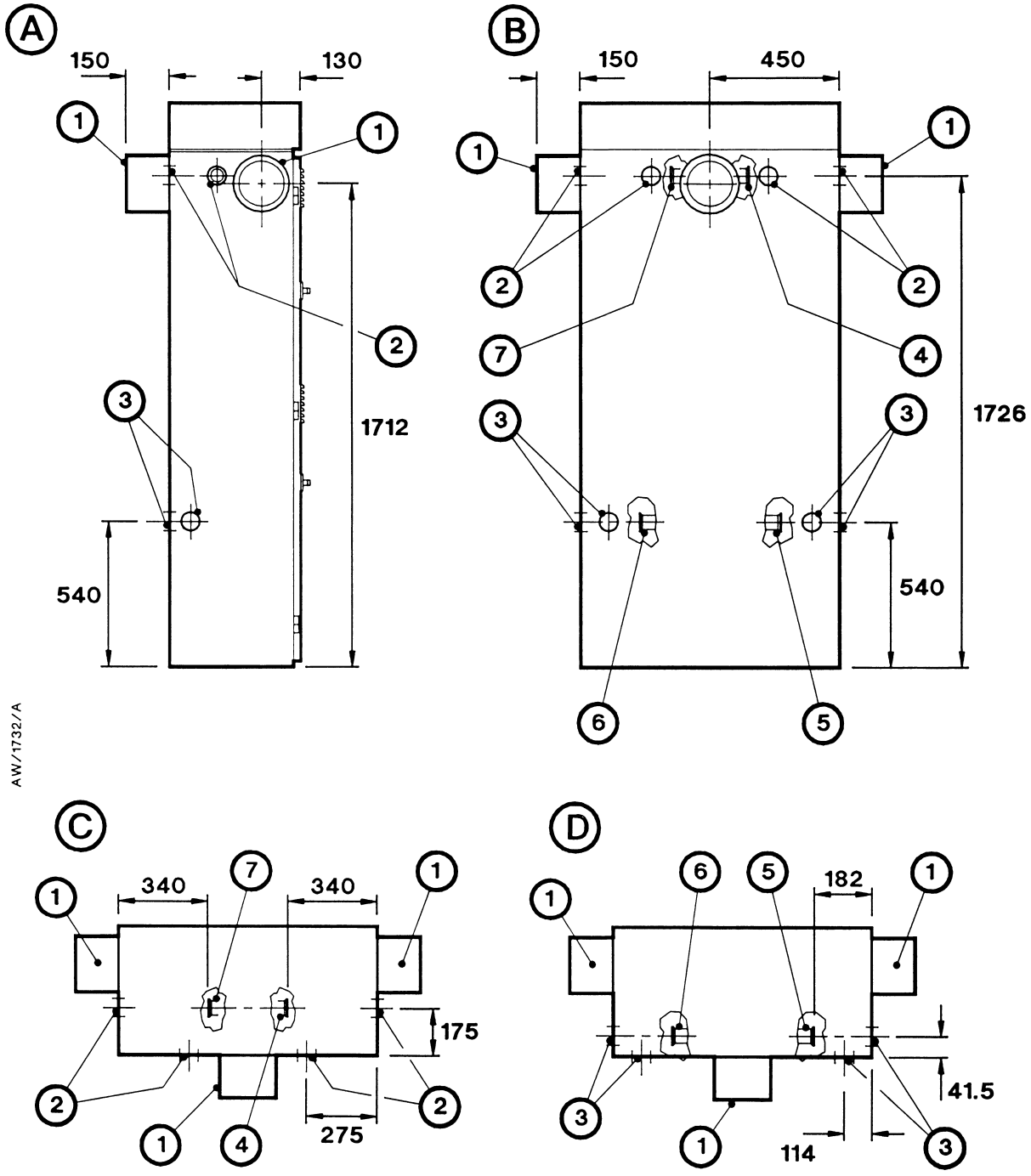
The purge flow is only on if the off-line cartridge is being purged and cooled, or if a newly fitted cartridge is being leak tested.



A Front view
B Side view
C Top view of base of enclosure

1. Control unit
2. D150 enclosure
3. Area required to remove heater unit (to change the cartridge)
4. Air-extraction flange
5. Fixing hole: ∅10

Figure 13 - D150 enclosure dimensions (mm)



A Side view
B Rear view
C Top view of outlet positions
D Top view of inlet positions

1. Optional air-extraction flange positions
2. Optional outlet pipe leadthrough positions
3. Optional inlet pipe leadthrough positions
4. D150 outlet-flange position (as supplied)
5. D150 inlet-flange position (as supplied)
6. Optional inlet-flange positions
7. Optional outlet-flange positions

Figure 14 - D150 connections dimensions (mm)

2.6 Manufacturing materials

Enclosure	Welded mild steel, epoxy-polyester powder painted
Cartridge body	Welded stainless steel
Vacuum pipelines	Stainless steel
Vacuum seals	
'O' rings	Fluoroelastomer
Carriers	
Inner	Stainless steel
Outer	Aluminium

2.7 Connections

GRC inlet and outlet	NW40
Cartridge inlet and outlet	NW40
Air extraction flange	150 diameter x 150 deep
Control unit	
Electrical supply cable gland	Suitable for 5-core double insulated cable; maximum wire size 4 mm^2
Compressed air supply connector	$^1/_4$ inch Swagelok
Nitrogen supply connector	$^1/_4$ inch Swagelok
Remote alarm electrical connector	9-way D type plug
Remote input connector	6-way DIN

3 INSTALLATION

3.1 Safety

> WARNING
>
> Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment.

- A suitably trained and supervised technician must install the D150.
- Ensure that the installation technician is familiar with and complies with the safety procedures which relate to the products processed by the pumping system.
- Vent and purge the process system before you start any installation work.
- Leak-test the system after installation and maintenance to prevent leakage of dangerous substances out of the system and leakage of air into the system.

3.2 System design

> WARNING
>
> If the flow of untreated process gas into your exhaust-extraction system may result in a hazardous situation, you must incorporate suitable safety features in your control system.

> CAUTION
>
> The design of the exhaust-extraction system must prevent the drainage of moisture or condensation in the exhaust-extraction pipeline into the D150 pipelines. If it does not, the D150 may be blocked or corroded.

Connect the D150 **as close as possible** to the outlet of the pumping system in order to ensure the immediate treatment of the exhaust gases. If the pipeline which connects the pumping system to the D150 is long, there will be a large volume of pipeline in which solids can be deposited, corrosion can occur and flammable exhaust gases may collect.

On certain processes, you will need to heat the pipeline between the pumping system outlet and the D150 inlet to prevent condensation of solids. If you use the D150 in one of these types of processes:

- You should have ordered a Temperature Management System (TMS) to be factory fitted to your D150 (see Section 1.10).
- You must fit additional TMS components to the pipeline between the pumping system outlet and the D150 inlet (see Section 3.16).

If you wish to connect more than one pumping system to the D150, you must:

- Ensure that the total gas flow does not exceed 60 slm.
- Ensure that it is safe to combine the exhaust gases from the pumping systems; for example, you must not mix silane with air, chlorine or NF_3, or NH_3 with NF_3.
- Obtain advice from Edwards; use form GRC1 at the end of this manual.

You must incorporate suitable safety devices in your control system to:

- Stop the flow of process gas to the D150, if failure of the D150 and the subsequent flow of untreated process gas into the exhaust-extraction system may result in a hazardous situation.
- Switch off the pumping system if a dangerous pressure rise is detected in the pipeline between the pumping system and the D150, when the D150 electrical supply has failed.

The exhaust gas from the D150 will be hot (approximately 50 ^{o}C), but the thermal capacity of the gas is usually low so the gas will cool very quickly. The first two metres of the pipeline from the outlet of the D150 to the exhaust-extraction system must therefore be metal. After two metres, the gas will be at approximately ambient temperature; it is therefore acceptable to use a fibreglass or plastic pipeline.

The design of the exhaust-extraction system must prevent the drainage of moisture or condensation in the exhaust-extraction pipeline into the D150 pipelines. Water above the outlet-valves will enter the D150 pipelines if one of the outlet-valves is opened and could react with the exhaust gases or deposits in the pipeline and cause blockage or corrosion.

3.3 Unpack and inspect

Note: Cartridges (in packs of two or five) are supplied in a separate package.

Each D150 is supplied mounted on a mini-pallet. The D150 and mini-pallet are mounted on a large pallet and enclosed by packaging which is secured by spring clips and steel bands. Use the following procedure to unpack and inspect a D150.

1. Use the lifting points provided to turn the package into the upright position.
2. Remove the three steel bands which secure the package.
3. Use an appropriate tool to release the spring clips and remove the top panel of the package.
4. Release the spring clips on the side panels (remove the centre spring clips last) and remove the side panels.
5. Use a fork-lift truck to remove the D150 (on the mini-pallet) from the large pallet.
6. Remove the plastic wrapping from the D150 and open the right-hand door of the enclosure.
7. Push the rod on the door lock (Figure 3, item 23) and open the left-hand door of the enclosure.
8. Refer to Figure 15. Remove the transit supports (6) from under the heater units and remove the two packages which are behind the transit supports.
9. Remove the two packages from the top of the heater units.
10. Inspect the enclosure and the components in the packages. If any of the equipment is damaged, notify your supplier and the carrier in writing within three days; state the Item Number and Serial Number of the D150 together with your order number and your supplier's invoice numbers. Retain all packing materials for inspection. Do not use the D150 if it is damaged.
11. Check that you have received the items listed in Table 3. If any of these items is missing, notify your supplier in writing within three days. If the D150 is not to be used immediately, replace the protective covers and packaging. Store the D150 in suitable conditions as described in Section 6.

Qty	Description	Check (✓)
1	D150 enclosure (with all pipelines, heaters and control unit)	❑
4	NW40 clamping rings	❑
4	NW40 trapped 'O' rings	❑
1	Cartridge change handle	❑
1	Air-extraction flange	❑
1	Temperature Management System instruction manual*	❑
2	Heater unit top-plates	❑
1	Bottle of end-point detector fluid	❑
Fitting-kit, which contains:		
4	Button lock / safety interlock keys	❑
2	Temperature controller hexagonal keys	❑
2	184 ^{o}C thermal fuses	❑
1	91 ^{o}C thermal fuse	❑
2	1 A fuses	❑
2	4 A fuses	❑
2	50 mA fuses	❑
2	10 A fuses*	❑
2	250 mA fuses*	❑
1	Cartridge temperature controller instruction manual	❑
1	Spare end-point detector bottle†	❑

* If you have ordered the D150 with a TMS: see Section 1.10.

† If you have ordered the D150 with an end-point detector: see Section 1.9.

Table 3 - Checklist of enclosure package components

3.4 Locate the D150 enclosure

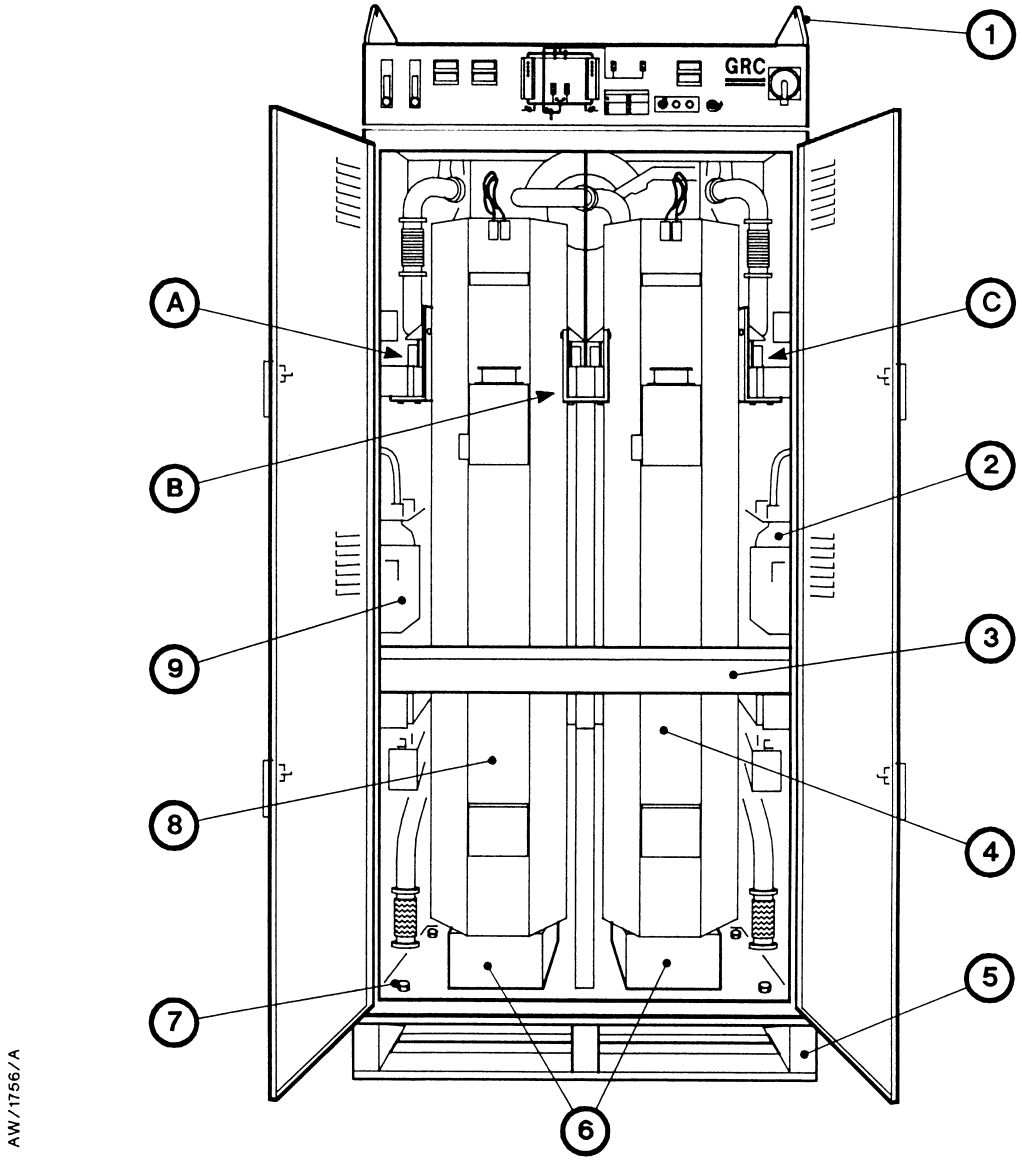
> WARNING
>
> Use suitable lifting equipment to move the D150. The mass of one D150 with two heater units fitted is 304 kg.

Before you install the D150, prepare a suitable base for the D150 enclosure. The base must be firm and level and you must leave enough space to enable the heater unit to be easily moved into and out of its operating position: see Figure 13. Do not allow debris to get into the D150 or the pipelines when you install the D150.

1. Refer to Figure 15. Remove the four screws (7) which secure the D150 enclosure to the mini-pallet (5).
2. Refit the transit supports (6) in the enclosure, under the heater units.
3. Push the rod on the door lock (Figure 3, item 23) and close the left-hand door of the enclosure, then close the right-hand door of the enclosure.
4. Attach suitable lifting equipment to the lifting brackets (1) and move the D150 enclosure into its final operating position. Ensure that there is enough space in front of the enclosure for you to easily remove the heater units (see Figure 13).
5. Use suitable bolts through the four fixing-holes in the base of the enclosure(s) to secure the enclosure in position (see Figure 13).
6. Undo the bolts which secure the lifting brackets (Figure 15, item 1) to the sides of the enclosure and remove the lifting brackets. Retain the lifting brackets for future use.

3.5 Remove the transit brackets and level the enclosure

1. Open the right-hand enclosure door.
2. Push the rod on the door lock (Figure 3, item 23) and open the left-hand door of the enclosure, then close the right-hand door of the enclosure.
3. Refer to Figure 15. Remove the wooden cross-member (3) and the transit supports (6) from the enclosure.
4. Refer to detail B. Remove the nut, bolt and washer (19) which secure the centre transit bracket (17) to the roller carriage (12) of the GRC1 heater unit.
5. Remove the nut, bolt and washer (16) which secure the centre transit bracket (17) to the roller carriage (15) of the GRC2 heater unit.
6. Remove the two nuts, bolts and washers (20) which secure the centre transit bracket (17) to the enclosure centre frame (18) and remove the transit bracket.
7. Refit the two bolts, washers and nuts (20) to the enclosure centre frame (18).



1. Lifting bracket
2. Right-hand enclosure side
3. Wooden cross-member
4. Heater unit (GRC2)
5. Mini-pallet
6. Transit supports
7. Bolt (4 off)
8. Heater unit (GRC1)
9. Left-hand enclosure side
10. Bolt
11. Left-hand transit bracket
12. Roller carriage (GRC1)
13. Nut, bolt and washer
14. Heater support frame
15. Roller carriage (GRC2)
16. Nut, bolt and washer
17. Centre transit bracket
18. Centre heater support frame
19. Nut, bolt and washer
20. Bolts
21. Bolt
22. Heater support frame
23. Bolt and washer
24. Right-hand transit bracket

Figure15 - Remove the transit brackets: sheet 1 of 2

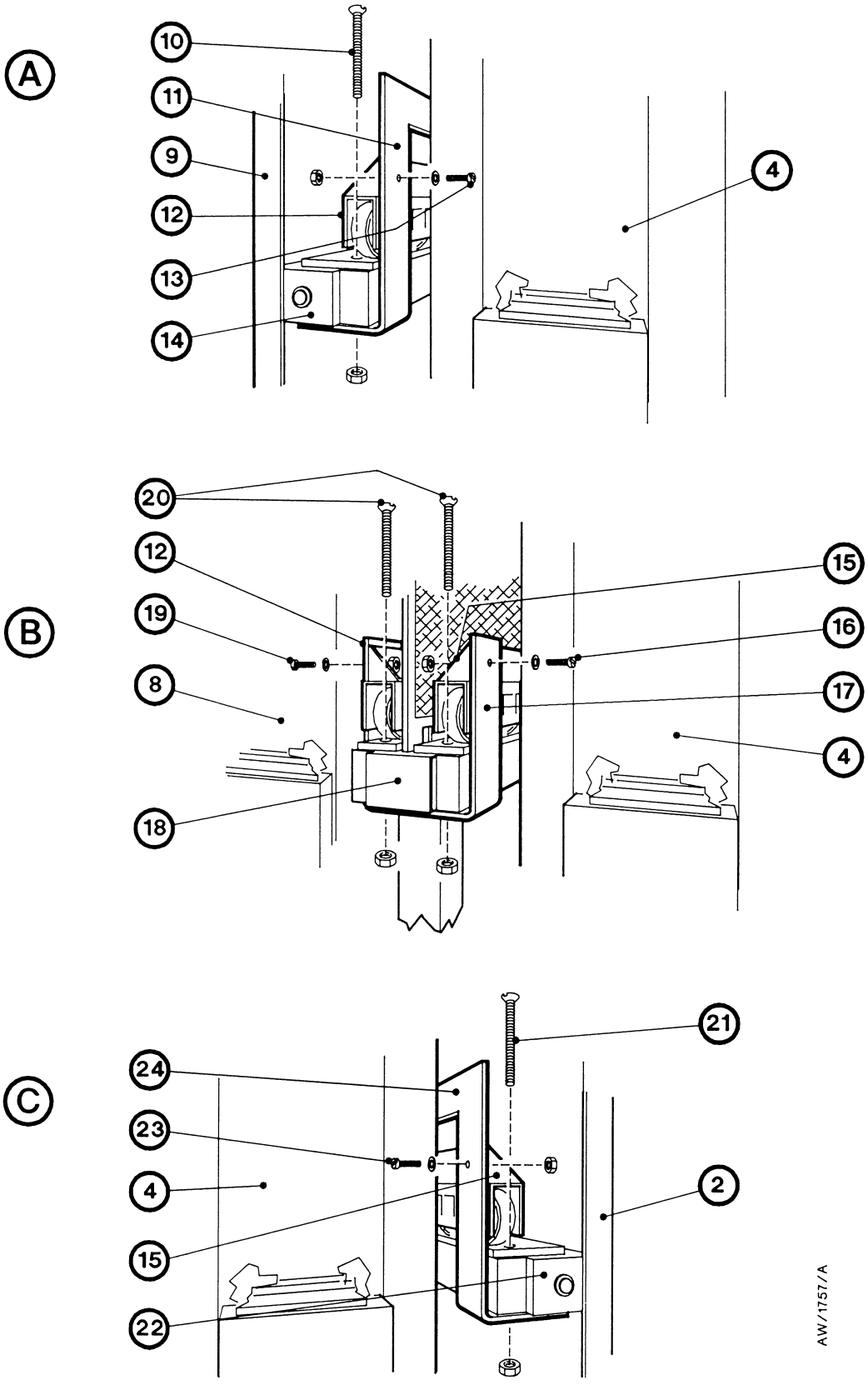


Figure 15 - Remove the transit brackets: sheet 2 of 2

8. Refer to detail A. Remove the nut, bolt and washer (13) which secures the transit bracket (11) to the roller carriage (12) of the GRC1 heater unit (4).

9. Remove the nut, bolt and washer (10) which secure the transit bracket (11) to the side frame (14) of the enclosure and remove the transit bracket.

10. Refit the nut, bolt and washer (10) to the side frame (14) of the enclosure.

11. Refer to detail C. Remove the nut, bolt and washer (23) which secure the transit bracket (24) to the roller carriage (15) of the GRC2 heater unit (4).

12. Remove the bolt, nut and washer (21) which secure the transit bracket (24) to the side frame (22) of the enclosure and remove the transit bracket.

13. Refit the bolt, nut and washer (21) to the side frame (22) of the enclosure.

14. If necessary, place plates under the enclosure so that the two heater units hang vertically in the enclosure and so that the gaps between the heater units and the sides of the enclosure are equal.

3.6 Connect the remote alarm outputs (if required)

WARNING

If the flow of untreated process gas into your exhaust-extraction system may result in a hazardous situation, you must incorporate suitable safety precautions in your control system.

Notes: Table 4 shows the default warning and alarm conditions which are preset in the D150 when supplied. These conditions can be configured; if you want to change the alarm and warning conditions, contact your supplier or Edwards for advice.

A warning or alarm condition will also cause the appropriate LED(s) to go on: refer to Table 2 and to Section 4.6.

The top panel of the control unit has a 9-pin remote alarm connector (Figure 16, item 7). Pins in this connector are connected to contacts which are open or closed when a fault is present, as shown in Table 4.

If required, you can interlock these signals to your process system, central control or to the safety system. A mating socket is supplied with the D150. If you use the remote alarm output signals, you should respond to the signals as described in Section 4.6.

Fault type	Fault condition	Open contacts	Closed contacts
Warning level 1	End-point detector flow fault, pressure warning, leak test failed, cartridge awaiting change.	Pins 4 and 9	Pins 4 and 5
Warning level 2	High pressure, circuit breaker tripped, compressed-air supply failure, temperature fault.	Pins 7 and 3	Pins 7 and 8
Alarm	The pump start valve is open	Pins 1 and 6	Pins 1 and 2

Table 4 - Alarm and warning conditions

3.7 Connect the remote inputs (if required)

The top panel of the control unit has a 6-pin remote input connector (Figure 16, item 8). The D150 can be supplied configured to use the signals on the pins in this connector; for example, a remote pump start signal can be used to select the pump start valve open.

If your D150 is configured to use the remote inputs, use the mating socket supplied to connect your control system to the D150 control unit.

3.8 Connect the gas supplies

Note: Your nitrogen and compressed air supplies must be clean and dry and must meet the specification in Section 2.

1. Switch off the electrical supply to the D150.
2. Refer to Figure 16. Connect your compressed air supply pipe to the $^{1}/_{4}$ inch Swagelok compressed air supply connector (9) on the top of the control unit. Do not switch on the compressed air supply yet.
3. Connect your nitrogen supply pipe to the $^{1}/_{4}$ inch Swagelok nitrogen supply connector (10) on the top of the control unit. Do not switch on the nitrogen supply yet.

3.9 Connect the electrical supply

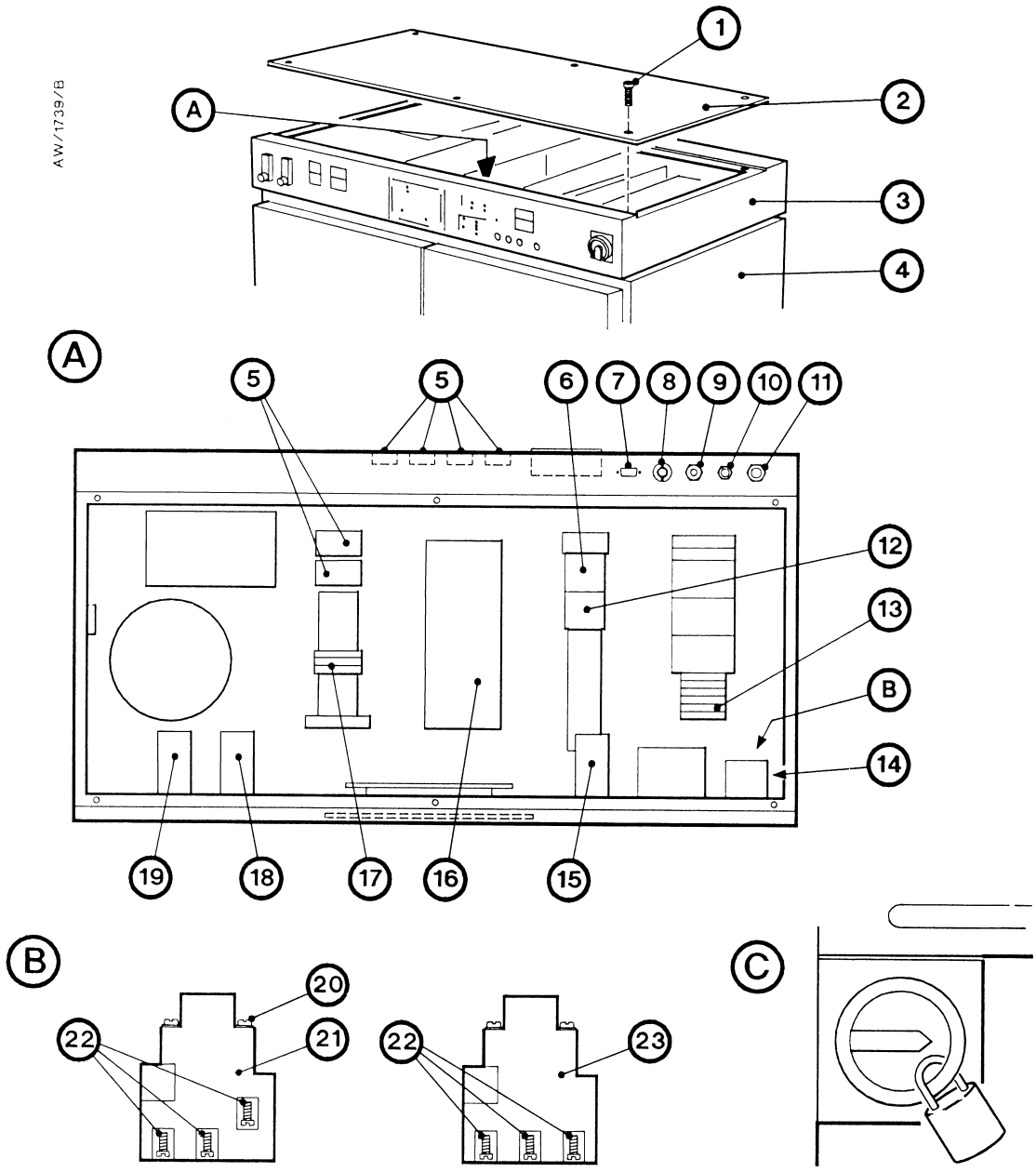
Use the following procedure to connect the electrical supply to the control unit. Connect the electrical supply through a suitably fused isolator.

