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Capacitance Array Tool

CAPACITANCE ARRAY TOOL

12 SENSOR SPRINGBOW, $1^{11}/_{16}$″, ULTRAWIRE™

Operational & Maintenance Manual

CE

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0 ABOUT THIS MANUAL

0.1 MANUAL HISTORY

Date	Issue	Description	Auth	Chk	App
09/04/03	A	First Issue.	DH/DO	SA	DH
12/05/03	B	Addition of Chapter 8, various amendments.	DH/DO	SA	DH
28/09/04	C	Drawing and Parts List update. Ref: ECR 1959, 1453, 1627 & 1573.	FV	DO	DH
20/03/06	D	Drawing and Parts List update. Ref: ECR 2273, 2253, 2787, 2235, 2107, 2545, 2740, 2904, 3091, 3567, 3562. Update Chapter 0.	FV	SA	DH
20/03/07	E	Drawing and Parts List update. Ref: ECR 3520, 3573, 3907, 3866	FV	DH	DH
13/05/09	F	Drawing updates. Ref: ECRs 5313, 5357, 5446, 4372, 4483, 5334, 5443, 3866, 5186, 5380, 5706, 5771 & 6018	RS	RS	(TG)
20/10/09	G	Ref. ECR 58465. “carry tube” removed from Section 2.2 (Caution). Section 4.3.3 & Appendix C added.	RS	RW	TG

0.2 UPDATES TO BE USED WITH THIS MANUAL

Consult the CD Directory for the appropriate Manual Updates to be used with this Manual.

0.3 TECHNICAL HELP

For further technical help, contact Sondex as follows:

Address: Unit 1, Saxony Way
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0.4 FEEDBACK

Please help us improve future issues of this manual by adding your comments or corrections to www.ge-energy.com/oilfield, referencing the document number.

Thank You.

Photographs and sketches are for illustration purposes only. Depending on the tool model that you have, certain features or dimensions may differ from those shown.

Documents from external sources (i.e. MSDS), supplied with/referenced in this manual, are considered the latest version at time of manual issue. However, the document can be altered by the external source without prior notice to Sondex.

1 EQUIPMENT

The Capacitance Array Tool (CAT) is designed to solve the problem of accurate fluid phase identification in horizontal or highly deviated wells. It is run centralised within the wellbore, ideally combined with an Inclinometer tool to aid interpretation.

The tool has an array of 12 specially developed miniature capacitance sensors, mounted on the inside of a set of springbows. Each sensor of the array measures the capacitance of the surrounding fluid close to the well casing. All 12 values are simultaneously transmitted to the surface or into a Memory section. Because the measurements are taken in a single plane across the diameter of the wellbore, rather than spaced along it, an accurate cross-sectional plot can be generated. Optional CATview software can be used to provide a 3D image of the phases along the well.

The use of springbows allows the tool to be used when running in or out of the well and minimises power requirements, particularly when deployed using Memory recording.

Figure 1.1 CAT

1.1 OPERATING PRINCIPLE

Oil, gas & water have different dielectric constants. The output frequency of a sensor changes with the dielectric constant of the fluid surrounding it. A simple calibration of the sensors enables the identification of the fluid surrounding each sensor.

1.2 APPLICATIONS

- Phase identification in horizontal & highly deviated wells.
- Calculation of the percentage of each phase present.
- Plotting of phase composition along the wellbore.
- Identification of water entry areas.
- Changes of wellbore fluids with time or different production rates.

1.3 INTERFACING & TOOL COMBINATIONS

- Available with MIT or Ultrawire™ telemetry.
- Ultrawire™ models provide simultaneous operation with other Sondex Ultrawire™ tools.
- Memory or Surface Readout operations.
- Combines with PIA to give well inclination.
- Standard $1^{3}/_{16}$″ UN 12tpi Sondex or GO end connectors.

1.4 SPECIFICATION

Parameter	Specification	Remarks
Tool Address	13 dec.	Set by links on telemetry board.
Max. Pressure	15,000psi (103.4MPa)	
Max. Temperature	177°C (350ºF)	
Nominal Diameter	$1^{11}/_{16}$″ (43mm)	Springbow fully closed.
Make-up Length	51.43″ (130.6cm)	
Overall Length	55.25″ (140.3cm)	Including thread protectors.
Depth Offset	18.9″ (48cm)	From bottom of tool to sensors.
Weight	8.62kg (19.0lbs)	
Number of sensors	12	1 sensor per springbow.
Width of springbow	0.25″ (6.35mm)	
Telemetry	Ultrawire™	
Operating Current (logging mode) • Minimum: • Typical: • Maximum:	 20mA 25mA 35mA	
Recommended Casing sizes	3″ - 7″	
Accuracy of Water Holdup Measurement	±3% typ.	With 5% water volume fraction, horizontal stratified.
Accuracy of Water Holdup Measurement	±5%[a] typ.	With 50% water volume fraction, horizontal stratified.
Max. Frame Rate	>100 Hz	Polling interval usually limited by bus controller/wireline telemetry speed and Warrior configuration.
Scan time per sensor	255µs	Time over which the pulses from each sensor are counted.
Relative Bearing accuracy (Rotation)	5°	
Relative Bearing Range	>5º / 175º	From vertical.
End threads (top/bottom)	$1^{3}/_{16}$″ 12 UN2A GO (female/male)	
End connectors (top/bottom)	4mm single conductor (male pin/female socket)	Sondex Ends

a. Accuracy in horizontal stratified flow is worst with approx. 50% water volume fraction due to finite number of probes available to detect the interface.

2 SAFETY

In normal use, there are few specific safety instructions for the safe handling of the CAT004. The following are guidelines only and should be followed in addition to any specific company and regional regulations.

2.1 PERSONAL SAFETY

Warning!

HOT WORK! Sondex equipment may, under certain circumstances or failure modes, become a potential source of ignition. Using it must therefore be considered "HOT WORK" and appropriate precautionary procedures should be followed when testing at surface in areas where there is a risk of gas leaks or other potentially explosive atmospheres.

There are no springs inside the tool which could pose a hazard through high compression/tension. However, one spring is visible from the outside. This spring is under low compression and therefore poses very little hazard to the operator.

Warning!

Heavy Equipment

The tool is heavy and appropriate safe handling procedures should be followed when moving it.

Liquid O-ring

LOR101 is used for lubricating the tool during maintenance. Contact with skin or eyes can be harmful. For more details, refer to the Material Safety Data Sheet for Liquid O-ring.

2.2 TOOL SAFETY

The tool contains very sensitive electronic sensors and circuitry. Consequently the tool should be handled with care.

Caution!

The sensors are made of ceramic and may be cracked by dropping the tool. When being transported, the closing rings should be placed around the springbows to protect the sensors from damage. The tool should then be carried in its flight case which has suitable protective padding.

Caution!

Pressure Washing

DO NOT pressure wash the sensors, as this may result in serious damage to the tool.

2.3 ELECTRO STATIC DISCHARGE

Caution!

Electro Static Discharge (ESD)

All tools with electronic boards that contain solid state circuits (transistors, diodes, semiconductors) may become damaged when contacted with an electrostatic charge.

When handling tools, which contain electronic parts that are ESD sensitive, the following guidelines should be followed to reduce any possible electrostatic charge build-up on the user's body and the electronic parts:

- Always ensure proper ESD precautions are taken when handling electronic parts that are ESD sensitive during maintenance.
- Avoid touching the tool electronics, unless stated otherwise in this manual.

Note that ESD is less likely to affect tools when the housing is fitted.

2.4 RECOMMENDATIONS

High Voltage Risk!

The product should be installed, adjusted and serviced by qualified electrical maintenance personnel. Improper installation or operation of the equipment may cause injury to personnel or equipment. Before beginning any installation or commissioning work make sure the electrical power is disconnected and locked out.

NOTE: Installation must meet National Wiring Regulations in accordance with IEC/UL 61010 latest revision.

WARNING 1: The outer casing of the product should be connected to a known good system ground (earth) before making any other electrical power connection. This system ground (earth) is to be maintained until all electrical power connections are disconnected and locked out.

WARNING 2: Units with exposed Electrical Connectors are supplied with protective insulating end caps bearing a warning of High Voltage. These end caps should be removed only when Electrical Power is disconnected and locked out for the purposes of interconnection to other Units. Under no circumstances should equipment be operated with the Electrical Connectors exposed.

WARNING 3: Units with moving parts (such as callipers) can be activated immediately on application of Electrical Power. A safe area should be established around any such Units before the application of Electrical Power.

WARNING 4: Units with moving parts (such as springs) can retain significant Potential Energy. Great care should be exercised when removing Closing Rings or handling assemblies that have been over-tightened.

WARNING 5: Units that contain seals may trap pressure. Disassembly should be carried only out in accordance with the recommended procedures to make sure the pressure is released prior to the disengagement of cap threads.

WARNING 6: When the equipment is not installed, commissioned and used in accordance with the specifications of the manufacturer, any protection that may have been provided may be impaired.

Standard Personal Safety Gear!

The standard personal safety gear must be worn at all times, including but not limited to: Safety glasses, gloves and steel-toed boots.

Equipment that exceeds 18Kg (39,7lbs) in weight should be handled with extreme care. Heavy items should be lifted mechanically. Any installation of equipment that weighs 10Kg (22lbs) or more and is to be lifted over 1,0 metre (3,3 feet) should be at least a two-man lift. Good lifting practice should be exercised at all times, including but not limited to:

- The use of correct personal safety gear
- Lift through the use of the legs and not the back
- **Not** proceeding with a lift in the presence of any doubt of completing the lift safely
- The use of mechanical lifting aids wherever possible
- Making sure the work area is free of clutter and possible trip hazards

3 THEORY OF OPERATION

3.1 BLOCK DIAGRAM

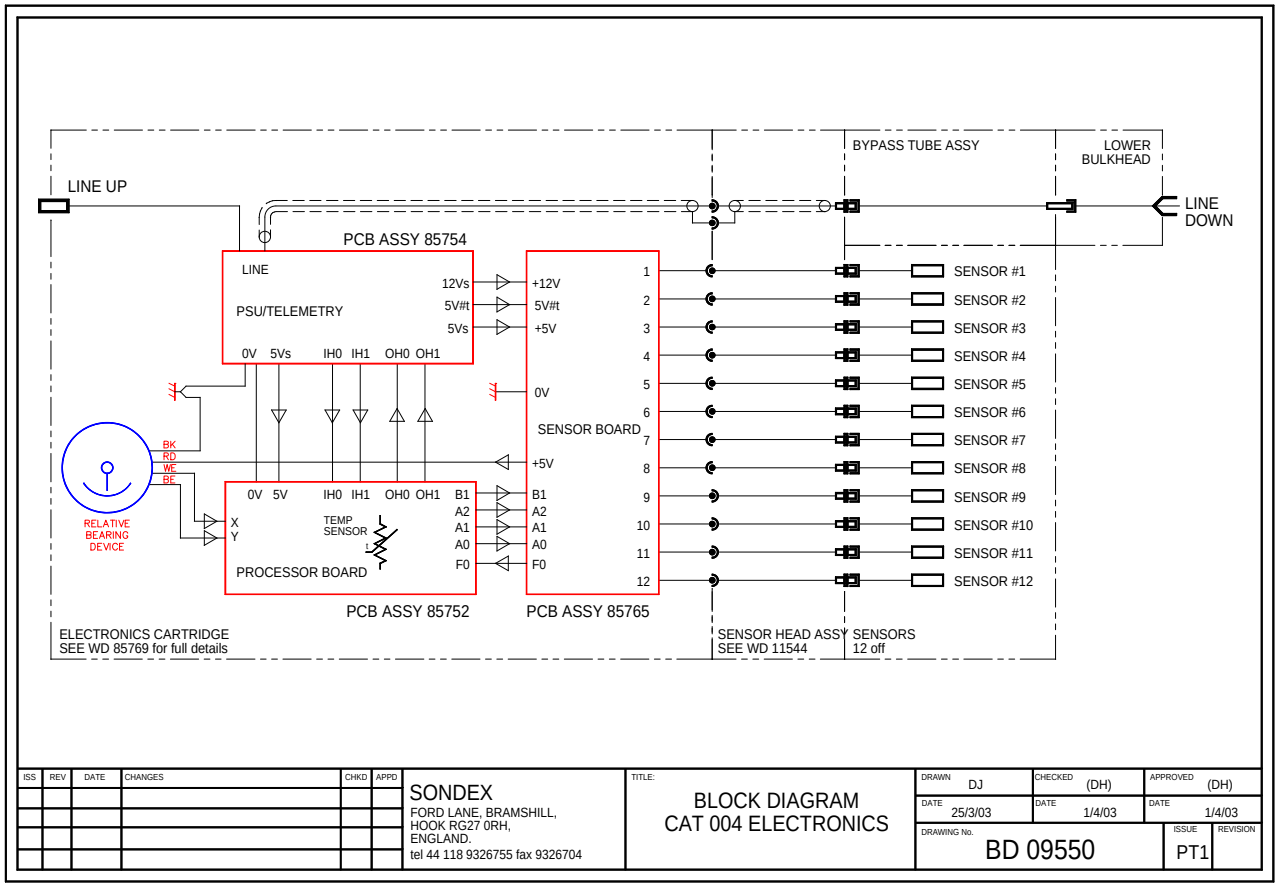


Figure 3.1 Block Diagram CAT004

3.2 DESCRIPTION

3.2.1 GENERAL

The CAT004 Capacitance Array Tool consists of a set of 12 springbows that open outwards from the tool body to the casing. A sensor is attached to the inside of each sensor, approximately 0.5″ from the springbows themselves.

The principle of operation is similar to conventional capacitance water-holdup tools. However, a novel measurement circuit has been developed, using the same principles to take capacitance measurements from 12 localised sensors. An oil/water calibration curve can then be fitted to the measurements to determine the fluid surrounding each sensor. Qualitatively, gas produces the highest frequencies, oil slightly lower frequencies, and water produces frequencies approximately one third of the air frequency.

Within each of the fingers, near the tip, is a miniature capacitance sensor. Each sensor, with its associated measurement circuitry, produces a frequency output that is related to the permittivity of

the surrounding fluid. Hence the fluid (oil, water or gas), surrounding each of the sensors, can be determined. The total oil/water/gas component fractions over the cross section of the well can then be calculated.

The tool operates on Ultrawire™ telemetry and can collect data in excess of 100 frames per second. However, other parts of the system, e.g. wireline telemetry speed, will usually limit the maximum frame rate significantly. For example, the default configuration of the Warrior logging software is set at 24 samples/foot.

The next section gives a brief description of the various sensors in the tool. Further details can be found in *Section 6 Electrical Description*.

3.2.2 SENSOR OPERATION

There are three types of sensor on the Capacitance Array Tool. The primary measurement is obtained from an array of capacitance sensors. There is also a relative bearing device and an uncalibrated temperature sensor. The operation of these are described next.

3.2.2.1 Capacitance Sensor

Figure 3.2 shows the principle of the sensor operation.

Essentially, the sensor consists of a logic inverter gate, configured as an oscillator circuit. There is a fixed feedback resistor R_X from the output to the input. The sensor is connected to the input of the gate and the capacitance of this sensor, C_X is charged and discharged through resistor R_X.

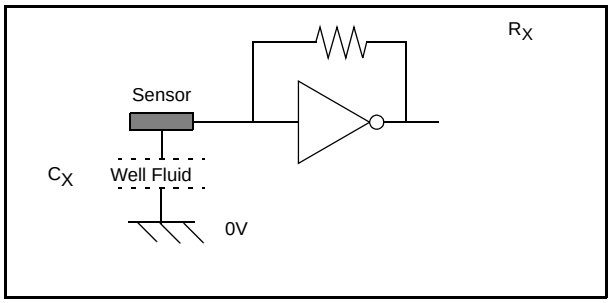


Figure 3.2 Sensor Equivalent Circuit

The capacitance C_X of the sensor is dependent upon the permittivity of the fluid surrounding the sensor. This principle is repeated for each of the 12 sensors.

The gas, water and oil permittivities have the following values:

Gas: Low permittivity (ε_r =1).

Water: Highest permittivity ($\varepsilon_r \approx 80$, but it has a complicated function).

Oil: Intermediate permittivity dependent on the precise nature of the oil, but $\varepsilon_r \approx 5$.

Thus, the fluid surrounding each sensor can be identified from the oscillation frequency. It is worth noting that due to stray capacitance, amongst other things, the oscillation frequency is not 80 times less for water than it is for air. In practice, the water frequency tends to be around 20% of the air frequency and the oil frequency tends to be approximately 80% of the air frequency.

As a first step in interpretation, the readings from each sensor are normalised, such that oil has a fixed normalised value (0.2).

This produces normalised readings in the range 0-1, where gas = 0, oil = 0.2 and water = 1.

i.e.: If Raw Reading ≥ Oil Calibration Reading, THEN normalise with respect to GAS - OIL (i.e. 0-0.2).

i.e. $$NormReading = 0.2 \times \frac{Gas - Raw}{Gas - Oil}$$

If Raw Reading < Oil Calibration Reading, THEN normalise with respect to OIL - WATER (i.e. 0.2 - 1.0).

i.e. $$NormReading = 0.2 + 0.8 \times \frac{Oil - Raw}{Oil - Water}$$

There are two possibilities for converting a normalised reading to an oil/water/gas fraction:

1 Two or more thresholds can be applied to the normalised readings as follows (four thresholds shown):

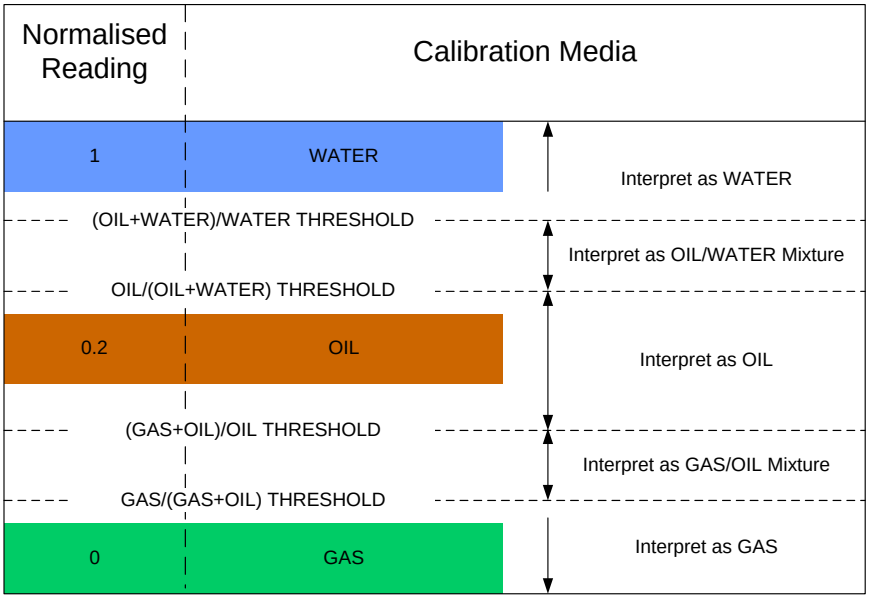


Figure 3.3 Normalised Readings

This approach is used in the CAT tool module of the Warrior logging software for converting a normalised value to one of five screen colours.

