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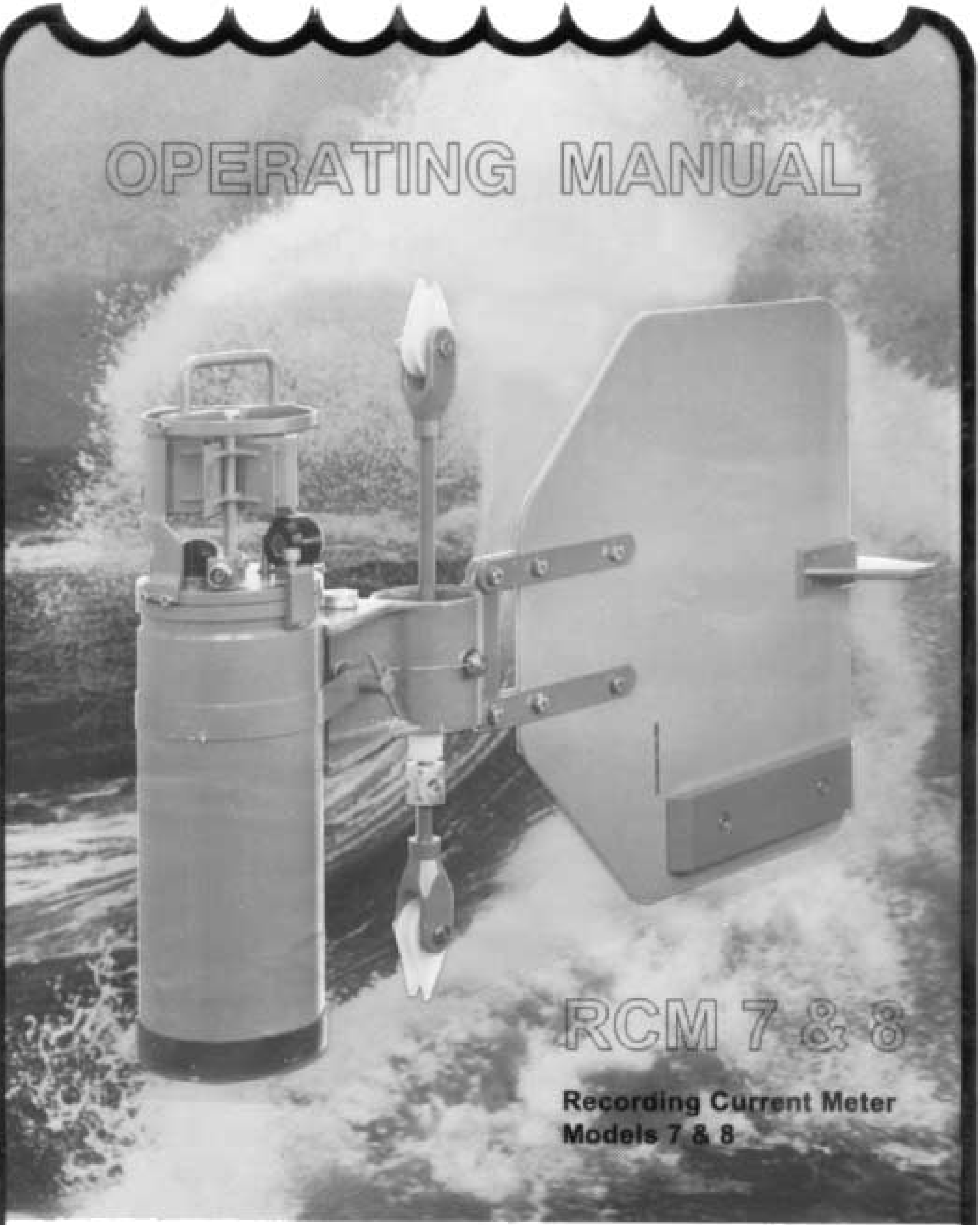
OPERATING MANUAL



RCM 7 & 8

**Recording Current Meter
Models 7 & 8**

AANDERAA INSTRUMENTS

DATA COLLECTING INSTRUMENTS FOR LAND, SEA AND AIR

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LIST OF FIGURES.

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INTRODUCTION

This manual describes the Vector Averaging Recording Current Meter, RCM7. The information provided is correct at the date of compilation, but is subject to change. The main features of the instrument have been unchanged since December 1987.

The use of this instrument for measuring ocean currents requires practical insight into several fields including mooring, deployment and recovery of instruments, operation and maintenance, sensor calibration, data processing and interpretation.

From time to time a number followed by a bracket occurs in the text, e.g. 4). This indicates that a change has been made at some stage of the particular function or component described. The changes are described in the appendix. The illustrations in chapter 8 include some 4 and 6 digit stock identification numbers which should always be quoted when ordering spare parts. This manual also covers the operation of a deep water versions of the instrument, namely the RCM 8, which has a depth rating of 6000 m. Features of the RCM 8 which differ from the RCM 7 are noted in chapter 9.

