

Instruction Manual

AUTO 306 Vacuum Coater

Volume 2 - Operating Instructions



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1 INTRODUCTION

1.1 Scope and definitions

This manual is supplied in two volumes; Volume 1 provides installation and maintenance instructions for the Edwards AUTO 306 Vacuum Coater (abbreviated to AUTO 306 in the remainder of this manual), Volume 2 provides operating instructions. You must use the AUTO 306 as specified in this manual.

Read this Volume of the manual and the instruction manuals supplied with any accessories fitted to the AUTO 306 before you use the AUTO 306. Important safety information in this manual is highlighted as WARNING and CAUTION 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.

1.2 Overview of the AUTO 306

The AUTO 306 is a compact, versatile vacuum coater. A wide range of accessories is available (refer to Volume 1). These allow you to configure and operate the AUTO 306 for your specific applications.

The AUTO 306 is designed for physical vapour deposition processes under high vacuum. It is not suitable for use on processes which use chemical vapour deposition.

The major components of the AUTO 306 are:

- A pumping system.
- A baseplate.
- An electrical system which incorporates the AUTO 306 Controller.

All of these components are contained in the AUTO 306 control cabinet.

There are three types of AUTO 306:

- AUTO 306 with diffusion pumping system.
This type of AUTO 306 has a rotary pump and a diffusion pump.
- AUTO 306 with cryo pumping system.
This type of AUTO 306 has a rotary pump and a cryopump.
- AUTO 306 with turbomolecular pumping system.
This type of AUTO 306 has a rotary pump and a turbomolecular pump.

Refer to Volume 1 for a full description of the pumping system fitted in your AUTO 306.

Your AUTO 306 will have a vacuum chamber attached to the baseplate. The vacuum chamber can be any of the following:

- Glass Bell Jar.
- Cylinder Chamber.
- FL400 Box Vacuum Chamber.

Refer to the instruction manual supplied with the vacuum chamber accessory for more information.

2 SAFETY

2.1 Safety features of the AUTO 306

The AUTO 306 is safe to operate and maintain as long as you obey a number of basic safety instructions and take note of all the appropriate precautions.

The AUTO 306 incorporates safety features which ensure that you cannot operate or use the equipment in a way which is dangerous; these features are described below.

- Controller automatic operation

The operation of the pumps and the valves is automatically controlled by the AUTO 306 Controller. The Controller incorporates interlock mechanisms which ensure that the equipment operates in the correct sequence. The Controller can detect faults in the pumping system and will display these to the operator. After any fault, the Controller enables the equipment to be shut down in a safe manner.

- Vacuum interlock

The vacuum chamber incorporates a vacuum interlock switch. When the chamber is not under vacuum, the electrical supplies are isolated from any accessories in the chamber, and the accessories cannot be operated.

- Control cabinet locks and safety switches

The front door of the control cabinet has an integral electrical isolation switch and a lockable catch to prevent unauthorised access to the cabinet. The rear and top panels of the control cabinet incorporate safety switches. When the door or the panels are opened, the electrical supply is automatically isolated from the control cabinet.

2.2 Safety hazards

2.2.1 Introduction

WARNING

Obey the safety instructions listed in this volume of the manual and take note of appropriate precautions. If you do not, you can cause injury to people.

The following sections outline a number of potential safety hazards associated with the use of the AUTO 306 and list the safety instructions and precautions appropriate to these hazards. Specific safety instructions are included at the appropriate points in Sections 3 to 6.

Note that you must also obey any WARNING and CAUTION instructions included in the instruction manuals for any accessories fitted to your AUTO 306.

2.2.2 Dangerous materials

If you use dangerous source materials to coat specimens, you must wear appropriate safety clothing when you come into contact with the materials, or with specimens which have been coated with the materials:

- Wear non-absorbent gloves and a laboratory coat when you prepare the source materials, when you load the materials into the chamber and when you remove specimens from the chamber.
- Wear non-absorbent gloves, a laboratory coat, a protective face-mask and an orinasal respirator (to BS2091, BS6061 or later standards) when you clean inside the vacuum chamber and when you clean components from the chamber.
- If you get the materials on your hands, wash your hands thoroughly before you handle food, drink or cigarettes.
- Store the materials and prepared evaporation sources in suitable containers. Mark these containers to identify their contents.
- Securely seal items contaminated with the materials (for example, aluminium foil and damaged source boats) in polythene bags before you dispose of them (see Section 6).

2.2.3 Cleaning solutions

- Wear suitable safety-clothing (for example, a laboratory coat, gloves and eye protection) when you use cleaning solutions to clean components contaminated with dangerous materials.
- Use cleaning solutions in a well-ventilated area. Use a fume-cupboard if you clean a large surface area, or if you use the cleaning solution for a long period of time.

2.2.4 Oils, greases and vapour pump fluid

The synthetic oils and greases used in the rotary pump and the fluid used in the diffusion pump are generally safe to use, however dermatitis can result from prolonged skin contact.

- If required, wear protective gloves when you handle the oils, greases and diffusion pump fluid.
- If oil, grease or diffusion pump fluid comes into contact with your skin, wash it off immediately.

2.2.5 Temperature hazards

Surfaces of the diffusion, rotary and turbomolecular pumps can get very hot during operation. The cryopump coldhead can get very cold during operation. The pumps and the coldhead are enclosed in the control cabinet to prevent accidental contact with these pumps.

Accessories in the vacuum chamber and internal and external surfaces of the vacuum chamber can get very hot during process operation.

Liquid nitrogen (used in the liquid nitrogen trap) and helium (used in the AUTO 306 with cryo pumping system) can cause severe frost burns.

- If you need to open the control cabinet front door, leave the AUTO 306 until the rotary pump (and the diffusion or turbomolecular pump, if fitted) have cooled to a safe temperature.
- Do not touch the chamber or accessories in the chamber until they have cooled to a safe temperature.
- Wear suitable protective clothing and obey all necessary safety precautions when you handle liquid nitrogen.

2.2.6 Vacuum hazards

- You must never place sealed, closed items (for example, cans or capped tins) in the vacuum chamber. Such items can explode when the pressure inside the vacuum chamber is reduced.
- Always use the implosion guard when you operate the AUTO 306 with the Glass Bell Jar.

2.2.7 Electrical hazards

Some of the AUTO 306 accessories use high-voltage electrical supplies which can be dangerous. Always observe the following precautions:

- Allow only a suitably trained and supervised technician to install, configure and maintain accessories which require electrical connections.
- Always switch off the AUTO 306 and isolate it from the electrical supply if you will leave the AUTO 306 unattended.
- Keep the control cabinet locked. Do not leave the key in the lock

If your AUTO 306 has a Cylinder Chamber, you may have high voltage accessories (such as an EM Magnetron Sputtering Source) fitted to the chamber top-plate.

If you remove the chamber top-plate from the Cylinder Chamber (but do not electrically disconnect the accessories) and then you operate the AUTO 306 with another top-plate fitted, the safety interlocks will not prevent the supply of high voltages to the accessories fitted to the Cylinder Chamber top-plate.

Similarly, if you remove the Cylinder Chamber (but do not electrically disconnect the accessories) and then you operate the AUTO 306 with another chamber fitted (such as a Glass Bell Jar), the safety interlocks in the AUTO 306 will not prevent the supply of high voltages to the accessories fitted to the top-plate.

- If you have a Cylinder Chamber on your AUTO 306 and have high voltage accessories fitted to the chamber top-plate, you must electrically disconnect the accessories if you operate the AUTO 306 when the top-plate is not fitted to the Cylinder Chamber on the AUTO 306.

2.2.8 Intense light

- Some of the accessories used in the vacuum chamber may produce intense light. Always wear protective glasses when you look at such accessories in the vacuum chamber.

2.2.9 RF radiation

- Some of the accessories used in the vacuum chamber may produce RF radiation. You must use suitable RF shields when you use such accessories.

2.2.10 Liquid spillage

Liquids spilled into the AUTO 306 can cause electrical short circuits. Solvents or corrosive liquids spilled into or onto the AUTO 306 can damage it.

- Do not stand containers of liquids on the AUTO 306.
- Do not stand containers of liquids close to the AUTO 306.

3 USE OF THE CONTROLS

3.1 On/off switch and lamp

Refer to Figure 2. Use the on/off switch (5) to turn the AUTO 306 on and off.

The on/off lamp (4) is on when the electrical supply to the AUTO 306 is on and the on/off switch is in the 'on' position (position '1').

3.2 AUTO 306 Controller

3.2.1 Overview

The AUTO 306 Controller (see Figure 1) automatically controls the operation of the pumping system. During operation of the AUTO 306, the Controller display (1) shows the current status of the AUTO 306. The display can also be used to show the pressures measured by any of the pressure gauges or other information associated with the operation of the AUTO 306 (refer to Section 6).

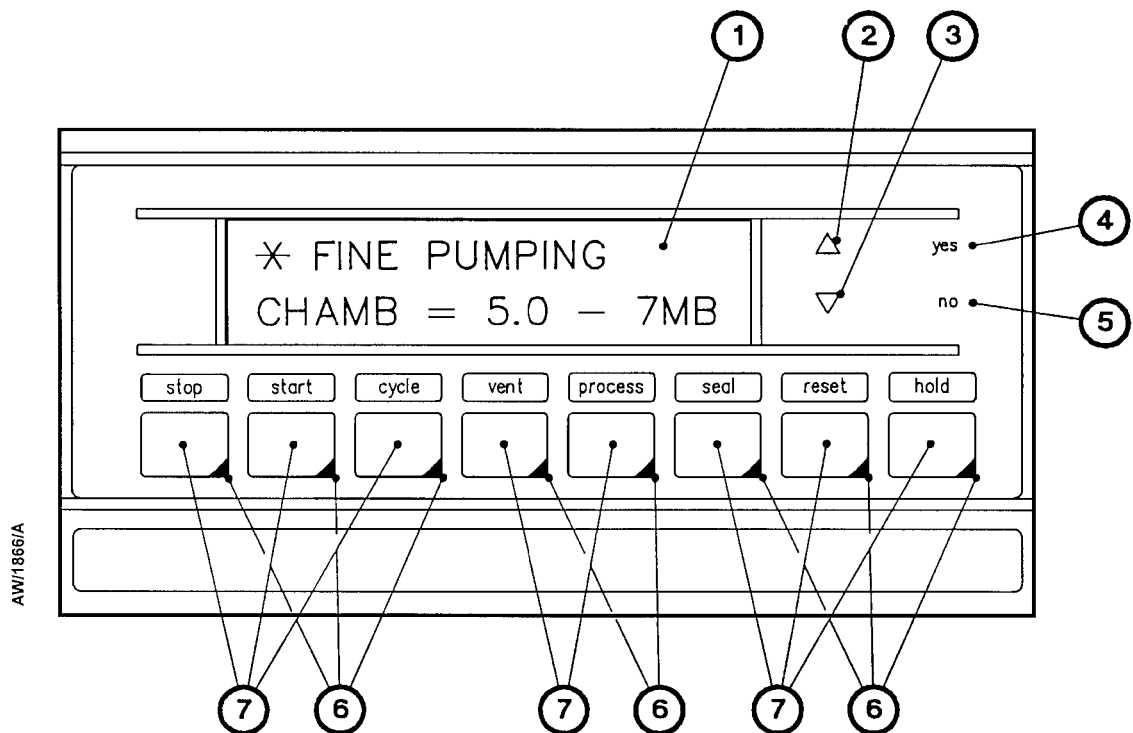
3.2.2 Use of the process selector buttons

Note: Each of the process selector buttons has a LED at the bottom right-hand side of the button. If the LED is on, this means that the button can be pressed to initiate the button function. If the button is pressed when the LED is off, the button will have no effect.