2 For raw readings between the water and oil readings, an oil-water calibration curve can be used to determine the water fraction.

For raw readings between the oil and gas readings, a linear fit between the oil and gas readings can be assumed.

This is more general than method one and is used in the CATview software. Note that the full accuracy of a calibration curve can only be realised if the oil-water mixture forms a fine oil-continuous emulsion.

The second method is the recommended method, as it automatically includes the "simple" threshold approach.

If it is known that the tool is in two-component oil-water flows (i.e. below the bubble point so no gas is present), it may be advantageous to add any calculated Gas fraction to the Oil fraction.

3.2.2.2 Relative Bearing Device

The relative bearing device is a pendulum-based device which is used to measure the rotation of the tool. It is not intended to be a survey instrument, but merely to indicate which capacitance sensor on the tool is uppermost.

3.2.2.3 Temperature Sensor

The temperature sensor is designed to be a coarse, but simple, indicator of circuit board temperature. It provides a possible means of software temperature compensation for residual electronic drifts with temperature. **However, there are currently no plans to implement this**. It is not intended as an indicator of well temperature. A dedicated well temperature tool, such as the Platinum Resistance Thermometer (PRT), should be used for this purpose. A PRT will also give a more accurate measurement of the actual probe temperature, should this be desired.

4 OPERATING PROCEDURE

Note: Also refer to *Section 7.2 Extraordinary Maintenance*.

4.1 PRE-LOGGING CHECKS

Ref.: CAT004 General Assembly *09550*
Sensor Head Assembly *11544*

4.1.1 MECHANICAL

1 Check that O-rings and sealing surfaces are undamaged, clean and greased.

2 Ensure upper and lower electrical connectors are clean, dry and undamaged.

3 Remove the closing rings.

4 Check that all springbows are in good condition.

5 Check that all sensors are in good condition and located securely within the appropriate springbow.

6 Check that the Locking Ring (item 25, 11544) is hand tight, so that the sensors are held in the Sensor Head. Also check that the Locking Ring is locked down to the Central Shaft by ensuring that the appropriate Grub Screws (3 x items 29, 11544) are tight.

7 Check that the Bow Clamp Locking Rings are tight (2 x items 15, 09550).

8 Check that the Inner Split Ring (item 7, 11544) on the Sensor Head is tight and also that the 2x Grub Screws are tightened to prevent it from unscrewing.

4.1.2 ELECTRICAL

1 Using a Multimeter, check the through-resistance between the top and bottom LINE connections. It should be a short-circuit and the resistance should be <0.5Ω.

Note: The resistance of the connecting leads should be taken into account when taking this measurement.

2 Using a Multimeter, check the resistance between the LINE connections and the chassis (effectively the D.C. resistance of the internal electronics). The resistance should exceed 100kΩ.

4.1.3 OPERATIONAL

1 Connect the CAT to a controller (XTU), and to a logging system via a wireline cable or suitable dummy cable.

2 Attach a Bullnose Ultrawire Terminator (BUL006) to the bottom of the toolstring. Although the tool may appear to work without the Bullnose, it will be more susceptible to telemetry errors if the Bullnose is not used.

3 Switch on the logging system.

4 The CAT tool current should be approximately **25mA**.

5 Slide the closing ring off the tool, so that the springbows open.

6 Check that all springbows are opened correctly and that the sensors are held correctly within them.

7 Check that the air readings for each sensor are within specification, see *Section 4.2 Calibration*. **However, do not take any water readings at this stage**.

8 Perform a sensor calibration (see *Section 4.2*). A water and oil calibration may not be necessary if this has recently been done. However, an air calibration should always be done. This is because air readings are the most sensitive. When complete, check that the tool is logging correctly. With the sensors in air, ensure that each sensor responds when the permittivity of the surrounding fluid is changed. This is most easily done by simply surrounding each sensor in turn with your fingers.

4.2 CALIBRATION

Sensor calibrations should always be performed with the springbows open. This is because there is more grounding around the sensors when they are closed, and this can affect the readings by a few bits. The calibration should be done in a metal container.

Minimum calibration recommendations are that air, water and oil calibrations are carried out at base. This provides a sufficiently accurate calibration, allowing the tool to return useful data during logging. An oil calibration should be carried out, as it is useful to know what readings the sensors give in oil. In the absence of crude oil, kerosene or heating oil can be used.

At the well site it may only be practical to carry out an air calibration. The permittivity of fluids vary slightly with both temperature and pressure, therefore a down-hole calibration in water at the bottom of the well should be performed if possible. In the case of oil/gas wells with no water, an oil calibration will be very helpful.

In cases where there is a zone of 100% oil, an oil calibration will be very useful. In general, there will often be a zone at the bottom of the well where there may be an accumulation of the denser fluid, e.g. water in an oil/water well. Similarly, when the well is shut in, it may be possible to perform an oil calibration since there will often be a region of 100% oil near the surface.

Note that oil readings may be slightly dependent on the amount of dissolved gas.

Note: The surface air calibration of the well site will usually be the most reliable air calibration, and must always be done as a minimum requirement. However, great care must be taken to ensure that the sensors are perfectly dry. In some cases, environmental conditions may make this difficult (e.g. rain), if not impossible (high humidity, resulting in condensation on the sensors).

Before performing a calibration, the sensors should be cleaned and thoroughly dried. This is particularly important for an air calibration.

It is also recommended that calibrations are performed in order of decreasing permittivity, i.e. air calibration, followed by an oil calibration, followed by water. During logging, the calibration files created at base should be used, unless **great care** has been taken for the on-site calibration.

Any downhole calibrations should usually be for post-log analysis only.

Where a reliable air calibration has been performed at the well-site, it is recommended that this calibration is used during logging.

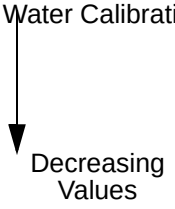
It is not generally necessary for the client to perform a relative bearing calibration as this is done once at the factory.

Table 4-1 Recommended Calibration Procedure

Fluid	Base	Well Site	Down Hole
Air	Essential Minimum	Highly Recommended	Not recommended
Water	Essential Minimum	Where conditions permit	Where conditions permit
Oil	Essential Minimum	Where conditions permit	Where conditions permit

Table 4-2 Typical Range of Values for Gas, Oil and Water Calibrations

Calibration Media	Typical Range
Gas	200 - 240
Oil	150 - 180
Water	35 - 55



4.3 CONNECTING TO TOOLSTRING

4.3.1 GENERAL

In terms of measurement, the position of the CAT within the toolstring is not particularly critical. However, other tools can affect where the CAT can be placed. This is mainly where other PL tools, any XSH and/or a tractor are used. The main criteria is to ensure that the CAT is centralised.

4.3.2 CENTRALISATION

Centralisation is very important, and becomes a critical issue in horizontal wells. If the CAT is below centre, all the sensors will be below their desired positions, resulting in an overestimate of the water fraction. If the tool is very significantly de-centralised, the uppermost finger may not reach the casing (in 7″ casing); in such cases, any oil flowing along the top side of the well may go undetected.

A common mistake is to believe that just because a toolstring supports itself on the ground, it will centralise in a horizontal well. This is not necessarily the case, for the following reasons:

1 Firstly, the supporting force from centralisers decreases as they close further. Thus, centralisation becomes more difficult as the casing diameter decreases. However, even in 7″ casing, de-centralisation can still be very significant if care is not taken.

2 Secondly, toolstrings flex as they become longer. This can cause significant decentralisation of the CAT if there are too many tools between the CAT and its centralisers.

3 Thirdly, when self-supported on the ground, there will be two arms of a centraliser supporting the tool. In a horizontal well, the centraliser may be oriented such that only one arm is supporting the tool.

4 Finally, it is believed that the supporting force of Centralisers decreases when moving. This is due to the frictional component between the casing and centraliser roller being less when moving than when stationary, i.e the static friction is greater than the dynamic friction.

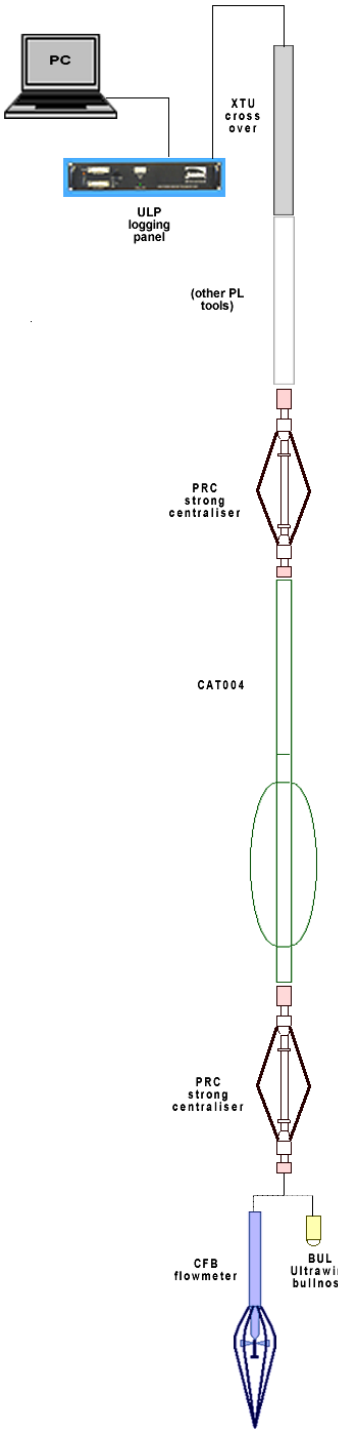


Figure 4.1 Recommended Toolstring configuration

As a minimum therefore:

- There should be no tools between the CAT and its nearest centraliser.
- Consider the use of strong centralisers (e.g. 70-100lbs) at each end of the CAT; 40lb centralisers may not be sufficient in small (3″ diameter) casing.

Great care must be taken when other tools are added to the toolstring. If possible, assemble the string in sections, based on casing diameters found in the well to be logged. If this cannot be done, use more centralisers than thought to be absolutely necessary.

Knuckle joints may also be used as appropriate, particularly if weight bars are used.

It is a useful exercise to assemble the tool horizontally in sections of 6″ casing to see the effect of adding extra tools. Even the effect of adding an extra tool between the CAT and a centraliser is usually quite significant. In 3″ casing or tubing the centralisation problems are even greater.

4.3.3 USE OF RESTRICTOR RINGS WITH MAP TOOLS

The CAT tool will open out to a nominal 7" diameter in its standard form. If logging is required and the tool is not required to open to its maximum diameter, a restrictor ring can be fitted beneath the springbow opening tension spring. Three sizes of restrictor rings are available giving nominal maximum opening sizes of 6 inches, 5 inches and 4 inches. Fitting instructions are shown in *Appendix C Fitting of Restrictor Rings*.

4.4 LOGGING

The following are guidelines only and must be used in conjunction with local policy and specific well site conditions both downhole and at surface. The table below is appropriate for near vertical wells and must be adjusted accordingly when in deviated wells. Use of a Head Tension Unit is highly recommended.

Note: Do not exceed the calculated safe working load of your selected weakpoint. If in doubt, use a head tension unit, especially in deviated wells where calculation from surface tension is less accurate.

Depth (ft)	Speed Pulling Out of Hole	Speed Running in Hole
In/out of catcher (pressure rig up only)	Dead slow or manual.	
30 to 150	30ft/min	
150 to 400	60ft/min	
>400 clear cased hole	Surface tension not to exceed 120% of tension when tool stationary. Speed not to exceed 150ft/min.	Surface tension should not be less than 80% of tension when tool stationary. Speed not to exceed 150ft/min.
>400 clear open hole	Surface tension not to exceed 130% of tension when tool stationary. Speed not to exceed 150ft/min.	Surface tension should not be less than 70% of tension when tool stationary. Speed not to exceed 150ft/min.
Approaching potential obstacles[a]	30ft/min	
Logging Data	**Do not exceed the above speeds.** Recommended speed is <30ft/min.	

a. For example: Reduced diameters, gas lift mandrels, fluid levels, valves, tubing shoes, packers, cross overs and other downhole equipment.

Caution! **To avoid damage to the sensors, speed should NOT exceed 40ft/min through major ID changes.**

Logging can (and normally would) be done whilst logging both up and down. However, the down-passes can sometimes produce superior data to the up-passes. This is because the fluid is less likely to stagnate around the sensors when the tool motion is opposite to the fluid motion. Also,

due to the unique design of the tool, it is recommended that stationary passes are taken at zones of particular interest.

4.5 POST LOGGING DISASSEMBLY

1 Clean the tool before disassembly, paying particular attention to the sensors. Use a damp cloth to clean the sensors initially and wipe them **carefully and thoroughly** dry with paper tissue or a dry cloth. **DO NOT** use any abrasive material and **DO NOT** pressure wash the sensors.

2 Keep electrical connectors clean and dry.

3 Refit thread protectors.

4.6 TRANSPORT, HANDLING & STORAGE

Store with end threads lightly greased and with water tight thread protectors fitted.

Do not subject the tool to extreme shock, such as dropping or hitting with a hard object.

5 MECHANICAL DESCRIPTION

5.1 OVERVIEW

The CAT004 tool consists of three main sections:

- Electronics section.
- Sensor Head.
- Central Shaft Assembly.

The 12 CAT sensors plug into the Sensor Head. A set of springbows is fitted to the Sensor Head at one end, and the Central Shaft Assembly at the other.

The Sensor Head acts as a hub for the 12 CAT sensors. The sensors simply plug into the Sensor Head and have an O-ring Seal. This allows very easy replacement. The 12 flexible Tubes each carry a single wire to the sensors. This single wire (plus the chassis ground) provides power to the sensors, and in addition, the frequency signal from the sensor is sent back down this single wire to the main tool Electronics.

The springbows are anchored at the Sensor Head end and actuated by an Expansion Spring at the other end. Each sensor is guided under its corresponding springbow by metallic Clips.

The sensor tubes flex with the springbow. The Clips guide the sensor tubes to allow the sensors to keep a set distance from the springbow and therefore lessen the shielding effect on the flow from the springbows.

The springbows are fixed to the tool by a Clamping Ring at each end, which can be backed off to allow replacement of all or individual springbows.

The Electronics Section simply plugs into the Sensor Head to allow for easy removal.

5.2 DISASSEMBLY

5.2.1 ELECTRONICS SECTION ACCESS/REMOVAL

Ref.: CAT004 General Assembly *09550*
Electronics Assembly *85769*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

1 Remove Pressure Housing (item 3), using a 38mm Spanner and a ’C’-Spanner.

2 Lightly screw in Grub Screws (3x item 24, 85769), securing the Electronics Assembly (item 2) to the Sensor Assembly (item 1), clockwise into the electronics assembly until flush.

Note: Do not apply excessive torque, because this will hamper removal and possibly damage the Lemo Connector in the Electronics Assembly.

3 The Electronics Assembly (item 2) can now be unplugged from the Sensor Head Assembly (item 1) by simply pulling them apart, see *Figure 5.1*.

Figure 5.1 Separating Electronics and Sensor Assemblies

Note: The Electronics boards are now accessible by removing the appropriate half-shell that keep the circuit boards in place. Only the upper (larger) half-shells should normally be removed; the half-shells along the "lower" side of the chassis (the smaller half-shells) should not be removed unless access to the relative bearing wiring is required.

5.2.2 SPRINGBOW REMOVAL

Ref.:	CAT004 General Assembly	*09550*
	Sensor Head Assembly	*11544*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

1 Remove the Deflectors, fitted to the Clips on the Springbow & Deflector Assembly (item 4).

2 Unclip the Single Pin Sensor Assembly (item 5) from the Clips on the Springbow & Deflector Assembly (item 4).

Repeat for each springbow to be replaced.

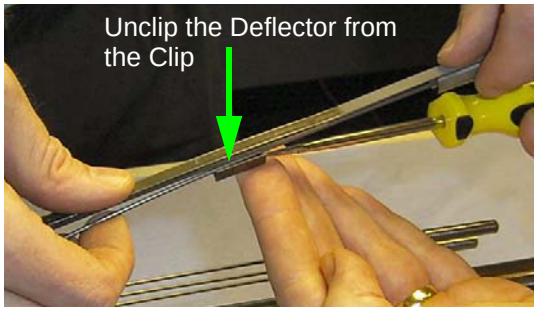


Figure 5.2 Unclipping the Deflector

Note: This can be done by applying sufficient force behind the tube to overcome the spring force of the clip, and simultaneously levering the Clip open. The sensor tube should first be released from the Clip closest to the sensor.

3 Using two 'C' spanners, loosen the Bow Clamp Locking Rings (2x item 15).

4 Slide the Lower Bow Clamp Ring (item 14) away from the springbows. It is now possible to disengage the Springbow (item 4) from its location holes.

Figure 5.3 Using 'C' spanners to tighten/loosen Bow Clamp Locking Rings (tightening shown)

Note: Take care to ensure that the sharp edges of the springbow do not damage the coating on the sensors.

Note: If only a small number of springbows are to be removed, the Lower Bow Clamp Ring (item 14) can be used to lock the remaining springbows onto the Lower Bow End Termination Body (item 13) by retightening the Bow Clamp Locking Rings (2x item 15). Ensure that the pegs of each springbow are correctly aligned.

5 At the other end of the springbow, screw in the Bow Clamp Inner Split Ring (item 7, 11544), and slide the Bow Clamp Outer Split Ring (item 8, 11544) and Bow Clamp Outer Ring Bursting Disc (item 11, 11544) away from the springbows in a similar fashion as in operation *4*.

6 Disengage Springbow (item 4) from its location holes.

Figure 5.4 Tightening/loosening Bow Clamp Split Rings (tightening shown)

Note: If only a small number of springbows are to be removed, the Bow Clamp Outer Ring (item 8, 11544) and Bow Clamp Outer Ring Bursting Disc (item 11, 11544) can be used to lock the remaining springbows onto the Sensor Head, by unscrewing the Bow Clamp Inner Ring (item 7, 11544). Ensure that the pegs of each springbow are correctly aligned, and that the Bow Clamp Outer Ring (item 8, 11544) is aligned with the keyway in the Sensor Head.