1. Refer to Figure 16. Undo and remove the six bolts (1) which secure the top panel (2) to the control unit, then remove the top panel.
2. Pass your electrical supply cable through the cable gland (11) on the top of the control unit.
3. Refer to detail B. Connect the three phase wires of the electrical supply cable to the phase connections (22) on the electrical supply isolator (21 or 23) inside the control unit.
4. If your electrical supply is 380-415 V, connect the neutral wire of the electrical supply cable to the neutral connection (20) on the electrical supply isolator (21).
5. Connect the ground (earth) wire of the electrical supply cable to the earth terminal block (14).
6. Tighten the cable gland strain-relief screws.
7. Refit the top panel (2) to the control unit and secure with the six bolts (1). Do not switch on the electrical supply yet.

3.10 Remove a heater unit from the enclosure

Note: The D150 enclosure is supplied with the inlet pipeline configured to be at the left or the right of the enclosure. If your D150 has the inlet at the left of the enclosure, remove the GRC1 heater unit from the enclosure. If your D150 has the inlet at the right of the enclosure, remove the GRC2 heater unit from the enclosure.

1. Ensure that none of the electrical connectors (Figure 19, items 2, 3, 8 and 9) are connected to the heater units, then switch on the electrical supply. Check that the pump start LED (Figure 6, item 8) goes on to indicate that the pump start valve is open.
2. Carefully remove the heater unit from the enclosure as described in Section 5.4.3, steps 9 to 14.



A Interior of the control unit
B Electrical supply isolator
C Lockout position

1. Bolt
2. Top cover
3. Control unit
4. GRC enclosure
5. Solid-state relays
6. Heater controller (GRC2)
7. Remote alarm connector
8. Remote input connector
9. Compressed-air supply connector
10. Nitrogen supply connector
11. Electrical supply cable-gland
12. Heater controller (GRC1)
13. Fuses 1 to 6
14. Earth (ground) terminal (under item 21 or 23)
15. Cartridge temperature controllers (GRC2)
16. PLC
17. Fuses 7 and 8
18. Cartridge temperature controllers (GRC1)
19. TMS temperature controllers*
20. Neutral electrical supply connection
21. Electrical supply isolator: 380/415 V
22. Electrical supply phase connections
23. Electrical supply isolator: 200/208 V

* If a TMS is fitted to your GRC

Figure 16 - Services connections and interior of the control unit

3.11 Connect the D150 inlet

Notes: A typical installation configuration is shown in Figure 18.

You will need an NW40 elbow (refer to Section 7) to connect to the D150 inlet flange if you use one of the inlet leadthrough holes on the rear of the enclosure.

The D150 enclosure is supplied with the inlet pipeline configured to be at the left or the right of the enclosure. If you want to install the D150 with the inlet pipeline on the opposite side to that supplied, contact your supplier or Edwards.

There are four leadthrough holes on the enclosure for the D150 inlet pipeline: two at the rear of the enclosure (6) and two at the side of the enclosure (5). One of the leadthrough holes will be open; the other leadthrough holes will be covered by a blanking-plate.

1. If the leadthrough hole that you want to use is not open, remove the blanking plate from the selected leadthrough hole (5 or 6), then fit the blanking-plate over the open leadthrough hole which you will not use.
2. Use an 'O' ring with a metal pressure retaining ring and connect the exhaust pipeline from the pump to the D150 inlet (7 or 8):
   - If you use one of the leadthrough holes (5) on the side of the enclosure, connect a pipe with an NW40 flange to the inlet flange.
   - If you use one of the leadthrough holes (6) on the rear of the enclosure, connect an NW40 elbow to the inlet flange; you can then connect a pipe with an NW40 flange to the elbow.

3.12 Connect the D150 outlet

Note: You will need an NW40 elbow (refer to Section 7) to connect to the D150 outlet flange if you use one of the outlet leadthrough holes on the rear of the enclosure.

Refer to Figure 17. Your D150 is supplied with the outlet flange on the left of the enclosure (3). If required, you can turn the outlet elbow so that the outlet-flange (3) is on the right-hand side of the enclosure.

There are four leadthrough holes on the enclosure for the D150 outlet pipeline: two at the rear of the enclosure (2) and two at the side of the enclosure (1). One of the leadthrough holes will be open; the other leadthrough holes will be covered by a blanking-plate.

1. If you want the outlet flange on the right of the enclosure:
   - Remove the clamp which secures the outlet elbow.
   - Turn the outlet elbow through 180^{o}.
   - Refit the clamp to secure the outlet elbow.
2. If the leadthrough hole that you want to use is not open, remove the blanking-plate from the leadthrough hole you want to use, then fit the blanking-plate over the other open leadthrough hole.

3. Connect the D150 outlet (3 or 4) to the exhaust-extraction system pipeline. Use suitable pipeline materials, as described in Section 3.2:

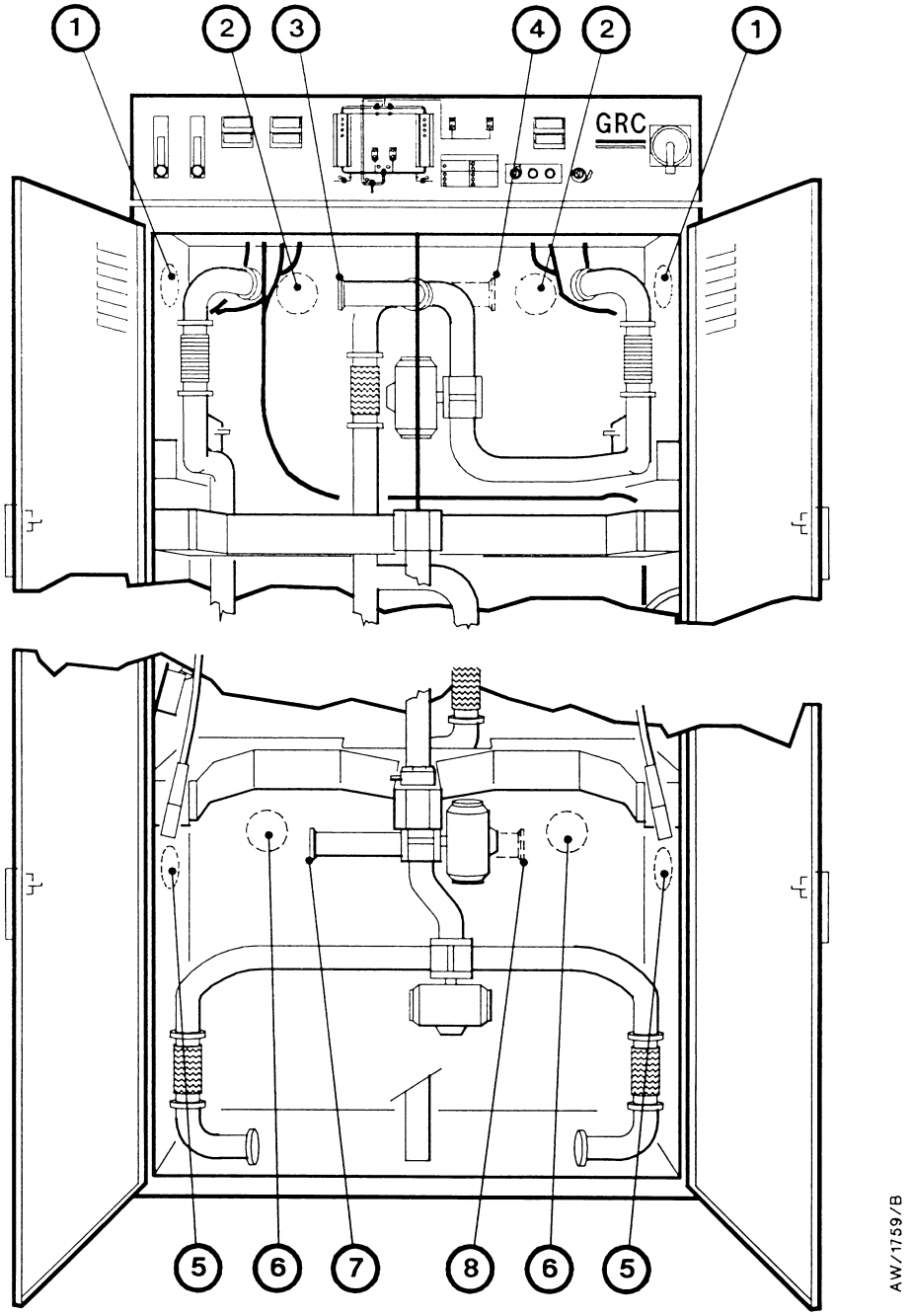
   - If you use one of the leadthrough holes (1) on the side of the enclosure, connect a pipe with an NW40 flange to the outlet flange.
   - If you use one of the leadthrough holes (2) on the rear of the enclosure, connect an NW40 elbow to the outlet flange. You can then connect a pipe with an NW40 flange to the elbow.

3.13 Fit a cartridge and refit the heater unit

1. Refer to Figure 3. Use one of the clamps and trapped 'O' ring seals supplied to fit the outlet pipeline elbow (2 or 8) to the enclosure pipeline; note that you must fit the clamp so that the nut is at the side of the clamp nearest to the side of the enclosure. Do not tighten the clamp yet.
2. Use one of the clamps and trapped 'O' ring seals supplied to fit the inlet pipeline elbow to the inlet pipeline in the enclosure (item 18 or 21). Do not tighten the clamp yet.
3. If you have end-point detectors fitted to your D150, use the procedure in Section 5.4.4 to remove, fill and refit the end-point detector bottle. Use the bottle of end-point detector fluid supplied; the bottle contains enough fluid to fill both end-point detector bottles.
4. Refer to Figure 22, detail A. Pull out the catch (5) on the side of the cartridge change cart, turn the cartridge change cart frame and lock it in the horizontal position as shown in Figure 22; when you turn the frame, the safety legs (4) will automatically fall into place.
5. Fit a cartridge to the heater unit (removed in Section 3.7) as described in Section 5.4.6.
6. Fit the heater unit (with the new cartridge) in the enclosure as described in Steps 1 to 9 of Section 5.4.7; do not fit the electrical connectors as described in Step 10.
7. Tighten the clamps which secure the outlet and inlet pipeline elbows.
8. Refer to Figure 11. If you have a TMS fitted to your D150, fit the pipe insulation jacket (4) and the cartridge inlet insulation jacket (5) to the inlet pipeline.

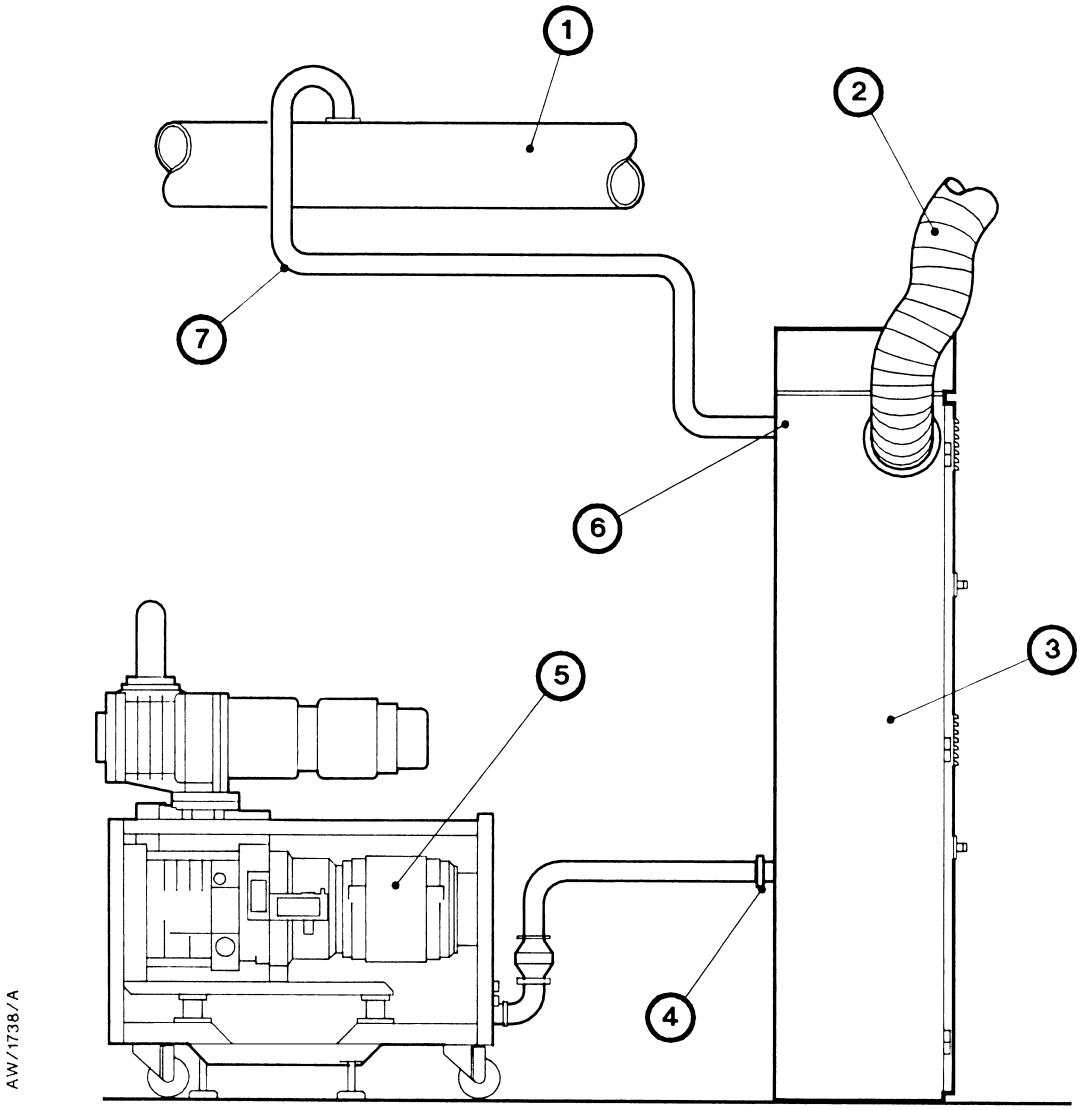
3.14 Remove the other heater unit (if necessary)

1. Remove the other heater unit from the enclosure: refer to Section 3.7.
2. If you have not already connected the D150 outlet, connect the D150 outlet: refer to Section 3.9.
3. We recommend that you fit a cartridge to the heater unit and refit the heater unit as described in Section 3.10.



1. Outlet pipeline leadthrough hole on side of enclosure
2. Outlet pipeline leadthrough hole on rear of enclosure
3. Outlet-flange
4. Alternative outlet-flange position
5. Inlet pipeline leadthrough hole on side of enclosure
6. Inlet pipeline leadthrough hole on rear of enclosure
7. Inlet-flange
8. Alternative inlet-flange position

Figure 17 - Inlet and outlet connections



1. Exhaust-extraction system (metal/plastic)
2. Air-extraction pipe
3. D150
4. D150 inlet
5. Pumping system
6. D150 outlet
7. Pipeline from D150 outlet to exhaust-extraction system (metal)

Figure 18 - Typical installation configuration

3.15 Connect to your air-extraction system

> CAUTION
>
> Ensure that your air-extraction system can provide the necessary air flow (see Section 2). If it does not, the D150 will overheat and shut down.

Refer to Figure 14. Note that there are three possible positions for the air-extraction flange (1). Each position has a leadthrough hole; two of the leadthrough holes are covered by a blanking plate.

1. If necessary, remove the blanking plate from the selected leadthrough hole, then fit the blanking plate to the other leadthrough hole.
2. Fit the air-extraction flange to the selected leadthrough hole.
3. Connect the air-extraction flange to your air-extraction system. Your air-extraction system must provide at least the minimum air-extraction specified in Section 2. If it does not, the D150 will overheat and will shut-down or may be damaged.

3.16 Fit the pump exhaust TMS components: optional

> CAUTION
>
> If you have a TMS fitted to your D150, you must fit the necessary TMS components to the pipeline between the pumping system and the D150 inlet. If you do not, deposits will form in the D150 process pipelines and the pipelines may become blocked.

Notes: The following description and procedure assumes that your D150 has a TMS fitted (see Section 1.10). If you have a TMS in your D150, the TMS connector will be fitted to the rear of the D150 enclosure (as shown in Figure 10), next to the right or the left inlet leadthrough hole, depending on the inlet configuration you have ordered.

The D150 can operate up to 2 m of additional pipe heaters. If the pipeline between the pumping system and the D150 inlet is longer than 2 m, you must install an additional TMS Control Unit: refer to the TMS instruction manual for further details.

If you have a TMS fitted to your D150, you must fit the necessary TMS components to the pipeline between the pumping system outlet and the D150 inlet. The temperature of the pipeline will then be controlled by the TMS temperature controllers on the control unit (Figure 5, item 3). Use the following procedure to fit and connect the components.

1. Fit the necessary TMS heater and insulation components to the pipeline, as described in the TMS instruction manual (supplied with the D150).
2. Refer to Figure 10. Fit the connector on the Distribution Unit cable to the TMS connector (1) on the rear of the D150 enclosure.

3.17 Fit other accessories

WARNING

Incorporate a safety device to shut down the pumping system if the pipeline between the pumping system and the D150 is over-pressurised.

If you want to use other accessories with your D150, fit them now. Details of the accessories available from Edwards are given in Section 7. Fit and prepare an accessory for use as described in the instruction manual supplied with the accessory.

The D150 cannot detect and respond to pressure surges in the pipelines if the electrical supply or the compressed air supply to the D150 has failed (see Section 4.8). You must therefore incorporate suitable safety devices (such as a gas pressure module) in the system to prevent over-pressurisation of the D150 process pipelines, the pipeline between the pumping system exhaust and the D150 inlet, and the exhaust-extraction system pipeline.

3.18 Leak-test the system

Refer to Figure 2. The D150 is supplied with the pump start valve (19) open and the GRC isolation-valves (10 and 29) closed. After you have connected the D150 inlet and outlet to your pumping system and to your exhaust-extraction system, there is therefore a direct gas path between the pumping system and the exhaust-extraction system through the D150. Before you operate the D150, leak-test this installation and seal any leaks found to prevent leakage of dangerous substances out of the system and leakage of air into the system.

Note that you do not need to leak test the other pipelines in the D150 before use. The GRC pipelines and the cartridge are automatically leak tested when you changeover to use a newly installed GRC heater unit.

4 OPERATION

> CAUTION
>
> Do not operate the D150 with a gas flow (through a GRC cartridge) less than 5 slm or greater than 60 slm. If you do, the D150 may not operate correctly and your exhaust-extraction system may be damaged.

If you operate the D150 with a gas flow through the cartridge less than 5 slm or greater than 60 slm, the efficiency of the D150 will be reduced. A high gas flow through the cartridge can also damage the D150 and your exhaust-extraction system.

4.1 Use of the D150 with new process equipment

When new process equipment is installed and before it has been fully commissioned, it is common practice to use the process equipment to pump large quantities of air. If air is regularly passed through a GRC cartridge, a back-pressure can be created as the moisture in the air will react with the contents of the cartridge. This will reduce the life of the cartridge.

If you use new process equipment in this way, you should therefore ensure that the D150 is operated with the start-up valve open. For example, if your D150 is configured to use remote inputs (see Section 3.14), operate your control system to send the remote pump start signal to the D150.

4.2 Initial start-up

Use the following procedure to start up the D150 after you have installed it or after the D150 has been shut down (as in Section 4.7) for maintenance. The following procedure assumes that you have fitted the heater units in the D150 enclosure as described in Section 3. Note that you can use the procedure below even if you have only fitted one heater unit in the enclosure.

1. Ensure that only purge gas is flowing through the pumping system, that is, that no process gas is pumped.
2. Refer to Figure 5. Ensure that the controls on the control unit are in the correct position:
   - Ensure that the electrical supply isolator (9) is in the off position
   - Ensure that the safety interlock key (10) is in the cartridge change (fully anticlockwise) position
   - Ensure that the button lock key (13) is in the locked (fully anticlockwise) position.
3. Refer to Figure 19. Ensure that the electrical supply and control connectors (2 and 3 or 8 and 9) are fitted to one of the heater units (7 and 4).
4. Ensure that the off-line purge and pressure-switch purge flow control valves (Figure 5, items 1 and 2) are fully closed (that is, are turned fully clockwise).

5. If your D150 has end-point detectors, ensure that both of the end-point isolation-valves (Figure 3, items 4 and 7) are open (as shown in Figure 3, detail E).

6. Turn on the nitrogen supply and compressed air supply; ensure that the supply pressures are correct: refer to Section 2.

7. Switch on the external electrical supply and switch on the electrical supply isolator on the control unit (Figure 5, item 9).

8. Check that the pump start valve LED (Figure 6, item 8) on the status display is on to indicate that the start-up valve is open.

9. Refer to Figure 5. Turn the safety interlock key (10) to the unlocked (fully clockwise) position; then immediately turn the off-line purge flow control valve (1) anticlockwise so that a flow of 1 $m^3.h^{-1}$ is shown on the flow-meter.

10. Refer to Figure 6. Check that the leak test fail LED on the status display (4) flashes to indicate that leak test is in progress.

11. After 70 seconds, the leak test fail LED should go off to indicate that the leak test was successful. If the LED goes off, continue at Step 13, otherwise continue at Step 12.

12. If the leak test LED goes permanently on (that is, the leak test failed):

    - Turn the safety interlock key (Figure 5, item 10) to the locked (fully anticlockwise) position.
    - Check that the cartridge inlet and outlet pipeline connections are correctly fitted.
    - Refer to Figure 19. Remove the electrical supply connector (2 or 9) from the heater unit, wait five seconds, then refit the connector.
    - Turn the safety interlock key to the unlocked (fully clockwise) position to leak test the cartridge again. If the leak test continues to fail, the process pipeline connections may be incorrectly fitted, or the cartridge may not be leak tight and must be replaced.

13. When the leak test is successful, the corresponding available LED on the status display will go on. Close the enclosure door for the available GRC.

14. Refer to Figure 5. Ensure that the button lock key (13) is in the unlocked (fully clockwise) position.

15. Press and hold the changeover button (11) for at least 10 seconds, then look at the status display LEDs:

    - The corresponding on-line LED for the GRC goes on to indicate that the heater is starting to heat up.
    - After approximately 10 seconds, the pump start LED goes off to indicate that the pump start valve has closed
    - The corresponding changeover LED and the GRC outlet isolation-valve LED for the on-line GRC go on to indicate that process gases now pass through the cartridge in the on-line GRC.
    - The temperature LED and the level 1 warning LED on the status display (Figure 6, item 4) go on to indicate the cartridge in the on-line GRC has not yet reached operating temperature.

16. The on-line GRC will now preheat to its operating temperature which is reached after five hours. When the temperature of the GRC cartridge is in the correct operating temperature range, the red temperature alarm LEDs on the temperature controllers will go off and the temperature and warning level 1 LEDs on the status display will go off.

17. To fit the second heater unit and make it available for future operation, use the procedure in Section 5.4.

4.3 Automatic preheat and changeover

After you have installed the D150 as described in Section 3 and have started the D150 as described in Section 4.2, the only operator action required is to change cartridges when necessary (as indicated by the await change LED on the status display).

If you change cartridges when indicated, the D150 will automatically start to preheat the available GRC when required and will automatically changeover as described in Section 1.2.2.

Note however that after the automatic preheat sequence of the available GRC is started, it may then be cancelled by the D150 controller if:

- The automatic preheat sequence is started because of a breakthrough indication and the breakthrough indication clears at any time during the five hour preheat time (before automatic changeover has occurred).
- The automatic preheat sequence is started because of a warning pressure indication and the warning pressure indication clears at any time during the five hour preheat time (before automatic changeover has occurred).

4.4 Manual preheat and changeover

4.4.1 Introduction

Note: We recommend that you always manually select preheat before you manually select changeover.

If required, you can operate the D150 manually; that is select preheat when required, then select manual changeover:

- To manually select preheat, refer to Section 4.4.2.
- To manually select changeover, refer to Section 4.4.3.

Note that manual selections will not override automatic operation. For example, if the automatic preheat sequence has been started, you cannot use the preheat start button to cancel the preheat sequence. However, if automatic preheat has started, you can manually select changeover to make the available D150 on-line before the end of the preheat.

4.4.2 Manually select preheat

Note: If you have accidentally pressed the preheat start button and you want to cancel the preheat operation, press and hold the preheat start button for five seconds; the previously selected preheat will then be cancelled.

If you have fitted a new cartridge in the off-line GRC and it has passed the leak test (that is, the GRC is available), you can use the following procedure to start to heat up the cartridge.

1. Refer to Figure 5. Ensure the button lock key (13) is in the unlocked (fully clockwise) position.
2. Press and release the preheat button (12). The preheat LED on the status display (Figure 6, item 4) will then go on to indicate that the available cartridge has started to heat up.

The cartridge temperature controllers for the GRC will display the temperature of the cartridge (see Section 1.8.3). When the cartridge has reached operating temperature, the temperature alarm LEDs on the controllers will go off.

4.4.3 Manually select changeover

Note: If you have accidentally pressed the changeover button and want to cancel the changeover sequence, press and hold the changeover button for five seconds or more, then release it. Do not hold the button pressed for 10 seconds or more, otherwise

You can only cancel the changeover selection before the available GRC becomes the on-line GRC. Once the changeover has happened, you cannot cancel it.

To manually select changeover, use the following procedure.

1. Refer to Figure 5. Ensure that the button lock key (13) is in the unlocked (fully clockwise) position.
2. To initiate a preheat, followed by automatic changeover, press and release the changeover button (11). The off-line GRC will then start to preheat; five hours later, when the off-line GRC is at operating temperature, the preheated GRC will go on-line and the currently on-line GRC will go off-line.

   To immediately initiate changeover (whether the cartridge in the off-line GRC is at operating temperature or not), press and hold the changeover button (11) for at least 10 seconds, then release it; the off-line GRC will go on-line and the currently on-line GRC will go off-line.

   Whenever changeover occurs, the corresponding LEDs on the status display change to indicate that:

   - The GRC which was on-line before the changeover is now off-line.
   - The GRC which was available before the changeover is now on-line.

4.5 Cartridge change

When a cartridge is ready to be changed (that is, it is off-line and has been purged and cooling for 24 hours), the warning level 1 LED and the corresponding await change LED on the status display will go on. Change the cartridge in the corresponding GRC as described in Section 5.4.

4.6 Fault indications

CAUTION

If a warning or alarm LED goes on, take the necessary operator action as soon as possible. If you do not, untreated process gas may flow directly into the exhaust-extraction system.

In normal operating conditions, once one GRC is on-line and the other GRC has a new cartridge and has been successfully leak tested, only green LEDs on the status display should be on (that is, the corresponding on-line and available LEDs).

