

# **Vacscan and Vacscan Plus Manual**

LP101002 Rev 2.04  
January 2002

As part of our continuous product improvement policy, we are always pleased to receive your comments and suggestions about how we should develop our product range. We believe that the manual is an important part of the product and would welcome your feedback particularly relating to any omissions or inaccuracies you may discover.

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## EC DECLARATION OF CONFORMITY

Spectra SensorTech Ltd.  
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United Kingdom

DECLARES THAT THE FOLLOWING PRODUCTS:

LM62, LM10 VACSCAN 100  
LM63, LM10, LM4 VACSCAN PLUS 100, 200  
LM61, LM10, LM4, LM9 SATELLITE 100, 200, 300  
LM56 MICROVISION  
LM70, LM76 MICROVISION PLUS  
LM77 VISION 1000P  
LM79 VISION 1000I  
LM89 VISION 1000B  
LM90 VISION 1000 C / E  
LM78 VAC CHECK  
LM80 MINILAB

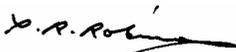
ARE IN CONFORMITY WITH THE FOLLOWING EUROPEAN  
DIRECTIVES:

89/336/EEC ELECTROMAGNETIC COMPATIBILITY DIRECTIVE  
73/23/EEC LOW VOLTAGE DIRECTIVE AS AMMENDED 93/68 EEC

THE APPLICABLE STANDARDS ARE:

EN 61326:1998 ELECTRICAL EQUIPMENT FOR MEASUREMENT,  
CONTROL & LABORATORY USE  
EN 61010-1:1993 SAFETY REQUIREMENTS FOR ELECTRICAL  
EQUIPMENT FOR MEASUREMENT,  
CONTROL & LABORATRY USE.

SIGNED:



T.R.ROBINSON  
EUROPEAN OPERATIONS MANAGER

DATE: 1<sup>ST</sup> JULY 2001

## **Additional Installation Maintenance and Operating Instructions**

In order to comply with European regulations, the following procedures must be followed :-

### **A) INSTALLATION**

- 1) The installation procedures given in the operating and technical manuals must be followed, in addition to these instructions.
- 2) The mains power cable must conform to local regulations and must have a protective earth (PE) conductor securely connected to the power plug protective earth contact.
- 3) The short earthing braid supplied with some products must be fitted between the terminal on the RF head and one of the CF40 vacuum flange bolts.
- 4) Only cables supplied with the equipment may be used for interconnections. If extension cables are required to obtain a greater separation between control unit and RF head, or if longer serial communications cables are required, they must be supplied by Spectra SensorTech Ltd.
- 5) Cables attached to all other ancillary signal and control ports must have a length of less than 3 metres. If greater length is required, Spectra SensorTech Ltd must be contacted for technical guidance on possible EMC and safety issues.
- 6) The vacuum system on which the analyser/RF head is mounted must be earthed, to a protective earth, preferably to the same protective earth as the control unit.

### **B) OPERATION**

- 1) The equipment is not authorised for use as a critical component in a life support or safety critical system without the express written approval of Spectra SensorTech Ltd.
- 2) All instructions given in the operating manual must be followed.
- 3) Adjustments are strictly limited to those accessible from the control panel and computer keyboard and only when running software supplied by Spectra SensorTech Ltd.

### **C) MAINTENANCE**



**WARNING-DANGEROUS VOLTAGES EXIST INSIDE THE EQUIPMENT**

- 1) Maintenance functions must only be carried out by competent persons.
- 2) During the warranty period, faulty equipment must be returned to Spectra SensorTech Ltd., unless special arrangements are made.
- 3) There are no user replaceable parts in the electronic equipment. Certain components are EMC and safety critical and must not be substituted. Replacement parts are available from Spectra SensorTech Ltd.
- 4) Equipment enclosures embody certain special fastening and bonding devices that affect EMC and safety performance. These must be correctly re-fitted after servicing.

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# Errata and addenda

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MKS name change only.

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# Section 1.

## Specification

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### 1.1. About this manual

The Vacscan manual is designed to gradually introduce you to the wonderful world of both the Vacscan and residual gas analysis. If you follow the sections through you will learn progressively of the many available features. You don't have to read the whole manual before you get the instrument operational, but we do recommend that you follow the course.

This manual covers the operation of the family of Vacscan instruments comprising of the standard Vacscan with the optional software upgrades Vacsoft 1 and Vacsoft 2 and the big brother Vacscan Plus. In this manual the following icons are used to identify sections that refer to the extra features available with Vacsoft 1, Vacsoft 2 and Vacscan Plus:-



= Vacsoft 1



= Vacsoft 2



= Vacscan Plus

All sections which indicate Vacsoft 1 or Vacsoft 2 options are applicable to Vacscan Plus.

The Appendices contain information on residual gas analysis itself and, as well as backing up the main manual with information, are designed to answer some of the questions you may be asking if you are new to this field.

## 1.2. Getting help

We are always pleased to provide assistance where we can. If you are experiencing any difficulties or need help please feel free to call your local Spectra facility and ask for the service department. Please have the following information ready so that our technical staff may help you quickly and efficiently:

1. The serial numbers of the analyser, RF head and control unit; each of these numbers begins with the letters “LM”
2. The software version number displayed at the top of the opening screen including any Vacsoft suffixes (-A and/or -B)
3. The information displayed in the Vacscan or Vacscan Plus diagnostics screen refer to section **4.10.8. Diagnostics** in this manual .
4. The type of software operating with the Vacscan or Vacscan Plus e.g. RGA for Windows, together with the software version number (refer to the manual for the operating software if you are un-sure how to find this).

## 1.3. Mechanical specification

### 1.3.1. Vacscan

Size: 3U x 84T

Dimensions: Front panel height 132mm, width 484.5mm inc. carrying handles.

Depth from rear of front panel over rear panel connectors 300mm.

Weight: 9kg

### 1.3.2. Vacscan Plus

Size: 4U x 84T

Dimensions: Front panel height 177.5mm, width 484.5mm inc. carrying handles.  
Depth from rear of front panel over rear panel connectors 300mm.

Weight: 9.5kg

## **1.4. Electrical specification**

Power Inlet: 100-120 or 220-240Vac 47-63 Hz 50VA

Installation Category II

Pollution Category II

Fuses: 5mm x 20mm Ceramic IEC127

Power Entry Module:

3.15A (T) 100/120V          1.6A (T) 220/240V

PCB: FS1&2 3.15A (T) FS3&4 1.6A (T)

## **1.5. Safety**

Class I

The Yellow/Green core of the Power Cord must be connected to the Power source Protective Earth Terminal.

There are no user serviceable parts within the Vacscan or Vacscan Plus unit.

These units have an IP Rating of 0 for protection against fluids.

### **1.5.1. External Warning Labels**

#### **Rear Panel**



The Exclamation Mark (ISO 3864, No.B.3.1) refers to the following:

- a. The voltage on the EXT TRIP jack plug must not exceed 60V D.C. and be current limited to less than 2mA.
- b. The RF Head connector has Hazardous voltages on it, and should only be disconnected with the unit isolated from the mains supply.



The Electric Shock (ISO 3864, No.B.3.6) symbol placed on the rear panel refers to the SEM supply output, and the possibility of electric shock if the connector is removed.

### Top Cover



The Exclamation Mark (ISO 3864, No.B.3.1) refers to the need to disconnect the unit from the mains supply before removing the top cover.

### 1.5.2. Internal Warning Labels



The Exclamation Mark (ISO 3864, No.B.3.1) on PCB next to the Lithium Battery refers to the replacement type and the method of disposal of the spent battery.  
i.e. Replacement type is Varta Lithium CR AA or UL approved equivalent.

Note: The Lithium Cell installed in this equipment should be discarded in accordance with applicable national statutory regulations.

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## Section 2.

# Installation

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This section deals with getting the equipment you have just bought out of its box, installed on your system and ready to go. If you have any questions or experience any difficulties, contact your local representative who will be able to help you.

### 2.1. Unpacking and inspecting

#### 2.1.1. Unpacking

When you receive the Vacscan carefully check each item before removing the foam packaging and plastic wrapping to ensure that no physical damage has occurred during shipment. Also make sure all items have been received by checking against the enclosed packing slip.

## CAUTION

Do not open the vac-formed envelope at this stage

If there has been obvious damage during shipment or if there are items listed on the packing slip as shipped which are not in the box, immediately contact your local sale/service representative.

## **CAUTION**

Most insurance claims for shipment damage must be placed within 7 days from the date of delivery - in WRITING. So don't let your Vacscan get buried in its box.

**Check it out !!.**

### **2.1.2. Removing the analyser cover**

## **CAUTION**

**The analyser is both fragile and very easily contaminated by the slightest touch from your fingers or undesirable surfaces.**

**THE WARRANTY DOES NOT COVER CLEANING OF THE ANALYSER.**

The analyser is shipped in a vac-formed envelope for protection. Carefully remove the tape and unfold the envelope to allow access to the analyser.

Hold the analyser **ONLY** at the vacuum flange.

If you have to set the analyser down for a moment, carefully return it back to the plastic envelope for protection.

**DO NOT LEAVE THE ANALYSER IN THIS CONDITION.**

The rules of gravity are known to deviate from the norm around unattended analysers and it can fall and smash if the work surface is bumped. It will also collect dust which will give a very strange mass spectrum!

### **2.1.3. Inspecting the analyser**

Hold the analyser with the quadrupole and ioniser structure vertically up. Carefully inspect all the observable insulators for damage.

Look at each lead from the flange to its termination point to ensure that it does not touch any other element of the analyser.

But note, the less you adjust or change, the lower the possibility of breaking something.

### **2.1.4. Replacing the analyser cover**

To avoid possible damage to the analyser now is the time to put it back in its plastic envelope. Simply reverse the instructions in section **2.1.2. Removing the analyser cover.**

## **2.2. Installing the analyser**

### **2.2.1. Checking the vacuum chamber dimensions**

The vacuum chamber in which you intend to mount the Vacscan analyser must have a 2.75 inch UHV Conflat® flange fitted with a tube of (35.0mm) 1.375" minimum inner diameter inclusive of a good welded joint.

The distance from the end of the analyser to its mounting flange depends on the type of analyser. Refer to the table below:

<b>Analyser Type</b>	<b>Length</b>
100 amu	155mm (6.1")
200 amu single filter	155mm (6.1")
200 amu double filter	180mm (7.1")

The table assumes the analyser is fitted with a standard ion source.

There must be at least the distance given above free of obstructions inside the vacuum chamber. If your chamber does not have that much room or only a small flange you should use a specially designed adapter so that the analyser can be mounted outside the chamber. Please contact your local Spectra facility for further information.

### **2.2.2. Checking the system pressure**

Quadrupole analysers cannot be operated at pressures higher than  $1 \times 10^{-4}$  torr and for dual (faraday and electron multiplier detectors) the multiplier should not be used at pressures above  $2 \times 10^{-6}$  torr. If you intend to monitor a sputtering or plasma etching process, remember that, if the mass analyser is mounted directly in the chamber, you will not be able to switch on the unit while at sputtering pressures.

CAUTION - A worse problem is that sputtering is meant to 'throw' materials around corners. If the mass filter extends into the 'throw area' of the sputtering deposition, it will rapidly become coated and cease to function properly. Turning off the power to the Quad during sputtering or etching will not prevent this contamination. It is most important to ensure that the analyser is shielded from his type of contamination.

Remember, the warranty does not cover cleaning of the analyser.

We do, however, supply High Pressure Adapter Kits (HPA's) for just these types of applications.

### **2.2.3. Mounting the analyser**

The standard 2.75" Conflat® flange on the analyser can be sealed to the vacuum chamber with either a copper gasket or a Viton® gasket with a square cross section. Which one you choose depends on the ultimate

pressure you expect in your system.

Remove the analyser from its shipping cover, see section **2.1.2. Removing the analyser cover.**

Clean the gasket with suitable solvent, dry it and slip it over the quadrupole structure. Set it in the grooves of the flange surface.

Carefully insert the analyser into the vacuum chamber ensuring that you do not allow the leads to touch the walls of the vacuum chamber. Make sure the gasket does not slip part way out of its slot as you push the two flanges together.

Rotate the flange until the locating key on the feedthrough housing tube is as close to 11 o'clock as the bolt holes will allow. This will ensure that the cable on the RF generator will hang vertically and, therefore put little stress on the connector.

Bolt the feedthrough flange to the vacuum chamber flange using the torque appropriate for the gasket material used. Fit one end of the short, heavy earth strap under the head of the lowermost bolt.

## **2.3. Connecting up the system**

### **2.3.1. Installing the RF power supply**

Rotate the locking ring on the RF/analyser connector so that the slot lines up with the keyway on the connector tube.

If you hold the RF power supply such that the cable hangs downwards, you will be able to slide the power supply onto the analyser. The locating key on the analyser will ensure correct alignment. TAKE GREAT CARE as the vacuum feedthrough pins are easily damaged. DO NOT force the RF power supply onto the analyser.

When all of the pins are engaged, push the power supply firmly onto the analyser to ensure electrical continuity. The last 1/8th of an inch (3mm) is important.

Finally, rotate the locking ring to lock the power supply in place. You will not be able to do this if the power supply is not pushed fully onto the analyser. Connect the free end of the earth strap to the binding post on the RF power

supply.

### **2.3.2. Installing the adapter box**

THIS IS A NON STANDARD ITEM, WHICH IS ONLY SUPPLIED WHEN SPECIALLY REQUESTED AND REQUIRED.

In some instances, customers who wish to use RF and analyser pairs from other manufacturers can be accommodated by means of an adapter box. This box is inserted 'in line' between the control unit and the RF power supply.

Attach the 37-way connector on the flying lead on the adapter box to the socket marked RF Head on the rear of the Vacscan control unit. The cable from your own RF head should then be connected to the available socket on the adapter box.

### **2.3.3. Electrical connections**

If you are using another manufacturers RF power supply and analyser read section **2.3.2. Installing the adapter box** before continuing at this point.

Ensure the POWER switch is in the OFF position (top of the switch OUT on US and Japanese models, top of switch IN on European versions).

Insert the 37-way connector on the cable from the RF power supply into the socket marked RF HEAD on the rear on the control unit.

If you have a Multiplier detector version, attach the high voltage cable supplied to the BNC connector on the RF power supply and the connector marked MULTIPLIER on the rear of the control unit.

**CAUTION**

**The Electron Multiplier (SEM) MUST NOT be operated at temperatures above 50°C.**

With dual (faraday and electron multiplier) detector instruments serious damage will be caused to the electron multiplier if it is operated at temperatures above 50°C. Where instruments use a standard RF power supply the RF must be removed to bake out so there is no chance of the multiplier inadvertently being switched on.

It is possible to run instruments using RF power supplies fitted with a bakeable adapter during a bake out. In this case only the faraday detector should be used NOT the multiplier.

No damage is caused to the multiplier by high temperatures provided it is not switched on.

The only remedy when a multiplier has been damaged due to being operated at higher temperatures is to replace it.

THIS IS AN EXPENSIVE REPAIR.

Attach the line cord supplied to the plug on the rear panel of the control unit. The unit will be set to operate on the local line voltage. This can be verified by checking the indicator above the line connector.

Take a break to recap. At this point you should have all the bits you got out of the box connected up ready to go. Don't forget about the help that's on hand at your local Spectra facility. Remember, asking **US** can save **YOU** time and money. So, now for the moment of truth - **THE SWITCH ON**. We recommend you work through the next section of this manual, which will check out the operation of your Vacscan or Vacscan Plus.

If you intend using your Vacscan Plus or Vacscan in conjunction with RGA for Windows software run on a PC we strongly recommend you to ensure satisfactory operation in the stand alone mode before running from the PC. Please work through the next section of this manual and then refer to the RGA for Windows manual.



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## Section 3.

# Initial operation

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This section takes you step by step through the initial powering up of the instrument and will check the Vacscan for correct operation. It ensures that the instrument has arrived in good working order and is installed properly. No attempt is made to describe all the functions or even to explain what we are asking you to do. This is an instrument integrity check and a confidence builder for yourself.

### 3.1. Vacuum requirements

The table below shows the minimum pressure requirements for each analyser type. Whenever the unit is to be switched on the pressure must be checked before anything else. Operating the Vacscan at significantly higher pressures will lead to unreliable operation and damage to the filaments and multiplier detector.

Detector Type	Max. Pressure
Faraday	$1 \times 10^{-4}$ torr
Dual (faraday / multiplier)	$2 \times 10^{-6}$ torr

### 3.2. System checkout

#### 3.2.1. Location of the keys

A description of the keys is to be found in section 4.1.1. **Front panel keys** of this manual.

#### 3.2.2. Powering up

Press and hold any front panel key in whilst turning the power on. Hold until you hear an acknowledgement beep and then release it. After a few seconds a second beep will be heard which indicates that the command has been taken and the unit has been reset to the factory pre-set conditions. This is a

POWER UP RESET and the pre-set conditions are detailed in section **Appendix 6. Power up reset** of this manual.

If you do not hear a beep after 15-20 seconds, switch off the power and leave for 10 to 15 seconds before starting again. If necessary you can do this a number of times.

This display will appear on the monitor:-



11 Sep 90	<b>VACSCAN</b> <b>PLUS</b>	15:15
V1.00		200 DUAL DETECTOR

11 Sep 90	<b>VACSCAN</b>	15:15
V1.21		200 DUAL DETECTOR

THIS  
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R.G.  
with  
AUT

<b>CONCEPT</b>		
THIS IS A GENERAL PURPOSE RGA ABLE TO OPERATE IN ONE OF THREE MAIN MODES:-		
VACUUM SCAN - autosearch through the mass range and list the 6 largest peaks found		
LEAK CHECK - using selectable probe gas to trace system leaks.		
R.G.A. Conventional residual gas analysis with multiple mode operation.		
AUTO HELP can be disabled in utilities Press ENTER to continue		

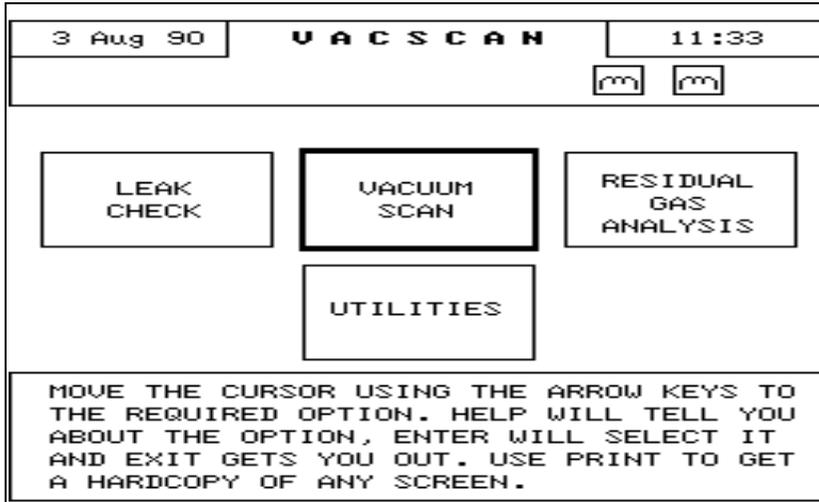
The date and time are displayed separately in the top left and top right corners of the screen respectively. These should be set to local date and time, however, if they are not correct, refer to section **4.10.2. Set time and date**. You don't need to do that right now, save it for later when this check is complete.

The Vacscan software issue number is shown along with the instrument title, mass range and detector options at the top of the screen. If the standard Vacscan has Vacsoft 1 or Vacsoft 2 fitted then the version number will include the suffix -A or -B respectively. Instruments with both options will have the suffix -A-B. Remember where to find this as you may be asked to

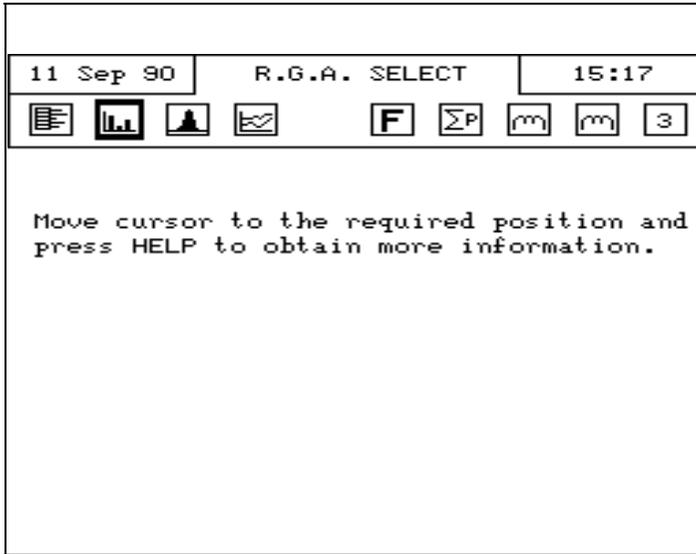
quote this number if you contact your local sales/service point with any enquiries.

### 3.2.3. Take off

Press the **ENTER** key to enter the Main Menu on the screen as shown below:-



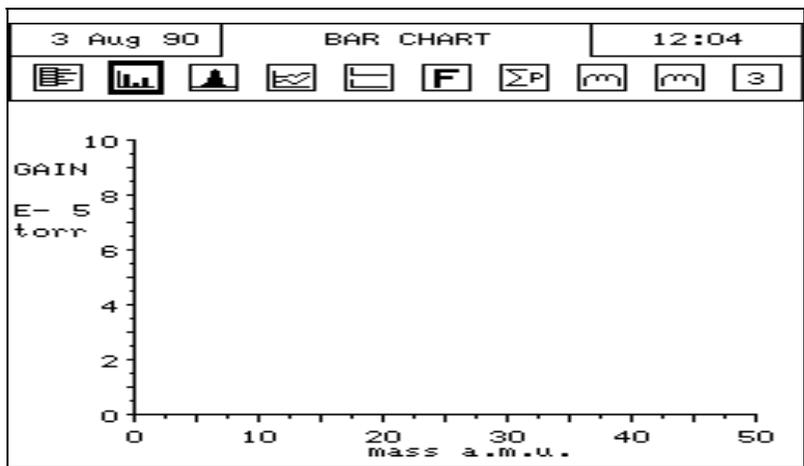
Press the **RIGHT ARROW** key once to move the cursor box (which always appears over the default mode - VACUUM SCAN) to RESIDUAL GAS ANALYSIS and select this mode by pressing the **ENTER** key. The following display will appear:-



The cursor is over the BAR CHART icon:-



so you can press the **ENTER** key to select the BAR CHART mode:-



Make sure that the vacuum chamber pressure is lower than the maximum recommended in section 3.1. **Vacuum** requirements, before going any further. Operation of the instrument at significantly higher pressures can lead to early filament failure, damage to the analyser and/or unreliable performance.

