Huntleigh HEALTHCARE

SERVICE MANUAL

Dopplex® Hand Held Dopplers

Service Agreements

Periodic inspection and preventative maintenance are essential to ensure continued effective operation. Contact the Company or its approved agents or distributors for further information on service contracts.

DIAGNOSTIC Products Division

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1. General Information

Although every care has been taken to ensure that the information in this manual is accurate, continuous development may result in equipment changes. The Company reserves the right to make such changes without prior notification, and resulting manual inaccuracies may occur. This manual and any changes are protected by copyright.

1.1 Introduction

This service manual provides the technical information required for repair and maintenance of the Huntleigh Healthcare Ltd...

- Mini Dopplex - D900-P
- Audio Dopplex - D920-P (with fixed waterproof 2MHz probe), D930-P (with fixed waterproof 3MHz probe)
- Fetal Dopplex II - FD1-P
- Super Dopplex II - SD2-P
- Multi Dopplex II - MD2-P
- Fetal Dopplex - FD1-P (with fixed waterproof 2MHz probe)
- Rheo Dopplex

... hand held Dopplex range, including the range of OPHS (Obstetric High Sensitivity Probes) and VPHS (Vascular High Sensitivity Probes) interchangeable transducers.

Please note that the Super Dopplex 1, Multi Dopplex 1 and (NTD) probes are not compatible with the D900-P, FD1-P, SD2-P, MD2-P, RD2.

1.2 Servicing Policy

Due to the nature of static sensitive surface mount technology specialised equipment and training is required when working on the surface mounted components used within these products.

For this reason circuit diagrams are not included in this manual. Block diagrams and fault finding sections are included to make fault finding to leaded component level possible. Units within the warranty period must not be dismantled and should be returned to Huntleigh Healthcare Ltd for repair. Any units returned showing signs of tampering or accidental damage will not be covered under the warranty (refer to user manual for further details).

1.3 Description

The Dopplex range of products includes the D920-P, D930-P, D900-P, FD2-P (Obstetric Doppler with heart rate display) SD2-P (dedicated vascular Doppler), MD2-P (Bi-directional vascular Doppler), D920-P, D930-P (Mini Dopplex with waterproof probe), FD1-P (Obstetric Doppler with heart rate display and waterproof probe) and RD2 (vascular Dopplex with Photoplethysmographic sensor).

The FD1-P and D920-P have dedicated 2MHz probes that are hard wired via a retractile cable. The D930-P has a dedicated 3MHz probe that is hard wired via a retractile cable.

Mini Dopplex (D900-P) is primarily a vascular unit with a non-directional waveform output. The Mini Dopplex accepts the obstetric probes, providing audio only output.

Fetal Dopplex II (FD2-P) has interchangeable probes accepting the full range of obstetric and vascular probes, although it is primarily a Fetal Dopplex with a heart rate display. Using the vascular probes, only audio signals are available and there is no rate counting facility, or waveform outputs.

Super Dopplex II (SD2-P) is a dedicated vascular Doppler with all the vascular functions of the MD2-P, but without the RS232 waveform output.

Multi Dopplex II (MD2-P) is a multi-purpose Doppler with bi-directional waveform and stereo headphone outputs. Graphical representation of velocity waveforms is given by the LCD display. The same obstetric features of the FD2-P are incorporated into the MD2-P.

Audio Dopplex (D920-P D930-P) are dedicated obstetric Dopplers with fixed waterproof 2MHz (D920-P) and 3MHz (D930-P) probes.

Aqua Dopplex Plus (FD1-P) is derived from the FD2-P, but has a hardwired waterproof probe.

Rheo Dopplex II(RD2) has the vascular functions of the MD2-P with the addition of a Photoplethysmographic sensor.

For further details on the controls of the D900-P, D920-P, D930-P, FD2-P, SD2-P, MD2-P, FD1-P and RD2 units, please refer to the user manuals.

1.4 Antistatic Handling

Due to the nature of the components used within the D900-P, D920-P, D930-P, FD2-P, SD2-P, MD2-P, FD1-P, RD2 units special precautions must be taken to avoid damage to the CMOS and microcontroller based circuitry. Static damage may not be immediately evident but could cause premature failure.

This series of units must only be dismantled and serviced within a specialised handling area (SHA) as defined by CECC00015 (published by CENELEC) to avoid damage to the assemblies.

1.5 Construction

The control unit comprises a single PCB on which all circuitry and electro-mechanical components are mounted directly except for the loudspeaker which is attached by flying leads. A hard wired cable provides the connection to the probe.

The PCB has surface mounted components on both sides. All leaded and electro-mechanical components are on one side.

All electro-mechanical and through hole components on the control PCB are serviceable using standard tools and soldering techniques, provided that anti-static precautions are always observed.

The case of the control unit is moulded in ABS polycarbonate alloy, and comprises two halves. The loudspeaker, on/off switch and display are on the front of the unit.

2. Safety Aspects

2.1 Safety

The D900-P, D920-P, D930-P, FD2-P, SD2-P, MD2-P, FD1-P, RD2, Dopplers and their probes are designed to high standards of performance, reliability and safety.

Checks should always be made after carrying out any repairs or dismantling of the equipment.

2.2 Maintenance

Regular inspections must be made to check the integrity of the unit, and to ensure that the cable is not showing any signs of wear or is noisy when flexed.

For functional testing of specific product features, refer to the user manual.

If you require any assistance with safety testing your Dopplex equipment, contact Huntleigh Healthcare Ltd or your supplier directly.

For the U.K. refer to the Health Equipment Information Document No 95 - Code Of Practice For Acceptance Testing Of Medical Equipment.

The following safety summary should be read before operating or carrying out any of the procedures described in this manual.

2.3 Cautions

Do not use the D900-P, D920-P D930-P, FD2-P, SD2-P, MD2-P, FD1-P, RD2 units in the presence of flammable gases such as anaesthetic agents.

This product is not designed for sterile use. Do not use in the sterile field unless additional barrier precautions are taken.

Do not
- immerse in any liquid (except probe on D920-P, D930-P/FD1-P.
- use solvent cleaners.
- use high temperature sterilising processes (such as autoclaving).
- use E-beam or gamma radiation sterilisation.

2.4 General Care And Cleaning

Handling	The control unit and the body of the probe are robust and require no special handling. However, the ultrasound probes have delicate faceplates and must be handled with care. Do not apply excess pressure directly to the probe faceplate. Take great care not to drop or knock the probe, stress the PPG sensor cable or scratch the sensor face.
Maintenance	Other than normal cleaning and replacement of batteries the Dopplex units do not require maintenance.
Storage	If your Dopplex unit is to be stored for a long period of time the battery should be removed.
Cleaning	Excess gel should always be wiped off after use before parking the ultrasound probes. The probes and main unit can be cleaned with a damp cloth impregnated with a mild detergent, but take great care not to allow any water or other fluid to seep into either unit. To assist in disinfection, a soft cloth dampened with a solution of sodium hypochlorite 1000ppm may be used, and the units wiped dry. Alternatively, alcohol saturated swabs can be used on the faceplate and nosecone area of the ultrasound probes and on the PPG sensor. Please be sure to check your local control of infection policies, or any equipment cleaning procedures.
Caution	Phenolic, or antiseptic solutions such as Steriscol or Hibiscrub should never be used on any part of the system, as these chemicals will damage the case material.
Coupling Gel	The use of water based gel supplied by Huntleigh Healthcare is strongly recommended. Oil based gels can damage the probe and must not be used. The use of oil based gels will invalidate your warranty.

WARNING : This product is not designed for sterile use. For underwater use where contamination or cross contamination may occur, e.e. during labour and delivery, additional barrier precautions must be taken.

3. Specifications

3.1 Safety

Type of protection against electric shock.	Class 1 (when operated via the supplied PSU) / internally powered.
Degree of protection against electric shock	Type B applied part 
Mode of operation.	Continuous
Degree of protection against water ingress	IPX0
Degree of Safety in Presence of Flammable Gases:	Not suitable for use in the presence of flammable gases.

3.2 Power Supply

Battery Type	9 Volt alkaline manganese 6LF22, 6LR61 or equivalent (e.g.MN1604).

3.3 Enclosure

Case Material	Injection moulded ABS Polycarbonate Alloy.
Dimensions (mm) (Height x Width x Depth)	140 x 74 x 27
Weight	295 gms (including probe and battery)

3.4 Controls and Indicators

LCD Display	Custom reflective liquid crystal display
*3 x 7 segment display***	Displays fetal heart rate and probe frequency

** Available on RD2, FD2-P, SD2-P, MD2-P and FD1-P only.

Symbol	Description
	Indicates Standard FHR Mode Selected (FD1-P, FD2-P, MD2-P only).
	Indicates Smoothed FHR Mode Selected (FD1-P, FD2-P, MD2-P only).
	Indicates Manual FHR Mode Selected (FD1-P, FD2-P, MD2-P only).
	Represents Bi-directional blood flow velocity. RD2, in PPG mode indicates size of signal from sensor. (MD2-P, SD2-P and RD2 only).
	Indicates RS232 communication enabled. This flashes when communication is in progress. (FD2-P, MD2-P only).
	Audio/Mini- indicates power on. FD2-P/SD2-P/RD2/MD2-P- indicates power on with probe not connected.
	Indicates battery low and requires replacement.
	RT indicates Venous Refilling Time (RD2 only).
	VP indicates Venous Pump Power (RD2 only).
	Shows when blood flow waveforms are inverted (RD2 only).
Probe Alignment	Arrow on socket of probe and on barrel of plug
On/Off Button	Front panel push-on / push-off
Mode Buttons	Refer to User Manual

3.5 Auto Shut Off

FD2-P, SD2-P, MD2-P, FD1-P, RD2	If no signal detected for 3 minutes within a 10 minute time out.
D900,D920, D930	Fixed 5 minute time out.

3.6 Outputs

Audio Output	
Power	500mW rms into 8Ω internal speaker 25mW rms max (32Ω headphones)
D920-P, D930-P, D900-P,FD2-P, FD1-P, RD2	3.5mm stereo socket on top panel (mono output).
MD2-P, RD2, SD2-P	3.5mm stereo socket on top panel (stereo output).

Data Output Port	
FD2-P, MD2-P, RD2	Sub-miniature 8 pin DIN socket.

WARNING: *The Dopplex units must only be connected to equipment which complies with international safety standards such as IEC601-1, IEC950, UL544 or IEC65, and where the system is configured to meet IEC601-1-1.*

Waveform Socket	
Non-directional (Mini Dopplex)	3.5mm mono socket. Fixed f/V 0.5V/kHz.
Bi-directional (MD2-P, RD2)	Sub-miniature 8 pin DIN socket, 3.5V Full scale. Variable f/V depending on gain setting - refer to user manual.

Cal Signal	
Mini Dopplex	0kHz, 1kHz, 2kHz, 0kHz stepped pulse.
MD2-P, RD2	Stepped pulse sequence at 0.05% and 0.1% of probe frequency. Zero baseline at start and end of sequence (available on x1 gain setting only).

3.7 Probes

D900-P, FD2-P, SD2-P, MD2-P, RD2 (in addition to PPG)	OP2HS, OP3HS Obstetric Probes VP4HS, VP5HS, VP8HS, VP10HS, EZ8 Vascular Probes
D920-P, FD1-P	Fixed 2Mhz obstetric waterproof probes.
D930-P	Fixed 3Mhz obstetric waterproof probe.

4. Technical Description

4.1 The Doppler Principle

The Dopplex Range all use a technique based on the Doppler principle for non-invasively monitoring movement within the body.

The Doppler principle states that if a signal is transmitted at a fixed frequency and is reflected by a moving body, the frequency of the received signal will be shifted. An increase in frequency results if the reflector is moving towards the transmitter/receiver, and a decrease results if moving away from the transmitter/receiver. The amount of frequency shift is proportional to the velocity of the reflector relative to the transmitter/receiver.

In the Dopplex range, a fixed frequency ultrasonic signal is transmitted from the probe into the body. This is reflected from, for example, moving blood cells. The signal is reflected from these cells and is received by the probe. Due to the movement of the blood cells, a frequency shift results, which is proportional to the blood flow velocity. The Doppler shift is also affected by the angle between the probe and the direction of flow. The Doppler shift is greatest when the flow is directly towards, or away from, the probe.

4.2 Doppler Audio Processing

The pocket Dopplex probe contains a transmitter and receiver. In use, the probe sends out a continuous ultrasonic signal (carrier), generated by the piezo-ceramic transmitter crystal, in the frequency range 2 to 10 MHz (depending on probe).

This signal is scattered by blood cells or any other "interface" such as skin, muscle layers, organs, walls of vessels etc. A small proportion of the scattered signal will be reflected back and detected by the receiver.

By demodulating the received signal (removing the high frequency carrier) the Doppler shifted component (i.e. the difference between the transmitted and received signals) can be produced. With typical target velocities found in the human body, this Doppler shift signal falls within the audio frequency range. It can therefore simply be amplified and heard through a loudspeaker. It is important to remember that the sound you hear is an artificial sound, the frequency (pitch) of which is proportional to the velocity of the moving target. It is not the real sound made by blood rushing through an artery or vein, or movement of the fetal heart.

4.3 Fetal Heart Rate Processing, (FD2-P, MD2-P, FD1-P)

In addition to providing this Doppler sound, the circuitry in the FHR signal conditioning section generates an amplitude envelope of the Doppler audio signal. Using auto-correlation, this signal is further processed by the microcontroller to calculate FHR.

4.4 Bi-directional Signal Processing (MD2-P, SD2-P, RD2)

To achieve bi-directional flow indication, the Doppler signal must be further processed to separate forward and reverse components.

Components of the Doppler signal produced by positive frequency shift represent flow towards the probe, referred to as forward flow. Components of the Doppler signal produced by negative frequency shift represent flow away from the probe, referred to as reverse flow.

The circuitry achieves this separation in the vascular signal processing section producing two frequency envelopes using zero crosser techniques. This signal is presented at the waveform output (MD2-P, RD2).

The microcontroller also receives these bi-directional signals and displays them on the LCD bargraph to give a visual indication of blood flow velocity and direction.

4.5 Probe Identification

Probe identification is utilised on the D900-P, FD2-P, SD2-P, MD2-P and RD2 Doppler units. This is to allow the control unit to identify which probe has been fitted. Fitting an obstetric probe will disable the waveform output(s).

The FD2-P/SD2-P/MD2-P/RD2, with an obstetric probe connected, will display the probe frequency whenever the probe is changed.

The FD2-P/SD2-P/MD2-P/RD2, with a vascular probe connected, will give a continuous indication of probe frequency.

In the SD2-P, MD2-P and RD2 the frequency to voltage conversion factor is changed according to the frequency of the connected probe and the gain setting, effectively rescaling the output.

4.6 Active Noise Reduction

Active noise reduction is used to reduce the amount of "hiss" that is present. When a signal is below a set level, the cut off point of the low pass filter is lowered effectively reducing the noise level.

When a large signal is detected, the bandwidth is increased to allow the full range of the signal to be heard at the loudspeaker.

4.7 Intelligent Auto Shut Off (FD2, SD2, MD2, FD1, RD2)

To increase battery life within the FD2-P, SD2-P, MD2-P, FD1-P and RD2 units, the microcontroller will turn the unit off after 3 minutes of no signal. The unit will also switch off after 10 minutes regardless of signal presence. This function is disabled when it is connected to a Printa which is printing in obstetric or vascular mode (not applicable to SD2-P or FD1-P).

4.8 Calibration Pulses

The calibration pulses for the D900-P are of 1 and 2kHz irrespective of probe frequency. The MD2-P and RD2 will output pulses of 0.05% and 0.1% of the frequency of the connected probe. The MD2-P and RD2 have bi-directional calibration pulses to scale both forward and reverse channels. The calibration facility is disabled when using gain settings other than x1.

4.9 Waveform Conversion

The D900-P has a fixed waveform conversion factor of 0.5V/kHz, whereas the SD2-P, MD2-P and RD2 have a conversion factor determined by the probe fitted and the gain setting.

The use of a variable conversion factor results in the waveform output presenting a voltage that is essentially constant regardless of the frequency of probe fitted for the same velocity signal.

4.10 PPG

The RD2 incorporates a photoplethysmographic sensor which uses a sensitive infra-red sensor to assess, non-invasively, venous incompetency of the lower limb, in response to a calf muscle exercise.

The electronics for the PPG is enclosed within a pod to which the PPG sensor is attached by a lightweight straight cable.

4.11 Data Output

The data output feature on the FD2-P and MD2-P allows fetal heart rate data to be sent to the Dopplex Printa in real time.

The MD2-P and RD2 units send fetal heart rate data via the data socket to the Dopplex Printa in real time OR vascular data to the Dopplex Reporter/Dopplex Printa.

The FD2-P, MD2-P and RD2 will flash the data symbol ( )during information transfer.

The MD2-P and RD2 will output bi directional waveform information in an analogue format via the data socket.

4.12 Microcontrollers

The D900-P, D920-P, D930-P, FD2-P, SD2-P, MD2-P, FD1-P and RD2 units use a 4 bit microcontroller to carry out "house keeping" duties, such as driving the LCD display and auto shut-off timer.

In addition to the 4 bit microcontroller, the FD2-P, SD2-P, MD2-P, FD1-P and RD2 have a second 8/16 bit microcontroller. This performs FHR processing (including auto-correlation), controls the data output, probe decoding and waveform generation.

4.13 Standard/Smoothed Mode FHR

The FD2-P and MD2-P can display FHR in Standard or Smoothed mode. Smoothed mode FHR uses 8 beat averaging while Standard mode FHR uses 4 beats averaging.