If one of the warning or alarm LEDs on the status display goes on, you must determine the cause and take the necessary operator action. The conditions which will cause the warning and alarm LEDs to go on are described in Table 4. The priorities of the warning and alarm LEDs are as follows:

- If the warning level 1 LED is on, operator action is required within 24 hours (for example, the cartridge in the await change GRC should be changed).
- If the warning level 2 LED is on, operator action is required as soon as possible.
- The alarm LED goes on when the pump start valve is open (that is, process gas passes directly from the D150 inlet to the D150 outlet) and should only go on during initial start-up of the D150 and your pumping system. If the alarm LED goes on at any other time, you must shut down the system immediately.

4.7 Shutdown

CAUTION

Ensure that the system has been fully purged before you use the following procedure. If you do not, the D150 will be shut down with process gases in the D150 inlet pipelines.

1. Refer to Figure 5. Switch off the electrical supply isolator (9) and leave the D150 to cool down for at least 24 hours.
2. Open the door of the GRC which was off-line, then push the rod on the door lock (Figure 3, item 23) to release the door of the other GRC, and open the other door.
3. Refer to Figure 19. Remove the electrical supply and control connectors (9, 8, 2 and 3) from the heater units.
4. Switch on the electrical supply isolator and check that the pump start LED on the status display (Figure 6, item 8) goes on to indicate that the pump start valve is open.
5. If required, remove the heater units from the D150: refer to Section 5.4.3.
6. Switch off the electrical supply isolator, then turn off the external electrical supply and the compressed air and nitrogen supplies.

5 MAINTENANCE

5.1 Safety

5.1.1 General precautions

> WARNING
>
> Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment.

The following general safety precautions apply to all maintenance work:

- A suitably trained and supervised technician must maintain the D150.
- Dismantle the D150 with the correct tools and safety facilities available.
- Ensure that the maintenance technician is familiar with the safety procedures which relate to the products processed by the pumping system. Wear the appropriate safety-clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume-cupboard.
- Isolate the D150 from the pumping system and allow the D150 to cool to a safe temperature before you start maintenance work.
- Isolate the D150 from the electrical supply so that it cannot be operated accidentally.
- Check that all the required parts are available and of the correct type before you start work.
- Do not reuse damaged 'O' rings.
- Dispose of components safely (see Section 6.2).
- Take care to protect sealing-faces from damage.
- Do not touch or inhale the thermal breakdown products of fluorinated materials which may be present if the seals on the D150 have been heated to 260 ^{o}C and above. The seals in the D150 are made from fluorinated materials which are safe in normal use, but can decompose into very dangerous thermal breakdown products if they are heated to 260 ^{o}C and above. Edwards Material Safety Data Sheets for fluorinated materials used in the D150 are available on request: contact your supplier or Edwards.
- Leak-test your system after maintenance and seal any leaks found to prevent leakage of dangerous substances out of the system and leakage of air into the system.
- If you need to mechanically dismantle the D150 or to work on the D150 electrical system:
    - Shut down the D150 and switch off all of the services as described in Section 4 before you start work.
    - Use a suitable electrical lockout procedure to prevent accidental injury by electric shock: see Section 5.1.2.

5.1.2 Electrical lockout

> WARNING
>
> Lockout the D150 from the electrical supply if you will dismantle it or work on the electrical system. If you do not, there will be a risk of injury or death by electric shock.

If you will mechanically dismantle the D150 or work on the electrical system, you must ensure that the D150 is isolated from the electrical supply, so that it cannot be switched on and operated accidentally. The D150 electrical supply isolator has a lockout facility for this purpose: see Figure 16, detail C.

In accordance with OHSA requirements, you must implement a suitable electrical lockout procedure. We recommend that you use the following procedure:

1. Notify all affected persons of the shut-down of the D150 for maintenance or servicing.
2. Identify the person who has locked out the D150, and the reason for the lockout on a 'tagout' sheet or tag.
3. Maintain a log of the time, date, purpose and authoriser of the lockout.
4. Switch off the electrical supply at the lockout location.
5. Securely attach a 'lockout' device to the electrical supply at this location. Use a lock or other device which cannot be readily removed.
6. Display a 'tagout' notice in an easily seen location.

When you want to return the D150 to normal use after maintenance or servicing:

1. Ensure that all tools and other equipment have been removed from the D150 and that the D150 is fully and correctly assembled.
2. Ensure that all appropriate persons are notified that the D150 is to be switched on.
3. Check that all of the D150 controls are in the correct 'off' position.
4. Remove the lockout devices and switch on the electrical supply to the D150.
5. Notify all affected persons that the maintenance or servicing is complete and that the D150 is ready for normal use.
6. Complete the log to identify when the lockout was removed and when the D150 was switched on again.

5.2 Maintenance plan

The plan shown in Table 5 details the maintenance operations necessary to maintain the D150 in normal operation. Further instructions are given in the section shown. If necessary, adjust the maintenance plan according to your experience.

Operation	Frequency	Refer to Section
Check the pressure-switch and process gas purge flows	Daily	5.3
Change the cartridge	As determined or when necessary	5.4
Check the outlet gas composition (optional)	As required by cartridge change interval	5.5
Dismantle and clean the pipelines & valves	As necessary	5.6
Replace the thermal fuses	As necessary	5.7
Adjust the cartridge temperature controllers	As necessary	5.8
Adjust the heater controllers	As necessary	5.9
Check the off-line purge flow	As required when cartridge is purged	5.10

Table 5 - Maintenance plan

5.3 Check the pressure-switch and process gas purge flows

1. When the D150 is in use and at operating temperature, check that the total process gas and nitrogen purge flow through the GRC is between 5 and 60 slm.

2. Check that there is a reading of approximately 100 slh on the pressure-switch purge flow-meter on the control unit (Figure 5, item 2). If necessary, adjust the flow-control valve.

5.4 Change the cartridge

5.4.1 Cartridge life

The life of a cartridge depends on the quantity of process gases treated and a back-pressure will not always be detected before the cartridge has been exhausted. If you have end-point detectors in your D150 (see Section 1.5.2), the end-point detectors will determine when a cartridge reaches the end of its life, however you can also measure the level of exhaust gases in the outlet from the D150; these exhaust gas measurements, together with your knowledge of the gas flows in your process, will allow you to estimate the useful life of cartridges.

You can connect a suitable measuring device to the sampling port on the outlet of the D150 (Figure 3, item 30). Suitable devices include:

- Spot samplers

  These are tubes of crystals which change colour in the presence of a specific gas. The sampling port is provided with a flexible pipe for connection of spot samplers.

(Continued on page 62)

- On-line monitors

  Many gas monitors are available; these use either electrochemical cells, chemical-sensitive tape or semiconductor devices. These monitors are generally designed for ambient air monitoring and are very unlikely to be suitable for continuous monitoring of the gases in the D150 outlet, where the gas may be 100% dry nitrogen.

  You can connect an on-line monitor to the sampling port to periodically sample the gases. However it may be more suitable to connect the monitor at a point downstream in the exhaust-extraction system, where air and moisture (from other exhaust-extraction pipelines) will be present.

5.4.2 Cartridge change log cards

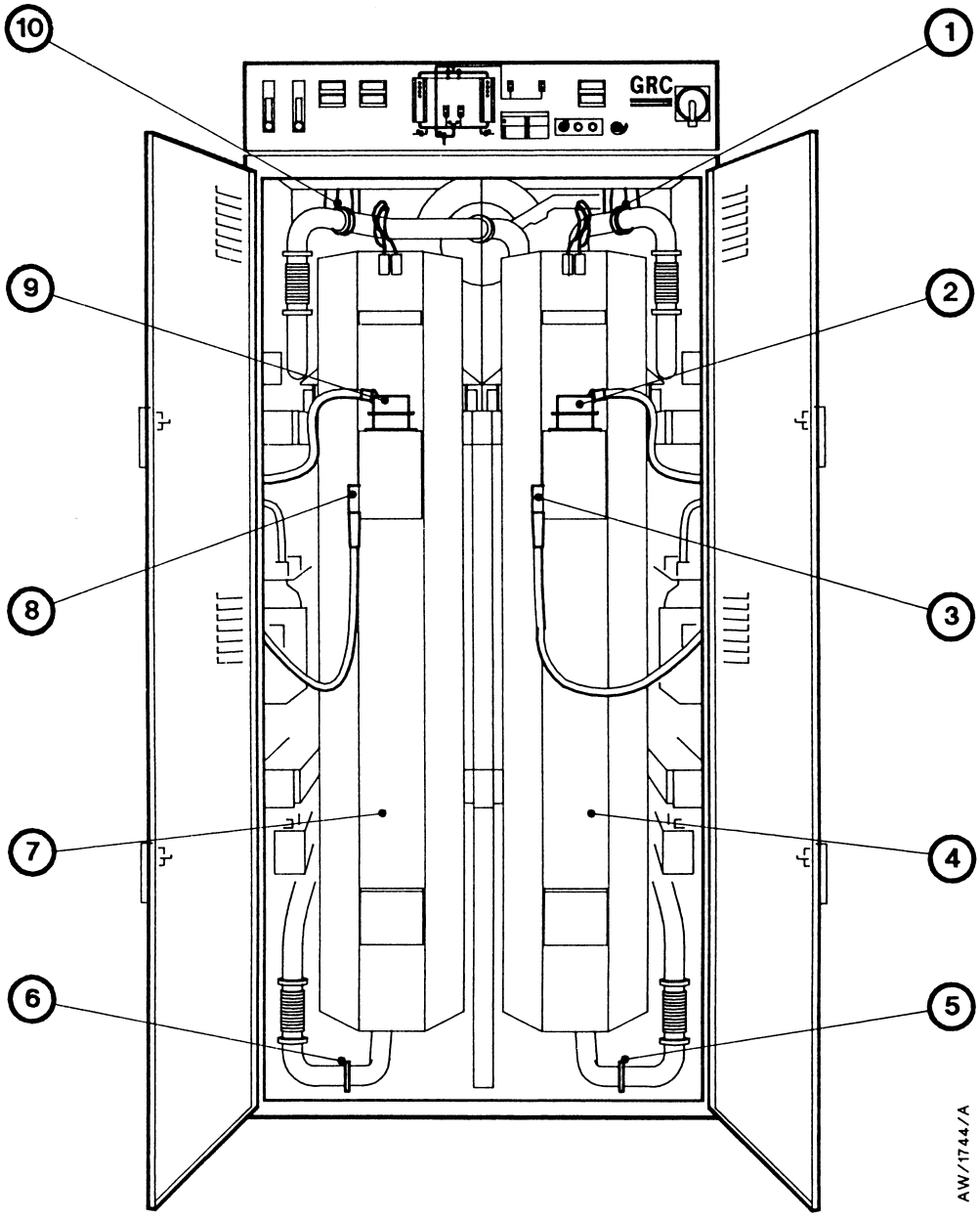
Cartridge change log cards are supplied with new packs of cartridge. If required, these cards can be used as a reminder to change cartridges at the proper time.

5.4.3 Remove the heater unit from the enclosure

Note: The D150 enclosure has a two-way door lock. The door corresponding to the currently 'on-line' GRC is secured by the lock; the door corresponding to the other GRC is not.

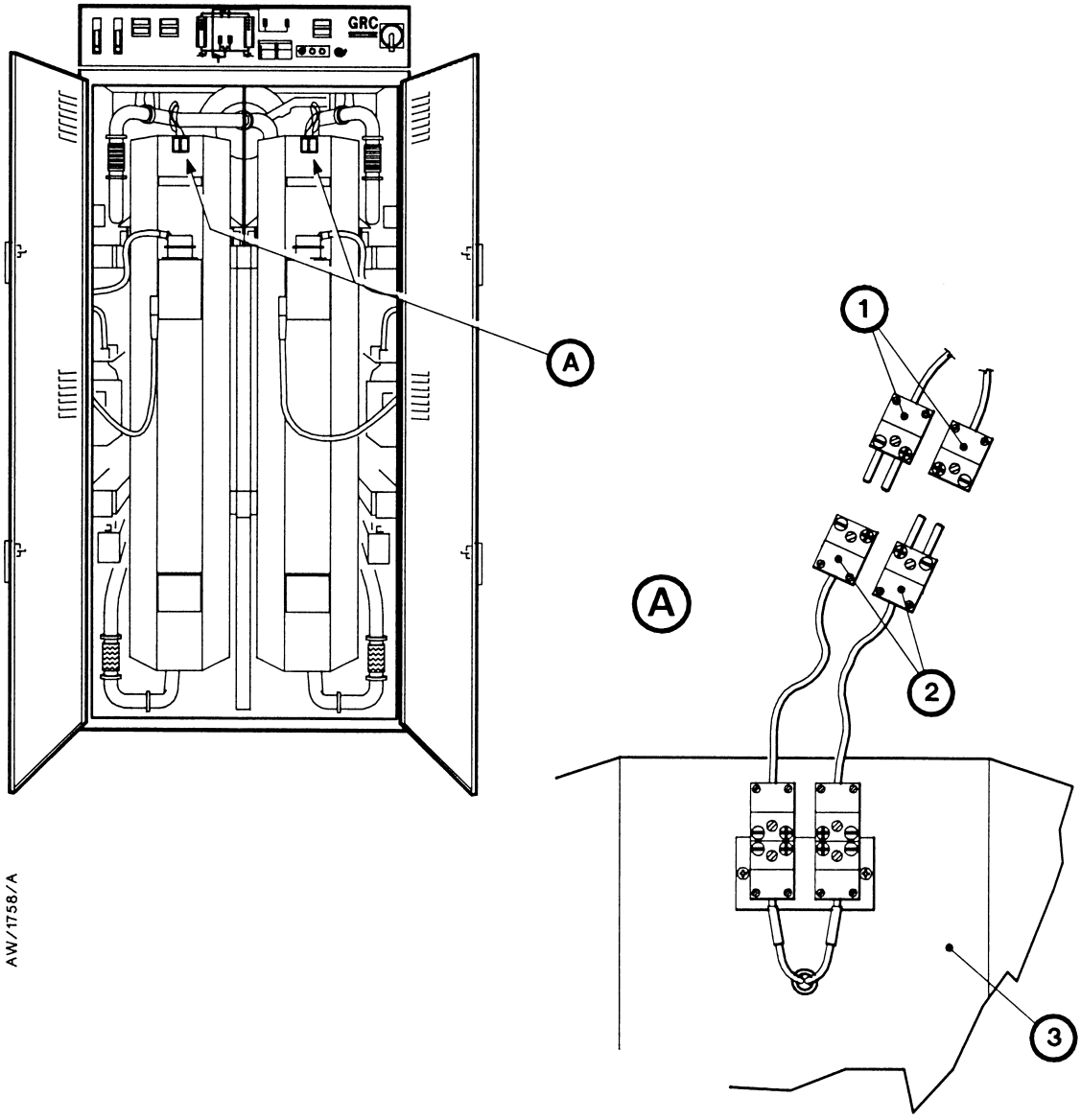
1. Refer to Figure 6. Ensure that the Await Change cartridge status LED (1) is flashing to indicate that the cartridge must be changed.
2. Refer to Figure 5. Look at the temperatures shown on the cartridge temperature controllers for the appropriate GRC (4 and 5 for GRC1, 7 and 8 for GRC2). If the cartridge is still hot, do not continue with the procedure, but wait until the cartridge is cool enough to be changed.
3. Refer to Figure 5. Turn the Safety Interlock key (10) to the cartridge change (fully anticlockwise) position. Check that the Await Change cartridge status LED (Figure 6, item 1) goes permanently on.
4. Open the appropriate door of the D150 enclosure (Figure 3, items 3); that is, the door on the same side of the enclosure as the Await Change LED. If you cannot easily open the door, the GRC may still be on-line: see the note above.
5. Refer to Figure 19. Remove the electrical supply and control connectors from the heater unit which contains the used cartridge (8 and 9 for GRC1, 2 and 3 for GRC2).
6. Refer to Figure 20. Remove the thermocouple connectors on the cartridge (1) from the thermocouple connectors (2) on the heater unit extension leads.
7. Refer to Figure 19. Remove the clamp (10 or 1) which secures the cartridge outlet elbow to the D150 pipeline and remove the trapped 'O' ring.
8. Remove the clamp (6 or 5) which secures the elbow on the cartridge inlet to the D150 pipeline and remove the trapped 'O' ring, then turn the cartridge so that the outlet elbow points outwards.
9. Ensure that the cartridge change cart is in the upright position (see Figure 12, detail A).

(Continued on page 66)



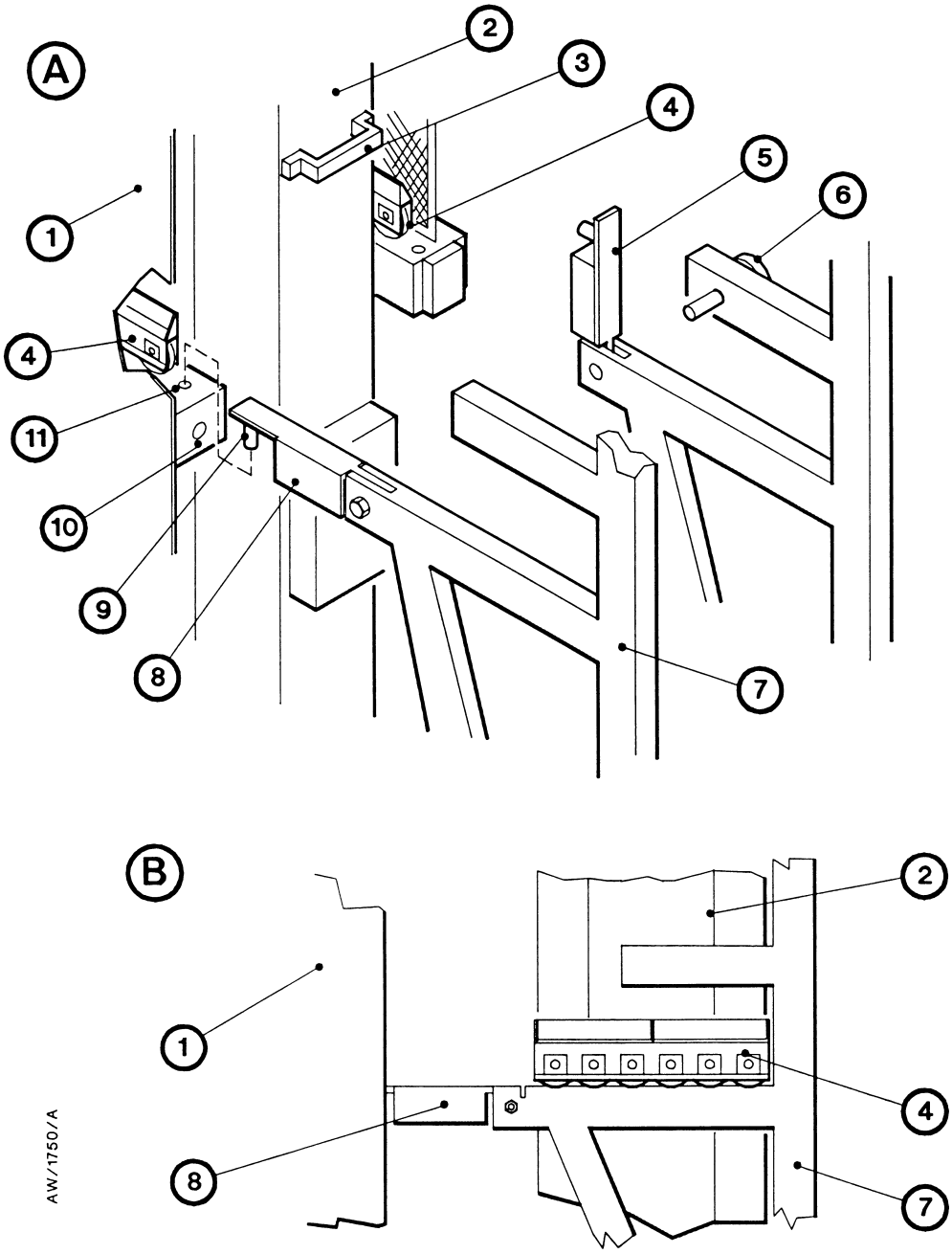
1. Cartridge outlet clamp (GRC2)
2. Electrical supply connector (GRC2)
3. Electrical control connector (GRC2)
4. Heater unit (GRC2)
5. Cartridge inlet clamp (GRC2)
6. Cartridge inlet clamp (GRC1)
7. Heater unit (GRC1)
8. Electrical control connector (GRC1)
9. Electrical supply connector (GRC1)
10. Cartridge outlet clamp (GRC1)

Figure 19 - Disconnect the heater unit from the D150 enclosure



1. Thermocouple connectors on cartridge
2. Thermocouple connectors on heater unit extension leads
3. Heater unit

Figure 20 - Connect or disconnect the thermocouple connectors



1. Enclosure
2. Heater unit
3. Handle
4. Roller carriage
5. Heater unit support arm (vertical position)
6. Catch
7. Cartridge change cart
8. Heater unit support arm (horizontal position)
9. Pin
10. Solenoid catch release button
11. Locating hole

Figure 21 - Remove the heater unit from the D150 enclosure

10. Refer to Figure 21. Ensure that the heater unit support arms are in the vertical position (5).

11. Push the cartridge change cart in front of the heater unit, then turn the two support arms (8) so that the pins (9) under the arms go into the holes (11) in the heater unit support.

12. Press and hold the solenoid-catch release button (10) and pull the handle (3) on the heater unit to slide the heater unit (2) on its roller bearings (4) onto the cartridge change cart (7).

13. Refer to detail B. Slide the heater unit (2) fully onto the cartridge change cart (7). The catch (6) will then automatically secure the heater unit on the change cart.

14. Lift up the support arms into the vertical position (5) and move the cartridge change cart to the location where you will fit the cartridge.

15. Refer to Figure 3. If you have an end-point detector fitted to your D150, close the end-point isolation valve (4 for GRC1, 7 for GRC2). Detail D shows an isolation-valve in the closed position.

16. We recommend that you fit blank flanges or blanking caps to the cartridge inlet and outlet flanges in the enclosure.

5.4.4 Refill the end-point detector bottle (if fitted)

CAUTION
Refill the end-point detector bottle with fluid of the correct conductivity. If you do not, spurious flow faults will occur.

Note: Typically, the deionised water supply within a semiconductor manufacturing facility will have a conductivity of 0.6 $\mu S.cm^{-1}$ (a resistivity of 18 $M\Omega.cm^{-1}$).

If you have end-point detectors fitted to your D150, use the following procedure to remove, refill and refit the end-point detector bottle. Refer to Figure 3 detail A for GRC1, detail B for GRC2.

When you refill the end-point detector bottle, you must ensure that the fluid in the bottle is in the correct conductivity range, as defined in Section 2.

If you have a supply of deionised water with a conductivity less than 0.2 $\mu S.cm^{-1}$ (a resistivity greater than 5 $M\Omega.cm^{-1}$), you can refill the end-point detector bottle with this water as long as you have adjusted the water's conductivity into the correct range of 0.2 to 5.0 $\mu S.cm^{-1}$ (a resistivity range of 5.0 to 0.2 $M\Omega.cm^{-1}$). Use one of the following methods:

- Leave the bottle open to stand in air for 30 to 60 minutes. In this time, the water will dissolve sufficient carbon dioxide from the air to bring the conductivity of the water into the correct range.
- Dissolve 0.5 cm^3 of pH indicator solution in 450 cm^3 of the deionised water. pH indicator solutions are weak acids, and the addition of a small amount of such a solution results in an increase in the water's conductivity.

We recommend that you use the second method given above, as pH indicator solutions change colour to provide a visual confirmation of the change in acidity of the fluid in the end-point detector bottle.

If you use a pH indicator in the end-point detector fluid, the fluid may or may not change colour before breakthrough is detected; this will depend on the indicator you use. For example, the pH indicator in the fluid supplied with the D150 changes from blue to orange-pink at a pH value of 4.5. This is the same pH value at which the end-point detector indicates breakthrough. However, if you use an indicator (for example, Bromophenol Blue) which changes colour when its acidity is 3.5, breakthrough will occur before the fluid changes colour.

1. Unscrew and remove the end-point detector bottle (33) from the end-point detector unit in the enclosure.
2. Dispose of the contents of the bottle; note that the contents will be mildly acidic.
3. Rinse the bottle twice with new fluid, then fill the bottle with the correct charge of new fluid (see Section 2).
4. Open the end-point isolation-valve for the GRC (4 for GRC1; 7 for GRC2). Detail E shows an isolation-valve in the open position.

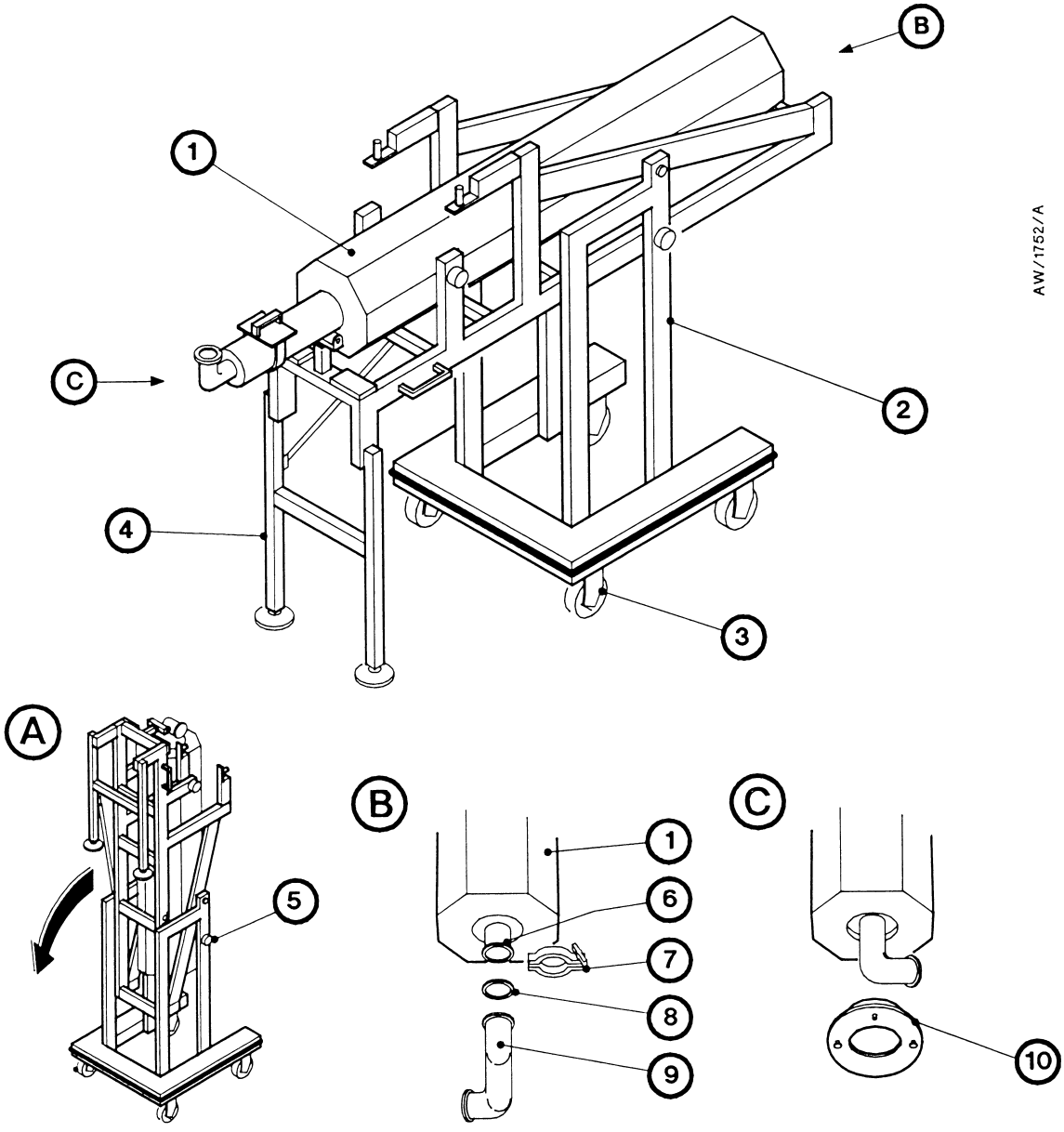
5.4.5 Remove the used cartridge

> WARNING
>
> The mass of a used cartridge is approximately 40 to 50 kg. Two people are therefore required to remove the used cartridge from a GRC heater unit.

