Flame Photometer

Models PFP7 and PFP7/C

Operating and Service Manual

500 795

Safety

Please read this information carefully prior to installing or using this equipment.

1. The unit described in this manual is designed to be operated only by trained personnel. Any adjustments, maintenance and repair must be carried out as defined in this manual by a person qualified to be aware of the hazards involved.

2. It is essential that both operating and service personnel employ a safe system of work in addition to the detailed instructions provided in the manual.

3. The covers of the unit should only be removed by personnel who have been trained to avoid the risk of shock. At this point the unit must be disconnected from all services i.e. gas and electric.

4. References should always be made to the health and safety data supplied with any chemicals used. Generally accepted laboratory procedures for safe handling of chemicals should be employed.

5. If it is suspected that safety protection has been impaired in any way, the unit must be made inoperative and secured against any intended operation. The fault condition should be reported immediately to the appropriate servicing authority. In all such reports the serial number of the flame photometer must be quoted.

6. Please read the operating precautions in section 4.6.

7. For further help and advice please visit www.jenway.com or contact your local distributor, e-mail: support@jenway.com or for service enquiries please email: service@jenway.com.

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Section 1

Introduction

1.1 Instrument description

The PFP7 and PFP7/C are low temperature, single channel emission flame photometers designed for the routine determination of sodium (Na) and potassium (K). Additional filters are available for the determination of lithium (Li), calcium (Ca) and barium (Ba). Both versions are fitted with automatic flame failure detection for user safety, making them ideal for use in clinical, industrial or educational applications. The model PFP7/C is specifically designed for use in clinical applications. The in-built lineariser circuitry enables readings of both Na and K, at normal clinical serum concentrations to be displayed directly in mmol/l. Serum samples must be diluted 200:1 or 100:1 prior to presentation to the flame photometer. Jenway are able to offer a diluter to enable this to be carried out efficiently and accurately.

1.2 Principles of operation

Flame photometry relies upon the fact that the compounds of the alkali and alkaline earth metals can be thermally dissociated in a flame and that some of the atoms produced will be further excited to a higher energy level. When these atoms return to the ground state they emit radiation which lies mainly in the visible region of the spectrum. Each element will emit radiation at a wavelength specific for that element. The table below gives details of the measurable atomic flame emissions of the alkali and alkaline earth metals in terms of the emission wavelength and the colour produced.

Element	Emission Wavelength (nm)	Flame Colour
Sodium (Na)	589	Yellow
Potassium (K)	766	Violet
Barium (Ba)	554	Lime Green
Calcium (Ca)	622*	Orange
Lithium (Li)	670	Red

*Note: Calcium is measured by using the calcium hydroxide band emission at 622nm as the Calcium main atomic emission occurs at 423nm.

Over certain ranges of concentration the intensity of the emission is directly proportional to the number of atoms returning to the ground state. This is in turn proportional to the absolute quantity of the species volatized in the flame, i.e. light emitted is proportional to sample concentration.

It can be seen that if the light emitted by the element at the characteristic wavelength is isolated by an optical filter and the intensity of that light measured by a photo-detector, then an electrical signal can be obtained proportional to sample concentration. Such an electrical signal can be processed and the readout obtained in an analogue or digital form.

A simple flame photometer consists of the following basic components:

a) The burner: a flame that can be maintained in a constant form and at a constant temperature.
b) Nebuliser and mixing chamber: a means of transporting a homogeneous solution into the flame at a steady rate.
c) Simple colour filters (interference type): a means of isolating light of the wavelength to be measured from that of extraneous emissions.
d) Photo-detector: a means of measuring the intensity of radiation emitted by the flame.

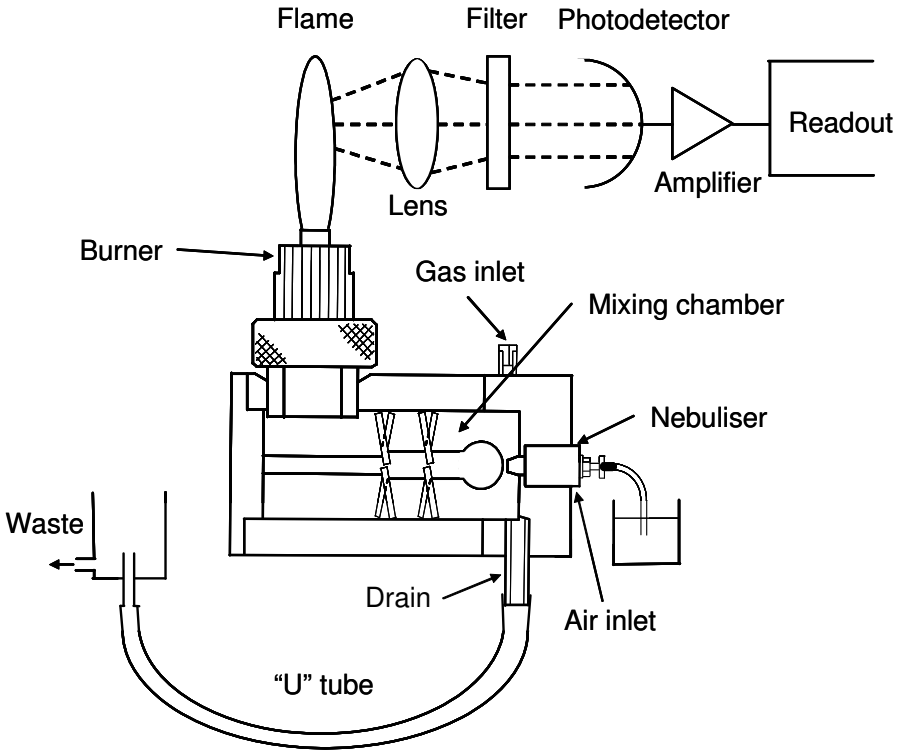

Figure 1.2.1: Schematic diagram showing the component parts of a flame photometer.

The analysis of alkali and alkaline earth metals by flame photometry has two major advantages:

i. Their atoms reach the excited state at a temperature lower than that at which most other elements are excited.
ii. Their characteristic wavelengths are easily isolated from those of most other elements due to wide spectral separation.

The analysis of Na, K, Li, Ba and Ca are typically determined at low temperatures, i.e. 1500-2000°C, therefore suitable fuel mixtures are propane/air, butane/air and natural gas/air.

1.3 Specification

	PFP7		PFP7/C	
Ranges:	-		120-160 mmol/l Na (linearised) 0-10.0 mmol/l K	
Limits of Detection:	Na	0.2ppm	-	
	K	0.2ppm	-	
	Li	0.25ppm	Li	0.25ppm
	Ca	15ppm	Ca	15ppm
	Ba	30ppm	Ba	30ppm

Reproducibility: 1% Coefficient of variation (C.V.) for 20 consecutive samples using 10ppm Na set to read 50.0.
Readings taken at 20 second intervals.

N.B. C.V. is defined as: $\frac{\text{the sample standard deviation}}{\text{mean reading}} \times 100$

And sample standard deviation as: $\sqrt{\frac{(\bar{x}-x^2)}{n-1}}$

Where x is the reading, $\bar{x}$ is the mean readings of the series and n is the number of readings.

Linearity: Better than 2% when concentration of 3ppm Na and K and 5ppm Li are set to read 100.

Specificity: Interference from Na, K and Li when equal in concentration to the test element will be less than 0.5%.

Stability: Better than 2% over 5 minutes when continuously aspirating 10ppm, sample set to read 50.0.
Zero drift better than 2% per hour.
N.B. Note warm up requirement.

Sample Requirements: Between 2 and 6ml/minute.

Recorder Output: Nominal 1.00 volt for readout of 100.0.

Warm Up: The flame must be alight for at least 15 minutes to ensure achievement of the above stated specifications.

Services:

Electrical:	90-125V or 190-250V @ 50/60Hz.
Air:	Moisture and oil-free. 6 litres/minute at 1kg/cm^2 (14psi).
Fuel:	Propane, butane, natural gas or L.P.G.

Operating Environment: 15ºC to 35ºC

Size: 420 x 360 x 300mm

Weight: 8kg

Section 2

Installation

2.1 Services required

The fuel and air supplies to the instrument must be clean and dry and supply pressures regulated within the limits specified. Any contamination, moisture or variation in supply pressure will directly affect the performance of the instrument.

NOTE: The instrument will only operate with the correct type of air compressor and gas regulator.

2.1.1 Voltage

90 - 125V or 190 - 250V @ 50 or 60Hz.

2.1.2 Fuel

- Propane or butane regulated to 10-15 inches water gauge (0.36-0.54psi or 0.025-0.038kg/cm^2).
- Natural gas at mains pressure between 3 and 10 inches water gauge (0.11-0.36psi or 0.0076-0.025kg/cm^2).
- L.P.G. as for propane.
- Suitable regulators are available from Jenway; refer to Section 2.5.

2.1.3 Air

A supply of dry, clean and pulse-free air at a pressure between 14 and 30 psi (approx. 1-2 kg/cm^2) at 6 litres/minute is required. A suitable compressor and water separator are available from Jenway; refer to Section 2.5.

2.1.4 Drain

The instrument will need to be sited near a drain or sink to enable disposal of waste liquid. A suitable receptacle can be utilised if provision is made for easy disposal of its contents. **WARNING:** The waste liquid will still contain any hazardous materials that were in the original samples and should be handled and disposed of with the same care. Waste liquid should always be considered to be of a pathogenic nature where the instrument is used in a clinical environment.

2.2 Unpacking

Remove the instrument from the packaging and ensure the following items are present:

	Part Code
Model PFP7 or PFP7/C Flame photometer	
Auxiliary power plug	009 035
Mains cable with connector (plug optional as ordered)	013 046
Nebuliser inlet tube (500mm)	500 193
Gas tube, low pressure (2 metres)	500 191
Silicon rubber tube (drain)	023 003
Air tube (2 metres)	500 192
Nozzle 1: gas	026 012
Nozzle 2: air	026 013
Allen key, 2.5mm	060 037
Adjustable hose clip	060 083
Drain trap	500 018
Drain trap clip	500 114
Nebuliser cleaning wire	500 194

Any shortages or damage should be reported immediately to the manufacturer or local distributor.

2.3 Assembly

Place the instrument on a bench and proceed as follows (see **Figures 2.3.1** and **2.3.2** below).

1. Take the mixing chamber assembly and ensure that the fluted burner (1) is in place (remove the retaining tape); offer up to the chimney. Look down the chimney and ensure that the burner locates centrally in the inner chimney. Screw the locking ring (2) onto the threaded boss provided and tighten until finger tight, ensuring that the mixing chamber is at right angles to the side of the instrument.

2. Fit the nebuliser (3) into the end cap and screw on the tube (4) provided. Ensure that the sealing olive is fitted correctly between the nebuliser and the screw on connector.

3. If natural gas is to be used, remove the restrictor (5) fitted into the end of the fuel inlet (6) on the mixing chamber. The restrictor should remain in place if butane, propane or L.P.G. is to be used as fuel. Keep the restrictor screw in case of any future change in gas supply. Push the fuel tubing onto the fuel inlet connector (7). This tube does not need securing.

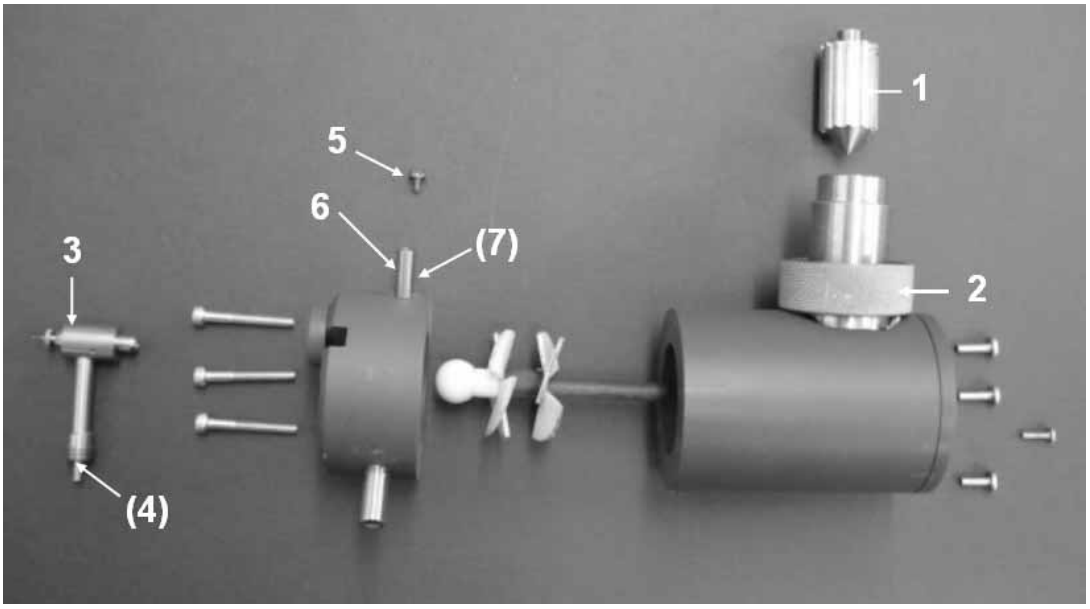

Figure 2.3.1: Assembly of the mixing chamber, burner and nebuliser.