MOORINGS

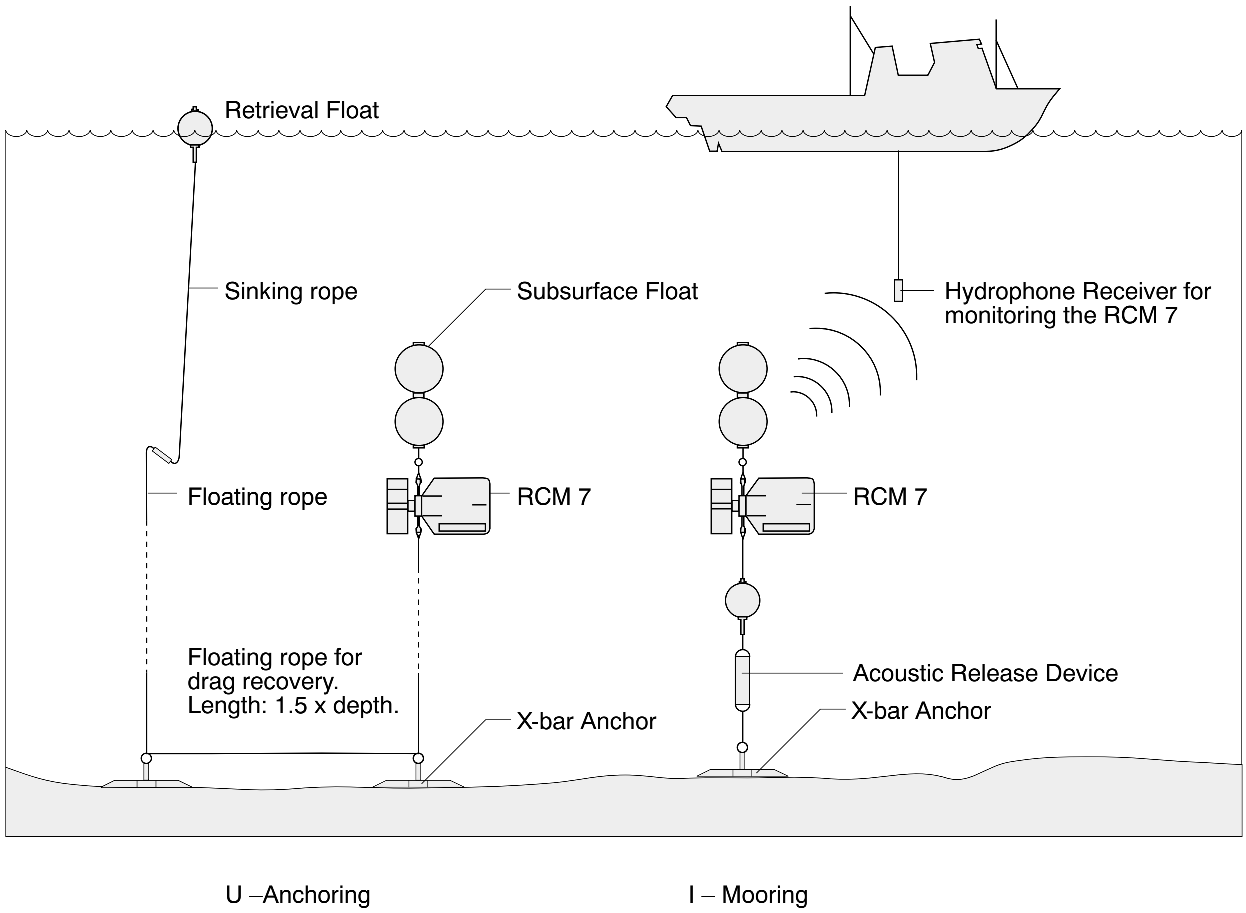


Fig.0.01 Mooring of Current Meters

CHAPTER ONE

SHORT DESCRIPTION, SPECIFICATIONS.

Recording Current Meter Model 7 (RCM 7) is a self-recording current meter intended to be moored to obtain and record the vector averaged speed, direction and temperature of ocean currents. As an option it can be furnished with sensors for conductivity and water pressure. These sensors are easily installed on a standard instrument. An advantageous feature of Aanderaa current meters is that the calibration of a sensor is valid for all RCM 7 and 8 types of instruments.

Figure 0.01 shows 2 typical ways of mooring the instrument, “U-anchoring” is suitable for shallow waters, while “I-anchoring” can be used for all depths, provided that the depth capability of the release device or current meter is not exceeded. For “U-anchoring” a piece of heavy chain can be used as an anchoring weight rather than a solid weight because it is easier to hoist off the bottom.

The instrument records data internally in a removable and reusable solid-state Data Storage Unit (DSU) 2990. A built-in quartz clock triggers the measuring cycle at regular, programmable intervals. The measuring cycle consists of 6 channels in sequence, which are:

1. Reference (a control and identification reading)
2. Temperature
3. Conductivity (when installed)
4. Pressure (when installed)
5. Current direction
6. Current speed

The reference is a fixed reading that serves as a control on the performance of the instrument and to identify data series from individual instruments. The instrument will record fixed values in channels 3 and 4 when optional sensors are not installed, (0 and 1023 respectively).

Temperature is measured by a thermistor fitted into a stud which extends into the water. Conductivity is measured by an electrodeless induction type conductivity cell and pressure (instrument depth) is measured by a silicon pressure sensor.

As the current meter aligns itself in the current, the orientation of the instrument is measured by a compass located at the bottom of the recording unit.(Response time: 1m waterway) The current speed is sensed by a rotor at the top of the recording unit. The revolutions of the rotor are magnetically transferred to an electronic counter inside the unit. Every half revolution is counted. A vector averaging method is used for recording the speed and direction of the current.

As data is recorded and stored in the PDC-4 code (see page 2-12), an acoustic transducer transmits real-time data in the same code. This permits monitoring data from a submerged instrument using a hydrophone receiver.

Figure 8.01 shows an assembled current meter. It consists of two main parts, the vane assembly and the recording unit. The vane assembly is furnished with a spindle rod, which should be shackled onto the mooring line. The complete instrument is free to swing around the spindle. The spindle has a ball bearing housed in a pair of gimbals, permitting the spindle to deviate up to 27° from vertical in any direction. The vane plate is furnished with a pair of balance weights, ensuring static balance of the instrument. A pair of tail fins at the rear end of the vane plate ensures dynamic balance of the meter.

The recording unit is held to the gimbal housing of the vane assembly by a fastening band. Correct orientation of the unit is ensured by an orientation block mating a stud on the gimbal housing.

Figure 8.02 shows the recording unit. All external and internal parts are fastened to the top end plate, and the instrument can be lifted out of the pressure case in one piece after removing the two C-clamps.

All external parts are protected from corrosion by a durable olive green epoxy coating. Further corrosion protection is ensured by the use of three sacrificial zinc anodes, one fitted to the top end plate, one to the gimbal housing and one to the spindle. The top end plate is furnished with a rotor shield, of which the upper part is formed as a handle for carrying the unit. The rotor shield is equipped with a guard ring to protect the rotor during transport.

The top end plate also has an electrical terminal. This can be used for calibrating and checking the performance of the instrument, as it allows triggering, as well as real-time data reading. A digital display unit e.g. Deck Unit 3127 or Computing Unit 3015, can be connected to display data. By use of PDC-4/RS232C Deck Unit 3127, the output signal can be read by a personal computer via the same terminal.

Figure 8.03 shows the interior of the recording unit seen from the battery side. The electronics are hermetically encapsulated in a board of low density polyurethane. The switch for selecting sampling intervals is embedded in this board. Another embedded switch is the temperature range selector switch by which 3 ranges; Low, Wide and High can be selected.

The 9 volts battery is located at the lower end of the unit. This battery must be non-magnetic due to its vicinity to the compass.

The main switch is located near the battery. When the switch is turned on, the unit is powered, and the clock is reset. A push-button switch, located just above the main switch, permits manual start of the instrument when the interval selector switch is in the position 0 (MS). If you wish to change the interval while the instrument is running, set the required interval and push manual start.

Figure 8.04 shows the interior of the recording unit seen from the Data Storage Unit (DSU) side. The DSU is attached to the instrument by means of its electrical connector at the top and 2 snap-on locks at the lower end.

A new recording unit, when delivered from the factory, is equipped with Data Storage Unit and battery installed, ready for use. The only preparation needed prior to use, is to set the desired sampling interval, flip the main switch to on and attach the unit to the vane assembly.

When shipped, the recording unit and vane assembly are packed separately in two plywood box-es as shown on figure 8.05 and 8.06. The box containing the vane assembly also contains a set of spare parts and accessories.