YOU HAVE BEEN WARNED AGAIN!

When you're sure the pressure is OK you can switch a filament on. Move the cursor using the **ARROW** keys to either of the FILAMENT icons:-



Press the **ENTER** key. The icon selected will change to that shown below so acting as the on screen filament status indicator.



Section **4.2. Filament icons** details all available Filament Icons.

The Vacscan is now scanning from 1 to 50 amu as indicated by the moving dot under the mass axis.

It's a good idea to make friends with the moving dot. If you ever lose track of what's going on, he (or she or it - whichever you like) will show you where the Vacscan is up to.

Whenever a system like this is 'fired up' there will always be some outgassing. Don't be surprised, therefore, if the total pressure rises.

What you see on the screen now depends on the pressure in the vacuum system. You may well need to increase the sensitivity of the system since the factory pre-set conditions include the least sensitive range.

Move the cursor to the Gain Range field on the display (The E-5 which is on the left of the screen under the word GAIN). Pressing the **ENTER** key will highlight the gain range field on the screen.

The **UP** and **DOWN ARROW** keys can now be used to increase and decrease the sensitivity setting. Use the **UP ARROW** to increase the sensitivity in decade steps to bring the mass spectrum up on the screen.

If the unit has passed these tests and you have a mass spectrum up on the screen then you can be pretty confident that your Vacscan is installed correctly and operating as an RGA. Pat yourself on the back, you've completed your inaugural flight.

### **3.3. Additional checks**

This will only apply to customers who have instruments fitted with dual (faraday and electron multiplier) detectors.

After completing the tests for the Faraday detector (i.e. those detailed above) its time to check out the multiplier detector.

## CAUTION

**Before you attempt to switch the multiplier on, ensure the indicated total pressure is below the limit given in section 3.1. Vacuum requirements**

Whilst the Vacscan is running on the Faraday detector and showing a spectrum on the screen, look for your new friend, the moving dot. Observe how fast it's moving.

To get the MULT key on the screen you will need to position the cursor over the DETECTOR icon:-



If the GAIN RANGE field is still highlighted you will need to press the **ENTER** key to de-select the GAIN RANGE variable before you can move the cursor around the screen.

With the cursor in position press the **ENTER** key and check the DETECTOR icon has changed to:-



indicating that the MULTIPLIER is ON.

You will now find that your moving dot is a little harder to catch up with. The Vacscan will scan faster with the multiplier on.

You can observe this more clearly by switching between the two detectors. Repeatedly pressing the **ENTER** key switches between the detectors.

As you switch back and forth, you should also check that the peaks measured in both modes are "roughly" the same height. Don't worry if they're not exactly the same, as you have not yet calibrated the multiplier. More on that later, **4.10.6. Calibrate multiplier**

To exit from this mode and return to the Main Menu page press the **EXIT** key on the front panel.

Sit down, put your feet up, grab a coffee and recap over what you've just done. Make sure you understand the set-up you've just put together.

---

## Section 4.

# Operation

---

In the last section you got your Vacscan up and running for the first time. This section deals in detail with how to drive the instrument.

You must remember one important message:-

The entire Vacscan system is written with the objective of minimum training requirement using simple to follow ICON mode selectors, basic instructions and a series of HELP screens which are easily selected at all stages of operation. These screens do not interfere in any way with the operation of the unit but merely overwrite part of the display with useful information or prompts.

**DO NOT BE AFRAID TO USE THESE**

When you become familiar with the operation of the instrument the help text displayed on some screens can be deselected in the UTILITIES menu using the AUTO HELP function.

### 4.1. Basic operation

#### 4.1.1. Front panel keys

**HELP** The HELP function can be accessed at any time during the operation of the instrument. When this key is pressed, information is presented about the ICON or PARAMETER currently selected.

**PRINT** This key generates a printout of the screen on a printer connected to the integral Centronics printer interface. If the unit is scanning then it will wait until the end of the current

scan before initiating a print. If the instrument is in one of the scanning modes and the **PRINT** key is pressed twice, then the Print Continuous mode is entered. In this mode each time the printout finishes a scan is performed which is then printed.

**EXIT** Press the **EXIT** key to leave the current mode.

**R.G.A.** Enter the R.G.A. Select display directly.



### **LEAK CHECK**

Enter the Leak Check mode directly.



### **VACUUM SCAN**

Enter the Vacuum Scan mode directly.



### **ARROWS**

The four **ARROW** keys **UP**, **DOWN**, **LEFT**, and **RIGHT** perform two functions:-

- i) Move the cursor around the screen between the fields available (TEXT and ICONS see section **4.1.2. Moving the cursor**).
- ii) Change the value of the selected **parameter** (see section **4.1.3. Parameter setting and mode selection**).

### **ENTER**

The **ENTER** key is used for parameter or mode selection. (see section **4.1.3. Parameter setting and mode selection**)

### 4.1.2. Moving the cursor

In each screen display on Vacscan there are fields where the cursor may be positioned using the **ARROW** keys. If a high pitch "BEEP" is heard when one of the **ARROW** keys is pressed then you have reached the last field in that direction. It is worth spending some time getting to know your way around the screens. Each field is either the way into a mode or a parameter you can vary. Remember you can press the **HELP** key at any time to get information about the selected field.

### 4.1.3. Parameter setting and mode selection

Parameter setting and mode selection is generally performed by moving the cursor to the required field (TEXT or ICON) and pressing the **ENTER** key. What happens next will vary depending on which field you have selected. Detailed descriptions are included in the following sections, but simply one of three things will happen:-

- i) A new mode will be entered.
- ii) The setting of a parameter with 2 possible states will be changed.
- iii) The field will be highlighted (dark image on light background) indicating that the **ARROW** keys may now be used to increment or decrement the selected parameter. When the parameter has been set to the required value press either the **EXIT** or **ENTER** key to deselect the parameter.

## 4.2. Filament icons

These ICONS also act as Filament Status Indicators as can be seen here.

### 4.2.1. Filament select



Before an analysis can take place in any mode the filament (and preferably the appropriate detector, see section **4.3. Detector** icon) should be selected using this ICON.

### 4.2.2. Filament ok



If the filament is functioning normally this ICON will show on the screen. When this is displayed, the filament is switched off by selecting this ICON and pressing **ENTER**.

### 4.2.3. Filament failure



If the filament is inoperative this ICON will be displayed.

This does not necessarily mean that the filament has blown, check you've got good connections between the control unit and the RF head before checking for blown filaments.

If the filament has blown, the second filament should be selected.

Do this only after the pressure in the vacuum system has been checked by an independent method.

## 4.3. Detector icon

### 4.3.1. Faraday / multiplier detector



Providing the pressure in the system is within the required limits (see section **3.1. Vacuum requirements**), faraday / multiplier detector selection is made using this ICON.

## 4.4. Mode icons

### 4.4.1. User peak mode



Six user programmable peaks (gasses) are adjustable by moving the cursor to the channel of interest, selecting the **ENTER** key and the **UP / DOWN ARROW** keys to select either the mass number or the gas of interest. Similarly the detector, gain or alarm level for a TTL external trip can be set.

### 4.4.2. Bar chart mode



A conventional RGA spectrum can be viewed again using the cursor to select the mass range at the bottom of the screen, pressing **ENTER** and the **ARROW** keys to choose the mass window of interest. Similarly gain and autogain can be selected.

### 4.4.3. Analogue display mode



This mode provides a 10 amu wide analogue type display where the raw signal is displayed to facilitate evaluation of the performance of the quadrupole. The gain and mass window position on the mass scale, can be controlled by the user.

This mode enables resolution and mass alignment checks to be carried out.

#### 4.4.4. Trend mode



Six user programmable peaks (gasses) may be selected in a similar manner to the User Peak mode. The settings in this mode will be copied automatically to the User Peak mode and vice versa. When the six channels have been scanned and the time interval set has elapsed the results are plotted on the display. The time interval is variable between 1 and 99 seconds. Note that if the scan takes longer than the time interval set the display will continue to scroll at the set interval but no data will be plotted until the scan has finished.

### 4.5. General icons

#### 4.5.1. Total pressure



The unit measures the total pressure by monitoring the total current generated by the ion source instead of the filtered partial pressures measured in the analytical modes. When selected this is clearly displayed under the main header display.

#### 4.5.2. Speed setting



This number (user selectable between 1 and 6) affects the amount of signal processing carried out by the control unit in the measurement routine. It follows then, that the more work that is done, the longer it will take and so the slower the instrument will scan, but, the answers generated after a lot of work will be more accurate. It is good to follow the practice of leaving the scan speed at a setting of three (3) for general work as normally this is more than sufficient for optimum speed and accuracy.

## 4.6. Vacuum scan mode icons

### 4.6.1. Vacuum scan initiate



Once selected the instrument will start at the lowest gain range (lowest sensitivity) and scan the entire mass range until it has successfully listed the six largest peaks in decreasing order of intensity. Optional assistance in the form of possible gas species can be selected but care should be taken in referring to these recommendations in case complex process species are present.

### 4.6.2. Review last vacuum scan



Selection of this ICON will enable the user to remind himself of the last Vacscan results before he moves onto a new scan.

### 4.6.3. List possible gasses



This will list against each mass number a possible gas species.

## 4.7. User peak mode icons

### 4.7.1. Alarm page



This provides a page from which the alarm levels can be set. Moving the cursor around the screen allows control over the alarm level, the range, whether an audible signal is given or not and whether the alarm is OFF, a HIGH or a LOW alarm. The type of alarm is indicated by the arrow or dash after the alarm value.

- Indicates alarm is off
- < Indicates a low alarm.
- > Indicates a high alarm.

The level is clearly indicated in the graphical scale to the right of each channel.

## 4.8. Leak check mode icons

### 4.8.1. Audio on/off



When leak checking out of sight of the Vacscan display, this provides an audio output whose pitch is proportional to intensity of the peak. Be careful to ensure that the signal is not saturated at full scale, if it is, you'll not hear a change in pitch and you'll never find that leak!!

## 4.9. Bar chart mode icons

### 4.9.1. Dual display

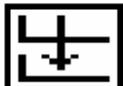


This is the way into the Library and background facilities available on Vacscan. This display shows the live spectra and below it the selected library or background spectra.

### 4.9.2. Library/background selection

This is the field to the right of the screen above the live spectra and indicates which background or library entry is selected. It may be varied in the usual way by selecting the field and then using the **UP** and **DOWN ARROW** keys to step through the background and library entries available. This field is not present in full screen Bar Chart mode.

### 4.9.3. Store background



The live spectra is copied to the selected background at the end of the scan. Note you cannot use this function if one of the library spectra is selected.

### 4.9.4. Background subtract



This mode displays the live spectra minus the selected background. Note it is not possible to enter this mode if one of the library entries is selected or if the gain range of the live spectra is different from that of the background.

### 4.9.5. Background create



When you select this mode you will be able to create and store your own background spectra for subsequent use by the Background Subtract or Library Search facilities.

The steps involved in creating a background spectra are:-

- 1) Select the background entry you wish to use.
- 2) Select the mass cursor field (the area that contains the MASS No. and PEAK HEIGHT information).
- 3) Use the **LEFT** and **RIGHT** arrow keys to select a mass number then use the **UP** and **DOWN** arrow keys to adjust the height of the peak.
- 4) When all the peaks have been set to the required values, the spectra should be stored into the battery backed RAM by moving the cursor to the **SAVE** field and pressing the **ENTER** key.

If you are overwriting a background which already contains a spectra you can erase it by selecting the **CLEAR** field and pressing the **ENTER** key. This will only clear the display at this time. The battery backed RAM will

only be updated if you select the SAVE field and press **ENTER**.

It is possible to reset all the backgrounds by using the RESET field. Since this is not the sort of thing you would like to happen by accident you must follow the following procedure:-

- 1) Select the RESET field (move cursor to RESET field and press **ENTER**).
- 2) Press each of the four **ARROW** keys at least once in any order.
- 3) Finally press the **ENTER** or **EXIT** key and all the backgrounds will be erased.

#### 4.9.6. Library / background search



In this mode it is possible to select a mass number which will be searched for in all the library and background spectra. On completion of the search it is possible to step through all the spectra found that contained a peak at the selected mass.

### 4.10. Utilities

This section is used to change special parameters which in general are specific to a users' set up and will not be changed often.

#### 4.10.1. Autohelp on/off

This enables / disables the detailed screen AUTOHELP messages. As you get more familiar with the operation of the unit you'll want to disable these messages.

#### 4.10.2. Set time and date

The integral real time clock / calendar can be updated to accommodate local time zones by following the on screen instructions.

### 4.10.3. RS232 interface

The various interface parameters detailed below are addressed here.

Parameter	Range
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19200
Parity	Odd, None, Even
Stop Bits	1 or 2
Data Bits	7 or 8

### 4.10.4. Pressure trip

The Total Pressure trip may be set to protect the instrument. This is independent of the alarms set in the User Peak mode.

### 4.10.5. I/O input

The auxiliary output connector on the rear panel by default provides the alarm contacts as programmed in the User Peak mode. You can have an Analogue Output Module connected to the Vacscan to provide up to six analogue voltages corresponding to the six User Peak channels.

The Analogue Output Module is an optional unit and is not supplied with any Vacscan or Vacscan Plus model as standard.

This Utility switches between the Alarm and Analogue modes.

### 4.10.6. Calibrate multiplier

This is fully automatic and will be indicated by screen displays as to system progress. The instrument seeks out and measures a suitable peak in the faraday mode and checks instrument stability. When it is satisfied it will measure the same peak using the multiplier and adjust the drive voltage as required. To cater for system differences and the differing residual gases available on which to perform this operation, the Vacscan will automatically follow a mass 28, 14, 12, 44, 18 sequence before indicating a Calibrate Failure.

The Multiplier will be set to have a gain over the Faraday detector of a factor of 100 times.

#### 4.10.7. Degas ion source

This Degas facility will run for a user variable time period. Use the arrow keys to set the time period. But...

## CAUTION

Degas is strictly a U.H.V. (Ultra High Vacuum) tool. Serious damage can occur if this procedure is carried out at pressures higher than  $5 \times 10^{-8}$  torr. At pressures higher than this it simply will not be needed and you will gain no advantage by using it. You have been warned – don't let curiosity get the better of you  
- look what it did to the cat . . . . .

#### 4.10.8. Diagnostics

This is an automated electronic diagnostic package which checks out all key internal voltages and presents a report covering the following:-

Degas Supply  
-65 volts supply  
-130 volts supply  
-15 volts supply  
Multiplier supply  
+15 volts supply  
+70 volts supply

---

## Section 5.

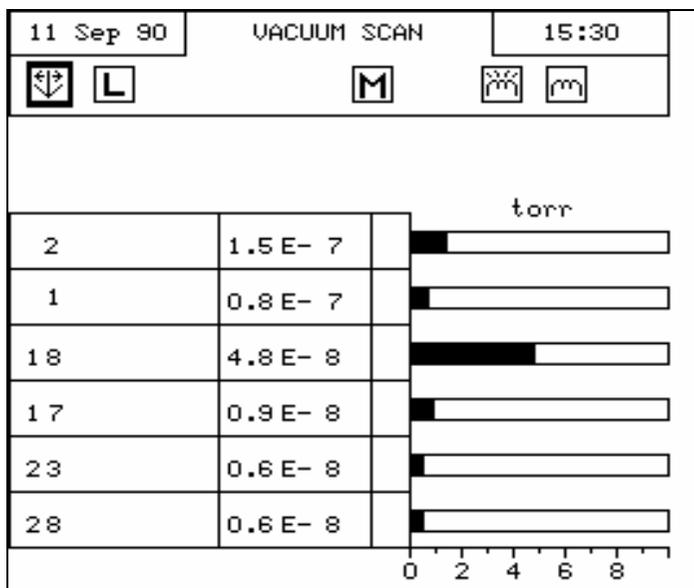
# Operating modes

---

This section details the main operational modes available on the Vacscan. You will probably have a number of different applications for which you will want to use the Vacscan. The different modes offer different advantages and it is a good idea for you to read this section to familiarise yourself with the various analytical approaches available before trying to operate the instrument with specific objectives in mind.

### 5.1. Vacuum scan

This is the default mode for the instrument and it is from this that the unit takes its name. If you are unfamiliar with the techniques of Residual Gas Analysis (RGA) or you don't have the time to interpret the results the Vacscan generates, then this is the answer to your problems.



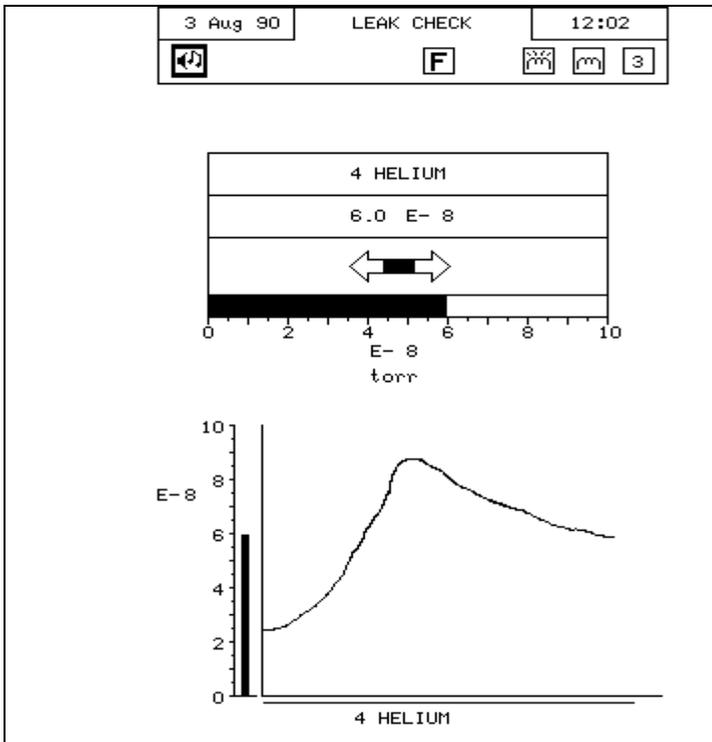
Vacuum scan is a fully automated vacuum analysis program, which, once instigated, can be left on its own. It will scan the vacuum system for the six largest peaks, display them in descending order of intensity then present you

with a list of suggested gases which may be present. With a single key press you can have a vacuum system analysis which not only presents you with a list of mass numbers, but also gives you a list of gases for the six peaks. In most cases this represents over ninety percent of the vacuum constituents.

This mode carries out a basic RGA check and as such should be used regularly for system monitoring. All too often people forget about the quality of their vacuum until something goes wrong. With Vacuum Scan you can regularly check the vacuum quality and print the results for hard copy without spending any time on the system yourself.

As this mode locks on to the largest peaks it is also very useful if you have a sudden change as you can set the unit in operation without interrupting any of the other urgent tasks you probably also need to do.

## 5.2. Leak check



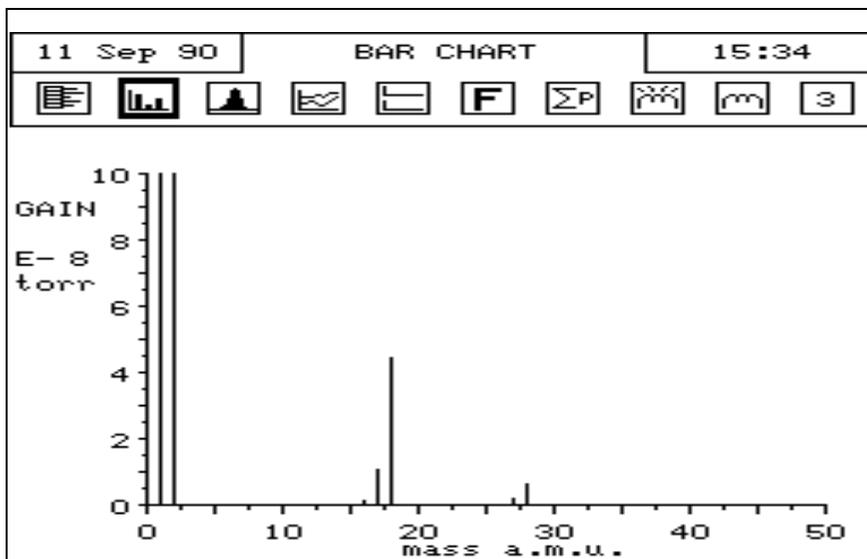
Leak checking is one of the fundamentals of vacuum system maintenance and it is a function expected of any modern day RGA. Quadrupoles have simplified the process of leak checking.

You can use the Vacscan for leak checking by simply tuning to mass 4 and probing with Helium. However, if you like you have the ability to freely change the probe gas. This makes the Vacscan a truly flexible leak checker indeed.

### 5.3. Residual gas analysis

#### 5.3.1. Bar chart

In this mode the peak intensity information is presented in a histogram format. The end point of the scan can be adjusted between 20 and 100 amu as can the gain (range) on which the scan is taken.

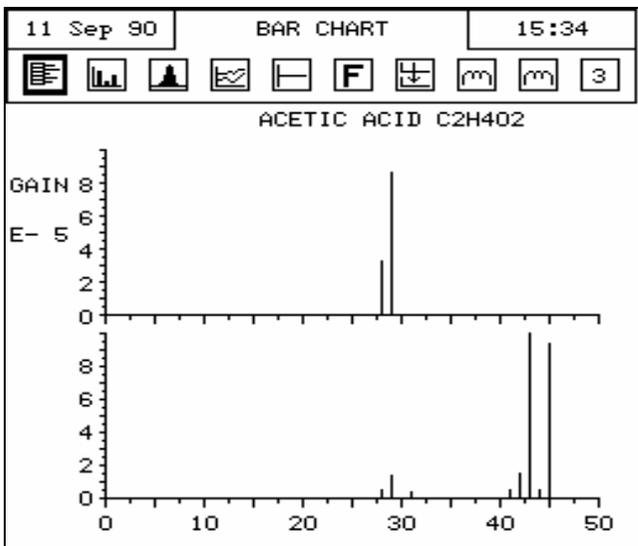


This mode is used for taking a general over-view of the vacuum system. As such, it is the mode in which you are likely to find that something has gone wrong.