5.2.3 REPLACING SENSORS

Ref.:		
	Sensor Head Assembly	*11544*
	Sensor Assembly Single Pin	*15296*

Note: Item numbers refer to the Sensor Head Assembly, unless stated otherwise.

1 Remove the springbows as described in *Section 5.2.2*.

Note: If only a small number of sensors are to be removed, it is not necessary to remove every springbow.

2 Slacken the Grub Screws (3x item 29) in the Locking Ring (item 25).

3 Prior to unscrewing the locking ring, rotate the CAT radially so the marker, indicating the first sensor, is facing down.

Figure 5.5 Slackening Grub Screws

Note: Failing to do so might cause the bearing ball (located under the locking ring) to fall out of the assembly.

4 Unscrew the Locking Ring (item 25) from the Sensor Head.

5 Using a small screwdriver, carefully lever out the desired Sensors (item 20) from the sockets in the Sensor Head. There is a recess in each sensor for this purpose.

6 Clean out the corresponding sockets in the Sensor Head to ensure that there are no traces of well fluid left. Isopropanol or a similar solvent can be used. Dry out the socket with soft tissue paper or similar.

7 If a sensor has leaked, it may be necessary to service the Sensor Head, see *Section 5.2.4*.

8 Prior to replacing sensors, service them as described in *Section 7.2.2*.

Note: When replacing the sensors, check that the Connector and corresponding Socket in the Sensor Head are clean and thoroughly dry.

9 When replacing sensors, take care when inserting them back into the Sensor Head. This will reduce the risk of damaging the O-rings (item 9, 15296) and Canted Coil Springs (item 10, 15296).

10 Retighten the Grub Screws (3x item 29) in the Locking Ring (item 25).

11 Refit the springbows (see *Section 5.3.3*) and clip the sensors back into the springbows.

5.2.4 SENSOR HEAD DISASSEMBLY

Ref.:		
	CAT004 General Assembly	*09550*
	Sensor Head Assembly	*11544*
	Wiring Diagram	*WD-11544*

Notes:

- Item numbers refer to the General Assembly, unless stated otherwise.
- O-rings (item 44, 11544) can be replaced without disassembling the Sensor Head.

Sensor Head should not be removed, unless a leak occurred in a high pressure / temperature well. Servicing the Sensor Head Assembly involves rewiring the Sensor Head and is not recommended, except in extreme circumstances.

---

1 Remove the Electronics Assembly (see *Section 5.2.1*), springbows (see *Section 5.2.2*) and sensors (see *Section 5.2.3*).

2 Prior to unscrewing the locking ring, rotate the CAT radially so the marker, indicating the first sensor, is facing down.

Note: Failing to do so might cause the bearing ball (located under the locking ring) to fall out of the assembly.

3 Remove Locking Ring (item 25, 11544) from Sensor Head (item 1, see *Figure 5.5*).

Note: Take care not to lose the Ball Bearing, located under Locking Ring (item 25, 11544), which lock the Shaft to the Sensor Head.

4 Remove 3 Ball Bearings from Sensor Head before unscrewing Shaft.

5 Unscrew the Central Shaft (item 19) from the Sensor Head (item 1).

Note: There is a flat spanner surface on the Central Shaft for this purpose. The Sensor Head is now isolated.

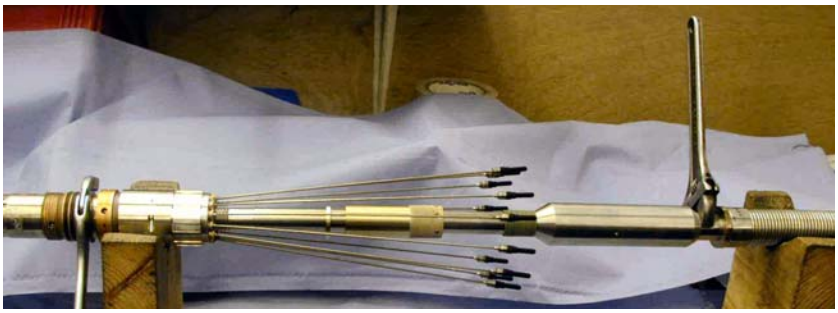


Figure 5.6 Unscrewing/tightening Central Shaft and Sensor Head (shown ready for tightening)

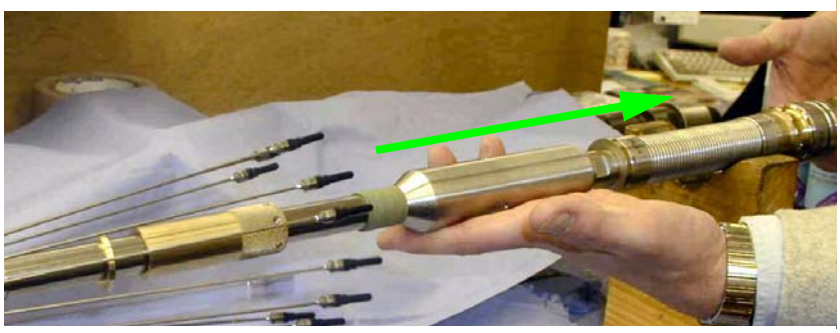


Figure 5.7 Separating Central Shaft from Sensor Head

6 Using a punch, remove Spirol Pin (item 60, 11544).

7 Gently pull Lemo Connector Assembly (items 27, 28, 49 & 51, 11544) out of Sensor Head (item 2).

8 Unscrew the Kemlon Connector (item 66, 11544), using the Kemlon Tool (p/n 10051).

9 Desolder the appropriate wire(s) from the Lemo Connector (item 28, 11544), see WD-11544.

10 Using a Feedthrough Retaining Nut Assembly Tool (p/n 15283), unscrew the Feedthrough Retaining Nut (item 20, 11544).

Note: When replacing the Feedthrough Retaining Nut (item 20, 11544), do not tighten excessively. It should only be lightly hand-tight.

11 Insert the Kemlon Removal Tool (p/n 15263) into the Sensor Head (from the Lemo side), and using a hammer, carefully punch out the desired sensor kemlons. Take care not to damage the wiring.

5.2.5 DISASSEMBLY OF CENTRAL SHAFT ASSEMBLY

Ref.: CAT004 General Assembly *09550*

1 Remove the springbows (see *Section 5.2.2*) and unscrew Central Shaft Assembly from the Sensor Head (see up to operation 4 of *Section 5.2.4*).

2 Remove the O-rings (12x item 70), which protect the sensors.

3 Unscrew Grub Screws (3x item 55) from the Lower End Sub (item 16) and tap the Lower End Sub (item 16) with a hammer to release, or at least loosen the 3 Bearings (3x item 68).

4 Unscrew the Lower End Sub (item 16) from the Central Shaft (item 19).

Note: This will release any of the Bearings (item 68) that did not fall out when tapped with the hammer.

5 If desired, the Bypass Cable Assembly (item 30) can now be pulled out of the Central Shaft (item 19).

6 Also if desired, the Lower Connector Assembly (item 56) can be removed from the Lower End Sub (item 16) by removing the Circlip (item 46) and then the Spirol Pin (item 48).

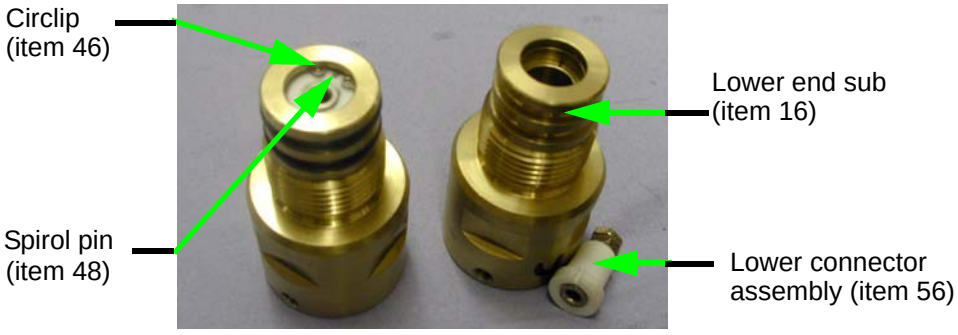


Figure 5.8 Removing Lower Connector Assembly

7 Using a punch, remove Spirol Pins (2x item 61) that secure the Spring Retaining Ring (item 8) to the Lower End Bow Termination Body (item 13).

8 Slide back Spring Retaining Ring (item 8) from the Lower End Bow Termination Body (item 13), and unscrew the Spring (item 67) **clockwise** off the Lower End Bow Termination Body (item 13).

Note: A small 'C' spanner can be used to open up the Spring in order to help this task.

9 The Lower End Bow Termination Body (item 13) and the assembled Spring End Stock (item 12) can now be removed from the Central Shaft (item 19).

5.3 REASSEMBLY

5.3.1 REASSEMBLY OF CENTRAL SHAFT ASSEMBLY

Ref.: CAT004 General Assembly Drawing *09550*

1 Slide a Spring Retaining Ring (item 8) over Extension Spring (item 67) and screw Spring (item 67) **anti-clockwise** onto Lower End Bow Termination Body (item 13).

Note: A small amount of silicone grease may aid with this assembly.

2 Secure the Spring Retaining Ring (item 8) to the Lower End Bow Termination Body (item 13) with Spirol Pins (2x item 61).

3 Slide the second Spring Retaining Ring (item 8) over the Spring (item 67) and slide the assembly onto the Central Shaft (item 19), along with the Spring End Stock (item 12) from the other end.

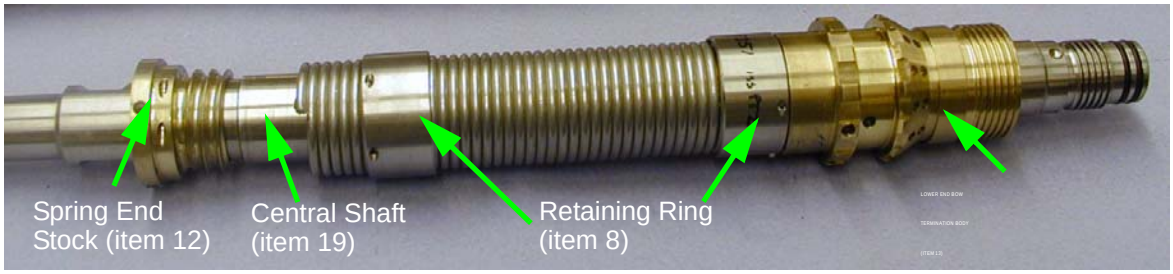


Figure 5.9 Central Shaft Assembly

4 Screw the Extension Spring (item 67) **anti-clockwise** to the Spring End Stock (item 12).

Note: A small amount of silicone grease applied to the End Stock will aid with this assembly.

5 Fit one of the Retaining Rings (item 8) over the Spring (item 12) and secure to the Spring End Stock (item 12) with Spirol Pins (2x item 61).

Note: The assembly should now be assembled as shown in *Figure 5.9.*

6 Fit the Bow Clamp Ring (item 14) and Clamp Locking Rings (2x item 15) to the Lower End Bow Termination Body (item 13).

7 Insert the Bypass Cable Assembly (item 30) into the Central Shaft (item 19).

8 Fit O-rings (2x item 40) to the lower end of the Central Shaft (item 19).

Note: Grease the grooves on the Central Shaft (item 19) and the O-rings with Liquid O-ring prior to fitting the O-rings.

9 Fit O-ring (item 34) to Lower End Sub (item 16) and apply silicone grease.

10 If removed during disassembly, fit Spirol Pin (item 48) to Lower End Sub (item 16) and insert Lower Connector Assembly (item 56). Secure Lower Connector Assembly to the Lower End Sub (item 16) using a circlip (item 46), see *Figure 5.8*.

11 Screw the Lower End Sub (item 16) onto the end of the Central Shaft (item 19). Lock in position using Bearings (3x item 68) and Grub Screws (3x item 55).

Ensure the Lower End Sub (item 16) is fully tightened onto the Central Shaft (item 19).

12 Fit 2 off O-rings (item 47) to Lower End Sub (item 16).

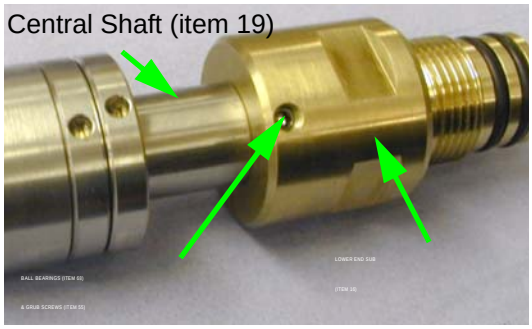


Figure 5.10 Lower End Sub screwed onto Central Shaft

13 Slide the O-rings (12x item 70) onto the Shaft (item 19) as indicated on the drawing. These O-rings help to cushion the sensors from blows onto the Shaft.

14 Fit O-rings (2x item 73) to the end of the Central Shaft (item 19) that screws into the Sensor Head (item 1).

Note: Lubricate the O-ring grooves on the Shaft (item 19) and the O-rings with Liquid O-ring prior to fitting.

5.3.2 SENSOR HEAD REASSEMBLY

Ref.:	CAT004 General Assembly	*09550*
	Sensor Head Assembly	*11544*
	Wiring Diagram	*WD-11544*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

Note: The O-ring (item 42, 11544) can easier be replaced when the springbows are refitted, see *Section 5.3.3*.

1 Grease O-rings on the Sensor Kemlons (item 4, 11544) with a little Silicone Grease.

2 Insert Sensor Kemlons (item 4, 11544) into the Welded Sensor Head Assembly (item 6, 11544) by hand as far as possible. Then, gently but firmly, punch it fully home, using the Kemlon Removal Tool (p/n 15263).

3 Lock it in place with a Feedthrough Retaining Nut (item 20, 11544) using the Feedthrough Retaining Nut Assembly Tool (p/n 15283). This should be hand tightened only.

4 Insert the Line Kemlon (item 66, 11544) into the Welded Sensor Head Assembly (item 6, 11544) using the Kemlon Tool (p/n 10051).

5 Re-solder all wires to the Lemo Connector (item 28, 11544).

Note: Ensure that the Line connection is thoroughly shielded. Thoroughly check that all connections are correct.

Caution! If the Line Wire is inadvertently connected to a sensor, the corresponding sensor **will** be destroyed.

6 Carefully feed the wire loom back into the Sensor Head Welded Sensor Head Assembly (item 6, 11544).

7 Insert the Lemo Connector Assembly (items 27, 28, 49 & 51, 11544) back into the Welded Sensor Head Assembly (item 6, 11544) and lock in place with Spirol Pin (item 60, 11544).

8 Fit and screw the Central Shaft (item 19) back onto the Sensor Head (item 1).

Note: There is a flat spanner surface on the Central Shaft for this purpose.

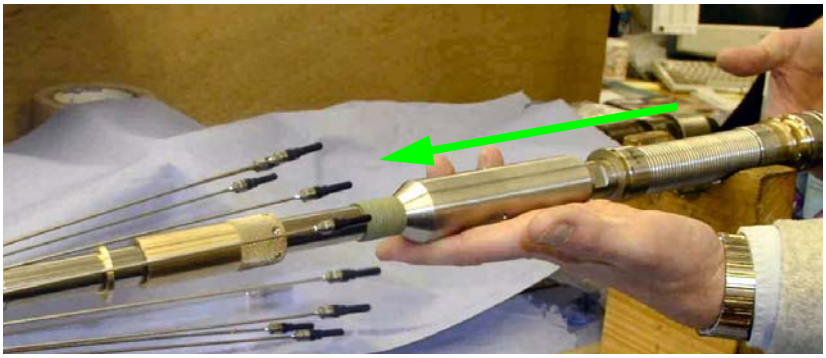


Figure 5.11 Fitting Central Shaft to Sensor Head

Figure 5.12 Tightening Central Shaft and Sensor Head

9 Insert Ball Bearings into each of the 3 holes in Sensor Head. These lock the Shaft to the Sensor Head.

10 Refit the Locking Ring (item 25, 11544) onto the Sensor Head (item 1).

11 Refit the Electronics Assembly (see *Section 5.3.4*), springbows (see *Section 5.3.3*) and sensors (see *Section 5.2.3*).

Figure 5.13 Tightening Grub Screws

5.3.3 REFITTING SPRINGBOWS

Ref.: CAT004 General Assembly *09550*
Sensor Head Assembly *11544*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

1 Using two 'C' spanners, loosen the Bow Clamp Locking Rings (2x item 15).

2 Slide the Lower Bow Clamp Ring (item 14) away from the springbows.

Figure 5.14 Tighten Bow Clamp Locking Rings

Note: If only a small number of springbows are to be refitted, the Lower Bow Clamp Ring (item 14) can be used to lock the remaining springbows onto the Lower Bow End Termination Body (item 13) by retightening the Bow Clamp Locking Rings (2x item 15). Ensure that the pegs of each springbow are correctly aligned.

3 Fit a Springbow Assembly (item 4) orientated so the sensor tube clips are at the Sensor Head (item 1) end.

Figure 5.15 Tightening/loosening Bow Clamp Split Rings (tightening shown)

Note: If the springbows are new, it may be convenient to use an elastic band at each end to hold them in place until the Bow Clamp Rings are tightened. This is not usually necessary once they have been tightened into place for some time. Repeat this procedure for each of the remaining 11 Springbow Assemblies.

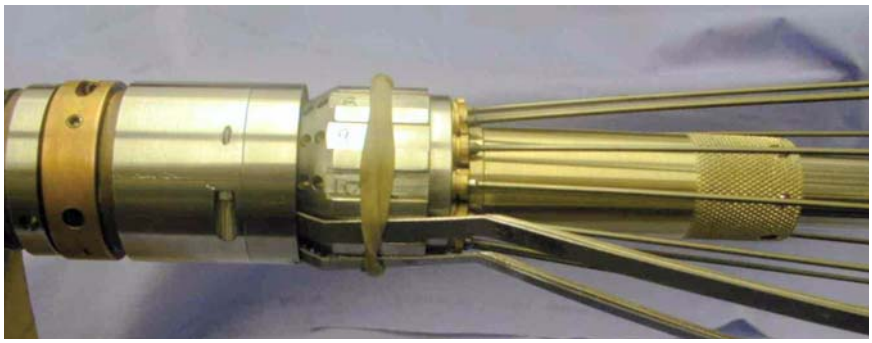


Figure 5.16 Use of elastic band to retain Springbows

Figure 5.17 Fitting Springbow Assemblies

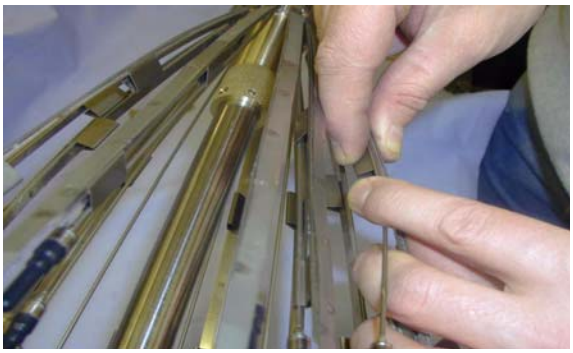
4 Secure the springbows at both ends by retightening the Rings from operation 1 & 3 with 'C'-Spanners, see *Figure 5.14* and *Figure 5.15*.