4. Take the drain trap clip (8) and, with the screw provided, fix to the hole situated at the chimney end of the rear panel. Fix a length of silicon rubber tubing (9) onto the side port on the drain trap such that it is long enough to reach either the sink or the waste receptacle to be used. Fit the drain trap into the clip on the rear panel and run the short piece of tubing (10) from the bottom of the drain trap to the drain trap outlet (11) on the bottom of the mixing chamber. This tube can be pushed on and does not need securing.

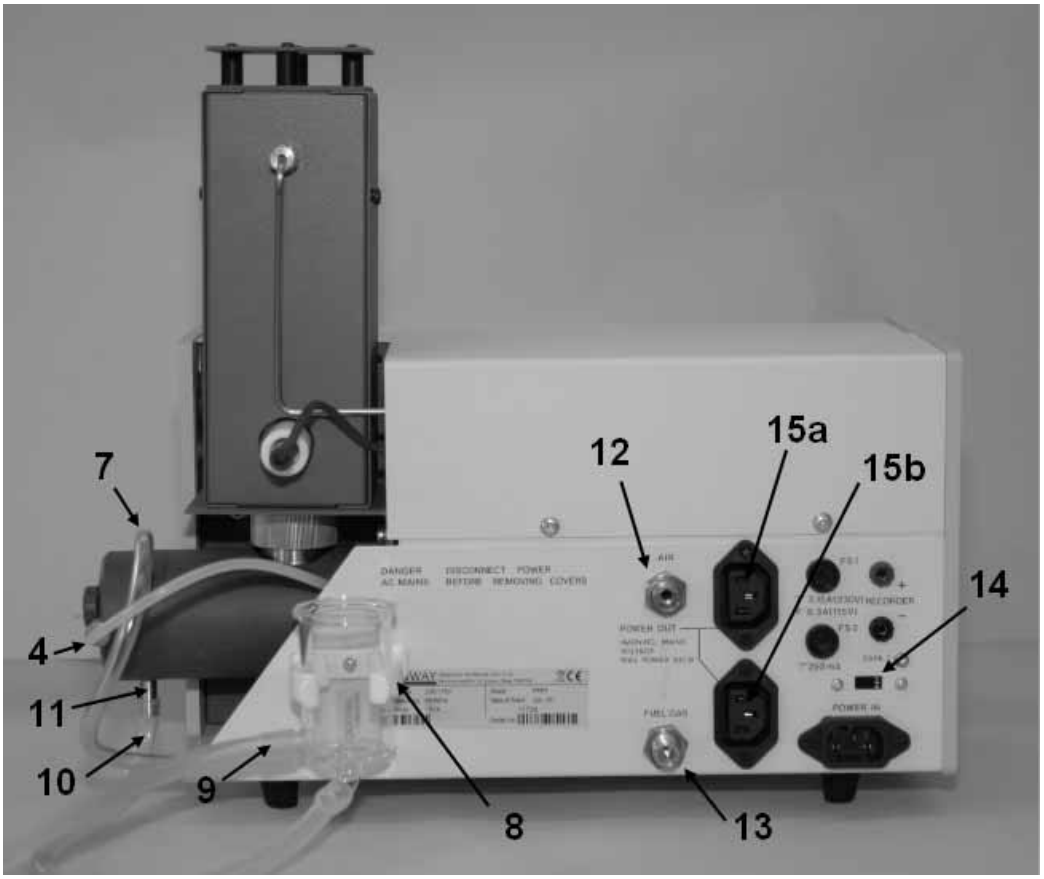

Figure 2.3.2: Rear panel showing the drain trap, air and fuel tubing.

2.4 Installation

WARNING

The exhaust gases from the chimney are very hot. No obstruction should be placed above the instrument and the instrument should be located in a position that makes accidental contact with the chimney or its exhaust unlikely.

The instrument needs to be operated in a well-ventilated room (although very strong draughts should be avoided).

Ensure the air tubing is routed away from sources of heat.

Fit the air and fuel inlet connectors to the ports provided on the rear of the instrument.

1. Fit the appropriate lengths of tubing to the connectors (12 and 13) and secure with the screw clips provided. Run the tubing to the air and fuel supplies to be used.

   NOTE: The maximum inlet pressure and regulation requirements are defined in Section 2.1.

   Turn on the fuel supply at the cylinder or source and check all fuel joints for leaks by using soap solution.

2. Check the position of the voltage selector switch (14) on the rear panel and the value of the fuse FS1. If necessary, adjust to suit your supply voltage. If necessary connect a

suitable plug to the 3-pin AC supply lead. The colours of the wires conform to the internationally recognised standard such that:

BROWN	**LIVE**
BLUE	**NEUTRAL**
GREEN/YELLOW	**EARTH**

IMPORTANT – THE INSTRUMENT MUST BE EARTHED.

The green/yellow wire in the AC supply must be connected to a properly grounded terminal.

If a compressor and/or pen recorder is to be run directly from the instrument then they should be wired to the plugs provided and connected to the POWER OUT sockets (15a and 15b).

Press the power switch on the front panel. The digital readout should be illuminated.

3. Fill the centre tube of the drain trap and the connecting silicon rubber tubing to the mixing chamber with deionised water. Check that no air bubbles are trapped in this tube and that it flows and runs to waste freely. Ensure that the drain trap is pushed completely down on its clip.

2.5 Accessories

Always use recommended spares and accessories. Even if an alternative part may appear obviously suitable there may be some minor variations in specification that could degrade the performance of the instrument.

Accessory	**Part Code**
Model 8515 air compressor (220V 50Hz)	535 001
Model 8516 air compressor (110V 60Hz)	535 002
Dilutor 230V	037 001
Dilutor 110V	037 002
Analogue to RS232 Data Logger	037 501
Calcium filter	500 125
Lithium filter	500 126
Barium filter	500 127
Butane regulator	500 178
Propane regulator	500 179
Natural gas regulator	500 180
Water separator (small)	500 176
Water separator (large)	500 177
Dust cover	500 134
Cleaning solution (1 litre)	025 171
Minor spares kit	500 172
Major spares kit	500 173

Section 3

Analysis Preparation

3.1 Calibration standards

A comprehensive range of aqueous calibration standards is available from Jenway in both industrial and clinical levels. These must be diluted to a suitable concentration for aspiration into the flame (see Sections 3.3 and 4.3)

Clinical Standards (500ml)	**Part Code**
1.00mmol/l Li	025 008
100mmol/l Na, 100mmol/l K	025 004
140mmol/l Na, 5mmol/l K	025 006
120mmol/l Na, 2mmol/l K	025 007
160mmol/l Na, 8mmol/l K	025 005
160mmol/l Na, 80mmol/l K	025 027

Industrial Standards (500ml)	**Part Code**
1000ppm K	025 023
1000ppm Li	025 024
3000ppm Ba	025 025
1000ppm Na	025 021
1000ppm Ca	025 009

When preparing standards always observe the following:

1. Standards must always contain the constituents that are present in the samples in the same concentration ratios; i.e. if samples are prepared in 0.05M HCl then the standards should also contain 0.05M HCl.

2. Always ensure that the standards encompass the expected range of the sample concentrations.

3. Standards should be prepared so as to ensure that the region in which measurements are made coincide with the concentrations that produce the optimum performance from the flame photometer, i.e…

    - …when measuring sodium, the top standard is ideally 10ppm,
    - …when measuring potassium, the top standard is ideally 10ppm,
    - ...when measuring calcium, the top standard is ideally 100ppm,
    - …when measuring barium, the top standard is ideally 1000ppm,
    - …when measuring lithium, the top standard is ideally 10ppm.

    A minimum of four standards should be prepared to enable an accurate calibration curve to be constructed.

NOTE: The blank used should contain all the constituents of the standard solutions except the element being measured.

Since a flame photometer measures the concentration of the element itself in solution, standard solutions prepared from the salts of sodium, potassium, lithium, calcium and barium must be made up to contain the concentrations required in terms of the quantity of the elements.

Below are two examples of how to prepare standards of 1mg Na/100ml (10ppm Na) and 1mg K/100ml (10ppm K).

3.1.1 Sodium

Accurately weigh 0.634g of dry “Analar” quality NaCl, dissolve in pure deionised water and wash into a 500ml volumetric flask. Fill to the mark with pure deionised water. To prepare the standard solution for use with the flame photometer, this stock solution should be diluted 1 in 50.

Calculation:

Atomic weight Na = 23.0 Molecular weight NaCl = 58.46

Therefore, 0.634g NaCl contains $\frac{0.634 \times 23}{58.46} = 0.25$g Na

Thus in 500ml of solution there is 250mg Na or 50mg Na/100ml.
Diluting 1 in 50 gives a standard of 1mg Na/100ml = 10ppm Na.

3.1.2 Potassium

Accurately weigh 0.477g of dry “Analar” quality KCl, dissolve in pure deionised water and wash into a 500ml volumetric flask. Fill to the mark with pure deionised water. To prepare the standard solution for use with the flame photometer, this stock solution should be diluted 1 in 50.

Calculation:

Atomic weight K = 39.1 Molecular weight KCl = 74.56

Therefore, 0.477g KCl contains $\frac{0.477 \times 39.1}{74.56} = 0.25$g K

Thus in 500ml of solution there is 250mg K or 50mg K/100ml.
Diluting 1 in 50 gives a standard of 1mg K/100ml = 10ppm K.

3.1.3 Storage

Store solutions away from direct sunlight in a cool place, ideally at temperatures below 25ºC. Glass containers should not be used for storage as they can affect the sodium concentration levels. Standards should be stored in sealed, plastic vessels and in high concentrations, (e.g. as a stock 1000ppm solution) and dilutions prepared as required. The long-term storage of low concentration standards is not recommended due to degradation of ionic species.

3.2 Sample preparation

There are several practical points regarding sample preparation, which should be adhered to in order to achieve the required accuracy in your analysis:

1. Avoid handling samples with fingers. This leads to serious contamination, e.g. if a finger is immersed in 20ml of deionised water the resulting Na concentration will exceed that of a 10ppm standard.

2. All analyses involve the use of a diluent, which is almost always deionised water. This should be of the highest quality for accurate flame analysis. Sodium, potassium and calcium are present in high concentrations in tap water and thus efficient deionisation is essential.

3. Species that cause interference should be removed from samples or the equivalent concentration of the interferant should be present in the standards so as to avoid erroneous results, e.g. if a sample of approximately 10ppm Na contains approximately

1000ppm Ca, then Na analysis can only be achieved by removing the Ca with oxalate/oxalic acid or ensuring all standards contain 1000ppm Ca.

4. Always try to follow a well-documented analytical procedure, which should contain information pertaining to interference removal when applicable.

5. Standards and samples should not be exposed to the atmosphere for long periods due to contamination from airborne particles and the evaporation of the solvent that could lead to elevated concentrations.

6. When in doubt about the equipment or application, the operator should contact Jenway for advice.

3.2.1 Sample extraction

A number of methods for extracting sodium, potassium, lithium, calcium and barium from a wide variety of raw materials may be obtained by contacting the technical support helpline at support@jenway.com.

The sample must be in the form of an aqueous solution, with no solid matter present, to be suitable for direct introduction into the flame photometer. This is achieved by:

- Extracting the salts from solid samples using deionised water or suitable extractants e.g. saturated $CaSO_4$ for sodium in soil. Extraction is more successful using a blender, macerator or shaking machine.
- If the sample is organic then the organic material should be removed by ashing. The remaining oxides are then dissolved using strong acids.
- Filtration/centrifugation is used to remove solid debris.

When aqueous, the sample can then be diluted to a known, accurately measured volume using deionised water. If it is a concentrated sample then the dilution ratio should be increased. If the sample concentration is low then a small volume of diluent and initial extractant should be used. Whichever method of extraction is used, the resultant solution must always be free of any particulate matter that may cause blockages in the nebuliser capillary tube.

3.3 Dilution

In order to obtain samples and standards of the right concentration for aspiration into the flame, various levels of dilution will often be necessary. Good quality deionised water should normally be used for carrying out these dilutions and it is recommended that the same batch of water should be used for diluting the samples and standards. More information on typical dilution ratios is given in Section 4.3.