Use the following procedure to replace the used cartridge with an new one. The cartridge should be cool when you change it, but if you think it may be warm, wear suitable heat-resistant gloves.

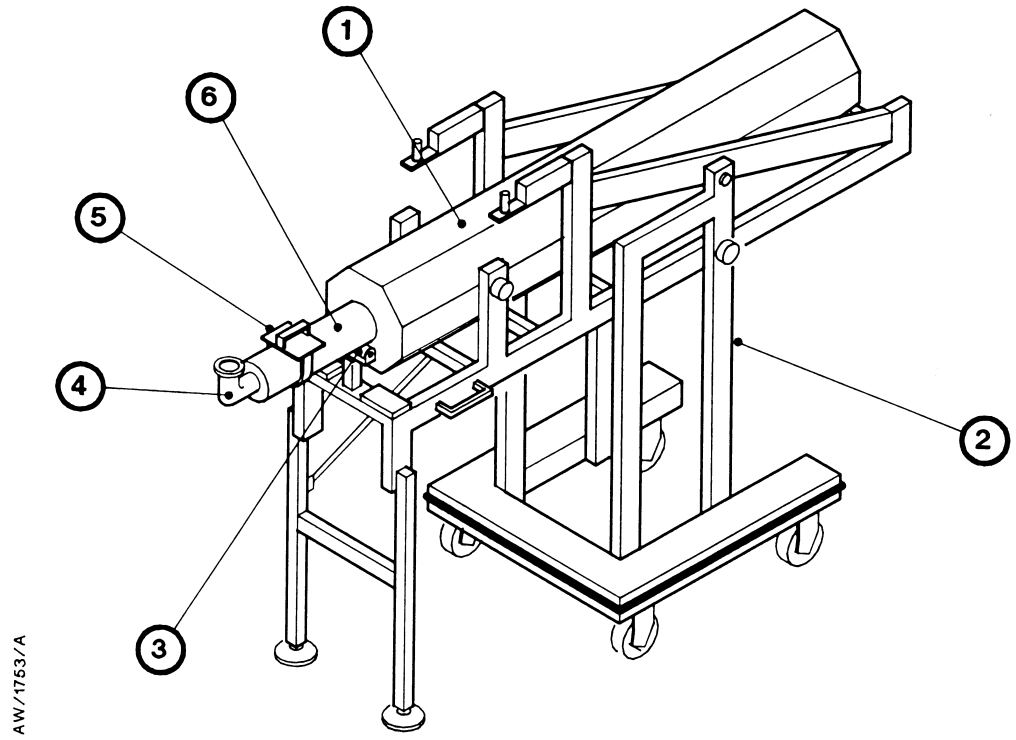
1. Refer to Figure 22, detail A. Pull out the catch (5) on the side of the cartridge change cart, turn the heater and cart frame and lock it in the horizontal position as shown in Figure 22; when you turn the cartridge and heater assembly, the safety legs (4) will automatically fall into place.
2. Refer to detail B. Undo the clamp (7) and remove the elbow (9) and trapped 'O' ring (8) from the cartridge inlet (6). Retain the trapped 'O' ring, clamp and elbow. Refer to detail C. Remove the heater unit top-plate (10).
3. Refer to Figure 23. Hold the cartridge outlet elbow (4) and pull the cartridge (6) out of the heater unit by approximately 40 mm.
4. Fit the cartridge change handle (5) over the outlet end of the cartridge.
5. Slowly pull the cartridge (6) from the heater unit (1); as you pull the cartridge out, slide the cartridge change handle (5) down towards the inlet end of the cartridge. One person must use the cartridge change handle and one person must hold the cartridge outlet.

(Continued on page 70)



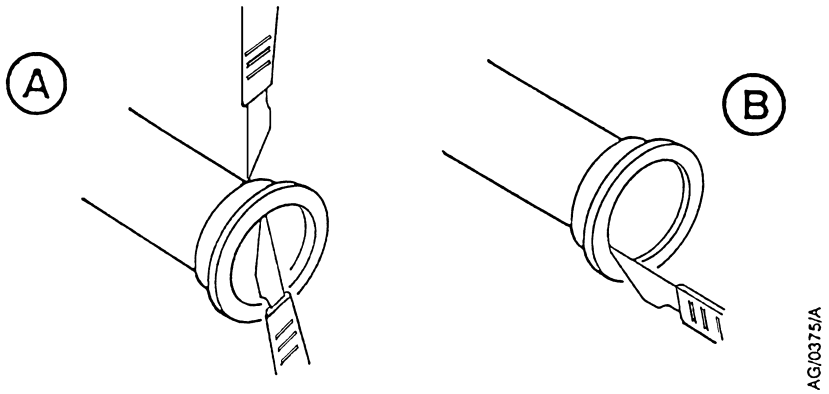
1. Heater unit
2. Cartridge change cart
3. Castors
4. Safety legs
5. Catch
6. Cartridge inlet
7. Clamp
8. Trapped 'O' ring
9. Elbow
10. Top-plate

Figure 22 - Prepare to remove the cartridge



1. Heater unit
2. Cartridge change cart
3. Roller
4. Cartridge outlet elbow
5. Cartridge change handle
6. Cartridge

Figure 23 - Remove the used cartridge



A Correct method of removal
B Incorrect method of removal

Figure 24 - Remove the plastic seal

6. Place the used cartridge in a safe place.

7. We recommend that you push the plastic blanking-plugs supplied into the ends of the used cartridge to seal the ends of the cartridge.

5.4.6 Fit the new cartridge

WARNING

Ensure that the contents of the new cartridge have not settled. If you use a cartridge whose contents have settled, the efficiency of the D150 will be reduced.

CAUTION

Take care not to damage the inlet and outlet-flanges of the cartridge when you remove the seals. If you damage the flanges, you may not be able to use the cartridge.

Note: If you think that the contents of the new cartridge have settled (for example, if the cartridge has been stored or transported horizontally), use one of the following methods to resettle the cartridge contents:

- *Before you fit the cartridge in the heater unit (in Step 3 below), hold the cartridge vertically, with the outlet elbow at the top, then use a rubber headed mallet to tap all round the outside of the cartridge.*
- *After you have placed the cartridge in the heater unit and turned the heater unit upright (in Steps 3 and 4 below), but before you fit the top-plate (in Step 5 below), hold the outlet elbow and shake the cartridge up and down for a minute or more.*

1. Check that the plastic seals on the new cartridge are undamaged. If the seals are damaged, moisture in the air may have reacted with the contents of the cartridge and reduced its life.

2. Use a sharp knife to remove the seals. Cut parallel to the cartridge inlet and outlet-flanges and take care not to damage the flange sealing-faces (see Figure 24). If the sealing-faces are damaged, the cartridge may fail the leak test when you refit the heater unit into the D150 enclosure and you may have to change the cartridge again.

3. Refer to Figure 23. Slide the new cartridge (6) into the heater unit (1), so that the outlet elbow points upwards, then push the cartridge as far as it will go into the heater unit.

4. Refer to Figure 22, detail A. Pull out the catch (5) on the side of the cartridge change cart and turn the heater and cart frame upright, so that the cartridge falls fully into the heater unit.

5. Fit the heater unit top-plate (10) to the heater unit.

6. Pull out the catch (5), turn the cart frame and heater unit and lock it in the horizontal position.

7. Turn the outlet elbow of the cartridge to its correct orientation against one of the alignment blocks on the cartridge change cart: turn the outlet elbow anticlockwise when you change the GRC1 cartridge; turn the outlet elbow clockwise when you change the GRC2 cartridge.

8. Refer to detail B. Use the clamp (7) and trapped 'O' ring (8) to secure the elbow (9) to the cartridge inlet (6), so that it points vertically down with the outlet elbow in its correct orientation.

9. Refer to detail A. Pull out the catch (5) on the side of the cartridge change cart, turn the heater unit and cart frame and lock it in the upright position.

5.4.7 Refit the heater unit in the enclosure

1. If you have fitted blank flanges or blanking caps to the cartridge inlet and outlet flanges in the enclosure, remove them.

2. Wheel the cartridge change cart in front of the D150 enclosure.

3. Refer to Figure 21 detail A. Turn the support arms (5, 8) so that the pins (9) on the arms fit in the locating holes (11) in the heater unit support.

4. Pull out the catch (6) and push the heater unit (2) on its roller bearings (4) off the cartridge change cart (7), over the support arms (8) and into the enclosure.

5. Pull on the handle (3) to ensure that the catch in the enclosure retains the heater unit. If the heater unit still slides forward, push it fully into the enclosure until the catch engages.

6. Refer to detail A. Turn the support arms into the upright position (5), then remove the cartridge change cart and locate it in its storage position.

7. Refer to Figure 19. Ensure that the cartridge outlet elbow is in the correct orientation, then use the clamp (10 or 1) and trapped 'O' ring to connect the cartridge outlet elbow to the outlet pipeline in the enclosure.

8. Use the clamp (6 or 5) and trapped 'O' ring removed in Section 5.4.3 to connect the elbow on the cartridge inlet to the inlet pipeline in the enclosure.

9. Refer to Figure 20. Fit the thermocouple connectors on the cartridge (1) to the thermocouple connectors (2) on the heater unit extension leads. Ensure that the connectors are correctly aligned; that is, that the '+' and '-' indicators on the connectors match.

10. Refit the electrical connectors (8 and 9, or 2 and 3) to the connectors on the heater unit.

5.4.8 Prepare the heater unit for operation

1. Turn the Safety Interlock key (Figure 5, item 10) to the unlocked (fully clockwise) position.
2. Refer to Figure 6. The Leak Test Fail LED on the status display (4) should now flash to indicate that the leak test is in progress.
3. After 70 seconds, the Leak Test Fail LED should go off to indicate the leak test fail was successful. If the LED goes off (that is, the leak test was successful), continue at Step 5, otherwise continue at Step 4.
4. If the LED goes permanently on (that is, the leak test failed):
   - Turn the Safety Interlock key (Figure 5, item 10) to the change cartridge (fully anticlockwise) position
   - Check that the cartridge inlet and outlet pipeline connections are correctly fitted
   - Refer to Figure 19. Remove the electrical supply connector (2 or 8) from the heater unit, wait five seconds , then refit the connector.
   - Continue at Step 1 to leak test the cartridge again. If the leak test continues to fail, the connections to the cartridge may not be leak tight: remove the heater unit; inspect all flanges and 'O' rings for damage; replace or refinish any damaged components; refit the heater unit.
5. Refer to Figure 5. Turn the button lock key (13) to the unlocked (fully clockwise) position.
6. Close the door of the enclosure.

5.5 Check the composition of the outlet gas (optional)

If you use a monitoring device or a spot sampler to check the composition of the gases at the D150 outlet, we recommend that you regularly check the level of dangerous gases in the outlet to ensure that the level is acceptable.

A regular check of the gases will also enable you to more accurately determine the life of cartridges on your process application.

5.6 Dismantle and clean the pipelines & valves

5.6.1 General procedure

If you think there is a blockage in the pipelines or if a pipeline is corroded or damaged, dismantle, inspect and clean the process pipelines and replace any damaged component. Use the following procedure to dismantle, inspect and clean the D150 pipelines and valves.

1. Isolate the pumping system from the process gases and purge the system for a period suitable for the process gases pumped, then shut down the pumping system and shut down the D150 as described in Section 4.7.
2. If you have fitted a TMS to the system, remove the insulation jackets, pipe heaters and thermocouple from the pipeline which connects the pumping system to the inlet of the D150.
3. Dismantle the pipeline which connects the pumping system to the inlet of the D150 and check the pipeline for deposits and corrosion. If the pipeline is very corroded, you must replace it. Use a cleaning method suitable for the gases pumped to clean the pipeline.
4. If you have a TMS fitted to the D150:
   - Refer to Figure 11. Remove the pipe insulation jackets (4) and the cartridge inlet insulation jackets (5) from the pipelines between the D150 inlet and the two GRC cartridge inlets.
   - Remove the pipe heaters (1) and flexible bellows heaters (3) from the pipelines, then remove the thermocouples (2) from the pipelines. Do not disconnect the thermocouples and heaters from the distribution units.
5. Dismantle the process pipelines in the D150 enclosure; refer to Figure 25 which shows the process pipelines. Use a cleaning method suitable for the gases pumped to clean the pipelines and components.
6. Remove the pneumatic pipes from the pneumatic connectors on the process pipeline valves, then dismantle and clean the process pipeline valves: refer to Sections 5.6.2.
7. Ensure that all components are dry, then reassemble the valves (refer to Sections 5.6.3 and 5.6.4) and all of the process pipelines. Reconnect the pneumatic pipes to the pneumatic connectors on the valves.
8. If you have a TMS fitted to the D150:
   - Refer to Figure 11. Refit the thermocouples (2) to the pipelines between the D150 inlet and the two GRC cartridge inlets, then refit the pipe heaters (1) and flexible bellows heaters (3) to the pipelines.
   - Refit the pipe insulation jackets (4) and cartridge inlet insulation jackets (5) to the pipelines between the D150 inlet and the two GRC cartridge inlets.
9. Refit the pipeline which connects the pumping system to the D150.
10. If you have a TMS fitted to the D150, refit the thermocouple, pipe heaters and insulation jackets to the pipeline which connects the pumping system exhaust to the D150 inlet (Figure 17, item 7).

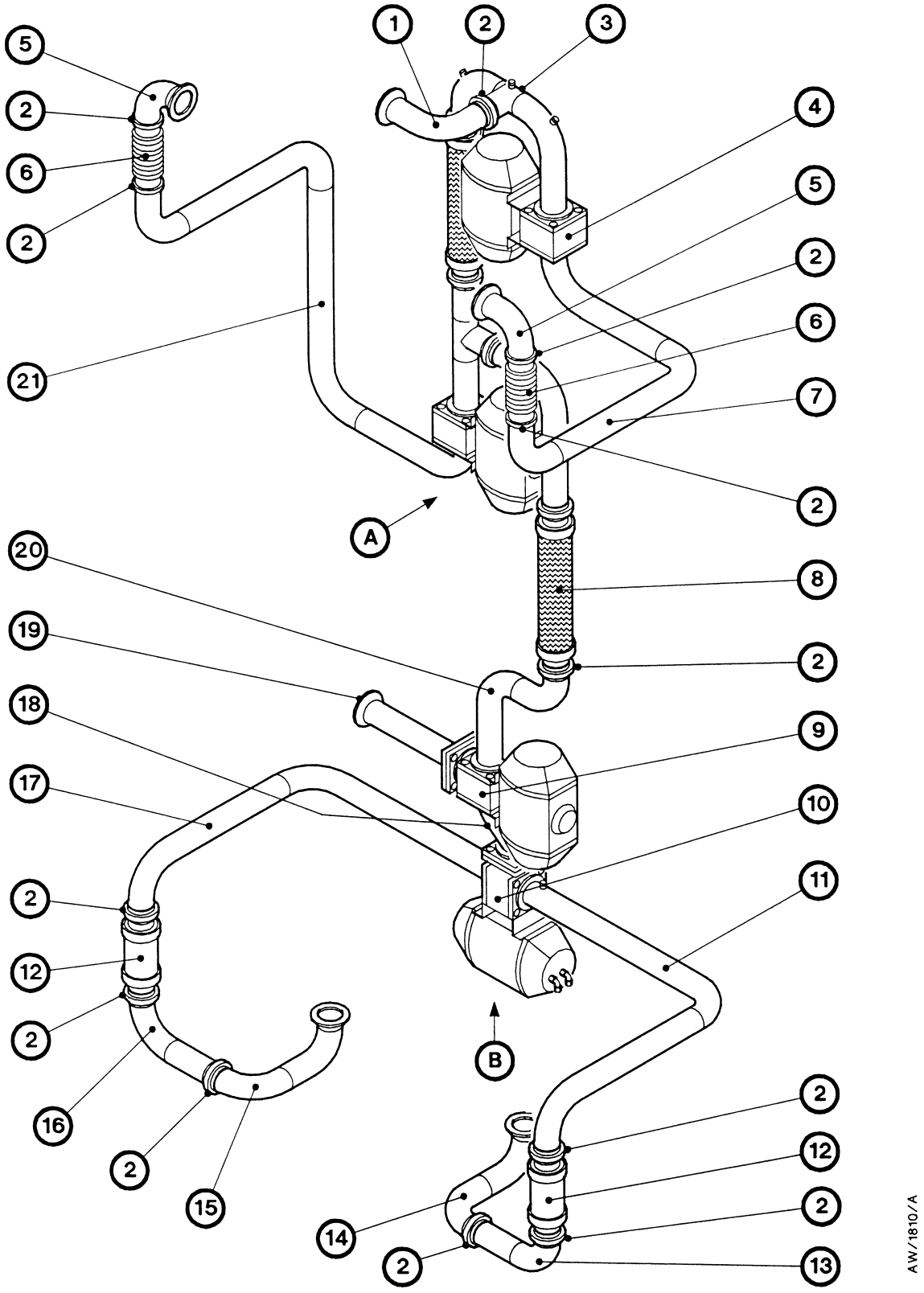
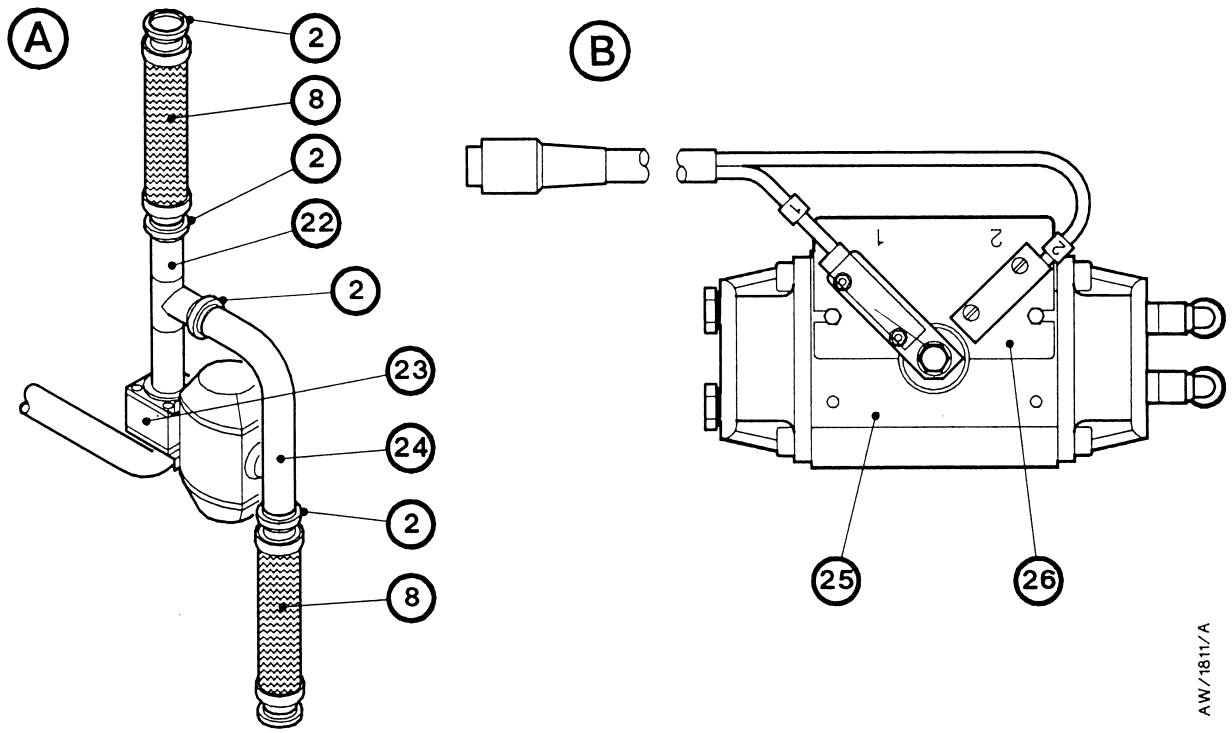


Figure 25 - Process pipelines: sheet 1 of 2



1. D150 outlet pipe
2. Trapped 'O' ring and clamp
3. Upper 'T' outlet pipe
4. GRC2 outlet isolation-valve
5. NW40 elbow
6. Flexible bellows
7. GRC2 outlet pipe
8. Braided flexible pipeline: 250 mm
9. Pump start valve
10. Changeover valve
11. GRC2 inlet pipe
12. Braided flexible pipeline: 135 mm
13. GRC2 front inlet elbow
14. GRC2 cartridge inlet pipe
15. GRC1 cartridge inlet pipe
16. GRC1 front inlet elbow
17. GRC1 inlet pipe
18. Changeover connection pipe
19. D150 inlet pipe
20. Pump start connection pipe
21. GRC1 outlet pipe
22. Pump start 'T' pipe
23. GRC1 outlet isolation-valve
24. Pump start pipe
25. Changeover valve actuator
26. Magnetic reed-switch assembly

Figure 25 - Process pipelines: sheet 2 of 2

5.6.2 Dismantle a process pipeline valve

CAUTION

The valve must be fully open when you remove the valve-body. If it is not, you can damage the valve.

Notes: When you dismantle and clean a valve, we recommend that you use the ball valve seal repair kit available as a spare (refer to Section 7).

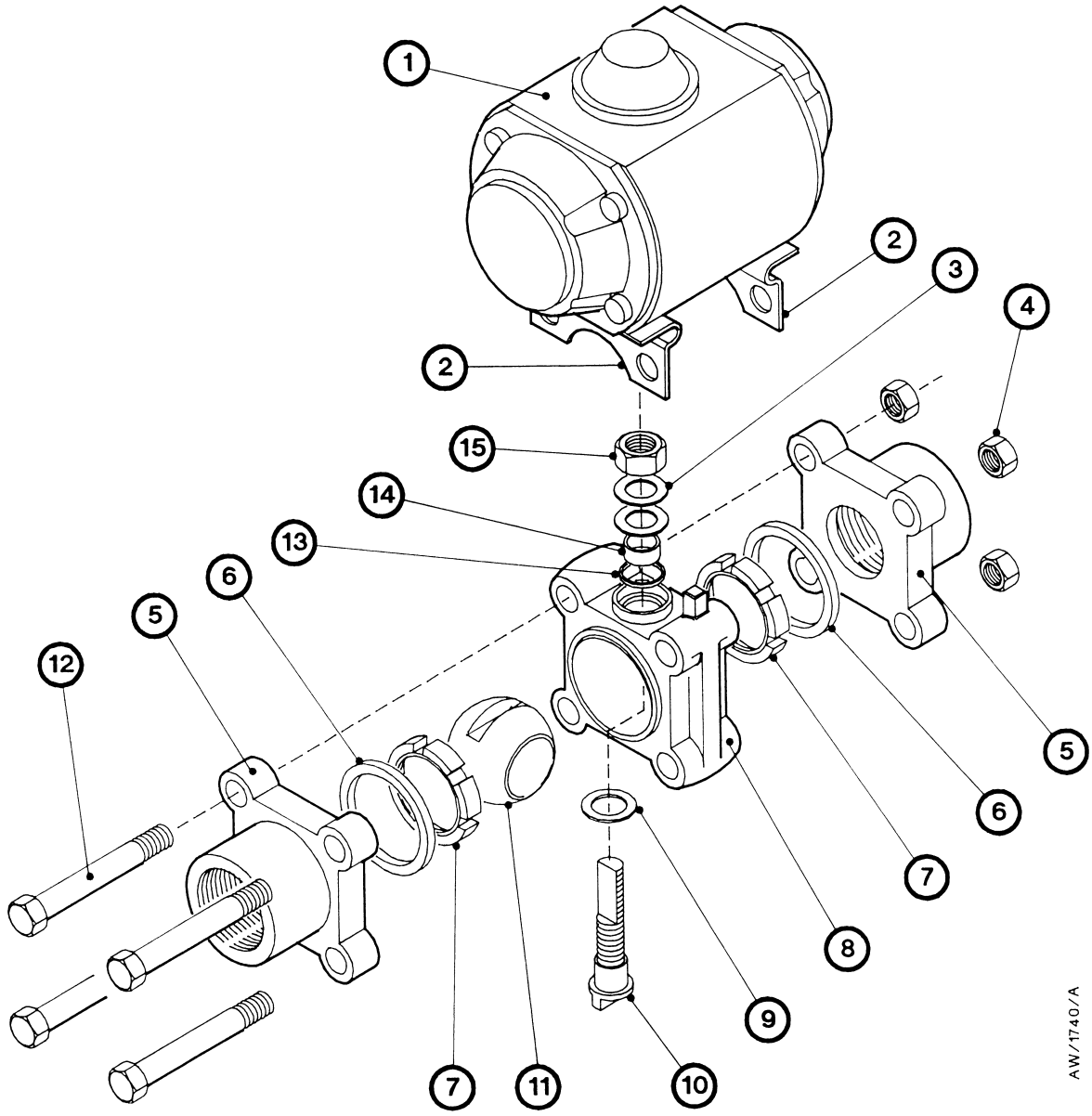
Take note of the orientation of a valve before you remove it from the enclosure and dismantle it.

All of the process pipeline valves are almost identical, except that the changeover valve and the pump start valve are three-way valves and the GRC outlet isolation-valves are two-way valves.

The general procedure to dismantle a valve is given below; note however that before you can dismantle the changeover valve, you must remove the magnetic reed-switch from the actuator: refer to Figure 29.

Refer to Figure 26 and use the following procedure to dismantle a process pipeline valve.

1. Ensure that the valve is fully open.
2. Undo and remove the body connector nuts (6) and remove the body connector bolts (12).
3. Lift the valve actuator (1) with the actuator brackets (2) attached from the valve.
4. Slide the body connectors (5) apart and remove the valve-body (8).
5. Turn the valve to the half-closed position and remove the seal (6) and the seat ring (7) from each side of the valve-body (8).
6. Turn the valve-ball (11) to the fully closed position and push it out of the valve-body; ensure that you do not damage the valve-ball when you remove it.
7. Hold the stem (10) so that it cannot turn and remove the gland nut (15), the two disc springs (3) and the gland (14). Remove the gland packing (13).
8. Turn the stem (10) so that the wrench flats on the stem are aligned with the valve-body (8) and remove the stem.
9. Remove the stem thrust seal (9) from the stem (or from the aperture in the valve-body, if the seal has not been removed with the stem).
10. Clean all of the components. Use a cleaning method suitable for the process gases pumped.
11. Inspect the components; pay particular attention to the seals and sealing faces. If any component is damaged, it must be replaced; use the spares and repair kits available from Edwards (refer to Section 7).
12. Continue at Section 5.6.3 to reassemble the valve.