Note that there is a keyway at the Sensor Head end, so care should be taken to ensure that this is correctly aligned.

5 Tighten the Grub Screws (item 54, 11544) in the Blow Clamp Inner Split Ring (item 7, 11544) to lock it onto the Sensor Head (item 1).

6 Clip the Single Pin Sensor Assembly (item 5) back into the clips on the springbow & deflector assembly (item 4). The sensor tube should first be fitted into the Clip nearest to the Sensor Head, then into the Clip nearest to the sensor.

Note: Prior to clipping the Single Pin Sensor Assembly (item 5) into place, check the condition of the PEEK deflector (p/n15274, part of item 4), located in the clips, and replace if necessary.



Step 1: Fitting Sensor tubes into clip nearest Sensor Head

Step 2: Fitting Sensor tubes into clip nearest Sensor

5.3.4 ELECTRONICS SECTION REASSEMBLY

Ref.: CAT004 General Assembly *09550*
Electronics Assembly *85769*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

1 Plug the Electronics Assembly (item 2) into the Sensor Head Assembly (item 1)

Note: Note the orientation of the Lemo Connectors.

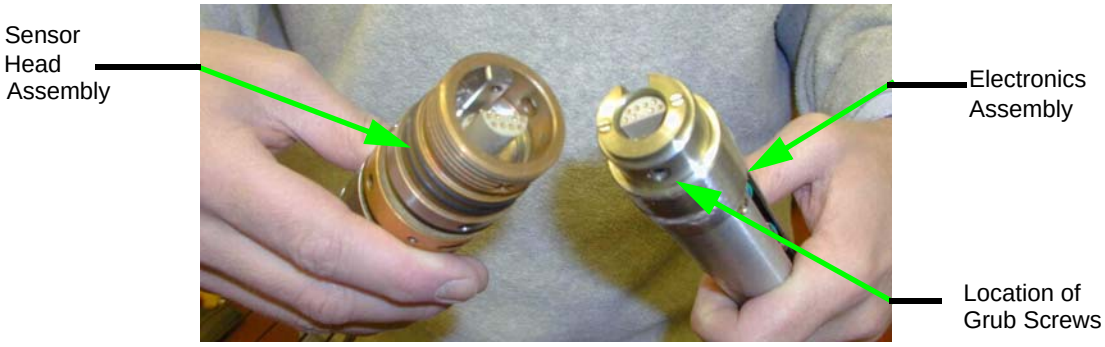


Figure 5.18 Connecting Electronics to Sensor Head

2 Lightly screw Grub Screws (3x item 24, 85769) anti-clockwise, securing the Electronics Assembly (item 2) to the Sensor Assembly (item 1).

3 Refit Pressure Housing (item 3), using a 38mm Spanner and a 'C'-Spanner.

6 ELECTRICAL DESCRIPTION

There are three PCBs in the tool:

- PSU / Telemetry Interface.
- Processor .
- Sensor Interface.

6.1 PROCESSOR PCB

Ref.: Processor PCB *CD-85752*

The two main devices on this PCB are the microcontroller U2 and the Actel U1.

The microcontroller controls the operation and timing of the tool. It also measures tool rotation (from inputs on RotX and RotY) and measures the electronics temperature.

The Actel is read and written from/to by the microcontroller. It decodes AMI telemetry pulses, provides the address and control lines for the capacitance sensors, and counts the pulses from the sensors.

The telemetry is modulated onto the line as 1V AMI (alternate mark inversion) at 500kbaud.

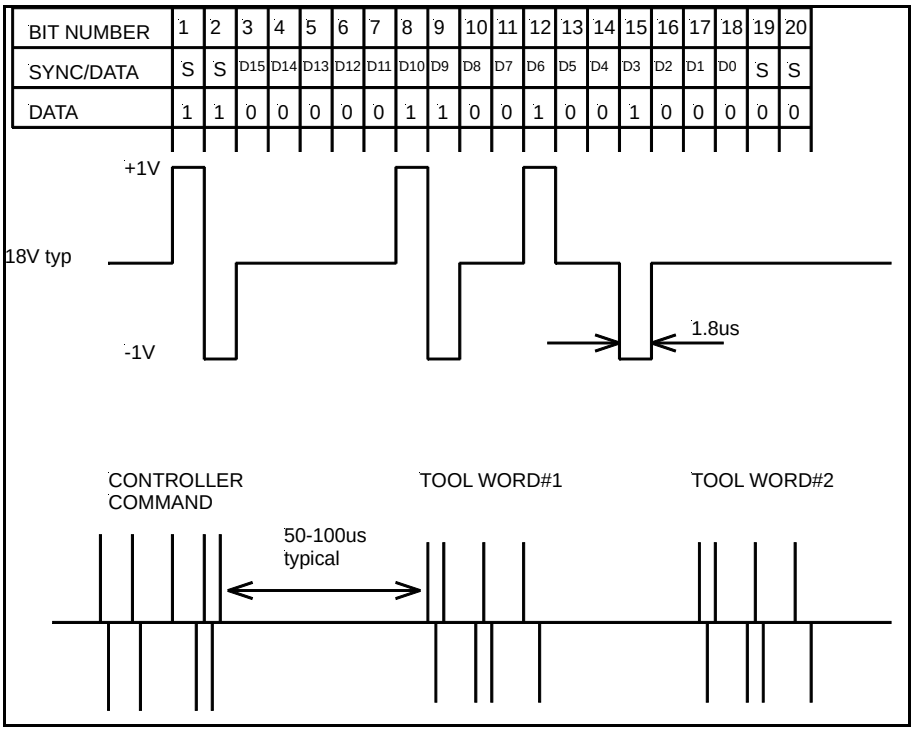


Figure 6.1 Ultrawire Signal Shape

The Ultrawire telemetry is a master-slave protocol. The controller, which is always the master, sends a command to the tool. This may be a global command (to all tools), or a tool specific command which contains the address of the target tool. The tool's "hard" address is set in the range 0-63 by links 2a-2f; note however, that addresses 0 and 63 are should not generally be used as these are reserved for special cases. Tool specific commands are acknowledged by the tool, global commands are executed but do not generate a response.

When the controller is in logging mode, it will periodically send a global TimeStamp command to all the tools, a global "Sample Now" command, and then poll each tool individually with a "Send Data" command. The "Sample now" command causes the latest counts from each sensor to be frozen in a shadow register, and this count is then passed to the controller in response to the "Send Data" command.

The received data is removed from the line by the power supply PCB, and passed to the processor PCB Actel, which validates the address. The command is interpreted by the PIC, which if necessary, generates the response packet and passes it to the Actel. The Actel then provides suitable telemetry drive signals for the PSU PCB.

Ultrawire words are 20 bits long. The first and last two bits are for synchronisation. The first bit is always '1'. The intervening 16 bits are tool data.

6.2 SENSOR INTERFACE PCB

Ref.: Sensor Interface PCB *CD-85765*

This PCB consists of a multiplexer for selecting each sensor in turn, depending on the address applied to it from the processor PCB. The net result is that each sensor is powered sequentially by the 5V#T voltage.

Each sensor modules the current it draws and this variation in current is converted to a voltage variation by the first op-amp stage. A differential amplifier converts this differential voltage variation to a single-ended voltage variation, referenced to 0V. This voltage variation is then applied to comparator U4, which provides a digital frequency output.

These pulses are then sent to the processor board where they are counted over a fixed measurement interval.

6.3 TELEMETRY PROTOCOL

The CAT004 operates on Ultrawire telemetry. Because commands can potentially be sent to it faster than it can acquire measurements, it makes use of the Timestamp feature of the Ultrawire telemetry protocol (see below).

The general sequence of events in acquiring data from the tool is as follows:

i. The controller issues a global TimeStamp command to all the tools on the string. This effectively tells the tools the current time.
ii. The controller issues a global SampleNow command.
iii. The controller polls each of the tools on the string with a tool-specific SendData command.

If the CAT has data when it receives this command, it sends back a data packet containing the TimeStamp associated with the SampleNow that initiated the measurement (see below for the data packet format). If the CAT has not acquired a new measurement set when it receives the SendData command, it returns a DataNotReady reply.

This procedure is normally transparent to the user.

6.4 DEFAULT TOOL ADDRESS

The tool is shipped pre-configured to Ultrawire address 13 (decimal). If desired, this can be changed using wire links on the processor board (see *CD-85752* for the link settings used to set a particular address). Note that although the Ultrawire protocol supports SMART tools that allow automatic address re-allocation, this is not currently supported by the CAT (i.e. it is a DUMB tool).

6.5 DEFAULT DATA PACKET FORMAT

The default CAT004 data packet (sent in response to a SendData command) is as follows:

Word No	High	Low
0	ACKH	ACKL
1	TimeStampH	TimeStampL
2	F0	F1
3	F2	F3
4	F4	F5
5	F6	F7
6	F8	F9
7	F10	F11
8	Rotation	
9	Reserved (0)	
10	Electronics Temp	Reserved (0)
11	Reserved (0)	Reserved (0)
12	Reserved (0)	Reserved (0)
13	Reserved (0)	Reserved (0)
14	Reserved (0)	Reserved (0)
15	Reserved (0)	Reserved (0)
16	Reserved (0)	Reserved (0)
17	Reserved (0)	Reserved (0)
18	Reserved (0)	Reserved (0)
19	StatusH	StatusL

Word #0 is the Ack that always gets sent, even if no data is ready.

Words #2-7 contain the 12 frequency counts.

Word #8 contains the actual rotation measurement (0=0°, 65535=360°).

Word #9 is reserved.

Word #10 (8 MSBs) contains the electronics temperature. This is only a rough indicator and not a precise measurement. At 25°C, it will have a value of approximately 128 and increase by approximately 1 bit for every 6°C rise in temperature.

The high byte of Word#10 is reserved.

Words #11-18 are reserved.

Word #19 is notionally reserved for tool status. These bits are not yet defined and should be 0.

6.6 RELATIVE BEARING (ROTATION) CALIBRATION

This is done once at the factory, and should not need to be repeated by the customer.

7 EXTENDED CHECKS

7.1 PREVENTATIVE MAINTENANCE

7.1.1 GREASE & LUBRICANTS

Sondex recommends the use of “Liquid O-ring type 101” (p/n LOR101) on threads and O-rings.

All O-rings and housing threads are assumed to be and must be lightly greased, unless specifically indicated otherwise.

Correct use of grease and lubricants is essential to the maintenance of all Sondex downhole equipment.

Note that some threads are internal, which can cause grease to get inside the tool. Do not use excessive quantities.

Sondex does not recommend Copper loaded greases since some types can cause electrical leaks. Some types for grease are not suitable for use on O-rings. Silicone grease may be used on O-rings, but must be kept clear of threads, especially stainless steel to stainless steel.

Caution! The use of certain greases, which contain volatile content, (e.g. some types of Lubriplate) can cause electrical failure due to production of corrosive gasses inside the tool when burned off.

7.1.2 MECHANICAL

Refer to *Section 5 Mechanical Description* as required for disassembly / re-assembly instructions.

1 Remove dirt and old grease from pressure housing threads and O-rings and replace with fresh.

2 Inspect O-rings for damage or ageing/hardening and replace where required.

3 Check for:

- Damaged wires.
- Wires that are loose and likely to be crushed on re-assembly.
- Damaged components.
- Loose screws/nuts/components/connectors.

Note: If RTV or similar compound is used to secure loose components, it must be fully cured before housing is replaced.

- Electrical components shorting to chassis.
- Heat or chemical damage (discoloured components).
- Incorrect thread grease or excessive quantity, see *Section 7.1.1*.

Also check any connectors for cleanliness and loose / bent pins before replacing.

Check all fixings for tightness.

7.1.3 ELECTRICAL

1 With the electronics cartridge removed, make the following meter checks at the Lemo connection at the bottom of the electronics assembly. Use a standard Multimeter and not a high voltage Megohm Meter for these tests. See *Figure 7.1* below for pin position.

Pin 13 to chassis	Sensor #1	> 1MΩ
Pin 14 to chassis	Sensor #2	> 1MΩ
Pin 15 to chassis	Sensor #3	> 1MΩ
Pin 16 to chassis	Sensor #4	> 1MΩ
Pin 9 to chassis	Sensor #5	> 1MΩ
Pin 10 to chassis	Sensor #6	> 1MΩ
Pin 11 to chassis	Sensor #7	> 1MΩ
Pin 12 to chassis	Sensor #8	> 1MΩ
Pin 5 to chassis	Sensor #9	> 1MΩ
Pin 6 to chassis	Sensor #10	> 1MΩ
Pin 1 to chassis	Sensor #11	> 1MΩ
Pin 2 to chassis	Sensor #12	> 1MΩ
Pin 3 to chassis	GND	< 0.2Ω
Pin 4 to Upper Banana Pin	Through Line	< 0.2Ω
Pin 4 to chassis	Through Line	> 1MΩ

Pins 7 and 8 are not connected.

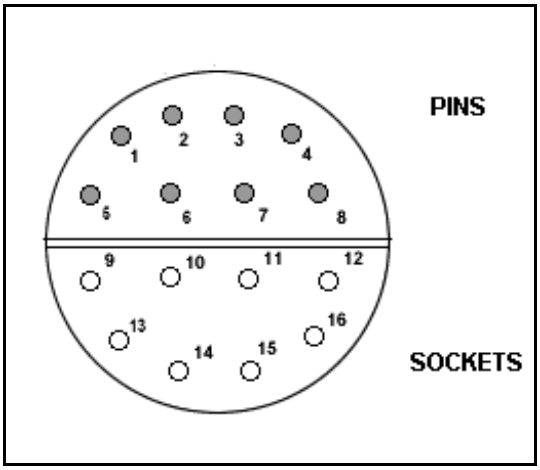


Figure 7.1 Lemo pin positions

2 Replace the electronics cartridge.

3 Check through line resistance and tool current, see *Section 4.1.2*.

4 Connect to logging system and check for correct data. Apply some gentle vibration and rotation to expose potential failure.

5 Take readings in air. Check that readings are similar to last test and have not drifted significantly

6 Take readings in water. Check that readings are similar to last test and have not drifted significantly. (Note that one should ideally allow the electronics to stabilise at the same temperature as the sensors).

7.1.4 AGEING OF ELECTRONICS

At 150°C, significant electronic ageing failures are expected after 4000hrs typical use, hence PCB replacement should be considered at this point. Every additional 10°C halves the time. Life of the electronics is also accelerated by vibration and corrosive gas inside the chassis. Visual inspection and logging previous history is recommended, but is unlikely to predict premature failure.

Tools that may be suspected of reliability problems due to age or unusual log response may be heated to 120°C, which would not normally age the electronics, and afterwards subjected to moderate vibration. A moderately hard blow from a wooden hammer is recommended.

DO NOT USE METAL HAMMERS.

Whilst heating the tool, it is recommended that the sensors should either be removed, or be immersed in oil.

7.1.5 HEAT TESTING ABOVE 150°C

This is not generally recommended since it shortens tool life expectancy.

Heat testing may be required for contractual reasons, tool out of use for a long period, or job with unusually high well temperature. The test should be carried out slightly above expected well temperature only and the tool should not be kept at temperature for more than 1 hour.

7.2 EXTRAORDINARY MAINTENANCE

7.2.1 SERVICING SENSOR HEAD

This should rarely be necessary, unless there has been a leak in a high pressure / temperature well. If this has happened, the Kemlons inside the Sensor Head can be cleaned and the O-rings on them changed. Ordinarily, none of the Kemlons are exposed to well fluid or pressure. Servicing the Sensor Head assembly involves rewiring the Sensor Head and is not recommended, except in extreme circumstances.

7.2.2 SERVICING SENSOR ASSEMBLY

Ref.: Single Pin Sensor Assembly *15296*

After every run

1 Remove the insulator (item 12).

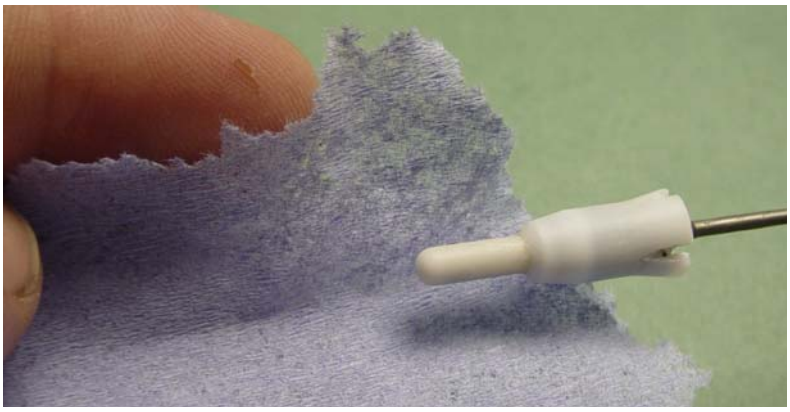
2 Clean the sensor end, using isopropanol and fresh water. Dry with soft tissue paper.

3 Apply Sapphire Endure Grease (item 13) generously around the metal ceramic junction of the Sensor Tube Assembly (item 1) and the Zirconia brazed Crucible assembly (item 2).

4 Refit the Insulator (item 12) by pushing it slowly, but firmly, over the probe (item 2). Hold the probe at the Sensor Tube Assembly (item 1). Do not use any appliance; hold by hand.

Note: Grease will be squeeze out via the ceramic.

When the insulator reaches the end of its travel, remove excess grease, using a tissue.



Note: Take care not to damage the ceramic probes.

Prior to re-inserting previously used sensors

1 Remove the insulators, clean the probes and refit the insulator as described above.

2 Clean the connector end (item 6 & 7) with isopropanol or a similar solvent. Dry with soft tissue paper. This will ensure that no traces of well fluid are left around the connector end of the sensor.

3 When all traces of well fluid has been removed, allow time for the sensor to dry thoroughly. Sensors could also be placed in an oven for a short while at a moderate temperature (e.g. 70° C for 3 hours).

4 Grease the O-ring (item 9) and the O-ring groove on the Head with Liquid-O-ring and fit the O-ring.

Note: Do not overstretch the O-ring when sliding it on. A special assembly tool (Sondex p/n 15272) is available for this purpose.