4.14 Manual Mode FHR

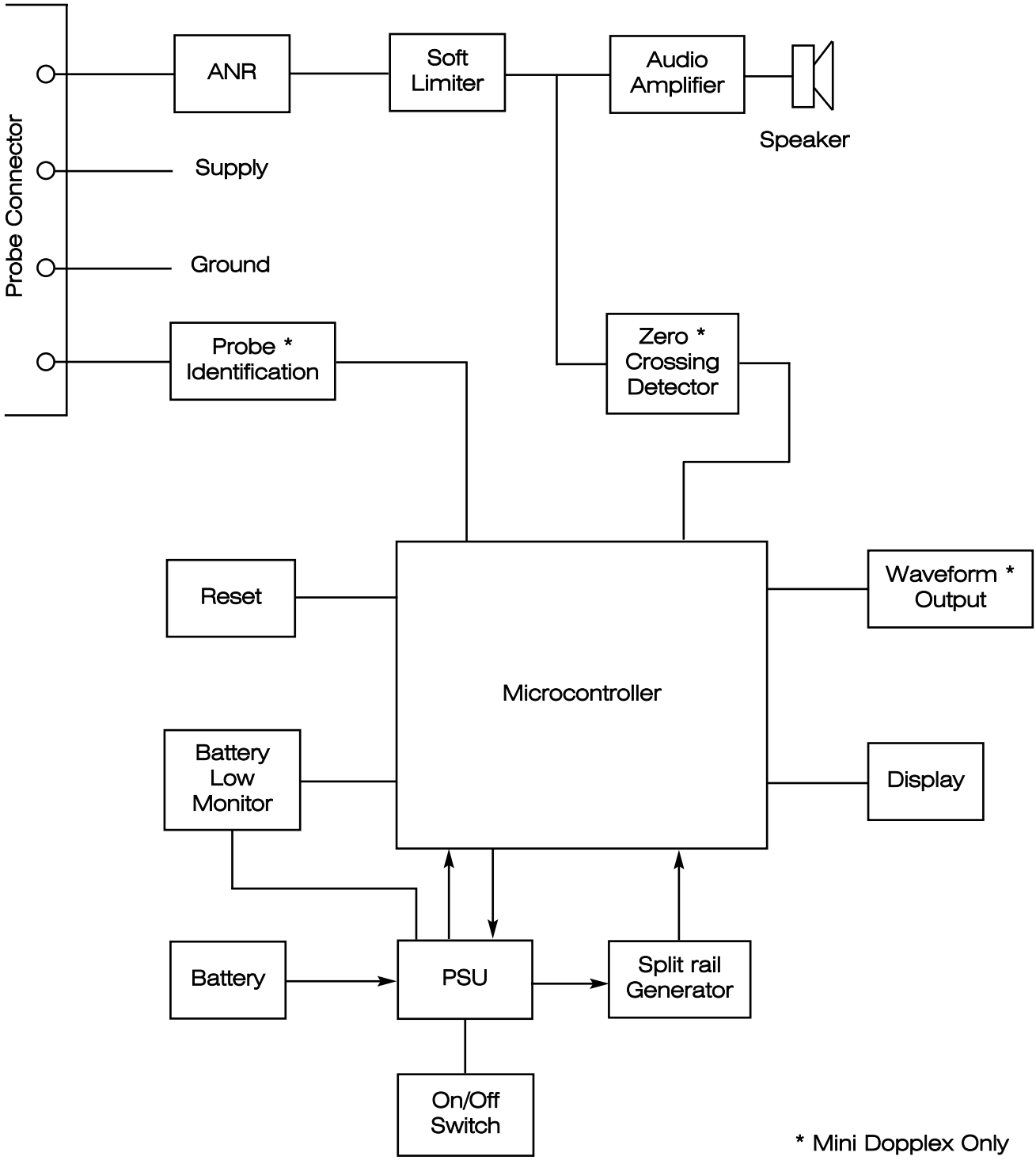
The manual mode on the FD2-P and MD2-P can be used when the heart sound can be heard, but is too weak or noisy for the microcontroller to calculate the heart rate automatically.

In this mode, the Dopplex unit operates as a stop watch calibrated in BPM (beats per minute).

The stop watch is activated by depressing the "Start/Stop" button, 10 heart beats should then be counted and the button released. The display will then show the average heart rate over the last 10 beats.

4.15 Audio Dopplex (D920-P, D930-P), Mini Dopplex (D900-P)

Block Diagram



Power Supply

The power supply regulates the battery voltage and provides 5V dc to the microcontroller and all circuitry apart from the audio power amplifier which is supplied directly from the battery. The power supply is activated by the on/off switch. The supply is firstly turned on by the on/off switch and then the microcontroller takes over and keeps the power supply on, turning the supply off when the auto shut off time has elapsed or when the on/off switch is depressed a second time.

Power On Reset

Resets the microcontroller whenever the unit is switched on.

Probe Identification (D900-P)

The probe identification feature is used to disable the waveform output whenever an obstetric probe is being used. The probe identification detects the DC level on the output from the probe thus determining the type of probe fitted.

Battery Monitor

The battery monitor circuit enables the microcontroller to assess the battery voltage by comparing this to a reference voltage.

Active Noise Reduction (ANR)

Active noise reduction is a technique used to reduce the amount of noise or "hiss" depending on signal level.

When a large signal has been detected the cut off point of the filter is moved so that there is no reduction in high frequency content of the signal. When the signal level is low, or no longer present the filter is switched in to reduce the high frequency hiss.

Soft Limiter

The soft limiter reduces the level of any harsh overload signals that may occur, for example, when the probe is moved.

Audio Power Amplifier

The audio power amplifier drives the loudspeaker or headphones. The input level is set by the volume control.

The output signal is fed to the loudspeaker, via the switched headphone socket. On start up there is a delay in the supply of power to the audio amplifier. This allows the circuit to stabilise.

Zero Crossing Detector (D900-P)

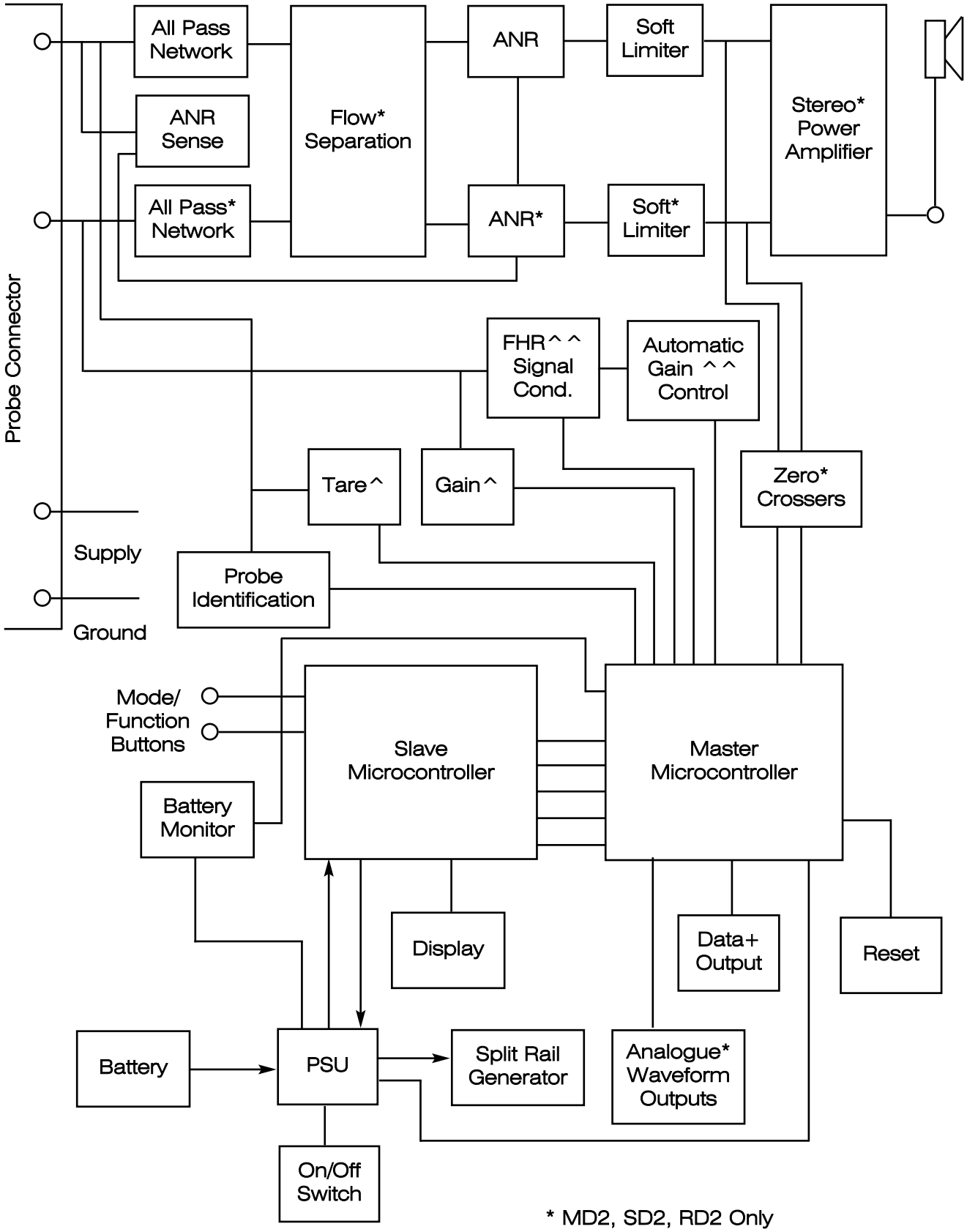
A zero crossing detector converts the Doppler signal to a corresponding pulse train. This is then fed to the microcontroller which outputs a pulse position modulated signal which is low pass filtered to produce the waveform output voltage.

Split Rail Generator

The split rail generator is necessary to bias the amplifiers correctly to allow linear operation. The split rail generator supplies a +2.5V dc reference so that the maximum output swing from the amplifiers can be achieved.

4.16 FD2-P, SD2-P, MD2-P, FD1-P, RD2

Block Diagram



* MD2, SD2, RD2 Only
\+ Not fitted on SD2, FD1-P
^ Fitted on RD2
^^ Not fitted on RD2, SD2 or FD2

Power Supply

The power supply regulates the battery voltage and provides +5Vdc to the microcontroller and all circuitry apart from the audio power amplifier which is supplied directly from the battery. The power supply is activated by the on/off switch. The supply is firstly turned on by the on/off switch and then the microcontroller takes over and keeps the power supply on, turning the supply off when the auto shut off time has elapsed or the on/off switch is depressed a second time.

Power On Reset

This resets the master microcontroller whenever the unit is switched on. The slave microcontroller is reset by the master microcontroller.

Probe Identification

The probe identification feature is used to automatically select the operating mode, depending on the probe type and in the SD2-P, MD2-P and RD2, to automatically scale the waveform output. The probe identification circuit detects the DC level on the output from the probe thus determining the type of probe fitted.

Battery Monitor

The battery monitor circuit enables the microcontroller to assess the battery voltage by comparing this to a reference voltage.

Active Noise Reduction (ANR)

Active noise reduction is a technique used to reduce the amount of noise or "hiss" depending on signal level.

When a large signal has been detected the cut off point of the filter is moved so that there is no reduction in high frequency content of the signal. When the signal level is low, or no longer present the filter is switched in to reduce the high frequency hiss.

Active Noise Reduction Sensing

The active noise reduction system relies on the control signal from the sensing circuitry. The filter response is dependent on the control signal level.

Soft Limiter

The soft limiter reduces the level of any harsh overload signals that may occur, for example, when the probe is moved.

Audio Power Amplifier

The audio power amplifier drives the loudspeaker or headphones. The input level is set by the volume control.

The output signal is fed to the loudspeaker, via the switched headphone socket. On start up there is a delay in the supply of power to the audio amplifier. This allows the circuit to stabilise.

Zero Crossing Detector (SD2-P, MD2-P, RD2)

Two zero crossing detectors convert the Doppler signals to corresponding pulse trains. The pulse trains are then fed to the microcontroller which converts them to pulse width modulated signals which are then filtered to produce the waveform output voltages.

Split Rail Generator

The split rail generator is necessary to bias the amplifiers correctly to allow linear operation. The split rail generator supplies a +2.0V dc reference so that the maximum output swing from the amplifiers can be achieved.

Data Output

The data control IC is an RS232 interface device enabling the microcontroller to communicate with the Dopplex Printa or a computer. The data/waveform socket presents the data from the microcontroller which represents either bi-directional flow waveforms or fetal heart rate, depending on operating mode.

All Pass Network

The All Pass network is used to apply 90° phase shift to one quadrature probe output signal with respect to the other.

Flow Separation

The two phase shifted signals are added and subtracted to produce the forward and reverse flow channels.

Stereo Audio Power Amplifier (SD2-P, MD2-P, RD2)

The audio power amplifier provides stereo outputs to the headphone socket. These are combined in the internal loudspeaker.

FHR Signal Conditioning

The FHR signal conditioning circuit produces an amplitude envelope from which the microcontroller calculates the fetal heart rate when using an obstetric probe.

Gain control

The gain of the first amplifier of the FHR signal conditioning circuit is increased or decreased by the microcontroller, to regulate the signal level avoiding overloading the following stages.

Analogue Waveform Outputs

Pulses representing the frequency envelopes of the Doppler signals are output from the microprocessor to two integrating low-pass filters. The two filter outputs are then fed to the analogue waveform/data output socket.

Gain

A small amount of gain is applied to the incoming PPG signal to ensure that the Microcontroller is functioning at its maximum resolution.

This signal is multiplexed with data relating to the infra red intensity.

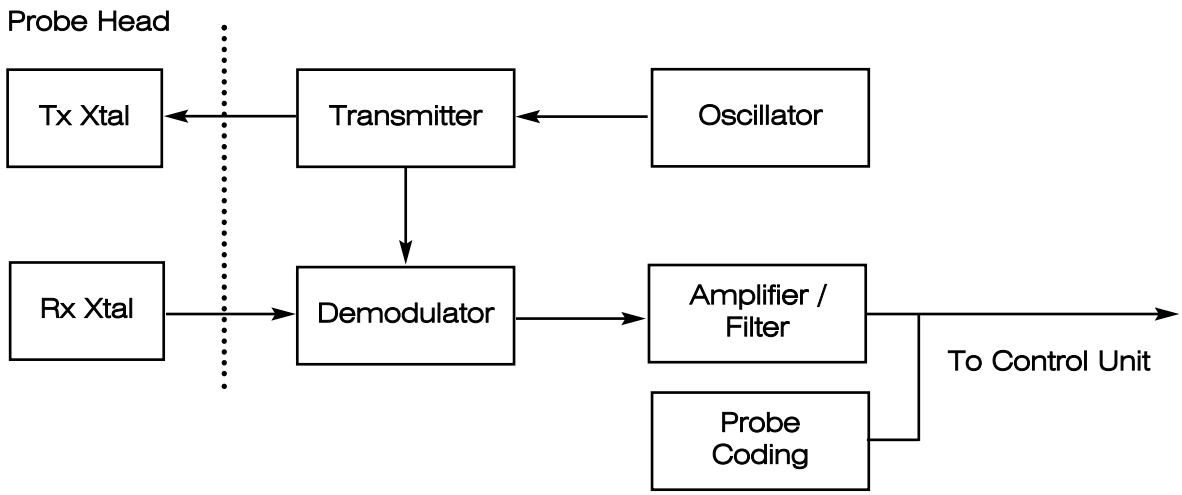
Tare

The Tare line from the Microcontroller is sent to the PPG pod, this will reset the DC level at the output from the probe and start the test.

This signal is also the control line for the multiplexer.

4.17 Obstetric Probe (OP2HS, OP3HS, D920-P, D930-P, FD1-P)

Block Diagram



Oscillator

A ceramic resonator based oscillator circuit provides a reference for the probe receiver and, via the transmitter, the output signal.

Transmitter

The output from the oscillator is amplified by a single transistor; the gain of this stage is controlled by a variable resistor.

This allows the output voltage to be set according to the impedance of the probe head, thus setting the output power level.

Demodulator

The demodulator effectively removes the carrier (transmitter frequency), which leaves us with a Doppler shifted signal.

The demodulator stage requires a reference signal from the transmitter stage.