Specifications of the Vector Averaging Recording Current Meter, RCM 7 and 8, are as follows:

Measuring system:

Self balancing bridge with sequential measuring of 6 channels, and a solid state memory. 10-bit binary word for each channel. The channels are:

Ch. 1. Reference: A fixed reading to check the RCM´s performance and to identify individual instruments.

Ch. 2. Temperature:

Sensor type:	Thermistor (Fenwall GB32JM19).
Resolution:	0.1% of selected range.
Accuracy:	±0.05°C.
Response time:	12 seconds (63%).
Selectable Ranges:	
Low range:	–2.4 to 21.4°C.
Wide range:	–0.3 to 32.1°C.
High range:	10.1 to 36.0°C.
Optional:	
Arctic range:	–2.6 to 5.6°C in channel 4.

Ch. 3. Conductivity: (optional)

Part Number	RCM 7: 2994, RCM 8: 3994
Sensor Type:	Inductive Cell
Ranges:	0 – 74 mmho/cm (standard). 24 – 68 mmho/cm (on request). 24 – 36 mmho/cm (on request).
Accuracy:	± 0.1% of range.
Resolution:	0.1% of range.

Ch. 4. Pressure: (optional)

Part number:	RCM 7: 3239 or RCM 8: 3249
Sensor Type:	silicon piezoresistive bridge.
Ranges:	700, 3500, 7000 KPa, 14, 20, 35 and 60 MPa. 35 and 60 MPa is for RCM 8 only.
Accuracy:	±0.5% of range.
Resolution:	0.1% of range.

Ch. 5. Direction:

Sensor Type:	Magnetic compass with needle clamped onto potentiometer ring.
Resolution:	0.35°.
Accuracy:	±5° for speeds from 5 to 100 cm/s. ±7.5° for current speeds 2.5 to 5 and 100 to 200 cm/s.

Ch. 6. Speed:

Sensor Type:	Rotor with magnetic coupling.
Range:	2 to 295 cm/s.
Accuracy:	±1 cm/s or ±4% of actual speed whichever is greater.
Starting Velocity:	2 cm/s.

Note.
Vector Averaging of Current Speed and Direction
The number of rotor revolutions and the direction are sampled every 12 seconds and broken up into North and East components. Successive components are added and recorded as speed and direction. For recording intervals longer than 10 minutes, speed and direction are sampled every 1/50 of the recording interval.

Clock:

Type:	Quartz crystal.
Accuracy:	Better than ±2 s/day within 0 to 20°C.
Recording Intervals:	0.5, 1, 2, 5, 10, 20, 30, 60 or 120 min.
External Triggering:	A 6 volt pulse to terminal activates instrument.

Recording System:

Type:	Data Storage Unit 2990 or 2990E.
Data Format:	PDC-4. (Pulse Duration Code 4 s).
Storage Capacity:	
DSU 2990:	10 900 records of all channels.
DSU 2990E:	43 600 records of all channels.

Telemetry:

Acoustically:	Acoustic carrier keyed on and off.
Frequency:	16.384 KHz ±5 Hz.
Detection Range:	Up to 800 m with Hydrophone 3079. The acoustic transducer for RCM 8 is optional

Battery: Non-magnetic.

Li. Battery 3382: 7.2V, 10–14 Ah (depending on load), sufficient for 30835 records (214 days) of all channels at 10 minute intervals (one record is a measuring cycle of all six channels).

Depth Capability: RCM 7: 2000 m; RCM 8: 6000 m.

Weight (kg):	Recording Unit		Vane Assembly	
	in air	in water	in air	in water
RCM 7 Nett:	13.6	8.8	12.2	9.5
RCM 7 Gross:	18.5		20.0	
RCM 8 Nett:	15.2	10.9	14.1	11.8
RCM 8 Gross:	20.5		22.0	

Dimensions (mm):

RCM 7:	495 x 128	485 x 500
RCM 8:	520 x 128	485 x 500

Packing:

Plywood case (mm):	190 x 250 x 600	140 x 520 x 770

Mooring:

Thimbles:	Maximum 15 mm diameter rope.
Gimbal Rings:	Permits 27° tilt.
Spindle:	Breaking load 4000 kg.

External Materials:

Pressure Case:	CuNiSi alloy (OSNISIL) and stainless, acid proof steel. Epoxy coated.
Other Metal Parts:	Nickel plated bronze and stainless, acid proof steel. Epoxy coated.

Spares: A set of recommended spares is delivered free of charge with each instrument (rotor, bearings, O-rings etc).

Warranty: Two years against faulty materials and workmanship.

CHAPTER TWO

THEORY OF OPERATION.

Preliminary.

The measuring system used in this instrument is a self-balancing bridge system that processes its 6 sensor channels sequentially. The sensor forms one half of the bridge. The other half of the bridge is a 10-step R-2R approximation network. The system carries out the same process for all sensors. How the bridge and sensors act together is described as follows. The output code is the PDC-4 code (see 2-09). This code is chosen because it is simple, compact and well suited for telemetering. Data is stored in the Data Storage Unit (DSU) 2990. Computer compatibility is taken care of when reading the DSU via the DSU Reader 2995. The PDC-4 coded information is then converted to ASCII coded RS-232C signals.

R-2R network measuring bridge.

The advantage of a measuring system that uses a balancing bridge is that the accuracy is independent of a precise reference voltage. In RCM 7 the sensor and a 10-step R-2R network form the bridge. The R-2R network gives the binary number directly for the sensor output voltage. The half-bridge sensor is the left side of the bridge with the R-2R network as the other.
The R-2R network has 10 electronic switches. Before balancing, all switches are in the “zero” position. The sensor’s output voltage varies with the surrounding medium to be measured and at any specific moment, the sensor has a constant voltage output to be balanced. The balancing process starts with S1, switching to “On” or “one” position. The sensor output and balancing network voltages are compared. If the Comparator output is positive it signifies a higher voltage from the network than the sensor. S2 is then closed, which reduces this control voltage.