WHEN DO YOU USE BAR CHART?

This mode is useful in many circumstances....

- a) When you wish to take a snapshot picture of the vacuum system at any point in time.
- b) If you do not know what is going on in the vacuum system you would use this mode to see which species are dominating.
- c) If you are collecting data on more than 6 components which could be handled by the user peak mode (See **5.3.6. User peaks** ).



### 5.3.2. Library and backgrounds

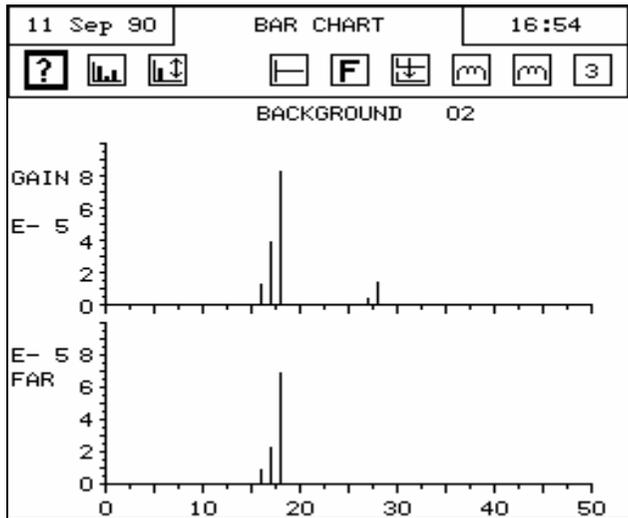


In this mode the live spectra (top) is displayed along with one of the fixed library entries or stored backgrounds (bottom). To enter this mode select the DUAL DISPLAY icon ( See section **4.9.1. Dual display** ) from the Bar Chart mode.

This mode is useful when you have to identify the live spectra. You can look at the live spectra while you step through the library looking for a match (See section **4.9.2. Library/background selection**). From this mode you may

also copy the live spectra to one of the backgrounds available (See section 4.9.3. **Store background**). You can then use the programmed background as an extension to the fixed library or it may be subtracted in the Background Subtract mode. (See section

### 5.3.3. Background subtract ).



### 5.3.3. Background subtract



In this mode the selected background is subtracted live data and the resulting spectra is displayed with intensities ranging from -10 to +10. This mode is useful if you want to detect changes from a normal stable state or if want to ignore a background spectra which is always present in your system.

### 5.3.4. Library create



The library create feature allows library / background spectra to be entered from the key pad and saved as a backgrounds for subsequent use by Background Subtract (See section

**5.3.3. Background subtract** ) or Library Search (See section **5.3.5. Library search**).

### 5.3.5. Library search

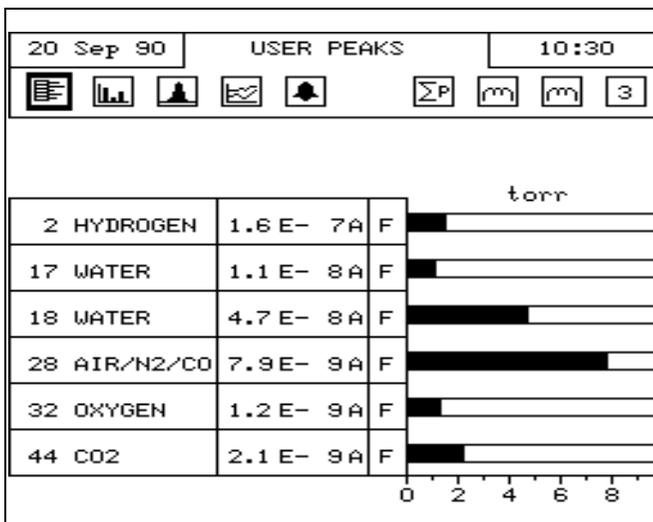


The mass cursor can be set to the mass number of interest and the search started. All the fixed library and background spectra are searched for occurrences of the selected mass. At the end of the search the number of spectra found containing that mass will be listed and it is possible to step through and view these spectra.

### 5.3.6. User peaks

Having established that the general condition of your vacuum system is satisfactory your attention will probably turn to a limited number of specific components on which your process depends. You now no longer need to spend time measuring every peak in the system but want to concentrate on a limited few. Enter User Peaks.

This mode enables you to individually select any number between one and six specific mass numbers. You can assign to these chosen peaks either a specific gain or set the instrument to autogain when it will follow each peak independently throughout the whole dynamic range of the instrument. This gives tremendous flexibility for process monitoring as you can monitor high and low level components simultaneously. As you are only spending time looking at the specific chosen peaks this gives you a major time saving which you can consider from two angles.



Firstly, you could say that this would enable you to take readings more frequently. This is correct and is the conclusion most people come to. However, the Vacscan offers a variable accuracy code which enables you to control the measurement routine. Basically, the more accurate the answer, the longer the time it will take. What this means is that, instead of using the time gained in User Peaks to acquire more data points, you could acquire the same number of data points but with considerably improved accuracy. (Or, of course, you could choose a happy medium). The display format combines digital readouts with thermometer type displays for each channel for easy reading.

As you can see you have individual control over all parameters for each channel. These include features like individual alarms which can be set to be a high or low alarm.

## WHEN DO YOU USE USER PEAKS?

There are a number of key advantages for this mode which govern when it is best used.

- a) The autoranging ability makes this the mode to use for any kind of process monitoring. Alarms enable the system to be used to regulate key process priorities.

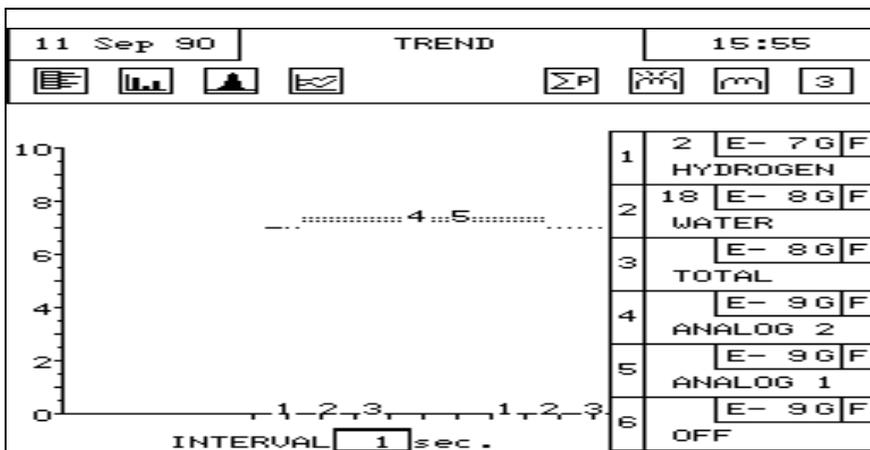
- b) The increased speed with which data can be collected makes this the mode to be used for short-term experimental monitoring applications.
- c) The control you have over the accuracy makes this the mode for detailed experimental work.

### 5.3.7. Trend

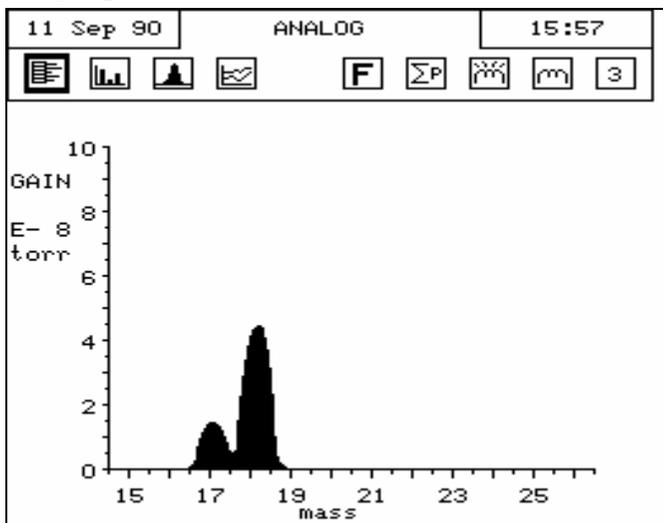


Very often when only a few components are being measured you may not be interested in the intensity value as much as the general trend (i.e. peak height with time) of the component. Trend enables you to follow the Trend of anywhere between one and six components for which, as in User Peaks, you can individually select key parameters, mass, range etc. As you can see below, they are displayed on an intensity versus time graph which scrolls across the screen.

The Trend mode has a special form of continuous print. Instead of the usual screen dump output a condensed character output printout is produced which is similar to that produced by a multi pen chart recorder. This may be of particular use when you need to acquire data over a long period.



### 5.3.8. Analogue peaks



This is not an analytical mode. It is provided more as a means of monitoring the general condition of the quadrupole analyser. The conventional analogue display that is produced by this mode can provide engineers with information to help in assessing the operational condition of the instrument. It does provide an output of a type many of us are more familiar with and reminds us that the Vacscan is a quadrupole at heart.



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## Section 6.

# Analyser maintenance

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### 6.1. General overview

The quadrupole analyser is the front end of your mass-spectrometer, it produces electrical signals which when presented to your electronics enable them to display in a meaningful fashion the content of either your vacuum system or of some other "interesting" gasses introduced via an inlet.

The analyser can be broken down into four separate areas by virtue of their function.

#### 6.1.1. The ion source or ioniser

This is located at the top (furthest from the flange) of your analyser and its function is to take a representative sample of molecules and atoms from your vacuum chamber, convert them into ions and present them to the quadrupole filter. The exact construction will depend upon which source option is fitted.

#### 6.1.2. The quadrupole filter

This is the centre section of your analyser. Its function is to take the ion beam generated in the source and separate the various ions by their mass to charge ratio ( $m/e$ ) and present the single selected  $m/e$  to the collector. Again the exact construction will depend on which type of filter is fitted.

#### 6.1.3. The collector

This area of your quadrupole analyser is "hidden" inside the flanged housing. Its function is simply to convert the filtered ion beam presented by the quadrupole filter into a small electrical current which can be passed to the electronics for amplification and subsequent display to the outside world.

#### **6.1.4. The flanged housing**

This is the only part of your analyser that you will see under normal operating conditions. Comprising of an industry standard 2.75" Conflat® flange with an electrical feedthrough which carries the various supplies and signals to and from the quadrupole analyser.

Figure 3 later in this section shows an exploded view of a typical analyser where you can see all the above-mentioned parts. Remember, though, due to the variety of analyser options your particular model may not be exactly the same as this.

#### **6.1.5. Maintenance of your analyser**

Most, if not all, quadrupole analysers have areas of inherent weakness requiring periodic maintenance. This should be viewed as similar to automobiles, which from time to time require oil changes etc. to protect the performance of the engine. Just like the automobile the frequency with which this work has to be carried out depends upon many factors such as the number of miles driven, the climate, the average length of journey and the speed at which the vehicle is usually driven.

Similarly with quadrupole analysers the type and cleanliness of the vacuum system, the hours of operation and the type and size of sample being analysed play a large part in determining the maintenance frequency. Apart from these considerations there are times when the analyser will require maintenance and these are when "accidents" happen i.e. when someone vents the vacuum system to air when the filament is still switched on or when someone forgets to turn on the water cooling for the oil diffusion pump etc. These occurrences only vary in the magnitude of the disaster that ensues.

Routinely there is only one area of the analyser that requires any maintenance. This is the ion source. The ion source contains two filaments, only one of which will be in use at any one time. The filament is heated to approximately 2000 deg K at which temperature it emits electrons which are used to produce the ions required by the quadrupole filter. At this high temperature there are two deleterious effects.

The filament material slowly evaporates and condenses upon the surrounding surfaces. This effect is extremely slow but would require from

time to time the cleaning of the surrounding source plates and ceramics and the replacement of the filaments.

The second effect is similar to the first except that the vacuum under which the source is operating has either a high oxygen or water content. Then instead of metal being deposited upon the surrounding source plates a layer of metal oxides is deposited. These, being insulators, have a far more noticeable effect upon the performance of the source and therefore a more frequent cleaning program should be undertaken.

## CAUTION

**THE QUADRUPOLE FILTER IS VERY ACCURATELY ALIGNED BY SKILLED PERSONNEL USING SPECIALIST TOOLS AND JIGS. UNDER NO CIRCUMSTANCES SHOULD ANY OF THE SCREWS HOLDING THE RODS IN POSITION BE LOOSENED. IF THEY ARE, WE GUARANTEE THAT THE ANALYSER WILL NOT WORK. THE ONLY REMEDY WOULD BE A FACTORY RE-BUILD. IF YOU ARE IN ANY DOUBT PLEASE CONTACT YOUR LOCAL SERVICE CENTRE BEFORE PROCEEDING ANY FURTHER.**

### 6.2. Failed filaments

The filament status is constantly monitored by the power supply electronics and the operating software. This is done by measuring the flow of electrons emitted by the hot filament, referred to as the emission current, and flowing to the ion source cage. This is maintained at a fixed value of 1mA. The current flow through the filament is increased until the value of emission current is reached. If, however, the control electronics reaches the limit of its filament current supply capability and the emission current has still not reached 1mA a filament fail condition will exist. In the vast majority of cases this will be due to a blown filament, more correctly described as an open circuit filament. There are conditions such as a heavily contaminated

ion source which will result in a filament fail when the filament is not open circuit. So, checking that the filament is open circuit is worth doing before going to the trouble of removing the analyser from your vacuum system.

### **6.3. Ohm meter analyser checks**

There are a number of circumstances when carrying out some simple checks with an ohmmeter can be well worthwhile. If you suspect a failed filament or want to check for shorts following some maintenance, a lot of time can be saved by performing some simple checks.

In carrying out these checks we can legitimately accept two ranges of meter readings as possibly acceptable and anything outside these ranges as being a definite fail. Any readings less than 1 ohm we can take as a short and any reading above 5 Meg Ohm ( $5 \times 10^6$  ohms) as being open circuit. The following assumes that the analyser is still on the vacuum system and goes through all the possible tests.

Tools required:-

Ohmmeter with leads

Please refer to Figure 2 for the analyser pin numbers.

#### **6.3.1. Checking for shorts**

1. Attach the first meter lead to pin 1 of the analyser feedthrough.
2. Connect the second meter lead to the analyser flange, you should have a short circuit. If not you have a serious problem or more likely a faulty meter/meter leads.
3. Connect the second meter lead to each of pins 2 to 12 on the analyser feedthrough in turn.  
Each one should give an open circuit. If not you have a short to earth.

There are basically two types of short to earth; an internal short between one part of the analyser and an earthed part of the analyser, or more commonly a short between part of the analyser and the vacuum chamber. In either case remove the analyser from the vacuum chamber

and repeat the test. If the result is the same then you have an internal short and should contact your local Spectra facility and tell them which pins are shorting together. Otherwise you have a short to the vacuum chamber, check the dimensions of the vacuum chamber around the quadrupole analyser or try refitting the analyser in a slightly different orientation.

Repeat the ohmmeter test before pumping down the vacuum chamber. Remember that the ion source gets very hot during operation and the stainless steel components will expand slightly. Sometimes a short will only develop when the analyser has been run for a while and is up to temperature.

4. Attach the first meter lead to pin 2 of the analyser feedthrough. Connect the second meter lead to each of pins 3 to 12 on the analyser feedthrough in turn. Each one should give an open circuit. Now attach the first meter lead to pin 3 and check to pins 4 to 12. Proceed around the feedthrough until all possible connections have been checked.

All pins should show open circuit to all other pins EXCEPT pin 4 to pin 8, pin 4 to pin 10 and pin 8 to pin 10 which should show short, see the next section. If any of the pins do show short to an other pin contact your local service centre with the results of your testing and they will advise you how to proceed.

### **6.3.2. Checking filaments**

If you suspect a blown filament, for instance the control unit shows filament fail, carry out the following test before removing the analyser from the vacuum system.

Connect meter lead one to analyser feedthrough pin 8 which is the common connection to both the filaments.

Connect the second meter lead to pin 4 (Filament 1). You should have a short circuit, the resistance of the filament is about 0.5 ohms when it is cold. Now connect the second meter lead to pin 10 (Filament 2) again your meter should indicate a short circuit.

Note: measuring between pins 4 and 10 will also show short if both filaments are good as you are now measuring the two filaments in series.

If either or both filaments are blown the meter will indicate an open circuit and the filaments should be replaced.

If the meter reading suggests that the filament is good but the control unit shows a filament fail the most likely cause would be a break down in electrical continuity. Examine the RF/analyser connector on the front of the RF power supply, check that none of the gold sockets are pushed out of place.

## **6.4. Changing filaments**

Analysers are fitted with dual, independently replaceable, self-aligning filaments. Each filament consists of a semi-circular plate into which is fitted two small insulated feedthroughs. The filament wire is attached between these feedthroughs on the underside of the filament plate. The filaments are identical eliminating the need to maintain any particular orientation. The assembly consisting of filament plate, two feedthroughs and the filament wire form what we refer to as the “filament”. Changing filaments is probably the most common maintenance procedure that has to be undertaken with quadrupole analysers but the analyser has been designed to make the task as quick and easy as possible.

The basic procedure for changing filaments is the same for all types of ion source. The procedure describe below relates to a standard radial ion source. The procedure for the enclosed ion source is outlined later in this section.

### **6.4.1. Tools required**

Here is a list of the tools and equipment you will require. We recommend that you assemble the following items before you start. Remember that the instrument was supplied with a tool kit which contained some of the things you will need.

- A small jewellers screwdriver (2mm)
- A pair of tweezers
- A small pair of smooth jawed needle nosed pliers
- A pair of clean cotton gloves
- A clean bench on which to work
- An Ohmmeter
- A clean container in which to put small parts

Replacement filament(s)

The RF Head or some other method of holding the analyser in an upright position.

A pen and paper on which to make notes and sketches

#### **6.4.2. Removal of the filaments, general**

1. Place the RF head onto the clean bench with the cable coiled and placed out of the way.
2. Remove the analyser from the vacuum system making sure that you do not touch the exposed internal surfaces and place in the upturned RF head. Make sure that everything is stable and not likely to fall over. The filaments are located on the very top of the analyser and are retained by two M2x6 pan head screws. The electrical connections are made via two barrel connectors, one to each filament.
3. Hold one of the barrel connectors firmly with your pliers slacken the outermost screw undoing it 4 or 5 turns.
4. Now hold the threaded part of this screw lightly with your tweezers just behind the head of the screw. Undo the screw fully and lift it away (with the washer if fitted) and place it into your container.
5. Loosen but do not remove the screw at the other end of the barrel connector. Remove the barrel connector and place it in your container.
6. Repeat the above for the other filament.
7. Loosen the two M2x6 pan head screws that hold the filaments in place so that 3-4mm of thread is showing and remove the filaments.

It is worthwhile at this stage checking to see if the source requires any attention especially if the filament(s) have broken because of an over pressure situation in your vacuum system. With the filaments removed you have a clear view of the source cage where the signs to look for are powdery deposits of tungsten oxides. These will vary in colour but may be brown, blue, canary yellow or white depending upon the precise circumstances which led to their formation. If these oxides are present it is recommended

that you refer to the section on source removal and cleaning before proceeding any further.

### **6.4.3. Filament plate design**

Due to new ion source designs and a desire to keep the filaments interchangeable between the different ion source types the design of the filament plate was changed at the beginning of 1995. The modification increased the diameter of the central hole formed when the two filament plates are placed together on the repeller assembly of the ion source.

With the older type of filament plate this central hole is approximately 3.5mm (1/8inch) in diameter. On the newer type the central hole is approximately 6mm (1/4inch) in diameter.

These newer filaments may be used as direct replacements for all types of ion source. However, for the UHV/radial open ion source and the cross beam ion source an additional filament screening plate needs to be fitted. This is supplied with the replacement filaments. If you are removing older type filaments and replacing them with the newer type you will have to fit the filament screening plate. To do this:

1. remove the two M2x6 pan head screws that hold the filaments in place
2. position the screening plate centrally on the ion source with the two fixing tabs over the holes which take the M2x6 screws which hold the filaments in position
3. refit the two M2x6 pan head screws that hold the filaments in place leaving 3 to 4mm of thread exposed.

Fitting the filament screening plate in this way means that in future the filaments can be removed and the screening plate will remain in position.

### **6.4.4. Fitting of new filaments, general**

The fitting of new filaments is simply the reversal of the procedure for removing them. Care should be exercised at all stages to ensure that no

shorts are introduced and that the analyser is kept clean.

1. Place the filaments into the top of the source ensuring that the filament wire does not touch any part of the source and thus potentially causing damage.
2. With a gloved hand gently hold the two filament plates together and tighten the two M2x6 pan head screws that retain the filaments.
3. Place the barrel connector over the filament leg adjacent to the wire connection but do not tighten the screw at this stage.
4. Replace the small screw (and washer if needed) through the wire connection and screw into the barrel connector to locate the barrel connector in the right orientation.
5. Holding the barrel connector firmly with your pliers tighten both screws.
6. Repeat the above for the second filament.
7. Check with your ohmmeter for shorts.
8. Replace the analyser into your vacuum housing and again check for shorts or grounding to the outer vacuum housing see section **6.3. Ohm meter analyser** checks.

You are now ready to pump down and continue operation of your quadrupole.

## **6.5. In-situ source cleaning**

Sometimes it is possible to clean the ion source without removing it from the analyser. For the user who has the necessary equipment available it is usually worth trying this method before removing/replacing the ion source. However, it is only likely to be successful where the source is contaminated with loose or alcohol soluble deposits.