Section 4

Operation

4.1 Front and rear panel controls

4.1.1 Front panel controls

Figure 4.1.1: Front panel

power — A two-position rocker switch which controls the AC supply of the instrument. Any accessories connected to the auxiliary **POWER OUT** sockets on the rear panel are also controlled by the front panel **power** switch.

ignition — A spring loaded switch which, when depressed, will cause an electrical discharge between the ignition electrode and the burner unit, thereby causing fuel ignition.

d.p. — This switch controls the position of the decimal point.

fuel — A fine needle valve that controls the flow of fuel and enables optimum flame conditions to be set.

blank — This control sets zero (or low reading) when a blank standard is aspirated.

sensitivity: fine and coarse — Two controls which are used in conjunction to set the digital readout to an appropriate number when a calibration standard is aspirated.

filter select — A five position control which will select the appropriate optical filter for the element being determined.
NOTE: positions 1, 2 and 3 will normally be blank unless optional filters (Ca, Ba or Li respectively) have been fitted.

4.1.2 Rear panel controls

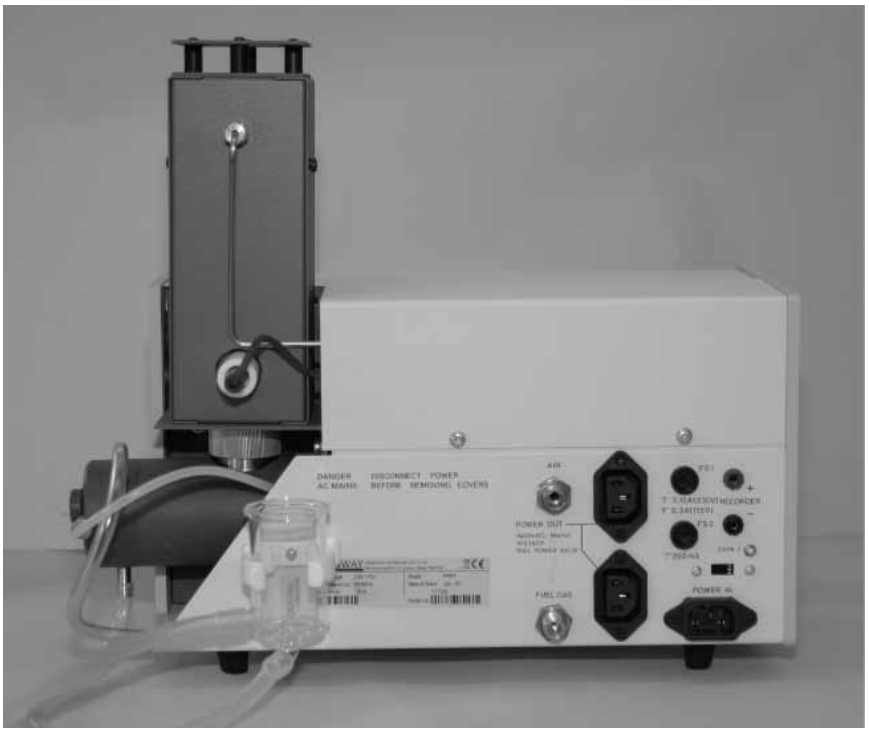

Figure 4.1.2: Rear panel

Voltage selection	A two-position switch marked 230 and 115. These positions allow operation from voltage supplies 190-250 volts and 90-125 volts respectively at either 50 or 60Hz. **WARNING: when adjusting the operating voltage it may be necessary to change the top fuse as indicated on the rear panel.**
Fuses	Two fuses are fitted to the instrument. **FS1** is the primary fuse provided to give protection to the instrument and any accessories connected to the **power out** sockets. **FS2** is to protect the electronic circuitry in the PFP7. Both FS1 and FS2 should be of an anti-surge type.
POWER IN	A three pin receptacle for the AC mains supply
POWER OUT	Two three pin sockets for flame photometer accessories such as a compressor and a pen recorder. The power from these sockets is controlled by the instrument **power** switch on the front panel.
RECORDER	Two 4mm sockets which will provide an analogue signal of approximately 1 volt when the readout is 1000 digits or 100.0, 10.00 and 1.000.
FUEL GAS	1/4" connector for fuel tubing. **IMPORTANT: Fuel supply must be regulated to 10-15 inches water gauge (0.36-0.54psi or 0.025-0.38kg/cm^2). See section 2.1.2 for information on different fuel types.**
AIR	5/16" connector for air tubing. **IMPORTANT: Air pressure on the inlet to the instrument must not exceed 30psi (2kg/cm^2). See section 2.1.3.**

4.2 Operation

1. Ensure that the drain trap is pushed fully down on its clip. Ensure that the drain trap has solution in it and that no air locks are present. If necessary, purge by adding deionised water and allowing the surplus to run away.

2. Close the **fuel** valve by turning fully clockwise. To avoid damaging the valve, it should not be forced.

3. Turn the **fuel** valve the required number of turns anti-clockwise depending on the fuel being used.

Fuel	**Number of turns**
Propane	3
Butane	4
Natural gas	Fully open
L.P.G.	3.5

4. Turn on the fuel supply at source i.e. cylinder.

5. Switch on electrical power by depressing the **power** switch. If the air compressor is powered separately, switch on the air compressor. Ensure that air is present by listening for the hissing created as it passes through the nebuliser.

6. Depress the ignition switch and hold down. Watch the **FLM** indicator in the display window. When this indicator is illuminated the flame is alight and the ignition switch can be released. If the **FLM** indicator does not light within approximately 20 seconds, release the switch and open the **fuel** valve one turn. Allow the gas to disperse before continuing. Depress the ignition switch for a further 20 seconds. This process may be repeated until successful ignition occurs. If the **fuel** valve has to be opened more than 5 turns more than recommended above, refer to Section 7.5.

7. Set the **filter select** control to the desired position.

8. Aspirate deionised water and set the readout to zero by adjusting the **blank** control.

9. Aspirate a standard solution of slightly higher concentration than expected in the samples to be tested. Adjust the **fine and coarse** control until a positive reading is obtained. This is a nominal value to be used in optimising flame conditions.

10. Adjust the **fuel** valve in a clockwise direction until a peak reading is obtained.

    NOTE: There is a time delay between adjusting the flow of fuel and seeing the effect of the adjustment. A pause of a few seconds is therefore necessary between making every fine adjustment.

    The optimum flame conditions are different for Na and K and retuning is necessary when switching between elements.

11. For optimum performance the instrument should be allowed 15 minutes to warm-up. During this warm-up period a blank deionised water sample should be aspirated. It should be noted that results, adequate for most purposes, can be obtained from switch on, although standardisation settings will need frequent checking during the warm-up period.

4.3 Calibration: PFP7

It is important to understand that the principles of flame photometry are such that, over **certain concentration ranges**, light emitted from the flame is **directly** proportional to the concentration of the species being aspirated.

The graph below shows that the direct relationship between the flame emission and concentration is only true at relatively low concentrations. Above these low levels the flame begins to saturate and the flame emission ceases to increase in a linear relationship to concentration.

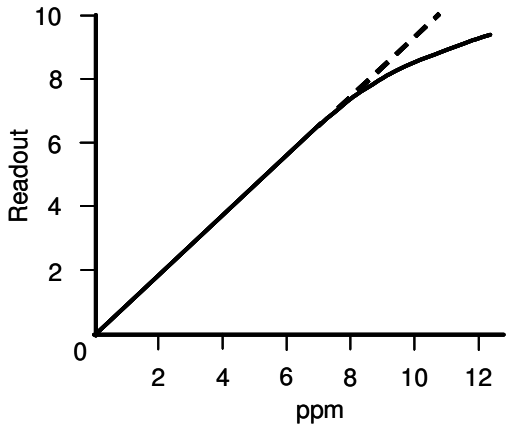

Figure 4.3.1: Relationship between sample concentration and flame emission.

If the samples being analysed lie on the linear part of the curve then the user can take direct concentration readings from the digital display. If, however, the concentration of samples are above the levels shown on the graph then the user has the choice of either:

a. diluting the samples so that they lie on the linear part of the curve, or
b. constructing a calibration curve and relating the digital display reading to the concentration by cross-reference to the curve.

A calibration curve is prepared using standard solutions containing known concentrations of the elements to be determined and if necessary, other materials to ensure that the standard and sample backgrounds match. The concentration range covered by the calibration curve will depend upon the expected concentration of the samples so that the sample readings fall somewhere in the middle of the calibration curve.

Once the calibration curve has been plotted, the readings for the sample solutions are compared with the curve to allow the sample concentrations to be established.

It is important to realise that each element has its own characteristic curve and separate calibration curves must be constructed.

If the same estimation is performed on a routine basis, the calibration curve need only be prepared once and checked periodically. Instrument re-calibration is easily achieved by setting the blank solution to read zero and the top standard to read the same value as it did when the calibration curve was initially prepared. The graph in **Figure 4.3.2** shows a typical curve obtained when measuring in parts per million (ppm).

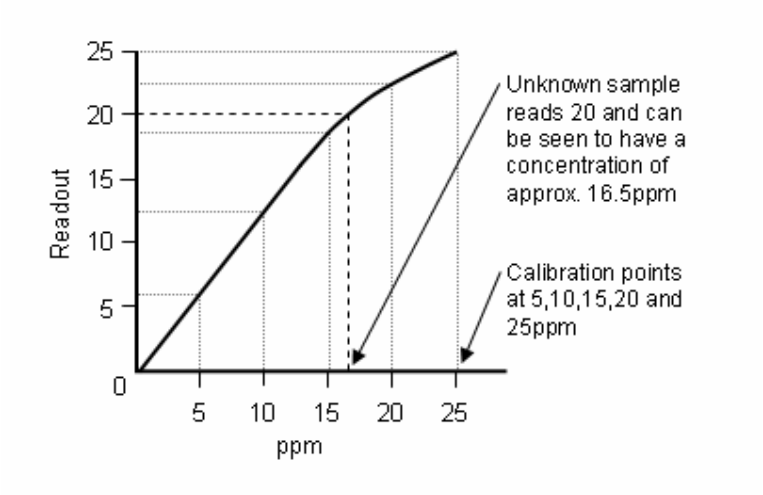

Figure 4.3.2: Typical calibration curve measuring ppm.

Customers working in medical environments are quite likely to be using the S.I. unit of mmol/l to report their results. The relationship between mmol/l and ppm is defined below:

Sodium	Na	1ppm = 0.0435mmol/l	1mmol/l = 23ppm
Potassium	K	1ppm = 0.0256mmol/l	1mmol/l = 39ppm
Lithium	Li	1ppm = 0.1441mmol/l	1mmol/l = 7ppm
Calcium	Ca	1ppm = 0.0250mmol/l	1mmol/l = 40ppm

This relationship means that Na and K samples in the normal clinical range of 136-145mmol/l Na and 3.5-5.0mmol/l K should be pre-diluted 1 in 100 or 1 in 200 to get optimum results from the flame photometer.

1. Aspirate a blank solution and set the readout to 000 using the **blank** control.

2. Aspirate the highest standard solution and set the readout to an appropriate reading using the **fine** and **coarse** sensitivity controls. Re-check the blank setting and adjust if necessary.

3. Aspirate the remaining standard solutions (if used) to construct the calibration curve and note the results.

4. When the blank and standards are set, unknown samples can be aspirated and the results noted, either directly from the instrument readout, or by deriving the concentrations from the calibration curve.

5. Calibration needs to be checked periodically by aspirating the blank and standard solutions. Initially this check should be carried out after every 10 samples. Experience and increased confidence in the PFP7 will enable you to best judge the frequency of this check.

6. The decimal point (**d.p.**) switch can be set to illuminate the decimal point in any significant position. This should be chosen to give sufficient resolution for the test required.

4.4 Calibration: PFP7/C

When using the PFP7/C, a calibration curve is not required as the display is calibrated in direct concentration units. Therefore only one top standard is required to enable this calibration to be performed.

Installation and set-up procedures should be carried out as for the standard Model PFP7.

NOTE: The Model PFP7/C allows direct readout of Na and K concentration in serum samples. Na levels in urine samples may also be read directly from the display, although K levels in urine can only be determined by plotting a calibration graph (refer to standard PFP7 calibration).

Samples of both serum and urine should be diluted 1 in 100 or 1 in 200 to obtain optimum results from the flame photometer.

To calibrate the unit for clinical use the following steps should be carried out:

1. Aspirate deionised water and set the display to read zero.

2. Select the appropriate element (Na or K) on the **filter select** control and the position of the decimal point using the **d.p.** switch.

3. Aspirate the required standard, e.g. 140mmol/l Na, 5.0mmol/l K which has been pre-diluted at least 1 in 100 and set the display reading accordingly using the **fine** and **coarse** sensitivity controls.

4. Adjust the **fuel** valve in a clockwise direction until a peak reading is obtained. Re-set the display reading accordingly for the standard being aspirated.

   NOTE: There is a time delay between adjusting the flow of fuel and seeing the effect of the adjustment. A pause of a few seconds is therefore necessary between making every fine adjustment.

   The optimum flame conditions are different for Na and K and retuning is necessary when switching between elements.