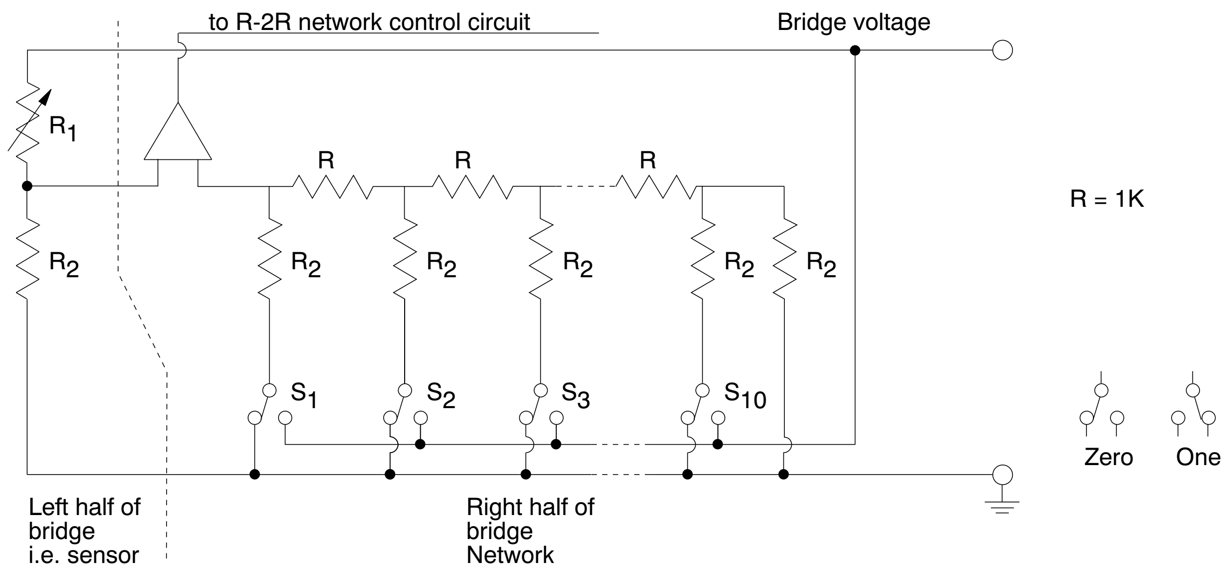


Fig. 2.01 R–2R Network Measuring Bridge

This continues and if a switch closure causes a negative control voltage, the switch is opened again and the next switch is brought into the circuit. This continues until the control voltage is zero.

Ten binary switches divide the measuring range in 1024 equal parts. After balancing, the switches S1, through S10 are left either in closed or open position signifying binary “ones” and “zeros”.

The bridge voltage is pulsed. For each pulse one switch is set. Ten pulses of -3V are generated for each sensor. The bridge shown in figure 2.01 will scan the full range from ground to bridge voltage. If the sensor output voltage covers less than the full range, a set of range reducing resistors are used as described in the following paragraph for each channel.

Reference reading (channel no. 1).

The fixed reference reading is a measure of the ratio between two set resistors. It identifies individual instruments and serves as a control of the measuring system. Note that the system has a digitization error of ± 1 bit.

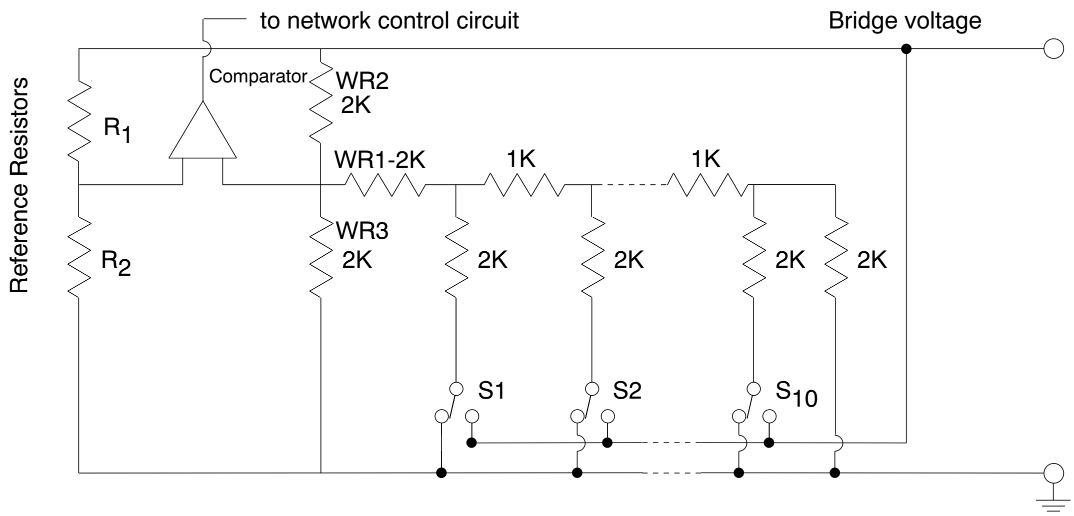


Fig. 2.02 Bridge used for Reference Reading

A set of range reducing resistors WR1, WR2 and WR3 is used, decreasing the range to 1/4 of full range. The reading (N) is (see figure 2.02):

$$\text{Reading (N)} = \left(\frac{R2}{R2 + R1} - \frac{3}{8} \right) \times 4 \times 1023$$

Temperature measurement (channel no. 2).

The RCM 7 uses a thermistor to measure temperature. Together with WR4 the thermistor forms a half-bridge. The output voltage does not cover full range, therefore range reducing resistors WR1, WR2 and WR3 are used. The values of these resistors vary with the temperature range

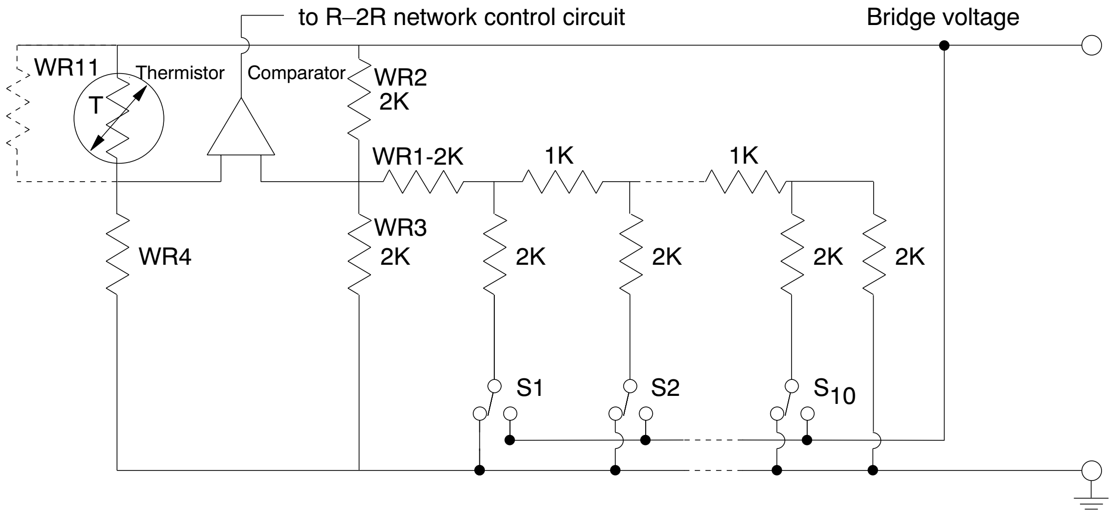


Fig. 2.03 Bridge used for Temperature Measurement

chosen by the temperature range selector switch. More details are given in paragraph 3, page 3-06. For Current Meters, serial nos 9647 and subsequent instruments, the electronic board is equipped with a temperature range selector switch (allowing choice of Low Range, – 2.46 to + 21.48°C; Wide Range, – 0.34 to + 32.17°C and High Range, 10.08 to 36.04°C).