### **6.5.1. Tools required**

A small jewellers screwdriver (2mm)

- A pair of tweezers
- A small pair of smooth jawed needle nosed pliers
- A pair of clean cotton gloves
- A clean bench on which to work
- An Ohmmeter
- A clean container in which to put small parts
- Replacement filament(s)
- Ultra-sonic bath
- Measuring cylinder (see text below)
- Iso-propyl-alcohol
- Heat gun
- The RF Head or some other method of holding the analyser in an upright position.
- A pen and paper on which to make notes and sketches

### **6.5.2. Cleaning the source**

Remove the analyser from the vacuum chamber, place it into the RF head and remove the filaments as described in section **6.4.2. Removal of the filaments.**

Insert the analyser into the measuring cylinder so that the knife edge side of the flange rests on the lip of the cylinder. Note the level which the ion source comes to on the measuring cylinder before removing the analyser and filling the measuring cylinder with sufficient Iso-propyl-alcohol to cover the ion source.

Put the measuring cylinder into the ultra-sonic bath for 10 to 15 minutes.

Remove the analyser and allow any excess alcohol to drain off. Keep the analyser inverted (feedthrough upper most) until it is dry. Do not let any alcohol run down the analyser into the flange assembly, it will get onto the multiplier and seriously damage it. Check the condition of the ion source. A second or third wash may be required.

Note: the ultra sonic bath may loosen some of the screws in the ion source take care note to throw these away when discarding the alcohol.

After the final wash remove the analyser and dry it using the heat gun.

Fit into the RF head on the bench and check all the screws in the ion source are tight, re-fit any which may have come out.

Re-fit the filaments then re-fit the analyser in the vacuum chamber.

## **6.6. Cleaning or replacing the ion source**

Generally the analyser design permits the removal of the ion source as one complete assembly which can be replaced or dismantled for cleaning. The ion source automatically aligns on the main analyser assembly allowing it to be easily replaced without the need for any special jigs.

### **6.6.1. Tools required**

Once again you are advised to get the necessary tools together before you start this job. It really does make life simpler.

A small jewellers screwdriver (2mm)

A pair of tweezers

A small pair of smooth jawed needle nosed pliers

A 0.89mm (0.035") Allen key

A pair of clean cotton gloves

A clean bench on which to work

A source alignment jig

4 pieces of straight clean wire (NOT tinned or insulated)

1mm (0.04") dia. 25mm (1") long

An Ohmmeter

A clean container in which to put small parts

Replacement filament(s)

Replacement source parts if necessary

A set of replacement ceramics is highly desirable if none are cracked and essential if any are broken

The RF Head or some other method of holding the analyser in an upright position.

A pen and paper on which to make notes and sketches

### **6.6.2. Removing the ion source**

1. Remove the analyser from the vacuum system, place it into the RF head and remove the filaments as described above.
2. Locate and remove the three very small socket set (Allen) screws that clamp the focus/extraction, source and repeller supply leads to their respective plates.
3. Locate and remove the two very small socket set screws that are positioned at the base of the source assembly.

The source is now free from the rest of the assembly and can be removed and placed onto the bench. Before proceeding any further you should make a sketch that defines the positions of the barrel connectors for the source and focus/extraction plates and the position of the repeller and source mounting plate relative to these so that when you come to reassemble the source you will have a clear idea of how the various plates fit together.

### **6.6.3. Standard radial source dismantle**

The following section applies to the dismantling of the Standard Radial ion source with a mesh repeller. As each of the plates is removed note its orientation and place it on the bench in the same orientation, it makes life much easier when you come to re-assemble the source.

1. Place the source assembly onto the source alignment jig making sure that the three cut-outs are aligned and taking care not to damage any of the source plates on the spigot in the centre of the jig.
2. Remove the four M1.6x10 screws, the M1.6 stainless steel washers and the 1mm thick ceramic washers that are equi-spaced around the repeller plate (topmost plate).
3. Remove the repeller plate which includes the repeller cage.
4. Remove the four exposed 1mm thick ceramic washers and lift away the source plate which includes the source cage.
5. Remove the 1mm thick ceramic washers then remove the focus/extraction plate.

6. Remove the four remaining ceramic washers and remove the 2mm diameter insulator tubes to leave just the source collar on the jig.

You now have a completely disassembled source ready for cleaning.

#### **6.6.4. Standard source re-assemble**

1. Place the source alignment jig flat on the bench and put the source collar on top making sure all the cut-outs are aligned properly. Insert into the four tapped holes the 25mm long pieces of wire, these will help to line up the ceramics as you build up the source.
2. Place the four 2mm diameter ceramic tubes over the wires followed by four 1 mm thick ceramic spacers, one to each wire.
3. Place the focus/extraction plate over the ceramic tubes making sure the barrel connector is in the right place.
4. Place four 1mm thick ceramic spacers over the top of the focus/extraction plate.
5. Place the source plate over the ceramic tubes, again making sure the barrel connector is in the right place, followed by four more ceramic spacers.
6. Fit the repeller plate and four 1mm thick ceramic washers.
7. Carefully remove one of the wires and replace with a M1.6x10 pan head screw and the M1.6 stainless steel washer which should be screwed down but not tightened, repeat this for the remaining three wires.
8. Check that all the plates and ceramics are seated properly before tightening the screws fully. Be careful not to over-tighten because you will break the ceramic spacers.
9. Remove the source assembly from the jig and place on a non-conducting surface. Check with your Ohmmeter that there are no shorts between any of the plates. If you do have any shorts correct them before continuing any further.

You are now ready to fit the filaments and fit the ion source on to the analyser.

#### **6.6.5. Solid repeller source dismantle**

The following section only applies to the dismantling of the Standard Radial ion source with a solid repeller which was used on older types of analyser.

1. Place the source assembly onto the source alignment jig making sure that the three cut-outs are aligned and taking care not to damage any of the source plates on the spigot in the centre of the jig. Undo the four screws that are recessed into the top of the repeller.
2. Remove the repeller block complete with the repeller base plate, four screws, washers and ceramic washers.
3. Remove the four exposed ceramic washers and the source plate.
4. Remove the four exposed ceramic tubes and washers and the focus/extraction plate.
5. Remove the four remaining ceramic washers and take the source mounting plate off of the jig.
6. Finally remove the two barrel connectors from the source and focus/extraction plates.

You now have a completely disassembled source ready for cleaning.

#### **6.6.6. Solid repeller source re-assemble**

1. Place the source alignment jig flat on the bench and put the source mounting plate on top making sure all the cut-outs are aligned properly. Insert into the four tapped holes the 25mm long pieces of wire, these will help to line up the ceramics as you build up the source.
2. Place the four 9mm ceramic tubes over the wires followed by four

ceramic spacers, one to each wire.

3. Attach a barrel connector to the focus/extraction plate and the source plate so that the tapped hole in the side is furthest away from the plate and facing outward.
4. Place the focus/extraction plate over the ceramic tubes making sure the barrel connector is in the right place.
5. Place four ceramic spacers over the top of the focus/extraction plate.
6. Place the source plate over the ceramic tubes, again making sure the barrel connector is in the right place, followed by four more ceramic spacers and the repeller base plate.
7. Insert a ceramic spacer followed by a washer into each of the counterbores in the repeller block.
8. Carefully remove one of the wires and replace with a M1.6x12 pan head screw which should be screwed down but not tightened, repeat this for the other three wires.
9. Check that all the plates and ceramics are seated properly before tightening the screws fully. Be careful not to over-tighten because you will break the ceramic spacers.

You are now ready to fit the filaments and the source on to the analyser.

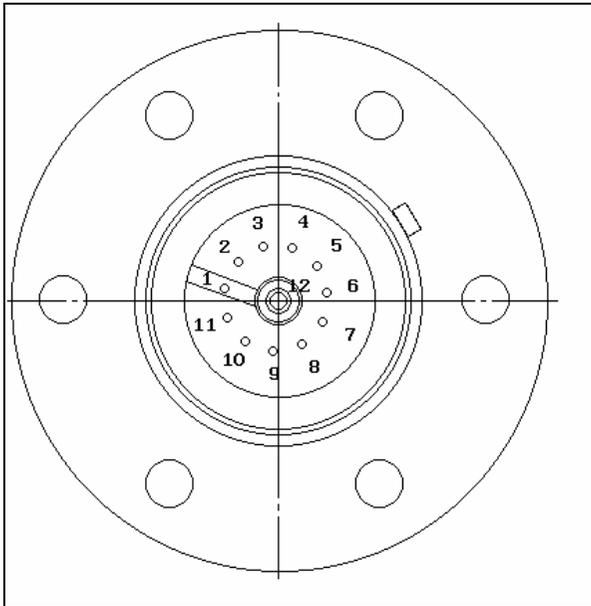


Figure 2 Analyser pin configuration

<b>Figure 2 Pin Descriptions</b>	
Pin	Connection
1	Earth
2	Source plate
3	Electron Multiplier
4	Filament 1
5	Extraction plate
6	Suppressor plate
7	R.F.1
8	Repeller plate / filament common
9	no connection
10	Filament 2
11	R.F.2
12	Collector

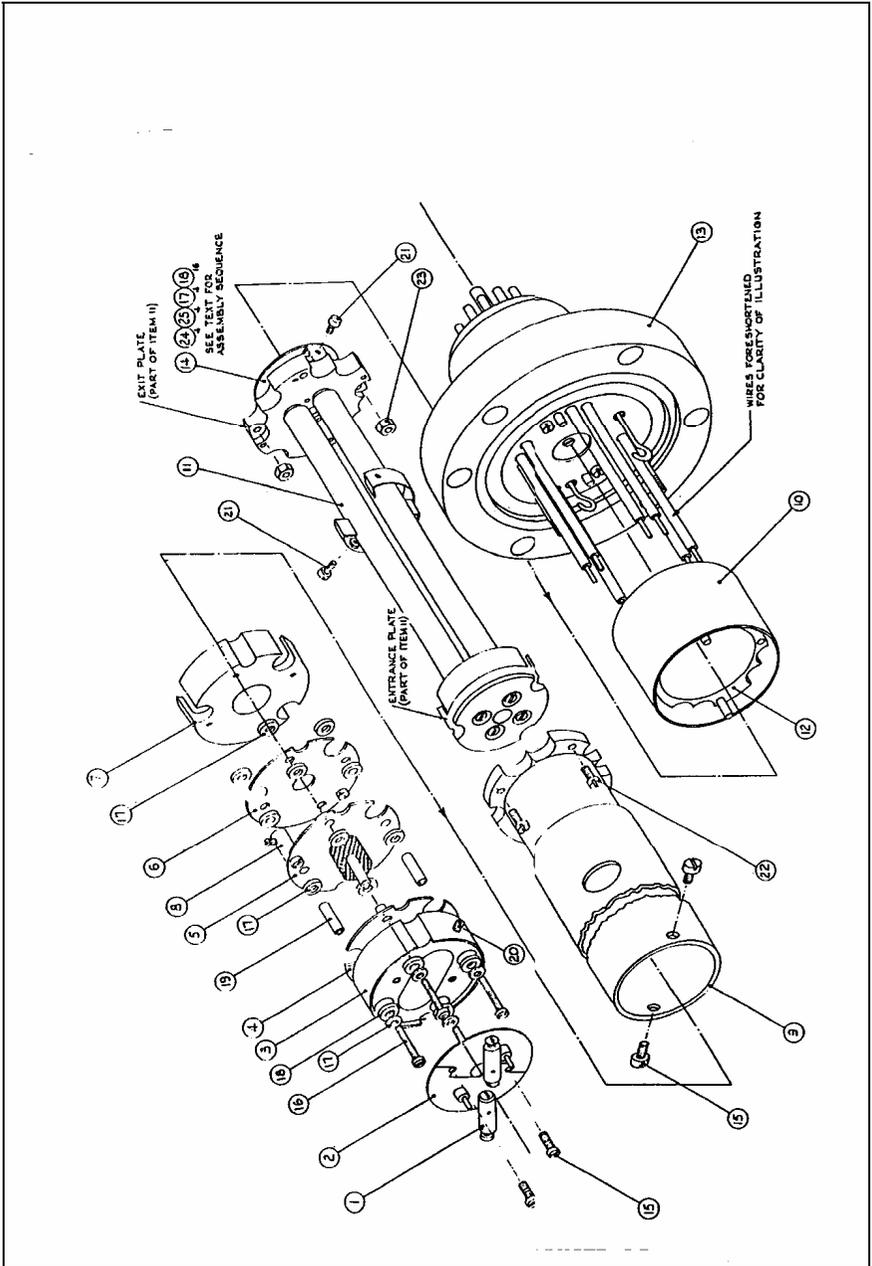


Figure 3 Exploded analyser assembly

<b>Figure 3 Item Descriptions</b>	
<b>Item</b>	<b>Description</b>
1	Barrel connector (Filament)
2	Filament plate
3	Source repeller block
4	Repeller plate
5	Source plate inc. source cage
6	Focus/extraction plate
7	Exit plate
8	Barrel connector
9	Support tube
10	Suppressor screen
11	Quadrupole filter assembly
12	Collector housing
13	Conflat® flange assembly
14	Multiplier assy.
15	Screw (M2x4)
16	Source screw (M1.6x12)
17	Washer (M1.6 flat)
18	Ceramic washer (source)
19	Ceramic tube (source)
20	Grub screw (M2)
21	Screw (M1.6x4)
22	Screw (M1.6x10)
23	Nut (M1.6)

## 6.7. Standard ion source drawings

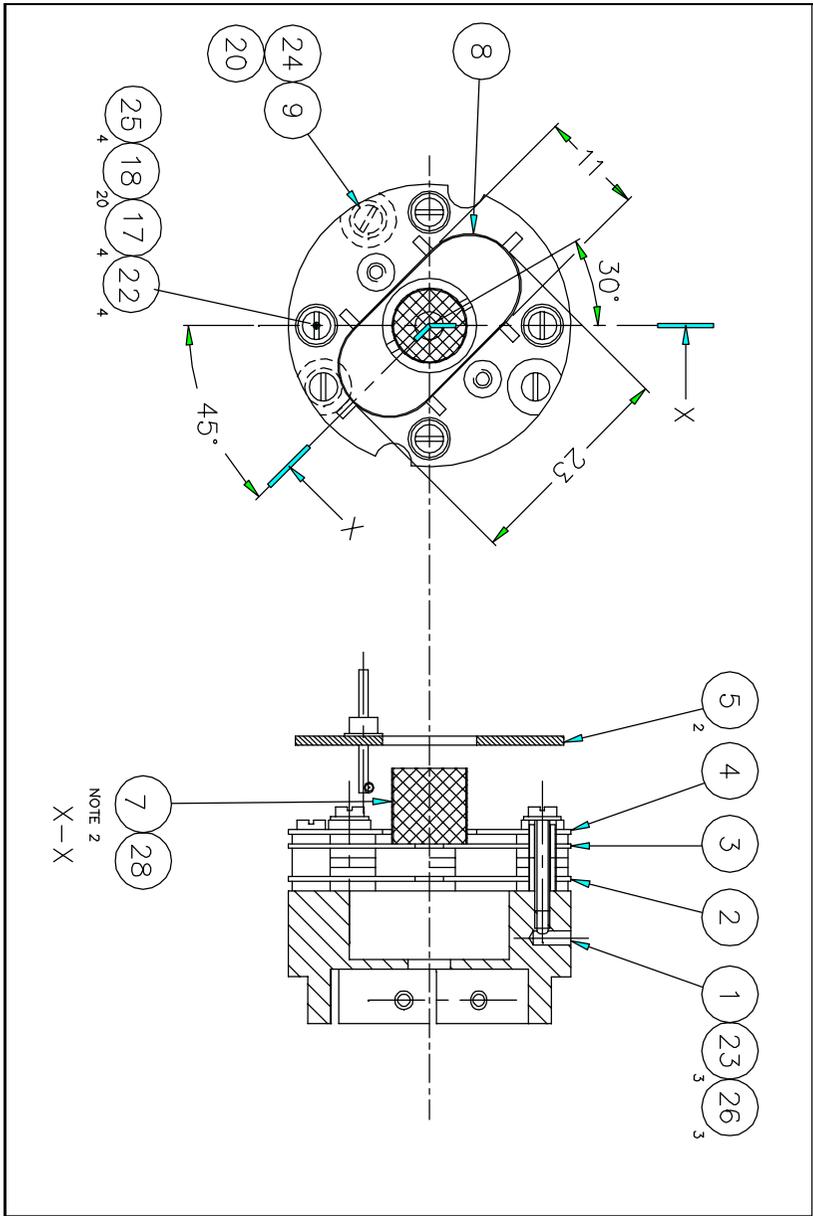


Figure 4 Standard open ion source (1)

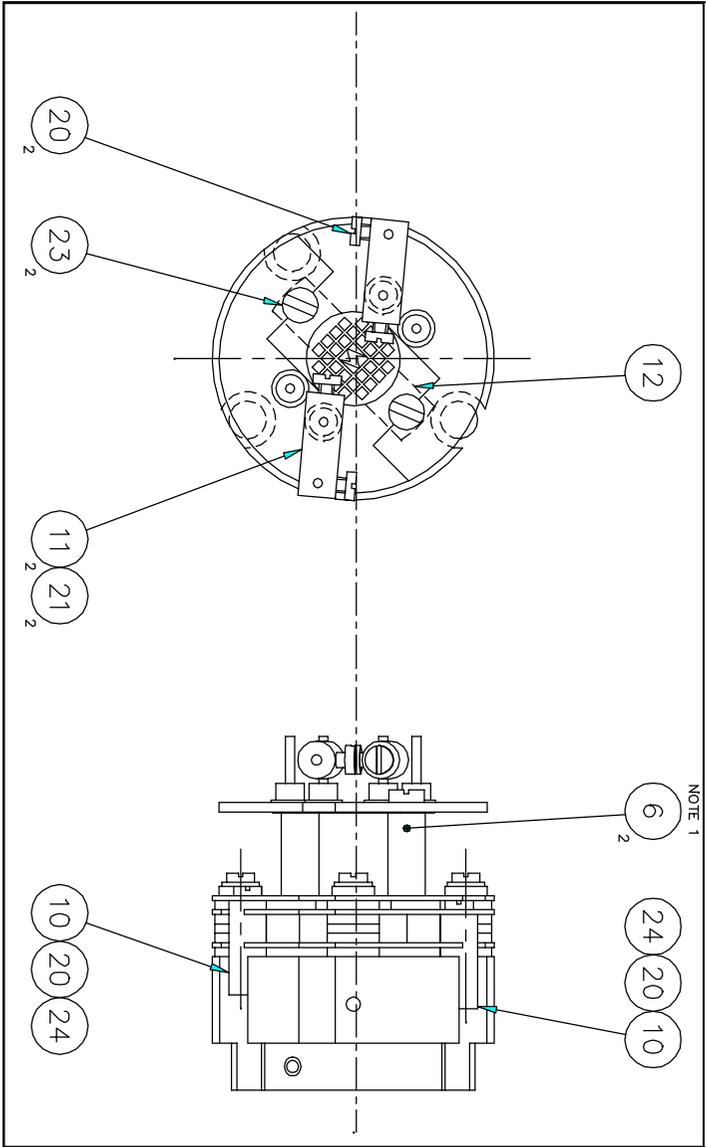


Figure 5 Standard open ion source (2)

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<b>Standard Ion Source Item Descriptions</b>	
<b>Item</b>	<b>Description</b>
1	Source Mounting Ring
2	Focus/Extraction Plate
3	Source Plate
4	Repeller Plate
5	Filament
6	Filament Support Spacer
7	Source Cage Support
8	Repeller Grid
9	Connector
10	Connector
11	Filament Connector
12	Filament Screen
17	Ceramic Spacer 1mm Pink
18	Ceramic Spacer 1mm White
19	Ceramic Tube 2.8mm Diameter
20	Screw M1.6 x 3
21	Screw M1.6 x 4
22	Screw M1.6 x 10
23	Screw M2 x 4
24	Screw M2 x 3 Socket Head
25	Washer M1.6 Plain
28	Stainless Steel Mesh

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## Section 7.

# Circuit descriptions

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This section details the operation of the various electronic circuits of the Vacscan and Vacscan Plus. The page size of this manual prevents schematics being included but full size circuit diagrams are available on request, please contact your local Spectra facility. Individual pin-outs for the multi-way connectors can be found in Appendix 1.

## **WARNING**

**Dangerous voltages exist inside this unit.  
The following circuit descriptions are for information only and do  
not imply any user serviceability.**

### **7.1. General system overview**

Both types of control unit are based on a single, large printed circuit board.

The power supplies for the mass spectrometer, the analogue electronics and the logic are all derived from a power supply sub-section, fed from a 50Hz mains transformer. A high voltage power supply board for the SEM is plugged into the motherboard on instruments fitted with a dual detector.

The microprocessor sub-system, complete with memory, I/O, and video display generator take up the largest single area of the motherboard. The remaining board area is occupied by the analogue electronics.

The display monitor electronics is carried on a separate printed circuit board that is mounted, with the mains transformer, on a metal chassis that is suspended above the motherboard. The Vacscan Plus is fitted with a second chassis, suspended behind the mains transformer chassis, which carries the memory expansion board. Some Vacscan instruments are also fitted with the memory expansion board.

The front panel carries the mains power switch and power indicator, the keyboard PCB, and the display tube.

With the exception of the mains power inlet, which is carried on a small metal sub-panel, all input/output connectors are arranged along the rear edge of the motherboard and appear through openings in the rear panel.

## **7.2. Mains distribution system**

The mains input connector is located on the rear panel of the instrument. The inlet unit also contains the main fuses, a voltage selector drum, and a mains input filter. Both fuse ratings and voltage setting MUST be correct for the local supply.

Power from the mains input passes firstly through the input filter and main fuses and thence, via pins G and H on the mains inlet unit to the front panel mounted power switch. Switched power from the power switch passes to the mains transformer via the voltage selector section of the mains input connector.

The mains transformer requires tap changing for each of the four voltage ranges of the instrument; this is achieved by the connection of its primary windings to the voltage selector part of the mains inlet unit (pins A,B,C,D,E,F).

## **7.3. Power supplies**

Schematic LM62-010-D Sheet 3

The main function of the power supplies section is to provide the main DC supplies for the logic, analogue electronics and the mass spectrometer. This section receives 50Hz AC power from the secondary windings of the mains transformer and produces several stabilised rails for the rest of the main board and the remote RF head. There is also provision to plug in a high voltage SEM supply.