The functions of the Controller process selector buttons (7) are summarised below. Note that you will not need to use all of these functions to operate the AUTO 306.

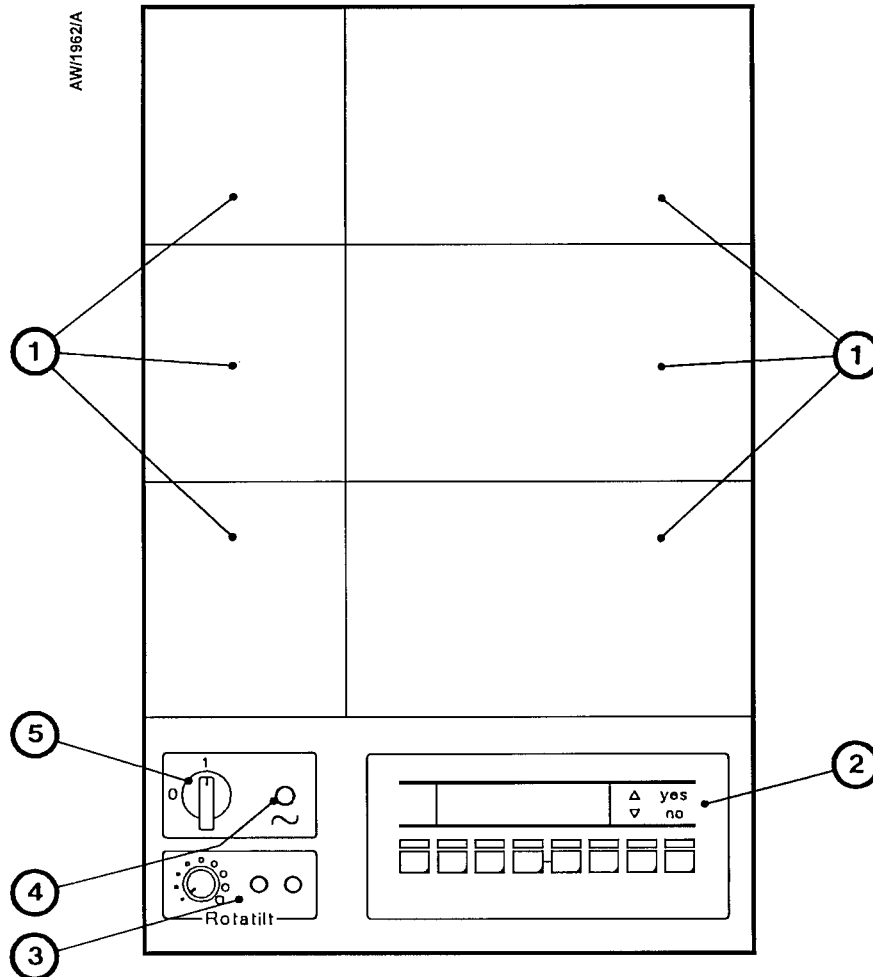
Stop	Use this button to shut down the pumping system. When pressed, the Controller operates the valves in the pumping system and shuts down the pumps in a controlled sequence. The AUTO 306 is then returned to STANDBY mode.
Start	Use this button to start up the pumps. The Controller automatically starts up the pumps and operates the valves in the pumping system in a controlled sequence.
Cycle	Press this button to open the high vacuum valve and pump down the chamber; the process relays are not activated.
Vent	Press this button to vent the vacuum chamber to atmospheric pressure so that you can open the vacuum chamber door. When you press the button, the high vacuum valve closes, the process relays are switched off and the chamber is vented to atmospheric pressure.

Process	Press this button to open the high vacuum valve, pump down the vacuum chamber and place the AUTO 306 into the 'plasma process' mode. In this mode you can do process operations such as HT cleaning. The process relays may be activated in this mode.
Seal	Press this button to close the high vacuum valve and to switch off the process relays.
Reset	Press this button to continue pumpdown in a safe controlled manner, after an error condition.
Hold	Press this button to maintain the AUTO 306 in its current state.



- | | |
|----------------|-----------------------------|
| 1. Display | 5. No button |
| 2. Up button | 6. Button on LEDs |
| 3. Down button | 7. Process selector buttons |
| 4. Yes button | |

Figure 1 - The AUTO 306 Controller



1. Blank panels (which may be used for accessories)
2. AUTO 306 Controller
3. Rotatilt controller (for use with rotary workholder accessory)
4. On/off lamp
5. On/off switch

Figure 2 - AUTO 306 controls

3.2.3 Controller menus

The Controller menus are summarised in Figure 5. Refer to Section 6 for detailed descriptions of the menus and menu options.

3.3 Rotatilt Controller

You will only use the Rotatilt Controller if you have fitted a rotary workholder accessory. For instructions on the use of the Controller, refer to the instruction manual supplied with the accessory.

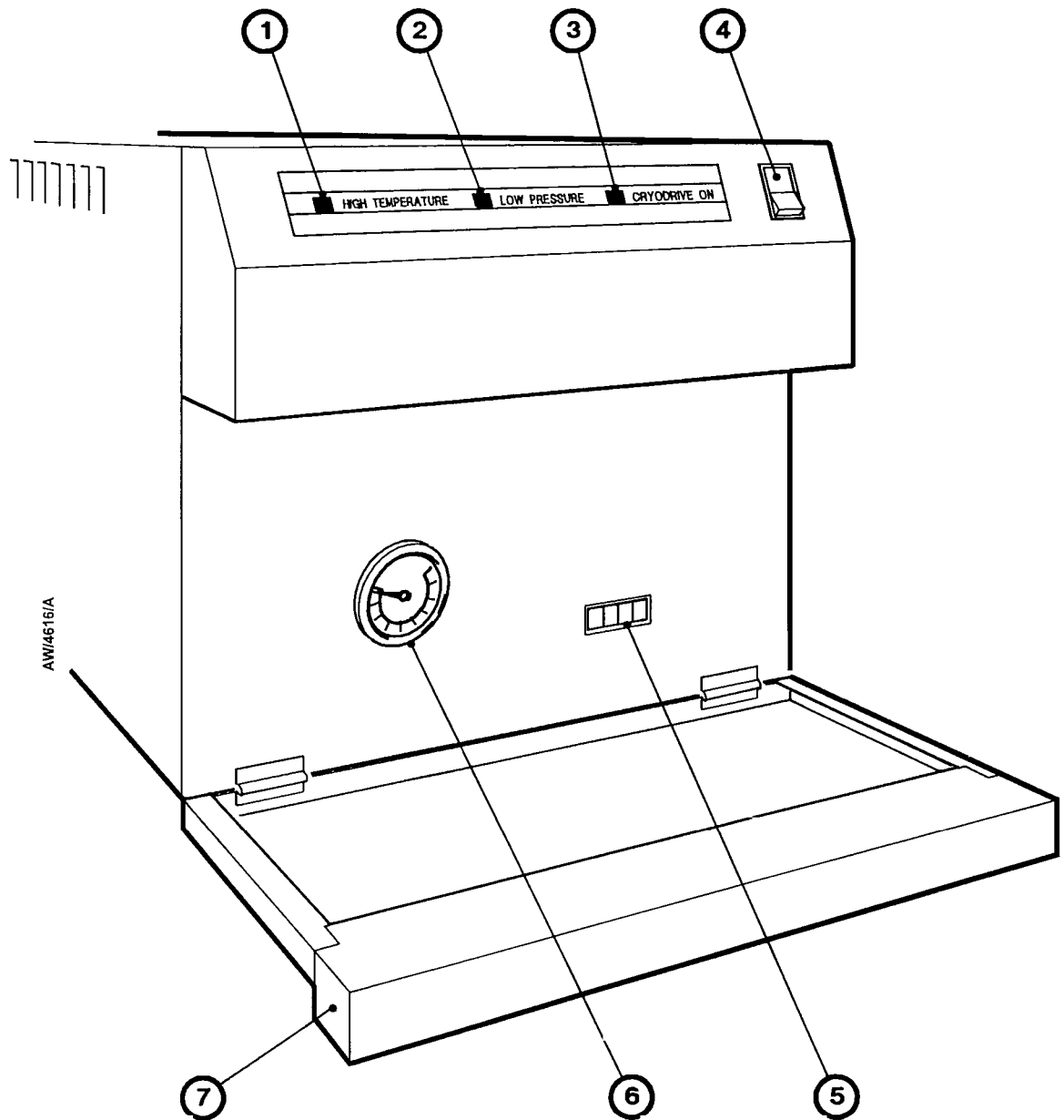
3.4 Cryodrive compressor (AUTO 306 with cryopumping system only)

Refer to Figure 3. The functions of the cryodrive compressor controls and indicators are summarised below. In normal operation, you will only need to use the on/off switch (4) and look at the LEDs (1, 2, 3)

High temperature LED (1)	This red LED goes on to indicate high cooling-water outlet temperature.
Low pressure LED (2)	This red LED goes on to indicate low helium pressure.
Cryodrive on LED (3)	This green LED is on when the cryodrive is operating.
On/off switch (4)	Use this to switch the cryodrive on and off.
Hours counter (5)	This shows the total cryodrive operating time in hours.
Pressure gauge (6)	This shows the helium pressure in the compressor system.

3.5 EXC Controller (AUTO 306 with turbomolecular pumping system only)

The AUTO 306 is supplied with the buttons on the EXC Controller configured for correct operation (that is, with the start/stop button in the 'start' position and the standby and heater buttons in the 'off' position); the AUTO 306 Controller is connected to the EXC Controller to control the operation of the turbomolecular pump. Refer to the EXC Controller manual (supplied as a Supplementary Publication) for a description of the indicators on the EXC Controller.