1. Valve actuator
2. Actuator bracket
3. Disc springs
4. Body connector nuts
5. Body connector
6. Seal
7. Seat ring
8. Valve-body
9. Stem thrust seal
10. Stem
11. Valve-ball
12. Body connector bolts
13. Gland packing
14. Gland
15. Gland nut

Figure 26 - Exploded view of a process pipeline valve

5.6.3 Reassemble a valve: general requirements

Use the procedure in Section 5.6.4 to reassemble a valve. This procedure describes the reassembly of the two-way GRC outlet isolation-valves, although the procedure for the three-way changeover and pump start valves is almost identical.

Take note of the following before you start to reassemble a valve or install it in the enclosure:

Reassembly of the GRC outlet isolation-valves

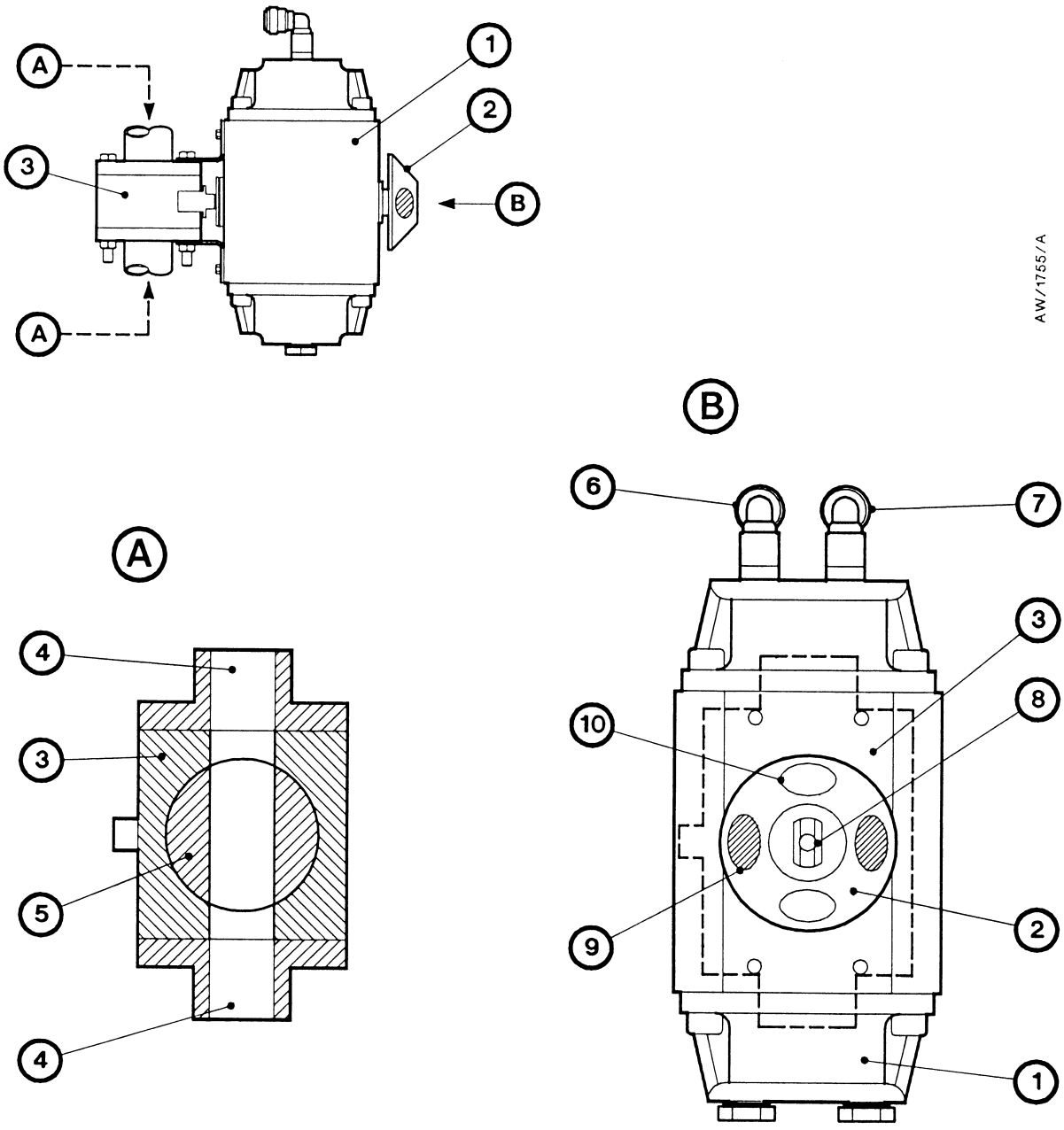
- Refer to Figure 27 detail A. Reassemble the valve-body so that the valve-ball (5) is in the open position; that is that the two ports (4) are open.
- Refer to detail B. Refit the actuator (1) to the valve-body (3) in the correct orientation noted in Section 5.6.1.
- Fit the position indicator disk (2) to the actuator spindle (8) so that the white (open) indicator circles (10) are in-line with the actuator and show that the two ports are open.

Reassembly of the pump start valve

- Refer to Figure 28 detail A. Reassemble the valve-body (3) so that the inlet of the valve-ball (5) is at the top of the valve-body and so that one port (4) is closed and the other port (6) is open.
- Refer to detail B. Fit the position indicator / locking washer (9) over the valve-stem (8) so that the port open indication cut-out (10) is at the open port (6) side of the valve-body (3).
- Refer to detail C. Refit the actuator (2) to the valve-body in the correct orientation noted in Section 5.6.1.
- Fit the position indicator disk (2) to the actuator spindle (11) so that the white (open) indicator circles (13) are in the positions shown in Figure 28 and show that port (6) is open.

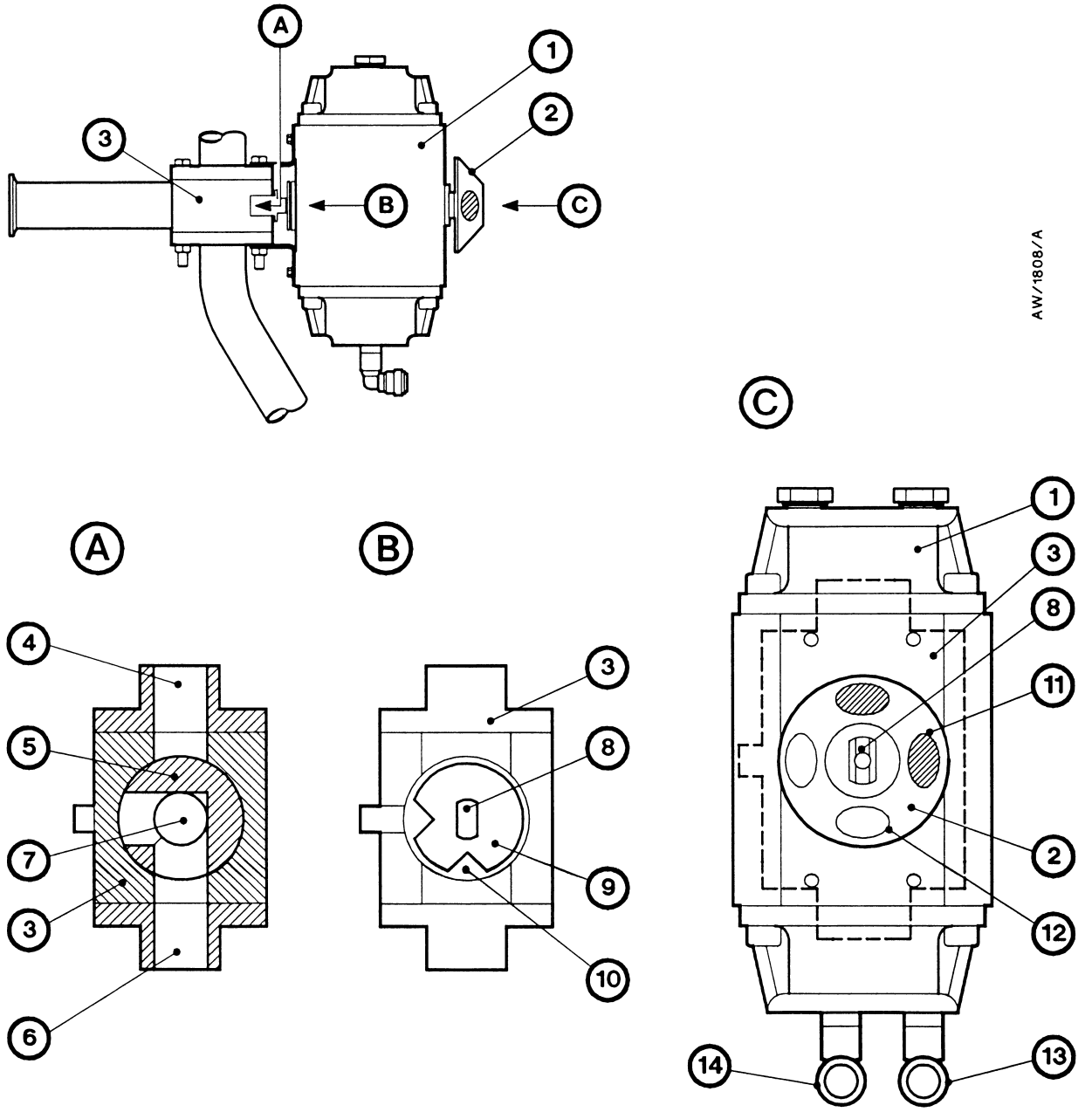
Reassembly of the changeover valve

- Refer to Figure 29 detail A. Reassemble the valve-body (1) so that the inlet of the valve-ball (6) is at the top of the valve-body and so that one port (5) is closed and the other port (7) is open.
- Refer to detail B. Fit the position indicator / locking washer (9) over the valve-stem (8) so that the port open indication cut-out (10) is at the open port (7) side of the valve-body (1).
- Refer to detail C. Refit the actuator (2) to the valve-body in the correct orientation noted in Section 5.6.1.
- Refit the magnetic reed-switch assembly (3) to the actuator spindle (13).



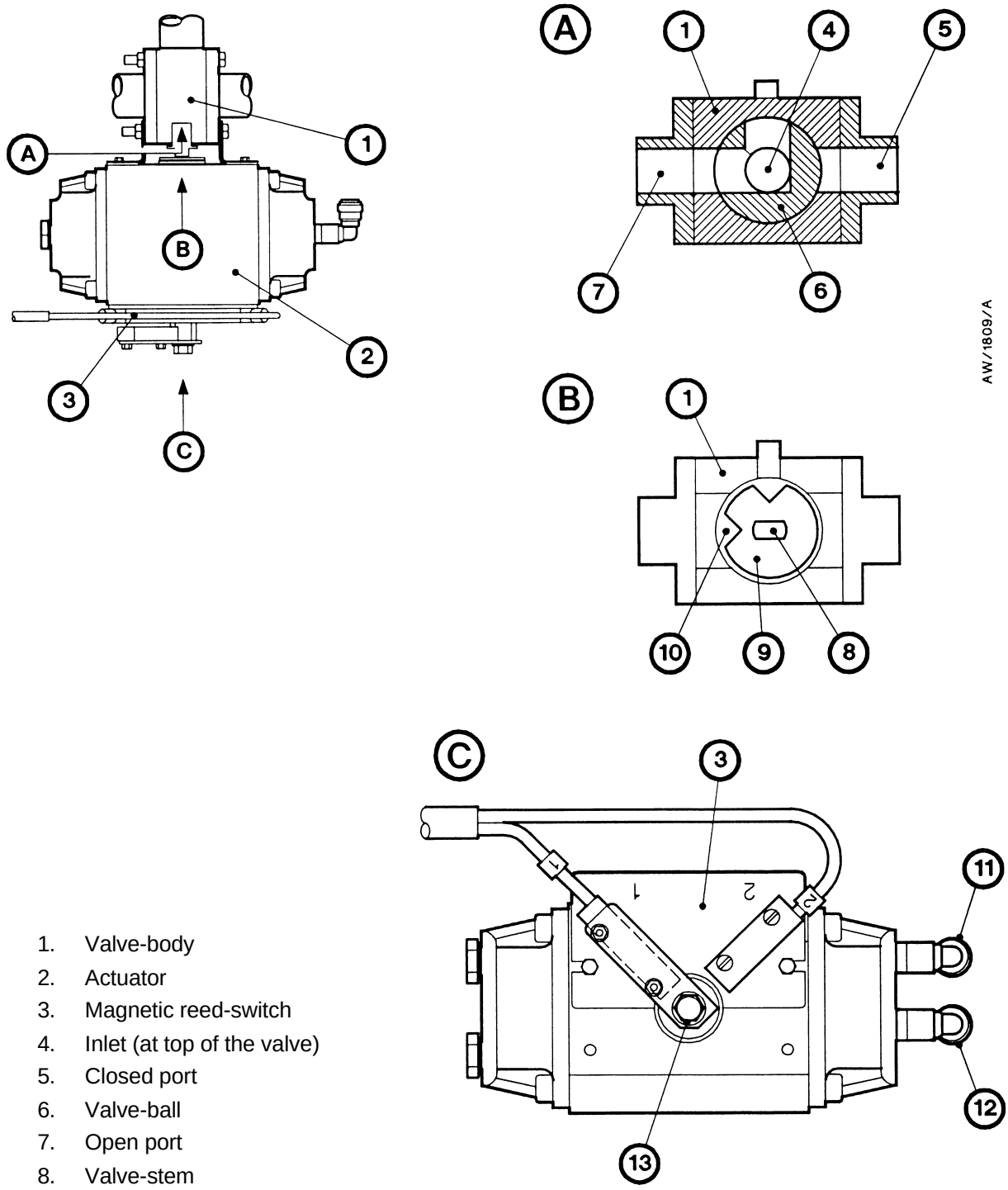
1. Actuator
2. Position indicator disk
3. Valve-body
4. Open port
5. Valve-ball
6. Pneumatic connector (6 mm)
7. Pneumatic connector (5 mm)
8. Actuator spindle
9. Red (port closed) indicator
10. White (port open) indicator

Figure 27 - Reassemble the GRC outlet isolation-valves



1. Actuator
2. Position indicator disk
3. Valve-body
4. Closed port
5. Valve-ball
6. Open port
7. Inlet (at bottom of valve)
8. Valve stem
9. Position indicator/locking washer
10. Port open indicator cut-out
11. Red (port closed) indicator
12. White (port open) indicator
13. Pneumatic connector (6 mm)
14. Pneumatic connector (5 mm)

Figure 28 - Reassemble the pump start valve



1. Valve-body
2. Actuator
3. Magnetic reed-switch
4. Inlet (at top of the valve)
5. Closed port
6. Valve-ball
7. Open port
8. Valve-stem
9. Position indicator/locking washer
10. Port open indicator cut-out
11. Pneumatic connector (6 mm)
12. Pneumatic connector (5 mm)
13. Actuator spindle

Figure 29 - Reassemble the changeover valve

5.6.4 Reassemble a valve: procedure

CAUTION

Do not over-tighten the gland nut as this will reduce the operational life of the valve.

CAUTION

The valve must be fully open when you refit the valve-body. If it is not, you can damage the valve.

Refer to Figure 26 in the following procedure.

1. Fit the stem thrust seal (9) to the stem (10), then turn the stem so that the wrench flats on the stem are aligned with the valve-body (8).
2. Insert the stem into the valve-body (8) and through the aperture at the top of the valve-body.
3. Fit the gland packing (13), the gland (14) and the two disk springs (3); the outer edges of the disk springs should touch each other.
4. Hold the stem (10) so that it cannot turn, then fit the gland nut (15) and screw it down until the disk springs (3) are firmly compressed.
5. Turn the stem three or four times, then tighten the gland nut (15) if necessary; do not over-tighten the nut.
6. Ensure that the stem is in the position shown in Figure 26, then insert the valve-ball (11) into the valve-body (8), so that the rib on the bottom of the stem (10) engages in the slot in the top of the valve-ball.
7. Turn the valve stem so that the valve stem and ball are in the position shown in detail A in the corresponding Figure 27 to 29.
8. If required, apply a light wipe of silicon-based lubricant to the seat rings (7) and seals (8); ensure that the lubricant you use is suitable for use with the gases which you will process in the D150. Fit the seat ring (7) and seal (6) to each side of the valve-body (8).
9. Slide the valve-body (8) between the body connectors (5); ensure that you do not damage the valve when you do this.
10. Fit the valve actuator (1) over the valve, so that the end of the stem (10) locates in the notch under the actuator and so that the fixing holes in the actuator brackets (2) align with the fixing holes in the valve body (8). Ensure that the valve and actuator spindle are as shown in detail A in the corresponding Figure 7 to 29.
11. Fit the four body connector bolts (12) and secure with the four nuts (4).

5.7 Replace the thermal fuses

5.7.1 Replace the enclosure thermal fuse

Refer to Figure 30, detail A. The enclosure thermal fuse (2) is located on the terminal block (3) at the top right of the enclosure, next to the leadthrough hole for the cables from the control unit.

To confirm that the fuse has failed, measure the electrical continuity across the fuse. If there is no continuity, replace the fuse.

5.7.2 Replace a heater unit thermal fuse

Refer to Figure 30, detail B. Each heater unit has a thermal fuse located under a cover in the top of the heater unit. If you think that a heater unit thermal fuse has failed:

1. Undo the two bolts (4) and remove the cover (5).
2. Measure the electrical continuity across the fuse:
   - If there is no continuity, the fuse has failed: continue at Step 3.
   - If the fuse has not failed, there may be an electrical fault in the heater unit or the enclosure. Continue at Step 4 to replace the cover, then contact Edwards.
3. Replace the thermal fuse (6) in the ceramic terminal-block.
4. Refit the cover (5) and secure with the two bolts (4).

5.8 Adjust the cartridge temperature controllers

Note: The procedures in the following sections are only summaries of the complete procedures for adjustment of the temperature controllers. Refer to the temperature controller instruction manual (supplied with the D150 if you have ordered it with the TMS ordering option) for full information.

5.8.1 Introduction

As supplied, the temperature controllers are preset for correct operation of the GRCs (and for correct operation of the TMS, if you have a TMS fitted to the D150). You should only change controller settings if you have been advised by your supplier or Edwards of a recommended change of settings (for example, when you intend to use the D150 on a different process application).

For convenience, the procedure to change controller settings is described in the following sections; refer to Figure 7 when you use these procedures.

The controller operating parameters are pre-programmed into memory in the cartridge temperature controllers. If your D150 has been switched off for 12 months or more, these operating parameters will be lost and you must re-enter them as described in Section 5.8.6.

5.8.2 Unlock the controller

Before you change controller settings, you must unlock the controller. Use the procedure below.

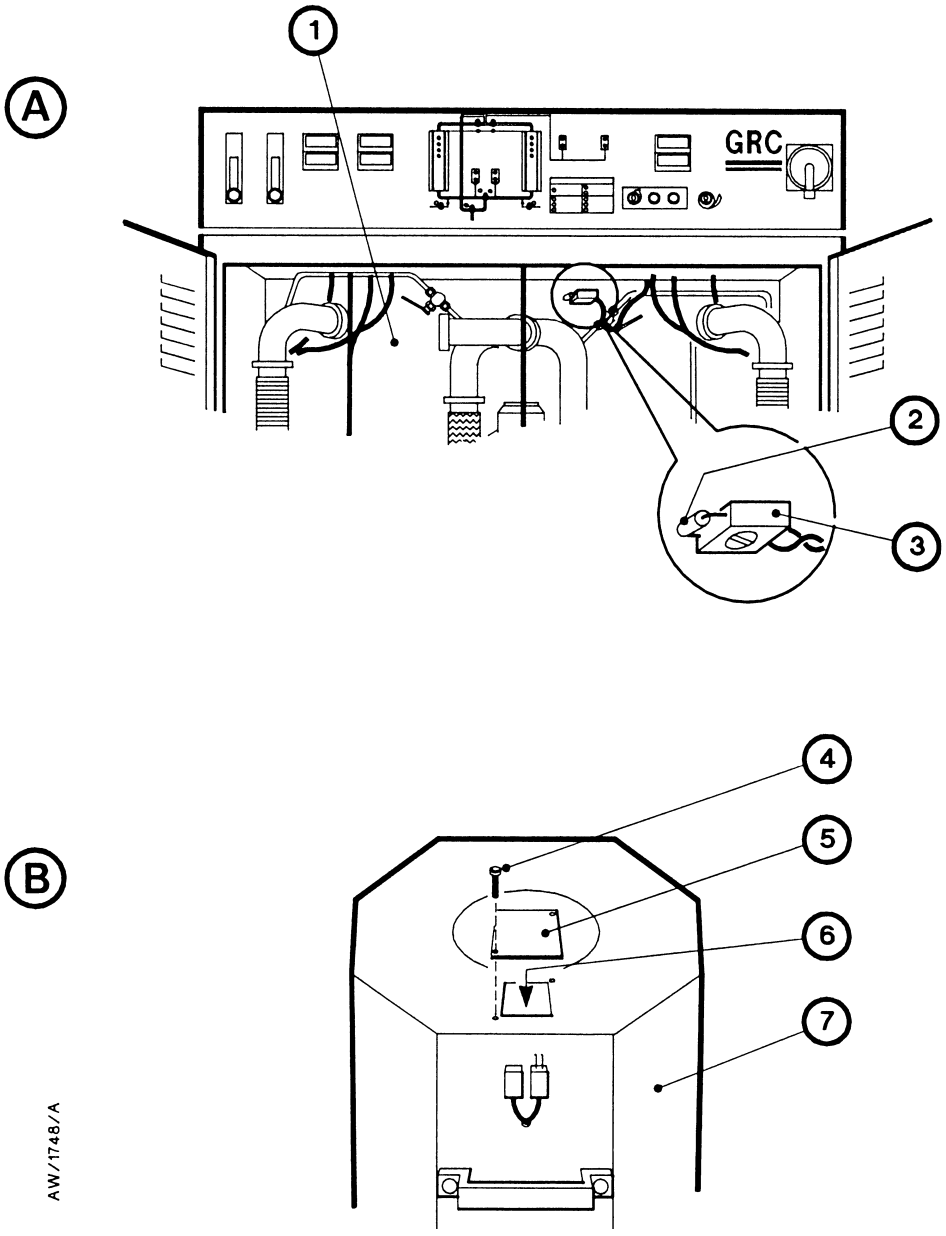
1. Press and hold ▲ and ▼ for three seconds. The controller display will then show 'TUNE'.
2. Press ▼ to change the display to 'LEVL1'.
3. Press and hold in the * button.
4. Press ▲ twice to change the display to 'LEVL3', then release the * button.
5. Press ▲ 11 times until 'VEr' is shown on the display.
6. Press and hold ▲ and ▼ for 10 seconds. When 'LOCK' appears on the display, release ▲ and ▼.
7. Press and hold in the * button.
8. Press ▼ three times until 'NONE'is shown on the display, then release the * button.
9. Press and hold ▲ and ▼ for three seconds to return to temperature display.

5.8.3 Change the default maximum temperature

The controllers are preset to a default maximum temperature. You cannot enter a set point temperature above this maximum temperature into the controller. if you need to change the maximum temperature, use the following procedure:

1. Press and hold ▲ and ▼ for three seconds. The controller display will then show 'TUNE'.
2. Press ▼ to change the display to 'LEVL1'.
3. Press and hold in the * button.
4. Press ▲ and the display will then change to 'LEVL2'. Release the * button.
5. Press ▲ eight times; the display will then show 'HiSc'.
6. Press and hold in the * button.
7. With the * button held in, press ▲ or ▼ to change the display to the required temperature.
8. Release the * button and press and hold ▲ and ▼ for three seconds to return to temperature display.

If you want to change the temperature set point, continue at Section 5.8.4. If you do not wish to change the temperature set point, use the procedure in Section 5.8.5 to lock the new maximum temperature into the controller.



A Location of the enclosure thermal fuse
B Location of the heater thermal fuse

1. Enclosure
2. Enclosure thermal fuse
3. Terminal-block
4. Bolt
5. Cover plate
6. Heater thermal fuse
7. Heater unit

Figure 30 - Thermal fuses

5.8.4 Change the temperature set point

1. Press and hold ▲ and ▼ for three seconds. The controller display will then show 'TUNE'.
2. Press ▲ seven times; the display will then show 'SP.LK'.
3. Press and hold in the * button. Press ▼ to change the display to ' OFF', then release the * button.
4. Press and hold ▲ and ▼ for three seconds to return to temperature display.
5. Press and hold in the * button.
6. With the * button held in, press ▲ or ▼ to change the display to the required set point, then release the * button.
7. Press the * button and confirm that the new temperature is now displayed, then release the * button. If the new temperature is incorrect, repeat Step 6. If the temperature is displayed correctly, continue at Step 8.
8. Repeat Steps 1 and 2; the display will then show 'SP.LK'.
9. Press and hold in the * button. With the * button held in, press ▲ to change the display to 'ON', then release the * button.
10. Press and hold ▲ and ▼ for three seconds to return to temperature display.

5.8.5 Lock the controller

After you have changed controller settings, you must lock the new settings into the controller. Use the following procedure.

1. Press and hold ▲ and ▼ for three seconds. The controller display will then show 'TUNE'.
2. Press ▼ to change the display to 'LEVL1'.
3. Press and hold in the * button.
4. Press ▲ twice to change the display to 'LEVL3', then release the * button.
5. Press ▲ 11 times until 'VEr' is shown on the display.
6. Press and hold ▲ and ▼ for 10 seconds. When 'LOCK' appears on the display, release ▲ and ▼.
7. Press and hold in the * button.
8. Press ▲ three times until 'ALL'is shown on the display, then release the * button.
9. Press and hold ▲ and ▼ for three seconds to return to temperature display.

5.8.6 Re-enter the operating parameters into the controller

Each of the temperature controllers has 23 preset functions held in memory; each function has an 'option' which is preset for correct operation of the TMS. If the TMS Control Unit has been switched off for 12 months or more, these options will have been lost. If so, you must use the following procedure to re-enter the correct options into the temperature controllers. You must enter the same options into both controllers. Use the following procedure for each controller.

1. Use the procedure in Section 5.8.2 to unlock the controller.
2. Press and hold ▲ and ▼ for three seconds. The controller display will then show 'TUNE'.
3. Press ▼ to change the display to 'LEVL1'.
4. Use the ▲ and ▼ buttons to select one of the level 1 functions shown in Tables 6 or 7. To set the option for the function:
   - Press and hold in the * button, then press ▲ or ▼ until the required option is displayed.
   - Release the * button.
5. Repeat Step 4 until the correct options have been set for all of the level 1 functions.
6. Press ▼ until 'LEVL1' is shown on the display.
7. Press and hold in the * button. Press ▲ and the display will change to 'LEVL2'. Release the * button.
8. Repeat Steps 4 and 5 until the correct options have been set for all of the level 2 functions.
9. Press ▼ until 'LEVL2' is shown on the display.
10. Press and hold in the * button. Press ▲ and the display will change to 'LEVL3'. Release the * button.
11. Repeat Steps 4 and 5 until the correct options have been set for all of the level 3 functions.
12. Press and hold ▲ and ▼ for three seconds to return to temperature display.
13. Use the procedure in 5.8.5 to lock the options into the controller.
14. Use the procedure in Steps 8 to 10 of Section 5.8.4 to lock the temperature setpoint into the controller.