Check the condition of the Canted Coil Spring (item 10). This provides the grounding between the sensor and the tool body. Replace if necessary.

7.2.3 O-RING REPLACEMENT

Ref.:	CAT004 General Assembly	*09550*
	Sensor Head Assembly	*11544*
	Single Pin Sensor Assembly	*15296*

Note: All item numbers refer to the General Assembly, unless stated otherwise.

The following guidelines are appropriate for normal operating conditions. If the tool experiences harsher conditions (e.g. high pressure, temperature, H_2S), then more thorough servicing is recommended.

To determine contact with H_2S, check for discoloration of the and Lower Sub (item 16). This parts are made of Al/Bronze and will turn black when in contact with H_2S. Local well site knowledge will also contribute to determine the possibility of H_2S exposure.

7.2.3.1 Every Run

Minimum recommendation is to replace the O-rings at the bottom of the tool (item 47) every time the tool joint is broken, when the tool has been under pressure, It is also recommended that the O-rings on the Sensor Head under the Pressure Housing (items 44, 11544) are replaced prior to every job.

7.2.3.2 Every 5 Runs

In addition to the O-rings that should be changed prior to every job, it is recommended that all "wet" O-rings (i.e. O-rings that experience well pressure) should be changed every 5 jobs. These are:

- 2x O-rings (item 73).
- 2x O-rings (item 40).
- 1x O-ring (item 9, 15296)

When replacing the sensor O-rings, **ensure that grease is applied into the O-ring groove prior to sliding on the new O-ring. A small amount of grease should also be applied to the outer side of the O-ring.** Immersing the O-rings in hot water will also soften them and aid their insertion, refer to *Section 7.2.2*.

During replacement of the O-rings, the tool is stripped down to its base assemblies, allowing the tool to be cleaned and serviced thoroughly.

7.2.4 USE OF PRESSURE TEST BLANK ASSEMBLY

Pressure Test Blank Assemblies (p/n 15286) can be inserted into the Sensor Head in place of a sensor. They are primarily used for in-house testing purposes; however they can also be used in the field and there are two main reasons for this:

- If a sensor has failed and no spares are available, one of these can be inserted into the Sensor Head. This will prevent the associated Kemlon in the Sensor Head from being contaminated with well fluid.
- In very low diameter tubing, there may be concerns over whether the tool will obstruct the flow too much, possibly causing it to be blown out of the well. In such cases, one may wish to operate the tool with only 6 sensors. The Pressure Test Blank Assemblies can then be inserted into the unused positions in the Sensor Head.

7.3 TROUBLESHOOTING

Refer to *Section 5* for disassembly instructions and *Appendix B* where necessary.

An Oscilloscope, Multimeter and other basic test equipment will be required.

Initial Inspection	Check for: • Damaged wires • Damaged components • Electrical components shorting to chassis • Heat or chemical damage (discoloured components) • Incorrect thread grease or excessive quantity; see *Section 7.1.1*. Also check all fixings are tight.

Excessive Current	Remove electronics assembly to isolate fault to electronics or Sensor Head / Shaft Assembly. Disconnect wires to isolate fault to: • Electronic circuit board • Upper head connector • Lemo connector on electronics • Sensor head assembly • Shaft assembly (incl. bypass tube). Fault find or replace PCB if necessary. With the electronics assembly removed, the line connection at the bottom of the tool may be tested 250V relative to chassis to check for electrical leak. Resistance should exceed 100MΩ. Disassemble to locate fault.
Little or no current	On PCB85754 check LINE = 18V, 12Va = 12V, 5Vs = 5V, 5Vt = 5V and 0V wire connects to chassis. Fault find or replace PCB.
No telemetry reply	On PCB85754 check LINE = 18V, 12Va = 12V, 5Vs = 5V, 5Vt = 5V and 0V wire connects to chassis. Fault find or replace PCB. On PCB85752 check TP6 for 4MHz clock. Replace U3 if faulty. Reduce R7 if clock < 3V amplitude. Check line for +1V and -1V, 1.8 s pulses from the controller and similar pulses from the tool. Logic pulses should be present on TP1 - 4. Fault find or replace PCB85752 or PCB85754.
All Sensor data reads zero	On PCB85765 check for: • pulses on Fo • signals on pads S1 - S12. Each should go high for 288μs • address lines A0 - A3 are operating. On PCB85752 check for: • pulses on Fo • address lines A0 - A3 and B1 are operating.
Single faulty Sensor	Swap sensors to determine if the sensor is faulty. Replace if necessary. If the fault is not with the sensor, check the wiring from the PCB, through the Lemo connectors, to the Kemlons on the Sensor Head. If a sensor reads low, the surface of the sensor may have absorbed water. In exceptional circumstances, and if the reading is not very low, it may be possible to dry it out by heating at 125ºC for a few hours. The tool should then be pressure tested in oil. (Pressure testing in oil tends to pre-impregnate the sensors with oil and reduce the tendency to absorb water). If a sensor has leaked, it should be replaced.
Rotation faults	With the tool horizontal, check that pendulum rotates freely. The voltages on ROTx and ROTy should increase as the tool rotates clockwise (looking down the tool). Check that they are offset by approximately 180º. This can only be checked roughly, but when ROTx is at 5V, ROTy should be approximately 2.5V.

APPENDIX A EQUIPMENT & RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	CAT004	Capacitance Array Tool, $1^{11}/_{16}$″, Ultrawire	1	

A.1 ANCILLARY EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	15265	Flight Case, $1\ ^{11}/_{16}$″	1	
2	15267	Calibration Tube Assembly	1	

A.2 MAINTENANCE EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	*91050*	Hand Tool Kit for all $1\ ^{11}/_{16}$″ tools	1	
2	15263	Kemlon Removal Tool	1	Included in KITR-CAT004.
3	15283	Feedthrough Retaining Nut Assembly Tool	1	Included in KITR-CAT004.
4	15272	O-ring Removal Tool	1	Included in KITR-CAT004.
5	LOR101	Grease for O-rings and threads	1	5oz pot.
6	LOR101L	Grease for O-rings and threads	1	16oz pot.

A.3 RECOMMENDED SPARES

Item	Part no.	Description	Qty	Remarks
1	*KITB-CAT004*	Basic Spares Kit	1	To support one run in hole.
2	*KITR-CAT004*	Recommended Spares Kit	1	To support 25 runs in hole.
3	KITU-MAPS	Kit Upgrade	1	
4	*41171*	Kit-Spacer Rings	1	Supplied in KITU-MAPS. Refer to *Appendix C* for fitting.
5	*KITO-CAT004*	O-Ring spares	1	

Note: Spares Kits, suitable for remote logging operation, can be supplied upon request.

PARTS LISTING

Part	*Issue*
91050	C

Description

Tool Kit for all 1 11/16 Tools SX and GO

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	91005	Spanner Open Ended 42mmx38mm	2	EA	
0002	91019	Spanner C 50mm 35mm	2	EA	
0003	10038	Spanner Box 3/8 x 5/16 Modified	2	EA	
0004	91028	Spanner O/E 3/8x5/16	1	EA	
0005	93876	Spanner Single Open End 18mm	1	EA	
0006	91029	Key, Hex Metric (Set)	1	EA	
0007	91030	Punch Pin Parallel set	1	EA	
0008	00615	Assy Spanner PKJ	1	EA	
0009	91293	Screwdriver Parallel tip (3 0 x 75)	1	EA	
0010	91105	Toolroll With SX Badge Large Black	1	EA	
0011	91104	Screwdriver Parallel tip (5 5 x 200)	1	EA	
0012	91103	Pliers Circlip 812 Chrome/Van	1	EA	
0013	91102	Pliers Mini Flat Nose 5 Inch	1	EA	
0014	10037	Bar Tommy	2	EA	
0015	10051	Kemlon tool Sondex - 4BA Hex Socket	1	EA	
0016	91280	Hammer, 4oz ball pein	1	EA	
0017	91130	Pin C Spanner 35-50mm	1	EA	
0018	91822	Medium Flat Blade Screwdriver, 5mm	1	EA	
0019	91255	T15 Torx driver, Sandvik Belzer 8915	2	EA	

PARTS LISTING

Part	*Issue*
KITB-CAT004	C

Description

Kit,Spares, Basic, CAT004 (Spgbow Type)

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	KITO-CAT004	Kit, Spares, O-Rings, CAT004	1	EA	
0004	91611	Bearing Ball 2mm Chrome Steel	3	EA	
0005	93043	Scr Grb Skt Hd M3x04mmLG SS-A2 (DIN 916)	3	EA	
0006	91000	Bearing Ball 3/16 Hard	6	EA	
0007	01082	Scr Grb Skt Hd M6 x 5 LG SS FLAT POINT	3	EA	
0008	01047	CIRCLIP INTERNAL 5/8 SS N1300	2	EA	
0009	01029	Screw Csk Hd(Slotted) M3 x 06mm LG SS	10	EA	
0010	92128	Spg Coil Canted 7mm Bore,4.6mm ID BeCu	12	EA	

PARTS LISTING

Part	*Issue*
KITR-CAT004	C

Description

Kit,SpaRes Rec'd(25Run) CAT004(Sprigbow)

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	KITB-CAT004	Kit,Spares, Basic, CAT004 (Spgbow Type)	2	EA	
0002	KITO-CAT004	Kit, Spares, O-Rings, CAT004	5	EA	
0003	15296	Assy Sensor Single Pin	12	EA	
0004	15287	Assy - CAT 7" Springbow and deflector	12	EA	
0005	15272	Tool Assy 0-Ring Sensor	1	EA	
0006	15276	Blank Pressure Test	6	EA	

PARTS LISTING

Part	*Issue*
41171	P1

Description

KIT-SPACER RINGS

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	41142-1	SPACER RING 6"	1	EA	
0002	41142-2	SPACER RING 5"	1	EA	
0003	41142-3	SPACER RING 4"	1	EA	
0004	93111	Pin Coiled 2.5mm x 20mm LG - SPIROL MCK	12	EA	

PARTS LISTING

Part	*Issue*
KITO-CAT004	A

Description

Kit, Spares, O-Rings, CAT004

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	95008	O-ring 008 Viton 75	1	EA	
0002	95009	O-ring 009 Viton 75	1	EA	
0003	95112	O-ring 112 Viton 75	1	EA	
0004	95211	O-ring 211 Viton 75	1	EA	
0005	95011	O-ring 011 Viton 75	1	EA	
0006	95111	O-ring 111 Viton 75	1	EA	
0007	95114	O-ring 114 Viton 75	2	EA	
0008	99903	O-ring 211 Nitrile 70	1	EA	
0009	99012	O-ring 012 Viton 90	2	EA	
0010	99006	O-ring 006 Viton 90	18	EA	
0011	99026	O-ring 026 Viton 90	1	EA	
0012	99125	O-ring 125 Viton 90	2	EA	
0013	99016	O-ring 016 Viton 90	2	EA	
0014	99211	O-ring 211 Viton 90	10	EA	

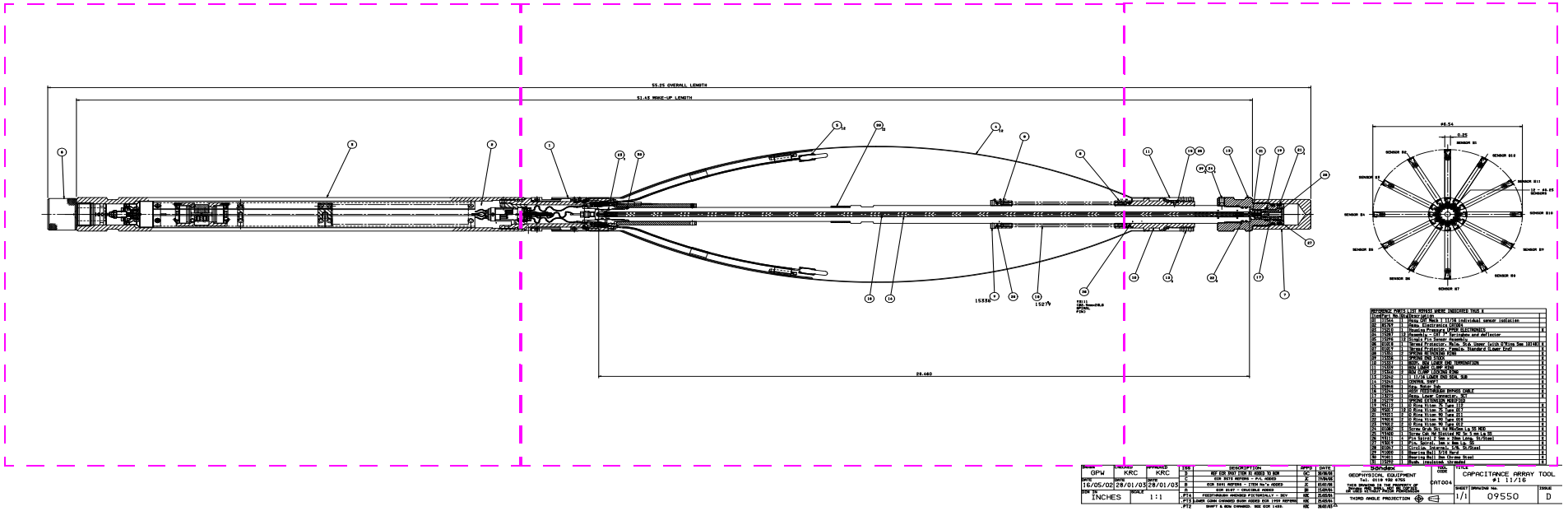
APPENDIX B DRAWINGS & PARTS LISTS

B.1 MECHANICAL DRAWINGS

Description	Drawing	Parts List
CAT004 General Assembly	*09550-D*	See Drawing.
Electronics Assembly	*85769-C*	See Drawing.
Sensor Head Assembly	*11544-F*	See Drawing.
Sensor Single Pin Assembly	*15296-C*	See Drawing.

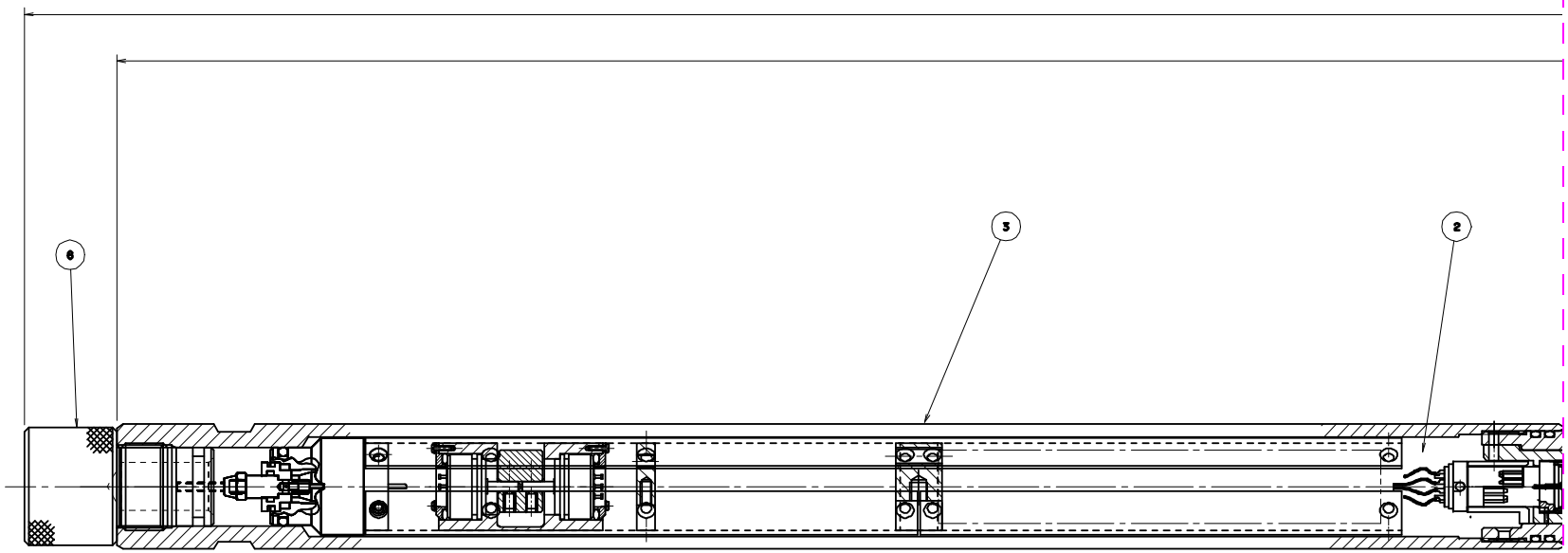
B.2 ELECTRICAL DIAGRAMS

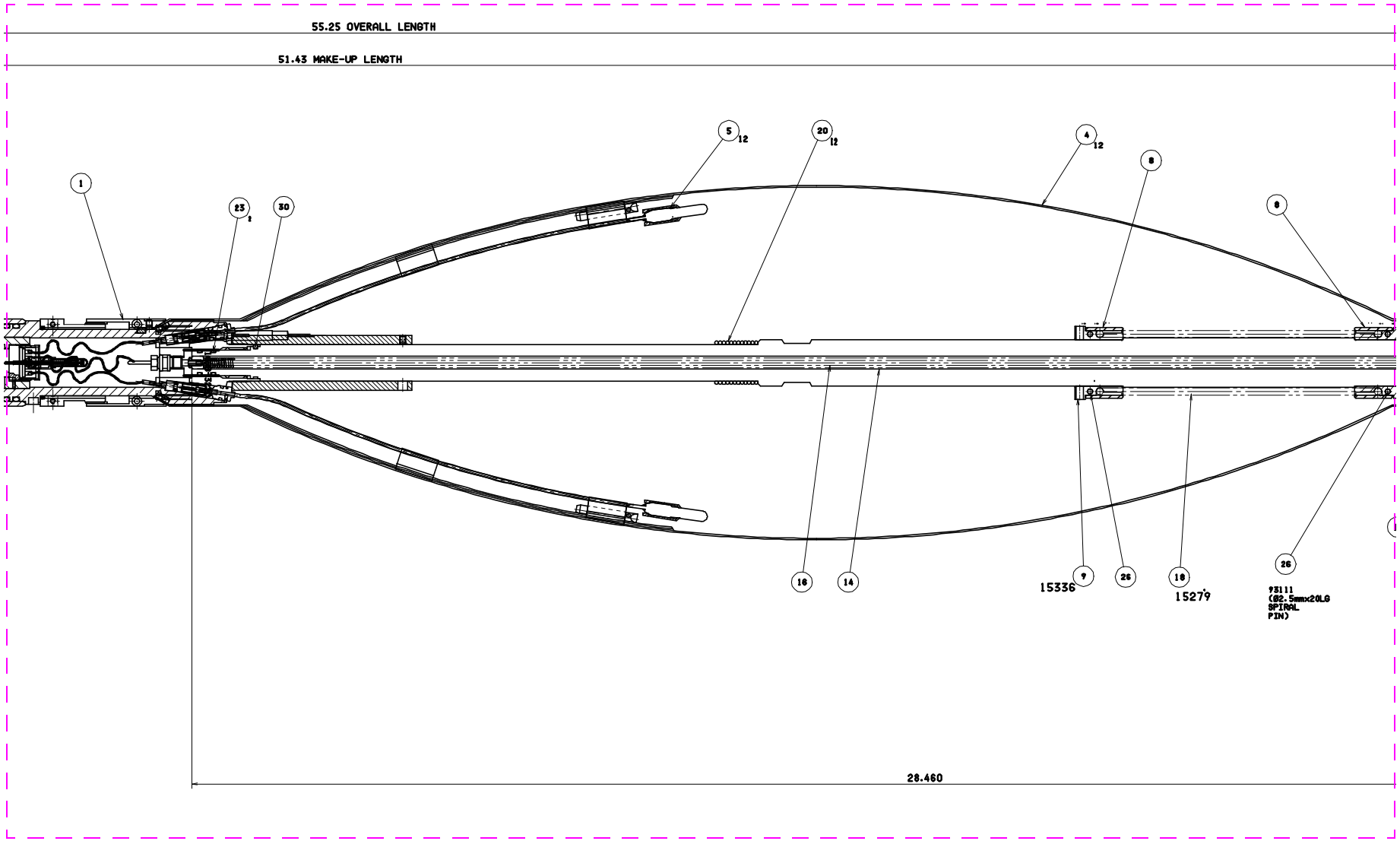
Description	Type	Drawing
Sensor Head Housing (5 sheets)	Wiring Diagram	*WD-11544-D*
Electronics Assembly	Wiring Diagram	*WD-85769-B*
PSU/Telemetry Assembly	Circuit Diagram	*CD-85754-E00x*
PCB Processor Assembly	Circuit Diagram	*CD-85752-C00x*
Sensor Interface	Circuit Diagram	*CD-85765-C00*