1. High temperature LED
2. Low pressure LED
3. Cryodrive on LED
4. On/off switch
5. Hours counter
6. Pressure gauge
7. Cover

Figure 3- Cryodrive compressor controls (AUTO 306 with cryopumping system only)

4 GENERAL OPERATION

4.1 Start-up

4.1.1 Fill the liquid nitrogen trap (if necessary)

WARNING

Obey all necessary safety precautions when you handle liquid nitrogen (refer to the safety instructions supplied with the AUTO 306). If you do not, you can cause damage to equipment and injury to people.

WARNING

If you use a pressurised vessel to fill the trap, ensure that the 'boil-off' gases can freely vent. If they do not, the trap may become pressurised and the trap or the filler pipe may rupture.

Note: When you initially fill the trap with the trap at ambient temperature, the nitrogen will boil from the trap. You will therefore require more than 1.4 litres of liquid nitrogen to fill the trap.

A liquid nitrogen trap is only fitted to AUTO 306 vacuum coaters with diffusion pumping systems and to AUTO 306 vacuum coaters with an EXT501 turbomolecular pumping system. The liquid nitrogen trap can be filled with 1.4 litres of liquid nitrogen; this is sufficient for up to approximately eight hours of operation.

If you will place samples which contain a lot of water vapour in the AUTO 306 chamber, fill the trap before you use the AUTO 306 to reduce the pump-down time. Refer to Figure 4 and use the following procedure.

1. Fit the liquid nitrogen filler (1) into the filler tube (2).
2. Use a suitable container to carefully pour liquid nitrogen into the filler to fill the trap, then remove the filler (1) from the filler tube (2).

Alternatively, use the following procedure:

1. Connect one end of a suitable filler pipe (no larger than 12 mm diameter) to the filler tube (2).
2. Connect the other end of the pipe to a filler-valve on a large free-standing pressurised liquid nitrogen vessel.
3. Open the filler-valve and allow the liquid nitrogen to fill the trap in the AUTO 306.
4. Close the filler-valve.
5. Remove the filler pipe from the filler valve and the filler tube (2) on the AUTO 306.

4.1.2 Start the AUTO 306

1. Turn on the cooling-water supply.
2. If you have connected a gas supply to the needle valve, turn on the gas supply; do not open the needle valve.
3. If you have connected a gas supply to the air-admit valve, turn on the gas supply.
4. Refer to Figure 2. Ensure that the on/off switch (5) is in the off position (position '0'), and that the Rotatilt Controller on/speed switch is in the 'off' position.
5. If the AUTO 306 has a cryopumping system, ensure that the cryodrive on/off switch (Figure 3, item 4) is in the off (0) position.
6. Turn on the AUTO 306 electrical supply, then turn the AUTO 306 on/off switch (5) to the 'on' position (position '1'). The on/off lamp (4) will then go on and the top line of the AUTO 306 Controller display will show POWER FAIL.
7. Refer to Figure 3. If you have an AUTO 306 vacuum coater with a cryopumping system, use the on/off switch (4) to switch on the cryodrive compressor, then check that the three LEDs on the front of the cryodrive go on and off in the sequence shown below.
 - If the LEDs do not go on and off in the correct sequence, do not continue with the start-up procedure; switch off the cryodrive and refer to the fault finding section of Volume 1.
 - If the LEDs go on and off in the correct sequence, wait for three seconds or more after the cryodrive on LED (3) stops flashing, then continue at Step 8.

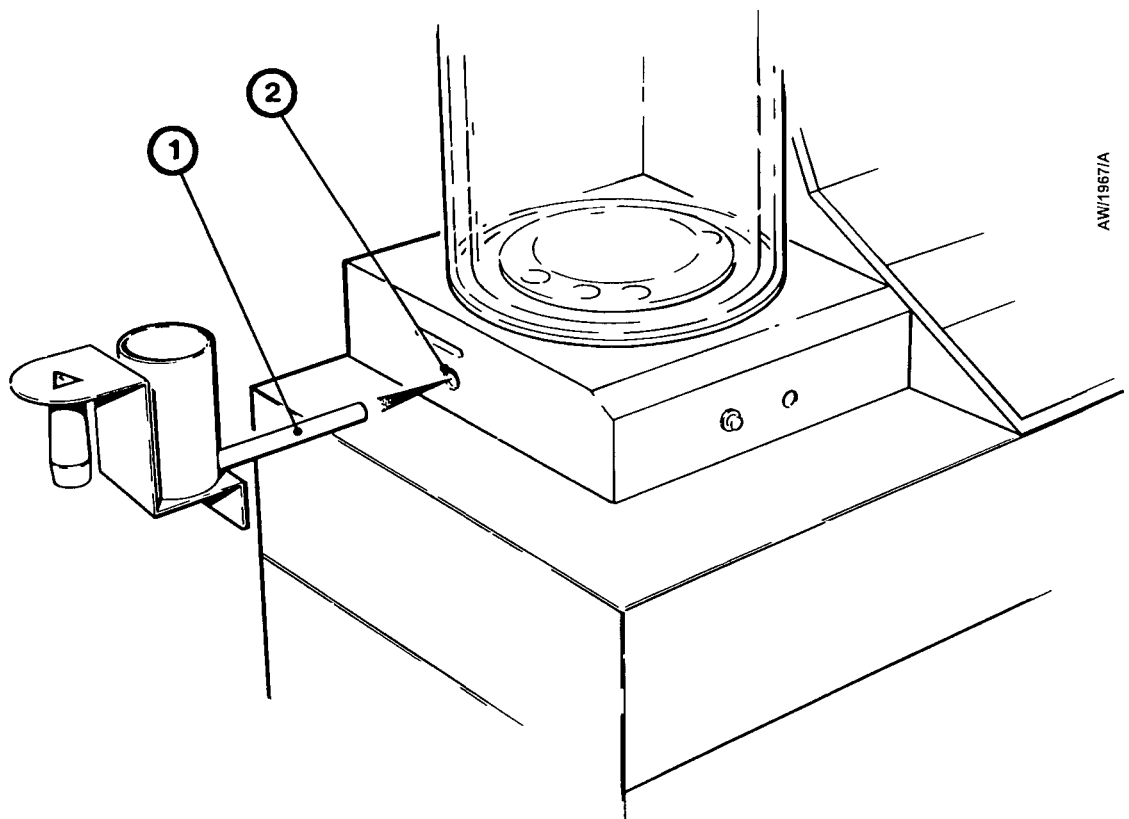
High temperature LED (red)	Low pressure LED (red)	Cryodrive on LED (green)
off	off	ON
off	ON	ON
ON	ON	ON
ON	ON	off
ON	off	off
off	off	off
off	off	FLASHING
off	off	ON

8. Press the Reset button on the AUTO 306 Controller. The top line of the Controller display will then change to show STANDBY.

9. Press the Start button on the AUTO 306 Controller. The top line of the Controller display will then show a number of stage labels, one after the other:

Type of AUTO 306	Stage labels displayed
Diffusion pumping system	PUMPS ON, BACKING, PUMP WARM UP, SEALED.
Cryopumping system	ROT PUMP ON, CRYO ROUGHING, COOL DOWN, SEALED.
Turbomolecular pumping system	PUMPS ON, BACKING, TURBO START, SEALED.

10. When the SEALED label is displayed, continue at Section 3.3 to load substrates in the chamber.



1. Liquid nitrogen filler
2. Filler tube

Figure 4 - Fill the liquid nitrogen trap (optional)

4.2 Load the chamber

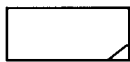
1. Press the Vent button on the AUTO 306 Controller. The top line of the Controller display will then show CHAMBER VENT.
2. Open the chamber and load substrates, sources and so forth in the chamber. Where necessary, refer to the instruction manuals supplied with your AUTO 306 accessories.
3. Close the chamber.

4.3 Cycle or Process operation

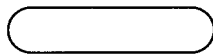
After you have loaded the chamber, further operations depend on how you want to use the AUTO 306: you can press either the Cycle button or the Process button on the AUTO 306 Controller:

- If you press the Cycle button, the chamber is pumped down again, but the process relays are not activated.
- If you press the Process button, the chamber is pumped down again, and the AUTO 306 then enters the 'plasma process' mode. In this mode you can perform operations such as HT cleaning; if required, the process relays may be activated in this mode.

Refer to Figure 5 which shows the labels displayed on the AUTO 306 Controller when you press the Cycle or Process buttons. The following symbols are used on Figure 5.



This specifies a Controller button.



This specifies a stage label shown on the top line of the Controller display.



This specifies some operation you can make.

4.4 Unload the chamber

When you want to unload the chamber:

1. Press the Vent button on the AUTO 306 Controller.
2. Wait for approximately one minute, until the chamber has vented to atmospheric pressure. The top line of the Controller display will then show CHAMBER VENT.
3. Open the chamber and remove substrates, or reload sources and so forth.
4. If you want to continue to use the AUTO 306, load new substrates (or change accessories and so forth) in the chamber, then continue at Section 4.2.

If you have finished with the AUTO 306, continue at Section 4.5 to shut it down.