5. Re-check the zero setting and adjust if necessary.

6. Aspirate the pre-diluted sample and note the reading.

7. Calibration needs to be checked periodically by aspirating the blank and standard solutions. Initially this check should be carried out after every 10 samples. Experience and increased confidence in the PFP7/C will enable you to best judge the frequency of this check.

4.5 Shutdown

1. Aspirate deionised water for at least ten minutes.

2. If the shutdown is short term i.e. the instrument is to be used again the same day/shift, it is adequate to remove electrical power from the unit by depressing the **power** switch. This will safely extinguish the flame.

3. If the shutdown is longer term or if the laboratory is likely to be left unattended during the shutdown, then the fuel supply should be turned off at source; wait for the **FLM** indicator to extinguish and then turn off the power. This ensures that there is no gas left in the tubing to the unit.

4.6 Operating precautions

1. The fuel gases used in the flame photometers are inflammable and therefore potentially hazardous. Cylinders of fuel gas should always be stored and used in line with the supplier's recommendation.

2. It is possible that a small quantity of fuel will escape from the instrument during the ignition sequence. The amount of fuel is harmless although may smell slightly. If the smell of fuel gas persists the instrument should be immediately shut down and the source of the leakage determined by using a soap solution on the hose joints.

3. Do not leave the instrument running unattended while the flame is alight.

4. The top of the instrument chimney unit becomes very hot when running and can cause severe burns if touched.

5. The exhaust gases from the flame are very hot and the area approximately 1 metre above the chimney must be avoided. Never attempt to look down the chimney whilst the flame is running. Always use the inspection window.

6. The instrument uses potentially hazardous electrical supplies. Never remove covers from the instrument without first ensuring that it has been isolated completely from the AC mains supply.

7. If the instrument is used in a pathology laboratory, all samples should be handled with the caution normally accorded to those known to contain pathogenic organisms. Care should also be taken when undertaking maintenance on instruments that have been used in these environments. A bactericidal agent should be used when cleaning parts during routine maintenance.

4.7 Good practice guidelines

1. It is most important that the nebuliser, mixing chamber and burner are kept clean by carrying out the correct shutdown procedure and by periodic maintenance. If high salt solutions are aspirated, correspondingly longer periods should be spent aspirating deionised water prior to shutdown.

2. It is recommended that blank and standard solutions should have a wetting agent (e.g. Triton X-100[1] or Decon 90) added to promote good stability and self cleaning. Any such wetting agent should be non-ionic and used at a concentration of less than 3ppm. It should be added to the blank, standards and samples at the same concentration.

3. Take care when preparing standards. The performance of the instrument depends upon the accuracy and purity of the calibration standards.

4. If standard solutions are required to be stored for any length of time or at an elevated temperature, a suitable mould inhibitor e.g. azide should be added. However if this contains the element to be measured (e.g. sodium) it is important that the samples also contain an equivalent amount.

5. Always sample from the top half of the sample container. The bottom half may contain sediment or particulate matter which could easily block the fine tubing used in the nebuliser.

6. Always use recommended spares. Even where an alternative part may be obviously suitable there may be good reasons for not using it.

7. Never use glass containers to store calibration standards.

[1] Triton X-100 is a registered trademark of Union Carbide Chemicals and Plastics Co. Inc.

Section 5

Accessories

5.1 Water separator

To avoid unstable readings it is essential that the air supply to the mixing chamber is clean and dry. Jenway recommends that a water separator be used with all flame photometers as when air is compressed, condensation occurs. The amount of condensation will depend on the humidity in the air, so in high humidity areas, water separators are essential. The water separator fits on the air-line between the compressor and the flame photometer. This is where condensation forms. Any water collecting in the tube will cause unstable readings and if it enters the instrument, will lead to the eventual corrosion of internal components in the air-line.

5.1.1 Features

1. Available in two sizes: large (normally recommended) (part code 500 177) or small (for areas of low humidity) (part code 500 176).
2. Complete with all parts to connect to the flame photometer.
3. Provides optimum performance in minimum space.
4. Provides effective liquid and solid separation.
5. No maintenance required.
6. Finger operated plungers for easy draining.

5.1.2 Specifications

	Large (500 177)	**Small (500 176)**
Port size:	1/4, 3/8	1/8, 1/4
Maximum operating pressure:	100psi	100psi
Working temperature range:	-5 to 80°C (with no freezing)	-5 to 80°C (with no freezing)
Nominal filtration rating:	5µm	5µm
Bowl material:	Polycarbonate	Polycarbonate
Bowl guard:	Yes	No
Drain capacity (ml):	25	8
Weight (kg):	0.22	0.18

5.2 Compressor

The 8515/8516 is a reliable, quiet air compressor of oil-less design requiring minimal maintenance. The compressor is constructed from a lightweight but rigid aluminium extrusion and is housed in a protective case to ensure maximum user safety and convenience. Load bearings are permanently lubricated and sealed for the life of the compressor. A Teflon composition cup offers excellent sealing and wear properties. The integral motor has its own cooling fan and is thermally protected against overload.

5.2.1 Specification

The 8515/8516 compressor gives a supply of dry, clean and pulse free air at a pressure between 14 and 30 psi (approximately 1-2 kg/cm^2) at 6 litres/minute.

Model	**8515**	**8516**
Part Code	535 001	535 002
Voltage:	230V, 50/60Hz	110V, 60Hz

5.2.2 Installation

The compressor should be positioned on a stable surface within 2 metres of the PFP7. Connection to the PFP7 should be carried out as follows:

1. Ensure the power supply to the PFP7 is switched off.
2. Connect the air tubing (supplied with PFP7) to the 8515/8516 outlet nozzle and secure with a hose clip.

3. Connect the other end of the air tubing to the air inlet located on the rear panel of the PFP7 and secure with a hose clip.
4. Plug the 8515/8516 mains lead into either auxiliary power socket located on the rear panel of the PFP7.

5.3 Diluter

The diluter is a stand alone diluter/dispenser that is programmed to dispense a final volume of 5.0ml of a 1 in 200 dilution of a sample in diluent, i.e.taking up 25 ml of sample and 4.975 ml of diluent. This is useful for the dilution of clinical samples prior to aspiration in the flame photometer.

5.3.1 Specification

Part Code	037 001
Syringe volume:	5ml
Resolution:	3000 steps
Ambient temperature:	0-40ºC
Reproducibility:	< 0.5% at 1% syringe volume
Accuracy:	< 1%
Voltage:	110 or 230VAC @ 50/60Hz
Dimensions:	110(l) x 150(d) x 210(h) mm
Weight (kg):	4

5.4 Datalogger

The analogue-RS232 datalogger is an easy to use PC based data acquisition product that plugs into the serial port of a PC (desktop or laptop) and requires no power supply. Replacing costly chart recorders, the datalogger enables data acquisition and printing from all PFP7 models. The PicoLog software can collect data at rates from once per hour to 1000 per second and up to 1 million samples can be collected. Data can be displayed in both graphical or spreadsheet format both during and after data collection.

5.4.1 Specification

Part Code	037 501
Number of channels:	8
Resolution:	16 bit + sign
Input range:	±2.5V
Overload protection:	±30V
Sampling rate:	1Hz
Accuracy:	0.2%
Input impedance:	1M
Input connector:	D25 female
Output connector:	D9 male to PC serial port
Outputs:	2 (fixed ±5V references)
Supplied software:	PicoLog for Windows Drivers and examples: C, Pascal, Delphi, Visual Basic, HP VEE and LabView. A macro is also provided to collect data directly into an Excel spreadsheet.

Section 6

Maintenance

6.1 General

The design of the Model PFP7 is such that maintenance requirements are minimal. To maintain good performance and prolong the life of the instrument it is important that the procedures defined in the manual are carried out regularly. The performance of the instrument depends upon an adequate supply of compressed air. Recommended compressor maintenance procedures should be carried out to ensure that compressor performance does not deteriorate.

6.2 Weekly maintenance

Ensure efficient nebuliser operation.

Equipment required: 10ml graduated measuring cylinder
Stop watch
Cleaning wire (500 194)

1. Switch on the air supply to the flame photometer but do not light the flame.

2. Fill the measuring cylinder with deionised water and present to the nebuliser inlet tube for one minute.

3. The consumption rate should be between 2 and 6ml/min. If correct, no further action is required.

4. If the consumption rate is too low, this is likely to be caused by a blockage in the fine capillary tubes and can usually be cleared by passing the cleaning wire through the nebuliser. If, after taking this action and re-checking the consumption rate it is still too low, then the inlet tube should be discarded and the test repeated using fresh tubing.

5. If the nebuliser operation is still unsatisfactory, remove the nebuliser from the mixing chamber, disconnect from the air line, remove the inlet tubing and soak the nebuliser in hot deionised water.

6. Refit the nebuliser and repeat the test.

7. If operation is still unsatisfactory, a new nebuliser should be fitted.

NOTE: Under no circumstances should the nebuliser be adjusted.

6.3 Monthly maintenance

Equipment required: 10ml graduated measuring cylinder
Stop watch
Cleaning wire (500 194)
Cleaning solution (025 171)

1. Carry out the **Weekly maintenance** schedule.

2. With the flame alight aspirate a 1 in 100 diluted sample of cleaning solution for 30 minutes, followed by deionised water for a further 30 minutes.

6.4 Six-monthly maintenance

Burner cleaning.

Equipment required:
10ml graduated measuring cylinder
Stop watch
Cleaning wire (500 194)
Cleaning solution (025 171)
Small, stiff brush

1. Carry out the **Weekly maintenance** schedule.

2. If the instrument has been running with the flame alight, allow 30 minutes for the burner system to cool down.

3. Disconnect the mixing chamber from the chimney unit by unscrewing the knurled locking ring and dropping the chamber clear of the chimney.

4. Remove the fluted burner from the top of the burner tube.

5. Rinse the burner in deionised water and remove any deposits or encrustations by brushing with a small stiff brush. If deposits are persistent, heating or boiling the deionised water will help.

6. Replace the burner, pointed end downwards and re-assemble the mixing chamber onto the chimney.

7. Carry out the flushing procedure as described in **Monthly maintenance**.

Section 7

Trouble shooting

7.1 General

This section is a step-by step guide that should allow an operator to take appropriate actions to clear simple faults. Any action not defined in this trouble shooting guide should only be undertaken by qualified personnel.

7.2 Unstable results

Check the instrument stability is within the limits of the instrument specifications by checking against the reproducibility, linearity, specificity and stability parameters defined in Section 1.3, Specification.

Possible cause	**Solution**
Condensation in the air supply.	Drain the tubing. If the problem persists a moisture-free air supply should be arranged by using a water separator.
Nebuliser blocked.	Check the nebuliser performance as defined in Section 6.2, Weekly maintenance.
Flame temperature not correctly set.	Ensure that the **fuel** valve is correctly set for the element being determined; refer to Section 4.2, Operation.
Fuel cylinder nearly empty.	Replace cylinder with a fully charged one.
Instrument in strong draught.	Relocate the instrument.
Instrument in very bright sunlight.	Relocate the instrument.
Instrument not draining correctly.	Ensure the “U” tube is clear of blockages and that the drain trap is at the correct level i.e. pushed down fully so the rim at the top is resting on the clip.
Atmosphere contaminated.	Remove source of contamination or improve ventilation.
Mixing chamber/burner contaminated.	Carry out the six-monthly maintenance procedures. Ensure the instrument is always flushed with deionised water before shutdown.

7.3 Unable to set standard reading

Possible cause	**Solution**
Calibration standard at incorrect concentration or incorrectly diluted.	Make new standards to check the calibration procedure.
Blank calibration standard contaminated or incorrectly set.	Re-make standard and re-set blank.
Nebuliser blocked.	Check the nebuliser performance as defined in Section 6.2, Weekly maintenance.

Incorrect filter selected.	Select correct filter.
Flame temperature not correctly set.	Ensure the **fuel** valve is correctly set for the element being determined, refer to Section 4.2.

7.4 Non-linear results

Possible cause	**Solution**
Nebuliser blocked.	Check the nebuliser performance as defined in Section 6.2, Weekly maintenance.
Contaminated deionised water.	Make up new standards in fresh water.
Incorrect dilution or incorrect calibration standard used.	Prepare fresh dilutions of the calibration standard.
Calibration curves incorrect.	Check the validity of the calibration curves using fresh standards.
Flame temperature not correctly set.	Ensure the **fuel** valve is correctly set for the element being determined, refer to Section 4.2.
Instrument not draining adequately.	Ensure the “U” tube is clear of blockages and that the drain trap is at the correct level.