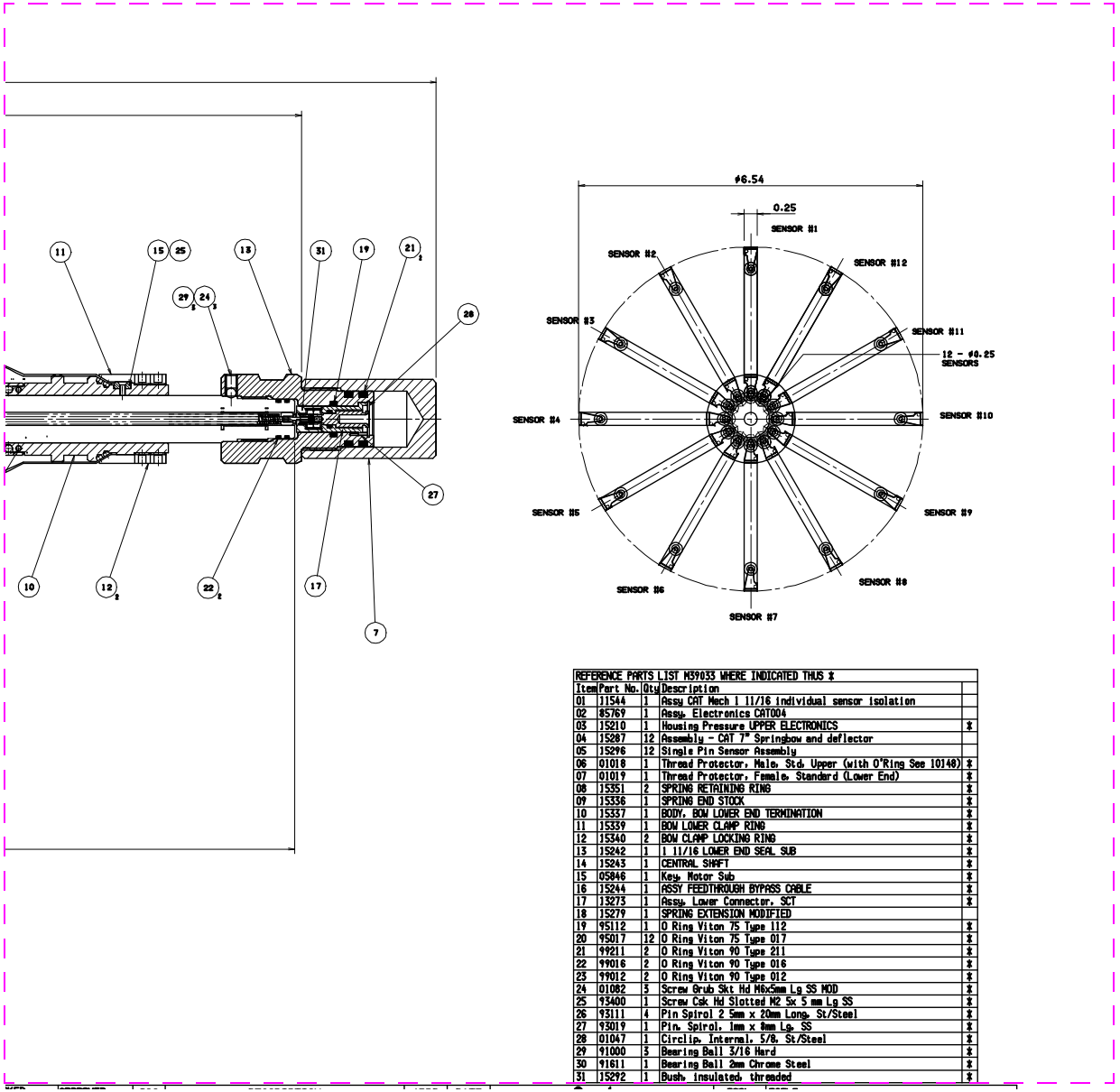


Capacitance Array Tool

CAT004



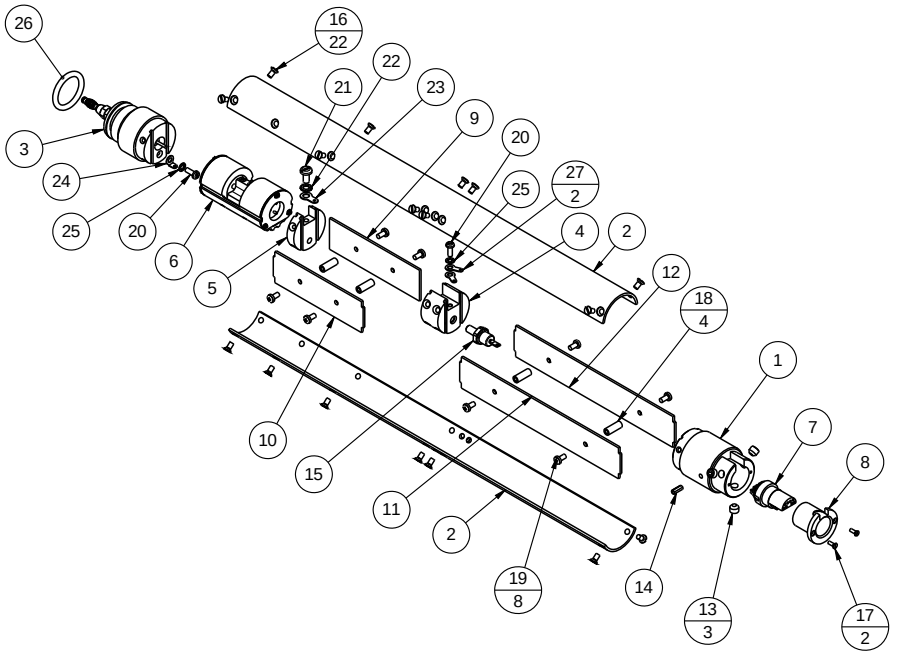


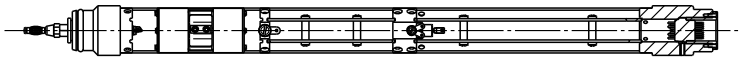


REFERENCE PARTS LIST M39033 WHERE INDICATED THUS ‡				
Item	Part No.	Qty	Description	
01	11544	1	Assy CAT Mech 1 11/16 individual sensor isolation	
02	85769	1	Assy. Electronics CAT004	
03	15210	1	Housing Pressure UPPER ELECTRONICS	‡
04	15287	12	Assembly - CAT 7" Springbow and deflector	
05	15296	12	Single Pin Sensor Assembly	
06	01018	1	Thread Protector, Male, Std. Upper (with O'Ring See 10148)	‡
07	01019	1	Thread Protector, Female, Standard (Lower End)	‡
08	15351	2	SPRING RETAINING RING	‡
09	15336	1	SPRING END STOCK	‡
10	15337	1	BODY, BOW LOWER END TERMINATION	‡
11	15339	1	BOW LOWER CLAMP RING	‡
12	15340	2	BOW CLAMP LOCKING RING	‡
13	15242	1	1 11/16 LOWER END SEAL SUB	‡
14	15243	1	CENTRAL SHAFT	‡
15	05846	1	Key, Motor Sub	‡
16	15244	1	ASSY FEEDTHROUGH BYPASS CABLE	‡
17	13273	1	Assy. Lower Connector, SCT	‡
18	15279	1	SPRING EXTENSION MODIFIED	
19	95112	1	O Ring Viton 75 Type 112	‡
20	95017	12	O Ring Viton 75 Type 017	‡
21	99211	2	O Ring Viton 90 Type 211	‡
22	99016	2	O Ring Viton 90 Type 016	‡
23	99012	2	O Ring Viton 90 Type 012	‡
24	01082	3	Screw Grub Skt Hd M6x5mm Lg SS MOD	‡
25	93400	1	Screw Csk Hd Slotted M2 5x 5 mm Lg SS	‡
26	93111	4	Pin Spirol 2 5mm x 20mm Long, St/Steel	‡
27	93019	1	Pin, Spirol, 1mm x 8mm Lg, SS	‡
28	01047	1	Circlip, Internal, 5/8, St/Steel	‡
29	91000	3	Bearing Ball 3/16 Hard	‡
30	91611	1	Bearing Ball 2mm Chrome Steel	‡
31	15292	1	Bush, insulated, threaded	‡

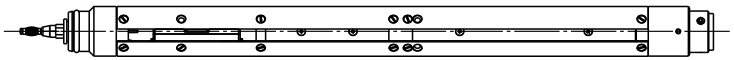
ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	15240	BULKHEAD LEMO CONNECTOR
2	1	15212	ELECTRONICS CHASSIS
3	1	10537	ASSY ELECTRONICS BULKHEAD SX(ISOLATION) MEM
4	1	08713	BULKHEAD TRANSISTOR
5	1	01002	Bulkhead, Intermeadiate
6	1	11517	Assy Relative$Bearing Device
7	1	14021	INSERT 16 WAY LEMO 4$MODIFIED
8	1	40565	TUBE LEMO RETAINER
9	1	85754	ASSY PCB$PSU/TELEMETRY (UW CAT)
10	1	85750	ASSY PROCESSOR BOARD PROGRAMMED CAT
11	1	85765	ASSY INTEGRATED SENSOR +TEMP CAT
12	1	85770	PCB BARE DUMMY
13	3	01082	SCREW GRUB SKT HD M6 x 05mm LG SS
14	1	93252	PIN SPIROL ø3 x 08mm LG SS
15	1	D004-0024V	DIODE ZENER BZY93C
16	22	01029	SCREW CSK HD SLOTTED M3 x 06mm LG SS
17	2	93352	SCREW CSK HD SLOTTED M2 x 06mm LG SS
18	4	93261	SPACER - M3 THRU$4.75mm OD x 12.7mm LG
19	8	93148	SCREW PAN HD POZI M3 x 06mm LG SS
20	2	93080	SCREW PAN HD SLOTTED M3 x 08mm LG SS
21	1	93173	SCREW PAN HD SLOTTED M4 x 08mm LG SS
22	1	93029	WASHER LOCK SERRATED EXTERNAL M4 SS (DIN6798A)
23	1	93086	SOLDER TAG M4
24	1	93097	Tag Solder M3
25	2	93028	WASHER LOCK SERRATED INTERNAL M3 SS (DIN6789J)
26	1	95211	O'RING 211 VITON 75
27	2	93097	TAG SOLDER M3

DO NOT SCALE





PART SECTION WITH
HALF-SHELL REMOVED



NOTES:
1. REMOVE ALL BURRS & SHARP EDGES.

ISS	DESCRIPTION	APPD	DATE
C	ECR 4483 REFERS - ITEM 25 P/N WAS 93089	NPB	02/12/08
B	ECR 4107 REFERS - REDRAWN	TG	22/07/08

DRAWN: ICJ | CHECKED: GHT | APP'D: TG
DATE: 18/07/08 | DATE: 22/07/08 | DATE: 22/07/08
DIM IN: INCHES | MATL: SEE DETAILS
SCALE: 1:2 | A2 | HEAT TREATMENT/CONDITION: SEE DETAILS

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

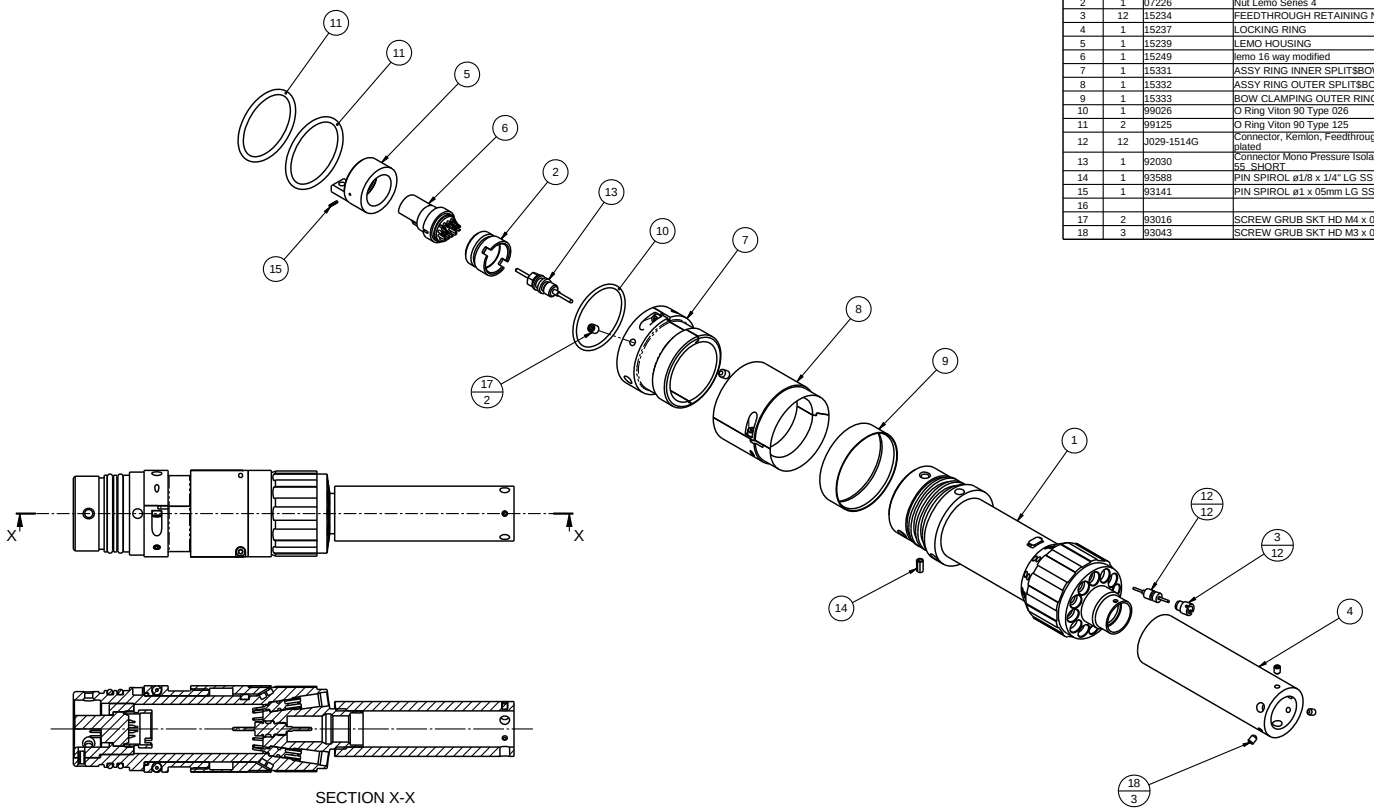
MACHINE FINISH 64 | USED ON: CAT004
GEN TOL: 0.X 0.020" | 0.XX 0.010" | 0.XXX 0.005" | ANGLE ±0.5°

TITLE: ASSY ELECTRONICS CAT004
SHEET 1/1 | DRAWING No. AD 85769 | ISSUE C | S W

SONDEX FM No: F0022

DO NOT SCALE

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	15294	ASSY SENSOR HEAD$WELDED PRESSURE BARRIER
2	1	07226	Nut Lemo Series 4
3	12	15234	FEEDTHROUGH RETAINING NUT
4	1	15237	LOCKING RING
5	1	15239	LEMO HOUSING
6	1	15249	lemo 16 way modified
7	1	15331	ASSY RING INNER SPLIT$BOW CLAMP
8	1	15332	ASSY RING OUTER SPLIT$BOW CLAMP
9	1	15333	BOW CLAMPING OUTER RING BURSTING DISC
10	1	99026	O Ring Viton 90 Type 026
11	2	99125	O Ring Viton 90 Type 125
12	12	J029-1514G	Connector, Kemlon, Feedthrough, K-16-PMS, Gold plated
13	1	92030	Connector Mono Pressure Isolation Pin 0 062 OD x 1 55 SHORT
14	1	93588	PIN SPIROL ø1/8 x 1/4" LG SS STD DUTY
15	1	93141	PIN SPIROL ø1 x 05mm LG SS
16			
17	2	93016	SCREW GRUB SKT HD M4 x 05mm LG SS
18	3	93043	SCREW GRUB SKT HD M3 x 04mm LG SS



SECTION X-X

NOTES:
1. REMOVE ALL BURRS & SHARP EDGES.
2. MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: IF NO SYMBOL IS SHOWN THE COMPONENT IS TOO SMALL AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075