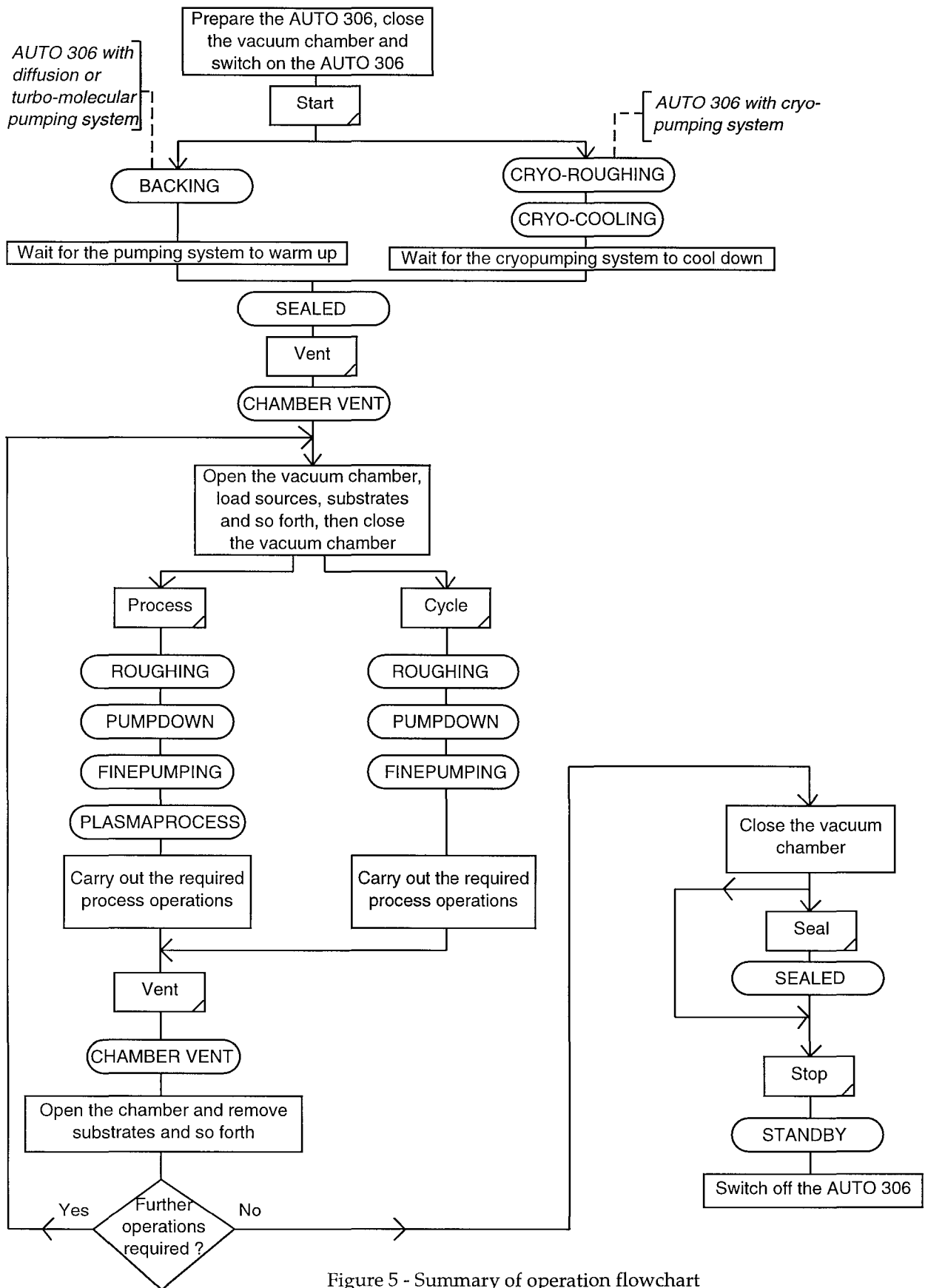


Figure 5 - Summary of operation flowchart

4.5 Shut down the AUTO 306

4.5.1 Shut down between operation

We recommend that you use the following procedure to leave the AUTO 306 under vacuum when you shut it down. Use the following procedure.

1. Ensure that the vacuum chamber is closed.
2. Press the Cycle button on the AUTO 306 Controller and wait until the pressure has fallen to 3×10^{-4} mbar or lower.
3. Press the Seal button on the AUTO 306 Controller, then press the Stop button. The top line of the Controller display will then show two stage labels, one after the other:

Type of AUTO 306	Stage labels displayed
Diffusion pumping system	DIFF PUMP OFF, STANDBY.
Cryopumping system	REGENERATION, STANDBY.
Turbomolecular pumping system	TURBO STOP, STANDBY.

4. When the top line of the Controller display shows STANDBY:
 - Turn the AUTO 306 on/off switch (Figure 2, item 5) to the 'off' position (position '0').
 - If you have an AUTO 306 with cryopumping system, move the cryodrive on/off switch (Figure 3, item 4) to the 'off' (0) position.
5. Leave the AUTO 306 for approximately 30 minutes to allow the pumping system components to cool down, then switch off the cooling-water supply.

4.5.2 Shut down for storage

If you want to shut down the AUTO 306 for storage, use the procedure in Section 4.5.1, but do not press the Seal button.

4.6 Restart after electrical supply failure

If the electrical supply fails during operation and is later restored, the on/off lamp will go off and the top line of the Controller display will show POWER FAIL.

Restart an AUTO 306 with turbomolecular pumping system as described in Steps 6 to 9 of Section 4.1.2.

On an AUTO 306 with diffusion pumping system, if the diffusion pump was on and at operating temperature before the electrical supply failure, the Controller will check whether the diffusion pump is still at operating temperature when the electrical supply is restored:

- If the diffusion pump is at operating temperature, the Controller will alternately display POWER FAIL and DIFF PUMP OK. If required, press the Reset button on the Controller; the AUTO 306 will then be in the SEALED mode and you can continue normal operation.
- If the diffusion pump has cooled down and is not at operating temperature, the Controller will alternately display POWER FAIL and DIFF PUMP OFF. Press the Reset button on the Controller to return the AUTO 306 to the STANDBY mode.

On an AUTO 306 with cryopumping system, if the cryopump was on and at operating temperature before the electrical supply failure, when the electrical supply is restored the Controller will check whether the cryopump is still at operating temperature:

- If the cryopump is at operating temperature, the Controller will alternately display POWER FAIL and CRYO PUMP OK. If required, press the Reset button on the Controller; the AUTO 306 will then be in the SEALED mode and you can continue normal operation.
- If the cryopump has warmed up and is not at operating temperature, the Controller will display POWER FAIL permanently. Press the Reset button on the Controller to return the AUTO 306 to the STANDBY mode, then press the Start button to restart the system.

4.7 Status and error messages

During normal operation the AUTO 306 Controller displays stage labels which identify the status of the AUTO 306. These stage labels are shown in Tables 2 to 4.

If any other message appears on the Controller (for example, HV VALVE ERROR), this means that there is a fault in the AUTO 306. Refer to the fault finding section of Volume 1 for the meanings of error messages.

5 OPERATING TECHNIQUES

5.1 Introduction

The process information in the following sections is provided as a guide only. The detailed operating instructions for a process will depend on a number of factors, such as the materials used, accessories fitted and so forth. You could also use two or more processes together, either concurrently or sequentially, to obtain different results.

Whenever you use a process, we recommend that you take a note of factors which affect the process, such as pressure, voltage, current and cycle time. You will be able to repeat your results accurately if you use the same operating conditions in subsequent processes.

Ensure that you are familiar with your process before you use the AUTO 306. Refer to standard text books on coating and electron microscopy techniques and theories. The following are recommended:

- Handbook of Thin Film Technology (L. I. Maisel and R. Glang): published by McGraw Hill, New York.
- Replica, Shadowing and Freeze Etching Techniques (J. H. M. Willison and A. J. Rowe): published by North-Holland.

5.2 Evaporation from a Filament Holder or Turret Source

CAUTION

Do not overtighten the needle valve. If you do, you may damage the valve.

You will need one or more of the following accessories for this process:

- Filament Holder or Turret Source
- Radiant Heater
- Selector Switch*
- HT Power Supply
- Baffle Plate and Tripod
- Plasmaglo
- Source Shutter
- HT/LT Controller
- LT Transformer Kit
- Workholder

* If you use two or more Filament Holders.

Use the following procedure, which assumes that you will use thermal sources. If you will use an Electron Beam Source accessory, refer to the instruction manual supplied with the accessory for detailed operating instructions.

1. Load the substrates and evaporation materials into the chamber.
2. Close the chamber.

3. Press the Cycle button on the AUTO 306 Controller, or press the Process button if you have fitted the Plasmaglo accessory. Wait until the AUTO 306 has pumped down the chamber. If you have pressed the Process button, the AUTO 306 will go into the plasma process mode.
4. Adjust the needle valve so that the chamber pressure is approximately 8×10^{-2} mbar. If necessary, use the AUTO 306 Controller to monitor the backing pressure (refer to Section 6); do not allow the backing pressure to rise to the pressure in pressure store 6.
5. Ensure that the power control on the HT/LT Controller is in the 0 position (fully anticlockwise), then move the HT/LT selector on the HT/LT Controller to the HT position.
6. Slowly turn the power control on the HT/LT Controller clockwise until the required current for Plasmaglo cleaning is reached. If necessary, adjust the needle valve to obtain the optimum discharge pressure in the chamber (at this pressure, the plasma extends over the maximum volume in the chamber). The high vacuum valve will open at the end of the process time: refer to Section 6
7. Plasmaglo clean for the required time and take a note of this time. A time of 10 minutes is typical, however this will depend on factors such as the material cleaned. We recommend that you try a number of different times and determine the optimum time from the results of subsequent depositions.
8. Slowly close the needle valve, turn the power control on the HT/LT Controller to the 0 position (fully anticlockwise) and turn the HT/LT selector on the HT/LT Controller to the 0 (off) position.
9. Switch on the Radiant Heater and adjust the temperature controller to the required substrate temperature.
10. Ensure that the Source Shutter is closed (that is, the substrate is shielded).
11. Turn the HT/LT selector on the HT/LT Controller to the LT position.
12. Slowly turn the power control on the HT/LT Controller to obtain a current below that required for evaporation, but sufficiently high to degas the evaporation source. Take a note of the power control position and the current for future reference.
13. Slowly turn the power control on the HT/LT Controller clockwise until the current required for evaporation is reached. Take a note of the power control position and the current for future reference.
14. Open the Source Shutter and allow deposition of the evaporant until the required film thickness is reached.
15. When the required deposition film thickness is reached:
 - Close the Source Shutter.
 - Turn the power control on the HT/LT Controller to the 0 position (fully anticlockwise) and turn the HT/LT selector on the HT/LT Controller to the 0 (off) position.
 - Switch off the Radiant Heater.

16. If further evaporant sources are to be used, repeat Steps 9 to 15 for each source and use the LT Selector Switch to select each source, or rotate the Turret Source accessory (if fitted) to select each source.

5.3 Sputter coating

CAUTION

Do not overtighten the needle valve. If you do, you may damage the valve.

Use the following procedure, which assumes that you will use the DC Sputtering Accessory and that you have connected a suitable gas supply (for example, air, argon or an argon/oxygen mixture) to the needle valve inlet on the AUTO 306 services panel (refer to Volume 1). If you also use an Auto Gas Bleed Kit accessory, refer to the instruction manual supplied with the accessory for detailed operating instructions.