Amplifier/Filter

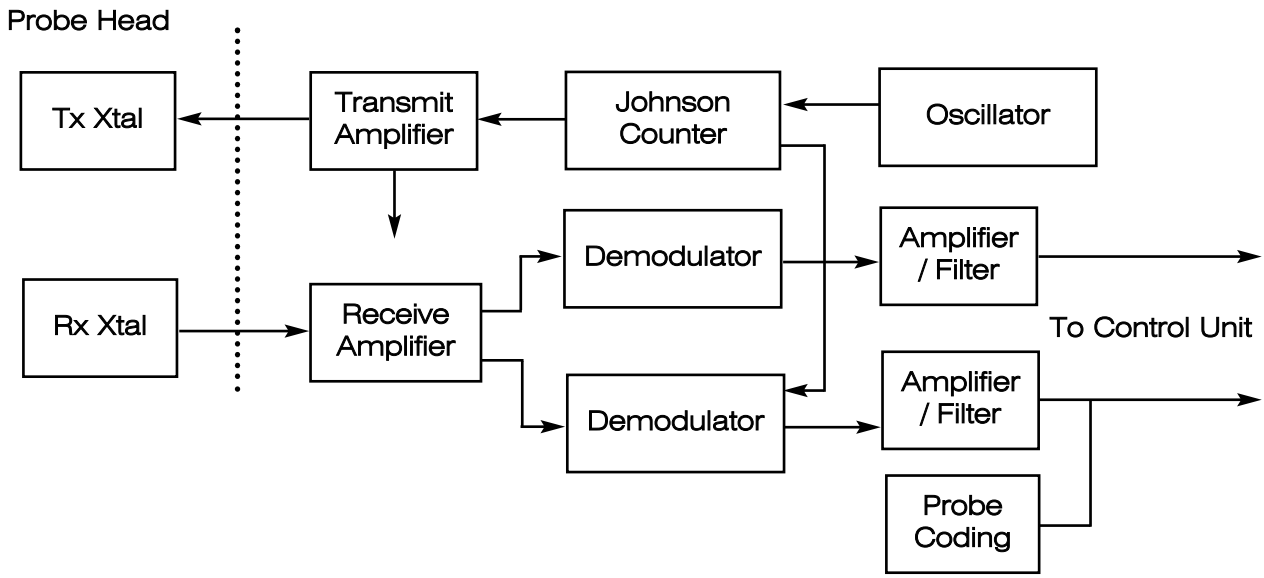
The amplifier/filter amplifies the signal from the demodulator stage and removes unwanted noise. The probe has a filter response tailored to maximise the output signal and minimise noise and overload.

Probe Coding

This superimposes a DC level (depending on probe frequency) onto the output signal.

4.18 Vascular Probe (VP4HS, VP5HS, VP8HS, VP10HS, EZ8)

Block Diagram



Oscillator

A crystal oscillator provides references for the probe demodulator and output signal. The oscillator frequency is four times that of the probe ultrasonic output.

Johnson Counter

The Johnson Counter provides two outputs, which are 90° phase shifted with respect to each other. It also divides the oscillator signal frequency by four.

Transmitter

The output from the oscillator is amplified by a single transistor; the gain of this stage is controlled by a variable resistor.

This allows the output voltage to be set according to the impedance.

Receive Amplifier

The received signal is amplified by two FETs (Cascode amplifier) providing the demodulators with a suitable signal.

Demodulators

The demodulators effectively remove the carrier (transmitter frequency), which leaves the Doppler shifted signals.

They have two quadrature reference signals from the Johnson Counter stage.

Amplifier/Filters

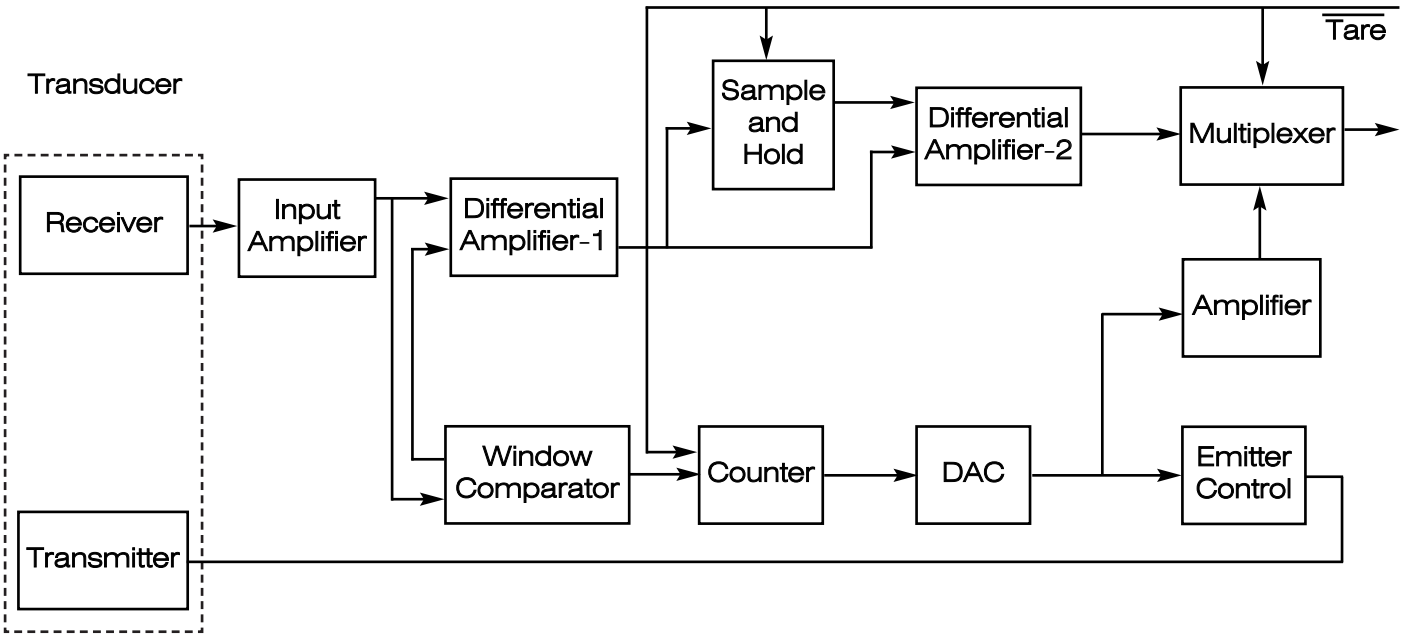
The amplifier/filters amplify the signal from the demodulator stages and remove unwanted noise. Each probe frequency has filters whose response is tailored to maximise the output signal and minimise noise and overload.

Probe Coding

This superimposes a DC level (depending on probe frequency) onto the output signal.

4.19 PPG Probe

Block Diagram



Transducer

The Transducer comprises of a pair of a transmitter LED and receiver infra-red Photodiodes.

Input Amplifier

This provides the necessary biasing from the receiving Photodiode and converts the current to a dc voltage.

Differential Amplifier-1

The Differential Amplifier is used to remove the majority of the dcoffset from the input amplifier. This is necessary as the dc signal from the Photodiode is much larger than the change that is to be studied.

Window Comparator

This monitors the incoming signal and is used to inhibit the clock when the signal is within the ranges preset.

Counter

The Counter provides the DAC with a six bit binary output which increments until inhibited by the Window Comparator.

Digital to Analogue Convertor (DAC)

The Digital to Analogue Converter, provides the emitter control circuitry with the necessary drive voltage when the received signal falls within the ranges set by the Window Comparator.

Emitter Control

This section regulates the drive current to the transmitter LED's and ensures that the drive current is sufficient to set the receive signal within the limits set by the Window Comparator.

Amplifier

The Amplifier allows the multiplexer to operate at maximum resolution, this signal amplified from the DAC allows the RD2 main unit to obtain the LED transmitter intensity.

Sample and Hold

This circuitry stores the signal from the receive Photodiode when selected by the TARE line. The TARE is selected periodically until the received signal stabilises and the test can begin.

Differential Amplifier -2

The second Differential Amplifier compares the signal from the Sample and Hold section with the receiver Photodiode signal and amplifies the difference.

This provides the RD2 via the multiplexer with the change in dc level since the last TARE signal.

Multiplexer

The Multiplexer alternates the output between the LED drive current and signal output.

5. Electrostatic Discharge (ESD) Precautions

5.1 What is Static Electricity?

Static electricity is generated when two materials move against one another. The voltage generated depends on the materials generating the electricity, the speed of movement, humidity and rate of discharge. All man made materials generate static, such as plastic coffee cups, plastic bags, binders and folders, all of which are likely to be within the working area.

Activity	10-20% Relative Humidity
Walking across carpet	35,000 Volts
Walking across vinyl floor	12,000 Volts
Working at bench	6,000 Volts
Plastic folder	7,000 Volts
Poly bag lifted from bench	20,000 Volts
Foam padded work chair	18,000 Volts

Static electricity is generated very easily, and is only felt by us when we discharge the built up charge rapidly by touching a grounded object such as a door handle. The voltages felt by us are as low as 3kV, but only 20V is necessary to damage some components. Voltages as high as 35kV and current spikes of 40A have been known.

The damage to the component, or assembly can be immediate or latent. Latent damage is not immediately obvious but can lead to the circuitry subsequently failing or becoming erratic.

5.2 Protective Measures

Measures must be taken to ensure that all charges generated are safely discharged before they build up to a dangerous level.

The use of dissipative mats for the work surface and wearing anti-static wrist straps are recommended ways of preventing this problem. The dissipative mats must be connected to ground via a resistance and the wrist strap to the same ground point. Anti-static bags must be used when storing or transporting static sensitive components.
Conductive mats are no longer regarded as being suitable, as a PCB or component could be electrostatically charged and it would be rapidly discharged by placing it on the conductive mat. This sudden discharge would be as damaging as placing a charged object in contact with the PCB or device.

All static sensitive devices or assemblies must be placed within an anti-static bag or container whenever being moved away from the specialised handling area.

For further information on static precautions and soldering equipment refer to Appendix A.

6. Servicing Procedures - Control Unit

Due to the complexity of the product and the use of surface mount technology, the electronic circuitry is not serviceable without specialised training and equipment.
The repairs detailed in this manual are therefore limited to replacement of certain parts in the control unit, and replacement of probe heads only.

Fault finding is limited to checking for the presence or absence of signals around suspect components using an oscilloscope or multimeter.

Repairs should only be undertaken by suitably skilled service personnel.

RD2 probe or sensor is not field serviceable as custom equipment is required during its alignment.

CAUTIONS: *This equipment contains static sensitive devices. Refer to Appendix A for recommended anti-static handling precautions. It is essential that these procedures, or equivalent, are adopted to avoid static damage to the circuitry.*

Due to the high density tracking and small size of components, extreme care in handling the PCB must be taken at all times.

When soldering, take care to ensure that the minimum heat is applied to the board and its components for the minimum time necessary to ensure high quality joints. Inspect the area around repairs for solder splashes and bridges. Refer to appendix A for details of recommended soldering techniques.

6.1 Control Unit Dismantling Procedure (see figs 6,7,8)

1. Remove the battery cover by depressing and sliding down and away from the unit.
2. Lift the battery out.
3. Remove the 4 small screws from the rear case half. Do not remove the larger screw in the top centre of the pocket clip.
4. Invert the unit and carefully separate the two case halves by hinging them apart from the base up, freeing the cable grommet from the case as necessary. Pay special attention to the labels on the side and top edges of the unit which adhere to both case halves.

Take care not to damage the locating lugs holding the top of the case halves together.

The PCB is now visible and the following components may be replaced without any further dismantling:

- Loudspeaker
- LCD

LCD Replacement (FD2-P, SD2-P, MD2-P, FD1-P, RD2)

1. Gently lift the display from its socket, noting the location of the orientation mark.
2. Fit the new display taking care to avoid stressing the display or bending the legs.
3. Remove protective film.

LCD Replacement (D920-P, D930-P, D900-P)

1. Cut off LCD legs, noting orientation and position in the socket (centred with spare hole at each end).
2. Desolder and remove legs.
3. Fit new LCD (observing correct orientation and position) and solder legs.
4. Remove protective film

Loudspeaker Replacement

The loudspeaker wires may be unsoldered from the back of the loudspeaker after sliding the sleeving from the terminals. Ensure that the sleeving is replaced on the new loudspeaker terminals.

6.2 PCB Removal

1. First remove case halves as previously described.
2. Remove the on/off button and spring from the switch by lifting away.

The PCB is now free to be removed from the case, by pushing the battery terminals from inside the battery compartment. Care should be taken not to damage the top panel label.

The PCB is located on three pillars, each having an "O" ring (see Fig 8) to ensure that the PCB is located correctly. These rings are essential to prevent stressing the board. Take care not to lose them.

The PCB is now freely accessible allowing replacement of electro-mechanical and leaded components.

6.3 Changing Components

After dismantling the control unit as previously described the following repairs can be undertaken.

Sockets/Switches

1. Carefully de-solder the component using solder wick. Do not use solder pumps as they may generate static.
2. Ease the legs free in the board and lift the socket/switch free taking extreme care not to lift or damage any tracking.
3. Clean the area around the component and fit the replacement.
4. Solder the component taking care not to overheat it or the PCB. Overheating the PCB could result in the tracks breaking.

Retractile Cable - Control Unit

1. Carefully de-solder the retractile cable using solder wick, leaving the holes clear to fit the new cable (See figures 1,2 and 3).

Cable Refitting

1. Fit new cable to control unit as described previously.

Volume Control

1. Carefully de-solder the three electrical connections and two supports using solder wick. Do not use solder pumps as they may generate static.

2. Ease the legs free in the holes and lift the volume control free taking extreme care not to lift or damage any tracking.

3. Clean the area around the volume control and fit the replacement.

4. Solder the volume control taking care not to overheat the volume control or PCB. Overheating the PCB could result in the tracks breaking and the volume control becoming unreliable.

6.4 Control Unit Reassembly (see figs 1,2,3)

After dismantling the control unit as previously described the following repairs can be undertaken.

Sockets/Switches

1. Clean any debris from inside the case halves and carefully wipe the LCD display and the window. This should be done with an anti-static cloth to avoid the build up of static.

   Note: When wiped, the LCD display may show marks and symbols when the unit is not turned on. This is caused by static charge on the display and will disappear after a short while.

2. Replace the three "O" rings on the PCB mounting pillars. CE 0088 Marked products, ensure the 1 copper washer and 2 beryllium washers are fitted as shown in Fig 3.

3. Replace the PCB taking care to ensure that:

   a) The switches and sockets are correctly engaged in the labels.

   b) Battery contacts are correctly located in the case.

   c) No leads are trapped under the PCB.

4. Position the loudspeaker in the PCB cut-out, making sure that the wires are twisted together and are clear of the case halves and switches.

5. Slide the spring over the shaft of the on/off switch button and clip the button on the shaft.

6. Replace the top case half taking care to engage the two locating lugs at the top of the case and to avoid damaging the labels. Ensure that no wires are trapped, that the retractile cable grommet is correctly placed and the On/Off button is located in the cut-out.

7. Check that all labels are secure and undamaged.

8. Replace the 4 fixing screws, and tighten them to a torque setting of 60cNm.

9. Replace battery and access cover.

After any repair work or dismantling, the unit should always be fully tested, checking that all functions operate correctly as described in the user manual.

Figure 1 D900-P Exploded View

T1	White	Violet
T2	Red	Orange
T3	Black	Pink
T4	Violet	Turquoise
T5	Screen	Screen

Several variations of cable colours are used as shown.