Conductivity measurement (channel no. 3).

The conductivity cell used in this instrument is an electrodeless induction type cell made of 2 toroids encapsulated in a resin with low temperature coefficient and low water solubility.

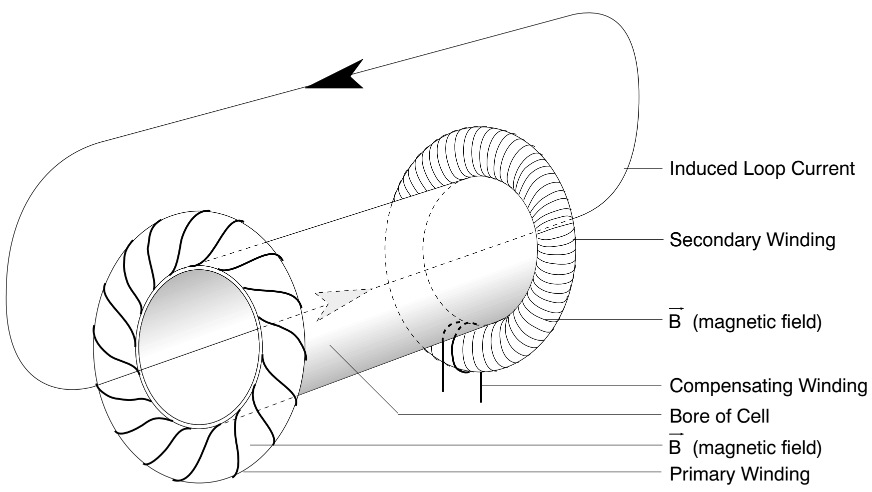


Fig. 2.04 Working Principle of Conductivity Cell

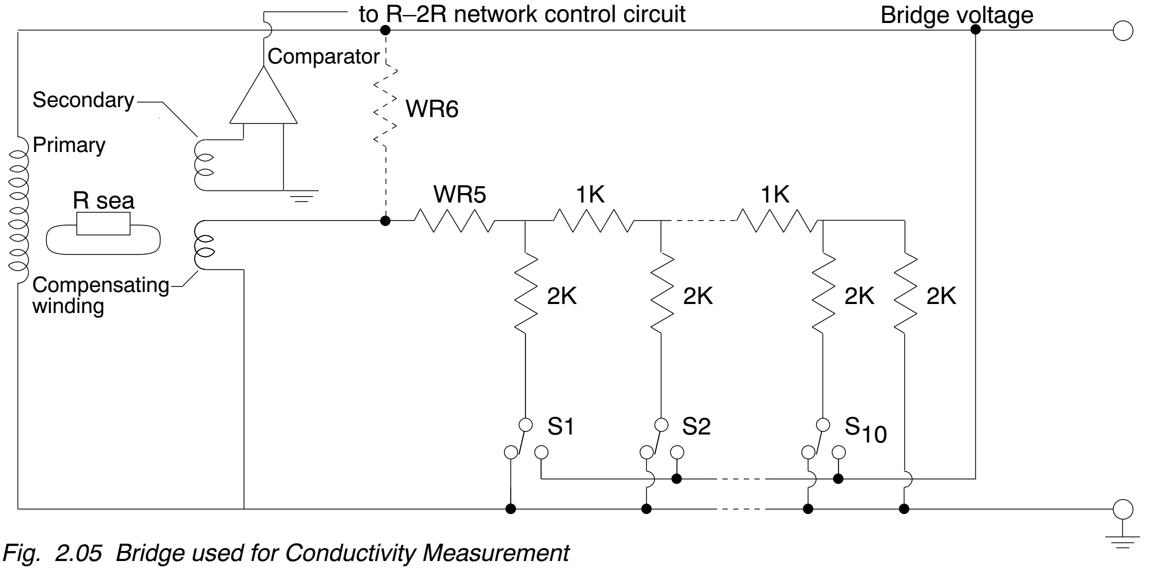


Fig. 2.05 Bridge used for Conductivity Measurement

The working principle is outlined in figure 2.04 above. The current in the primary induces a conductivity dependent loop current in the water. The loop current passes through the bore of the cell where it induces a voltage in the secondary winding. The measuring system balances this current so that the voltage in the secondary equals zero. The current required in the compensating windings is a measure of the conductivity of the water.

Pressure measurement (channel no. 4).

The pressure is measured by 4 piezoresistive elements diffused onto a silicon diaphragm. The signal is amplified before it is sent to the measuring bridge, See appendix [1)].

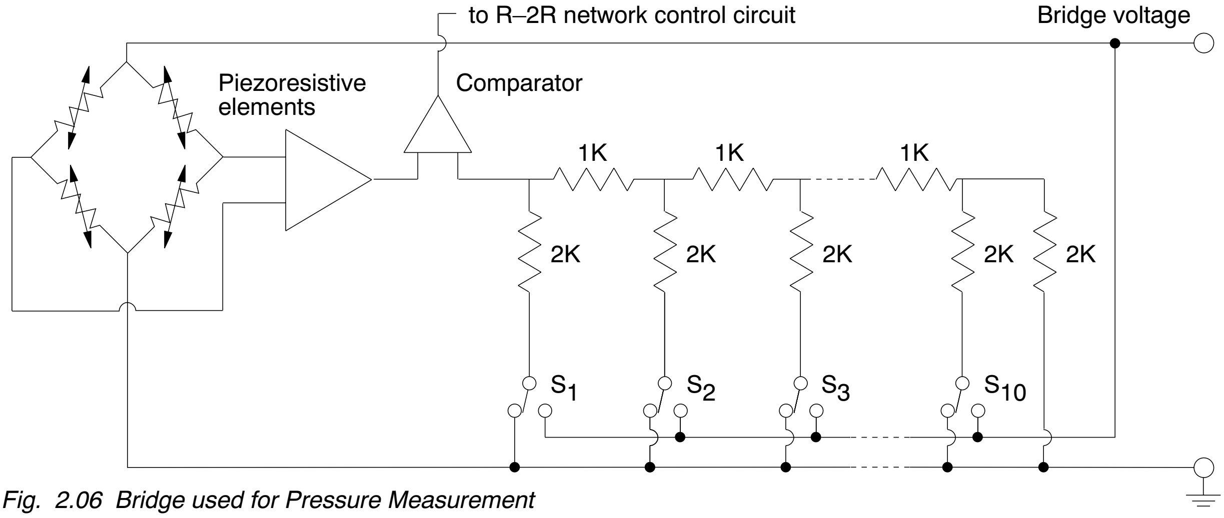


Fig. 2.06 Bridge used for Pressure Measurement

Current Speed and Direction Measurement (channel no. 5 and 6).