7.5 Flame will not light

Possible cause	**Solution**
Drain “U” tube empty.	Fill with deionised water.
Fuel cylinder empty or regulator pressures incorrectly set.	Replace cylinder or reset regulator.
Inadequate air supply.	Check air connection to the rear panel and the operation of the compressor.
Propane/butane fuel restrictor blocked.	Carefully “blow out” the restrictor. Do not use wire to clear the blockage as this will result in damage to the restrictor.
No ignition spark.	Igniter lead disconnected. Refit.
Flame not detected by the sensor.	Reposition the sensor.
Ignition electrode worn or bent.	Straighten electrode or replace with a new part set to the correct length.

7.6 No electrical power

Possible cause	**Solution**
AC supply not fully engaged.	Check the power lead is correctly inserted.

AC supply not available.	Check mains supply.
Fuse(s) blown.	Check fuses and replace if necessary. Check the setting of the voltage selector.

7.7 No reading on display

Possible cause	**Solution**
Incorrect filter selected.	Select correct filter.
Calibration standard incorrectly made.	Re-make standard.
Nebuliser completely blocked.	Check the nebuliser performance as defined in Section 6.2, Weekly maintenance.

7.8 Unable to set blank

Possible cause	**Solution**
Blank contaminated.	Re-make the blank and re-check.
Burner encrusted with salt.	Clean the burner as defined in Section 6.4, Six monthly maintenance. Ensure that the cleaning procedure is carried out more frequently.
Ignition electrode encrusted with salt.	Clean or replace the ignition electrode as detailed in Section 9.1.2.

Section 8

Service Information

8.1 Sample system description

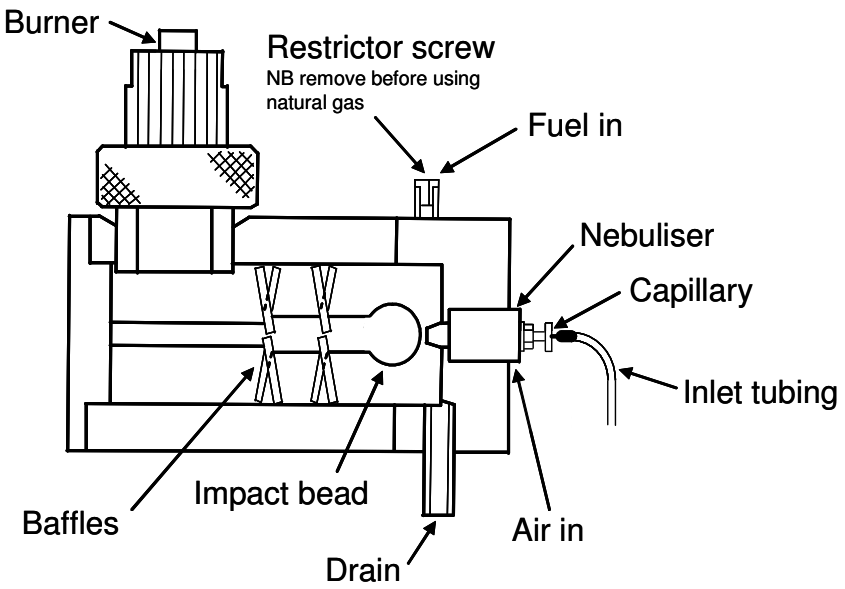

Figure 8.1.1: Sample system

The sample is taken up by a concentric type nebuliser unit. Air, at a constant pressure, is passed around the end of a small capillary tube forming a partial vacuum inside the capillary tube and drawing sample into it via the nebuliser inlet tubing. The sample leaves the end of the capillary as a fine aerosol. The volume and droplet size of the aerosol is controlled by varying the position of the capillary tube and air jet with respect to each other. This adjustment is the most important single factor affecting the linearity, stability and reproducibility of the instrument and is factory set and sealed.

The aspirated sample is passed into the mixing chamber where the fuel gas is introduced. The sample aerosol then strikes the PTFE impact bead which further breaks up any large particles in the spray. The fuel/air/sample mixture is then swirled around two PTFE baffles. The majority of sample strikes these baffles and runs out of the mixing chamber, via the drain trap to waste. The remaining sample, consisting of only the smallest droplets mixed uniformly with the fuel, reaches the modified Meker type burner where the mixture burns in a tall, round flame situated in a double skin chimney.

8.2 Combustion and ignition system description

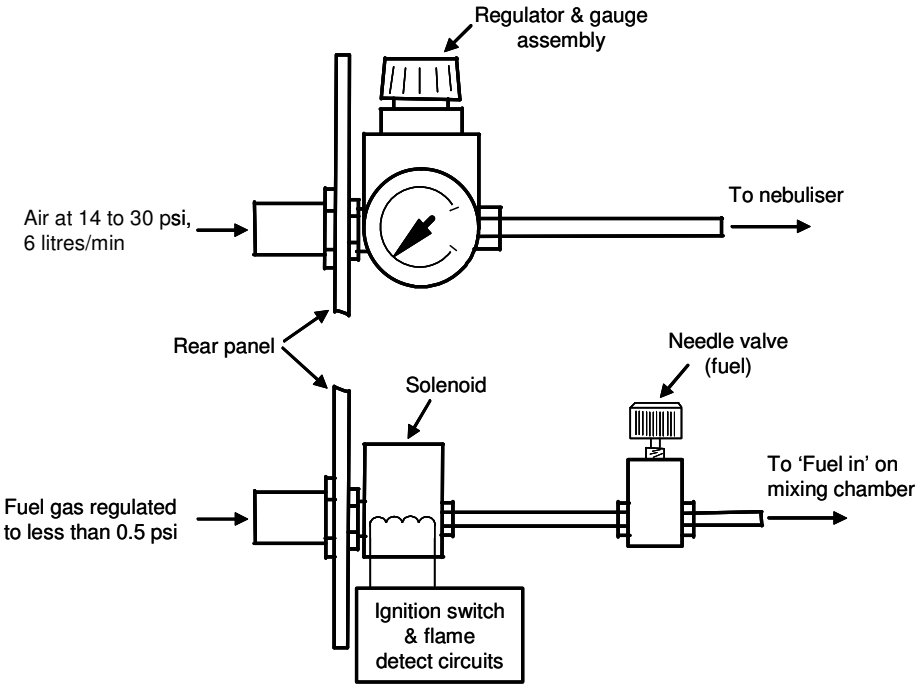

Figure 8.2.1: Combustion and ignition system

The PFP7 can be used with propane, butane, natural gas or L.P.G. at pressures as defined in Section 2. Immediately behind the rear panel fuel bulkhead is the **fuel** solenoid valve. This solenoid valve is normally closed when there is no power to the instrument or where there is power to the instrument but the flame is not alight. The solenoid will be latched in the open position when the flame is alight and has been detected by the flame thermocouple. The fuel solenoid can be held open manually during the flame ignition sequence by holding down the front panel **ignition** switch; fuel then flows through small bore copper tubing to the fuel valve on the front panel. This is a very fine needle valve and to avoid damage, this control should never be screwed hard fully clockwise and should not be used as an on/off valve. From the fuel valve the gas then passes to the mixing chamber and then on to the burner. A restrictor screw is fitted to the mixing chamber fuel inlet for use with propane, butane or L.P.G. but must be removed if natural gas is used.

Air is fed through the rear panel to the air regulator. The air regulator is factory set to 12psi. Adjustment should not be necessary but can be achieved by lifting the yellow locking ring and rotating the knob on the side of the regulator until the correct pressure is shown on the pressure gauge. From the air regulator the air passes to the nebuliser where it acts as an atomising agent.

Ignition is achieved by passing a high voltage spark between the ignition electrode and the centre of the burner. The spark is generated by the self-contained ignition unit mounted inside the instrument. This is activated by depressing the front panel **ignition** switch, which simultaneously opens the fuel solenoid, allowing gas to flow through the stream of sparks and hence ignite. The ignition switch must be manually held down until the thermocouple, mounted at the top of the back of the chimney, detects the temperature rise due to the flame, latches the solenoid in the open state and energises the FLM indicator in the display window. If the fuel flow ceases and the flame is extinguished, the thermocouple will detect the fall in temperature and the solenoid will automatically be closed, stopping any further gas escaping to atmosphere.

8.3 Optical system description

Light is emitted from the flame and collected by a plano-convex lens mounted on the inner chimney. The wavelength of light reaching the photo-detector is determined by up to 5 different interference filters mounted in a wheel. The filter in the light path is selected by the front panel control and is indicated by this control. Na (589nm) and K (766nm) filters are fitted as standard and positions 1, 2 and 3 can be fitted with Ca (620nm), Ba (520nm) and Li (670nm) filters to order.

The filters are held in the wheel by circlips. Should replacements or alternatives need to be fitted, care must be taken to prevent fingerprints getting onto the optical surfaces. If this does happen a small amount of ethanol on a very soft, lint-free cloth may be used to gently wipe away deposits.

Filtered light from the flame falls on the PIN diode mounted on a small PCB on fixing brackets that allow critical adjustment so that the lens on the diode can be set to an optimum position in the light path. The electrical signal from the diode is taken via a 3-pin connector and a screened cable to the main PCB.

8.4 Power supply description

Refer to **Figures 8.4.1** and **8.4.2**.

The mains AC supply is fed in via the rear panel socket/filter unit to a 3A anti-surge fuse (6A anti-surge fuse when operating on 115V). This fuse protects any equipment such as a recorder or compressor plugged into the **POWER OUT** socket on the rear panel.

The AC line is taken via a 250mA fuse, for protecting the internal circuitry, to the **power** switch on the front panel. The AC neutral is taken to the other pole of the **power** switch. The earth from the mains supply is taken directly to the chassis.

From the **power** switch the AC line is taken to a two-position **VOLTAGE SELECTOR** switch mounted on the rear panel and then onto the transformer primary winding; the other side of which is connected to the neutral from the **power** switch. The transformer primary is auto wound to provide a step up function to supply 240V for the igniter unit when a 115V supply is connected.

The two 12V secondary windings are joined with a centre tap which forms the 0V rail; they are full wave rectified to give a +12V and -12V supply with respect to the centre tap. The unregulated +12V is fed to the 7805 1 amp regulator to give the +5V rail. The unregulated -12V is fed to the 79L05 100mA regulator to give the -5V rail.

The unregulated +12V is used to automatically operate the fuel solenoid via the relay, but it is also fed to one pole of the ignition switch for manual operation. The other pole is fed with 240V which is then switched to the ignition unit, such that when the ignition switch is depressed, the fuel solenoid is opened and the ignition unit activated to generate a series of high voltage pulses (approx. 2 per second) which are discharged in the form of a spark between the ignition electrode and burner, which is at earth potential. Hence the fuel passing through the solenoid into the mixing chamber and out through the burner will be ignited by the series of sparks, whilst the solenoid is manually held open.

The thermo-electric potential developed by the thermocouple mounted on the top, back of the chimney is fed into the inverting input of the 741 (IC1). When this level becomes greater (due to flame temperature) than the level set by RV8 on the non-inverting input to the 741 (IC1) then the output rapidly switches from +4.5V approx. to -3.0V approx. turning off transistor TR2 which, in turn, switches transistor TR1 on, energising the relay coil. The normally open contacts close holding the +12V supply on the solenoid. If the flame should be extinguished the thermocouple cools down and the voltage on the inverting input IC1 decreases. When the level falls below that set by RV8 on the non-inverting input to IC1 the output goes back to +4.5V approx., turning on

transistor TR2, which, in turn, switches off transistor TR1 which de-energises the coil of the relay, breaks the relay contacts and removes the +12V supply from the solenoid, hence shutting off any further gas flow. The inputs of IC1 are protected from the high voltage sparks generated by the ignition discharge by diodes D1 and D2.

The reference level set by RV8 is factory set for optimum switching of the solenoid (on/off). Adjustment of this may have a significant impact on the safe operation of the flame photometer and should only be undertaken by trained engineers.

Back E.M.F.s generated by the coils in the relay and solenoid are dissipated by diodes D3 and D4.

The collector of TR1 is taken to the main PCB to activate the FLM indicator when the flame has been detected by the above circuitry.