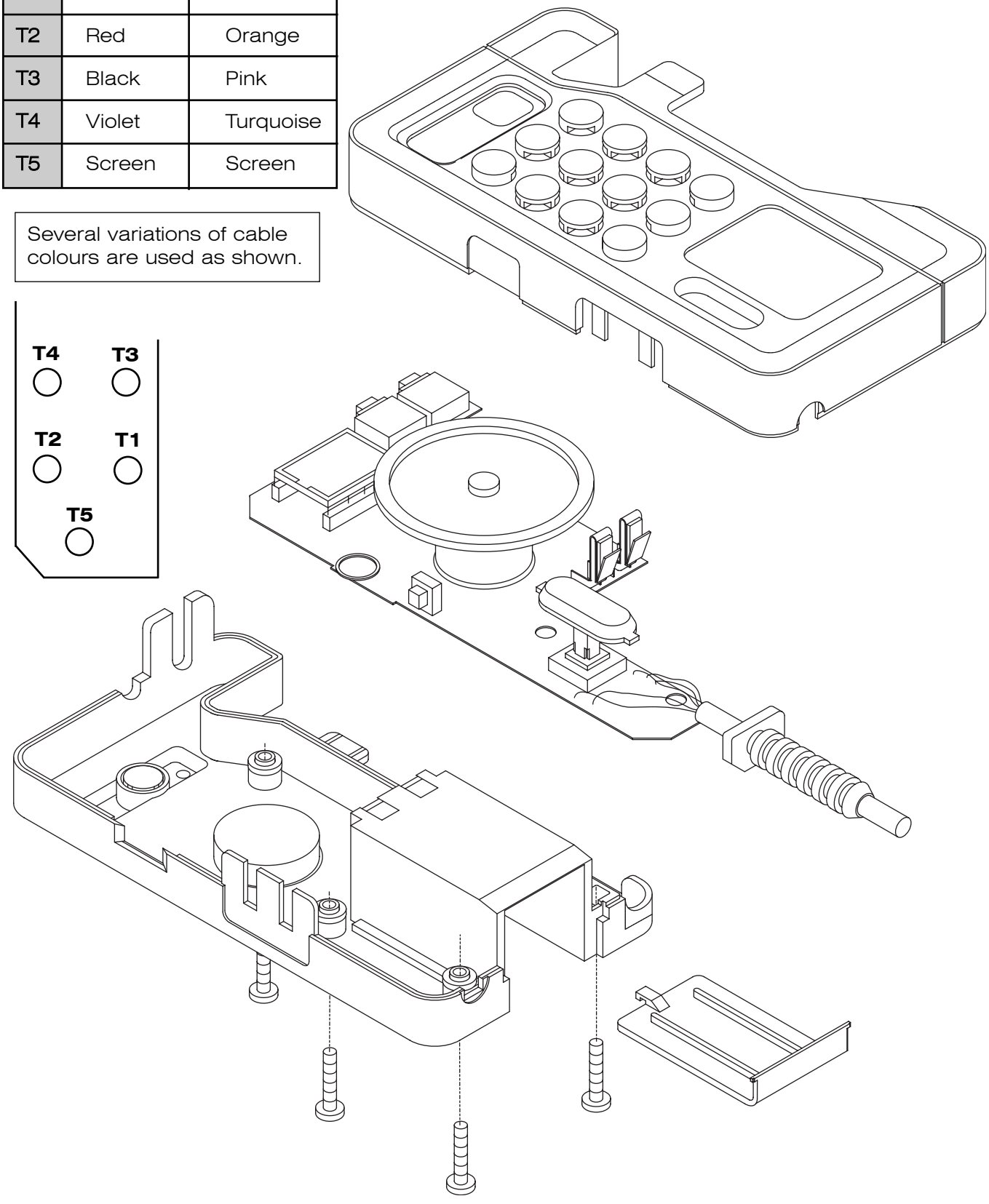
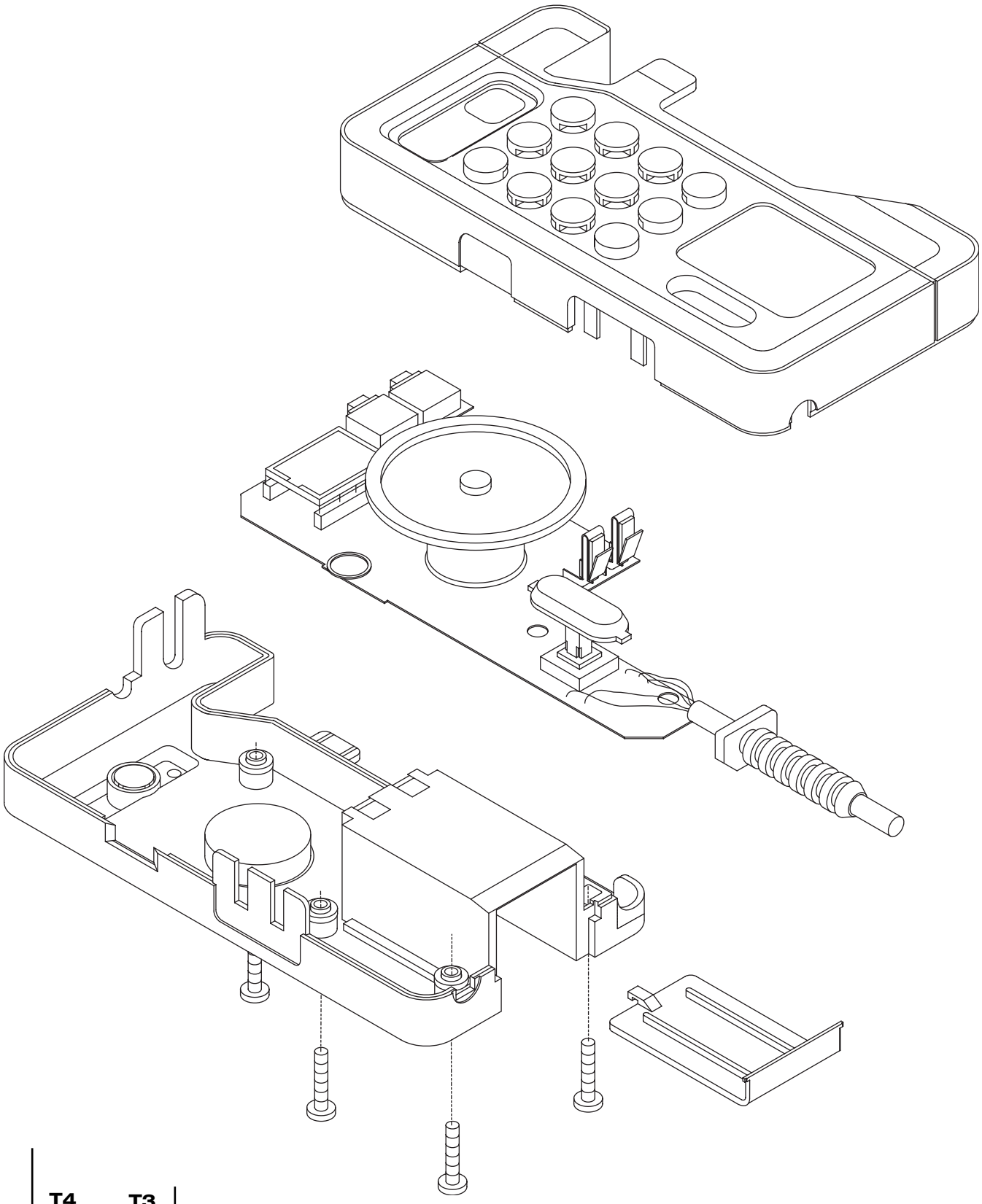
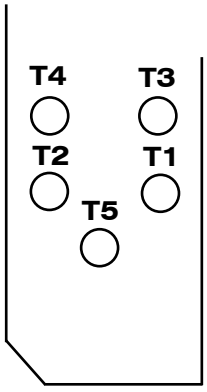


Figure 2 D920-P, D930-P Exploded View

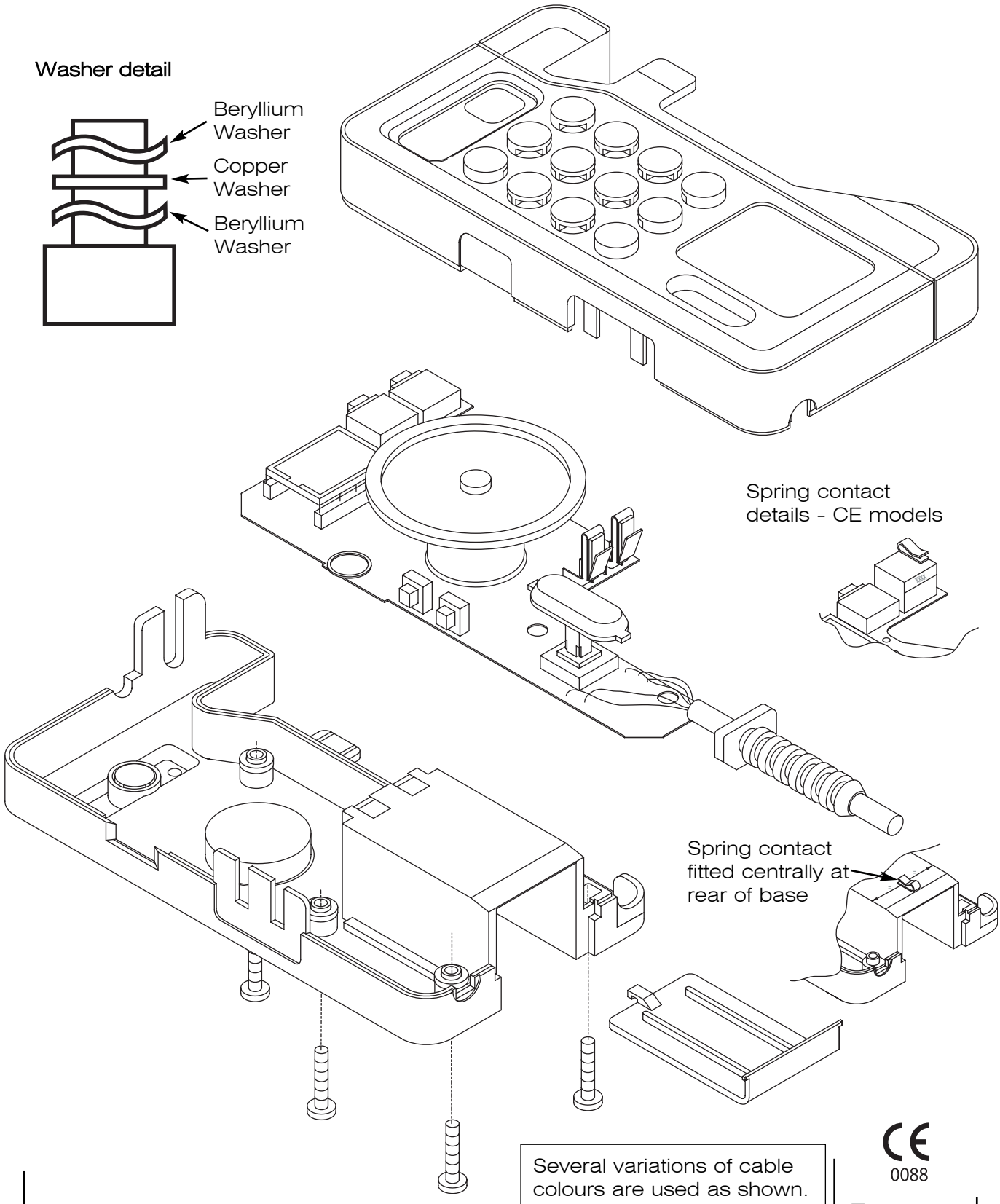




Several variations of cable colours are used as shown.

T1	White	Violet
T2	Red	Orange
T3	Black	Pink
T4	Violet	Turquoise
T5	Screen	Screen

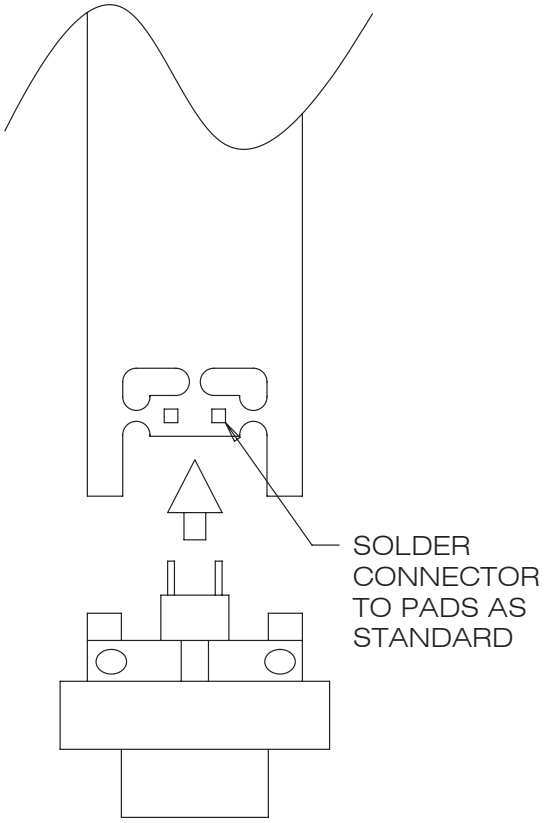
Figure 3 FD2-P, SD2-P, RD2, MD2-P, FD1-P Exploded View



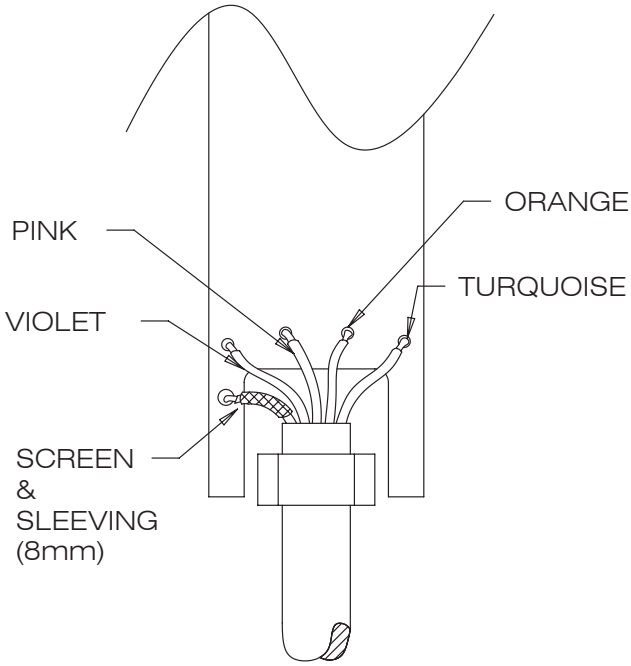
T1	White	Violet
T2	Red	Orange
T3	Black	Pink
T4	Violet	Turquoise
T5	Screen	Screen

Figure 2 D920-P, D930-P Exploded View

VP4-HS/VP5-HS/VP8-HS
VP10-HS/EZ8/
OP2-HS/OP3-HS PROBES



D920/D930/FD1 PROBES



7. Probe Head Replacement Procedure

7.1 Equipment Required

- Case splitter part number 6AE025 (not required for D920-P, D930-P & FD1-P).
- 20MHz Oscilloscope (Gould OS300 or equivalent) and x10 probe.
- Plastic jawed vice.
- DVM on current range (for specification see Appendix D).
- Synthesised signal generator (for specification see Appendix D).
- Head alignment service kit, part number 6AH072.
- Frequency counter (for specification see Appendix D).
- Soldering iron (for specification see Appendix A).
- New case halves, part number 6AE114.
- Power supply (for specification see Appendix D).

SPECIAL HANDLING PROCEDURES

The PCB assemblies used in the main unit and probe contain electrostatic device (ESSD). These may be permanently damaged by electrostatic potentials encountered in routine handling of the assemblies during servicing.

We therefore recommend that all servicing be carried out in a specialised handling area, (SHA) as defined by CECC00015 to avoid damage to the assemblies.

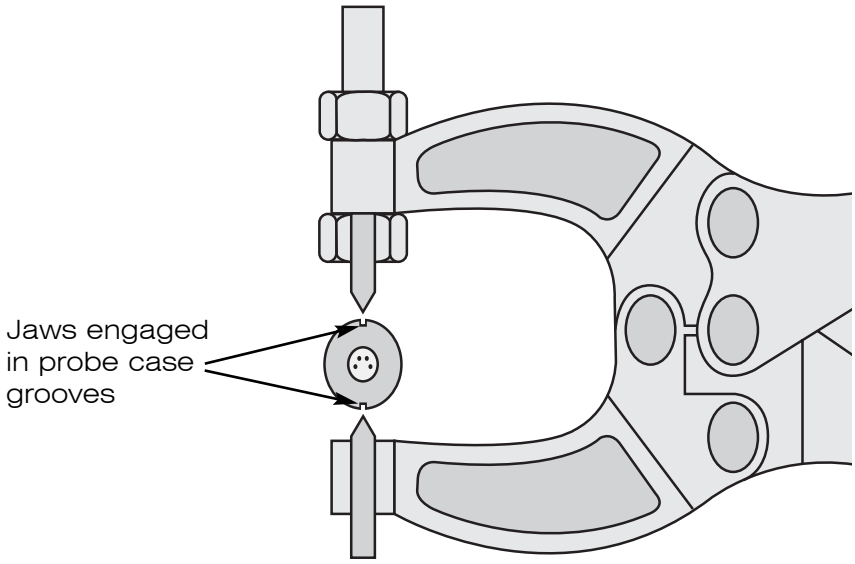
7.2 Preparation - For High Sensitivity Probes OP2HS, OP3HS, VP4HS, VP5HS, VP8HS, VP10HS, EZ8)

The retractile cable must be disconnected from the control unit before head replacement can begin (see section 6.3).

A spare retractile cable or the retractile cable from the unit must be disconnected from the control unit before a head replacement can begin.

7.3 Dismantling Procedure - (All probes except D920-P, D930-P & FD1-P)

1. Align the case splitter jaws as shown below.



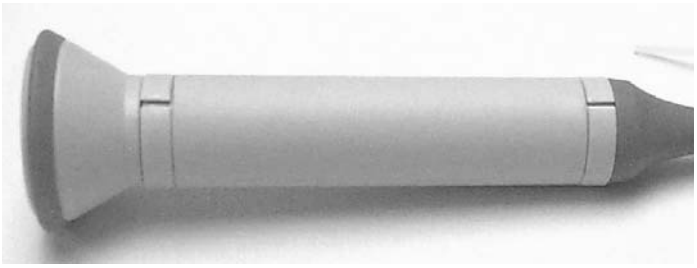
Splitting the Probe Case

2. Gently squeeze the splitter handles together to release the case internal clips.
3. Remove the case splitter and separate the case halves from the probe assembly.
4. Carefully unplug the probe head.
5. De-solder the wire(s) from the screen tube and remove tube.
6. Clamp PCB lightly in vice along its length avoiding stress to the board.

7.4 Dismantling Procedure - D920-P, D930-P & FD1-P

Please note: The retractile cable must be disconnected from the main unit before a head replacement can begin. (See sections 6.1 - 6.3).

1.



Remove the probe clips from the probe with a firm leverage.

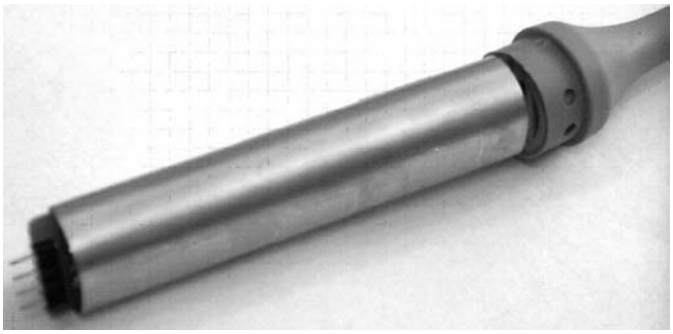
Discard clips.

2. With the clips removed, take off the Head Assy by disconnecting it from the 4 way connector on the Probe PCB.

3.

Detach the case moulding from the end cap and slide case moulding over the probe.

Discard the case moulding.



4. De-solder the wire from the copper screen tube.

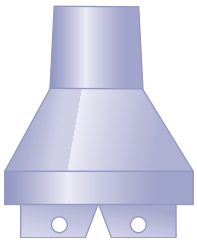
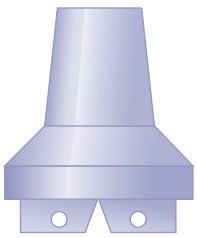
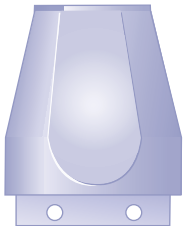
Remove the tube.

Refer to section 7.5 of the head fitting and alignment section of this service manual.