Direction Sensor.

The current direction sensor is a magnetic compass placed inside the recording unit, see figure 3.04. A current applied to a coil in the compass will cause the compass magnet to tilt, and a wiper will touch the potentiometer ring. The following circuit is used.

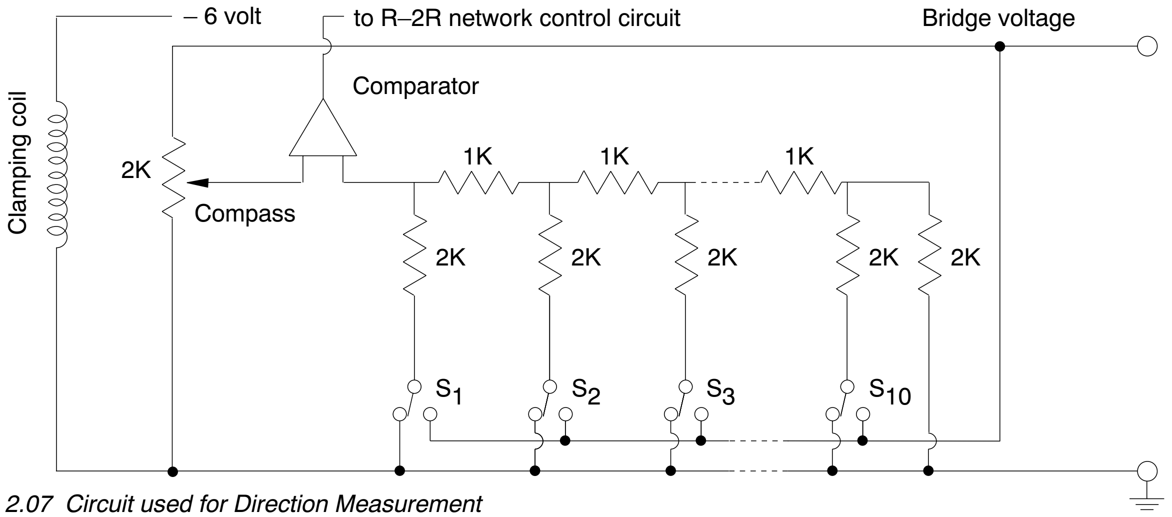


Fig. 2.07 Circuit used for Direction Measurement

Speed Sensor.

The current speed sensor is a rotor with a magnet at its lower end. The revolutions of the rotor are sensed by a Hall element placed in the rotor counter under the top end plate. The speed measurement is digital, while the other measurements are all analog. Every half revolution of the rotor is counted and stored.

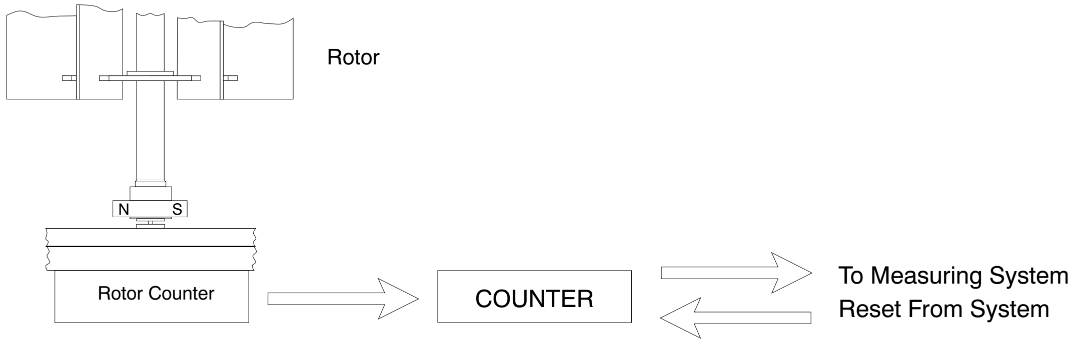
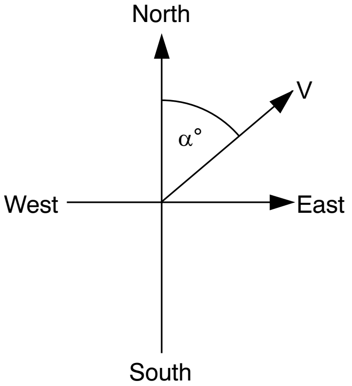


Fig. 2.08 Circuit for counting Rotor Revolutions

Vector averaging of current speed and direction.

During the selected recording interval, the number of rotor revolutions and compass direction are sampled every 12 seconds.*)
The combined data represents a current vector, its magnitude given by the rotor revolutions and its direction by the compass reading. The vector is resolved into two components, East-West and North-South. Successive components are added and intermediately stored. When the selected recording interval has elapsed, the resulting average vector and its angle are calculated and recorded.
*) For recording intervals longer than 10 minutes, speed and direction are sampled 50 times per recording interval, i.e. every 24 seconds for 20 minutes recording interval; every 36 seconds for

30 minutes and so on. For the 120 minutes sampling interval, 100 samples are taken. To reduce the current consumption for reading intervals 20 minutes and subsequent, the sampling rate of the speed and direction can be divided in half by interconnecting terminal 21 and 22.
The calculation of the average vector and its angle is as follows:
The calculation of the average vector and its angle is as follows:



Accumulated North-South components:

$$V_1\cos\alpha_1 + V_2\cos\alpha_2 + \ldots\ldots\ldots\ldots\ldots V_n\cos\alpha_n$$

Accumulated East-West components:

$$V_1\sin\alpha_1 + V_2\sin\alpha_2 + \ldots\ldots\ldots\ldots\ldots V_n\sin\alpha_n$$

V = number of 1/2 revolutions of rotor during each sampling interval.
α = direction of each sample.

Resultant Vector:

$$\sqrt{(\Sigma(V_{1-n}\cos\alpha_{1-n}))^2 + (\Sigma(V_{1-n})\sin\alpha_{1-n}))^2}$$

The angle of the vector:

$$\text{Arc tan}\left(\frac{\Sigma(V_{1-n}\sin\alpha_{1-n})}{\Sigma(V_{1-n}\cos\alpha_{1-n})}\right) = M°$$

The average vector direction measurement is transferred to a 10-bit number (N) and fed out in channel 5:

$$N = (M° - 1)\frac{1023}{358}$$

The raw data value of the vector averaged speed measurements, (N), is fed out in channel 6:

$$N = \frac{\text{resultant vector}}{P}$$

where the overflow protection factor P is a number derived from the used recording interval so that N shall not overflow 1023 at an average maximum speed of up to 300 cm/sec.

$$P = \frac{3}{4} \text{ x (recording interval in minutes)}$$

The formula for calculating direction in degrees magnetic:

Degrees magnetic = A + B x N

where A = 1 (compensation for the 2° dead angle of the compass)

$$B = \frac{358}{1023}$$

The formula for calculating speed in cm/s:

$$cm/s = A + B \times N$$

where A = 1.1 (fixed value worked out from rotor calibration)

$$B = 46.5 \times \frac{1}{2} \times \frac{1}{Int} \times \frac{1}{60} \times P$$

In the above formula the factors denote:

46.5: cm of waterway per rotor revolution

Int: recording interval in minutes

P: overflow protection factor $(\frac{3}{4} \times \text{int})$

Output signals.