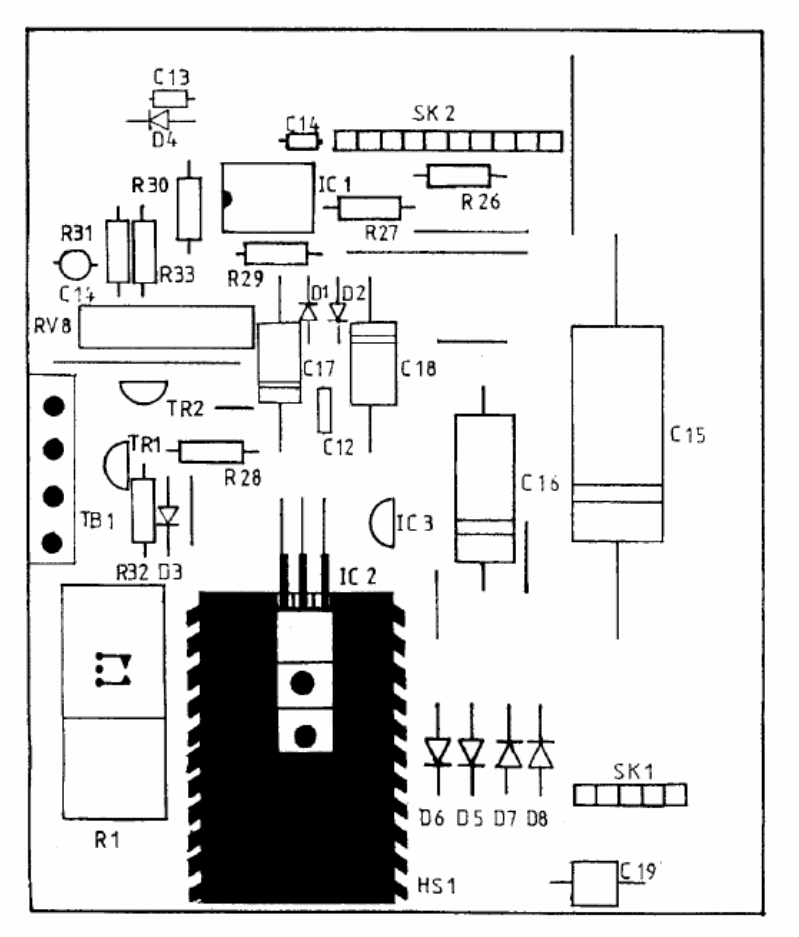

Figure 8.4.1: Power supply and flame failure detection printed circuit board layout.

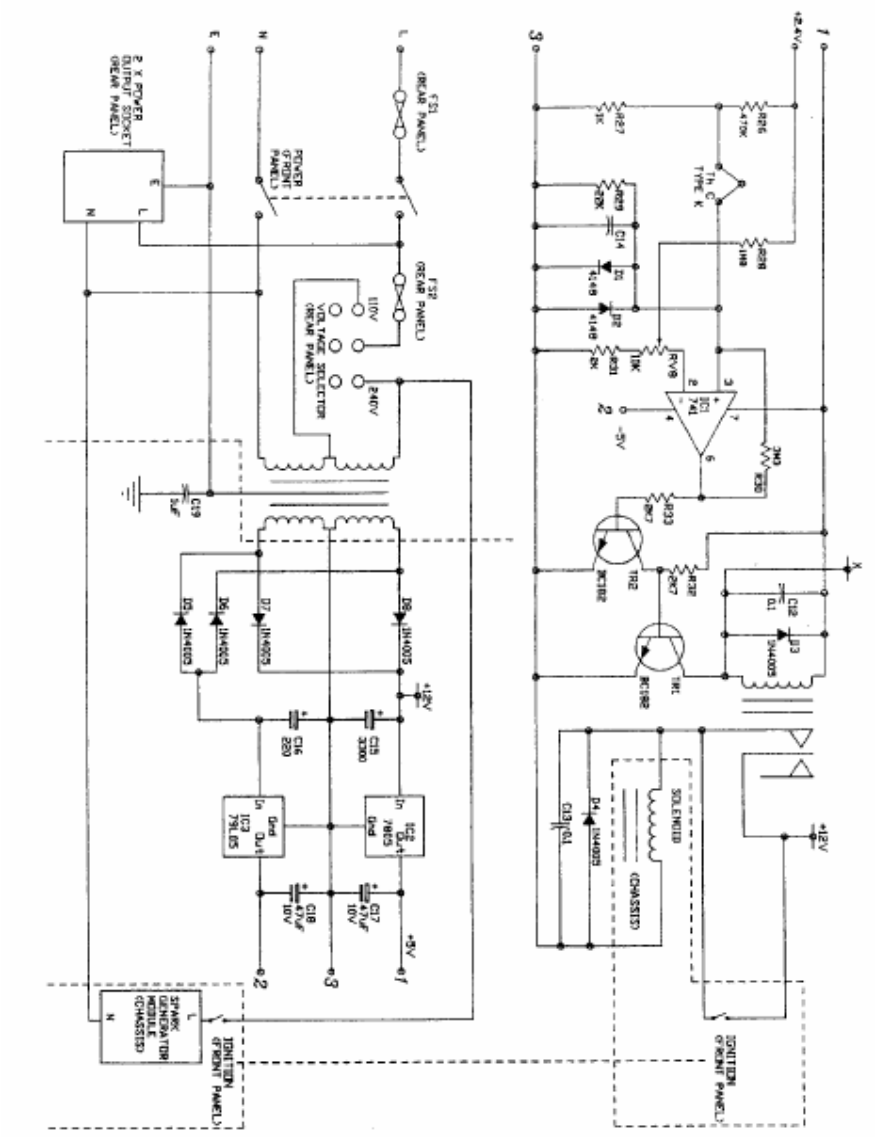

Figure 8.4.2: Power supply and flame failure detection circuit.

8.5 Signal processing description

Refer to **Figures 8.5.1** and **8.5.2**.

The signal from the PIN (PD1) diode is amplified by IC1, a high input impedance op-amp. The coarse gain control switches 1, 10 and 100 Megohm resistors into the feedback to change the gain on the first three ranges. On range 4 the 100 Megohm resistor is left in circuit and the sensitivity of the 7107(IC5) is increased by a factor of approximately 10. The 10 Kilohm potentiometer feeding into the inverting input of IC1 is a factory preset control for compensating for any dark current from the PIN diode and for any offset in IC1. The output of IC1 is then fed through a filter network consisting of R8, C4 and R9, C5; the signal is then fed into IC2 a non-inverting buffer with RV2 its preset offset adjustment.

The front panel **blank** potentiometer, RV3, provides an adjustable DC offset which is fed into the inverting input of IC3 to compensate for any signal from the flame background when setting the readout to zero with the flame alight.

The front panel **fine** sensitivity potentiometer, RV4, controls the gain of IC3 and the values in the feedback of this stage are selected to enable the sensitivity to be varied continuously between each of the switched steps of the coarse sensitivity control.

The output of IC3 is fed via a filter consisting of R15 and C7 to the 7107 (IC5). The 7107 is an Analogue to Digital converter complete with a 7 segment decoder/driver for the 3½ digit LED display. The sensitivity of the A to D converter is set by RV6 to approximately 1mV per digit on coarse sensitivity ranges 1, 2 and 3 and 0.1mV per digit on coarse sensitivity range 4 by SW1B and RV7. The output of IC3 is also fed to the non inverting buffer IC4 (with preset offset control RV5) to give a buffered recorder output of 1mV per digit on ranges 1, 2 and 3 and 0.1mV per digit on range 4. The preferred decimal point may be selected by SW2 which connects the relevant decimal point to 0V through a 560 ohm resistor, R16, R17 or R18.

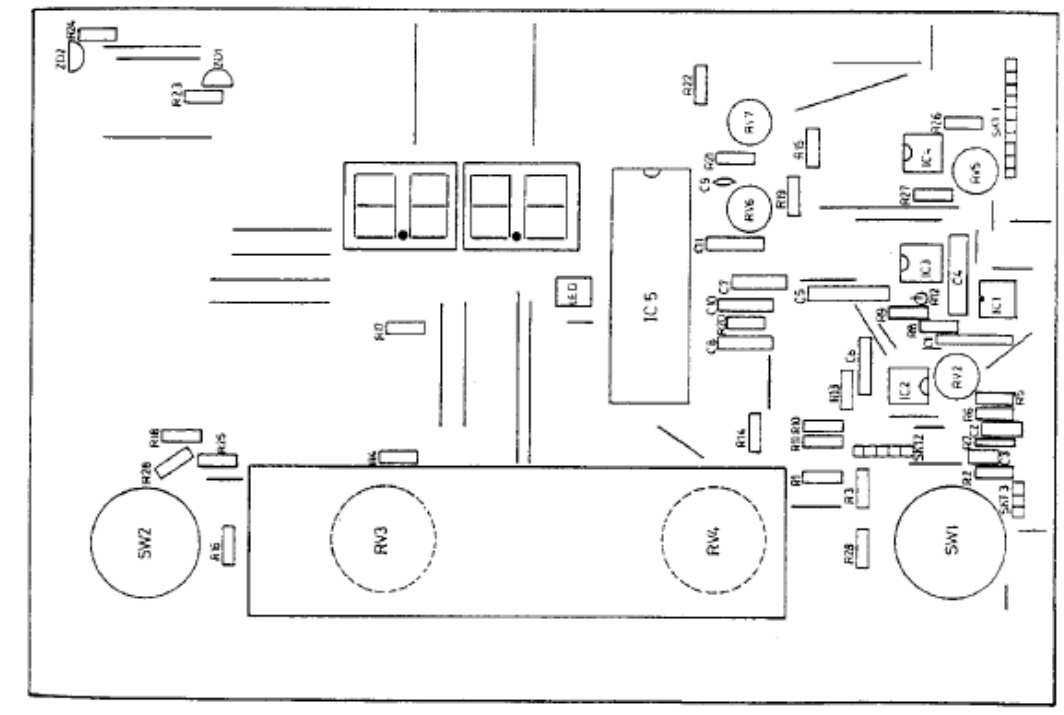

Figure 8.5.1: Main circuit board layout.

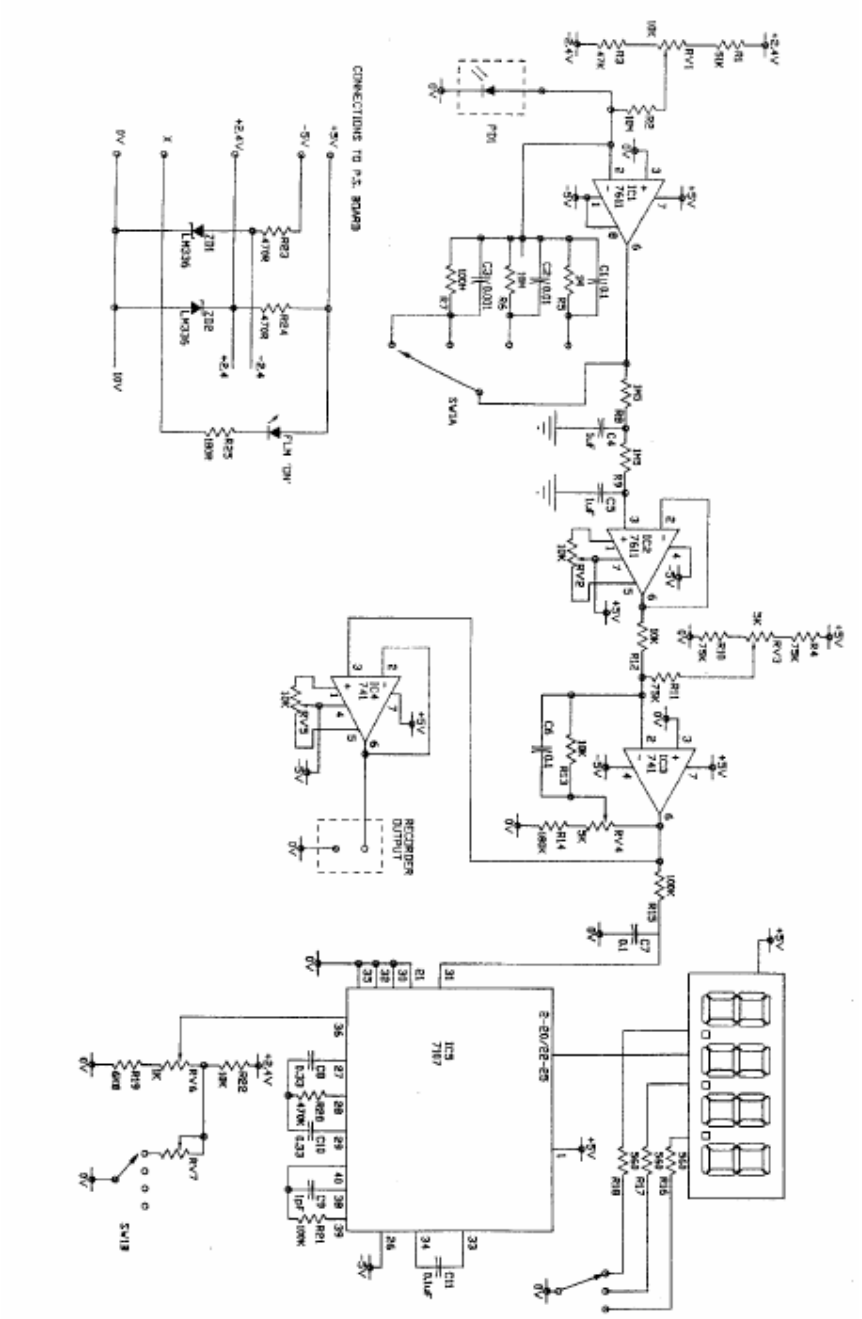

Figure 8.5.2: Main circuit board.