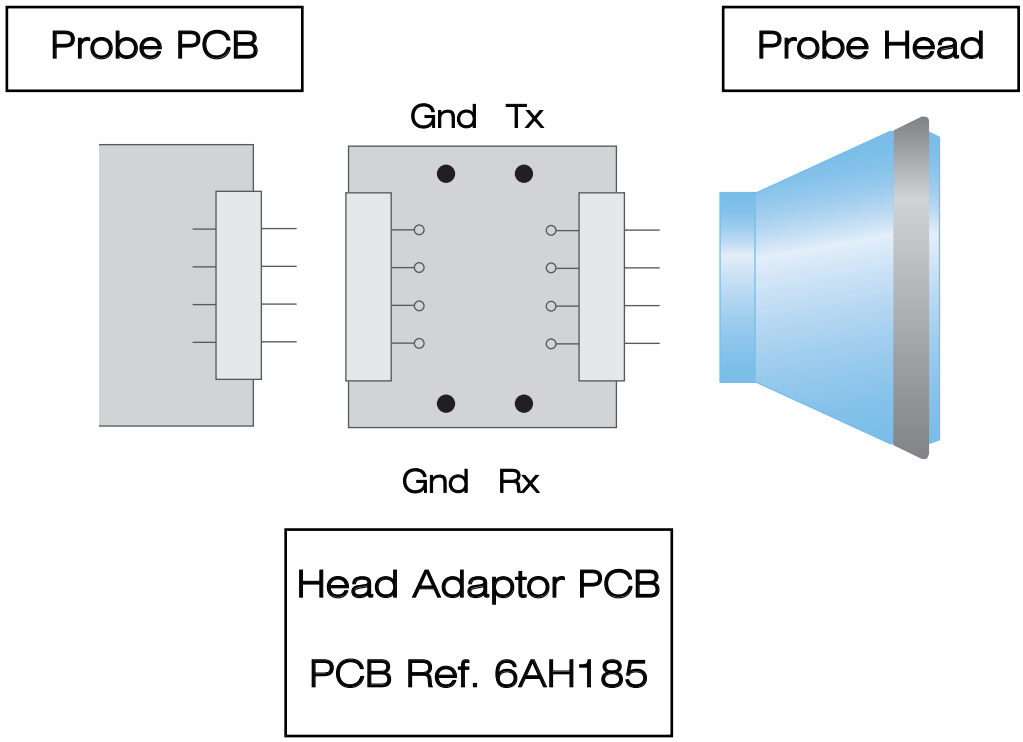
7.5 New Head Fitting and Alignment.

1. Select a new head of correct frequency, identified as shown below.

The probe heads are colour coded on the rear of the head as follows:

FREQUENCY	HEAD SHAPE	FREQUENCY	HEAD SHAPE
2MHz 3MHz		8MHz 10MHz	
4MHz 5MHz		EZ8	

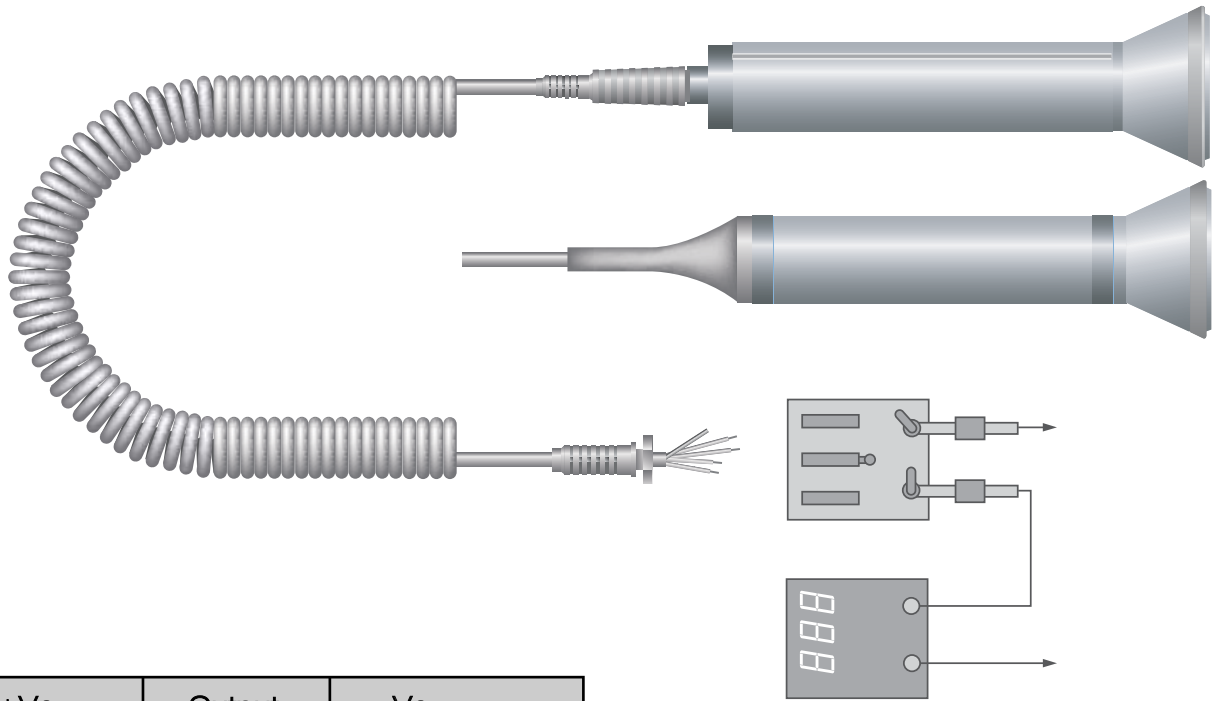
2. Connect the head adaptor PCB (supplied with head alignment service kit) to the probe. Fit the head to the adaptor PCB as shown below.



3. Connect the probe in series with the DVM set to measure current and power supply (check that voltage is 5V +/- 1%) as shown below, using power supply adaptor PCB(D920-P, D930-P) and adaptor cable (OP/VP probe).

CAUTION : Incorrect connection will damage probe electronics.

Power Supply Wiring



+Ve	Output	-Ve
Red	White	Black/Screen
Orange	Violet	Pink/Screen

Part No.	Description
6AH072	Head Alignment Service Kit

4. Switch on power supply.

5. Connect scope probe to the Transmitter Terminals (Tx) of the head adaptor PCB and observe Sine wave.

6. Adjust PR1 to obtain 1.5V +/- 0.5Vpp (see Figures 1 & 2).

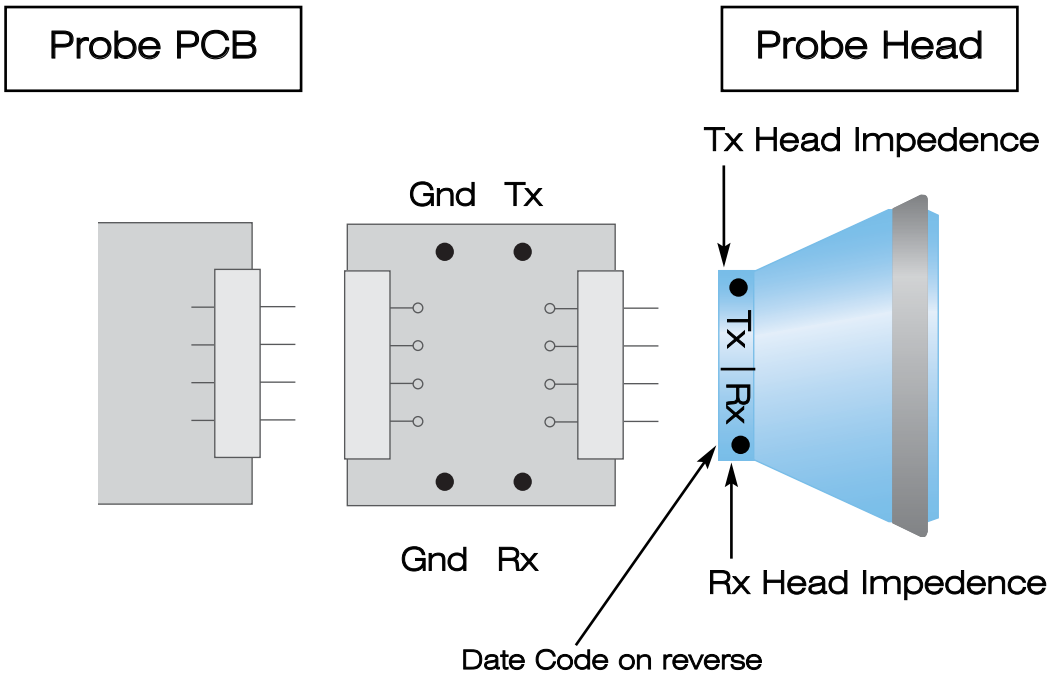


Figure 1 :Obstetric Probe Head Assembly

Head Adaptor PCB	
PCB Ref.	6AH185 6AH185-B

Head Adaptor PCB Ref : 6AH185

To be used with Head Assemblies:

SP-TDR HEAD - VP4HS
SP-TDR HEAD - VP5HS
SP-TDR HEAD - VP8HS
SP-TDR HEAD - VP10HS
SP-TDR HEAD - EZ8HS

SP-HEAD - OP2HSG1
SP-HEAD - OP3HSG1

SP-TDR - OP2HSB1
SP-HEAD - OP2HSB1

SP-TDR - OP3HSB1
SP-HEAD - OP3HSB1

Head Adaptor PCB Ref : 6AH185-B

To be used with Head Assemblies:

SP-HEAD - OP2HSG2
SP-HEAD - OP3HSG2

SP-TDR - OP2HSB2
SP-HEAD - OP2HSB2

SP-TDR - OP3HSB2
SP-HEAD - OP3HSB2

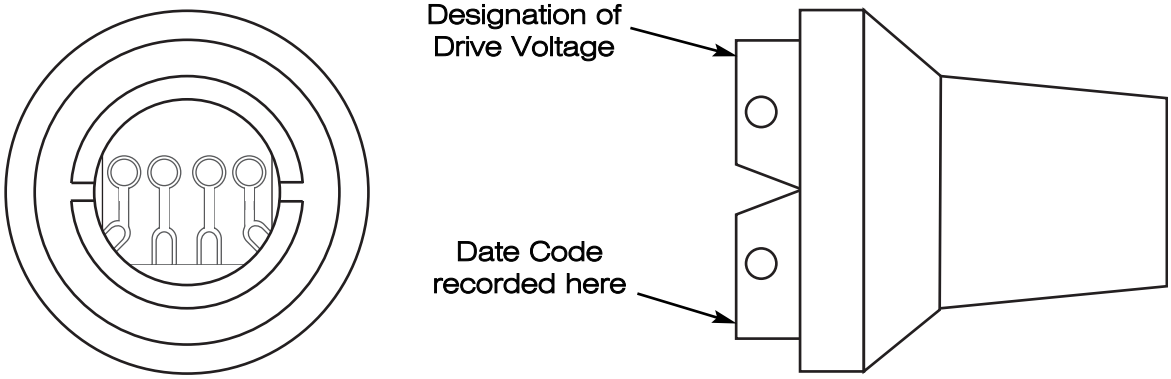


Figure 2 : Vascular Probe Head Assembly

7. Adjust T1 to minimise supply current.

8a. Vascular Probe Head Assemblies Only [e.g. VP8HS, VP5HS, VP4HS, VP10HS]

Refer to the Head Assembly to determine drive voltage output for the selected transmitter impedance (see Figure 2.) Set transmitter voltage using PR1(see Figure 3).

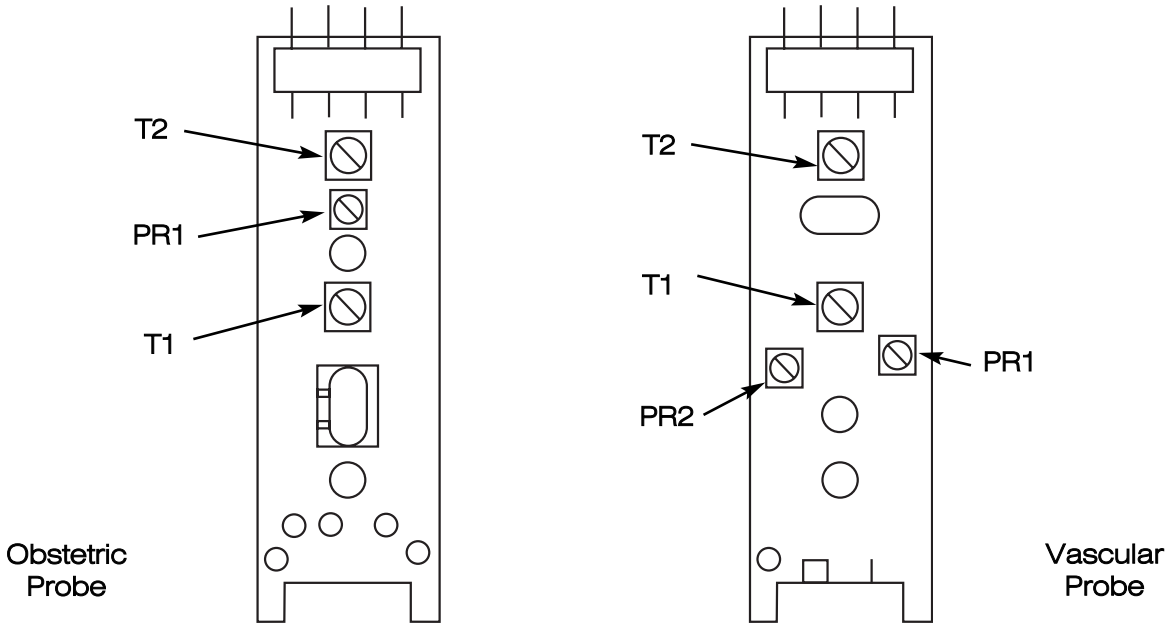


Figure 3 : Probe Layout

8b. Obstetric Probe Head Assemblies Only [e.g. OP2HS, OP3HS]

Refer to the power chart tables, (figures 4 & 5), to determine the drive voltage for the selected Tx transmitter impedence.
Set transmitter voltage using PR1. (See figure 3).

Figure 4 : 2MHz/OP2/AP Value (Tx Head)

Impedence	Rounded Nearest 0.02V	Resulting Power
7	1.64	48.04
8	1.74	47.32
9	1.84	47.04
10	1.94	47.06
11	2.04	47.31
12	2.14	47.72
13	2.22	47.40
14	2.30	47.25
15	2.38	47.22
16	2.46	47.29
17	2.54	47.45
18	2.62	47.68
19	2.68	47.27
20	2.76	47.62
21	2.82	47.35
22	2.90	47.80
23	2.96	47.63
24	3.02	47.52
25	3.08	47.45
26	3.14	47.42
27	3.20	47.42
28	3.26	47.46
29	3.32	47.52
30	3.38	47.62

Impedence	Rounded Nearest 0.02V	Resulting Power
31	3.44	47.73
32	3.48	47.32
33	3.54	47.48
34	3.60	47.66
35	3.64	47.33
36	3.70	47.55
37	3.74	47.27
38	3.80	47.51
39	3.84	47.28
40	3.90	47.55
41	3.94	47.34
42	4.00	47.63
43	4.04	47.46
44	4.08	47.31
45	4.13	47.39
46	4.18	47.49
47	4.22	47.38
48	4.27	47.50
49	4.31	47.40
50	4.36	47.54
51	4.40	47.54
52	4.45	47.58
53	4.49	47.63
54	4.54	47.69

Figure 5 : 3MHz Value (Tx Head)

Impedence	Voltage Required
8	1.74
9	1.84
10	1.94
11	2.04
12	2.14
13	2.22
14	2.30
15	2.38
16	2.46

Impedence	Voltage Required
17	2.54
18	2.62
19	2.68
20	2.76
21	2.82
22	2.90
23	2.96
24	3.02
25	3.08

Impedence	Voltage Required
26	3.14
27	3.20
28	3.26
29	3.32
30	3.38
31	3.44
32	3.48
33	3.54
34	3.60

Figure 5 (continued) : 3MHz Value (Tx Head)

Impedence	Voltage Required
35	3.64
36	3.70
37	3.74
38	3.80
39	3.84
40	3.90
41	3.94
42	3.99
43	4.04

Impedence	Voltage Required
44	4.09
45	4.13
46	4.18
47	4.23
48	4.27
49	4.31
50	4.36
51	4.40
52	4.44

Impedence	Voltage Required
53	4.49
54	4.53
55	4.57
56	4.61
57	4.65
58	4.69
59	4.73
60	4.77

9. Record this reading on the Device History Record Sheet (Appendix B) along with transmitter impedance and date code.

   (e.g. Date"21st June 1993", Product "OP2", Serial Number "135",

   Transmitter Head Impedance "24", Drive Voltage "3V", Date Code "TAD").

10. Check that supply current is;

    By adjusting T1, <40mA for OP2, OP3

    <35mA for VP4, VP5, VP8, VP10, EZ8

11. Turn off the power supply and disconnect probe.

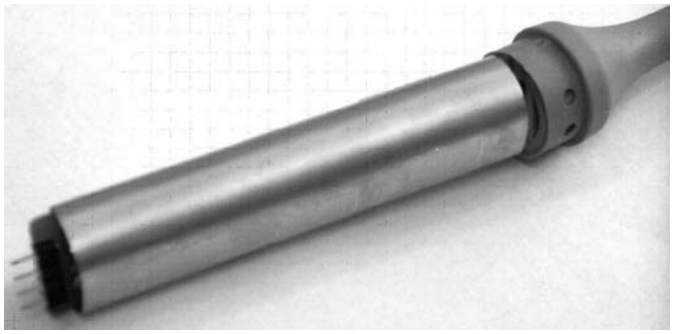
7.6 Reassembly Procedure - All probes except D920-P, D930-P & FD1-P

1. Remove the probe head from the PCB if fitted.
2. Slide the copper screening tube over the PCB.
3. Solder the ground wire(s) to the tube, and tuck the wire(s) into the end(s) of the tube. Fit the head, taking extreme care not to bend the connector pins.
4. Fit the new case halves ensuring that the locating lugs align with the holes in the head and end-cap.
5. The probe should now be functionally tested, see Section 8.