Level	Function	Options	
		Upper temperature controller	Lower temperature controller
1	tunE	oFF	oFF
	bAnd	20	45
	int.t	18	25
	dER.t	200	150
	dAC	4	4.0
	CyC.t	60	60
	oFSt	0	0
	SPLk	oFF *	oFF *
	SEt.2	99	75
	CyC.2	on.oFF	on.oFF
2	SP1.P	100	100
	hAnd	oFF	oFF
	PL.1	100	100
	PL.2	100	100
	SP2.A	bAnd	bAnd
	SP2.b	nonE	nonE
	diSP	1	1
	hiSC	650	650
	LoSc	0	0
	InPt	K	K
	unit	C	C
3	SP1.d	SSd	SSd
	SP2.d	rLy	rLy

* These options will be set to 'on' when the temperature setpoint has been entered into the controller.

Table 6 - GRC cartridge temperature controller operating parameters

Level	Function	Options	
		Upper temperature controller	Lower temperature controller
1	tunE	oFF	oFF
	bAnd	1	1
	int.t	3	3
	dER.t	7	7
	dAC	1	1
	CyC.t	20	20
	oFSt	0	0
	SPLk	oFF *	oFF *
	SEt.2	20	20
	CyC.2	on.oFF	on.oFF
2	SP1.P	0	0
	hAnd	oFF	oFF
	PL.1	100	100
	PL.2	100	100
	SP2.A	bAnd	bAnd
	SP2.b	nonE	nonE
	diSP	1	1
	hiSC	120	120
	LoSc	0	0
	InPt	K	K
	unit	C	C
3	SP1.d	SSd	SSd
	SP2.d	rLy	rLy

* These options will be set to 'on' when the temperature setpoint has been entered into the controller.

Table 7 - TMS temperature controller operating parameters

5.9 Adjust the heater controllers

5.9.1 Introduction

As supplied, the heater controllers are preset for correct operation of the D150 on your process application. Except as indicated in Table 8, you should only change controller settings if you have been advised by your supplier or Edwards of a recommended change of settings (for example, when you intend to use the D150 on a different process application).

For convenience, the procedure to change the operating temperature setting on a heater controller is described in Section 5.9.2.

5.9.2 Change the heater temperature setting

Use the procedure below to change the operating temperature setting on a heater controller.

1. Refer to Figure 16. Undo the bolts (1) and remove the top cover (2) of the control unit.
2. Refer to Figure 8. Use the hexagonal key supplied to turn the controller lock (4) anticlockwise to unlock the controller temperature setting.
3. Turn the temperature adjuster (1) so that the pointer shows the required operating temperature (in ^{o}C) on the temperature display (5).
4. Use the hexagonal key to turn the controller lock (4) clockwise to lock the controller temperature setting.
5. Refer to Figure 16. Refit the top cover (2) to the control unit and secure with the bolts (1).

5.10 Check the off-line purge flow

When a GRC is off-line and is being purged, check that there is a reading of 10 to 12.5 slm on the corresponding flow-meter on the control unit (Figure 5, item 1). If necessary, adjust the flow-control valve.

5.11 Fault finding

5.11.1 General

Use Table 8 to identify the nature of faults and to determine the actions to be taken to rectify the fault. If you have a TMS fitted to your D150, refer also to Table 9.

If you cannot identify the nature of a fault or you cannot rectify a fault after you have identified it, contact your supplier or Edwards for advice.

Fault	Symptom	Check	Action
F1	All LEDs and lamps are off.	Has the electrical supply failed ?	Check the external electrical supply and rectify any problem found.
		Has fuse FS1 failed ?	Check the fuse and replace as necessary. Only replace the fuse once you have identified and rectified the cause of the failure.
F2	An await change LED is on.	Has the cartridge reached the end of its life ?	Change the used cartridge (see Section 5.4).
F3	A breakthrough LED is on.	Has the cartridge reached the end of its life ?	If the other GRC is available, the DGR will automatically start to preheat it and will automatically changeover at the end of the preheat.
		Is the end-point detector disconnected or is it faulty ?	Check that the end-point detector is correctly connected to the control unit. If it is connected correctly and if changeover has just occurred (that is, breakthrough is almost immediately shown for a new cartridge), the end-point detector for the corresponding GRC may be faulty: contact your supplier or Edwards
F4	A flow fault LED is on.	Is the level of fluid in the end-point detector bottle too low ?	Check the level of fluid in the bottle and refill as necessary: refer to Section 5.4.4.
		Are the isolation valves closed ?	Ensure that the isolation valves are open.
		Is the end-point bottle correctly fitted ?	Check that the 'O' ring in the cap is in place and that the end-point bottle is correctly fitted to the end-point detector.
		Is one of the corres-ponding end-point pipelines blocked ?	Check the pipelines and unblock if necessary.
		Is the end-point detector disconnected from the control unit ?	Check that the end-point detector is correctly connected to the control unit.
		Is the sample pump faulty ?	Use the pump test button to test the sample pump. If the sample pump is faulty, contact your supplier or Edwards.

Table 8 - D150 fault finding

Fault	Symptom	Check	Action
F5	The temperature LED is on.	Is the gas flow through the on-line GRC too high ?	Ensure that the gas flow is between 5 and 60 slm.
		Has a heater failed in the on-line GRC ?	Check the current drawn on each phase of the electrical supply (refer to the wiring diagrams in Section 8).
		Is a cartridge thermocouple faulty in the on-line GRC ?	Check that the electrical connectors are correctly fitted to the heater unit. If all the connectors are correctly fitted, replace the cartridge.
		Is a heater in the on-line GRC on constantly ?	Check the currents drawn when the heaters should be off (that is, the heater LEDs on the cartridge temperature controllers are off). If current is drawn, a solid-state relay may have failed to short circuit and a heater is constantly on.
		Is there excessive reaction in the cartridge ?	High levels of process gas have reached the GRC: check the gas system on your process system for faults.
		Has the controller failed ?	If all of the above checks fail to identify a fault, the controller may have failed; contact your supplier or Edwards for advice.
F6	A temperature warning is shown on a cartridge temperature controller: the temperature is too low.	Is the gas flow through the on-line GRC too high ?	Ensure that the gas flow is between 5 and 60 slm.
		Has a heater failed in the on-line GRC ?	Check the current drawn on each phase of the electrical supply (refer to the wiring diagrams in Section 8).
		Is a thermocouple faulty in the on-line GRC ?	Check that the electrical connectors are correctly fitted to the heater unit. If all the connectors are correctly fitted, replace the cartridge. If the fault persists, the controller may have failed; contact your supplier or Edwards for advice.

Table 8 - D150 fault finding (continued)

Fault	Symptom	Check	Action
F7	A temperature warning is shown on a cartridge temperature controller: the temperature is too high	Is there a faulty thermocouple in the cartridge ?	Check that the electrical connectors are correctly fitted to the heater unit. If the connections are correctly fitted, replace the cartridge. If the fault persists, continue fault finding as described on the following page.
		Is a heater on constantly ?	Check the currents drawn when the heaters should be off (that is, the heater LEDs on the cartridge temperature controllers are off). If current is drawn, a solid-state relay may have failed to short circuit and a heater is constantly on.
		Is there excessive reaction inside the cartridge ?	High levels of process gas have reached the D150; check the gas system on your process system for faults.
		Has the controller failed ?	If all of the above checks fail to identify a fault, a controller may have failed: contact your supplier or Edwards for advice.
			Note: After a high temperature warning, inspect the cartridge outlet 'O' rings and the 'O' ring at the D150 outlet for damage or thermal set; replace the 'O' rings if necessary.
F8	The leak test fail LED is permanently on: the leak test has failed.	Is the heater unit fitted correctly ?	Check that the cartridge inlet and outlet connections are correctly made.
		Is the cartridge faulty ?	Change the cartridge as described in Section 5.4.
F9	The Leak Test Fail LED does not start to flash (that is, the D150 does not start the leak test) when you have changed a cartridge and refitted the heater unit.	Is the heater unit connected, has the end-point detector bottle been refitted and is the safety interlock key in the correct position ?	Check that the electrical connectors are correctly fitted to the heater unit, check that the safety interlock key is in the unlocked position and check that the end-point detector bottle has been refilled and refitted in the enclosure.

Table 8 - D150 fault finding (continued)

Fault	Symptom	Check	Action
F9	The Leak Test Fail LED does not start to flash (that is, the D150 does not start the leak test) when you have changed a cartridge and refitted the heater unit (continued).	Has the heater unit thermal fuse failed ?	Check the thermal fuse and replace if necessary (see Section 5.7).
		Is there an electrical fault ?	If the thermal fuse has not failed, there may be an electrical fault in the heater unit, enclosure or control unit.
F10	The air pressure LED is on.	Is the safety interlock key in the locked position ?	Ensure that the safety interlock key is in the unlocked position after you have changed the cartridge and refitted the heater unit in the enclosure.
		Has the compressed air supply failed ?	Check the compressed air supply. The supply pressure must be as specified in Section 2.
		Is a compressed air pipe disconnected ?	Check the pipes; reconnect any disconnected pipes.
F11	The MCB LED is on.	Has the circuit breaker tripped ?	A transient electrical supply failure may have tripped the circuit breaker. Switch off the electrical supply isolator, then switch it on again.
		Is there an electrical fault (has a phase failed) ?	Check the connection of the electrical supply to the control unit. If the connections are correct, there may be an electrical fault in the control unit or enclosure: contact your supplier or Edwards.
		Has fuse FS3 failed ?	Check the fuse and replace as necessary. Only replace the fuse once you have identified and rectified the cause of the failure.
F12	A warning pressure LED is on.	Has a back-pressure developed across the cartridge inlet and outlet ?	If the cartridge is exhausted and the other GRC is available, the D150 will automatically start to preheat the available GRC. If the pressure continues to rise, the D150 will automatically changeover and start to purge the currently on-line GRC ready for cartridge change

Table 8 - D150 fault finding (continued)

Fault	Symptom	Check	Action
F12	A warning pressure LED is on (continued).	Is the pressure-switch pipeline blocked or is there a blockage in the exhaust-extraction system ?	If a changeover has just occurred (that is, the warning pressure is associated with a new cartridge), the pipeline to the pressure-switch unit may be blocked. Clean the pipeline as described in Section 5.6. If the fault persists, your exhaust-extraction system may be blocked.
F13	A high pressure LED is on.	Is the pressure-switch blocked or faulty ?	Use a pressure gauge to check for correct operation of the pressure-switch unit (warning and alarm level outputs).
F14	Both the high and warning pressure LEDs for a GRC are on.	Is the plug disconnected from the corresponding pressure-switch unit ?	Check that the electrical connector is correctly fitted to the pressure-switch unit.
		Is the exhaust-extraction system pipeline blocked ?	Your exhaust- extraction system pipeline may be blocked ; inspect the pipeline and remove any obstructions.
		Is the pressure-switch pipeline blocked ?	If your exhaust-extraction system is not blocked, dismantle, inspect and clean the pipeline to the pressure-switch unit.
		Is the pressure-switch unit faulty ?	If all of the above actions fail to rectify the fault, the pressure-switch unit may be faulty: contact Edwards for advice.
F15	The warning level 1 LED is on.	Has the cartridge leak test failed ?	Refer to the checks and actions for 'the leak test fail LED is permanently on' symptom: fault F8.
		Is there an end-point detector flow fault ?	Refer to the checks and actions for 'the flow fault LED is on' symptom: fault F4.
		Is there a warning pressure ?	Refer to the checks and actions for 'a warning pressure LED is on' symptom: fault F12.
		Does a cartridge need to be changed ?	Refer to the checks and actions for 'the await change LED is on' symptom: fault F2.
F16	The warning level 2 LED is on.	Is there a temperature fault ?	Refer to the checks and actions for 'the temperature LED is on' symptom: fault F5.

Table 8 - D150 fault finding (continued)

Fault	Symptom	Check	Action
F16	The warning level 2 LED is on (continued).	Has the compressed air supply failed ?	Refer to the checks and actions for 'the air pressure LED is on' symptom: fault F10.
		Has the circuit breaker tripped ?	Refer to the checks and actions for 'the MCB LED is on' symptom: fault F11.
		Is there a high pressure in the pipelines ?	Refer to the checks and actions for 'a high pressure LED is on' symptom: fault F13.
F17	The alarm LED is on.	Is the pump start valve open ?	If the pump start valve is open because the pumping system is starting up, after start-up, the valve will close and the D150 will start to treat process gases.
		Is there a pressure surge ?	When the pressure surge is over, the pressure will fall, the pump start valve will close and the D150 will continue to treat the process gases.
		Are no GRCs available ?	Check that the electrical connectors are correctly fitted to the heater units. If they are correctly fitted, there may be an electrical fault: contact your supplier or Edwards.
F18	The temperature displayed on a temperature controller is increasing rapidly (and is outside the normal expected range) or 'InPt FAIL' is displayed on a cartridge temperature controller.	Are the thermocouple connectors disconnected ?	Check that the thermocouple connectors on the cartridge are correctly fitted to the connectors on the heater unit.
		Is the control unit disconnected from the heater unit ?	Check that the electrical connectors are correctly fitted to the heater unit.
		Is a thermocouple (or controller) faulty ?	If all the connectors are correctly fitted, replace the cartridge. If the fault persists, the controller may have failed; contact your supplier or Edwards for advice.
F19	A negative temperature is displayed on a temperature controller.	Are the thermocouple connectors incorrectly fitted ?	Check that the thermocouple connectors are correctly fitted; that is, that the '+' and '-' indicators on the male and female connectors match.
F20	A spare alarm LED is on.	Is there an alarm from the accessory connected to the D150 control unit ?	Refer to the instruction manual supplied with your accessory and take the recommended actions.

Table 8 - D150 fault finding (continued)

Fault	Symptom	Check	Action
F21	'InPt nOnE' is displayed on a cartridge temperature controller.	Has the D150 been in storage or been left switched off for 12 months or more ?	Re-enter the operating parameters into the temperature controllers as described in Section 5.8.6.
F22	All temperature controllers are blank (off).	Has fuse FS2 failed ?	Check the fuse and replace as necessary. Only replace the fuse once you have identified and rectified the cause of the failure.
		Has the enclosure thermal fuse failed ?	Check the fuse and replace as necessary.

Table 8 - D150 fault finding (continued)

Symptom	Check	Action
A temperature warning is shown on a temperature controller: the temperature is too low.	Is the gas flow through the on-line GRC too high ?	Ensure that the gas flow is between 5 and 60 slm.
	Are the heaters and insulation jackets fitted correctly ?	Check that the heaters and insulation jackets are correctly fitted.
	Has a heater thermal fuse failed ?	Check the heaters as described in the TMS instruction manual. Replace heaters if necessary.
	Is a thermocouple faulty ?	Check that the thermocouples are correctly fitted to the distribution units. If all the connections are correct, the thermocouple may be faulty: check and replace as necessary.
	Is there a fault ?	If the fault persists, the controller, control unit or distibution unit may have failed: contact your supplier or Edwards for advice.
A temperature warning is shown on a temperature controller: the temperature is too high.	Is there a faulty thermocouple in the cartridge ?	Check that the thermocouples are correctly connected to the distribution unit. If the connections are correct, replace the thermocouple(s).

Table 9 - TMS fault finding

Symptom	Check	Action
A temperature warning is shown on a temperature controller: the temperature is too high (continued).	Is there an electrical fault ?	If the fault persists, continue fault finding as described below.
	Is there excessive reaction inside the cartridge ?	High levels of process gas have reached the D150; check the gas system on your process system for faults.
	Has the controller failed ?	If all of the above checks fail to identify a fault, a controller may have failed: contact your supplier or Edwards for advice.
'InPt FAIL' is displayed on a temperature controller.	Is a thermocouple disconnected from the distribution unit ?	Check that the thermocouples are correctly fitted to the distribution units. If all the connections are correct, the thermocouple or cable may be faulty: check and replace as necessary.
'InPt nOnE' is displayed on a temperature controller.	Has the D150 been in storage or been left switched off for 12 months or more ?	Re-enter the operating parameters into the temperature controllers as described in Section 5.8.6.
All temperature controllers are blank (off).	Has fuse FS5 or FS6 failed ?	Check the fuses and replace as necessary. Only replace the fuses once you have identified and rectified the cause of the failure.
The temperature controllers show a permanent temperature alarm (the pipeline heaters are below the correct temperature)	Has fuse FS8 failed ?	Check the fuse and replace as necessary. Only replace the fuse once you have identified and rectified the cause of the failure.

Table 9 - TMS fault finding (continued)

5.11.2 Heater fault finding

To determine whether a heater has failed in a GRC, use the following procedure.

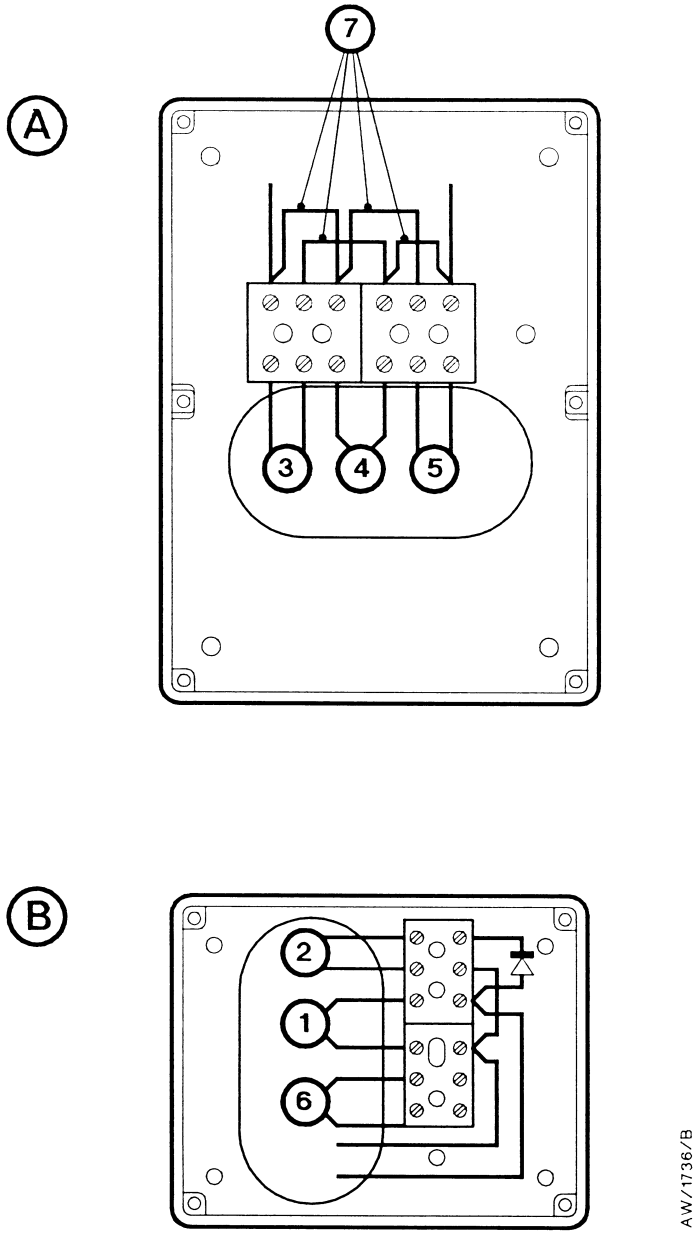
1. Switch off the D150 and isolate it from the electrical supply.
2. Remove the covers from the upper and lower terminal-boxes on the appropriate GRC heater unit.
3. Refer to Figures 31 and 32: Remove the links (7) from the upper terminal-box
4. Use a suitable meter to measure the resistances of the heaters (1 to 5):
   - If the resistances are not as shown in the appropriate Table 10 or 11, the heater has failed and must be replaced.
   - If the resistances are as shown in the appropriate Table 10 or 11, the heater has not failed: refit the links as shown in the appropriate Figure 31 or 32.

Heater (Figure 31 key)	Correct resistance (Ω)
5	64 ± 5
4	64 ± 5
3	64 ± 5
2	64 ± 5
1	29 ± 5

Table 10 - Heater resistances: 200 / 208 V

Heater (Figure 32 key)	Correct resistance (Ω)
5	29 ± 5
4	29 ± 5
3	29 ± 5
2	64 ± 5
1	29 ± 5

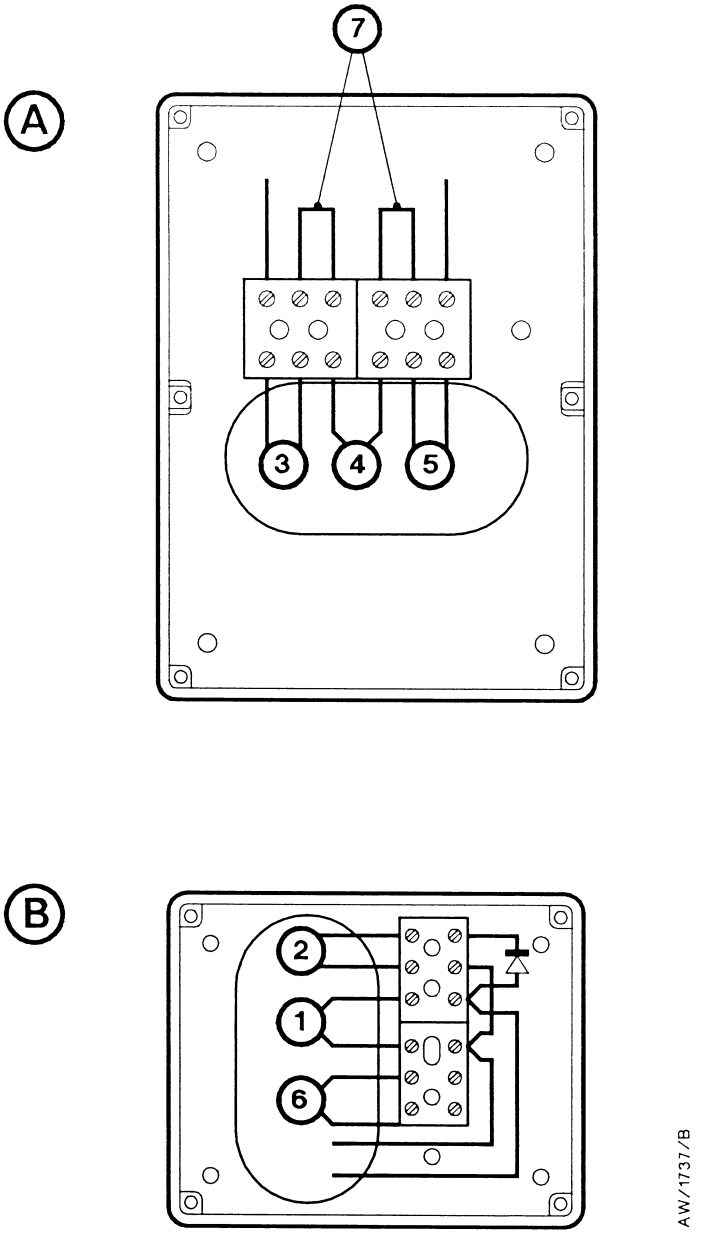
Table 11 - Heater resistances: 380 / 415 V



A Upper terminal-box
B Lower terminal-box

1. To heater 1 (lower heater)
2. To heater 2 (lower heater)
3. To heater 3 (upper heater)
4. To heater 4 (upper heater)
5. To heater 5 (upper heater)
6. To thermocouple
7. Links

Figure 31 - Heater unit terminal-box connections: 200-208 V



A Upper terminal-box
B Lower terminal-box

1. To heater 1 (lower heater)
2. To heater 2 (lower heater)
3. To heater 3 (upper heater)
4. To heater 4 (upper heater)
5. To heater 5 (upper heater)
6. To thermocouple
7. Links

Figure 32 - Heater unit terminal-box connections: 380 / 415 V

6 STORAGE AND DISPOSAL

6.1 Storage

6.1.1 D150 storage

Note: If the D150 is switched off and stored for 12 months or more, the operating parameters programmed into the temperature controllers will be lost. If the operating parameters have been lost, you must re-enter the parameters into the D150 cartridge temperature controllers (and the TMS temperature controllers, if the D150 has a TMS) as described in Section 5.8.6 before you use the D150.

Store the D150 as follows:

1. Shut down the D150 as described in Section 4.7.
2. If applicable, ensure that the pumping system has been shut down and disconnect the D150 from the pumping system.
3. Fit blanking-plates to all inlets and outlets. Place protective covers over the services connection points.
4. Store the D150 in clean, dry conditions until required.
5. When required for use, prepare and install the D150 as described in Section 3 of this manual.

6.1.2 Cartridge storage

The contents of the cartridges are granular and may settle if the cartridges are stored horizontally. If the cartridge contents settle, you will have to resettle the cartridge before you can use it: refer to section 5.4.6.

We therefore recommend that you store the cartridges vertically. If required, contact your supplier or Edwards for a suitable rack design for cartridge storage.

6.2 Disposal

6.2.1 General

Dispose of the D150 and any components safely in accordance with all local and national safety and environmental requirements.

Particular care must be taken with the following:

- Fluoroelastomers which have decomposed as the result of being subjected to high temperatures
- Components which have been contaminated with dangerous process substances.

6.2.2 Disposal of used cartridges

Dispose of used cartridges safely in accordance with all local and national safety and environmental requirements.

If the D150 has been used on silicon processes with fluorine, chlorine or bromine etching or silane deposition, the used D150 cartridge will contain stable inert solids. Such used cartridges are classified in the UK and some other countries as non-hazardous and are suitable for ordinary landfill disposal.

If you have used the D150 on another process, or you have any doubt as to the safety of the contents of your used cartridges, contact your supplier or Edwards for advice. Each Edwards site has people who can advise you on how to dispose of cartridges or recycle the cartridges to the steel industry.

A Material Safety Data Sheet on the contents of cartridges is available from Edwards on request.

7 SERVICE, SPARES AND ACCESSORIES

7.1 Introduction

Edwards products, spares and accessories are available from Edwards companies in Belgium, Brazil, Canada, France, Germany, Hong Kong, Italy, Japan, Korea, Switzerland, United Kingdom, U.S.A, and a world-wide network of distributors. The majority of these centres employ Service Engineers who have undergone comprehensive Edwards training courses.

Order spare parts and accessories from your nearest Edwards company or distributor. When you order, please state for each part required:

- Model and Item Number of your equipment
- Serial number (if any)
- Item Number and description of part.

7.2 Service

Edwards products are supported by a world-wide network of Edwards Service Centres. Each Service Centre offers a wide range of options including: equipment decontamination; service exchange; repair; rebuild and testing to factory specifications. Equipment which has been serviced, repaired or rebuilt is returned with a full warranty.

Your local Service Centre can also provide Edwards engineers to support on-site maintenance, service or repair of your equipment.

For more information about service options, contact your nearest Service Centre or other Edwards company.