DRAWN:	CHECKED: ICJ	APP'D: IH	
DATE:	DATE: 12/12/08	DATE 12/12/08	
DIM IN: INCHES	MATL: SEE PARTS LIST		
SCALE: 1:1	A1	HEAT TREATMENT/CONDITION: N/A	

ISS	DESCRIPTION	APP'D	DATE
F	ECR 5771 REFERS	IH	15/12/08
B	PARTS RESOLVED		08/08/08

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

USED ON: 40045

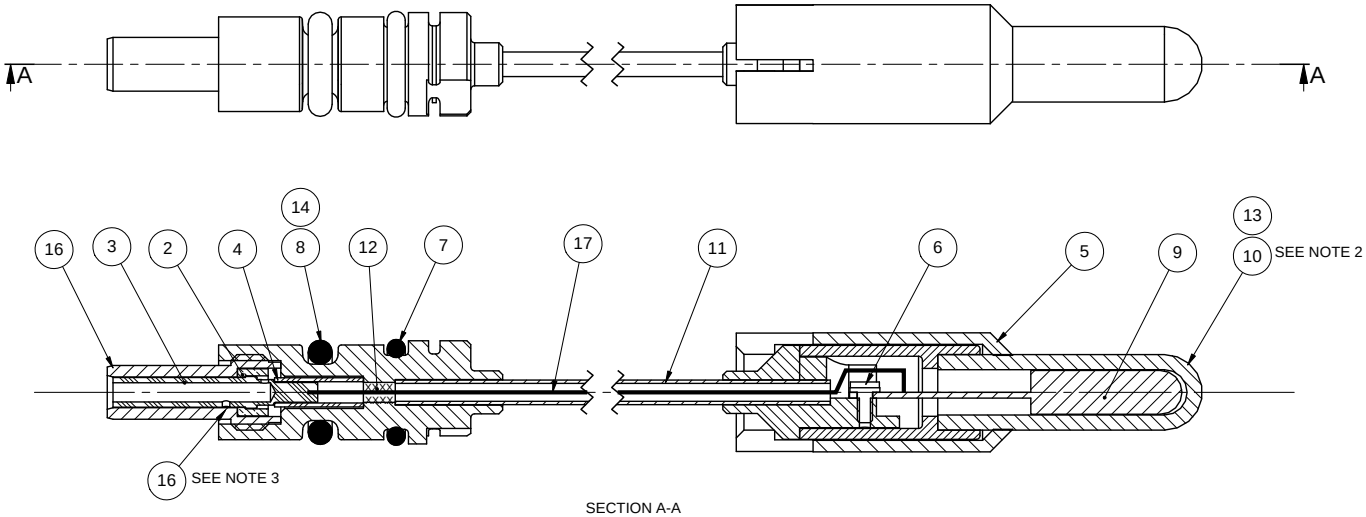
MACHINE FINISH: 63

GEN TOL: 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°

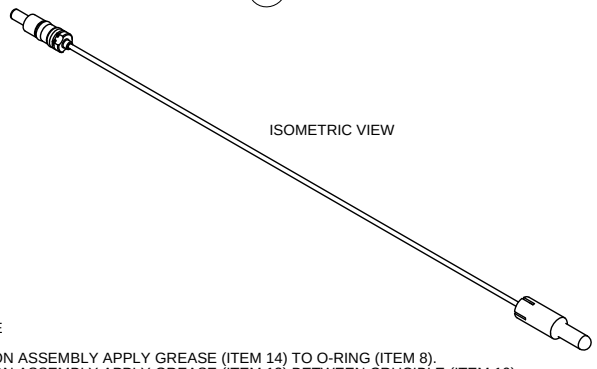
TITLE: ASSY CAT MECH 1 11/16 INDIVIDUAL SENSOR ISO

SHEET 1/1 | DRAWING No. AD 11544 | ISSUE F | S W

DO NOT SCALE



SECTION A-A



ISOMETRIC VIEW

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
16	15430	SOCKET RETAINER	1
2	15429	COLLAR RETAINING	1
3	94234	CONNECTOR HYPERTAC	1
4	15298	PIN SPACER	1
5	08847	INSULATOR$ CAT 5mm CRUCIBLE	1
6	93598	CHEESE HD SCREW M1x2mm long slot head	1
7	92128	CANTED COIL SPRING 100lb 7mm OD, 4.6mm ID, BeCu	1
8	99006	O RING VITON 90 TYPE 006	1
9	85773	ELECTRODE TO SENSOR BOARD ASSEMBLY	1
10	15259	ASSY ZIRCONIA BRAZED CRUCIBLE	1
11	15247	SENSOR TUBE ASSEMBLY	1
12	T006-03140	SILICONE RUBBER, RTV COATING, FLOWABLE	AR
13	91659	GREASE, SAPPHIRE ENDURE BG 741 100g TUBE	AR
14	91311	SILICONE GREASE 100g TUBE	1
15	A006-0099C	SOLDER WIRE	AR
16	MT-KAPTON005	KAPTON FILM 500HN 0.005" THICK	1m
17	W004-00109	WIRE, PTFE TYPE A	AR

NOTE

1. ON ASSEMBLY APPLY GREASE (ITEM 14) TO O-RING (ITEM 8).
2. ON ASSEMBLY APPLY GREASE (ITEM 13) BETWEEN CRUCIBLE (ITEM 10) AND PTFE INSULATOR (ITEM 5).
3. ADD SMALL PIECE OF TAPE (ITEM 16) AROUND AIR HOLE IN ITEM 3.

DRAWN: JC	CHECKED: GC	APP'D: NPB
DATE: 28/04/05	DATE: 14/06/05	DATE: 14/06/05
DIM IN: INCHES	MATL: SEE DETAIL DRGS	
SCALE: 5:1	A2	HEAT TREATMENT/CONDITION:

SONDEX FM No: F0022

ISS	DESCRIPTION	APPD	DATE
C	REF ECR 2545	NPB	14/06/05

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

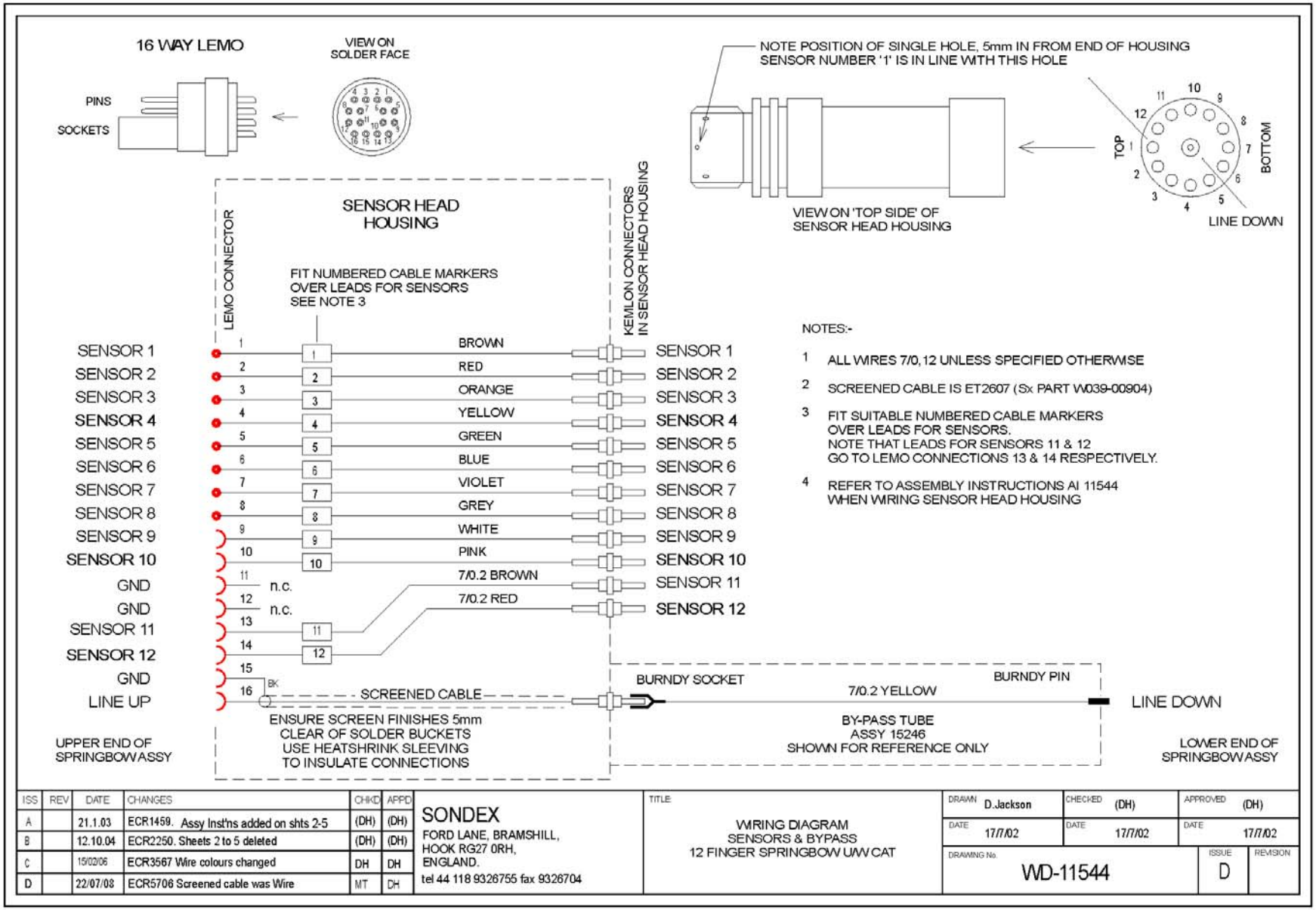
MACHINE FINISH 64

USED ON: CAT004

GEN TOL
0.X 0.020"
0.XX 0.010"
0.XXX 0.005"
ANGLE ±0.5°

TITLE
SENSOR ASSEMBLY
SINGLE PIN ZIRCONIA

SHEET	DRAWING No.	ISSUE	
1/1	AD 15296	C	SW



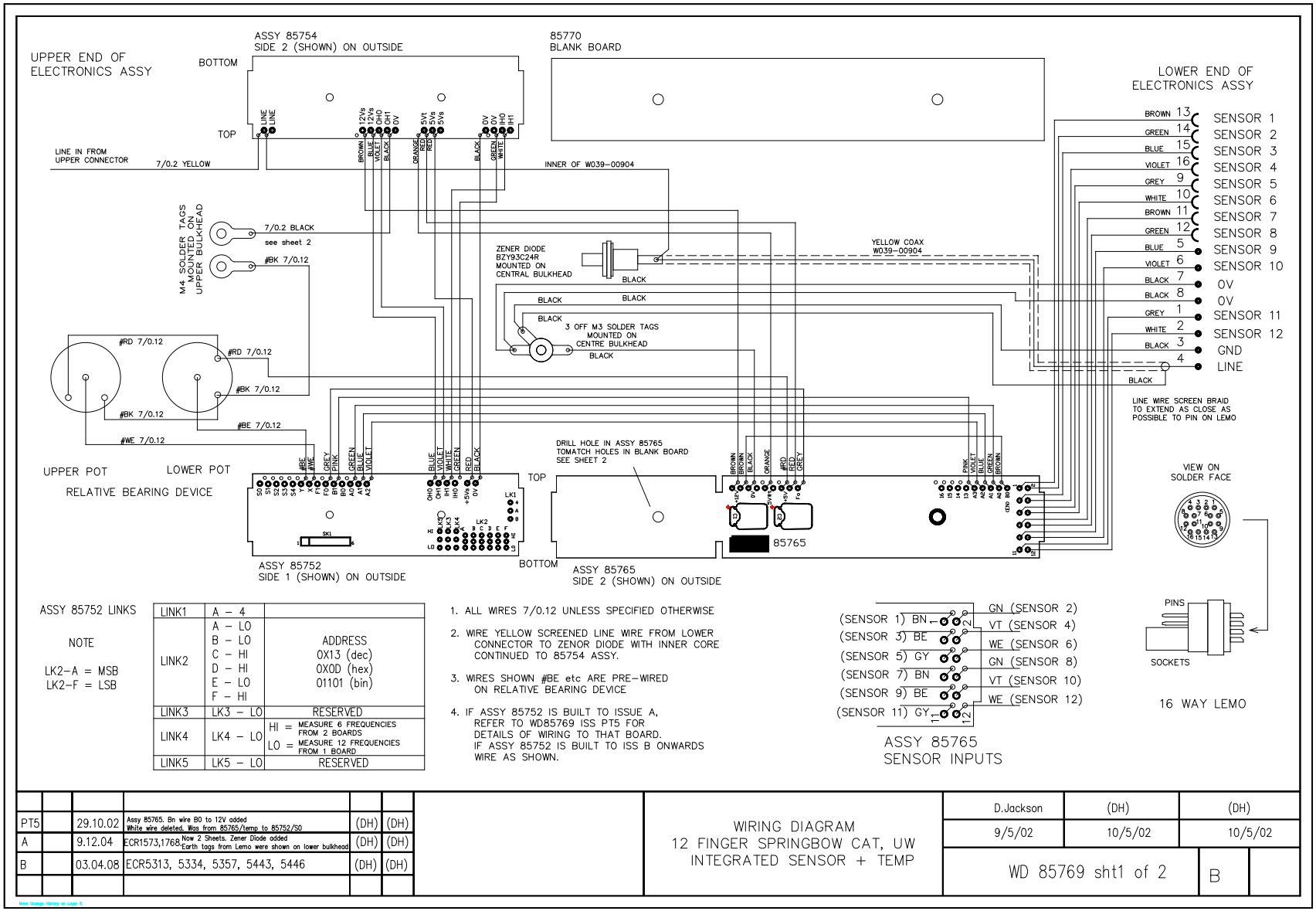
ISS	REV	DATE	CHANGES	CHKD	APPD
A		21.1.03	ECR1459. Assy Inst'ns added on shts 2-5	(DH)	(DH)
B		12.10.04	ECR2250. Sheets 2 to 5 deleted	(DH)	(DH)
C		15/02/06	ECR3567 Wire colours changed	DH	DH
D		22/07/08	ECR5706 Screened cable was Wire	MT	DH

SONDEX
FORD LANE, BRAMSHILL, HOOK RG27 0RH, ENGLAND.
tel 44 118 9326755 fax 9326704

TITLE: WIRING DIAGRAM SENSORS & BYPASS 12 FINGER SPRINGBOW UWV CAT

DRAWN	CHECKED	APPROVED
D.Jackson	(DH)	(DH)
DATE 17/7/02	DATE 17/7/02	DATE 17/7/02

DRAWING No. WD-11544 | ISSUE D | REVISION



ASSY 85752 LINKS

NOTE

LK2-A = MSB
LK2-F = LSB

LINK1	A – 4	
LINK2	A – LO B – LO C – HI D – HI E – LO F – HI	ADDRESS 0X13 (dec) 0X0D (hex) 01101 (bin)
LINK3	LK3 – LO	RESERVED
LINK4	LK4 – LO	HI = MEASURE 6 FREQUENCIES FROM 2 BOARDS LO = MEASURE 12 FREQUENCIES FROM 1 BOARD
LINK5	LK5 – LO	RESERVED

1. ALL WIRES 7/0.12 UNLESS SPECIFIED OTHERWISE
2. WIRE YELLOW SCREENED LINE WIRE FROM LOWER CONNECTOR TO ZENOR DIODE WITH INNER CORE CONTINUED TO 85754 ASSY.
3. WIRES SHOWN #BE etc ARE PRE-WIRED ON RELATIVE BEARING DEVICE
4. IF ASSY 85752 IS BUILT TO ISSUE A, REFER TO WD85769 ISS PT5 FOR DETAILS OF WIRING TO THAT BOARD. IF ASSY 85752 IS BUILT TO ISS B ONWARDS WIRE AS SHOWN.

(SENSOR 1) BN 1 — 2 GN (SENSOR 2)
(SENSOR 3) BE — VT (SENSOR 4)
(SENSOR 5) GY — WE (SENSOR 6)
(SENSOR 7) BN — GN (SENSOR 8)
(SENSOR 9) BE — VT (SENSOR 10)
(SENSOR 11) GY 11 — 12 WE (SENSOR 12)

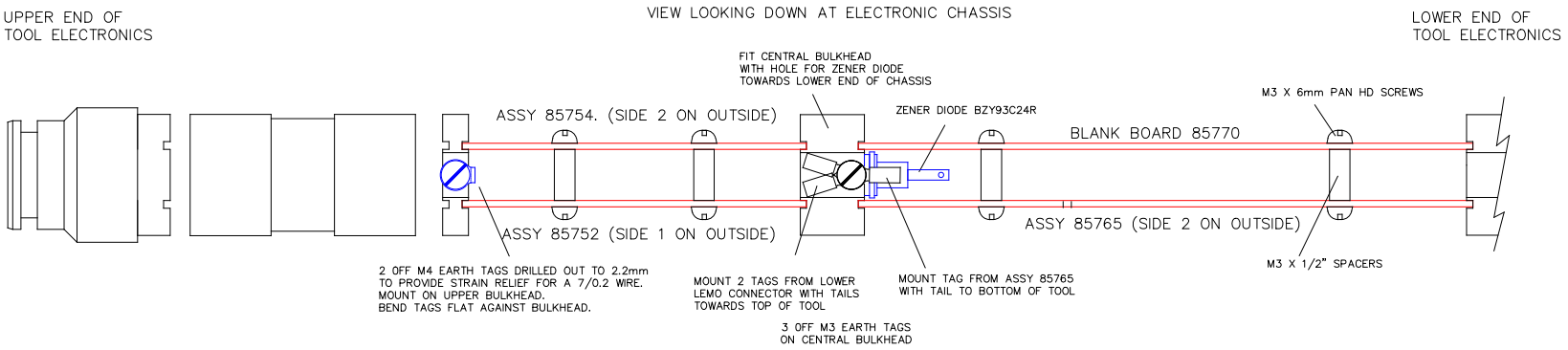
ASSY 85765
SENSOR INPUTS

PT5		29.10.02	Assy 85765. Bn wire B0 to 12V added White wire deleted. Was from 85765/temp to 85752/S0	(DH)	(DH)
A		9.12.04	ECR1573,1768 Now 2 Sheets. Zener Diode added Earth tags from Lemo were shown on lower bulkhead	(DH)	(DH)
B		03.04.08	ECR5313, 5334, 5357, 5443, 5446	(DH)	(DH)

WIRING DIAGRAM
12 FINGER SPRINGBOW CAT, UW
INTEGRATED SENSOR + TEMP

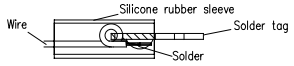
D.Jackson	(DH)	(DH)
9/5/02	10/5/02	10/5/02

WD 85769 sht1 of 2 | B

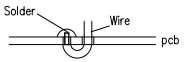


NOTES:

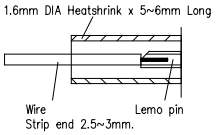
1. Strain relief of solder tag.