The external trip and filament supply circuits are also located in this section.

### **7.3.1. +/-15 volts supply**

Power from the 16.2-0-16.2V secondary passes through FS1 and FS2 to bridge rectifier BR1, connected as two bi-phase rectifiers. C24 and C17 provide smoothing to give +/- 24V unstabilised rails. VDR1 and VDR2 protect BR1 against voltage surges.

The +15volts stabilised rail is provided by REG1, a self-contained regulator IC. This IC features a built in reference, current limiting, and thermal protection. C13 provides output filtering to reduce output noise and improve transient response. R3 and R2 sample the output voltage for diagnostics purposes.

+15volts is distributed throughout the main board and fed to the SEM board via SK13, and the RF head through SK12.

The -15volts supply is similar in operation, consisting of regulator REG2, and capacitor C23. The diagnostics path is via R8, the other resistor in this chain being on sheet 2 of the schematic.

### **7.3.2. +70 volts supply**

Power from the 62-0-62v secondary passes through FS3 and FS4 to bridge rectifier BR2, whose positive output, in conjunction with the centre tap of the transformer winding forms a full wave bi-phase rectifier. VDR3 and VDR4 protect BR2 against voltage surges. The DC output is smoothed by C80 and C81 to give an unstabilised output of +87volts DC.

The stabiliser circuit consists of TR10, TR12, and TR13. The output of the supply is sampled by R88, R92, and R93 and fed to the base of TR13. TR10 and TR13 are connected as a long tailed pair; a +5volts reference being fed to the base of TR10. This reference is compared to the sampled output voltage at the base-emitter junction of TR13 and the error signal is amplified by TR13 and applied through R87 to the base of series pass transistor TR12 to provide the stabilising action. Base drive for TR12 is provided by R96 and R95, with C78 providing additional smoothing.

Current limiting is provided by TR11, R89, R90, and R94. With no load current flowing, current flow through R90 and R94 establishes a bias of -

0.69volts on TR11. Load current flowing through R89 produces a positive bias to counteract the negative bias, until, with approximately 80mA of load current flowing, TR11 begins to conduct, diverting base drive away from TR12.

Eventually, the output voltage begins to fall and this reduces the current flowing in R94 due to the output voltage; the effect of which is to reduce the current limit. A cumulative action follows which results in the output voltage reducing to zero, at a current limit of approximately 43mA. This foldback action is designed to limit the dissipation of TR12 to a safe level under all conditions.

### **7.3.3. -65 volts supply**

The -65 volts supply provides the electron energy voltage for the mass spectrometer source during normal operation.

The negative output of BR2, in conjunction with smoothing capacitors C116 and C118, provides an un stabilised supply of -87v DC. D43, R145 and R143 produce a forward bias of 2.7 volts on the base of TR17; C117 providing additional smoothing. This produces a constant voltage of 2.1 volts on the emitter of TR17 with respect to the anode of D43, leading to a constant emitter current of 9.5mA; determined by R147. The collector current of TR17 is thus made constant (neglecting the base drive).

This constant current is shared by D36, which establishes a voltage of -65 volts with respect to 0v, and by the external load. The constant current characteristic gives short circuit protection.

### **7.3.4. -130 volts supply**

Power is taken from one half of the 62-0-62v transformer secondary, through FS4 to a half wave voltage doubler consisting of D29, D30, C100, and C102, to produce -175 volts DC.

D31, R119, and R118 establish a forward bias of 2.7 volts on the base of TR15; additional smoothing being provided by C101. This produces a constant voltage of 2.1 volts on the emitter of TR15 with respect to the anode of D31, leading to a constant emitter current of 5.4mA; determined by

R121. The collector current of TR15 is thus made constant (neglecting the base drive).

This constant current is shared by D27 and D28, which establishes a voltage of -130 volts with respect to 0v, and by the external load. The constant current characteristic gives short circuit protection.

### **7.3.5. Degas supply**

The degas supply provides a high voltage electron energy supply for outgassing the mass spectrometer source.

Power from the 106v transformer secondary is fed through TH1 to a full wave voltage doubler circuit, comprising D25, D26, C82, and C83 to give an unregulated supply of -300 volts DC. TH1 is a positive temperature coefficient thermistor whose purpose is to provide short circuit protection for the transformer secondary.

The output passes through current limiting resistor R114, to the degas relay, RL1.

### **7.3.6. +5/+12 volts supply**

This is a switch mode supply that produces power for the logic and the display monitor. The circuitry comprises controller IC35, mosfet TR5, and flyback transformer T1.

At the beginning of the switching cycle the output at pin 6 of IC35 turns on TR5. Current builds up in the primary of T1, storing energy in the magnetic field. The current flow through T1 and TR5 is monitored as a volt-drop across R44 to R48.

When this current reaches a pre-determined level, TR5 is turned off. At this point the current flow switches to the secondaries of T1, delivering energy to the +12 and +5 volts supplies through D21 and D14, respectively. The energy pulses delivered are converted to steady DC voltages by C76 and C73, with additional smoothing provided by L2, L3, C72, and C74.

The output voltage of the +5 volts supply is sampled by R51, R43, and R38

and passed to the voltage sensing input of IC35, pin2. The duty cycle of the power switch is continuously adjusted to stabilise the +5 volts supply. The output voltage of the +12 volts supply is not directly regulated but depends on close cross-coupling to the +5 volts supply. This is provided by special features in the design of T1. D12, C52, and R52 are connected as a voltage clamp to limit the maximum voltage on TR5 at turn-off due to the leakage inductance of T1, and core flux reset is provided by D13 in conjunction with a tertiary winding on T1.

### **7.3.7. Filament power supply**

The filament power supply measures the emission current in the mass spectrometer source, and regulates the filament current to produce the correct emission.

Emission current flows from the +15 volts rail, through R15 to the source electrode via SK12 pin 6. The voltage at the junction of R15 and D1 is compared with the +5 volts reference by IC24. The amplified error signal appearing at the output of IC24 regulates the filament current so that the source current flowing through R15 produces a voltage of +5 volts at IC24 pin 2; this corresponds to a voltage of +5.5 volts at the junction of R14 and D1. Under these conditions the source current is 1mA.

Filament power is derived from a switch mode power supply.

IC28 is a switch mode controller IC. It is synchronised by a pulse amplifier, TR4 and TR3, to the +5/+12 volts supply.

The output, at IC28 pin6, turns on mosfet TR6. The voltage induced in the primary of transformer T2 is coupled to the secondary and forward biases the series diode in D23. Current builds up in inductors L4 and L5, and this is reflected back to the primary of T2 appearing as a current in TR6, R49, and R50. The primary current is related to the current in L4 and L5 by the transformer turns ratio. The current flowing in T2 and TR6 is monitored as a volt-drop across R49 and R50 by IC28 pin 3. When the current reaches a level determined by the error signal at IC28 pin 2, the output goes low turning off TR6. R65, D6, and C60 reduce the amplitude of the voltage spike produced by the leakage inductance of T2 when TR6 turns off and D7, in conjunction with a tertiary winding on T2, resets the core flux to zero ready for the next switching cycle.

The AC component of the current pulses from the secondary of T2 is routed through C128; the DC component flows through the mass spectrometer filament. The combined inductance of L4 and L5 maintains filament current flow through the shunt diode of D23 during the period when TR6 is turned off.

The filament circuit is also connected, through RL1 to either the -65 volts supply or to the degas supply.

During degas, the voltage at the anode of diode D24 rises to +15 volts which effectively puts R113 in parallel with R15. This increases the source current to 9mA.

The status of the filament circuit is monitored by IC29, connected as a window comparator. The two reference inputs of IC29 are set to +4.4 and +2.3 volts respectively, by R63, R64, and R66. So long as the input through R60 from IC28 is within these limits, the outputs of IC29 remain high. If the input exceeds these limits, one of the outputs of IC29 goes low signalling the EMISSION OK line false. This signal is passed to the logic section.

### **7.3.8. External trip**

The purpose of the external trip is to allow the mass spectrometer to be protected by an external vacuum gauge.

An additional secondary winding on T1 is connected to D22 and C89, configured as a half wave rectifier. The resulting DC voltage is smoothed by C89 and regulated to 4.7 volts by D44. This 4.7 volts supply is isolated from earth and all other supplies.

This supply feeds opto-isolator IC55 via R167 and SK14. SK14 has a set of normally closed contacts so that IC45 is energised in the absence of a jack plug in SK14. Under these conditions, current flows through the diode in IC55 and turns on the photo-transistor, producing a logic "0" at the lower end of R164. The logic levels at the lower end of R164 are referenced to digital 0V. The normally closed contacts in SK14 allow normal operation without the need for a link plug.

If vacuum protection is required, a jack plug wired to a set of normally

closed contacts, on a vacuum gauge, should be provided. The trip contacts on the vacuum gauge should be closed during normal operation, but should open on vacuum failure and when the unit is turned off.

The maximum allowable voltage across the jack plug contacts is 60V DC and the maximum allowable current is 2mA.

When a jack plug is inserted, the internal contacts are opened and the energisation of IC55 is governed by the external circuit. If the external circuit is broken, the photo-transistor in IC55 turns off and a logical "1" appears at R164. This signal passes to the logic section through IC45 pins 1 & 2 and is used to interrupt the processor, which turns off the filament and the SEM and puts a warning message on the screen.

### **7.3.9. Logic interface**

An interface is required between the mass spectrometer control signals generated by the logic and the various control relays and other devices on the mass spectrometer, since the logic generates only logic levels and the mass spectrometer requires that relays and other devices be controlled. IC47 and associated components perform this task.

The TOT RF signal from the logic is inverted by the top section of IC47 and produces an inverted logic signal for the RF head. There is a pull-up resistor to +15 volts in the RF head.

The FIL 1/2 signal is inverted by the second section of IC47 and drives the filament changeover relay in the RF head. The relay is energised from the +15 volts rail.

The DEGAS signal controls the degas relay, RL1 via the third section of IC47. The relay has two sets of contacts; one set selects either -65volts for normal source operation, or -300 volts in degas mode. The second set of contacts selects either -130 volts or +15 volts for the ion optics. The positive voltage is used to prevent contamination of the analyser during degas. In addition, +15 volts is supplied to R113 during degas; this increases the emission to 9mA.

The fourth section of IC47 inverts the SEM signal. The output logic level at IC47 pin15 is determined by pull-up resistor R141 and drives circuitry in the

RF head to alter the ion optics when in SEM mode.

The PAG control signal is inverted by the fifth section of IC47 and controls a feedback resistor selection relay in the pre-amplifier, via level changing transistor TR18. When TR18 is turned on, the relay, which is fed from the -15 volts rail is energised.

The B.O. (beam off) signal is used to remove the ion beam when the signal amplifier zero offset is being measured. The signal is inverted by the sixth section of IC47 and converted to a 15 volts logic level by pull-up resistor R142.

## **7.4. SEM power supply**

Schematic LM1-46-B

The SEM power supply is a small printed circuit board that is plugged into the main PCB.

Transistor TR1 and high frequency transformer T1 are connected as a self oscillating inverter. The voltage developed across the primary winding between pins 2 and 12 of T1 is stepped up by the secondary winding between pins 3 and 7.

The high voltage AC output is rectified by D1 and D2, connected as a half wave voltage doubler, and smoothed by C1, C2, R2, and R3 to produce high voltage DC for the electron multiplier detector.

The output control program, in the range 0 to -9.94 volts is produced by a digital to analogue converter located on the main board, and passes via SK13 pins 1 and 2 to the first half of IC1, R17, and R19 which invert the control program to cover the range 0 to +9.94 volts.

The program input is mixed with an additional, fixed, input from the +4.98 volts supply via R6 and RM3. RM3 is located on the main PCB, adjacent to the analogue to digital converter, IC39. The output voltage is sampled by R1 and is fed back to be mixed with the fixed and variable program inputs at pin 6 of IC1.

The resulting error voltage is amplified by the second half of IC1 whose output controls the conduction current of the inverter transistor, TR1, through control

transistor, TR2; thus controlling the output voltage of the inverter in the range -450 to -1200 volts DC.

R11, C5, and C6 provide compensation of the control loop.

The supply is switched on and off by the operating software, through a logic signal FAR/SEM applied from the logic via SK13 pin 4. When this logic level is high (+5v), a positive voltage appears at IC1 pin 5 which forces the output, at pin 7 to go positive irrespective of any input program voltage, turning off TR2 and causing the output voltage to drop to zero. When this logic level goes low, normal operation is restored.

#### **7.4.1. Display monitor**

The Vacscan display monitor is a proprietary 6 inch green screen monitor. The screen size for Vacscan Plus is 7 1/2 inch.

Power is supplied at +12 volts from the power supply section via PL4 pins 5 and 6.

The line and frame synchronising signals originate in the main board and travel to the monitor via PL4 pins 1 and 2.

The video signal is TTL, generated by circuitry on the main board. For further details see section **7.5.4. Video interface**.

### **7.5. Logic section**

Schematic LM62-010-D sheet 1

The logic section contains a large proportion of the dedicated mass spectrometer digital hardware, and all of the operating software.

#### **7.5.1. Microprocessor**

The processor used is a 65SC02A, a 2MHz CMOS version of the 6502. The processor performs the control and data acquisition tasks on instructions from the operating software; resident in IC7 and IC10, the processor roms.

The master clock is derived from a 7.3728 MHz crystal, divided by two and by four in IC32, to give 3.6864 MHz for the RS232 controller IC34, and 1.8432 MHz for the CPU IC3, and the video controller IC27. The use of one master clock for all subsystems ensures complete synchronisation.

The power up reset for the CPU and peripheral chips is provided by IC49, a device designed for this purpose. On power up, a current source in IC49 charges up C108, giving a delay of several hundred milliseconds before the reset signal goes high; the active level being low. The device continuously monitors the +5 volts rail and will generate a reset signal if the rail goes outside a +/- 5% tolerance band. This ensures that the +5 volts supply is well established before operation is allowed.

### **7.5.2. Address decoding**

The 64K total address space of the processor is partitioned in the following way:

- 0000 to 1FFF Battery backed RAM IC1
- 2000 to 3FFF Video RAM IC13
- 4000 to 7FFF Program ROM IC10 (Vacscan)
- 4000 to 7FFF Memory expansion board (Vacscan Plus)
- 8000 to 80FF input / output
- 8100 to FFFF Program ROM IC7

The input / output address space is decoded by IC11, IC17 and IC26, which enables IC33. IC33 sub divides the I/O address space into eight smaller block decodes of 32 addresses for the individual peripheral chips. The individual device allocations are as follows:

- 8000 to 801F ADC The analogue/digital convertor.
- 8020 to 803F DUART The dual serial/parallel port.
- 8040 to 805F DACS The digital/analogue convertors.
- 8060 to 807F VIA 2 The second digital i/o group.
- 8080 to 809F VIA 1 The first digital i/o group.
- 80A0 to 80BF RTC The real time clock/calendar.
- 80C0 to 80DF IEEE The IEEE488 parallel interface.
- 80E0 to 80FF Not used.

The IEEE488 interface is an optional, add on board.

The block of 32 bytes between 8040 and 805F is further decoded into eight blocks of 4 bytes each, by IC15.

The individual device allocations are as follows:

- 8040 to 8043 Not used.
- 8044 to 8047 CRTIC The video controller IC.
- 8048 to 804B DDAC The SEM and Autozero DACs.
- 804C to 804F LBMASS The low byte of the mass program.
- 8050 to 8053 HBMASS The high byte of the mass program.
- 8054 to 8057 HBAN The high byte of the analogue output.
- 8058 to 805B LBAN The low byte of the analogue output.
- 805C to 805F Not used.

The A15 address line is also used to decode the ROM space which occupies the top 32K of address space except for the 256 bytes of i/o space at the very bottom of this range. A15 is applied to IC18 pin 5; the i/o enabling signal from IC17 pin 8 going to IC18 pin 4. When both these inputs are high, the output at IC18 pin 6 goes low, enabling the ROM.

### **7.5.3. Battery backed RAM**

The RAM IC1 is supplied from an on board Lithium battery when mains power is removed. The RAM is used to store the mass spectrometer parameters so that, when the machine is switched on again, the previous machine settings are still in place.

The power for the RAM is supplied by IC16 and TR2. IC16 contains a voltage comparator that continuously compares the +3 volts battery voltage to the +5 volts supply. When +5 volts is present on pin 8 of IC16, the voltage on pin 6 goes low, turning on TR2 and applying +5 volts to the RAM. The voltage on pin 3 goes high turning on TR1. This FET is in series with the RAM chip enable.

When the +5 volts rail drops below the battery voltage, the comparator changes state, operating an internal FET switch that connects the battery through pin 1 to the RAM supply rail. The voltage at pin 6 goes high, turning off TR2 so that the battery does not supply the main +5 volts rail.

The voltage on pin 3 goes low, switching off TR1; this inhibits any chip enable signals to prevent corruption of the data.

#### **7.5.4. Video interface**

The video interface consists of display control IC27, video RAM IC13, data selector IC19, shift register IC46, and various bus buffer IC's.

The display controller IC27 receives a master clock signal on pin 21 that is 180 degrees out of phase with the CPU clock. This arrangement ensures that the display controller accesses the video RAM during the first half of the bus cycle and the CPU can therefore access the video RAM at its usual time during the second half of the bus cycle, when the system clock is high. A full specification of 6502 bus timing can be obtained from any 6502 data sheet.

The CPU writes the data to be displayed to the video RAM, IC13 via address and data buffers IC4,5,20 and IC22.

The display controller IC27 generates the correct line and frame sync. waveforms and also generates consecutive RAM addresses, thus the RAM is scanned continuously. The address bus is buffered by IC8 and IC9. The controller spends two consecutive bus cycles at each RAM address and IC19 selects either the most significant or the least significant nibble. Each nibble in turn is loaded into shift register IC46. The serial data is shifted out by the 7.3728MHZ PCK signal on pin 10. The PCK signal is at four times the frequency of the system clock. The serial data forms the pixel information and is buffered by IC45 and connected through PL4, together with line and frame sync signals, to the monitor.

#### **7.5.5. Real time clock**

IC2 is a special purpose clock/calendar chip. It contains an on board 32.768KHz oscillator circuit and internal counters that record both date and time. The device is powered from the battery back up system so that it keeps time when the mains power is off.

The clock chip is accessed by the CPU via the address and data busses, which fetch the date and time on demand.

## **7.6. Input / output sub-system**

Schematic LM61-010-D sheet 2

### **7.6.1. Keyboard interface**

The keyboard is on a separate PCB that forms part of the front panel of the instrument. It contains a matrix of 4\*4 cross point switches, which is monitored by its own keyboard IC (IC6). Vacscan uses 8 keys, Vacscan Plus having 11.

The function of the keyboard controller IC is to generate hex characters from the key presses, since each key press merely connects two points on the keyboard matrix.

The data outputs of the keyboard controller IC, feed into inputs 3,4,5, and 6 of IC34. The DATA AVAILABLE output of the controller IC is separately connected to input 2 of IC34. When a key has been pressed, an interrupt is generated and the operating software can determine which key has been pressed by reading the data.

### **7.6.2. RS232 interface**

There are two RS232 controllers built into IC34. Port A is used as the main serial link for communication with external computers, and port B is not used.

The inputs and outputs of port A are interfaced to PL10, the RS232 connector, via IC52 which converts the TTL level outputs from IC34 to RS232 levels, and also converts incoming RS232 signals to TTL levels.

An internal divider in IC31 sets the baud rate for transmission and reception on the serial port. The 3.6864 MHz input clock signal is divided down by a programmable divider within IC34.

### **7.6.3. Digital input / output**

There are two programmable interface chips IC43, and IC50. Both devices

are identical but are initialised differently at power up. In addition, some of the spare outputs of IC34 are used for control of the mass spectrometer source.

### **7.6.3.1. IC50**

The main function of IC50 is to produce, from an internal counter, regular interrupts every 300 microseconds. These interrupts are connected to the non maskeable interrupt input on the CPU and control the operation of the analogue to digital convertor.

Control output CB2, on pin 19, generates audio tones for use when the system is in leak detect mode and to acknowledge key presses.

The parallel input/output port A is connected directly to PL8 for use with external modules. The external modules can be used to operate relays, generate analogue output voltages, or carry out a variety of other process control functions.

The second port, port B is used to monitor and control the status of the mass spectrometer. On port B, all eight lines are configured as outputs but PB7 is not used.

PB0 and PB1 control the gain of the signal amplifier system; with both bits low, the gain is 1. With only PB0 set high, the gain is 10, and with only PB1 set high the gain is 100. The two bits are never set high together.

PB2 controls a relay in the pre-amplifier that changes the feedback resistor on the input stage. In conjunction with PB0 and PB1, six decades of amplifier sensitivity may be programmed.

PB3 is used to turn off the DC rod voltages so that a total pressure measurement can be made. It is used in conjunction with PB4, which changes the signal amplifier gain during total pressure measurement.

PB4 operates an analogue switch to change the gain of the amplifier system when in total pressure mode, to cater for the increased analyser sensitivity when in total pressure mode.

PB5, when low, turns on the SEM power supply. It also drives a solid-state switch that alters the biasing of the signal amplifier. A full explanation of this process is given in section **7.6.6. Signal amplification system.**

PB6 passes to the RF head via SK12 and IC47. This signal, when low, turns off the ion beam by increasing the DC rod voltages so that the amplifier zero level may be measured.

PB7 is not used.

### **7.6.3.2. IC43**

IC43 also contains two eight bit parallel input/output ports.

The whole of port A is configured as a parallel printer port. PA0 to PA7 form the eight data bits, the signals being buffered by IC44 and IC51, and connected to SK9, the printer socket.

CA2 acts as the data strobe line, and CA1 is the BUSY input from the printer.

PB0 to PB4 form additional I/O lines to PL8 for use with external modules.

PB5 to PB7 are configured as outputs.

PB5 receives an input from a monitoring circuit in the RF head. If this signal goes low, it signifies a fault in the RF generator system.

PB6 receives a signal from the emission regulator, which is normally high. If the filament in use fails, this signal goes low, generating an interrupt through its connection to CB2.