The output signals are in the PDC-4 code. It consists of a 10-bit word for each channel. Binary 1 is a short and binary 0 a long pulse. Each word is followed by a space. A set of 6 words makes a record. The end of the record is indicated by a sync pulse. The timing of a record and the PDC-4 coded pulses are given below:

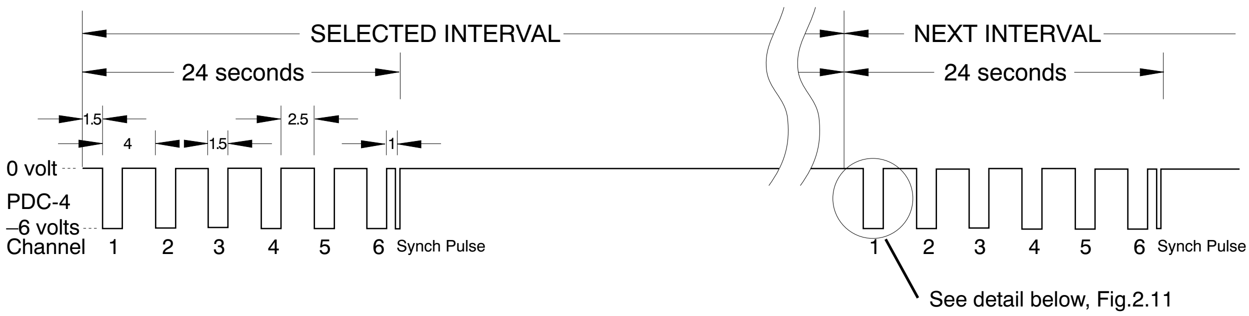


FIG. 2.10 Timing Diagram of one Record – Signal at Terminal 31.

The output pulses shown in the figures are fed simultaneously to the electrical output terminal at the top-end plate, to the acoustic transducer circuit and to the Data Storage Unit (DSU) 2990 where all data is stored in digital form.

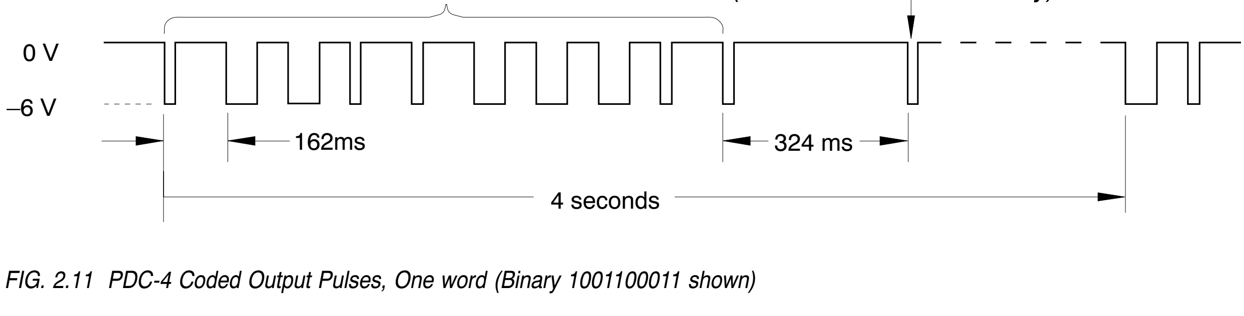


FIG. 2.11 PDC-4 Coded Output Pulses, One word (Binary 1001100011 shown)

CHAPTER THREE

DESCRIPTION OF COMPONENTS AND PARTS.

Pressure case.

The pressure case shown in figure 8.13 consists of an OSNISIL copper alloy tube (95% Cu, 3.5% Ni and 0.9% Si). The lower end plate, made of non-magnetic acid proof stainless steel (57.2% Fe, 17.5% Cr, 12.5% Ni, 2.7% Mo and maximum 0.06% C) is furnished with an O-ring and press fitted to the pressure tube. The lower end of the pressure case is fitted with a rubber base. At the top end of the pressure tube there is machined a circular groove into which the clamps grip, thus holding the top-end plate seated in the pressure case.

The pressure case and all external metal parts of this instrument are furnished with an olive green epoxy coating applied by an electrostatic powder process. This coating performs well in seawater and will protect the covered parts from corrosion. However, the O-ring seats are not epoxy coated but nickel-plated. The corrosion of these surfaces is inhibited by the use of a sacrificial zinc anode fitted to the top end plate.

Top end plate.

The top end plate, made of the same non-magnetic acid proof steel alloy as the bottom end plate, is seen in figure 8.15. All external and internal parts of the instrument are fastened to the top end plate, so that the instrument can be removed from the pressure case as one unit. The sealing between the top end plate and the pressure tube is obtained by an O-ring as seen in figure 8.13.

All top end plates are bored to accommodate optional sensors. When pressure sensors and conductivity cells are not required, sealing plugs 1197 and 2176 respectively are installed. These plug sizes are 10 and 16 mm. The electrical terminal 2924 is fitted to the top end plate and mates with plug 2828A.

Vane assembly.

The vane assembly shown in figure 8.16, ensures that the instrument lines up in the current. It is furnished with a set of balance weights at its lower edge. These balance weights can be adjusted horizontally to obtain static balance of the instrument. The instrument is designed so that both buoyancy and weight forces are symmetrical on each side of the spindle rod, therefore the instrument will be in balance both in air and water. The vane is equipped with a pair of tail fins at its rear edge to ensure that the instrument remains horizontal under all current speeds. The gimbal housing of the vane assembly is equipped with a sacrificial zinc anode to prevent corrosion.

The spindle rod, designed for shackling into the mooring line, is shown in figure 8.17. It is furnished with a set of gimbal rings that will permit the spindle rod to swing up to 27° in all direction. The spherical nylon rollers form a roller bearing that allows the complete instrument to turn freely without twisting the mooring line. Breaking load of the spindle rod is 4000 kg. The vane plate and tail fin are made of PVC. Other parts are made of stainless steel or bronze. These parts are coated with olive green epoxy for protection against corrosion. For additional protection sacrificial zinc anodes are attached to the gimbal housing and to the spindle rod.
Note! Do not attach magnetic material to the lower end of the spindle rod as
this may influence the compass reading (current direction)

Electronic board.