7.7 Reassembly Procedure - D920-P, D930-P & FD1-P

Please note: Remove the probe head from the PCB if fitted.

1.



Slide the copper screen, (item 30), over the probe and position so that the internal fold is located against the edge of the PCB.

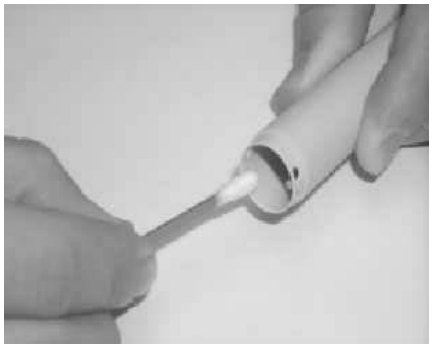
Re-solder in place using tinned copper wire.

2.

Before applying silicon grease to the End Cap, ensure there is no residue of glue left behind from the previous clips.

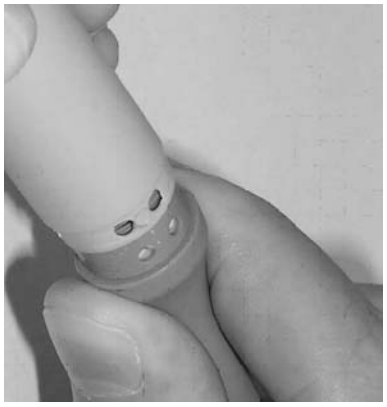
Ensure locating holes are clean.

Apply silicon grease to the End Cap and inside the case moulding at both ends, using a cotton bud as shown.



Apply grease to hatched area only. Avoid locating holes of End Cap.

3.



Slide the case moulding over the probe, ensuring that the holes are fully aligned.

Remove any excess silicon grease with a dry tissue.

4.

Apply silicon grease to the head assembly, as shown by the hatched area.

Ensure that the 4-way connector on the PCB is sitting flush with the board, and that no pins are bent or damaged.

5.

Attach Head Assembly to Probe Assembly.

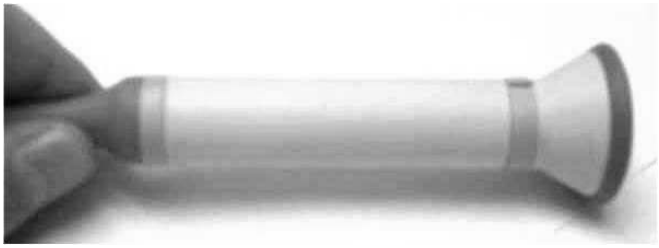
Ensure that the PCB fits into the slot and the holes are aligned.

Only use the side of the Head to press down.

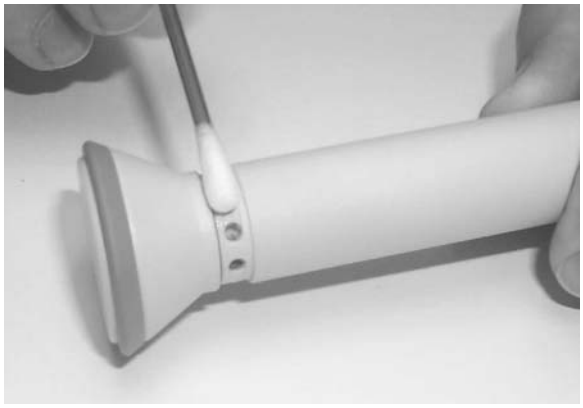
Ensure the pins of the PCB locate into the Head PCB socket.

6. Remove any excess grease from the probe with a dry tissue.

Check that the holes are aligned.



7.



First clean clip recesses at both ends using a dry tissue, then a cotton bud dipped in Propanol.

Allow to fully dry.

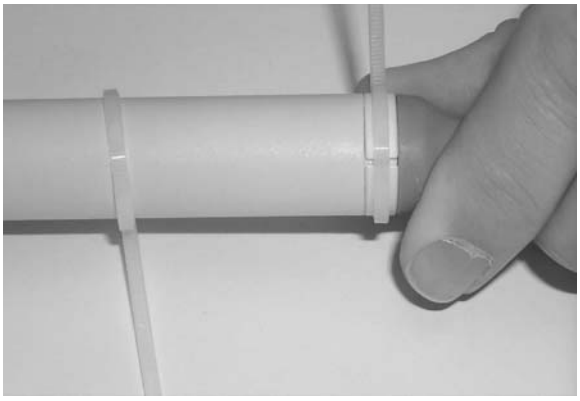
Note: Replacement clips must be cleaned prior to assembly using Propanol, to remove any excess grease.

8. In the centre of the first recess, apply adhesive* as a continuous bead of uniform thickness, around the whole circumference of the probe.

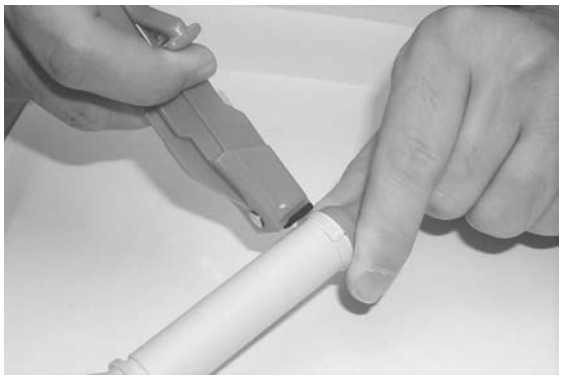
Apply a bead of adhesive* to the 4 holes, then fit clips.

** Recommended Adhesive : **Loctite 4850***

9.



Without delay, fit and tighten the tie wrap around the clips, ensuring that the tie wrap is centrally located.



10. Tighten the tie wrap using a tie wrap gun.

Repeat at other end.

11.

The tie wrap can be removed after 5 minutes by sliding them from the probe body onto the cable, where they can be cut off.

7.8 Waterproof Inspection & Test Procedure - D920-P, D930-P & FD1-P

IMPORTANT: This test is only to be carried out with D920-P, D930-P and FD1-P Waterproof probes.

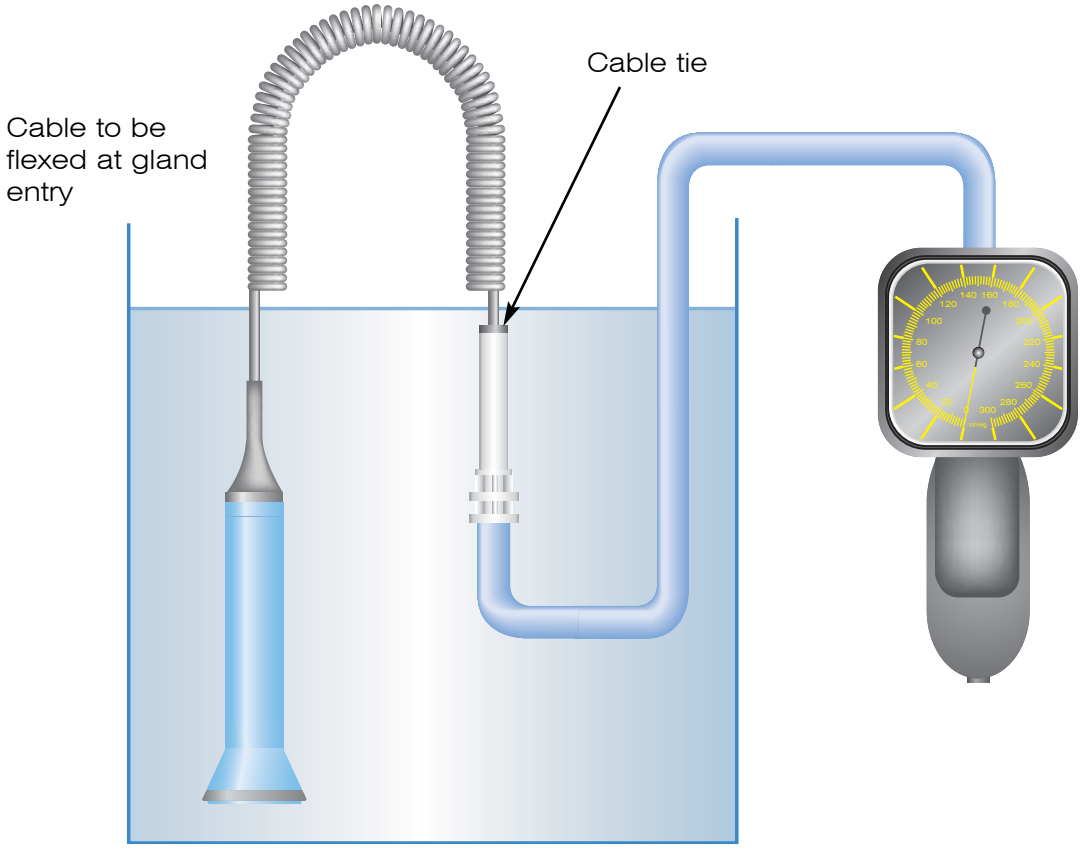
Equipment Required

1. Sphyg Pressure Indicator (ACC123)

Waterproof Testing

These tests are designed to ensure the probe is waterproof to an approximate depth of 1.5m of water.

They are done by immersing the probe in water, pressurising it with compressed air, and checking for air leaks.



Probe Test - To test the completed probe

1. Inspect grommet of AP2-P transducer and peel off any excess silicon from external surfaces before commencing the waterproof test.

2. Adjust the air supply to give 130 +/- 10mmHg.

3. The Probe is pressurised via the cable. Clamp the tube around the cable end using a cable tie. Check the joint to ensure there is no air leak by immersing in water. Flex the cable at gland entry and check for bubbles. If no bubbles are evident, continue test.

4. Check for leaks for a minimum of 30 seconds.

5. *If any air leaks are noted, further investigation is required.*

8. Probe Functional Test Specification

IMPORTANT: This test must always be performed after any service work has been undertaken on any probe. Test results should be recorded on Device History Sheet (Appendix B).

8.1 Equipment Required

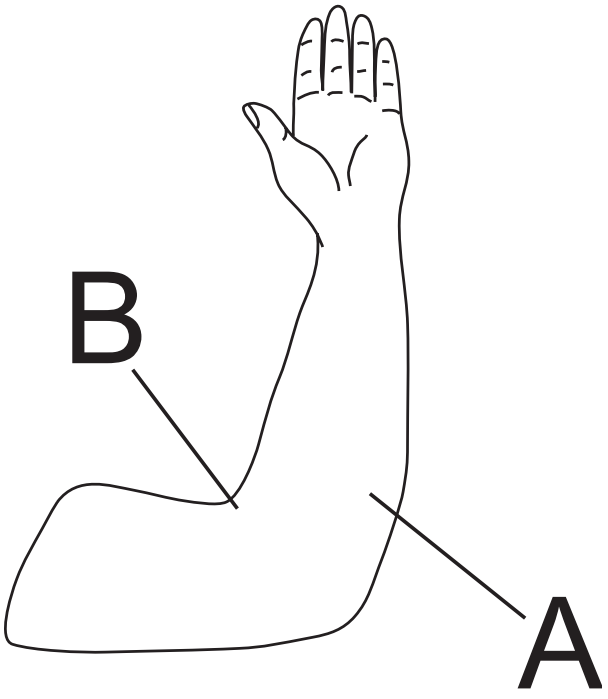
- Standard MD2-P (not required for D920-P, D930-P, FD1-P).
- Battery 9V alkaline manganese (6LF22, 6LR61) e.g. MN1604 or equivalent.
- Chart Recorder (not required for D920-P, D930-P, FD1-P, OP2HS or OP3HS). Refer to Appendix D for specification.
- Recorder Lead (not required for D920-P, D930-P, FD1-P, OP2HS or OP3HS). Part number 6AH073.
- Standard Probes as required

8.2 Functional Tests - Vascular Probes VP4HS - VP10HS & EZ8

1. Connect the probe to the test unit. Check that the chart recorder lead is plugged into the unit's waveform output socket and that the recorder is switched on.
2. With the unit switched on and with a dry faceplate listen for any RFI (Radio Frequency Interference) whilst handling the probe. This shows up as whines or whistles.
3. Background hiss levels should not be greater than the standard probes.
4. Check for crackling or intermittent audio when probe/retractile are moved.

   This may indicate a loose connection.
5. Evaluate the performance level of the probe by testing on the body. Refer to standard probe during test. See figure opposite for recommended probe testing sites.
6. Check that the control unit defaults to bi-directional mode. A probe symbol will be displayed on the right hand side of the screen. Obtain signal and note direction and velocity of blood flow, there should be no or very little cross-talk.
7. Obtain a test trace, refer to examples of traces in Appendix G.

Probe Testing Sites



A. OP2HS, OP3HS, D920-P, D930-P, and FD1-P tests on forearm.

B. VP4HS, VP5HS, VP8HS, VP10HS and EZ8 tests on arm (brachial artery).

8.3 Functional Test - Obstetric Probes OP2HS, OP3HS, D920-P, D930-P, FD1-P

D920-P, D930-P, FD1-P — Switch the unit on. Test the probe for noise and signal levels referring to the figure above for a suitable test site, (using a standard probe as a reference).

OP2HS, OP3HS — These must be tested with a MD2-P or FD2-P.

Check that the unit defaults to Fetal Mode, and that the frequency indication is correct. Test audio performance as above.

9. Fault Finding

9.1 LCD - Marks On Display

1. The LCD display may show marks and symbols when the unit is not turned on. This is caused by static charge on the display and will disappear after a short while.

2. If the marks do not disappear, then the display could be stressed or cracked.

   If this is the case fit a new display.

9.2 No Sound

1. Check for output at the headset socket. If present, check speaker and headset socket.

2. Check for signal on input to volume control potentiometer and output to headset socket.

3. If no fault is found with the headset socket, volume control or speaker fit a new PCB.

   N.B. *Stereo output is only available with the SD2-P, MD2-P or RD2 with headphones connected.*

9.3 Unit Dead

1. Check for supply voltage across the on/off switch, if supply is not present it may be a broken track, battery connector or a flat battery.

9.4 No Output From Sockets

1. Check integrity and continuity of sockets.

2. Refer to user manual to ensure that the Dopplex is in the correct mode.

9.5 Poor Heart Rate Tracking

1. Refer to user manual to ensure that correct technique is used.

9.6 Poor Sensitivity, Crackling

Test for cracked crystals as follows:

1. Connect transducer to control unit (not applicable to D920-P, D930-P, or FD1-P).

2. Set audio volume to maximum. Ensure that faceplate is clean, dry and unmarked.

CAUTION: *Under no circumstances should pressure be applied directly to the front face of the probe head or PPG sensor.*

3. Apply firm pressure radially around the outside edge of the faceplate using thumb and forefinger. Listen for clicking, instability or change in background noise level.

4. If any of these effects are heard, reject the probe for head replacement.

9.7 PPG not locking on

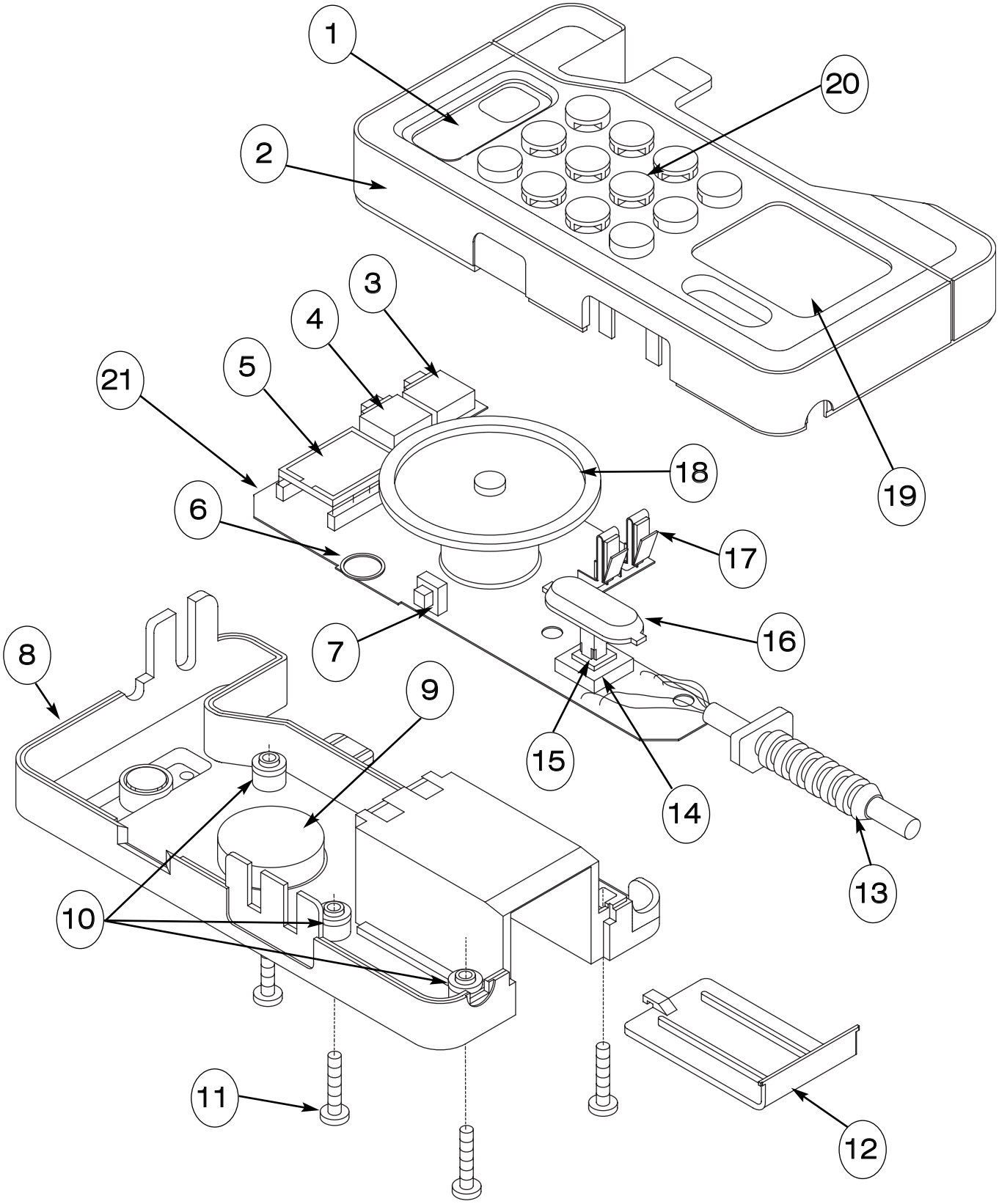
1. Check retractile cable with either known good PPG probe or vascular probe.