7.3 Spares

7.3.1 Cartridges

	Item Number
C150Y cartridges, pack of 2	A223-04-105
C150Y cartridges, pack of 5	A223-04-106

7.3.2 Recommended D150 spares

Spare	**Minimum recommended qty**	**Item Number**
NW40 clamping ring	10	C105-16-401
NW40 trapped 'O' ring	10	C105-16-490
NW40 x 250 mm braided flexible pipeline	1	C105-16-295
NW40 x 135 mm braided flexible pipeline	2	C105-16-294

Spare	Minimum recommended qty	Item Number
NW40 x 100 mm flexible bellows	2	A550-01-084
Safety interlock and button lock key	2	A551-01-004
Pressure-switch assembly	1	24863-012
Enclosure thermal fuse (pack of 10)	1 pack	A551-01-006
Heater unit thermal fuse (pack of 10)	1 pack	24867-023
Thermocouple extension leads (pair)	2 pairs	A551-01-007
500 mA x 20 mm fuse (pack of 10)	1 pack	A551-01-010
1 A x 20 mm fuse (pack of 10)	1 pack	A551-01-008
4 A x 20 mm fuse (pack of 10)	1 pack	A551-01-009
Upper cartridge temperature controller	1	A551-01-020
Lower cartridge temperature controller	1	A551-01-021
Heater temperature controller	1	28853-017
Cartridge change handle	1	A550-01-033
2-way $1^1/_4$ inch ball valve seal repair kit	2	22491-015
3-way 1 inch ball valve seal repair kit	2	A550-01-015
End-point monitor sample pump	1	A551-01-014
End-point monitor bottle	10	A551-01-015
End-point monitor orifice assembly	2	A551-01-016

7.3.3 Additional D150 spares

We recommend that you maintain a stock of the following additional spares; if so, you will ensure that your pumping system is switched off for as short a time as possible.

Spare	Minimum recommended qty	Item Number
Heater unit roller carriage (pair)	1 pair	A551-01-005
2-way $1^1/_4$ inch ball valve and actuator assembly	1	A551-01-023
3-way pump start valve and actuator assembly	1	A551-01-024
2-way $1^1/_4$ inch ball valve body assembly *	1	22491-022
3-way 1 inch ball valve and indicator assembly *	1	A551-01-026
Pneumatic actuator assembly *	1	A551-01-027
Display interface PCB	1	A551-01-028
PLC to ribbon interface board	1	A551-01-017
Solid-state relay (30 A)	1	22491-005
End-point monitor electronics assembly	1	A551-01-032

Spare	Minimum recommended qty	Item Number
End-point monitor pump / bottle assembly	1	A551-01-033
Solenoid catch assembly	1	A551-01-034
Reed-switch, plate and magnet kit	1	A551-01-035
DIN rail pneumatic assembly	1	A551-01-036
Pneumatic valve: 4-port, 2-position	1	A551-01-037
2-way solenoid-valve assembly	1	A551-01-039
Pilot operated 5-port, 2-position valve assembly	1	A551-01-040

* These items are a lower level of spares assembly and are included as component parts of other spares. If you order all of the other spares in the above list, you do not need to order these spares.

7.3.4 Recommended TMS spares

If your D150 has a TMS fitted, we recommend that you maintain a stock of the following spares:

Spare	Minimum recommended qty	Item Number
Temperature controller	1	A551-01-021
Solid-state relay (10 A)	1	A551-01-043
250 mA x 20 mm fuse (pack of 10)	1 pack	A551-01-044
4 A x 20 mm fuse (pack of 10)	1 pack	A551-01-009
10 A x 20 mm fuse (pack of 10)	1 pack	A551-01-045
Pipeline thermocouple assembly	2	A551-01-046
Flexible connector heater	1	A551-01-047
Pipeline heater: 50 mm	1	A551-01-048
Pipeline heater: 130 mm	1	A551-01-049
Pipeline heater: 210 mm	1	A551-01-050

7.4 Accessories

7.4.1 Cartridge change cart

The cartridge change cart (see Figure 12) allows you to easily remove a heater unit from the D150 enclosure and to easily change a cartridge in the heater unit (see Section 5.4).

Accessory	Item Number
Cartridge change cart	A551-07-000

7.4.2 Temperature Management System (TMS) accessories

These accessories have been developed to heat the D150 process pipelines and pipeline from the pump exhaust to reduce the formation of solids in the pipelines. You can order the D150 with a TMS fitted to the D150 process pipelines: see Section 7.6.1.

The accessories you need to install on the pipeline from the pump exhaust to the D150 inlet will depend on your process application and the installation configuration of your system: refer to the TMS instruction manual (supplied with the D150 if you have ordered the TMS option with the D150).

Note that the (optional) TMS fitted to the D150 can provide the electrical supplies for up to 2 m of pipe heaters. If the pipeline that you need to heat between the pump exhaust and the D150 inlet is longer than 2 m, you will need an additional TMS Control Unit.

7.4.3 Pressure Gauge Kit

Use the Pressure Gauge Kit to check for correct operation of the pressure-switch units.

Accessory	**Item Number**
Pressure Gauge Kit	A551-01-106

7.4.4 Gas Sampling Kit

Use the Gas Sampling Kit to connect to a spot sampler or other gas measurement/analysis equipment, when you want to measure the level of exhaust gases in the D150 outlet (see Section 5.4.1).

Accessory	**Item Number**
Gas Sampling Kit	A551-01-133

7.5 Pipeline components

You will need an NW40 elbow to connect to the D150 inlet flange if you use one of the inlet leadthrough holes on the rear of the enclosure. You will also need an NW40 elbow to connect to the D150 outlet flange if you use one of the outlet leadthrough holes on the rear of the enclosure.

Accessory	**Item Number**
NW40 90^{o} elbow (stainless steel)	C105-16-420

7.6 Ordering options

Your D150 can be supplied with a number of options fitted. These options are briefly described in the following sections.

7.6.1 TMS (Temperature Management System)

Select this option if your application requires the pipeline from the pumping system to be maintained at a high temperature (to prevent the formation of solids in the pipeline). When you order this option, the D150 will be supplied with thermocouples, heaters and insulation jackets fitted to the process pipelines between the D150 inlet and cartridge inlets, with electrical supply distribution units fitted in the enclosure, and with temperature controllers fitted to the control unit.

If your D150 is supplied with this option, you must also fit suitable TMS heaters and insulation jackets to the exhaust pipeline between the pumping system and the D150 inlet (refer to Section 3.16). These heaters will be controlled by the TMS pump line temperature controller fitted to the D150.

Refer to Section 1.10 for more information on the TMS.

7.6.2 Air Tuyere System

Select this option if you have been advised by Edwards that your application requires the use of C150R cartridges. If you select this option, the D150 enclosure will be configured to use C150R cartridges in which compressed air is introduced into the on-line cartridge.

7.6.3 Inlet orientation

The D150 can be supplied with the inlet on either the right or left of the enclosure. When you order the D150, you can specify which side you want the inlet; the D150 is then supplied with the inlet configured as requested. If you do not specify which side you want the inlet, the D150 is supplied with the inlet on the left of the enclosure.

7.6.4 End-point detectors

If your D150 is supplied with this option, an end-point detector is fitted to each GRC. The end-point detector measures the conductivity of the gases in the outlet of the GRC cartridge to determine when a cartridge should be changed. The end-point detectors are suitable for most etch applications. Refer to Section 1.5.2 for further information.

7.6.5 Inlet Pressure Sensor

Select this option if you want to see the pressure in the D150 cartridge inlet pipelines. If you select this option, the D150 is supplied with a digital pressure indicator, which shows the pressure in the inlet pipeline of the on-line GRC.

7.6.6 Remote Display

Select this option if you want to remotely monitor the status of the D150. If you select this option, the D150 is supplied with a connector, to which you can connect the remote display panel. The remote display panel has a status display which is identical to, and operates in the same way as, the status display on the D150 control panel (see Figure 6).

7.6.7 Central PC Monitor

Select this option if you want to use a PC with the Central PC Monitor software installed to remotely monitor the operation of the D150. If you select this option, the D150 is supplied with a connector to connect the D150 to a PC and is configured so that status information can be sent to the PC.

7.6.8 Remote inputs

The D150 can use a remote input signal. If you want to use the remote input signal, contact your supplier or Edwards for advice.

8 ENGINEERING DIAGRAMS

The circuit and wiring diagrams for the D150 are shown in Figures 33 to 39 on the following pages. The labels used on these diagrams are described in Table 12.

Label		Meaning
D150S/J/K	**D150E**	
SW1	SW1	Electrical supply isolator
C/B1	C/B1	Circuit breaker
CONT1	CONT1	Contactor: GRC 1
CONT2	CONT2	Contactor: GRC2
CR1	RL1	Relay: circuit breaker
CR3	RL3	Relay: remote control of pump start valve (ordering option)
CR4	RL4	Relay: TMS changeover
Temperature controller 1	Temperature controller 1	GRC1 upper cartridge temperature controller
Temperature controller 2	Temperature controller 2	GRC1 lower cartridge temperature controller
Temperature controller 3	Temperature controller 3	GRC1 heater controller
Temperature controller 4	Temperature controller 4	GRC2 upper cartridge temperature controller
Temperature controller 5	Temperature controller 5	GRC2 lower cartridge temperature controller
Temperature controller 6	Temperature controller 6	GRC2 heater controller
Temperature controller 7	Temperature controller 7	TMS temperature controller: GRC inlet
Temperature controller 8	Temperature controller 8	TMS temperature controller: pump line
CRE1	SSR1	Solid-state relay: GRC1 lower heaters
CRE2	SSR2	Solid-state relay: GRC1 upper heaters
CRE3	SSR3	Solid-state relay: GRC2 lower heaters
CRE4	SSR4	Solid-state relay: GRC2 upper heaters
CRE5	SSR5	Solid-state relay: TMS GRC inlet heaters
CRE6	SSR6	Solid-state relay: TMS pump line heaters
FB1	FS1	Fuse: High voltage supply
FB2	FS2	Fuse: High voltage supply
FB3	FS3	Fuse: MCB indication

Table 12 - Electrical component labels used on the control unit circuit diagrams

Label		Meaning
D150S/J/K	**D150E**	
FB4	FS4	Fuse: 24 V a.c.
FB5	FS5	Fuse: TMS electrical supply
FB6	FS6	Fuse: TMS electrical supply
FB7	FS7	Fuse: TMS temperature controllers
FB8	FS8	Fuse: TMS heaters electrical supply
PS1	PS1	Compressed air supply pressure-switch
SOL1	SOL1	Pneumatic valve solenoid: GRC1 outlet isolation-valve
SOL2	SOL2	Pneumatic valve solenoid: GRC2 outlet isolation-valve
SOL3	SOL3	Pneumatic valve solenoid: changeover valve
SOL4	SOL4	Pneumatic valve solenoid: pump start valve
SOL5	SOL5	Pneumatic valve solenoid: compressed air on / off
SOL6	SOL6	Pneumatic valve solenoid: off-line nitrogen purge
SOL7	SOL7	Pneumatic valve solenoid: pressure-switch nitrogen purge

Table 12 - Electrical component labels used on the control unit circuit diagrams (continued)

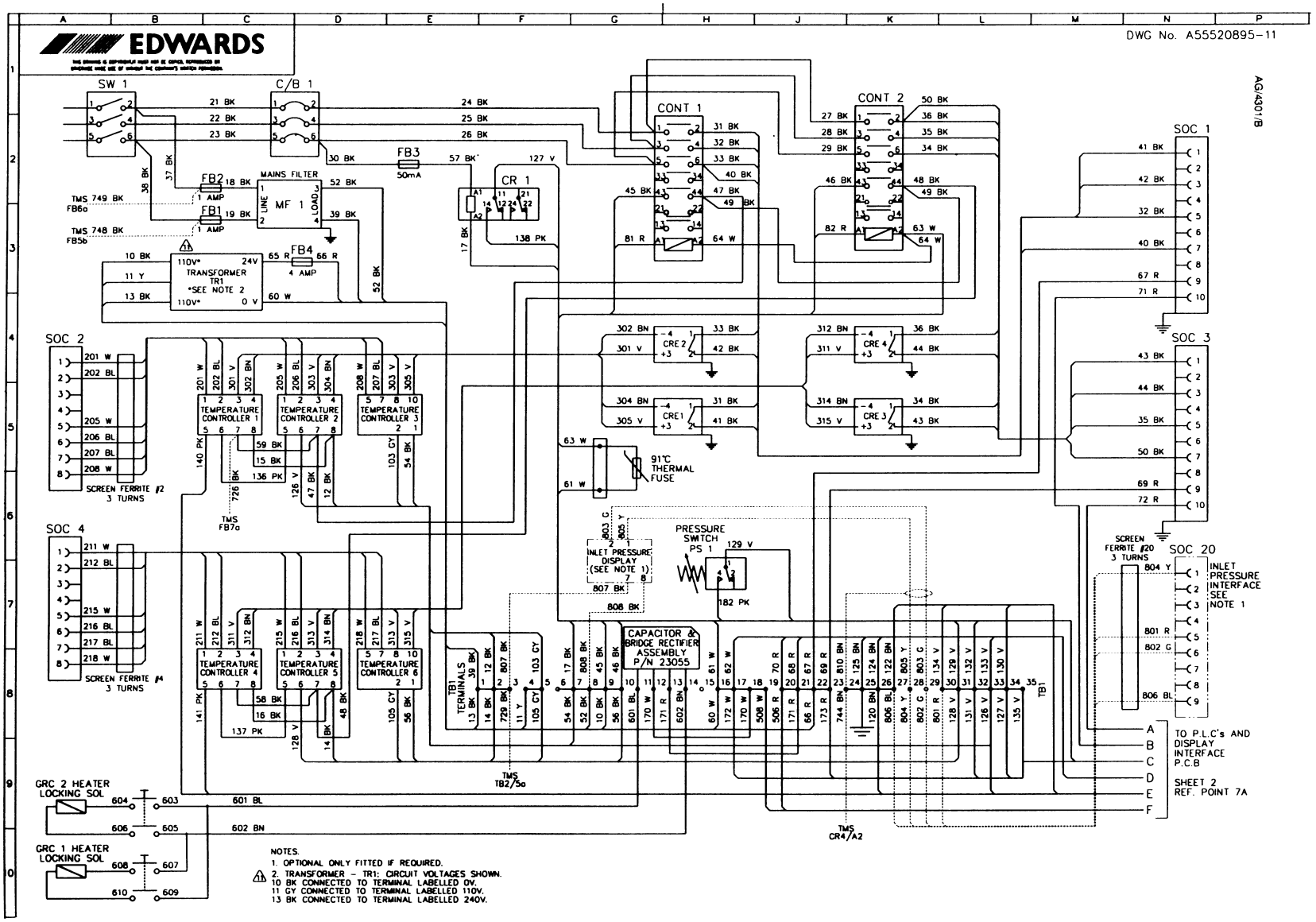


Figure 33 - Control unit circuit diagram (200-208 V): sheet 1 of 2

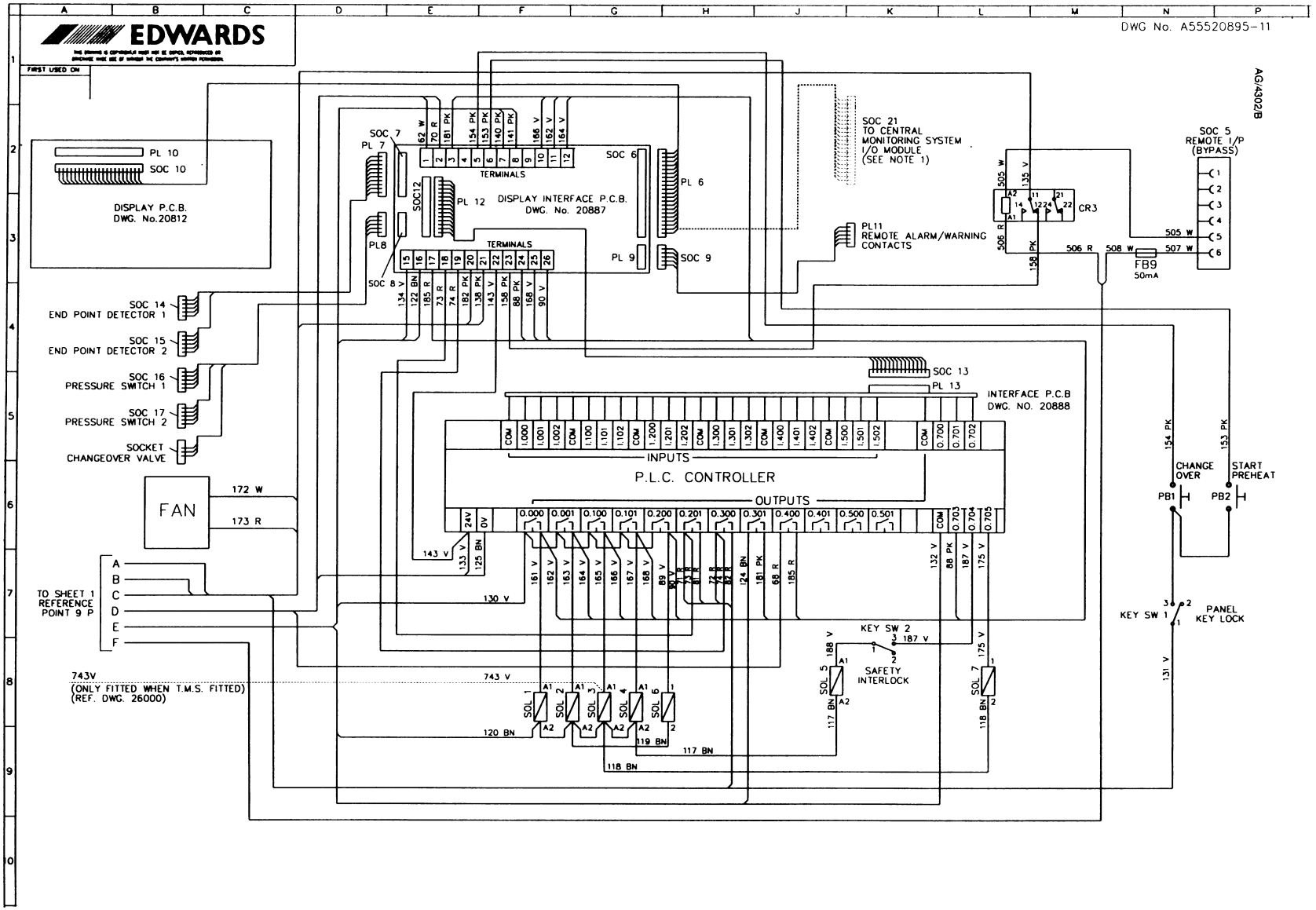


Figure 33 - Control unit circuit diagram (200-208 V): sheet 2 of 2

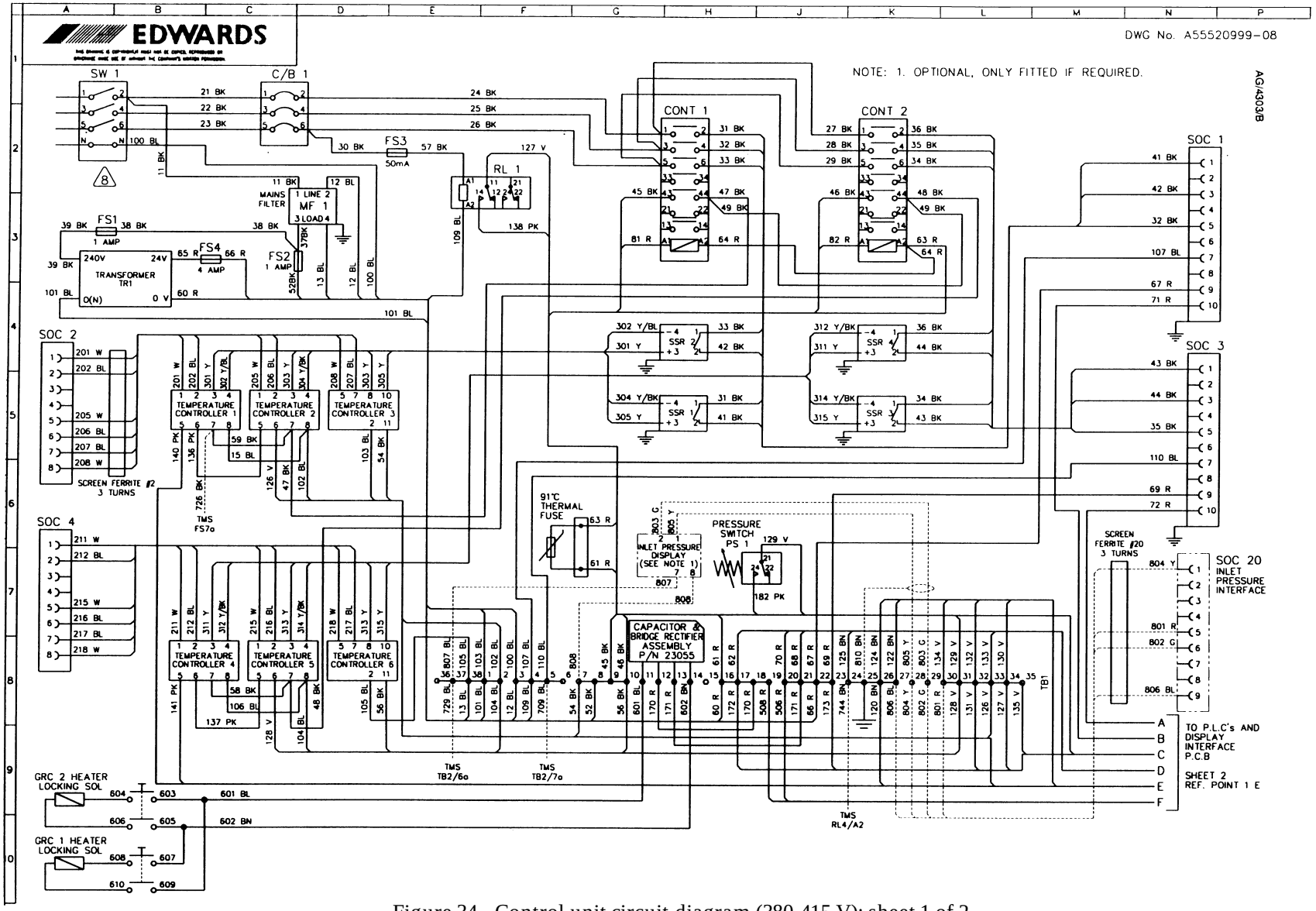


Figure 34 - Control unit circuit diagram (380-415 V): sheet 1 of 2

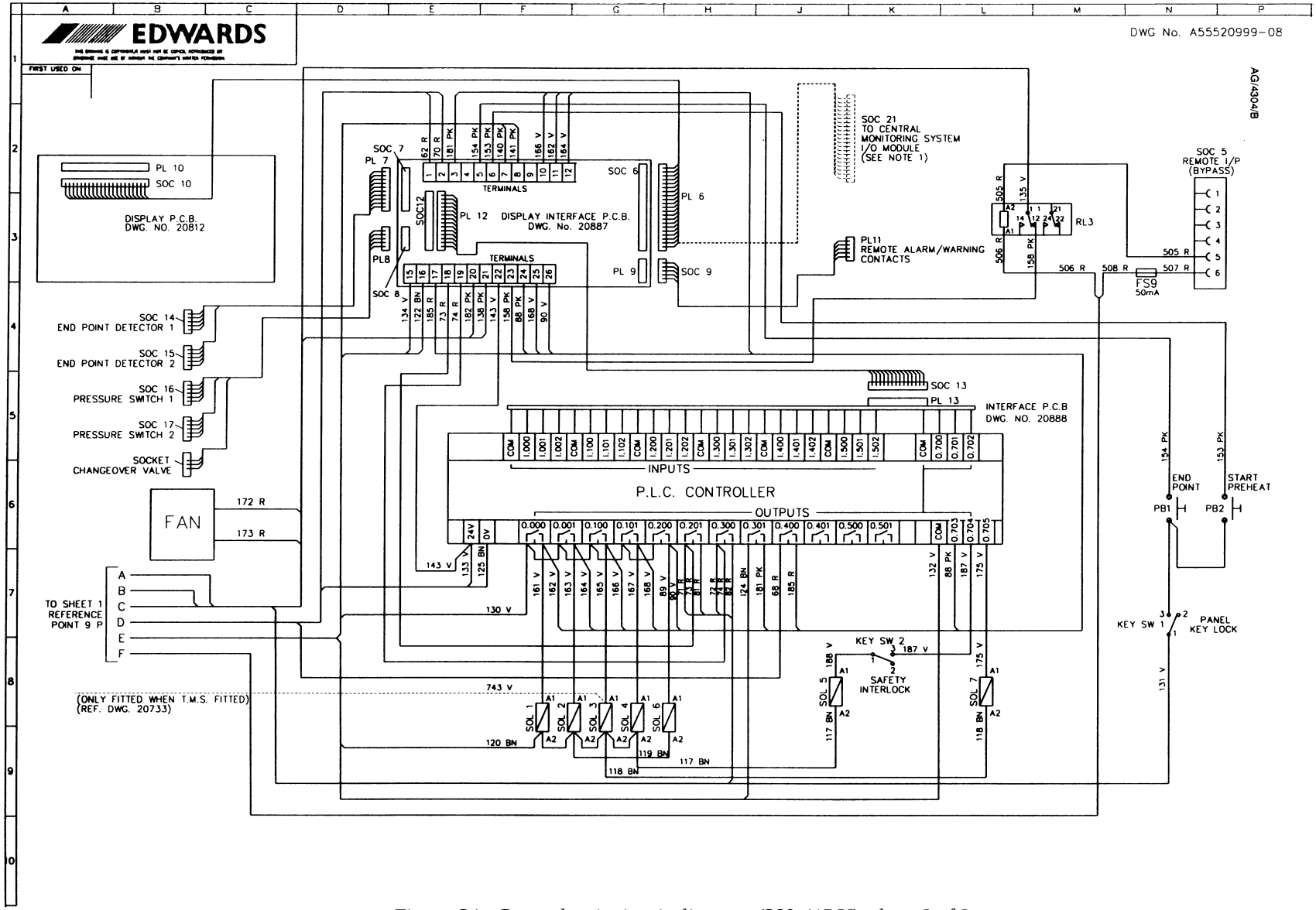


Figure 34 - Control unit circuit diagram (380-415 V): sheet 2 of 2

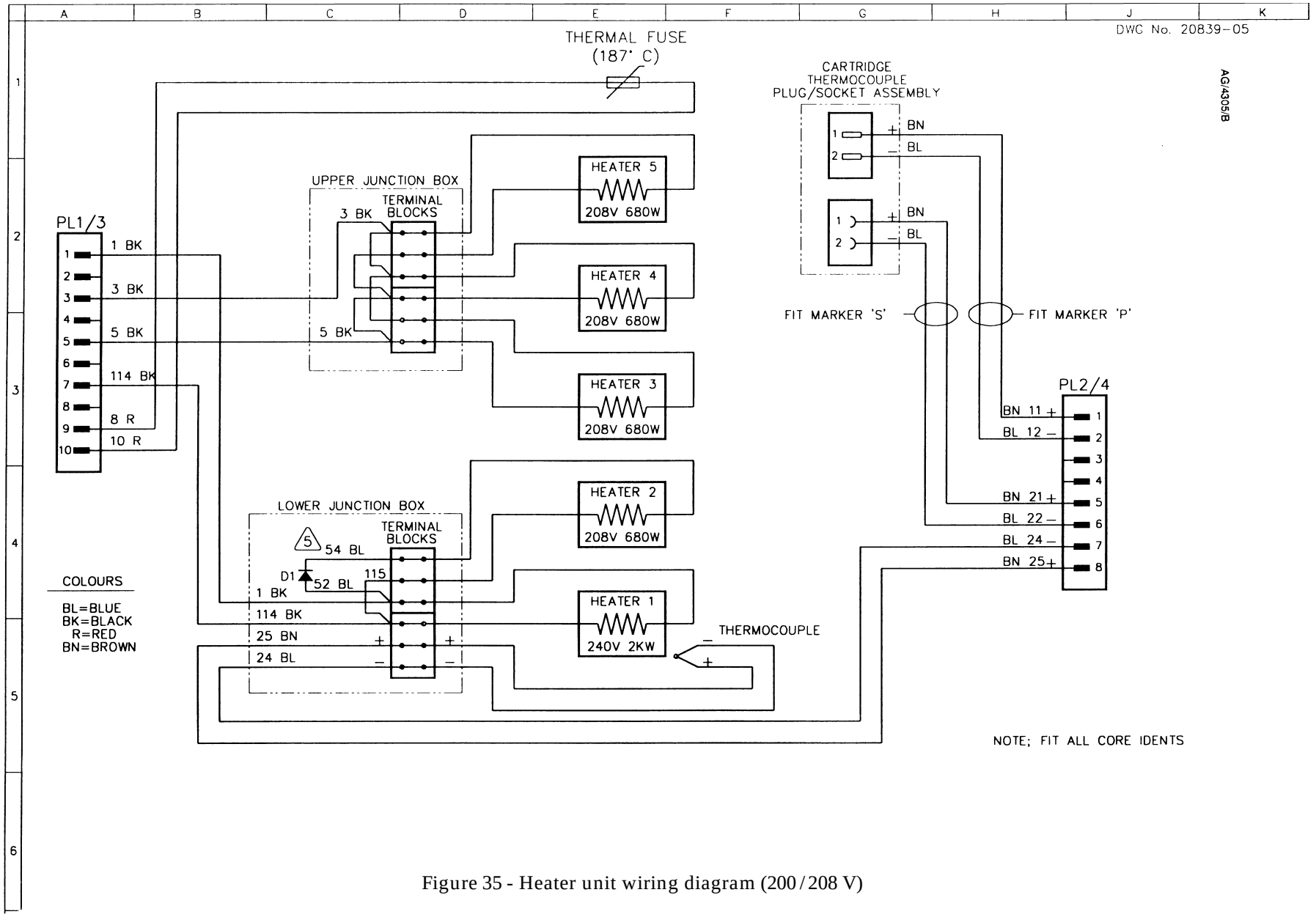


Figure 35 - Heater unit wiring diagram (200 / 208 V)