PB7 monitors the status of the external trip circuitry in the power supplies section, and generates an interrupt through CB1 if the trip is operated.

### **7.6.3.3. IC34**

OP2 switches the selected filament on and off.

OP3 controls the filament selection relay, located in the RF head.

OP5 controls the operational mode of the mass spectrometer source. When high, the source is in its normal mode; when low, degas mode is selected.

OP6 and OP7 are not used.

#### **7.6.4. Audio amplifier**

A loudspeaker is fitted to the mainframe of the unit. This has two functions; to generate "beeps" when a key is pressed and to generate continuous tones when in leak detect mode.

IC54 is the audio amplifier that drives the loudspeaker.

Both the key "beeps" and the tone signals from IC50 pin 19 pass through R154 and C125 to the rear panel mounted volume control, VR2. The output from VR2 passes to the input of IC54 at pin 3. The amplifier closed loop gain is determined by C120 and R151. The amplified output passes to the loudspeaker through C126 and the auxiliary contacts of SK6, a rear panel mounted jack socket. An external speaker may be connected via SK6, in which case the internal speaker will be muted. The minimum allowed speaker impedance is 8 Ohms.

#### **7.6.5. Analogue output sub-system**

Four digital to analogue convertors are employed, to generate the mass scanning program, to control the output voltage of the SEM power supply, to generate an amplifier zero error correction voltage and to generate an analogue output suitable for driving a chart recorder. Three of the convertors are fed from a precision voltage reference. The zero DAC and the SEM DAC are both contained within the same IC.

##### **7.6.5.1. Voltage reference**

The reference IC, ZN1 is a precision 5 volts source fed from the +15 volts rail through R81. VR1 is used to set the reference voltage to the exact value required by the mass scale generator; this is described in section **7.6.5.2.**

##### **Mass scale generator DAC.**

The reference output takes two routes. A voltage follower comprising a section of IC38 and D15 is used to buffer the reference for application to the ADC and to part of the signal amplifier system. Another section of IC38, in

conjunction with R102, R103, and R104 amplify the reference voltage from +4.98 to +9.94 volts for the digital to analogue convertors.

#### **7.6.5.2. Mass scale generator DAC**

The mass scale program is generated by IC40, a 12 bit digital to analogue convertor. The current output from IC40 is converted to an output voltage in the range 0 to -7.742 volts by IC41. IC42, R105, R106, R122, and R123 amplify and invert this to the range 0 to +3.2 volts at mass 100.

The mass program passes out through R125, and SK12 pin 2 to the RF head.

#### **7.6.5.3. Zero correction DAC**

In order to compensate for long-term drift in the signal amplifier, a zero error correction signal is applied to the amplifier. This signal is generated as a current by section A of IC37 and converted to a voltage in the range 0 to -9.94 volts by a section of IC38.

#### **7.6.5.4. SEM program DAC**

The gain of the SEM detector is determined by its applied voltage. The SEM is powered by a programmable supply, as described in section 7.4. **SEM power supply.**

The SEM program voltage, in the range 0 to -9.94 volts, is generated by section B of IC37 in conjunction with a section of IC38.

#### **7.6.6. Signal amplification system**

IC25, IC30, and IC36, and their associated circuitry buffer, amplify, and scale the signals from the pre-amplifier before they are digitised. The gain of the system can be ranged over three decades by the processor.

The signals from the pre-amplifier enter the main board through SK12 pin 3 together with its signal return on pin 21. IC25 is arranged as a differential amplifier to produce signals referred to the local analogue ground. C33 and C34 provide some noise filtering. The output of the zero error correction DAC is connected to the input of this stage via R23 and R24; the effect of R25 being to give a bipolar offset to the DAC signal so that offset errors of

either polarity may be nulled. This system can cope with pre-amplifier offset errors of up to +/- 33 millivolts.

IC30 is a programmable gain amplifier. It contains a network of amplifiers and analogue gates arranged to give gains of 1, 10, and 100 under the control of PB0 and PB1 on IC50.

The final amplifier stage, comprising IC36, TR8, and TR9 perform several functions. The normal output range is between 0 and +4.98 volts.

When the Faraday plate detector is in use a standing offset of +3.8 volts is established at the output of this stage by R39 and R78. The signals at TP16 are positive going, leading to negative going signals at the output on pin 6 of IC36. The normal full scale is at +1.2 volts which gives a 1.2 volts noise margin at each end, so that noise, which has both positive and negative excursions about the mean value may be fully digitised. In this way, no signal information is lost.

When the SEM detector is in use, the polarity of the signals is reversed, being negative going at TP16. The SEM control bit, in conjunction with IC26, R69, and TR7 change the standing offset to +1.2 volts. The normal full scale output is at +3.8 volts, giving a 1.2 volts noise margin as in Faraday mode.

TR8, TR9, R74, D8, and D9 are configured as a clamping circuit to constrain the output in the range 0 to +4.98 volts to suit the input limits of the ADC.

D8, D9, and R74 bias the bases of TR8 and TR9 0.6 volts above 0 volts and 0.6 volts below +4.98 volts, respectively. If the output signal tries to go below 0 volts TR8 turns on and shorts out the feedback resistor R73, so reducing the gain and clamping the signal at 0 volts until it returns within normal range. If the output signal tries to exceed +4.98 volts TR9 turns on, once again shorting out R73 and clamping the output.

When in total pressure measurement mode the sensitivity of the analyser increases, therefore the gain of the amplifier is reduced pro rata to restore calibration. R72 is switched in parallel with feedback resistor R73, by one section of IC31, to fulfil this function. R71, switched in with R72, restores the correct standing offset at the output.

Bandwidth limiting is provided on all measurement ranges to give an adequate signal to noise ratio into the analogue to digital convertor in normal operation. On the lowest gain range, smoothing is provided by C34, and C33. This is used with both pre-amplifier feedback resistors.

When IC30 is set to a gain of 10, C37 provides additional smoothing in conjunction with R22, and at a gain of 100 C32 and R21 are used.

When the larger of the two pre-amplifier feedback resistors is selected, the PAG signal activates two sections of IC31, so that further smoothing is provided by C36 and C31.

### **7.6.7. Analogue to digital convertor**

IC39 is a microprocessor bus compatible 10-bit analogue to digital convertor, complete with sixteen input analogue multiplexer and sample/hold control.

One input, AI0 is selected to digitise the amplifier output signals. AI2, and AI9 to AI15 are used to measure power rails for fault diagnosis, and AI3 and AI4 are available at pins 23 and 25 of PL8 for the measurement of external signals.

During conversion the GAINSEL signal on pin 2 goes high. The level on IC31 pin 16 goes low, opening the connection between the multiplexer output and the ADC input. During the conversion time C88 holds the ADC input at a steady value.

## **7.7. Memory expansion PCB**

Schematic LM7-11-D

With Vacscan Plus instruments, additional program and battery-backed memory is required in order to carry out the additional functions specified for this model.

The board is mounted above the motherboard, in an inverted position, towards the rear of the unit. It connects to the motherboard via a 40 way cable into the socket normally occupied by IC10.

The circuit operates on the "sideways memory" principle and has provision for three 64K byte ROMs and two battery backed 32K byte RAMs. Each ROM is divided into four 16K byte segments, each RAM having two segments.

The entire board is mapped into the 16K bytes of main address space between 4000 and 7FFF. Address 7FFF is uniquely decoded as the segment register.

### **7.7.1. Main board interface**

ICs 1,2, and 8 buffer the address lines A0 to A13 and data lines D0 to D7, so as not to place a large additional load on the main board. The buffered address and data busses are distributed to the memory sockets and decoding circuits.

### **7.7.2. Segment register address decoder**

ICs 12,13,14 are arranged as a 16 input AND gate to decode address 7FFF. This is achieved by ICs 13 and 14 which produce an output when A0 to A13 are all high, and IC12 which gates this condition with /MEM 2 (decoded on the main board as A14\*/A15). This signal, gated with the write signal, is passed to the segment register, IC9.

### **7.7.3. Segment register**

IC9 is an octal latch. One byte of data is written into this latch at address 7FFF as described above. This data byte specifies which segment of which memory IC is selected; the 16K byte segment then appears between 4000 and 7FFF in the main memory map. The selected segment remains in place until new data is written to this register.

The least significant nibble, D0 to D3 is assigned to the segment select function, although D2 and D3 are not used. Selection uses the built in decode functions in all memories, by driving the memories A14 and A15 lines.

#### **7.7.4. Chip select decoder**

The most significant nibble, D4 to D6 (D7 is not used) is decoded by IC10 into 8 chip enable lines, of which only CE0 to CE4 are used. The chip enable lines select which memory IC is accessed.

TR1 and TR2 are driven from the battery backup supervisory system on the main PCB and are turned off during power off conditions to disable the RAMs chip select and avoid corruption of the battery-backed data.

#### **7.7.5. Memory bank**

The three ROM (ICs 5,6,7) and two RAM (ICs 3,4) positions are connected to the buffered address and data busses and are accessed by the control circuits described in previous sections.

The two ROM positions are powered from the memory backup battery, located on the main PCB, by a separate connection.

The number of positions populated depends on the level of software fitted.

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# Section 8.

## RS232 Interface

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### 8.1. Introduction

Vacscan is supplied with an RS232 interface fitted as standard. The main use of the interface is to enable an external computer to control Vacscan ( i.e. to select a mode, set scan parameters, start scanning etc.) and to read back data for further processing.

To help you get started **Appendix 7. Dumb terminal emulator** contains a listing of a very simple BASIC program for an IBM PC or compatible computer for a Dumb Terminal Emulator. This program will enable you to type in the RS232 commands on the computer keyboard to control the Vacscan and any response down the RS232 will be displayed on the computer's VDU. The easiest way to check the communication link with the Vacscan and to get familiar with the RS232 commands and responses is to use this program or any other Dumb Terminal Emulator program you may have available.

### 8.2. RS232 interface fundamentals

#### 8.2.1. Pin connections

A 9-pin D-type plug is provided on the Vacscan to enable the external computer to be connected. The pins used on this connector are listed in Table 1.

Pin No.	Signal	Direction
1	N/C (No Connection)	
2	RxD (Receive Data)	Input
3	TxD (Transmit Data)	Output
4	DTR (Data Terminal Ready)	Output
5	GND (Ground)	
6	N/C (No Connection)	
7	RTS (Request To Send)	Output
8	CTS (Clear To Send)	Input
9	N/C (No Connection)	

*Table 1 RS232 pin connections*

### 8.2.2. RS232 cables

A null modem cable is required if the Vacscan is to be connected to a host computer. Two standard cables are available with either a 9 pin or a 25 pin D-type socket. Which one you need depends on the type of connector fitted to your computer. Contact your local Spectra facility for further details. The pin connections for both cables are shown in Table 2.

Vacscan Pin No.s	Computer Pin No.s	
	9 pin D-type Socket	25 pin D-type Socket
2	3	2
3	2	3
4	6	6
5	5	7
6	4	20
7	8	5
8	7	4

*Table 2 Null modem cable connections*

### 8.2.3. Parameter settings

The default parameters for the interface are:

- i) Baud rate:- 9600
- ii) Data bits:- 8.
- iii) Stop bits:- 1
- iv) Parity:- none

These parameters may be set in the UTILITIES screen to the following:-

- i) Baud rate:- 300,600,1200,2400,4800,9600,19.2K
- ii) Data bits:- 7, 8
- iii) Stop bits:- 1, 2
- iv) Parity:- none, even, odd

### 8.2.4. Making the link

By far the hardest thing about making two devices talk to each other via RS232 is getting the cable joining them together right! The easiest way to ensure this is to use one of the two standard cables, which we can supply, or ensure that your cable conforms to the details listed in tables 1 and 2.

Once you have connected the cable between the Vacscan and the your computer you are advised to check the link by using a Terminal Emulator Program which will allow characters typed on the keyboard to be transmitted down the serial link and display, on the VDU, any characters which the Vacscan transmits. A simple Basic program is listed in **Appendix 7. Dumb terminal emulator** which will perform this function.

To tests the link you should type the command **(A1)** and the Vacscan will respond “A”. If you then send the command **(M5)** the Vacscan should enter the Leak Check mode and respond with an “A”.

### 8.2.5. Fault finding

If you have a problem communicating with the Vacscan follow the check list below:-

- i) Ensure that the cable you are using is wired according to those specified in Table 2.
- ii) Check that your terminal emulator program is communicating with the serial

port to which you have connected the Vacscan. On an IBM PC or compatible two serial ports are normally provided which are called Com1 and Com2.

iii) Ensure that the RS232 parameters (baud rate, data bits, stop bits and parity) are correctly set at both ends. Initially try using the Vacscan default settings listed in section **8.2.3. Parameter settings**.

iv) Ensure that the Vacscan has been powered up using the Power Up Reset facility. This is performed by holding any key depressed when you switch on the Vacscan. Note this will reset the RS232 parameters to their default settings.

## **8.3. Command format**

All communications to and from the Vacscan are carried out using ASCII characters. To control or request data from Vacscan a message must be sent that consists of four parts, as detailed below.

### **8.3.1. Message start character**

All messages must start with the open bracket symbol "(" ASCII code 40 decimal / 28 hexadecimal.

### **8.3.2. Command type character**

Immediately following the message start character comes the command type character. There must be no spaces or any other characters between them. This character defines the type of command being sent to the Vacscan.

e.g. "K" ASCII code 75 decimal / 4B hexadecimal is the command character for a remote key press.

### **8.3.3. Command parameter field**

Depending on the command type there may be parameter fields following the command character. The format of the parameter field is one or more values separated by the ASCII character , ASCII code 44 decimal / 2C hex. The values are represented as decimal numbers using the ASCII characters in the range **0..9** ASCII code 48 decimal / 30 hex to 57 decimal / 39 hex.

### 8.3.4. Message end character

All messages must end with the close bracket symbol ")" ASCII code 41 decimal / 29 hexadecimal.

### 8.3.5. Carriage return and line feed

Carriage return ASCII code 13 decimal / 0D hexadecimal and line feed ASCII code 10 decimal / 0A hexadecimal are optional at the end of a message to the Vacscan. Most responses by the Vacscan will be terminated with carriage return line feed.

### 8.3.6. Command examples

- (R) - Reset the Vacscan to default values.
- (K1) - Press key 1 ( up arrow key )
- (k1,5) - Press key 1 ( up arrow key ) 5 times

## 8.4. Response format

It is possible to enable a command acknowledgement protocol for the Vacscan. When the instrument is first powered up, the command acknowledgement facility is disabled and may be enabled by sending the command **(A1)** to the Vacscan. When enabled the ASCII character **A** ASCII code 65 decimal / 41 hex will be sent in response to a valid command (ACKnowledge) or the character **N** ASCII code 78 decimal 4E hex if the command was invalid ( Not ACKnowledge or NACK ).

Some commands sent to the Vacscan will cause it to respond with peak heights or status information etc. If the command ACK facility has been enabled then the ACK character **A** will be received before the usual command response if the command was valid. The normal responses consist of one or more fields separated by a SPACE ASCII code 32 decimal / 20 hex and are described in detail in the following sections.

Note that a carriage return and line feed will not be transmitted after the ACKnowledge "**A**" if peak height or status information is to be transmitted as a

result of the command.

e.g. If the command (**P28**) was sent to read peak 28 in Bar Chart then a response of the following form would be received:-

A1.2E-07<cr><lf>

## 8.5. Command and response detailed description

The notation listed below is used to describe the format of the response fields. The \* will be substituted with a number to identify the field in the text.

- d\* - variable length string of ASCII characters 0..9 representing a decimal number.
- w\* - 4 ASCII characters in the range 0..9 A..F showing the hexadecimal representation of a binary word ( 16 bits )
- b\* - 2 ASCII characters in the range 0..9 A..F showing the hexadecimal representation of a binary byte ( 8 bits )
- p\* - 7 ASCII characters representing a peak height or total pressure value in the form a.bE-xy where a.b is the mantissa in the range 0.0 to 9.9 and xy is the exponent in the range 05 to 13. A mantissa of -.- indicates that the peak requested is not being scanned and >>> indicates that the peak height is greater than 9.9
- k - 4 ASCII characters in the form (Kn) where n is 0..8 representing a key number.
- ^ - the ASCII character for a SPACE.
- <cr><lf> - the ASCII characters for Carriage Return & Line Feed.

### 8.5.1. Command ack (enable / disable) A

Allows the command acknowledgement protocol to be enabled and disabled by the command:-



b1	High Alarm	0 = Off 1 = On
b0	Low Alarm	0 = Off 1 = On

Table 4 (C#) command byte b2 coding

### Example

To get the status of channel 1 send:- (C1)

A response of:- 2 50 8A 01 <cr><lf>

indicates:-

2 = mass 2  
50 = alarm level of 5.0  
8A = 10001010 in binary  
bit 7 = 1 i.e. detector = multiplier  
bit 6 = 0 " auto-gain = off  
bit 5 = 0 always 0  
bit 4 = 0 always 0  
bit 3 to bit 0 = 1010 i.e. gain = 10  
01 = 00000001 in binary  
bit 2 = 0 i.e. audio alarm is off  
bit 1 = 0 i.e. high alarm is off  
bit 0 = 1 i.e. low alarm is on

### 8.5.3. Channel status (single parameter) c

The current setting of one parameter for one user peak / trend channel can be obtained by the command:-

(c#,n)

Where:- # is the channel number in the range 1..6

n identifies the required parameter, see Table 5.

n	Parameter	Format
1	Mass number	See (C#) command

2	Alarm level	See (C#) command
3	Auto gain	0 = Off 1 = On
4	Gain	5 .. 13 = E-5 .. E-13
5	Detector	0 = Faraday 1 = Multiplier
6	Alarm flags	See (C#) command

*Table 5 (c#,n) parameter number*

#### 8.5.4. Echo key press E

The echo key press facility may be enabled by the command **(E1)** and disabled by sending any valid RS232 command.

When enabled each time any key is pressed a response of format **k** is send by the Vacscan indicating which key was pressed. If these responses are stored by the host computer, they may be used directly to reset the Vacscan to a required mode (see remote key press **K** below). Obviously, for a recorded key sequence to end in the required mode the starting position of the screen cursor and mode etc. must be the same as when the original key sequence was entered on the Vacscan. Known starting points for key sequences may be set by using the mode command **M** and the reset command **R**.

In this mode the HELP key has a special function. Instead of responding with **(K6)** the ASCII code for ctrl.Z ( 26 decimal 1A hex ) is returned. This could be used by the host computer to terminate a program reading key presses from the RS232.

**NOTE:** The response to each key press in this mode is NOT terminated by <cr><lf>.

#### 8.5.5. Cursor field select

The cursor can be moved to any field in the current screen using the command:-

**(Fn)**                      Where n is the field number.

**NOTE:** field numbers for the same icon/parameter vary from screen to screen.

**Appendix 8. Field numbers RS232 (Fn) command** identifies the most useful field numbers for the main scanning modes. If the field required is not documented then set the cursor to the required field on the required screen and send the **(f)** command see below.

**8.5.6. Report current cursor field number f**

Returns the field number of the current cursor position in the form:-

```
d1^<cr><lf>
```

Where:- d1 is the field number.

**8.5.7. Remote key press**

This mode allows the "pressing" of any front panel key via the RS232 interface. The only difference between using this method and physically pressing the key is that no audio tone will be generated.

To perform remote key press send:-

**(K\*)** where \* is the character for the desired key. See Table 6.

Example 1 To "press" the up arrow key send:- **(K1)**

Example 2 To "press" the EXIT key send:- **(K8)**

Key Name	ASCII Character	ASCII Code decimal / hex
Up Arrow	1	49 / 31
Left Arrow	2	50 / 32
Right Arrow	3	51 / 33
Down Arrow	4	52 / 34
Enter	5	53 / 35
Help	6	54 / 36

Print	7	55 / 37
Exit	8	56 / 38
Vacuum Scan *		
Leak Check *		
RGGA *		

*Table 6 Key numbers*

\* These keys are only available on Vacscan Plus instruments.

### 8.5.8. Multiple remote key press

Similar to the **(K\*)** command except the additional parameter **m** specifies how many times the key specified should be "pressed".

**(k\*,m)**

Example to "press" the UP ARROW key 10 times send:-

**(k1,10)**

### 8.5.9. Keypad lock L

The keypad lock mode is set by the command **(L1)** and reset by **(L0)**.

When the keypad is locked the Vacscan key actions are disabled. Keys may be enabled by any one of the following :-

- i) send **(L0)** command down the RS232
- ii) send **(R)** command down the RS232 ( see reset command )
- iii) Turn off the Vacscan.

### 8.5.10. Set mode m

This allows the Vacscan to be set into any of its main modes by a single command.

To set the mode send:-

**(M\$)** where \$ is an ASCII string for the required mode. See table Table 7.

Example To set bar chart mode send: **(M2)**

ASCII Character	Mode
0	R.G.A. Select
1	User Peaks
2	Bar Chart
5	Leak Check
6	Main Mode Select
7	Analogue
9	Vacuum Scan
11	Utilities
12	Date-Time
13	Alarm
15	Degas
17	Mult Cal
19	Trend

Table 7 Mode numbers

### 8.5.11. Read mode m

Returns the current mode number (see Table 7) in the form:-

d1^<cr><1f>

### 8.5.12. Read complete scan

Read complete scan (<cr><1f> delimited) P. To get the complete scan data when scanning in the Bar Chart, User Peaks and Trend modes send:-

**(P)**

The format of the response for Bar Chart and the Peak Jump and Trend modes is shown in Table 8.

<b>Mode</b>	<b>Response to (P) command</b>
User Peak & Trend	p1<cr><lf> .. p6<cr><lf> where: p1 is the channel 1 peak height p2 is the channel 2 peak height “ “ “ “ p6 is the channel 6 peak height
Bar Chart	m1<cr><lf>..mn<cr><lf>g<cr><if> where: m1 is the peak height of the first mass mn is the peak height of the last mass g is the gain range
Leak Check	p<cr><lf> where: p is the peak height of the last reading

Table 8 Read complete scan response

### 8.5.13. Read single peak P

Send only the peak height indicated by the # parameter when scanning Bar Chart, User Peaks Trend of Analogue Display modes.