   If fault still persists, consult Huntleigh Healthcare Ltd Service Department.

10. Spare Parts List

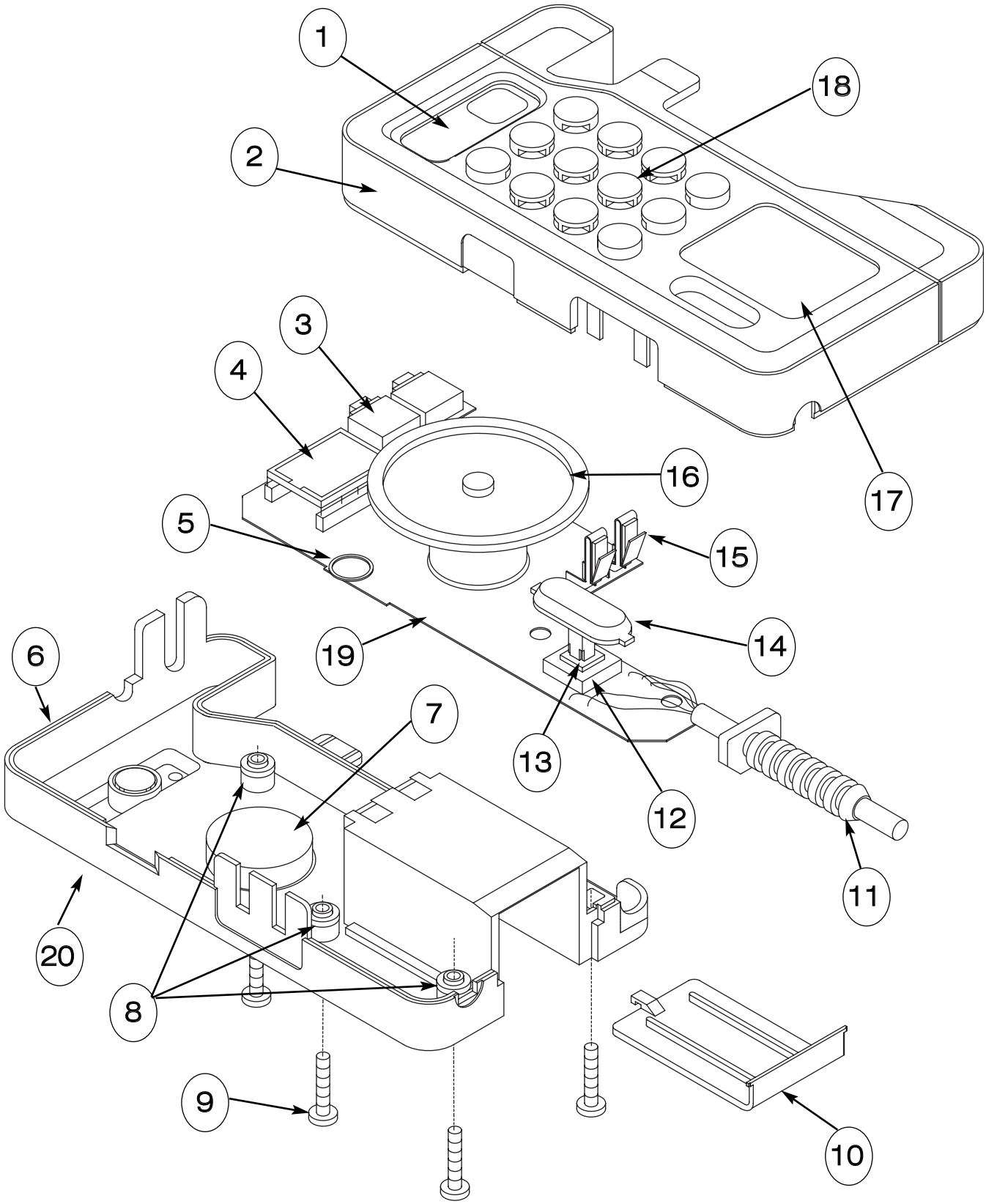
The following spare parts can be ordered from your dealer, or direct from Huntleigh Healthcare Ltd using the part numbers shown below:

10.1 D900-P Parts List



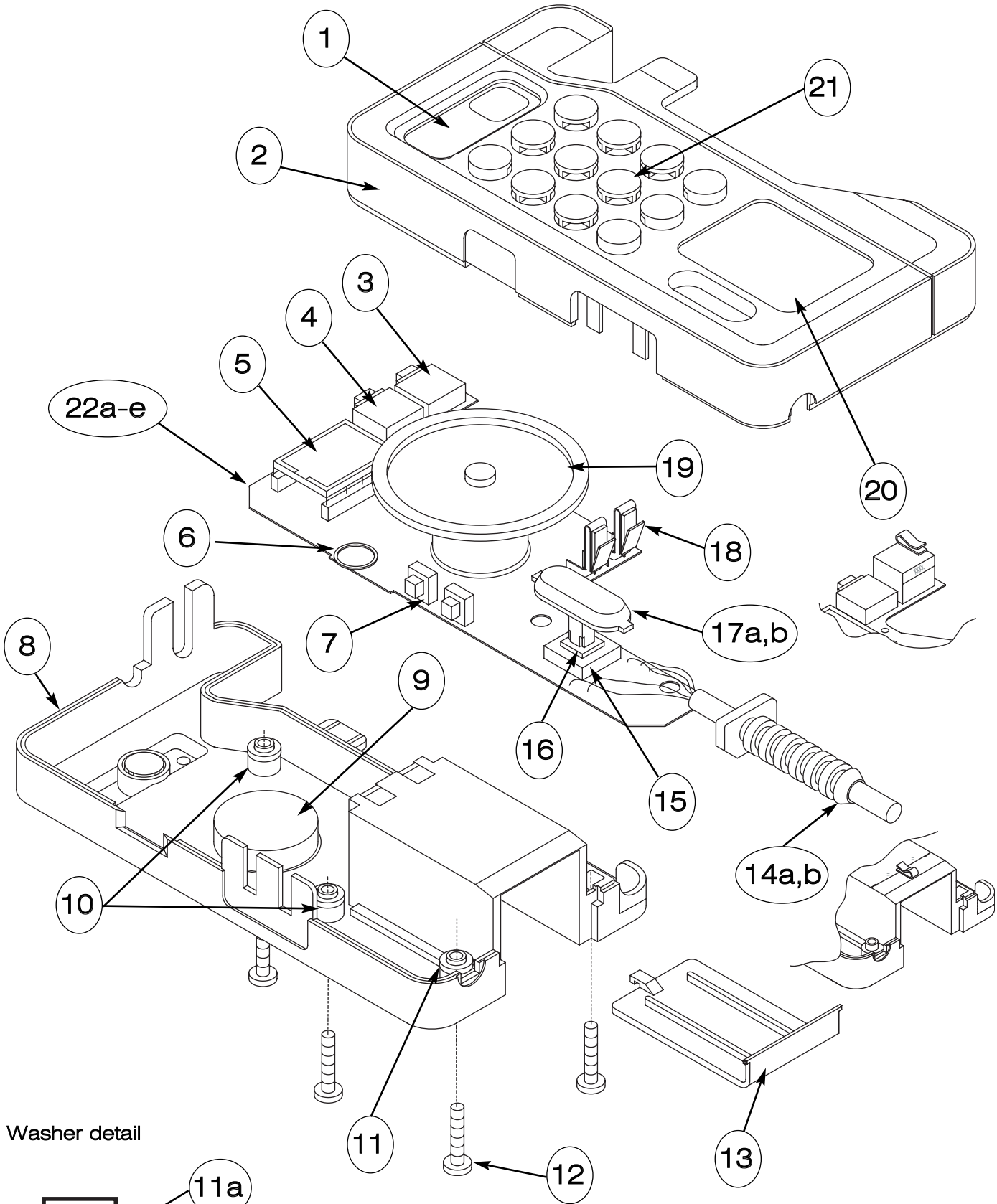
Ref	Part Number	Description
1	6AH102	Window Label
2	6AE102	Case Front
3	HSJ7061-01-450	Waveform Socket
4	HSJ7061-01-410	Headphone Socket
5	CS194	LCD Display
6	091BH-LOG	Volume Control
7	B3W-4050	On/Off
8	6AE103/2	Case Rear
9	6AE109	Foam Speaker Pad
10	200-901	'O' Rings
11	WN-1442-KB-25-20	Case Screw
12	6AE104	Battery Cover
13	SP-6AH104	Retractile Cable
14	B3F-3150	Calibration Switch
15	6AE171	On/Off Button Spring
16	SP-726335/P-A	On/Off Button
17	6AE108	Battery Terminal
18	A0200	Loudspeaker
19	SP-726308	Label Set
20	6AE232	Cork Gasket
21	SP-726069	D900-P PCB

10.2 D920-P, D930-P Parts List

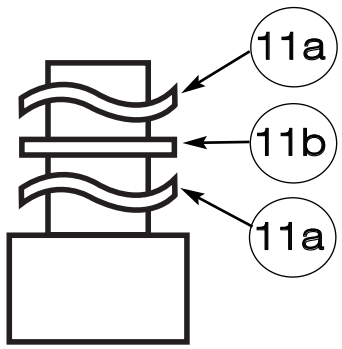


Ref	Part Number	Description
1	6AH102	Window Label
2	6AE102	Case Front
3	HSJ7061-01-410	Headphone Socket
4	CS194	LCD Display
5	091BH-LOG	Volume Control
6	6AE103/2	Case Rear
7	6AE109	Foam Speaker Pad
8	200-901	'O' Rings
9	WN-1442-KB-25-20	Case Screw
10	6AE104	Battery Cover
11	SP-726073	Fixed Waterproof Probe and Cable
12	B3F-3150	On/Off Switch
13	6AE171	On/Off Button Spring
14	SP-726335/B-A	On/Off Button
15	6AE108	Battery Terminal
16	A0200	Loudspeaker
17	SP-726309	D920-P Label Set
18	6AE232	Cork Gasket
19	SP-726075	D920-P, D930-P PCB
20	6AE107	Pocket Clip

10.3 MD-2, SD2-P, FD2-P, FD1-P, RD2 Parts List

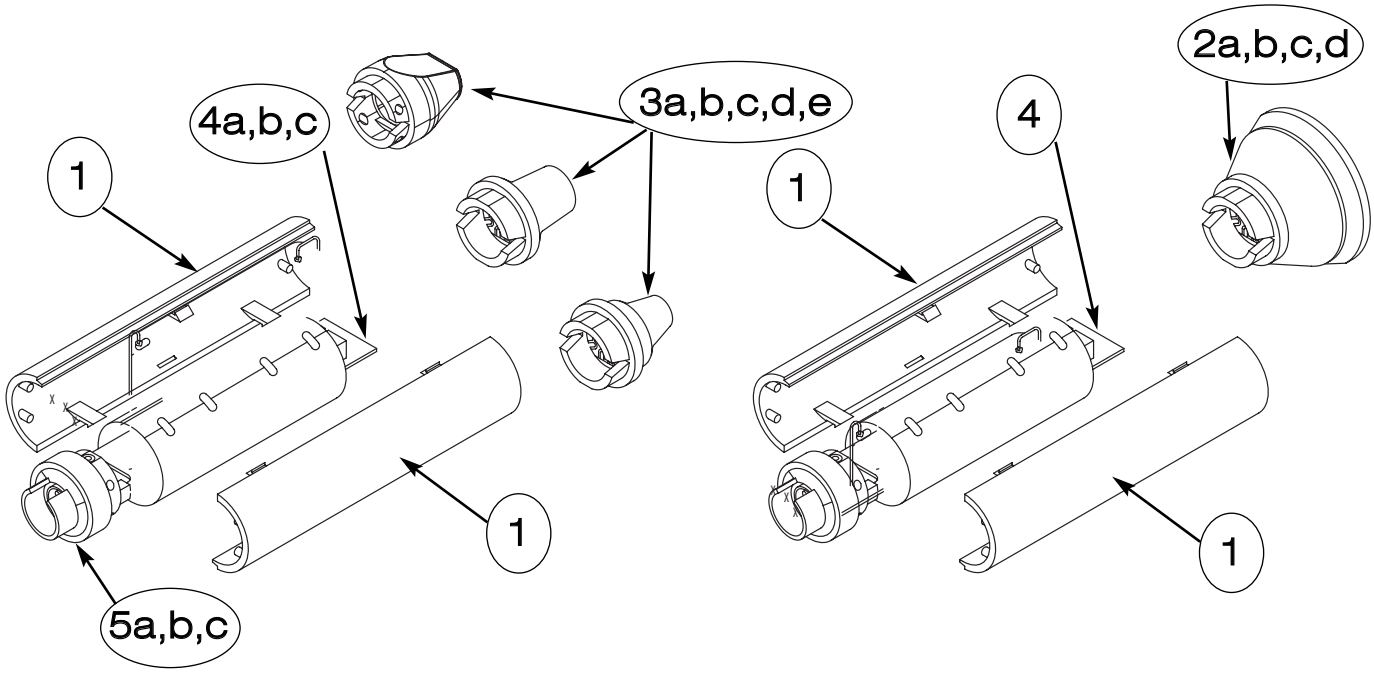


Washer detail



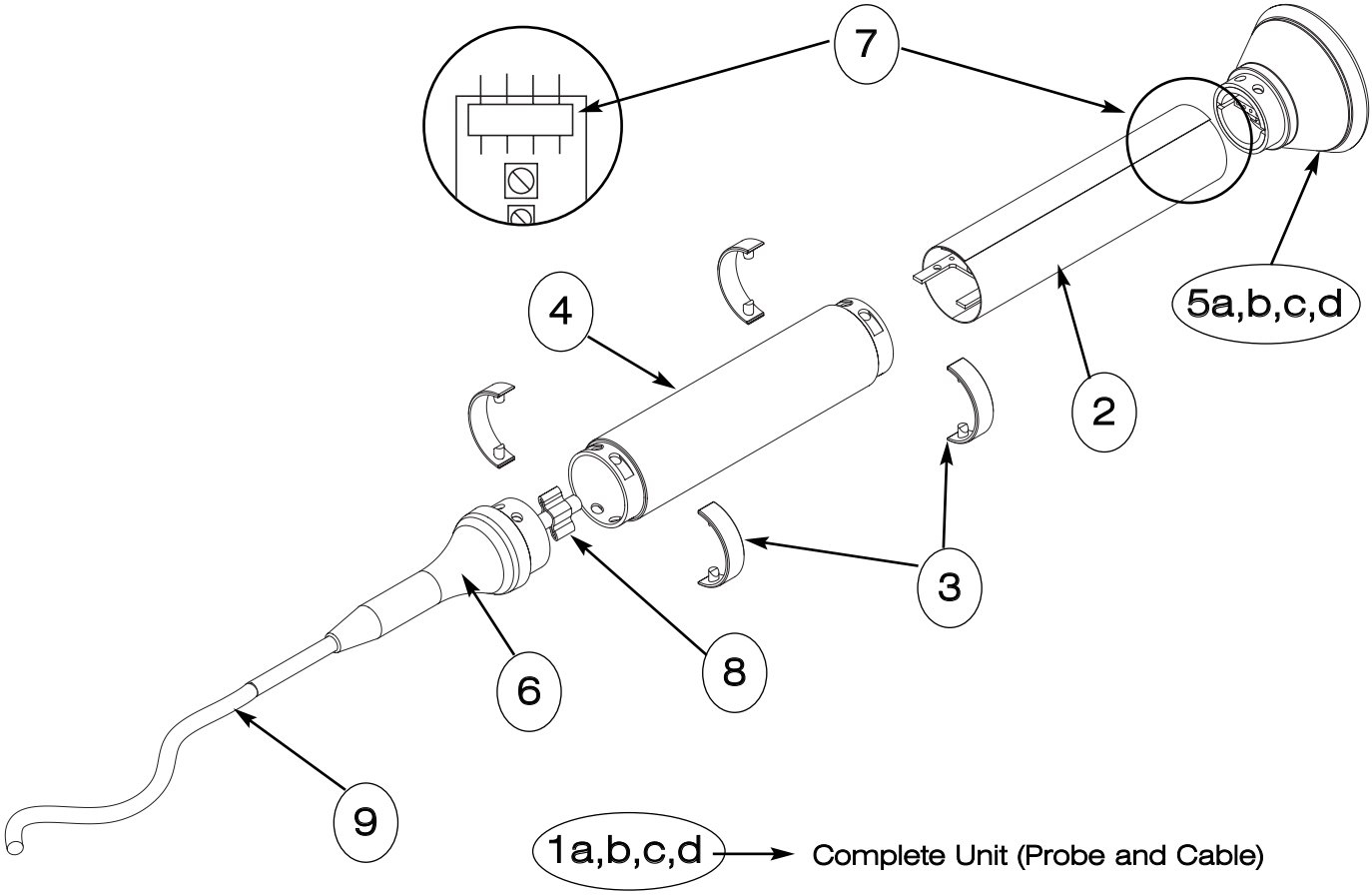
Ref	Part Number	Description
1	6AH103	Window Label
2	6AE102/SE-7	Case Front
3	MDJ8DM	Sub Miniature DIN Socket
4	HSJ7061-01-410	Stereo Socket
5	CS195	MD2-P LCD Display
6	092BH-LOG	MD2-P Volume Control
7	B3W-4050	Function/mode Switch
8	6AE103/2/SE-6 + 66EU102226	MD2-P Case Rear
9	6AE109	Foam Speaker Pad
10	200-901	'O' Rings
11a	SJ0001-HUNTLEIGH	Beryllium washer
11b	WST1-FLAT	Copper Washer
12	WN-1442-KB-25-20	Case Screw
13	6AE104	Battery Cover
14a	SP-6AH104	Retractile Cable
14b	SP-726073	Fixed waterproof Probe and Cable
15	B3F-3150	On/Off Switch
16	6AE171	On/Off Button Spring
17a	6AE106	On/Off Button
17b	726335/B-A	FD1-P Button On/Off
18	6AE108	Battery Terminal
19	A0200	Loudspeaker
20	SP-726303	MD2-P Label Set
20	SP-726304	SD2-P Label Set
20	SP-726306	FD2-P Label Set
20	SP-726314	FD1-P Label Set
20	602305	RD2 Label Set
21	6AE232	Cork Gasket
22a	SP-726054	MD2-P PCB
22b	SP-726059	SD2-P PCB
22c	SP-726064	FD2-P PCB
22d	SP-726090	FD1-P PCB
22e	SP-602078	RD2 PCB