1. Prepare the AUTO 306 and press the Process button on the AUTO 306 Controller to pump down the vacuum chamber and to enter the plasma process mode.
2. Ensure that the power control on the HT/LT Controller is in the 0 position (fully anticlockwise), then turn the HT/LT selector on the HT/LT Controller to the HT position.
3. Slowly turn the power control on the HT/LT Controller clockwise until approximately 3 kV is shown on the voltmeter on the HT Meter Panel.
4. Adjust the needle valve until a steady current of 25 mA is shown on the ammeter on the HT Meter Panel.
5. Sputter coat for the required time. Take a note of the voltage, current and cycle time.
6. Turn the power control on the HT/LT Controller to the 0 position (fully anticlockwise) and turn the HT/LT selector on the HT/LT Controller to the 0 (off) position.
7. Close the needle valve.
8. Press the Cycle button on the AUTO 306 Controller. Alternatively, if the time set for the process (in time store 14) is near to completion, leave the AUTO 306 to end the plasma process mode automatically.

5.4 Electron microscopy coating and cleaning

5.4.1 Introduction

You can use the AUTO 306 for any of the following processes, as long as you have fitted the necessary accessories:

- Manufacture of support films (from carbon or silicon monoxide).
- Manufacture of replicas (from carbon, platinum/carbon, silicon monoxide and so forth).
- Shadow casting (with platinum/carbon or high density metals).
- Cone shadowing.
- SEM coating.

5.4.2 Carbon support films and replicas

A support film is generally used to hold small specimens in place and ensure they do not sag when they are mounted on microscope specimen grids.

Plastic support films are easy to manufacture to thicknesses of as little as 200 Å. However, the use of plastic support films is not recommended, because they distort and are degraded in the microscope electron beam, and because they have an inherently high background structure. The use of evaporated carbon support films is recommended because they are almost structureless and because they conduct heat generated by the microscope electron beam away from the specimen. It is easy to manufacture evaporated carbon support films of thicknesses between 20 and 100 Å. and their strength and opacity make them easy to handle.

A replica is made of the surface features of a specimen, when it is not possible to mount the specimen in an electron microscope specimen grid. You can use plastic films to manufacture replicas, but these do not always closely follow the surface of the specimen, and they have a high background structure and can lead to misinterpretation of results from their study in the microscope.

Carbon deposited directly onto the specimen to form a replica provides the best results, but you cannot always remove the carbon film from the specimen without destruction of the specimen. One method to overcome this problem is to make a plastic replica of the specimen and then to deposit a carbon film on the plastic replica; it is then easy to remove the carbon replica from the plastic replica.

You will need the following accessories for these processes:

- Carbon Evaporation Source.
- Selector Switch.
- LT Transformer (10 V 90 A, 30 V 30 A).
- Filament Holder.
- HT/LT Controller.
- Baffle Plate and Tripod.

Use the following procedure for these processes. This procedure assumes that you will evaporate and deposit downwards and have configured the Filament Holder accordingly.

1. Place the substrate (mica sheet or a microscope slide glass) on the Baffle Plate and close the vacuum chamber.
2. Press the Cycle button on the AUTO 306 Controller to pump down the chamber to a pressure of 1×10^{-4} mbar or lower.
3. Turn the HT/LT selector on the HT/LT Controller to the LT position, then slowly turn the power control on the HT/LT Controller clockwise until the evaporation source glows.
4. Turn the power control on the HT/LT Controller further clockwise, so that the source evaporates and is deposited on the substrate.
5. When the required film thickness has been deposited, turn the power control on the HT/LT Controller to the 0 position (fully anticlockwise) and turn the HT/LT selector on the HT/LT Controller to the 0 (off) position.

It may be easier to make a replica of a specimen with rough surfaces if you mount the specimen in a suitable sample holder, fit the workholder to the Rotatilt accessory, then rotate the Rotatilt during evaporation.

To manufacture a hydrophilic support film, use the Plasmaglo accessory to glow discharge clean the support film for approximately 10 seconds: refer to Section 5.2.

If you want to use carbon string to manufacture carbon support films and replicas, clamp the carbon string in a Filament Holder and adjust the posts of the Filament Holder to provide a gap of 1 to 1.5 cm. Connect the Filament Holder to the 30 V transformer electrical supply: refer to the instruction manuals supplied with the Filament Holder and LT Transformer for more information.

5.4.3 Shadow casting

Shadow casting is the deposition of a film onto a specimen to increase its contrast when viewed in an electron microscope. The evaporation source is aligned at an angle to the specimen, so that when it is deposited onto the specimen, shadows are formed which are less electron dense than the parts of the specimen which are fully coated. If the shadow angle is known, you can use the shadows to determine the dimensions of surface features of the specimen.

Shadow casting can be combined with carbon coating (see Section 5.4.2) to manufacture shadow replicas.

You will need the following accessories for shadow casting:

- Carbon Evaporation Source.
- Selector Switch.
- LT Transformer (10 V 90 A, 30 V 30 A).
- Source Shutter.
- Filament Holder.
- HT/LT Controller.
- Baffle Plate and Tripod.
- Rotatilt with Grid Holders and SEM Planetary Workholder.

Use the following procedure for shadow casting. This procedure assumes that you will use thermal sources. If you will use an Electron Beam Source accessory, refer to the instruction manual supplied with the accessory for detailed operating instructions.

1. Place the substrate (mica sheet or a microscope slide glass) on the Baffle Plate and close the vacuum chamber.
2. Press the Cycle button on the AUTO 306 Controller to pump down the chamber to a pressure of 1×10^{-4} mbar or lower.
3. For cone shadowing, the manufacture of a shadow replica, or SEM specimen preparation, switch on the Rotatilt.
4. Turn the HT/LT selector on the HT/LT Controller to the LT position, then slowly turn the power control on the HT/LT Controller clockwise until the evaporation source glows.
5. Turn the power control on the HT/LT Controller further clockwise, so that the source evaporates, then open the Source Shutter so that the evaporant is deposited on the substrate. When the required film thickness has been deposited, close the Source Shutter.
6. Turn the power control on the HT/LT Controller to the 0 position (fully anticlockwise), turn the HT/LT selector on the HT/LT Controller to the 0 (off) position and switch off the Rotatilt.

5.4.4 Aperture cleaning

You can vacuum bake and degas electron microscope apertures in the AUTO 306. To do this, you will need the following accessories:

- HT/LT Controller.
- LT Transformer (10 V 90 A, 30 V 30 A).
- Filament Holder with molybdenum Source Boat.

Use the following procedure.

1. Place the aperture in the molybdenum source boat.
2. Press the Cycle button on the AUTO 306 Controller to pump down the vacuum chamber.
3. Turn the HT/LT selector on the HT/LT Controller to the LT position.
4. Watch the aperture in the Source Boat and slowly turn the power control on the HT/LT Controller clockwise, so that the aperture gets hot but does not melt.
5. After a few seconds, turn the power control on the HT/LT Controller to the 0 position (fully anticlockwise).
6. Turn the HT/LT selector on the HT/LT Controller to the 0 (off) position.

6 ADVANCED CONTROLLER OPERATION

6.1 Introduction

This section of the manual contains information to enable you to use the advanced operation features of the AUTO 306 Controller. You should only use the procedures in this section if you are familiar with the normal operation of the AUTO 306, as described in Section 4.

6.2 Controller menus

Note: When you use the Up (▲) and Down (▼) buttons to change a displayed digit, note that one press of the Up button decreases the digit by one, and that one press of the Down button increases the digit by one. Also, if the digit is currently 9 and you press the Down button, the digit changes to 0. Similarly, if the digit is currently 0 and you press the Up button, the digit changes to 9.

In normal operation, the top line of the Controller display shows the current status of the AUTO 306 (identified by <stage label>: see Figure 6), and the bottom line shows the chamber pressure. If required, you can change from the normal display to the <<MODE SELECT menu and then select other menu options.

Figure 6 shows the Controller menus and menu options. In this figure, each box shows the possible Controller displays:

- The top (bold) line of text in a box shows the top line of the Controller display.
- The other lines of text show options that can be displayed in the bottom line of the Controller display.

In general, you use the buttons to move around the menus and options as follows:

- Press the No button to move up a menu level (that is, move left to a new box on the figure to a different menu).
- Press the Yes button to move down a menu level (that is, move right to a new box on the figure to a different menu), or to select a menu option.
- Press the Down button to display the next option within a menu (that is, move down to the next line of text in a box) on the bottom line of the Controller display.
- Press the Up button to display the previous option within a menu (that is, move up to the previous line of text in a box) on the bottom line of the Controller display.

Detailed descriptions of the menu options are given in the following sections. Refer to Section 6.14 for examples of menu operation.

6.3 Normal display

The Controller software is divided into a number of stages, each of which performs a specific function during operation of the AUTO 306. Each stage has an associated <stage-no> (stage number) and <stage-label> which identifies the stage currently being executed. Tables 2 to 4 show the stage numbers and stage labels; error stage labels are listed in Volume 1.

During normal operation, the top line of the Controller display shows the current <stage label> and the bottom line of the display shows the current chamber pressure (in the currently selected pressure unit: see Section 6.10). Use the down and up buttons to select other display parameters, as shown in Table 1.

Display parameter	Meaning
CHAMB = <pressure>	Chamber pressure *
BACK = <pressure>	Backing pressure *
PIR B = <pressure>	Pressure indicated by the Pirani backing pressure gauge *
PENN = <pressure>	Pressure indicated by the Penning gauge *†
PIR A = <m-volts>	Pirani gauge output voltage (in mV) #
PIR B = <m-volts>	Pirani gauge output voltage (in mV) #
PEN L = <m-volts>	Penning low output voltage (in mV) #
PEN H = <m-volts>	Penning high output voltage (in mV) #
STAGE = <stage-no>	Current stage number #
LAST STAGE = <stage-no>	Previous stage number #

* Displayed in the currently selected pressure unit: see Section 6.10.

† If the Penning gauge is not on, OFF is displayed instead of pressure.

Only displayed if diagnostic display is selected: see Section 6.11.