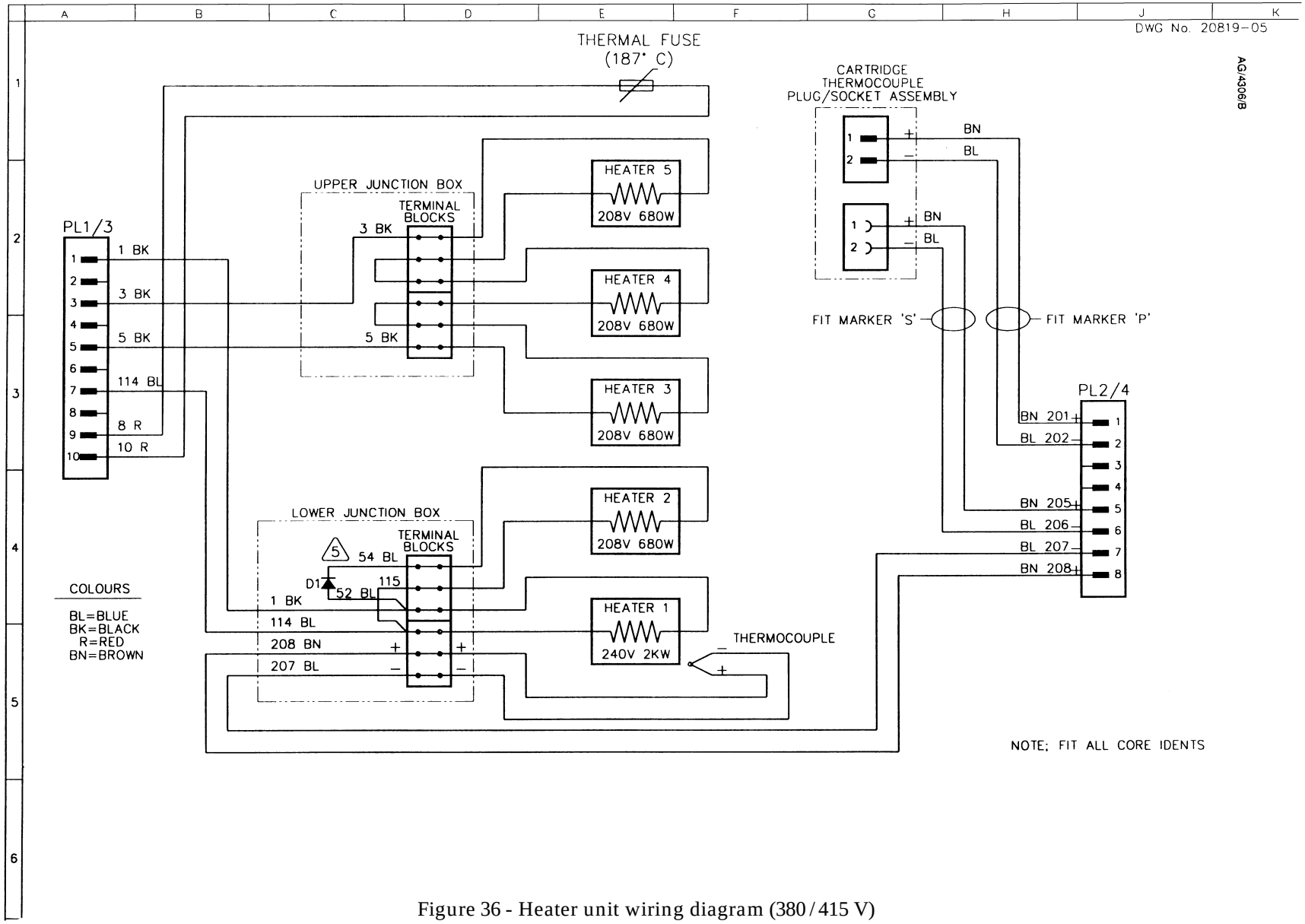


Figure 36 - Heater unit wiring diagram (380 / 415 V)

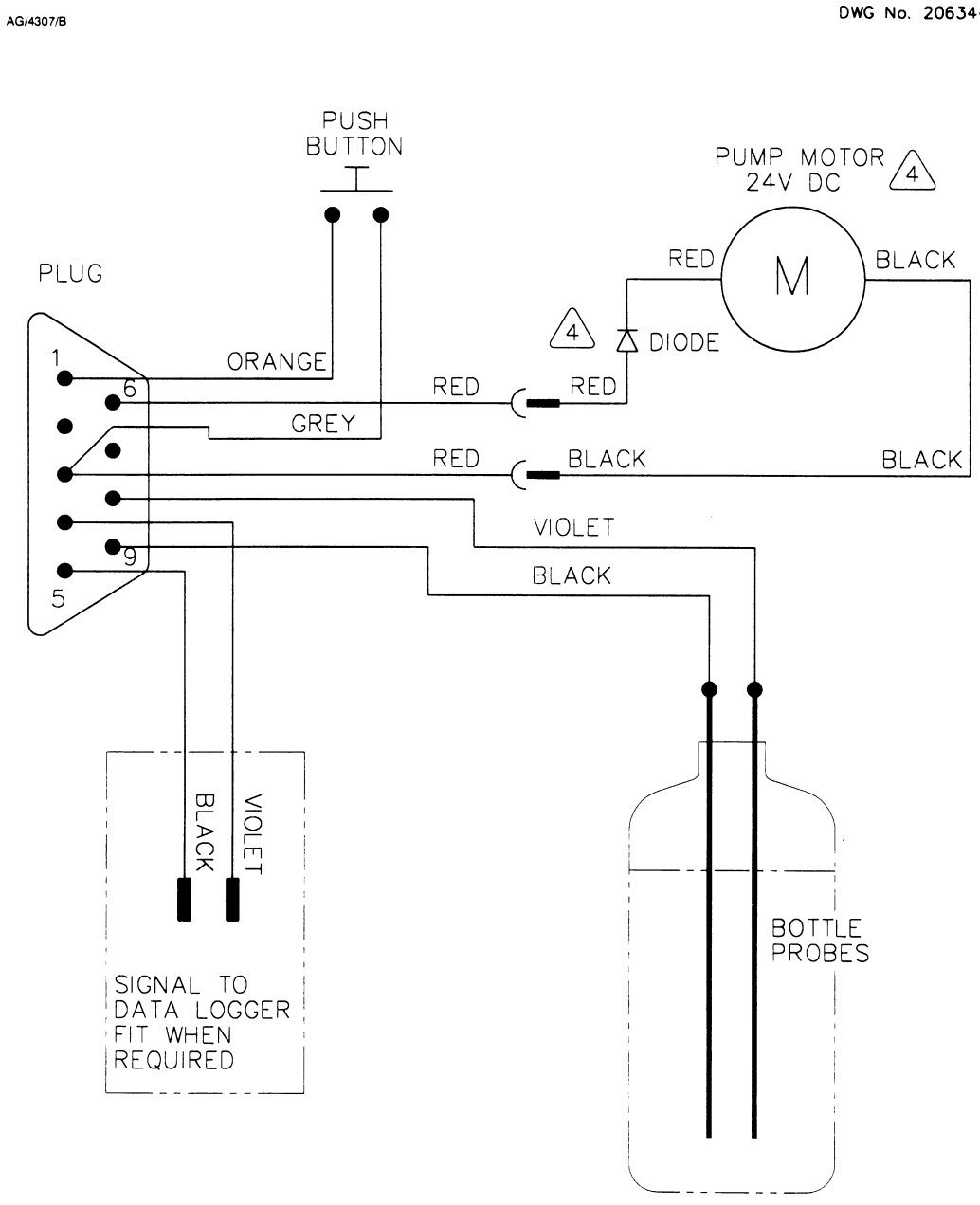


Figure 37 - End-point detector bottle enclosure wiring diagram

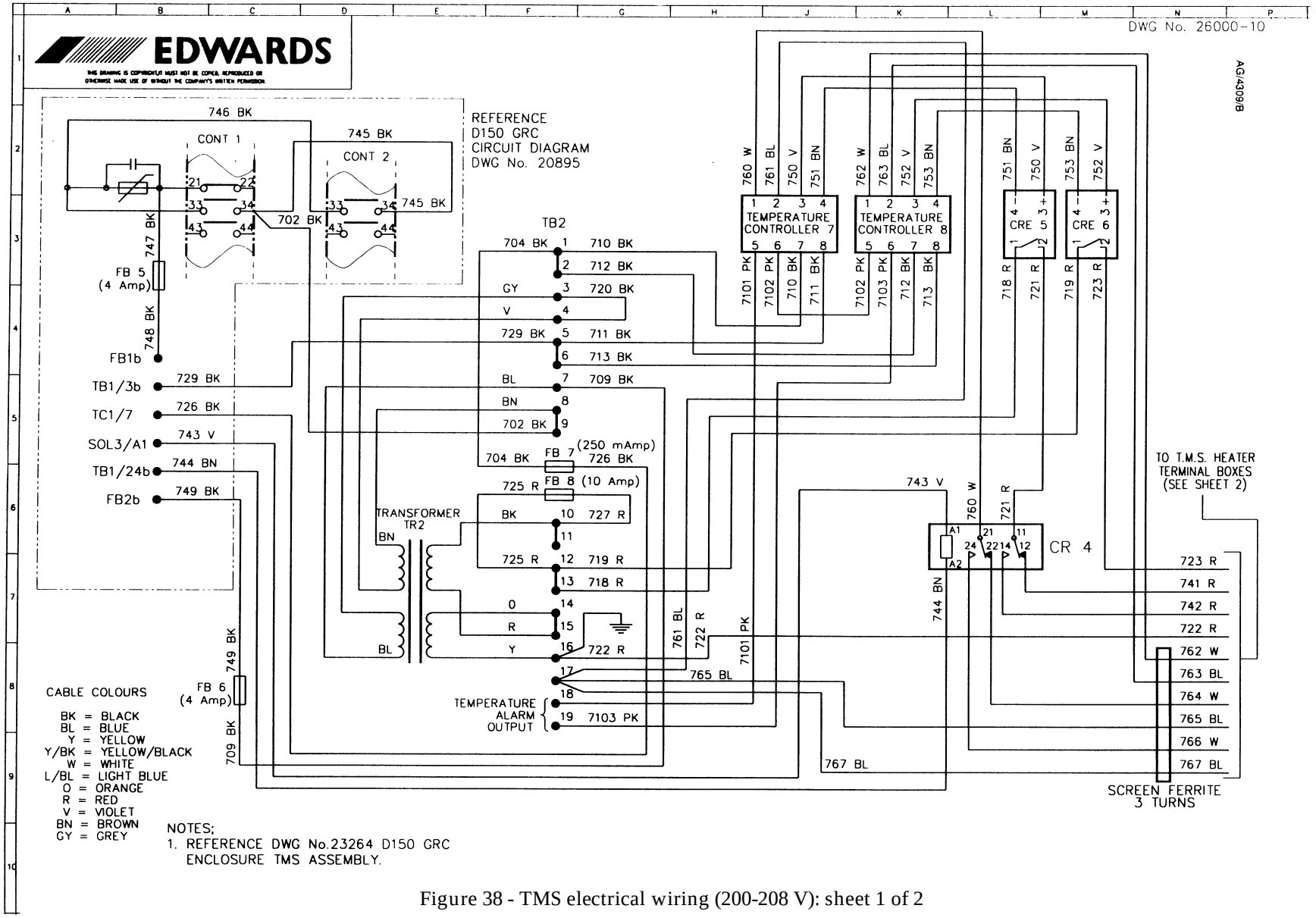


Figure 38 - TMS electrical wiring (200-208 V): sheet 1 of 2

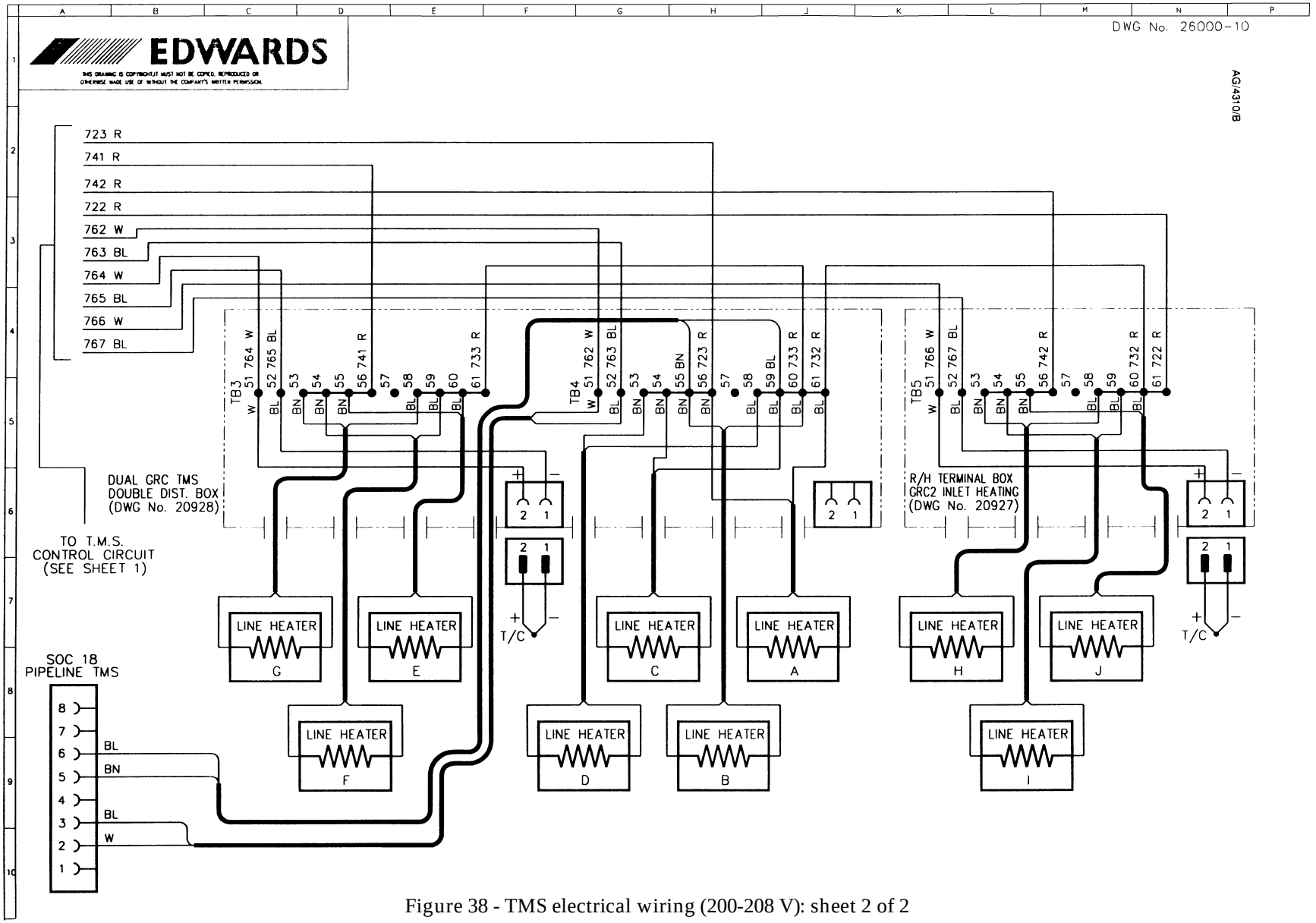


Figure 38 - TMS electrical wiring (200-208 V): sheet 2 of 2

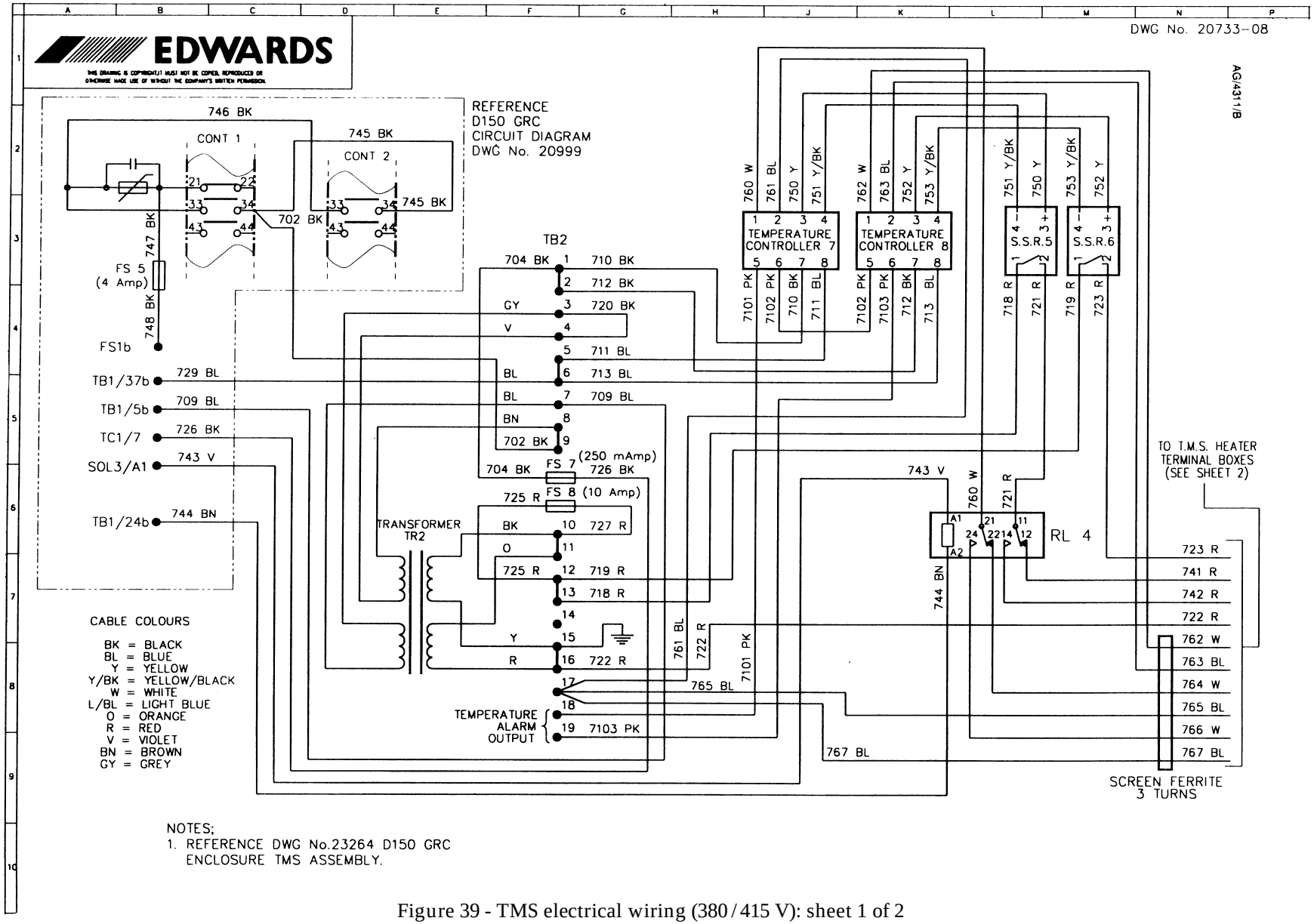
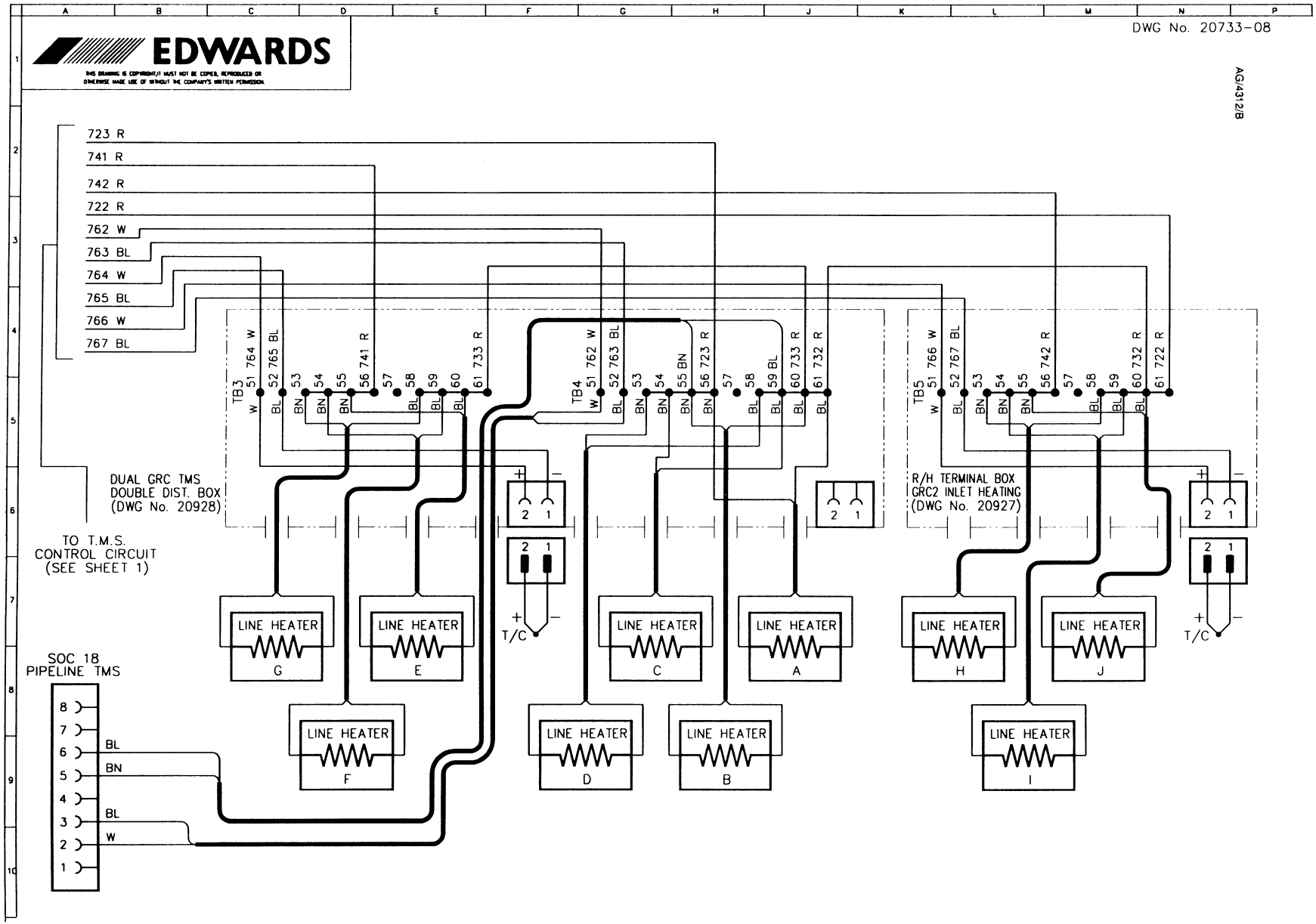


Figure 39 - TMS electrical wiring (380/415 V): sheet 1 of 2


EDWARDS
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DWG No. 20733-08
AG/4312/B
723 R
741 R
742 R
722 R
762 W
763 BL
764 W
765 BL
766 W
767 BL
TB3
TB4
TB5
DUAL GRC TMS
DOUBLE DIST. BOX
(DWG No. 20928)
TO T.M.S.
CONTROL CIRCUIT
(SEE SHEET 1)
R/H TERMINAL BOX
GRC2 INLET HEATING
(DWG No. 20927)
LINE HEATER
G
E
F
C
A
D
B
H
J
I
T/C
SOC 18
PIPELINE TMS
BL
BN
BL
W

Gas Reactor Column Application Form **(Form GRC1)**

So that we can provide accurate advice on the use of the Gas Reactor Column on your application, please complete section 1 (Application Data) of this form and return the complete form to your supplier or Edwards or fax the form to Edwards GRC, Nailsea (fax : +44 1275 810256). Section 2 (GRC Recommendations) will then be completed by our application engineers and the form will be returned to you.

DO NOT USE THE GRC ON A DIFFERENT APPLICATION UNLESS YOU HAVE RECEIVED THIS FORM OR HAVE CONTACTED YOUR SUPPLIER OR EDWARDS FOR ADVICE !

SECTION 1 : APPLICATION DATA

Process: _____

Process Machine Make: _____ Model: _____

Pump Make: _____ Model: _____

Oil used _____ Total N_2 purge: _____

		Gas type	Gas flow : sccm	Gas on time per wafer or batch	Wafers or batches per month
Process Step 1	1				
	2				
	3				
	4				
Process Step 2	1				
	2				
	3				
	4				
Process Step 3	1				
	2				
	3				
	4				

Print your name: _____ Print your job title: _____

Print your organisation: _____

Print your address: _____

_____

Telephone number: _____

Signed: _____ Date: _____

SECTION 2 : EDWARDS RECOMMENDATIONS

We recommend that you use the following cartridge type on your application: _____

On the application and gas flows specified in Section 1 above, cartridge lifetime is predicted to be between _____ and _____ weeks

Temperatures should be set as follows : Upper: _____ Lower: _____

Signed: _____ Date: _____

(Name in capitals) _____ Job Title: _____

P800-01-110 Issue B

EDWARDS