10.4 Obstetric and Vascular Probe Parts List



Ref	Part Number	Description
1	6AE114	Probe Case Half
2a	SP-HEAD-OP2HSG1	OP2 Head Assembly
2b	SP-HEAD-OP2HSG2	OP2 Head Assembly
2c	SP-HEAD-OP3HSG1	OP3 Head Assembly
2d	SP-HEAD-OP3HSG2	OP3 Head Assembly
3a	SP-TDR HEAD-VP4HS	VP4 Head Assembly
3b	SP-TDR HEAD-VP5HS	VP5 Head Assembly
3c	SP-TDR HEAD-VP8HS	VP8 Head Assembly
3d	SP-TDR HEAD-VP10HS	VP10 Head Assembly
3e	SP-TDR HEAD-EZ8HS	Easy & Wide Beam Head Assy
4a	DO1-999-20-01	Head Connector
4b	6AE025	Probe Case Splitter
4c	SP-6AH072-ASSY	Probe Alignment Service Kit
5a	6AH101	End Cap Assembly
5b	718-09-33890004	Probe Connector Socket
5c	M3x4-GRUB	M3x4 Grub Screw

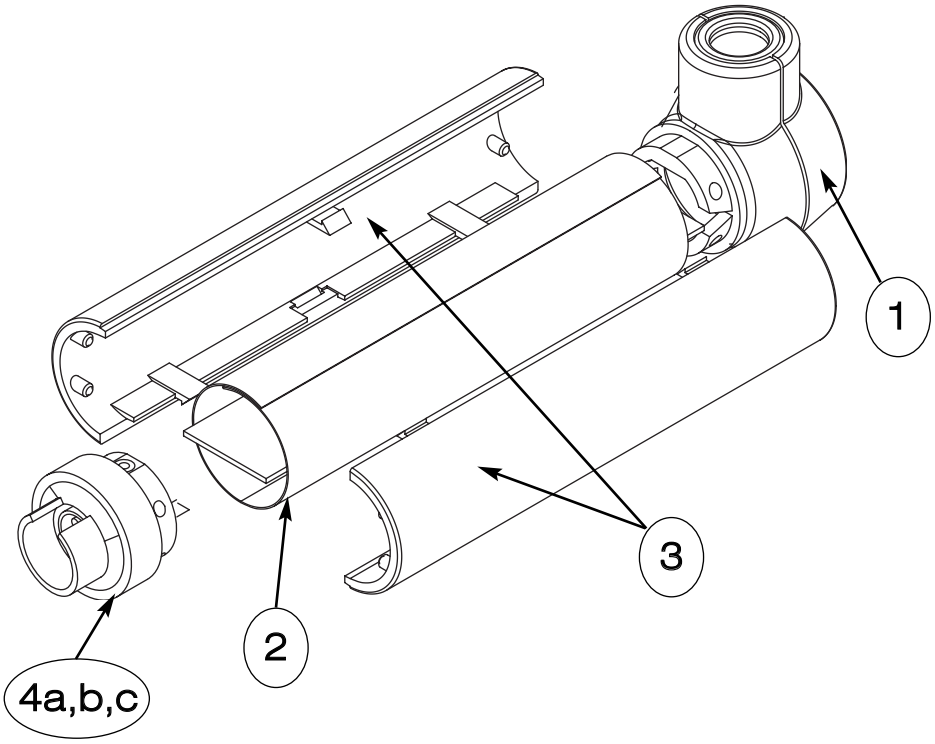
10.5 D920-P, D930-P, D930-P, FD1-P Probe Parts List



Ref	Part Number	Description
1a	SP-TDR - OP2HSB1	Fixed Waterproof Probe & Cable 2MHz
1b	SP-TDR - OP2HSB2	Fixed Waterproof Probe & Cable 2MHz
1c	SP-TDR - OP3HSB1	Fixed Waterproof Probe & Cable 3MHz
1d	SP-TDR - OP3HSB2	Fixed Waterproof Probe & Cable 3MHz
2	605059	Screen Assembly
3	606318	Case Clip
4	606312	Case Moulding
5a	SP-HEAD-OP2HSB1	OP2 Head Assembly (Blue)
5b	SP-HEAD-OP2HSB2	OP2 Head Assembly (Blue)
5c	SP-HEAD-OP3HSB1	OP3 Head Assembly (Blue)
5d	SP-HEAD-OP3HSB2	OP3 Head Assembly (Blue)
6	606320	Transducer Grommet Assy
7	M22-2530405	4 Way Connector
8	H0305	2-Ear Clamp
9	726381	Fixed Waterproof Probe Retractile Cable

N.B. For Wiring diagram, please refer to Appendix E.

10.6 ISP3 Probe Parts List



Ref	Part Number	Description
1	722061	PA8 Head Assembly
2	722065	Copper Screen Assembly
3	64E114	Probe Case Half x 2
4a	726316-A	End Cap Assembly
4b	M3x4-Grub	M3x4 Grub Screw
4c	718-09-33890004	Probe Connector Socket

11. Ordering Information

To order spare parts and for price information, contact the Service Department at Huntleigh Healthcare Ltd. Before phoning, be sure to have the following information available to ensure that our service department personnel are able to correctly identify your requirements:

- Control unit model number.
- Control unit serial number.
- Probe frequency.
- Probe serial number.
- Part numbers of items required.

The service department direct line shown below offers a 24 hour service. During office hours, trained staff will be available to assist you. Outside office hours, an answering machine will allow you to leave a message.

11.1 Service Returns

If for any reason your Dopplex product is being returned, please observe the procedure below;

1. Decontaminate the unit and probe
2. Pack the unit inside suitable packing
3. Attach the decontamination certificate to the outside of the packing
4. Mark the package Service Department - (product model)

For further details refer to NHS Document HSG(93)26.

Please note that waterproof models returned without observing the above procedure will be returned for decontamination.

Huntleigh Healthcare Ltd - Diagnostic Products Division,
Service Department,
35, Portmanmoor Road,
Cardiff, CF24 5HN, UK.
Service Department Direct Line: (029) 20496793 (24 hr answer service)
Fax: (029) 20492520

Appendix A

Special Handling Procedures

The PCB assemblies used in the control unit and probe contain electrostatic sensitive devices. These may be permanently damaged by electrostatic potentials encountered in routine handling of the assemblies during servicing.

We therefore recommend that all servicing be carried out in a specialised handling area (SHA) as defined by CECC00015 (published by CENELEC) to avoid damage to the assemblies.

Recommended Soldering Equipment for Rework

The following should be used for all soldering operations carried out on any Dopplex product in servicing:

Soldering Iron: 'Mini' type iron, temperature controlled to 375°C with fine tip (typically 0.8mm(1/32")) earth bonded. e.g.Weller EC3100D-ESP.

Solder: SN62 type solder with multi cored flux type RA conforming to QQ-S-571e (US federal specification). e.g.Multicore 'smart wire'.

If further information is required, please contact Huntleigh Healthcare Ltd

Appendix B

Device History Record Sheet

DATE	PRODUCT	SERIAL NUMBER	TX HEAD IMPEDANCE	DRIVE VOLTAGE	DATE CODE	MAINTAINED BY

Appendix C

Recommended Recorder Specifications

Vertical axis resolution:	6 dots/mm typical (if digital).
Chart Speed:	10-25mm/sec typical.
Minimum number of channels:	2.
Full scale span:	50mm or greater.
Input ranges:	20mV/mm and 50mV/mm.
Input impedance:	>50kΩ
Bandwidth:	DC to 25Hz minimum.

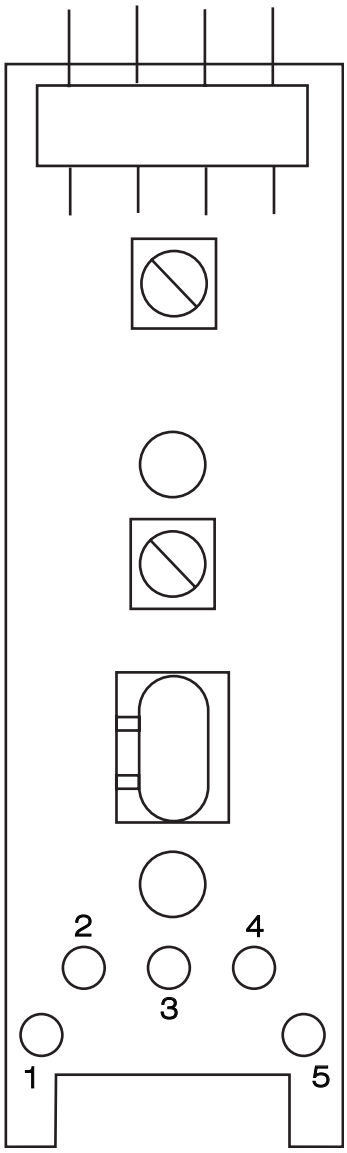
Appendix D

Test Equipment Specification

Synthesised Signal Generator	
Frequency Range	1-20MHz.
Frequency Resolution	10Hz or better.
Residual FM (0.03 to 20KHz)	<8Hz.
SSB Phase Noise	-136dBc typical.
Output Level Range	-100 to +13dBm.
Output Level Resolution	0.1dB or better.
Output Impedance	50Ω
Frequency Counter	
Frequency Range	5Hz - 20MHz.
Resolution	1Hz.
Digits	7.
Input Range	15mV - 10V rms.
Input Impedance (typical)	1MΩ with 30pF parallel.
Frequency Accuracy	+/- 0.1%.
DMM	
Current Range	0 - 100mA min.
Resolution	1mA min.
Digits	3 min
Power Supply	
Voltage	5Vdc.
Output Current Rating	100mA min.
Hum + Noise	-130dBV or less.
Overcurrent Protection	Yes (can be set to 100mA).

Appendix E

D920-P, D930-P Probe Cable Wiring Details

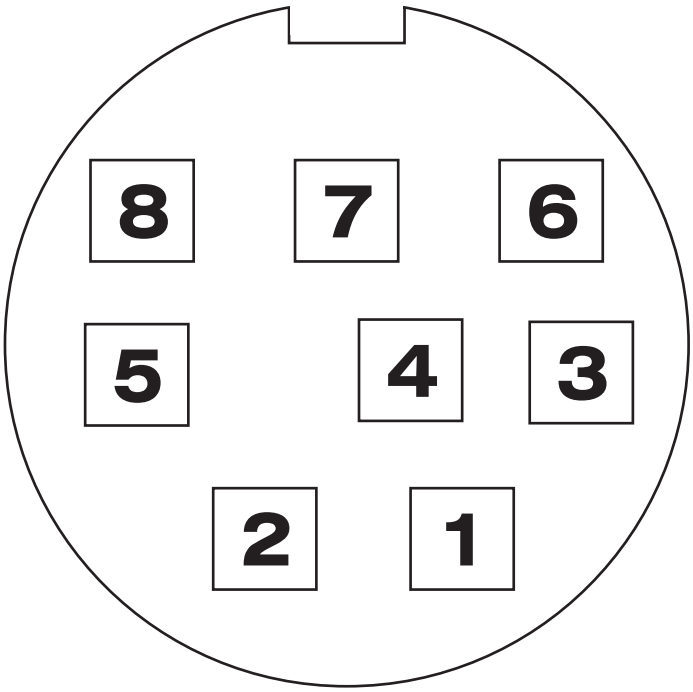


1	2	3	4	5
Screen	White	Black	Red	Yellow
Screen	Violet	Pink	Orange	Turquoise
Screen	White	Black	Red	Violet

Several variations of cable colours are used as shown.

Appendix F

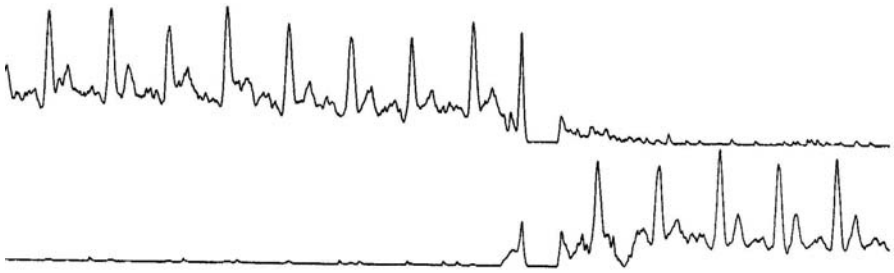
Waveform Output Connector Details - RD2 / MD2-P



Pin	Connection
1	RS232 - TX
2	RS232 - RX
3	GROUND
4	WAVEFORM
5	RS232 - BUSY
6	5V
7	WAVEFORM
8	RS232 - ENABLE

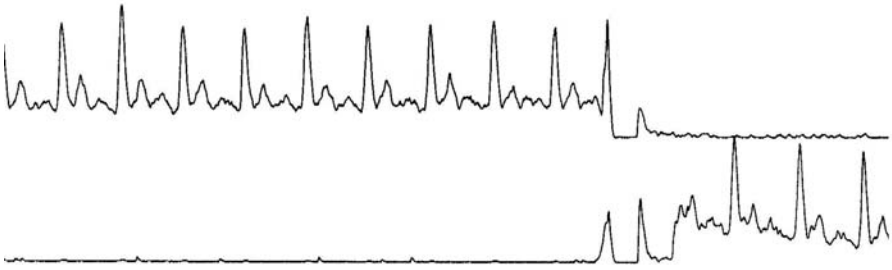
Appendix G

Trace Examples



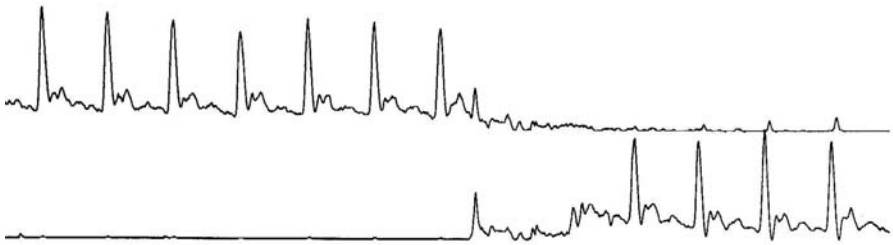
10mm/sec
50mV/mm

4 MHz



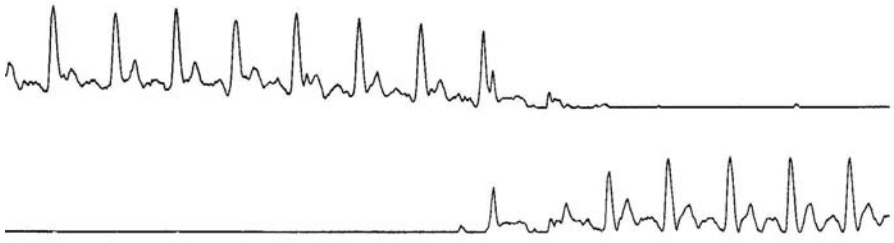
10mm/sec
50mV/mm

5 MHz



10mm/sec
50mV/mm

8 MHz



10mm/sec
50mV/mm

10 MHz

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