Table 1 - Normal display parameters

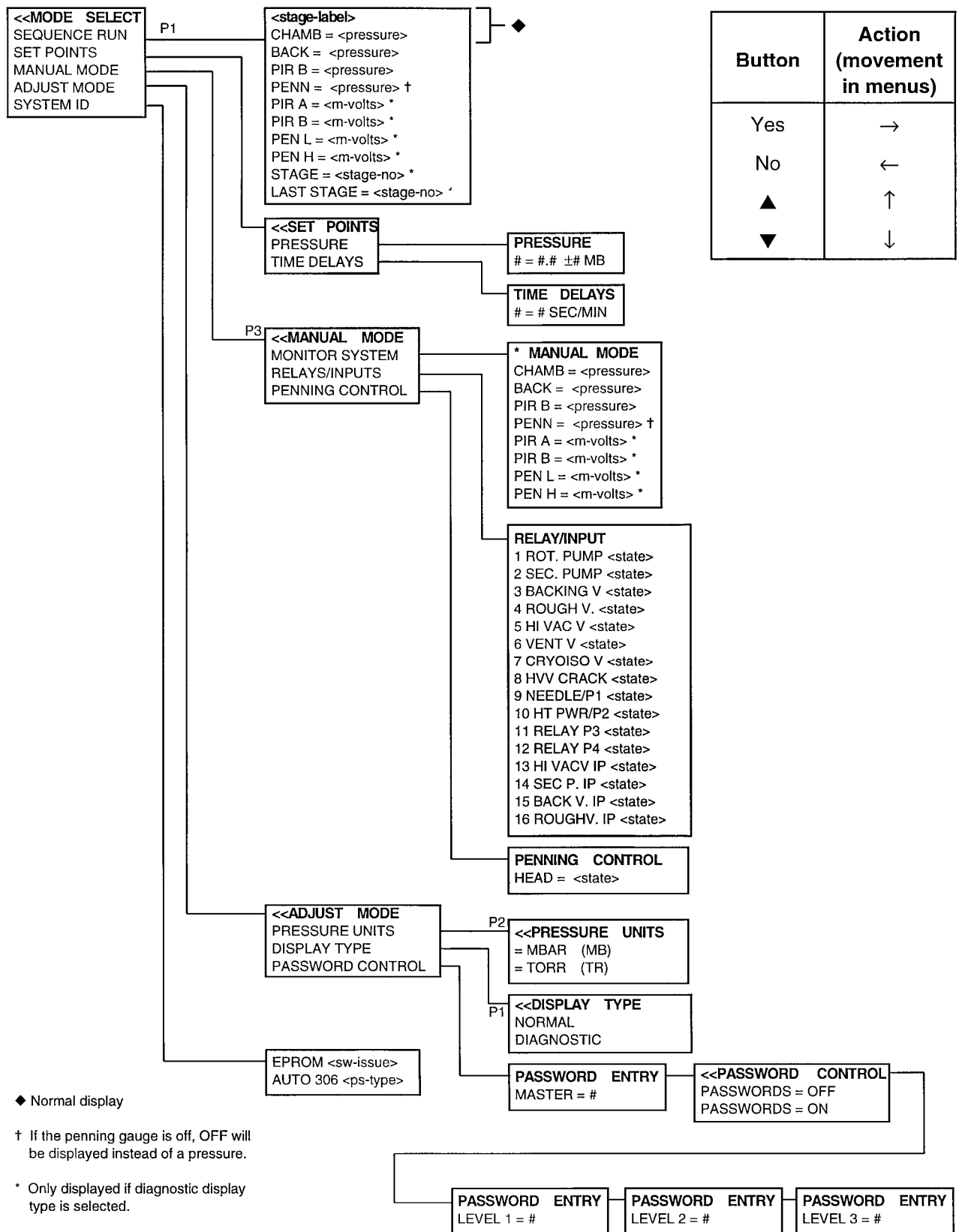


Figure 6 - AUTO 306 Controller menus

Stage number	Stage label	Meaning
1	POWER FAIL	The electrical supply has failed or the AUTO 306 has just been switched on.
9	STANDBY	The electrical supply to the AUTO 306 is on, but the pumping system is not switched on.
10	BACKING	The AUTO 306 is reducing the pressure inside the vacuum chamber, but fine pumping has not yet started.
11	PUMP WARM UP	The diffusion pump is warming up.
12	DIFF PUMP OFF	The diffusion pump is switched off and is cooling down.
13	SEALED	The high vacuum valve is closed and the chamber is sealed.
14	CHAMBER VENT	The high vacuum valve is closed and the vent valve is open. You can open the vacuum chamber.
16	ROUGHING	The high vacuum valve is closed and the rotary pump is reducing the pressure in the vacuum chamber.
17	PUMPDOWN	The high vacuum valve is open and the diffusion pump has started to reduce the pressure in the vacuum chamber.
18	FINEPUMPING	The high vacuum valve is open and the diffusion pump is reducing the pressure in the vacuum chamber to the final pressure for process operation.
20	PLASMA PROCESS	The AUTO 306 is in the plasma process mode.

Table 2 - Stage labels: AUTO 306 with diffusion pumping system

Stage number	Stage label	Meaning
1	POWER FAIL	The electrical supply has failed or the AUTO 306 has just been switched on.
9	REGEN COMPLETE	Cryopump regeneration has finished.
10	BACKING	The AUTO 306 is reducing the pressure inside the vacuum chamber, but fine pumping has not yet started.
11	CRYO-COOLING	The cryopump has started to cool down.
12	REGENERATION	The Stop button has been pressed and cryopump regeneration has started.
13	SEALED	The high vacuum valve is closed and the chamber is sealed.
14	CHAMBER VENT	The high vacuum valve is closed and the vent valve is open. You can open the vacuum chamber.
16	CRYO-ROUGHING	The rotary pump is reducing the pressure in the cryopump coldhead collar below the vacuum chamber. At a preset pressure, the collar is isolated and a pressure rise test is started.
17	PUMPDOWN	The high vacuum valve is open and the cryo pump has started to reduce the pressure in the vacuum chamber.

Table 3 - Stage labels: AUTO 306 with cryo pumping system

Stage number	Stage label	Meaning
18	FINEPUMPING	The high vacuum valve is open and the cryo pump is reducing the pressure in the vacuum chamber to the final pressure for process operation.
20	PLASMA PROCESS	The AUTO 306 is in the plasma process mode.
92	PUMPDOWN DELAY	The AUTO 306 is waiting until the cryopump is ready to start fine pumping the vacuum chamber.
95	STANDBY	The electrical supply to the AUTO 306 is on, but the pumping system is not switched on.
98	ROTARY PUMP ON	The rotary pump is on.

Table 3 - Stage labels: AUTO 306 with cryo pumping system (continued)

Stage number	Stage label	Meaning
1	POWER FAIL	The electrical supply has failed or the AUTO 306 has just been switched on.
9	STANDBY	The electrical supply to the AUTO 306 is on, but the pumping system is not switched on.
10	BACKING	The AUTO 306 is reducing the pressure inside the vacuum chamber, but fine pumping has not yet started.
11	TURBO START	The turbomolecular pump has started to accelerate to full speed.
11	PUMP DELAY	The AUTO 306 is waiting until the turbomolecular pump is ready to start fine pumping the vacuum chamber.
12	TURBO STOP	The turbomolecular pump has been switched off and is decelerating.
13	SEALED	The high vacuum valve is closed and the chamber is sealed.
14	CHAMBER VENT	The high vacuum valve is closed and the vent valve is open. You can open the vacuum chamber.
16	ROUGHING	The high vacuum valve is closed and the rotary pump is reducing the pressure in the vacuum chamber.
17	PUMPDOWN	The high vacuum valve is open and the diffusion pump has started to reduce the pressure in the vacuum chamber.
18	FINEPUMPING	The high vacuum valve is open and the turbomolecular pump is reducing the pressure in the vacuum chamber to the final pressure for process operation.
20	PROCESS	The AUTO 306 is in the plasma process mode.

Table 4 - Stage labels: AUTO 306 with turbomolecular pumping system

6.4 MODE SELECT menu

Press the No button to select the MODE SELECT menu from normal display. Note that you must enter the master password before the menu is displayed (see Section 6.12).

6.5 SYSTEM ID menu option

Select this option to display the following information:

- | | |
|------------|---|
| <sw-issue> | The issue state of the software in the Controller. |
| <ps-type> | The type of pumping system in the Controller, as follows: <ul style="list-style-type: none">• DIFF specifies that the AUTO 306 has a diffusion pumping system.• CRYO specifies that the AUTO 306 has a cryo pumping system.• TURBO specifies that the AUTO 306 has a turbomolecular pumping system. |

6.6 SET POINTS menu

6.6.1 Controller setpoints

The Controller monitors pressures measured by the pressure gauges and is pre-programmed for correct automatic operation of the AUTO 306. Although you cannot change the sequence of automatic operation, you can change some of the setpoints which control the operation.

The setpoints are of two types:

- Time stores There are 16 time stores which control the timing of the operational sequence: see Tables 5 to 7.
- Pressure stores There are 16 pressure stores; each pressure store contains a pressure at which some change in the operational sequence occurs: see Tables 8 to 10.

6.6.2 Change pressure stores

Use the << SETPOINTS/PRESSURE menu option to display the current values of pressure stores and to change the values of pressure stores.

When you select the menu option, the top line of the Controller display changes to PRESSURE and the bottom line of the display is as shown in Figure 6. You can then:

- Press the Up and Down buttons to select the pressure store number (0 to 15).
- Press the Yes button if you want to change the value of the pressure store. Use the Up and Down buttons to decrease or increase each digit of the value, then press the Yes button to enter the digit into the Controller.

Store number	Function	Minimum value	Default value	Maximum value
0	Rotary pump running time during diffusion pump cooling.	1 min	10 min	30 min
1	Diffusion pump warm-up time. This is usually set to 0 minutes and is overridden by the pump ready switch.	0 s	0 s	30 s
2	High vacuum valve closure time: the time taken for the valve to fully open or fully close.	5 s	10 s	20 s
3	Backing and roughing valves closure time.	2 s	4 s	8 s
4	Roughing limit. If rough pumping continues for more than this limit, an error is displayed. The hold function does not disable this check.	1 min	3 min	20 min
5	Pump down limit. If pump down continues for more than this limit, an error is displayed. The hold function does not disable this check.	30 s	2 min	255 min
6	Fine pumping limit. If the AUTO 306 is in the plasma process mode and the pressure does not fall to the pressure set in pressure store 13 before this time limit is reached, an error is displayed. The hold function disables this check.	0 s	10 min	255 min
7	HT time. If the AUTO 306 is in the plasma process mode, this is the process time. The hold function will extend this time. If this time is set to 0 seconds, the Controller by-passes this function (that is, it assumes the function is not required)	0 s	0 s	255 min
8	Vent valve closure delay. The valve closes after this time and the AUTO 306 is then 'sealed'.	2 min	3 min	255 min
9	Backing error limit. If the backing pressure rises above the pressure in pressure store 5 for longer than this limit, an error is displayed.	5 s	10 s	20 s
10	Foreline pumping limit. If the backing pressure remains above the pressure in pressure store 6 for longer than this limit with both the roughing and backing valves closed, an error is displayed.	1 min	1 min	1 min
11	Not used.	0 s	0 s	255 min
12	Not used.	0 s	0 s	255 min
13	Process relay P2 delay: see Section 6.13.	0 s	0 s	255 min
14	Process relay P1 delay: see Section 6.13.	0 s	0 s	255 min
15	Not used.	0 s	0 s	255 min