To read a peak height send:- (P#)

Where # is an ASCII number whose range will depend on the current mode of operation, see Table 9.

<b>Mode</b>	<b>Interpretation of # in (P#) command</b>
Bar Chart	Mass no. between 1 and max. mass (20,50,100 or 200)
User Peaks	The channel number in the range 1 to 6
Trend	The channel number in the range 1 to 6
Analogue	No. of 1/16th AMU offset from first mass - 1/2 AMU
Leak Check	Ignores #. Latest peak height always returned.

Table 9 Single peak read index interpretation

The peak height is returned as an ASCII string in format:- p<cr><lf>

Example 1 In Bar Chart to read the peak height of mass 28 assuming it is at 1.3E-07  
send:- **(P28)**  
receive:- 1.3E-07

Example 2 In User Peaks to read the peak height of channel 6 assuming it is at 2.4E-11  
send:- **(P6)**  
receive:- 2.4E-11

Example 3 In analogue to read the centre of the second peak on the screen assuming it is at 4.1E-06  
send:- **(P24)**  
receive:- 4.1E-06

NOTE: There are 16 samples per AMU and the first sample point is First Mass -1/2 AMU. Therefore peak centre of Second Mass displayed is given by :-  $(2 * 16) - 8 = 24$

When the Vacscan is in any of the above modes and Total Pressure measurement is enabled the command **(P0)** will initiate the Total Pressure reading being transmitted.

Example 4. To read the total pressure (assuming it is enabled and the current value is 2.7 E-6)  
send:- **(P0)**  
receive:- 2.7E-6

#### 8.5.14. Reset R

The reset command can be used to reset all the Vacscan parameters to there power up reset state except the RS232 interface setup which is left unchanged. The power up reset settings are listed in **Appendix 6**.

##### **Power up reset settings.**

To perform a reset send:- **(R)**

#### 8.5.15. Status S

To get the current status of the Vacscan send:- **(S)**

The response will be in the form:- d1^d2^d3^d4^w1^w2^<cr><lf>

Where:-

- d1 = bar chart first mass
- d2 = bar chart span
- d3 = analogue first mass
- d4 = trend interval
- w1 = Status word 1. See Table 10
- w2 = Status word 2. See Table 11

Bit	Description	Range
b15	Detector	0 = Faraday 1 = Multiplier
b14	Auto Gain	0 = Off 1 = On
b13	Reserved	0
b12	Total Pressure	0 = Off 1 = On
b11 .. b8	Gain Range	0100 .. 110 = E-5 .. E-13
b7	Reserved	0
b6 .. b4	Scan Speed	001 .. 110 = 1 .. 6
b3	Filament #2 Status	0 = Ok 1 = Failed
b2	Filament #1 Status	0 = Ok 1 = Failed
b1	Filament Selected	0 = Fil#1 1 = Fil#2
b0	Filament On	0 = Off 1 = On

Table 10 Read status command (status word 1)

Bit	Description	Range
b15 .. b3	Reserved	0
b2	Trend continuous print	0 = Off 1 = On
b1	Continuous print	0
b0	Single Print	0 = Off

		1 = On
--	--	--------

Table 11 Read status command (status word 2)

Example:- To get the status send:- **(S)**  
 A response of:- 1 50 18 10 9C33 0000 <cr><lf>  
 indicates:- 1 = bar chart first mass = 1  
 50 = bar chart span = 50  
 18 = analogue first mass = 18  
 10 = trend interval 10 sec  
 9C37 = 1001 1100 0011 0111 in binary  
 bit 15 = 1 detector = multiplier  
 bit 14 = 0 " auto gain = off  
 bit 13 always 0  
 bit 12 = 1 total pressure measurement is on  
 bits 8..11 = 1100 i.e. gain range = 12  
 bit 7 always 0  
 bits 6..4 = 011 i.e. scan speed = 3  
 bit 3 = 0 i.e. filament 2 is ok.  
 bit 2 = 1 i.e. filament 1 has failed  
 bit 1 = 1 i.e. filament 2 is selected  
 bit 0 = 1 i.e. filament is on  
 0000 = not printing

### 8.5.16. Status (single parameter) s

To get the current status of a particular parameter in the Vacscan send:-

**(sn)** Where:- **n** is the parameter listed in

The response will depend on which parameter is sent.

<b>n</b>	<b>Parameter</b>	<b>Response Format</b>
1	Bar Chart first mass	Same as (S) command
2	Bar Chart span	Same as (S) command
3	Analogue first mass	Same as (S) command
4	Trend interval	Same as (S) command
5	Auto Gain	0 = Off 1 = On
6	Gain Range	5 .. 13

7	Scan Speed	1 .. 6
8	Filament Status	Same as (S) command
9	Total Pressure	0 = Off 1 = On
10	Detector	0 = Faraday 1 = Multiplier
11	Filament Selected	1 = Fil #1 2 = Fil #2
12	Filament State	0 = Off 1 = On
13	Emission Status	0 = Failed 1 = OK
14	Probe Gas	Any valid mass number

Table 12 Read status (single parameter) command options

### 8.5.17. Filament control X

To control the filaments use the command:-

**(Xx,y)** Where:- **x** = filament number ( 1 = fil #1, 2 = fil #2)  
**y** = state (1 = on, 0 = off)

### 8.5.18. Parameter set Y

To set one of the parameters in Table 13 use the command:-

**(Yx,y)** Where:- **x** = parameter number  
**y** = value

Parameter	x	Mode				
		Trend	User Peaks	Bar Chart	Analogue	Leak Check
Multiplier on/off	1	X	X			
Total Pressure on/off	2					X
Accuracy / Speed	3					
First Mass	4	X	X			X
Mass Zoom	5	X	X		X	X
Range (Gain)	6	X	X			
Auto Range on / off	7	X	X		X	X
Time Interval	8		X	X	X	X

Probe Gas	9	X	X	X	X	
-----------	---	---	---	---	---	--

Table 13 (Yx,y) Parameter numbers

= Parameter valid for mode

X = Parameter invalid for mode.

### 8.5.19. Channel parameter set Z

To set a parameter in Table 14 for a particular channel use the command:-

(Zx,y,z) Where:- x = parameter number

y = channel number (1 .. 6)

z = value

Parameter values will be expressed as strings of ASCII characters in the range 0 .. 9 ASCII code 48 dec. / 30 hex. to 57 dec / 39 hex. Parameters which only have two states (on / off) will use the convention 0 = off and 1 = on.

Parameter	x	Mode	
		User Peaks	Trend
Multiplier on/off	1		
Channel on/off	2		
Mass Select	3		
Range (Gain)	4		
Auto Range on / off	5		
Alarm Level	6		X
Alarm Sense off/high/low	7		X
Audio Alarm on/off	8		X

Table 14 (Zx,y,z) Parameter numbers

= Parameter valid for mode  
X = Parameter invalid for mode.



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# Appendix 1.

## Connector pin-outs

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This section contains connector pinouts which you may need to refer to when connecting peripheral equipment or during servicing.

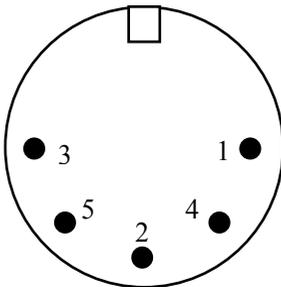
### 1.1 Aux. I/O port connection

Pin No.	Description
1	Not Used
2	Alarm for User Peak Channel #2
3	Alarm for User Peak Channel #4
4	Alarm for User Peak Channel #6
5 to 7	Not Used
8	Mass Scan Output
9	Not Used
10	0v Digital (for Alarms)
11	0v Analogue (for Analogue Inputs)
12	-15 Volts
13	+15 Volts
14	Alarm for User Peak Channel #1
15	Alarm for User Peak Channel #3
16	Alarm for User Peak Channel #5
17 to 19	Not Used
20	Analogue Output
21	Not Used
22	+5 Volts
23	Vref (4.98V)
24	Analogue Input #2
25	Analogue Input #1

### 1.2 Printer port connector

Pin No.	Description
1	Strobe
2	Data Bit 0
3	Data Bit 1
4	Data Bit 2
5	Data Bit 3
6	Data Bit 4
7	Data Bit 5
8	Data Bit 6
9	Data Bit 7
10	Acknowledge
11	Busy
12	P. End (out of paper)
13	Select
14	Auto Feed
15	Error
16	Initialise Printer
17	Select Input
18 to 25	Ground

### 1.3 Chart recorder connector



The Chart Recorder connector is a 180° 5 pin DIN socket. The above is a view looking at the rear of the Vacscan instrument.

Pin No.	Description
---------	-------------

1	Mass Scan Signal
2	0v Analogue
3	Analogue Output
4	not used
5	not used



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## Appendix 2.

# Glossary of vacuum terms

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### 1.1 Atomic mass unit (AMU)

Exactly one twelfth the mass of a neutral atom of the most abundant isotope of carbon,  $^{12}\text{C}$ .  $1 \text{ amu.} = 1.660 \times 10^{-27} \text{ kg.}$

### 1.2 Abundance sensitivity (Partial pressure analyser)

The smallest concentration of one gas that can be detected in the presence of another gas with a partial pressure analyser of a given design.

### 1.3 Active gas

A gas, which reacts readily with some substances to form chemical compounds.

### 1.4 Background spectrum (Partial pressure analyser)

A mass spectrum of residual gas species in a system. It is usually obtained before a sample of interest is introduced and analysed in order to deduce by subtraction of spectra the true mass spectrum of the sample.

### 1.5 Backstreaming

The movement of gases or vapours under molecular flow conditions in the opposite direction to the gas flow or pumping.

### 1.6 Bakeout

The term used to describe the process of heating a vacuum system to reduce or eliminate condensable gaseous contaminants.

### 1.7 Base peak

The largest peak in the spectrum of a pure compound.

### 1.8 Cold trap

A vacuum vessel containing an inner vessel which may be filled with liquid nitrogen. Vapours in the vacuum system are condensed onto the cold surfaces reducing contamination. They also prevent backstreaming of diffusion pump oil into the vacuum system. Well designed cold traps

will serve as an optical baffle to oil vapours so that liquid nitrogen is not required except to achieve very low temperatures.

## **1.9 Cracking pattern**

Tabulation of the peaks in the mass spectrum of a pure compound. Usually the heights are related to the height of the base peak which is assigned a value of 100 (or 1000). For a particular type of mass spectrometer operated under a fixed set of conditions, the cracking pattern remains more or less constant.

## **1.10 Cryopump**

Method for pumping of common permanent gases by freezing out onto cold surfaces below 30K. This is a similar principle to that used for the pumping of water vapour on a liquid nitrogen trap at 77K.

## **1.11 Detector**

A device which produces an output signal, usually an electrical signal, in response to an input signal.

## **1.12 Electron multiplier**

A detector which consists of cascaded stages, each intensifying the current from the preceding stage. Electrons released from the first electrode, cascade through the device to provide a charge or a current amplification. Electrons are released from the first electrode by the impingement of photons and/or by sufficiently high velocity heavier particles, charged or neutral.

## **1.13 Electron emission (From Surfaces)**

The release of electrons from a solid or liquid surface as a result of:-

- i) atom and/or molecule impact (secondary electron emission)
- ii) electron impact (secondary electron emission)
- iii) electric fields (field emission)
- iv) photon impact (photoelectric emission)
- v) previous mechanical and/or radiative chemical disturbance of the surface (exoemission)
- vi) thermal energy (thermionic emission)

Note: Thermionic emission is the method used to generate electrons in the source which in turn create ions.

### **1.14 Faraday cage**

A charged particle detector consisting of a metal electrode, cup shaped, for the collection and detection of charged particles. This geometry is used to prevent reduction of signal by suppression of secondary emission current.

### **1.15 Fingerprint spectrum**

A mass spectrum characteristic of a vacuum system, associated leak or processing environment.

### **1.16 Foreline trap**

A vessel filled with molecular sieve (or activated alumina) to trap backstreaming oil vapours. It is normally fitted between the high vacuum pump and rotary pump to prevent oil vapour backstreaming into the vacuum system.

### **1.17 Inert gas**

A gas which does not normally react chemically with other substances.

### **1.18 Ion**

Any atom or molecule which has resultant electric charge due to loss or gain of valence electrons.

### **1.19 Ion current**

The rate of ion flow.

### **1.20 Ion repeller**

The electrode in an ion source to which a potential is applied to provide an electric field which contributes to the initial acceleration of newly formed ions (See ion source).

### **1.21 Ion source**

A combination of electrodes to which potentials are applied to generate ions and to accelerate them as a beam.

### **1.22 Isotope**

One of a set of chemically identical species of atom which have the same atomic number but different mass numbers.

### **1.23 Leak rate**

Designated as the quantity of gas passing through a leak in a given

time, divided by that time. Leak-rate is a general concept whereas rate of pressure change is specific to the vacuum system volume. Leak-rate has therefore the advantage that component, or part leak-rates, can be added together to find an overall figure for a complete plant. A unit for leak-rate is the Millibar Litre per Second.

#### **1.24 Mass range (Mass Spectrometer)**

The interval between the smallest and largest masses which can be detected with a mass spectrometer.

#### **1.25 Mass analyser**

That portion of a mass spectrometer which separates the ion beam into its various mass to charge ratio components.

#### **1.26 Mass spectrum**

i) A recording of the ion current amplitude as a function of mass number obtained by scanning through all or part of the mass range.

ii) A tabulation or chart of peak ion current as a function of mass number.

#### **1.27 Mass to charge ratio**

The ratio of the mass to the charge of an ionised particle. (See Ion).

#### **1.28 Millibar**

Unit of pressure which approximates to 1/1000 of an atmosphere. The most widely used unit of pressure measurement in Europe.

#### **1.29 Minimum detectable partial pressure**

The smallest partial pressure the mass spectrometer can detect.

#### **1.30 Molecular flow**

The state of gas flow where the mean free path of the molecule is greater than the dimensions of the vacuum vessel so that molecules collide with the vessel wall rather than with other molecules. Typically occurs below  $7.5 \times 10^{-5}$  torr.

#### **1.31 Partial pressure**

The contribution that a gas component makes towards the total

pressure.

### **1.32 Pressure (gas)**

The average normal force per unit area exerted by gas molecules impacting on a surface.

### **1.33 Real leak**

Ingress of gas (usually air) into the vacuum system from the atmosphere outside the vacuum system.

### **1.34 Relative sensitivity**

The relative height of the base peak of a component compared to nitrogen measured at the same partial pressure. This difference is due to differences in ionisation efficiency for different gases. The indicated partial pressure on a mass spectrometer should be divided by the relative sensitivity factor to obtain the true partial pressure.

### **1.35 Resolving power**

The ability of a mass spectrometer to separate adjacent mass peaks.

### **1.36 Torr**

Unit of pressure. 760 torr equals one atmosphere.

### **1.37 Total pressure**

The sum of all the partial pressures present within the vacuum chamber.

### **1.38 Transition or knudsen flow**

The flow of low pressure gas through a tube several mean free paths wide. The flow is neither viscous nor molecular. Under these conditions, the microscopic concept of viscosity needs to be modified since the resistance to motion is due primarily to molecular collisions with the passage walls.

### **1.39 Vacuum**

"A space entirely devoid of matter"

In reality this cannot be achieved, hence one normally talks in terms of the degree of vacuum attained within the following pressure ranges.

Rough vacuum

1000 - 1.3 mbar.

Medium vacuum	1.3 - 1.3x10 <sup>-3</sup> mbar.
High vacuum	1.3x10 <sup>-3</sup> - 1.3x10 <sup>-8</sup> mbar.
Ultra-high vacuum	1.3x10 <sup>-8</sup> and higher vacuum.

#### **1.40 Vacuum leak**

Any fault on a vacuum chamber wall through which material can pass from higher to lower pressure regions.

#### **1.41 Virtual leak**

The effect caused by the outgassing of contaminants relating to the contents within an otherwise leak-tight vacuum chamber.

#### **1.42 Viscous flow**

The state of gas flow where the mean free path is less than the dimensions of the vacuum vessel so that molecules collide with other molecules rather than with the vessel walls. Typically occurs above 1x10<sup>-2</sup> mbar. There exists a region between 1x10<sup>-2</sup> and 1x10<sup>-4</sup> mbar where a mixture of viscous and molecular flow occurs.

---

## Appendix 3.

# Mass spectral interpretation

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### 2.1 Introduction

When the mass spectrum of a vacuum system has been taken, the first question is probably "What do all those peaks mean?" Although at first sight they may appear complex, interpretation in fact is a relatively simple matter.

#### 2.1.1 Major peaks

The first task is to identify the mass numbers of the major peaks in the spectrum (ignore all the smaller ones to start with). Search through a reference library for spectra with the same major peak.

#### 2.1.2 Secondary peaks

At some mass numbers there is the possibility of more than one component being present when using the base peak reference method of identification. With the exception of mass 28, identification is usually possible with the knowledge of which gases have been introduced into the vacuum system. For example, at mass 43 unless acetone or n-butane have been used in the system or the cleaning of vacuum components, it is unlikely that a peak at mass 43 is due to these compounds.

Comparing the secondary peaks from the reference library confirms the match and would show that the peak had most likely originated from rotary pump oil which can be confirmed by checking the presence of other peaks typical of this oil.

At mass 28, unless ethylene or ethane have been used in the vacuum system, the most likely source will be nitrogen or carbon monoxide, or a mixture of the two. Nitrogen is identified by checking mass 14, which is approximately 5% of the base peak intensity. The mass 28 contribution due to nitrogen can therefore be calculated. The remainder of mass 28 will be due to carbon monoxide, confirmed by the presence of a mass 12 peak of approximate intensity of 5% of the base peak. In practice, mass 28 is always present as it originates from chemical reactions of oxygen and carbon containing materials at the filaments of mass spectrometers, ion gauges, etc.

## 2.2 Typical fingerprint spectra

The fingerprint spectrum is a mass spectrum, which is characteristic of the vacuum system from which it is taken. The term is extended to include spectra which are characteristic of problems or faults commonly encountered in vacuum systems. The following fingerprints typify some of these problems and it should be remembered that a vacuum system could show a combination of two or more of these fingerprints.

### 2.2.1 Air leak

Characteristic spectrum of an air leak, masses 28 and 14 from nitrogen, 32 and 16 from oxygen, 40 from argon.

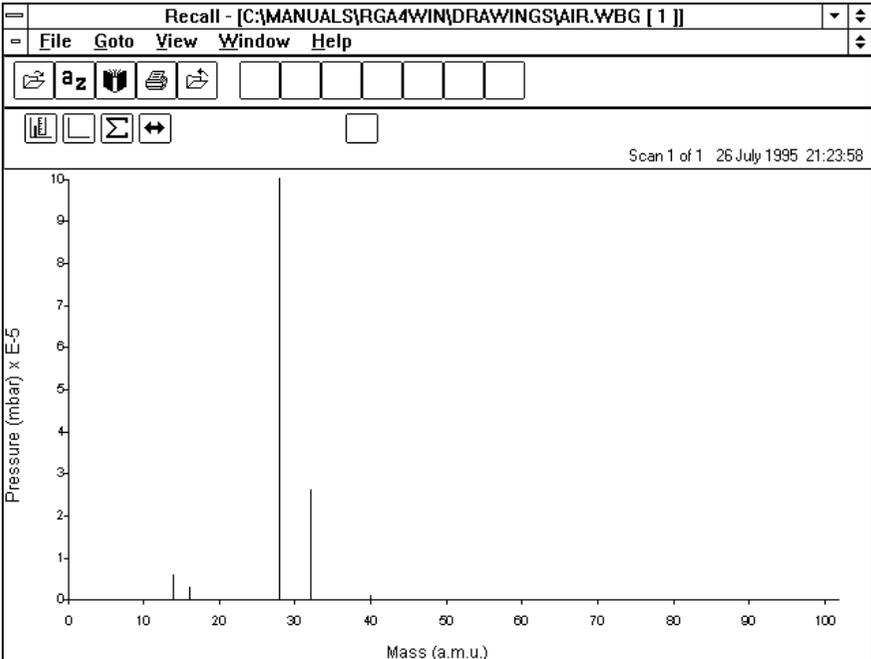


Figure 6 Air leak

To locate the leak, tune the quadrupole to mass 4 (helium) and probe all

joints, welds and feedthroughs etc., with helium. An increase in the helium peak on the mass spectrometer indicates the source of the leak. It is usually worth checking freshly made joints or newly added components first as these are the more likely sources of leaks on a previously leak-tight vacuum system.

### 2.2.2 Water vapour

Characteristic spectrum of water vapour in the vacuum system. The problem is solved by baking the system to 250 deg. C for some hours, preferably with an oven to ensure a uniform baking temperature. Remember to avoid sudden large temperature changes on ceramic and glass components to prevent damage.

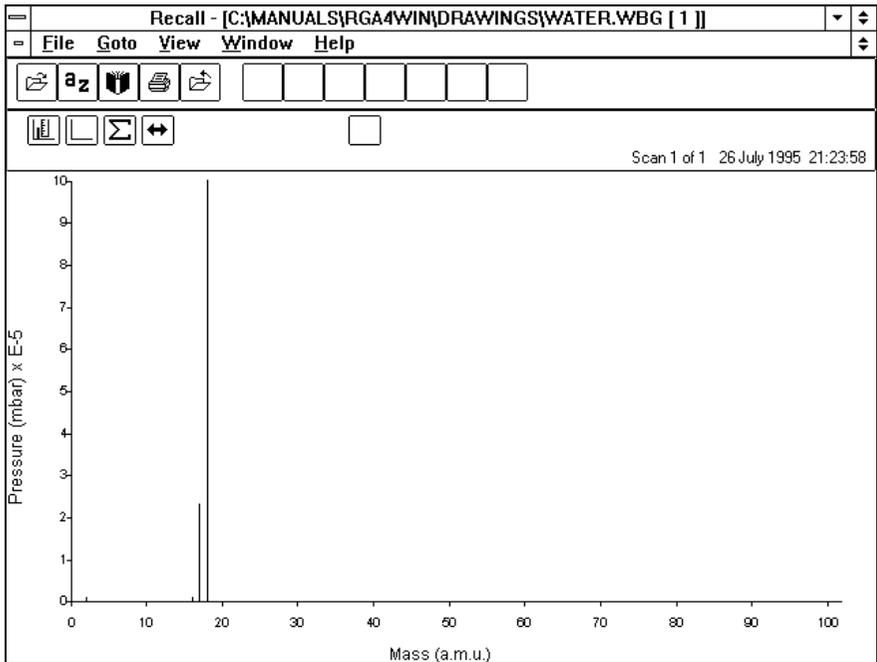


Figure 7 Water vapour

### 2.2.3 Rotary pump oil

Characteristic spectrum of rotary pump oil contamination, due to foreline trap not fitted or in need of reactivation. Solve by fitting or reactivating trap as appropriate and bake vacuum system as in appendix 2.2.2.