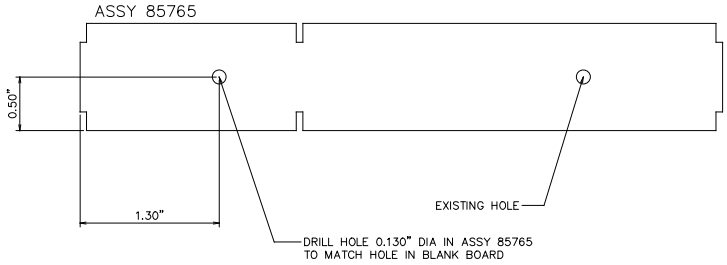


2. Strain relief of wiring.



3. Strain relief of Lemo connections.



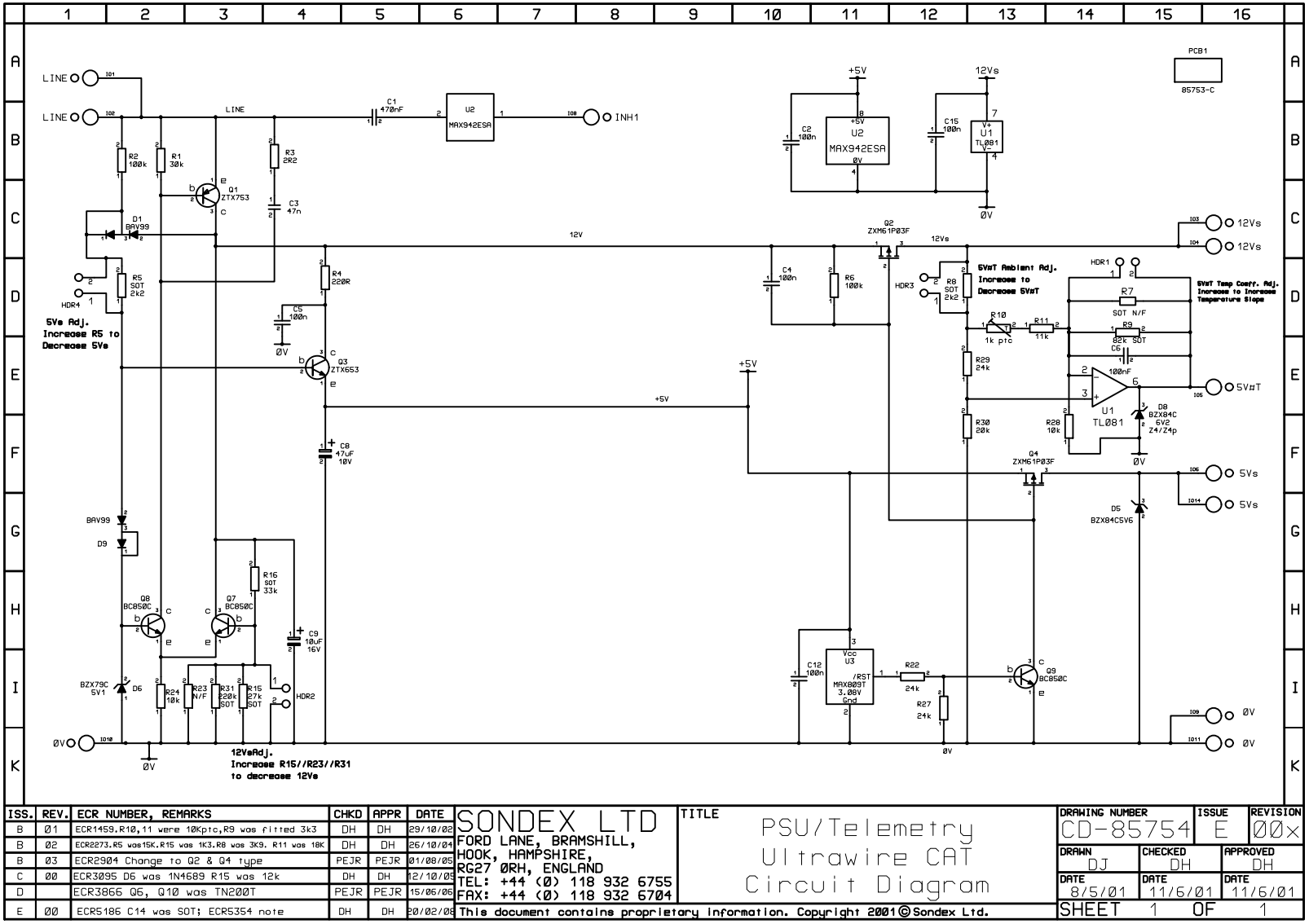


THIS DRAWING TO BE READ IN CONJUNCTION
WITH WD 85769 Sht 1

A		15.12.03	ECR1573. New Sheet. Replaces AI 85769 Iss PT2
B		03.04.08	ECR5313, 5334, 5357, 5443, 5446

ASSEMBLY INSTRUCTIONS
ELECTRONICS CHASSIS
12 SENSOR
ULTRAWIRE SPRINGBOW CAT

D.Jackson	(DH)	(DH)
13/5/02	10/7/02	10/7/02
WD 85769 sht2 of 2	B	



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
B	Ø1	ECR1459.R10,11 were 10Kptc,R9 was fitted 3k3	DH	DH	29/10/02
B	Ø2	ECR2273.R5 was15K.R15 was 1K3.R8 was 3K9. R11 was 18K	DH	DH	26/10/04
B	Ø3	ECR2904 Change to Q2 & Q4 type	PEJR	PEJR	Ø1/Ø8/Ø5
C	ØØ	ECR3095 D6 was 1N4689 R15 was 12k	DH	DH	12/10/Ø5
D		ECR3866 Q6, Q10 was TN2ØØT	PEJR	PEJR	15/Ø6/Ø6
E	ØØ	ECR5186 C14 was SOT; ECR5354 note	DH	DH	2Ø/Ø2/Ø8

SONDEX LTD
FORD LANE, BRAMSHILL,
HOOK, HAMPSHIRE,
RG27 ØRH, ENGLAND
TEL: +44 (Ø) 118 932 6755
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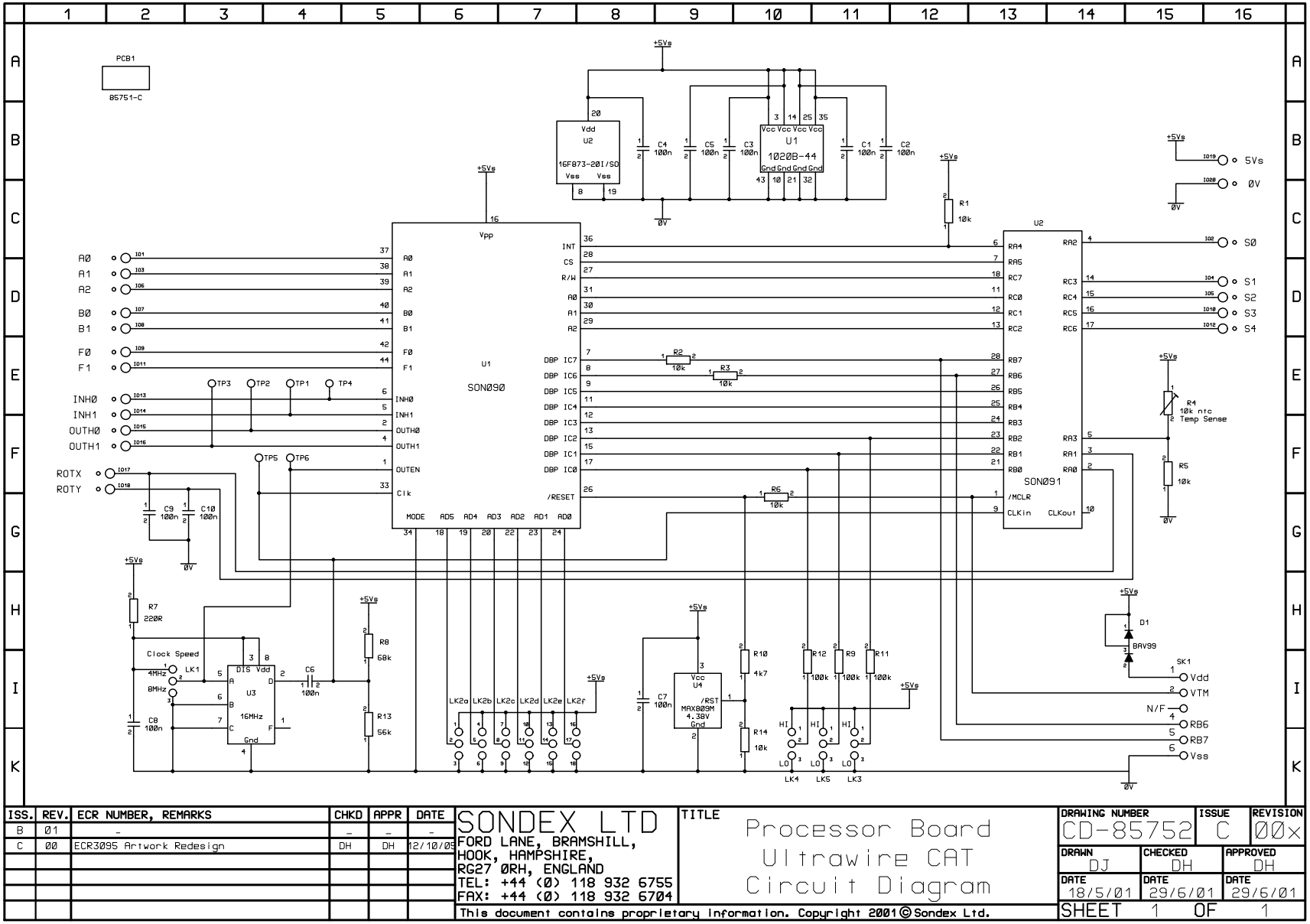
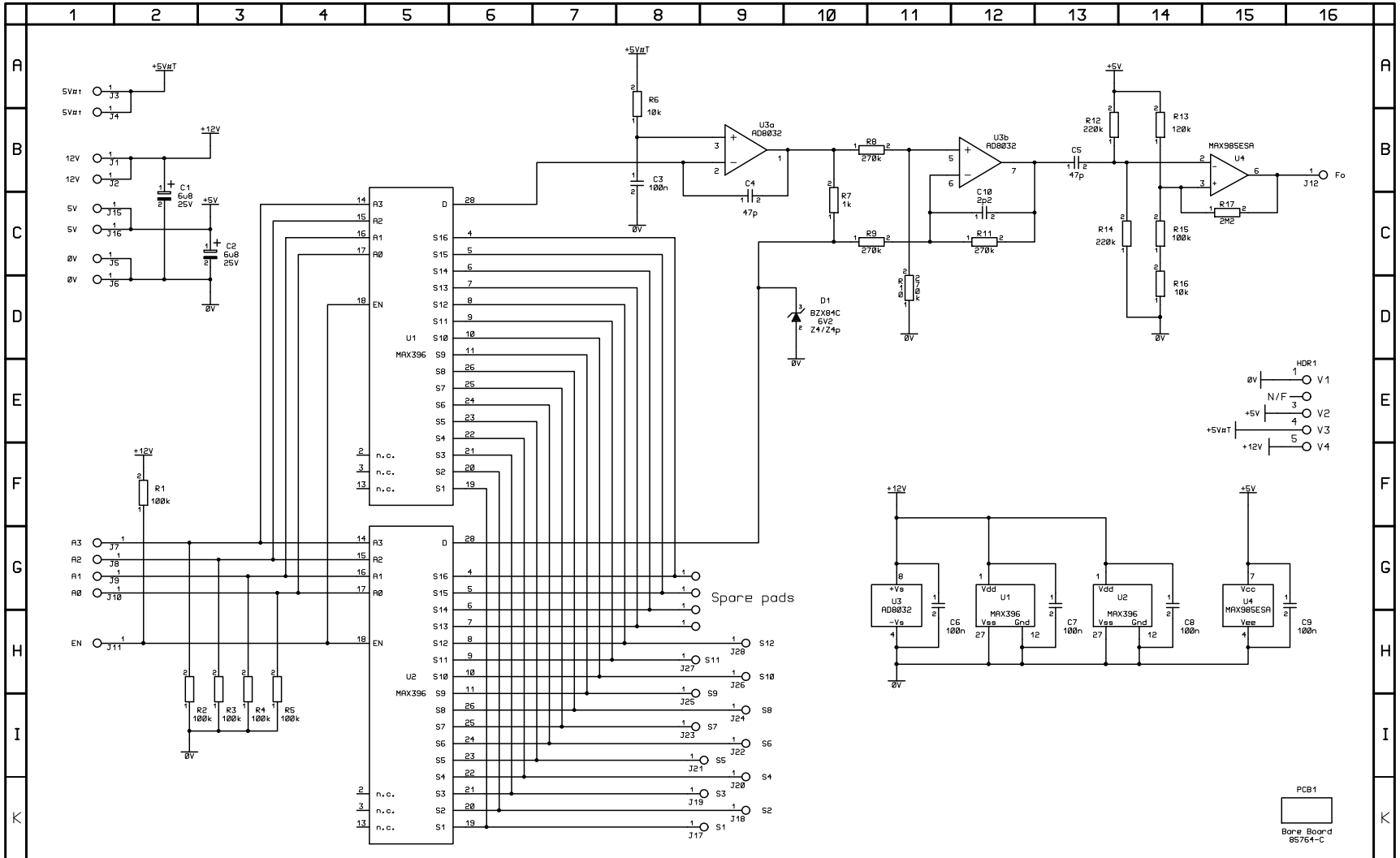
TITLE: PSU/Telemetry Ultrawire CAT Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-85754	E	ØØx

DRAWN	CHECKED	APPROVED
DJ	DH	DH
DATE 8/5/Ø1	DATE 11/6/Ø1	DATE 11/6/Ø1

SHEET 1 OF 1





ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
B	00	Production Release	DH	DH	15/01/03
B	01	ECR1953. C10 added	DH	DH	17/03/04
B	02	ECR3073 C4 was 10p, R7 was 1k5	DH	DH	26/8/05
C	00	ECR3181 Add header to PCB	DH	DH	26/10/05

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TITLE: Integrated CAT Sensor + Temp Interface

DRAWING NUMBER	ISSUE	REVISION
CD-85765	C	00

DRAWN	CHECKED	APPROVED
DJ	D.H.	D.H.
DATE 23/1/02	DATE 6/3/02	DATE 6/3/02

SHEET 1 OF 1

APPENDIX C FITTING OF RESTRICTOR RINGS

Ref: General Assembly *09550 Page B-5* & *41171*(P/N 41142)

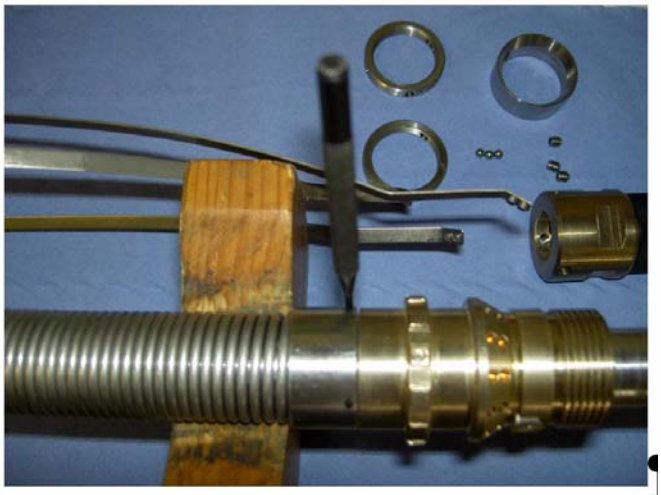
A set of three restrictor rings are available to limit the opening of the springbows on the tool.

The shortest ring (41142-1) will only allow the springbows to open to a 6 inch diameter. The medium ring (41142-2) allows the springbows to open to a 5 inch diameter and the longest ring (41142-3) restricts the opening to 4 inches diameter.

The rings are fitted beneath the long tension spring at the lower end of the tool:

1 Remove the lower sub (item 13) by unscrewing the three grubscrews (item 24) and releasing the 3/16" balls (item 29). Unscrew the sub from the shaft.

2 Release the springbows from the lower body (Item 10) by releasing the two locking rings (item 12) and sliding back the clamp ring (item 11).



3 Drive out the two 2.5mm spirol pins from the lower spring retaining ring (item 08).

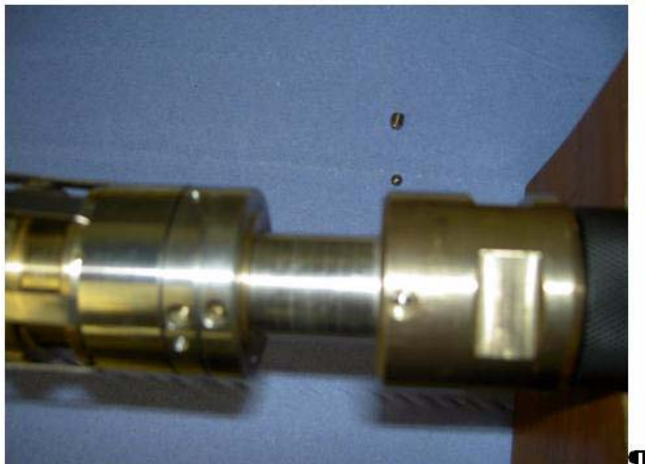
4 Unscrew the lower body from the spring (left-hand thread) and remove.

5 Slide the required size of restrictor ring onto the shaft up to the first shoulder. The ring will restrict the travel of the lower body and the springbow maximum travel.

6 Replace the lower body and slide the spring over the shaft and over the restrictor ring and screw onto the lower body.

7 Fit the lower spring retaining ring (item 08) using two new spirol pins (item 26).

8 Refit the springbows onto the lower body and hold in place with the clamp ring (item 11).



9 Hold the clamp ring in position with the locking ring (item 12) with the additional M3 tapped holes. Then screw on the second locking ring.

10 The M3 tapped holes are used as a calibration aid for the rotation sensors. Align one of the M3 holes with the axis of spinner No. 1 before locking the rings in their final position. This will allow rotation calibration points at 90° intervals to be taken.

11 Screw the Lower End Sub (item 13) onto the end of the Central Shaft. Ensure that the Lower End Sub is fully tightened onto the Central Shaft. Lock in position using 3 x 3/16" Ball Bearings (item 29) and grub screws (item 24).