Table 5 - Time stores: AUTO 306 with diffusion pumping system

Store number	Function	Minimum value	Default value	Maximum value
0	Pressure rise test time.	1 min	5 min	10 min
1	Cryopump regeneration time.	120 min	180 min	255 min
2	High vacuum valve closure time: the time taken for the valve to fully open or fully close.	5 s	10 s	20 s
3	Backing and roughing valves closure time.	2 s	4 s	8 s
4	Roughing limit. If rough pumping continues for more than this limit, an error is displayed. The hold function does not disable this check.	1 min	3 min	20 min
5	Pump down limit. If pump down continues for more than this limit, an error is displayed. The hold function does not disable this check.	30 s	2 min	255 min
6	Fine pumping limit. If the AUTO 306 is in the plasma process mode and the pressure does not fall to the pressure set in pressure store 13 before this time limit is reached, an error is displayed. The hold function disables this check.	0 s	10 min	255 min
7	HT time. If the AUTO 306 is in the plasma process mode, this is the process time. The hold function will extend this time. If this time is set to 0 seconds, the Controller by-passes this function (that is, it assumes the function is not required).	0 s	0 s	255 min
8	Vent valve closure delay. The valve closes after this time and the AUTO 306 is then 'sealed'.	2 min	3 min	255 min
9	Cryo failure delay.	0 s	10 s	5 min
10	Not used.	0 s	0 s	255 min
11	Not used.	0 s	0 s	255 min
12	Not used.	0 s	0 s	255 min
13	Process relay P2 delay: see Section 6.13.	0 s	0 s	255 min
14	Process relay P1 delay: see Section 6.13.	0 s	0 s	255 min
15	Maximum cryopump roughing time.	10 min	20 min	255 min

Table 6 - Time stores: AUTO 306 with cryo pumping system

Store number	Function	Minimum value	Default value	Maximum value
0	Turbomolecular pump run-down time (with rotary pump operating).	1 min	3 min	5 min
1	Not used.	0 s	0 s	30 min
2	High vacuum valve closure time: the time taken for the valve to fully open or fully close.	5 s	10 s	20 s
3	Backing and roughing valves closure time.	2 s	4 s	8 s
4	Roughing limit. If rough pumping continues for more than this limit, an error is displayed. The hold function does not disable this check.	1 min	3 min	20 min
5	Pump down limit. If pump down continues for more than this limit, an error is displayed. The hold function does not disable this check.	30 s	2 min	255 min
6	Fine pumping limit. If the AUTO 306 is in the plasma process mode and the pressure does not fall to the pressure set in pressure store 13 before this time limit is reached, an error is displayed. The hold function disables this check.	0 s	10 min	255 min
7	HT time. If the AUTO 306 is in the plasma process mode, this is the process time. The hold function will extend this time. If this time is set to 0 seconds, the Controller by-passes this function (that is, it assumes the function is not required).	0 s	0 s	255 min
8	Vent valve closure delay. The valve closes after this time and the AUTO 306 is then 'sealed'.	2 min	3 min	255 min
9	Backing delay: the delay before backing starts.	30 s	2 min	5 min
10	Foreline pumping limit. If the backing pressure remains above the pressure in pressure store 6 for longer than this limit with both the roughing and backing valves closed, an error is displayed.	1 min	1 min	1 min
11	Not used.	0 s	0 s	255 min
12	Not used.	0 s	0 s	255 min
13	Process relay P2 delay: see Section 6.13.	0 s	0 s	255 min
14	Process relay P1 delay: see Section 6.13.	0 s	0 s	255 min
15	Not used.	0 s	0 s	255 min

Table 7 - Time stores: AUTO 306 with turbomolecular pumping system

Pressure Store number	Function	Minimum value (mbar)	Default value (mbar)	Maximum value (mbar)
0	Diffusion pump start pressure. The pressure at which the diffusion pump starts to warm up.	1×10^{-2}	1×10^{-1}	6×10^{-1}
1	Roughing to pump-down changeover pressure. The pressure at which roughing stops and fine pumping starts. The hold function disables this facility.	5×10^{-2}	2×10^{-1}	6×10^{-1}
2	Not used.	0	0	1×10^3
3	Penning gauge on pressure. The Penning gauge is switched on when the pressure falls below this pressure. The gauge is switched off when the pressure rises to above 10% of this pressure store.	5×10^{-2}	2×10^{-1}	6×10^{-1}
4	High vacuum fail. If the chamber pressure rises above this pressure when the high vacuum valve is open, an error is displayed.	8×10^{-4}	1×10^{-3}	3×10^{-3}
5	Backing error. If the backing pressure rises above this pressure for longer than the time in time store 9, an error is displayed.	3×10^{-1}	6×10^{-1}	1
6	Backing valve open pressure. If the AUTO 306 is not roughing, the backing valve will open when the pressure measured by the Pirani gauge is less than this pressure.	8×10^{-1}	1	2
7	High vacuum valve close pressure. When the AUTO 306 changes from rough pumping to fine pumping, if the pressure measured by the Pirani gauge is higher than this pressure, the high vacuum valve will close.	2×10^{-1}	4×10^{-1}	8×10^{-1}
8	Process abort. If the pressure measured by the chamber Pirani gauge is higher than this pressure during the plasma process, an error is displayed.	5×10^{-3}	5×10^{-1}	1
9	Process relay P1 timer start setpoint: see Section 6.13.	0	0	1×10^3
10	Process relay P2 timer start setpoint: see Section 6.13.	0	0	1×10^3
11	Process relay P1 on pressure: see Section 6.13.	0	0	1×10^3
12	Process relay P1 off pressure: see Section 6.13.	0	0	1×10^3
13	Plasma process. If the Controller PROCESS button has been pressed, the AUTO 306 will change from fine pumping to the plasma process when the pressure is less than this pressure. The hold function disables this facility.	0	1×10^{-4}	5×10^{-3}
14	Process relay P2 on pressure: see Section 6.13.	0	0	1×10^3
15	Process relay P2 off pressure: see Section 6.13.	0	0	1×10^3

Table 8 - Pressure stores: AUTO 306 with diffusion pumping system

Pressure Store number	Function	Minimum value (mbar)	Default value (mbar)	Maximum value (mbar)
0	Pressure rise test start pressure.	5×10^{-2}	8×10^{-2}	5×10^{-1}
1	Pressure rise test upper pressure limit. If the pressure is less than this pressure store after the delay in in time store 0, the test has passed. This pressure store should always be set higher than pressure store 0.	9×10^{-2}	2×10^{-1}	6×10^{-1}
2	Roughing to pump-down changeover pressure. The pressure at which roughing stops and fine pumping starts. The hold function disables this facility.	1×10^{-1}	5×10^{-1}	1
3	Penning gauge on pressure. The Penning gauge is switched on when the pressure falls below this pressure. The gauge is switched off when the pressure rises to above 10% of this pressure store.	1×10^{-1}	5×10^{-1}	1
4	High vacuum fail. If the chamber pressure rises above this pressure when the high vacuum valve is open, an error is displayed.	8×10^{-4}	1×10^{-3}	3×10^{-3}
5	Not used.	0	0	1×10^{-3}
6	Not used.	0	0	1×10^{-3}
7	Not used.	0	0	1×10^{-3}
8	Process abort. If the pressure measured by the chamber Pirani gauge is higher than this pressure during the plasma process, an error is displayed.	5×10^{-3}	5×10^{-1}	1
9	Process relay P1 timer start pressure: see Section 6.13.	0	0	1×10^3
10	Process relay P2 timer start pressure: see Section 6.13.	0	0	1×10^3
11	Process relay P1 on pressure: see Section 6.13.	0	0	1×10^3
12	Process relay P1 off pressure: see Section 6.13.	0	0	1×10^3
13	Plasma process. If the Controller PROCESS button has been pressed, the AUTO 306 will change from fine pumping to the plasma process when the pressure is less than this pressure. The hold function disables this facility.	0	1×10^{-4}	8×10^{-4}
14	Process relay P2 on pressure: see Section 6.13.	0	0	1×10^3
15	Process relay P2 off pressure: see Section 6.13.	0	0	1×10^3

Table 9 - Pressure stores: AUTO 306 with cryo pumping system

Pressure Store number	Function	Minimum value (mbar)	Default value (mbar)	Maximum value (mbar)
0	Turbomolecular pump start pressure. The pressure at which the turbomolecular pump will start to accelerate to full speed.	1×10^{-2}	1×10^{-1}	6×10^{-1}
1	Roughing to pump-down changeover pressure. The pressure at which roughing stops and fine pumping starts.	5×10^{-2}	2×10^{-1}	6×10^{-1}
2	Not used.	0	0	1×10^3
3	Penning gauge on pressure. The Penning gauge is switched on when the pressure falls below this pressure. The gauge is switched off when the pressure rises to above 10% of this pressure store.	5×10^{-2}	2×10^{-1}	6×10^{-1}
4	Roughing/fine pumping changeover pressure.	8×10^{-4}	1×10^{-3}	3×10^{-3}
5	Backing error. If the backing pressure rises above this pressure for longer than the time in time store 9, an error is displayed.	3×10^{-1}	6×10^{-1}	1
6	Backing valve open pressure. If the AUTO 306 is not roughing, the backing valve will open when the pressure measured by the Pirani gauge is less than this pressure.	8×10^{-1}	1	2
7	High vacuum valve close pressure. When the system changes from rough pumping to fine pumping, if the pressure measured by the Pirani gauge is higher than this pressure, the high vacuum valve will close.	2×10^{-1}	4×10^{-1}	8×10^{-1}
8	Process abort. If the pressure measured by the chamber Pirani gauge is higher than this pressure during the plasma process, an error is displayed.	5×10^{-3}	5×10^{-1}	1
9	Process relay P1 timer start pressure: see Section 6.13.	0	0	1×10^3
10	Process relay P2 timer start pressure: see Section 6.13.	0	0	1×10^3
11	Process relay P1 on pressure: see Section 6.13.	0	0	1×10^3
12	Process relay P1 off pressure: see Section 6.13.	0	0	1×10^3
13	Plasma process. If the Controller PROCESS button has been pressed, the AUTO 306 will change from fine pumping to the plasma process when the pressure is less than this pressure. The hold function disables this facility.	0	1×10^{-4}	5×10^{-3}
14	Process relay P2 on pressure: see Section 6.13.	0	0	1×10^3
15	Process relay P2 off pressure: see Section 6.13.	0	0	1×10^3

Table 10 - Pressure stores: AUTO 306 with turbomolecular pumping system

6.6.3 Change time stores

Use the <<SETPOINTS/TIME DELAYS menu option to display the current values of time stores and to change the values of time stores.