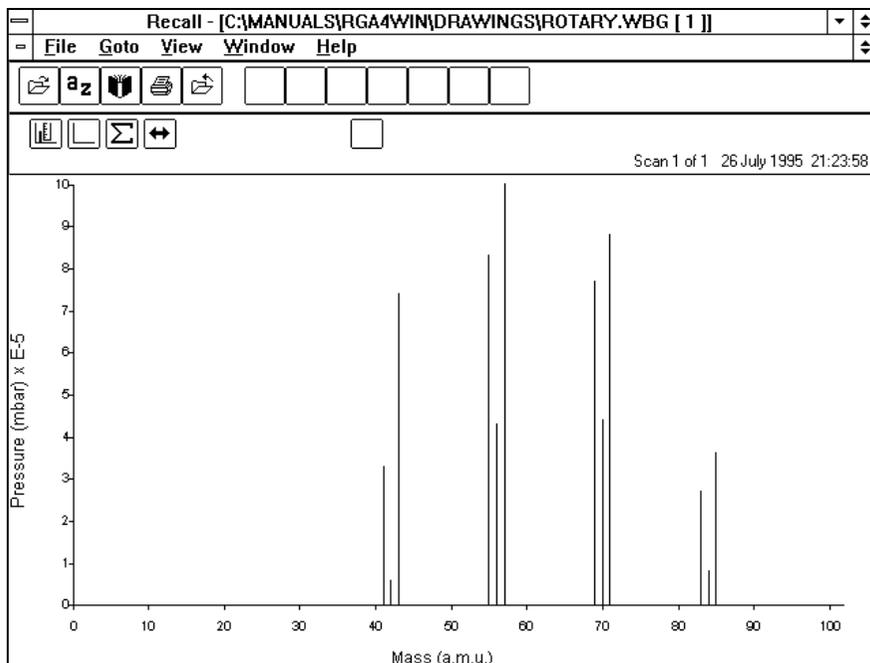


Figure 8 Rotary pump oil

## 2.2.4 Polyphenylether diffusion pump oil

Characteristic of spectrum of polyphenylether diffusion pump oil. Solve by fitting efficient baffle or cold trap and bake as in appendix 2.2.2.

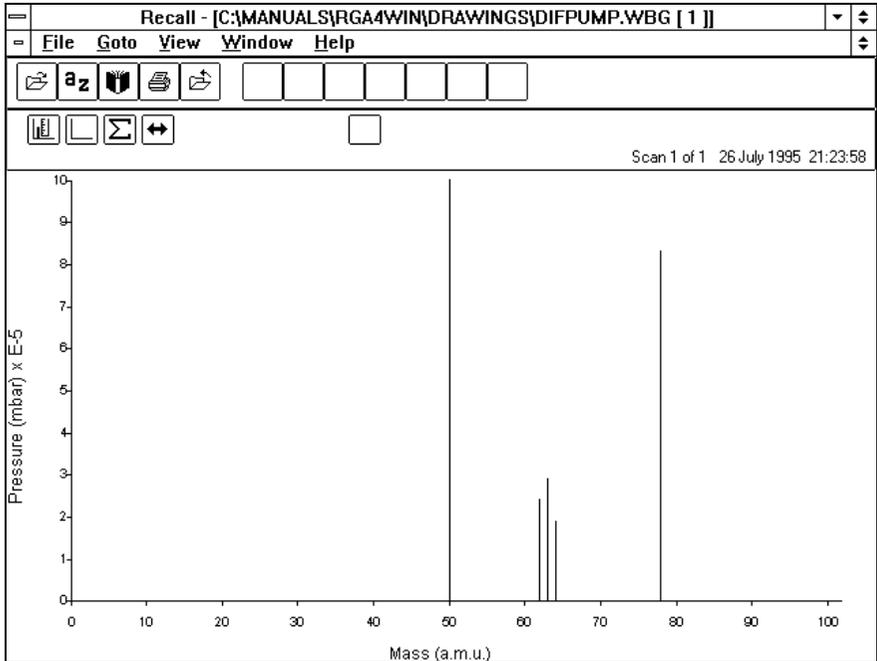


Figure 9 Polyphenylether diffusion pump oil

## 2.2.5 Carbon monoxide and carbon dioxide

Characteristic spectrum of carbon monoxide and carbon dioxide outgassed by filaments and ion source. Solve by switching quadrupole into degas remembering to degas filaments of other equipment such as ion gauges.

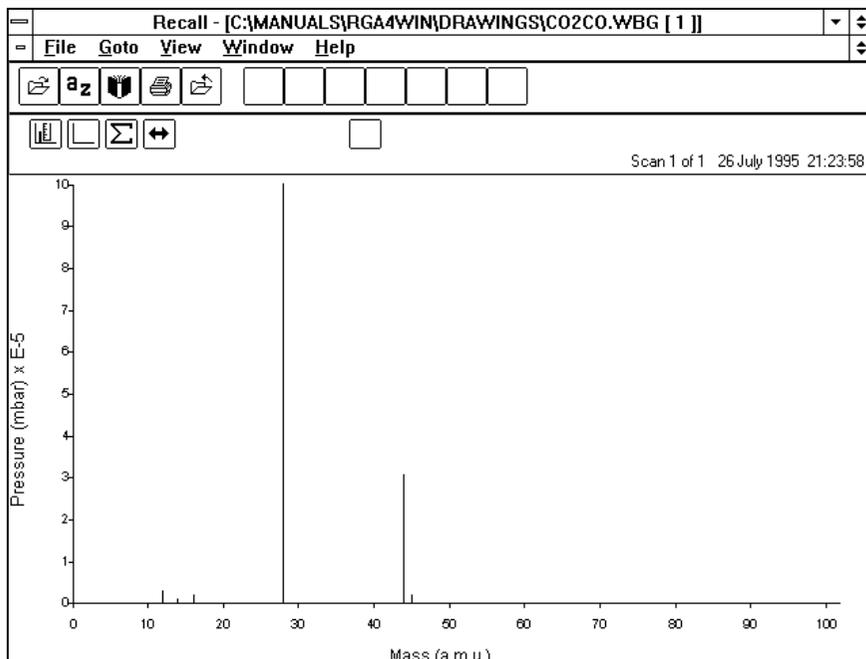


Figure 10 Carbon dioxide & monoxide

## 2.2.6 Clean high vacuum

Characteristic spectrum of a clean high vacuum. Note the relatively high level of hydrogen which is desorbed from the metal walls of the vacuum

system. Mass 28 due to carbon monoxide will always be present, the extent depending on how many filaments, and their types, are in operation.

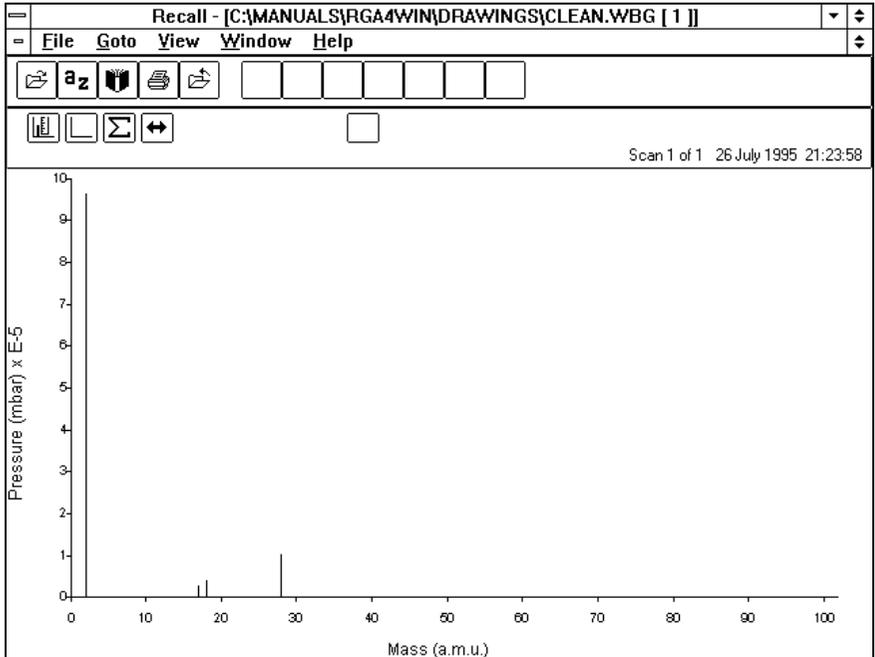


Figure 11 Clean high vacuum



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## Appendix 4.

# Cracking pattern table

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The following table lists some of the more common gases encountered in residual gas analysis along with their cracking patterns. The minor peaks are shown with their approximate intensity (Height) relative to the base peak which it is assumed equals 100.

COMPONENT	Base Peak	MINOR PEAKS (Height)		
		1	2	3
Hydrogen	2	1 (3)	-	-
Helium	4	-	-	-
Methane	16	15 (86)	14 (16)	13 (9)
Ammonia	17	16 (80)	15 (7)	14 (2)
Water	18	17 (21)	16 (1)	-
Neon	20	22 (10)	-	-
Ethylene	28	27 (64)	26 (63)	25 (12)
Carbon Monoxide	28	12 (5)	16 (2)	29 (1)
Nitrogen	28	14 (5)	29 (1)	-
Ethane	28	27 (34)	30 (24)	26 (23)
Methanol	31	32 (67)	29 (65)	28 (6)
Ethanol	31	45 (34)	27 (24)	29 (23)
Oxygen	32	16 (11)	-	-
Hydrogen Chloride	36	38 (32)	35 (17)	-
Argon	40	20 (13)	-	-
N-Butane	43	29 (38)	27 (28)	41 (28)
Acetone	43	58 (27)	27 (8)	42 (7)
Carbon Dioxide	44	16 (9)	28 (8)	12 (7)
Iso-Propyl Alcohol	45	43 (17)	27 (16)	29 (10)
Diffusion Pump Oil	45	59 (94)	43 (68)	41 (39)
Rotary Pump Oil	57	43 (73)	55 (73)	41 (33)
Sulphur Dioxide	64	48 (49)	32 (10)	16 (5)
Benzene	78	52 (19)	51 (19)	50 (16)
Trichloroethylene	95	130 (90)	32 (85)	60 (65)
Polyphenylether	446	77 (79)	51 (28)	39 (10)
Diffusion Pump Oil				



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## Appendix 5.

# Relative ionisation sensitivity table

---

Substance	Formula	Relative Ionisation Sensitivity
Acetone	$(\text{CH}_2)_2\text{CO}$	3.6
Air		1.0
Ammonia	$\text{NH}_3$	1.3
Argon	Ar	1.2
Benzene	$\text{C}_6\text{H}_6$	5.9
Benzonic Acid	$\text{C}_4\text{H}_5\text{COOH}$	5.5
Bromine	Br	3.6
Butane	$\text{C}_4\text{H}_{10}$	4.8
Carbon Dioxide	$\text{CO}_2$	1.4
Carbon Monoxide	CO	1.06
Carbon Tetrachloride	$\text{CCl}_4$	6.0
Chlorobenzene	$\text{C}_6\text{H}_5\text{Cl}$	7.0
Chloroethane	$\text{C}_2\text{H}_5\text{Cl}$	4.0
Chloroform	$\text{CHCl}_3$	4.8
Chloromethane	$\text{CH}_3\text{Cl}$	3.1
Cyclohexylene	$\text{C}_6\text{H}_{12}$	6.4
Deuterium	$\text{D}_2$	0.35
Dichlorodifluoromethane	$\text{CCl}_2\text{F}_2$	2.7
Dichloromethane	$\text{CH}_2\text{Cl}_2$	3.7
Dinitrobenzene	$\text{C}_6\text{H}_4(\text{NO}_2)_2$	7.8
Ethane	$\text{C}_2\text{H}_6$	2.6
Ethanol	$\text{C}_2\text{H}_5\text{OH}$	3.6
Ethylene Oxide	$(\text{CH}_2)_2\text{O}$	2.5
Helium	He	0.14
Hexane	$\text{C}_6\text{H}_{14}$	6.6
Hydrogen	$\text{H}_2$	0.44
Hydrogen Chloride	HCl	1.6
Hydrogen Fluoride	HF	1.4

<b>Substance</b>	<b>Formula</b>	<b>Relative Ionisation Sensitivity</b>
Hydrogen Iodide	HI	3.1
Hydrogen Sulphide	H <sub>2</sub> S	2.2
Krypton	Kr	1.7
Lithium	Li	1.9
Methane	CH <sub>4</sub>	1.6
Methanol	CH <sub>3</sub> OH	1.8
Neon	Ne	.23
Nitrogen	N <sub>2</sub>	1.0
Nitric Oxide	NO	1.2
Nitrous Oxide	N <sub>2</sub> O	1.7
Oxygen	O <sub>2</sub>	1.0
n-Pentane	C <sub>5</sub> H <sub>12</sub>	6.0
Phenol	C <sub>6</sub> H <sub>5</sub> OH	6.2
Phosphine	PH <sub>3</sub>	2.6
Propane	C <sub>3</sub> H <sub>8</sub>	3.7
Silver Perchlorate	AgClO <sub>4</sub>	3.6
Tin Iodide	SnI <sub>4</sub>	6.7
Sulphur Dioxide	SO <sub>2</sub>	2.1
Sulphur Hexofluride	SF <sub>6</sub>	2.3
Toluene	C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>	6.8
Trinitrobenzene	C <sub>6</sub> H <sub>3</sub> (NO <sub>2</sub> ) <sub>3</sub>	9.0
Water	H <sub>2</sub> O	1.0
Xenon	Xe	3.0
Xylene	C <sub>6</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>2</sub>	7.8

---

## Appendix 6.

# Power up reset settings

---

### General

#### Filament selected 1

Filament state Off  
Total Pressure Off  
Speed 3

### Bar Chart

Detector Faraday  
Gain E-5  
Auto-Gain Off  
Span 50

### Analogue

Detector same as bar chart  
Gain same as bar chart  
First Mass 18

### User peaks channels

Channel	Mass	Gain	Auto Gain	Detector	Alarm Level	Alarm State	Alarm Audio
1	2	E-5	On	Faraday	5.0	Off	Off
2	17	E-5	On	Faraday	5.0	Off	Off
3	18	E-5	On	Faraday	5.0	Off	Off
4	28	E-5	On	Faraday	5.0	Off	Off
5	32	E-5	On	Faraday	5.0	Off	Off
6	44	E-5	On	Faraday	5.0	Off	Off

## Trend

Interval 10 secs

Channels are the same as User Peaks

## Leak check

Detector same as bar chart

Gain same as bar chart

Probe Mass 4

Audio Off

## Utilities

Auto Help On

Aux I/O Alarm

Total Pressure

Mantissa 9.9

Exponent E-5

State Disabled

RS232 Interface

Baud Rate 1200

Parity None

Stop Bits 1

Data Bits 8

---

## Appendix 7.

# Dumb terminal emulator

---

```
10 REM **Dumb Terminal Emulator**
20 OPEN "COM1:1200,N,8,1" AS #3
30 ON COM(1) GOSUB 120
40 COM(1) ON
50 A$ = INKEY$
60 IF A$ = "" THEN GOTO 50
70 IF A$ = CHR$(1) THEN CLOSE : END
80 PRINT #3, A$
90 PRINT A$
100 GOTO 50
110 REM **PRINT CHARACTERS RECEIVED FROM VACSCAN**
120 B$ = INPUT$(LOC(3),#3)
130 PRINT B$
140 RETURN
```

Notes: The program is written in GW-BASIC for an IBM PC or compatible. VACSCAN should be connected to COM1 of the PC.

Line 20 Serial port COM1  
1200 Baud  
No Parity  
8 Data bits  
1 Stop bit

Line 30 Specify line number of subroutine to handle input from VACSCAN.

Line 40 Enable input trapping on COM1

Line 50 Read Keyboard

Line 60 Loop back to line 50 if no key pressed

Line 70 If key pressed was CtrlA then exit program

Line 80 Send ASCII code for key pressed to VACSCAN

Line 90 Echo key pressed to PC display

Line 100 Back to read next key press

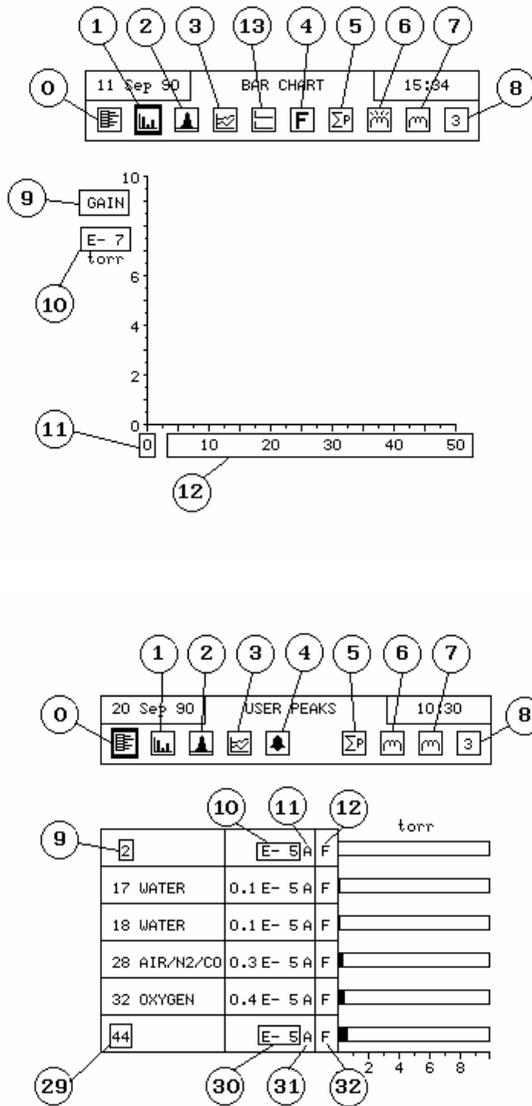
Line 120 Read characters sent by VACSCAN into B\$

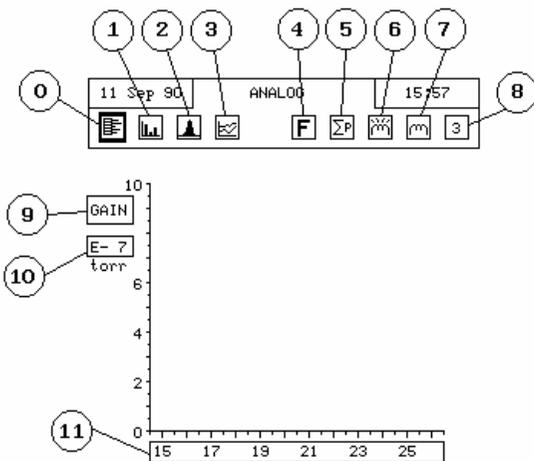
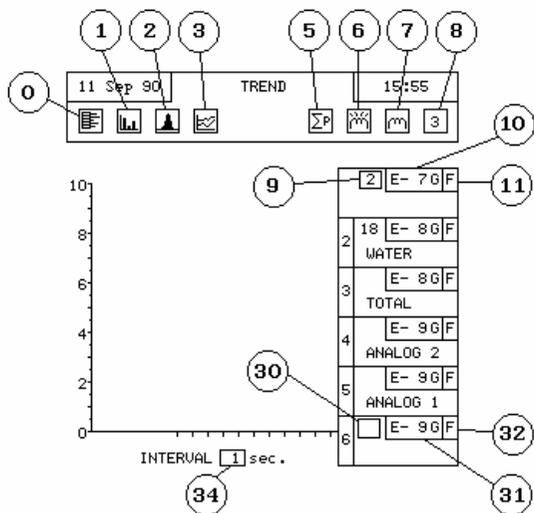
Line 130 Display Characters received on PC display

Line 140 End COM1 input trap routine

# Appendix 8.

## Field numbers RS232 (Fn) command





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## Appendix 9.

# **Health & safety clearance form**

1. This form must be used when returning analysers and other equipment for service.
2. A completed copy of this form should be faxed or sent by post to ensure that we have this information before we receive the equipment.

A further copy should be handed to the carrier with the equipment.

3. Failure to complete the form or comply with the procedure will lead to delays in servicing the equipment.

## **RETURNS FORM**

1. Please complete the form and fax or send by first class post to the appropriate Spectra facility. Fax numbers and addresses can be found on the inside front page of this manual. Please ensure that we have this information before we receive the equipment. A copy should also be given to the carrier.

**FAILURE TO COMPLETE THIS FORM OR COMPLY WITH THE PROCEDURE WILL LEAD TO DELAYS IN SERVICING THE EQUIPMENT**

Please Complete The Following

Our RMA number:

Customer P.O. No.

Customer Bill To Address:

Company  
Department  
Address

City  
Zip/Postal Code

Customer Return To Address (if different from above):

Company  
Department  
Address

City  
Zip/Postal Code

User's Name:

Phone No.:

Equipment Shipped  
Item 1:

Serial No.:

Item 2:

Serial No.:

Item 3:

Serial No.:

Please describe the system fault in detail:

Details of all substances pumped or coming into contact with the returned equipment.

Chemical names:

Precautions to be taken in handling these substances:

Action to be taken in the event of human contact or spillage:

I hereby confirm that the only toxic or hazardous substances that the equipment specified above has been in contact with are named above, that the information given is correct and that the following actions have been taken:

1. The equipment has been securely packaged and labelled.
2. The carrier has been informed of the hazardous nature of the consignment.

Signed:

Title:

Date:

Phone No