Section 9

Component replacement

9.1 Chimney and optical components

9.1.1 Mixing chamber dismantling

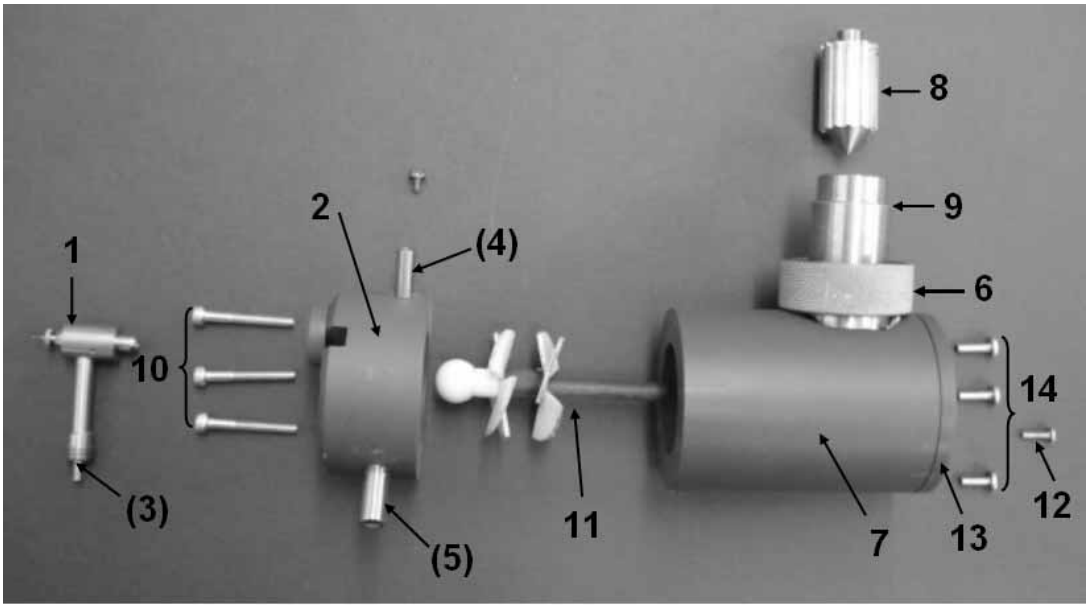

Figure 9.1.1: Mixing chamber, nebuliser and burner assembly.

1. Ensure power, fuel and air supplies to the instrument are disconnected.

2. Remove the nebuliser (1) by turning the retaining cam and withdrawing the nebuliser from the mixing chamber end cap (2). Unscrew the air inlet tube (3) from the nebuliser and place it safely to one side. Pull the fuel inlet tube (4) and drain tube (5) from their connectors on the mixing chamber end cap.

3. If the instrument has been running with the flame alight, allow 30 minutes for the burner system to cool down. When it is cool the knurled brass ring (6) may be unscrewed and the mixing chamber (7) lowered from the chimney and removed.

4. The burner (8) can be withdrawn from the burner tube (9) and the end cap removed by releasing the three socket head screws (10). The impact bead and impeller assembly (11) can be removed by releasing the centre pozidriv screw (12) in the rear plate (13) of the mixing chamber. The rear plate can be removed by releasing the three outer pozidriv screws (14).

5. All items should be inspected for damage and contamination before cleaning and re-assembly. Re-assembly is the reverse of dismantling and the end cap and rear plate retaining screws must be securely tightened to give gas tight seals.

6. Ensure that when re-assembling the mixing chamber that the baffles are positioned at 45 degrees to each other, as shown in Figure 9.1.2.

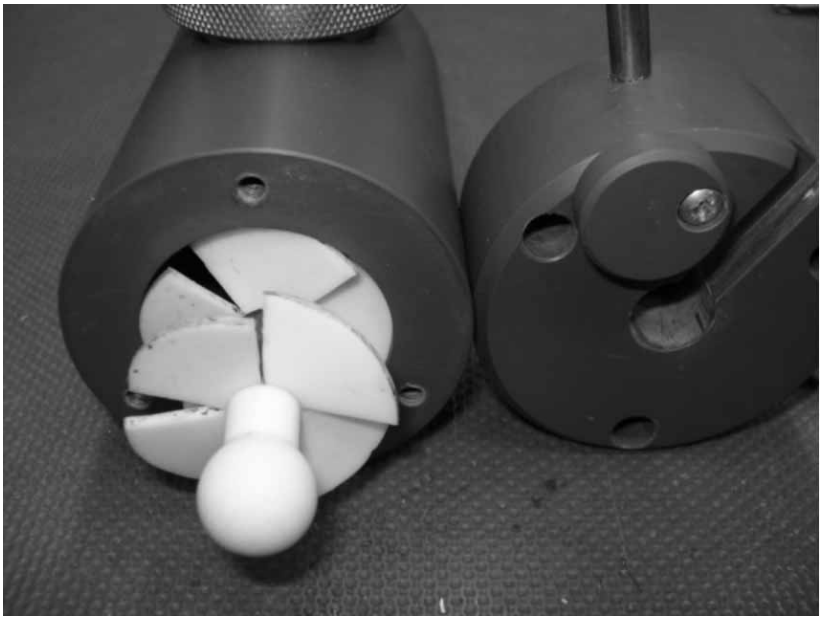

Figure 9.1.2: Mixing chamber, impact bead and impeller assembly.

9.1.2 Chimney dismantling

1. Ensure that power, fuel and air supplies to the instrument are disconnected. If the instrument has been running with the flame alight, allow 30 minutes for the burner system to cool down. When cool, remove the mixing chamber as detailed in Section 9.1.1.

2. To access the inner chimney for cleaning only, refer to paragraphs (3) and (4) below; for complete removal of the chimney continue to the end of this sub-section.

3. Pull the ignition cable connector from the ignition electrode housing, unscrew the PTFE ignition housing and place to one side.

4. Unscrew the three black pozidriv screws that hold the chimney back plate. Loosen the nut on the rear screw retaining the chimney top plate which passes through the top of the back plate. The chimney back plate can now be removed taking care not to strain the thermocouple cable. The stainless steel inner chimney can now be pivoted up and cleaned with a soft, lint-free cloth, as can the lens mounted on the front of the inner chimney.

5. The inner chimney can be fully removed by releasing the two screws that form the pivot and sliding the inner chimney out, taking care to retain the spacers and washers. The outer chimney can be removed by undoing the two pozidriv screws and two nuts that retain the fixing brackets at the base of the chimney.

   Replacement is the reverse of removal. Clean scale from the ignition electrode, or replace by loosening the grub screw sealed with plasticine, that clamps the electrode. Replace with a new electrode setting the protruding length to 10mm before retightening the grub screw and re-sealing with plasticine. The plasticine also acts as an insulator so the spark does not jump from the grub screw to the inner chimney.

9.1.3 Thermocouple removal

1. Ensure that power is disconnected from the instrument. If the flame has been alight allow 30 minutes for the burner and chimney to cool down.

2. When cool, unscrew the cap that holds the thermocouple in place, taking care not to loosen the housing retaining nut. Remove the thermocouple complete with the compression fixing.

3. Unscrew the thermocouple wires from the terminal block on the power supply PCB. Pull the wires through the grommet in the side panel. If re-fitting a replacement thermocouple ensure it is pushed through the housing as far as it will go before clamping the compression fitting. Ensure correct polarity is observed when fitting into the terminal block.

9.1.4 Filter wheel and filters

Refer to **Figure 9.1.3**.

1. Ensure that power is disconnected from the instrument. Remove the four socket head screws from the right hand side panel. Remove both left and right hand side panels and place carefully to one side.

2. Remove the filter select knob. Unscrew the four screws on the bottom of the unit that hold the chimney assembly in place. Carefully remove the chimney assembly from the unit. Remove the four screws on the cover plate to release the filter wheel assembly from the chimney assembly. Remove the two grub screws from the filter wheel to gain access to the filters.

3. To fit additional filters: push out the round plastic blanking piece; fit the new filter into the vacant position with the mirrored side towards the flame. Replace the circlip to retain the new filter and replace the filter wheel.

4. Ensure that the PIN diode housing is in alignment with the filter recess. This can be achieved by loosening the filter wheel via the two retaining grub screws and pushing the PIN diode housing into the filter recess. Tighten the filter wheel in this position and slide the PIN housing back to just clear the filter wheel in all positions.

9.1.5 PIN diode PCB removal

Refer to **Figure 9.1.3**.

1. Ensure that power is disconnected from the instrument. Remove the right hand side panel as detailed in the previous sub-section.

2. Unplug the 3 pin connector from the PIN diode mounting PCB (UOD1). The PCB may be removed complete with half of the mounting bracket by removing the two pozidriv screws that pass through the adjusting slots into the captive nuts on the other half of the bracket.

3. Replacement is the reverse of removal. Check that the diode is aligned with the optical path on re-assembly as described in section 9.1.4

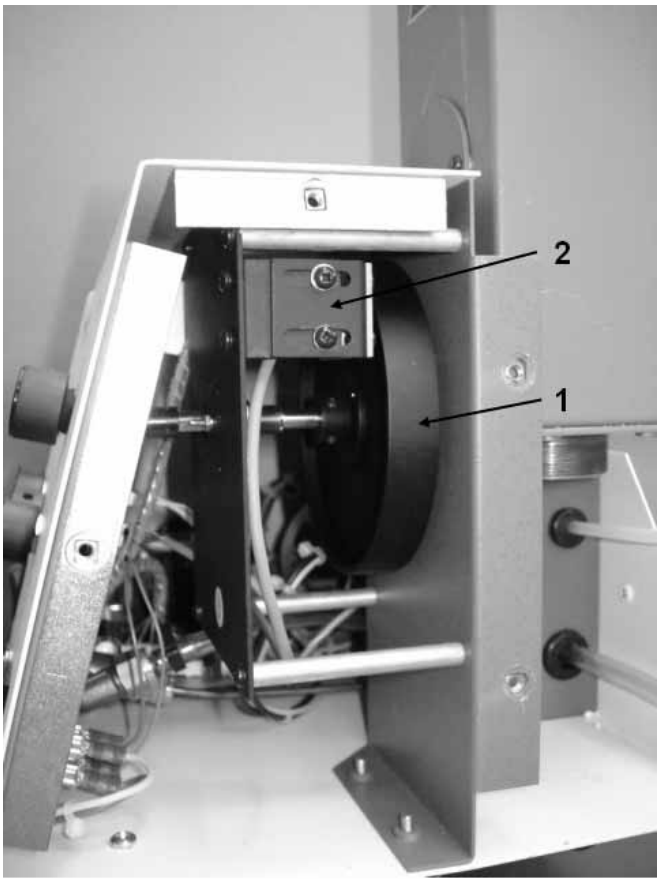

Figure 9.1.3: Filter wheel and filters.
1: filter wheel;
2: PIN diode PCB mounting bracket.

9.2 Power supply PCB

Refer to **Figures 9.2.1** and **9.2.2**.

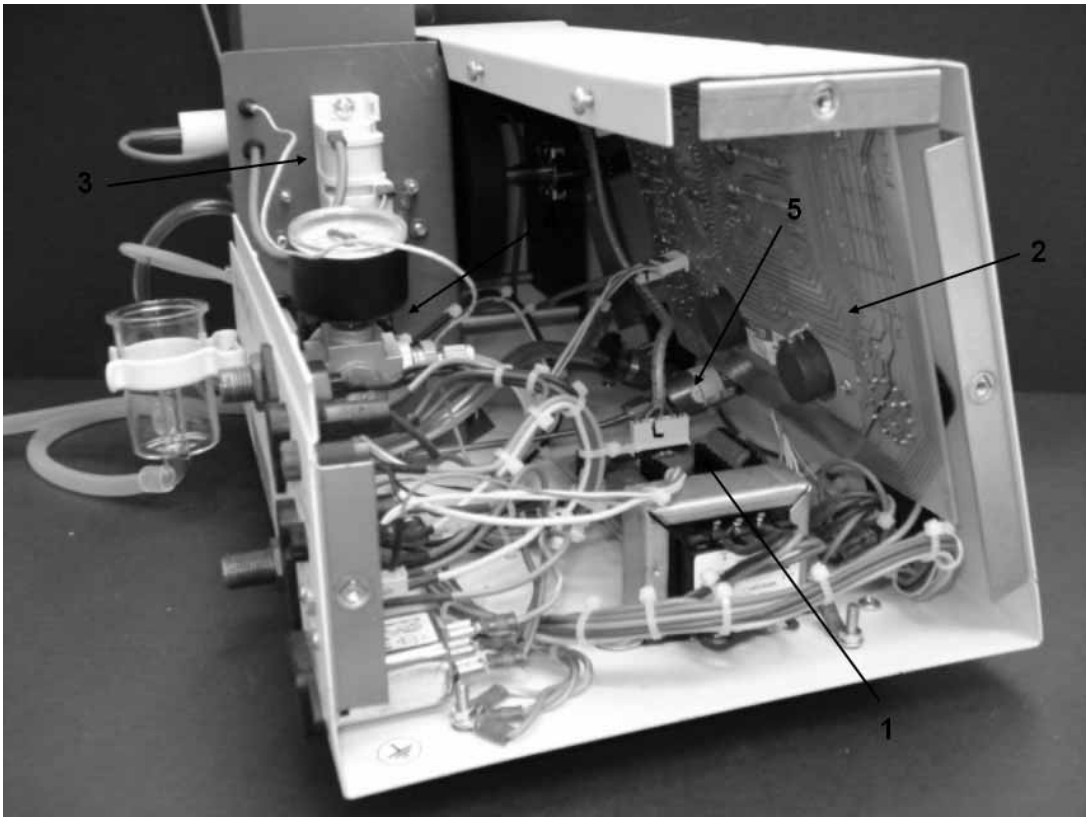

Figure 9.2.1: Main chassis component locations.
1: power supply PCB;
2: main PCB;
3: ignition spark generator module;
4: air regulator assembly;
5: fuel needle valve assembly.