When you select the menu option, the top line of the Controller display changes to TIME DELAYS and the bottom line of the display is as shown in Figure 6. You can then:

- Press the Up and Down buttons to select the time store number (0 to 15).
- Press the Yes button if you want to change the value of the time store. Use the Up and Down buttons to decrease or increase each digit of the value, then press the Yes button to enter the digit into the Controller.

6.7 MONITOR SYSTEM menu option

Select this option to display pressure gauge outputs and pressure indications in manual mode. Refer to Table 1 for the format of the available display parameters.

6.8 RELAYS/INPUT menu

WARNING

Do not operate the AUTO 306 in a way which could damage the equipment or cause injury to people.

Use this menu to display the current state of components of the AUTO 306 and to manually control the operation of components. For example, you can switch the Penning pressure gauge on and off. Refer to Table 11 which shows the menu options and their uses.

To control the operation of a component, press the Yes button. The state of the currently displayed component is then changed to its alternative state. For example, if the bottom line of the display shows 1ROT. PUMP OFF and you press the Yes button, the rotary pump is switched on.

In manual mode, the interlocks do not operate. If you use manual mode, you must therefore take great care to ensure that you do not operate the AUTO 306 in a way which could damage the equipment or could cause injury to people.

6.9 PRESSURE UNITS menu option

Use this menu option to select the required display pressure unit; that is, one of the following:

- MBAR (MB)
- TORR (TR)

Controller display	Function
1 ROT. P OFF/ON	Switch the rotary pump on and off
2 SEC. PUMP OFF/ON	Switch the secondary pump* on and off
3 BACKING V OFF/ON	Open and close the backing valve
4 ROUGH V OFF/ON	Open and close the roughing valve
5 HI VAC V OFF/ON	Open and close the high vacuum valve
6 VENT V OFF/ON	Open and close the air admit valve
7 CRYOISO V OFF/ON	Not used
8 HVV CRACK OFF/ON	Crack/uncrack the high vacuum valve
9 NEEDLE/P1 OFF/ON	Switch process relay P1 (needle valve) on and off
10 HT PWR/P2 OFF/ON	Switch process relay P2 (HT power supply) on and off
11 RELAY P3 OFF/ON	Switch process relay P3 on and off
12 RELAY P4 OFF/ON	Switch process relay P4 on and off
13 HI VACV IP OFF/ON	High vacuum valve input
14 SEC P. IP OFF/ON	Secondary pump* input
15 BACK V. IP OFF/ON	Backing valve input
16 ROUGHV. IP OFF/ON	Roughing valve input

* Diffusion pump, turbomolecular pump or cryopump.

Table 11 - RELAY/INPUT menu options

6.10 PENNING CONTROL menu option

<p>CAUTION</p> <p>Do not operate (switch on) the Penning gauge when the chamber pressure is above 1×10^{-4} mbar. If you do, you can damage the gauge.</p>

Use this menu option to display the current state of the Penning gauge (ON or OFF). When the top line of the display shows PENNING CONTROL:

- Press the No button to exit the menu option.
- Press the Yes button to change the state of the Penning gauge (that is, switch it on or off).

6.11 DISPLAY TYPE menu option

Use this menu option to select normal or diagnostic display. Some of the display parameters (in the normal display and MONITOR SYSTEM menu option) are only available if diagnostics display is selected: refer to Figure 6.

6.12 PASSWORD CONTROL menu option

6.12.1 Password levels

The Controller has a master password and (optionally) levels 1, 2 and 3 passwords. These passwords prevent unauthorised access to some of the Controller menus and options.

Once you have entered the master password, you can define the level 1, 2 and 3 passwords and enable these passwords. Figure 6 shows the menus and options protected by the passwords; that is, before the menu is displayed and available, the appropriate password must be entered. If the passwords have been disabled, all Controller menus are directly available to the user.

6.12.2 Set passwords and enable/disable passwords

When you select the PASSWORD CONTROL menu option, you must then enter the master password. Use the Up and Down buttons to decrease or increase each digit; when the digit is set to the correct value, press the Yes button to enter the digit into the Controller. After the last digit is entered, the Controller will check whether the password is correct.

When the correct master password has been entered, the top line of the display will change to <<PASSWORD CONTROL and the bottom line will indicate whether passwords are enabled (PASSWORDS = ON) or disabled (PASSWORDS = OFF).

If you want to disable the passwords (so that users have unrestricted access to all the Controller menus):

1. Press the Up or Down button if necessary so that the bottom line of the display shows PASSWORDS = OFF.
2. Press the Yes button.

If you want to enable passwords:

1. Press the Up or Down button if necessary so that the bottom line of the display shows PASSWORDS = ON.
2. Press the Yes button. The top line of the display will then change to PASSWORD ENTRY and the bottom line will show LEVEL 1 = #.
3. Enter the four digits of the new level 1 password. For each digit, use the Up and Down buttons to decrease or increase each digit. When the digit is set to the correct value, press the Yes button to enter the digit into the Controller. When the last digit has been entered, the bottom line of the display then changes to show LEVEL 2 = #.
4. Enter the four digits of the new level 2 password: use the method described in Step 3. When the last digit has been entered, the bottom line of the display then changes to show LEVEL 3 = #.
5. Enter the four digits of the new level 3 password: use the method described in Step 3.

6.13 Use of the process relays

The AUTO 306 has two process relays P1 and P2. You can connect your own accessories to these relays to control the operation of the accessories.

Operation of process relay P1 is controlled by time store 13 and pressure stores 9, 11 and 12; operation of process relay P2 is controlled by time store 14 and pressure stores 10, 14 and 15. You can adjust these stores (as described in Sections 6.6.2 and 6.6.3) to configure the relays to operate in a number of different ways, as described below.

To enable a process relay after a preset time delay (after pressing the process button):

- Set the process relay on and off pressures (pressure stores 11 and 12 or 14 and 15) to atmospheric pressure.
- Set the process relay timer start pressure (pressure store 9 or 10) to atmospheric pressure.
- Set the process relay delay (time store 13 or 14) to the required delay.

To enable a process relay at a preset pressure (after pressing the process button):

- Set the process relay on and off pressures (pressure stores 11 and 12 or 14 and 15) to the upper and lower pressure settings for the required pressure. (The process relay is energised when the pressure reaches the 'on pressure'. If the pressure then rises to the 'off pressure', the process relay is de-energised until the pressure falls to the 'on pressure' again.)
- Set the process relay timer start pressure (pressure store 9 or 10) to atmospheric pressure.
- Set the process relay delay (time store 13 or 14) to 0 seconds.

To enable a process relay at a preset pressure, and after a preset time delay (after pressing the process button):

- Set the process relay on and off pressures (pressure stores 11 and 12 or 14 and 15) to the upper and lower pressure settings for the required pressure.
- Set the process relay timer start pressure (pressure store 9 or 10) to atmospheric pressure.
- Set the process relay delay (time store 13 or 14) to the required delay.

To enable a process relay after a preset time delay after a preset pressure is reached (when the delay is initiated by a pressure setpoint):

- Set the process relay on and off pressures (pressure stores 11 and 12 or 14 and 15) to the upper and lower pressure settings for the required pressure.
- Set the process relay timer start pressure (pressure store 9 or 10) to the upper pressure setting entered above (into pressure store 11 or 14).
- Set the process relay delay (time store 13 or 14) to the required delay.

6.14 Examples of Controller menu usage

6.14.1 Select diagnostic display

If the normal display is shown (that is, the top line of the Controller display shows a stage label) and you want to select diagnostic display, use the following procedure.

1. Press the No button. The Controller display will then show:

```
PASSWORD ENTRY  
MASTER = #
```

2. Use the Up and Down buttons to change the first digit to the correct first digit of the master password, then press the Yes button. The Controller display then shows the following (where Δ is the first digit, already entered):

```
PASSWORD ENTRY  
MASTER =  $\Delta$ #
```

3. Enter the second, third and fourth digits of the master password: use the method given in Step 2. After the last digit is entered (if the password was entered correctly), the Controller display will show:

```
<<MODE SELECT  
SEQUENCE RUN
```

4. Press the Down button. The Controller display then shows:

```
<<MODE SELECT  
SET POINTS
```

5. Press the Down button again. The Controller display then shows:

```
<<MODE SELECT  
MANUAL MODE
```

6. Press the Down button again. The Controller display then shows:

```
<<MODE SELECT  
ADJUST MODE
```


7. Press the Yes button. The Controller display then shows:

```
<<ADJUST MODE  
PRESSURE UNITS
```

8. Press the Down button. The Controller display then shows:

```
<<ADJUST MODE  
DISPLAY TYPE
```

9. Press the Yes button. The Controller display then shows:

```
<<DISPLAY TYPE  
NORMAL
```

10. Press the Down button. The Controller display then shows:

```
<<DISPLAY TYPE  
DIAGNOSTIC
```

11. Press the Yes button to select diagnostic display.

6.14.2 Change pressure store 14 (from manual mode).

If you are currently in the MANUAL MODE menu (that is, the top line of the Controller display shows *MANUAL MODE), and you want to change the value of pressure store 14 to 2×10^{-4} mbar, use the following procedure (which assumes that the currently selected pressure display unit is mbar).

1. Press the No button. The Controller display then shows:

```
<<MANUAL MODE  
MONITOR SYSTEM
```

2. Press the No button. The Controller display then shows:

```
<<MODE SELECT  
MANUAL MODE
```

3. Press the Up button. The Controller display then shows:

```
<<MODE SELECT  
SETPOINTS
```

4. Press the Yes button. The Controller display then shows:

```
<<SET POINTS  
PRESSURE
```

5. Press the Yes button. The Controller display then shows:

```
<<PRESSURE  
0 = 1.0 -1
```

6. Press the Up button twice. The Controller display then shows:

```
<<PRESSURE  
14 = 0.0 +0
```

7. Press the Yes button. The Controller display then shows the following (where # indicates a flashing digit):

```
<<PRESSURE  
14 = #.0 ±0
```

8. Press the Down button twice. The Controller display then shows:

```
<<PRESSURE  
14 = 2.0 ±0
```

9. Press the Yes button. The Controller display then shows the following:

```
<<PRESSURE  
14 = 2.# ±0
```

10. Press the Yes button. The Controller display then shows the following, with the ± 0 flashing:

<<PRESSURE
14 = 2.0 ± 0

11. Press the Up button four times. The Controller display then shows the following:

<<PRESSURE
14 = 2.0 -4

12. Press the Yes button to enter the new value into the Controller.

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