1. Ensure that power is disconnected from the instrument. Remove the top rear cover from the instrument by undoing the two pozidriv screws at the top of the rear panel and lifting the angled cover from the retaining screws.

2. Identify the power supply PCB mounted on the base of the unit. Note the orientation and polarization of the two multiway connectors branching from the cableform. Disconnect these by pulling up on the connector housing; do not pull on the cables.

3. Remove the four wires (two from the solenoid and two from the thermocouple) from the screw terminal block on the PCB

4. The easiest way to remove the PCB is by undoing the four screws from underneath the instrument, leaving the pillars screwed to the PCB. The power supply PCB can now be lifted out of the instrument. Replacement is the reverse of removal.

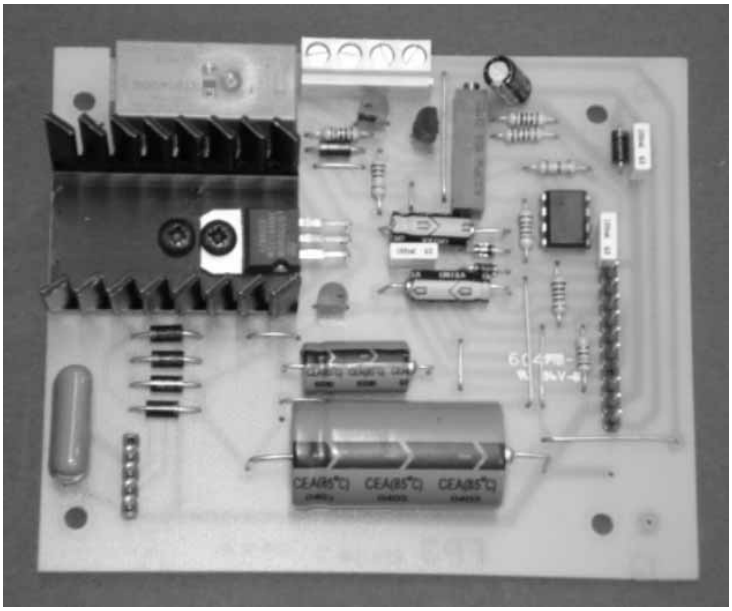

Figure 9.2.2: Power supply PCB

9.3 Main PCB replacement

Refer to **Figures 9.2.1**, **9.3.1** and **9.3.2**.

1. Ensure that power, fuel and air supplies to the instrument are disconnected.

2. Remove the knob from the front panel d.p., blank, fine and coarse controls by loosening the two grub screws in each. Remove the nuts securing the d.p. and coarse switches to the front panel.

3. Remove the top rear cover as described in Section 9.2 step 1. Disconnect the three connectors from the back of the main PCB by pulling on the housing box (do not pull on the cables). Note the orientation and polarization of each.

4. Remove the two thumb-screws, one in the top right hand corner and the other in the top left hand corner.

5. The PCB may be removed by tipping it back, releasing the front panel switch bosses from their mounting holes and lifting the PCB back and up through the rear top cover. Take care not to loose or disturb the washers on the switches. Replacement is the reverse of removal.

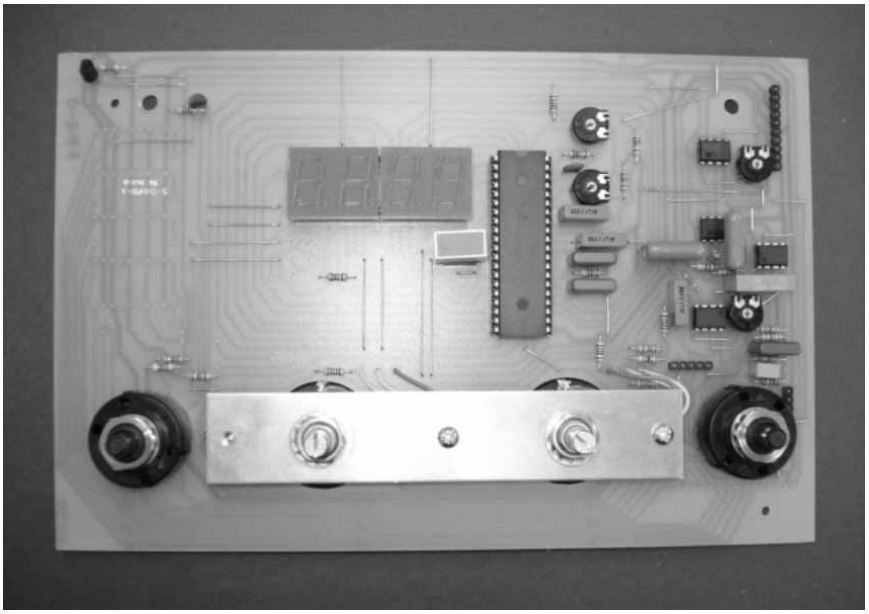

Figure 9.3.1: Main PCB

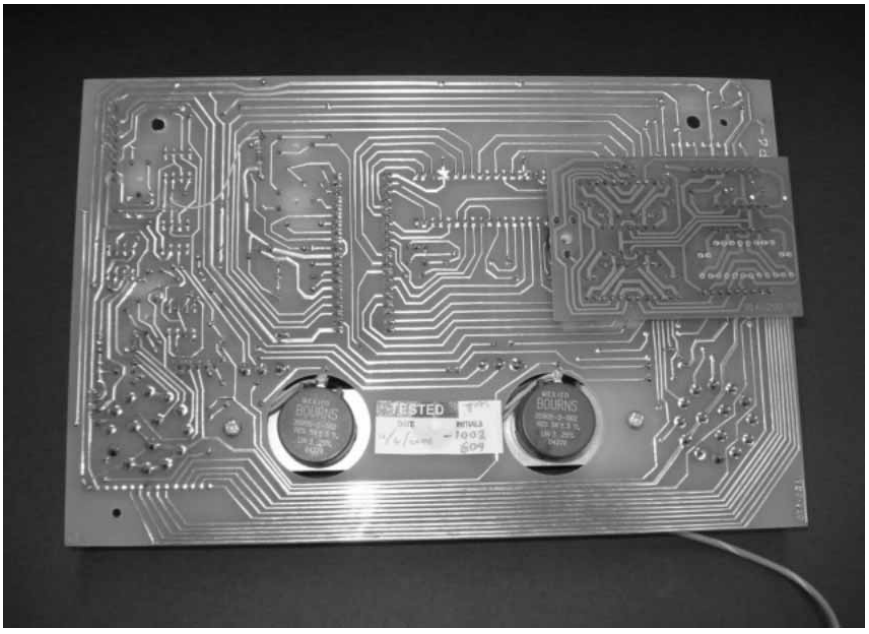

Figure 9.3.2: Main PCB rear view showing the linearization PCB for the model PFP7/C.

9.4 Fuel solenoid replacement

Refer to **Figure 9.2.1.**

1. Ensure that power, fuel and air supplies to the instrument are disconnected. Remove the top rear cover as described in Section 9.2 step 1.

2. Identify the two wires that come from the solenoid to the screw terminal block on the power supply PCB Remove these two wires from the terminal block.

3. Identify the cap nut on the compression fitting on the outlet of the solenoid. Loosen this nut and slide it away from the solenoid along the micro-bore copper tubing. Pull the compression fitting out of the solenoid outlet.

4. Remove the nut on the rear panel fuel inlet bulkhead connector. The solenoid can now be pulled forward and lifted out of the instrument. Replacement is the reverse of removal. Ensure that the solenoid is mounted at a slight angle so as not to foul the air regulator. It must not be mounted horizontally.

5. Check all joints are gas tight using soapy water before relighting the flame.

9.5 Fuel needle valve

Refer to **Figure 9.2.1.**

1. Ensure that power, fuel and air supplies to the instrument are disconnected. Remove the top rear cover as described in Section 9.2 step 1.

2. Pull the clear PVC tubing from the fuel inlet on the mixing chamber end cap. Locate this tube inside the instrument and pull it back through the grommet in the chimney corner into the instrument.

3. Remove the cap nut on the compression fitting on the inlet to the fuel needle valve. Slide the nut away from the needle valve along the micro-bore copper tubing. Pull the compression fitting out of the fuel needle valve inlet.

4. Remove the large knob from the fuel needle valve on the front panel by loosening the two grub screws and then fully close the valve (taking care not to over-tighten) and remove the preset stop knob by loosening the single grub screw. Care must be taken to ensure that the needle valve is never closed any further once this stop has been removed. If this position is maintained, then on re-assembly, it is only necessary to push the knob on as far as it will go to reset the correct stop position.

5. Remove the front panel mounting nut and then the needle valve may be taken back into the instrument and removed. Replacement is the reverse of removal.

6. Check all joints are gas tight using soapy water before relighting the flame.

9.6 Spark generator replacement

Refer to **Figure 9.2.1.**

1. Ensure that power to the instrument is disconnected. Remove the top rear cover as described in Section 9.2 step 1. Identify the ignition spark generator module mounted on the inside of the chimney corner.

2. Disconnect the high voltage cable from the push on connector on top of the module. Disconnect the green earth lead on top of the module in a similar manner. Remove the two M3 nuts and associated washers that retain the unit to the chimney corner.

3. Remove the switched line and neutral connections from the base of the module that can now be removed from the instrument. Replacement is the reverse of removal. Ensure correct polarity of all wires when reconnecting.

9.7 Air regulator assembly replacement

Refer to **Figure 9.2.1.**

1. Ensure that power, fuel and air supplies to the instrument are disconnected. Remove the top rear cover as described in Section 9.2 step 1.

2. Remove the compression fitting that retains the nylon tube to the outlet of the air regulator assembly. Pull the tube and compression fitting out of the air regulator assembly.

3. Remove the nut on the rear panel air inlet bulkhead connector. The air regulator assembly can now be pulled forward so the connector clears the rear panel and then remove from the instrument. Replacement is the reverse of removal.

4. Check that no air leaks are present and that the gauge can be set to 12psi with the nebuliser connected.

Section 10

Spare parts

10.1 Minor spares kit (500 172)

Description	Part code
Multi-turn potentiometer	007 034
LED double 7 segment display - red	012 004
Fuse 250mA (slow blow)	016 005
Fuse 3.15A (slow blow)	016 007
Fuse 6.3A (quick blow)	016 015
Inlet tube (500mm)	500 193
Silicon rubber tube	023 003
Drain trap	500 018
Nebuliser assembly	500 019
Ignition electrode (Qty 3)	500 070
Nebuliser cleaning wire (3 x 150mm long)	500 194

10.2 Major spares kit (500 173)

Description	Part code
Minor spares kit	500 172
Knob 10mm	008 021
Knob 21.8mm dia., black	008 039
Transformer 12VA	010 005
LED double 7 segment display – red (Qty 2)	012 004
Rocker switch illuminated – green	017 024
Rocker switch bias 1w	017 025
Display driver ICL7107 (Qty 2)	019 002
Thermocouple assembly	027 023
Allen key 2.5AF	060 037
Adjustable hose clip No. 14 (Qty 5)	060 083
Allen key M3	060 188
Allen key 1.27AF	060 196
Allen key 1.5AF	060 197
M3x6 skt set cone point, black	062 109
M5x6 skt set cone point, black	062 305
M14 plain washer zinc	062 836
Air regulator assembly	500 005
Needle valve assembly	500 025
Mixing chamber assembly	500 046
Ignition probe	500 067
Opto PCB assembly	500 103
Display PCB assembly	500 104
Power supply PCB assembly	500 106
Solenoid valve assembly	500 107
Electronic ignition unit	500 115
Sodium filter	500 123
Potassium filter	500 124
Universal joint	500 141
8515/8516 compressor inlet filter	535 008