The Electronic Board 3045 shown in figure 8.07 contains the main electronic circuitry of the instrument. It comprises a printed circuit board and screw terminals embedded in a polyurethane casting. This design makes the component a solid board which will not be affected by a harsh environment. The electrical functions of the board can be divided into seven main functions or circuits:

1. Voltage regulator and bridge voltage generator.
2. Multiplexer and sensor input circuits.
3. Comparator and bridge balancing circuits.
4. Control circuits and micro-processor.
5. Circuits for output pulses and remote start.
6. Acoustic Oscillator.
7. Quartz Clock.

The voltage regulators and bridge voltage generator provide all required operating voltages. Ten –3 volt pulses of 25µ-seconds duration are generated for each of the sensor channels and supplied to all channels simultaneously.

The multiplexer switches each of the sensor channels to the comparator and bridge balancing circuit. The micro-processor and control circuit initiate and control the various operations of the board and perform the sampling and vector averaging of the speed and direction sensors, see appendix 2)

The output signal circuit generates the PDC-4 coded output pulses as described on page 2-12. It also initiates triggering of the instrument when a positive pulse of 3 to 6 volts is applied to the output terminal. The pulse should be 50 milliseconds or more.

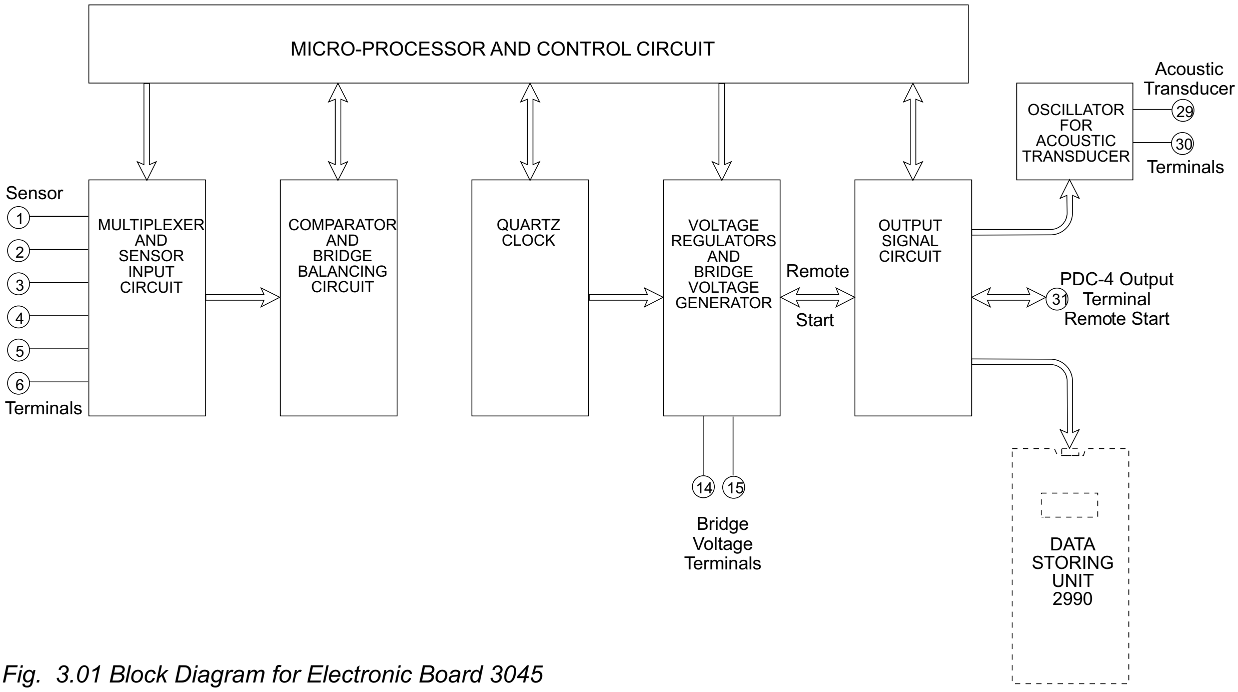


Fig. 3.01 Block Diagram for Electronic Board 3045

The acoustic oscillator is based on a 32768 Hz quartz crystal controlled oscillator operating continuously as long as the measuring cycle sequence is on. A derived signal of 16384 Hz from this oscillator is keyed on and off according to the PDC-4 coded output format and fed to the acoustic transducer terminals 29 and 30.

The quartz clock triggers the instrument at preset intervals. The intervals can be set to 0.5, 1, 2, 5, 10, 20, 30, 60 or 120 minutes by a small rotary switch embedded in the board. The switch has one position “MS” (manual start only) which inhibits triggering of the instrument by the clock. This feature
is useful during calibration or checking of the instrument as it will respond only to the remote start signal or manual start button. A small rotary temperature range selector switch is embedded in the board. Three ranges can be selected; Low, Wide or High. See specifications on page 1-04 for actual ranges in degrees Centigrade.

Data Storage Unit.

The Data Storage Unit (DSU), figure 8.08 is in the form of a solid board molded in low density polyurethane. It contains a set of EEPROMs for storage of data, see appendix [3)]. On its top there is a 6-pin receptacle for the input/output of data. A 5-digit liquid crystal display indicates the total number of data words stored. When reading the data, the display number is counted down, and the display will therefore always shows the number of words left to be read.

The DSU is furnished with a built-in, presetable, real-time quartz clock enabling time information to be recorded. Within a temperature range of –10 to + 45° the accuracy of the clock is ± 2 s/day. A time record consists of six 10-bit words. The first is a fixed binary reading equal to 7, followed by 5 words indicating year, month, day, hour and minute. Time information is recorded for the first measurement taken after the main switch has been turned on, and subsequently every day (24 hours) at the time of the first measurement after midnight. The clock features automatic leap year compensation. The unit can accept up to 65520 individual 10-bit words. When the unit is full, the input port will be blocked to disallow further storage of data.

When the main switch is on the DSU is powered by the instrument's battery. When disconnected a built-in battery (Lithium AA cell, 3.4 volts, 1.9 Ah) provides power for the display and the clock. The power consumption is 30µA, and the battery lasts at least 7 years, see appendix [4). For reading of stored data, setting the real-time clock and erasing data from the DSU, refer to page 5.01.

Rotor and rotor counter switch

The rotor is an Aanderaa type rotor that is furnished with a tungsten carbide pivot in the top end of its shaft and a cup-shaped stone of the same material at the lower end. The bearings consist of a pivot held by a nylon bushing at the lower end and of a cup-shaped stone in an adjustable nylon screw at the upper end, figure 3.02. The rotor shaft is furnished with a ring-shaped

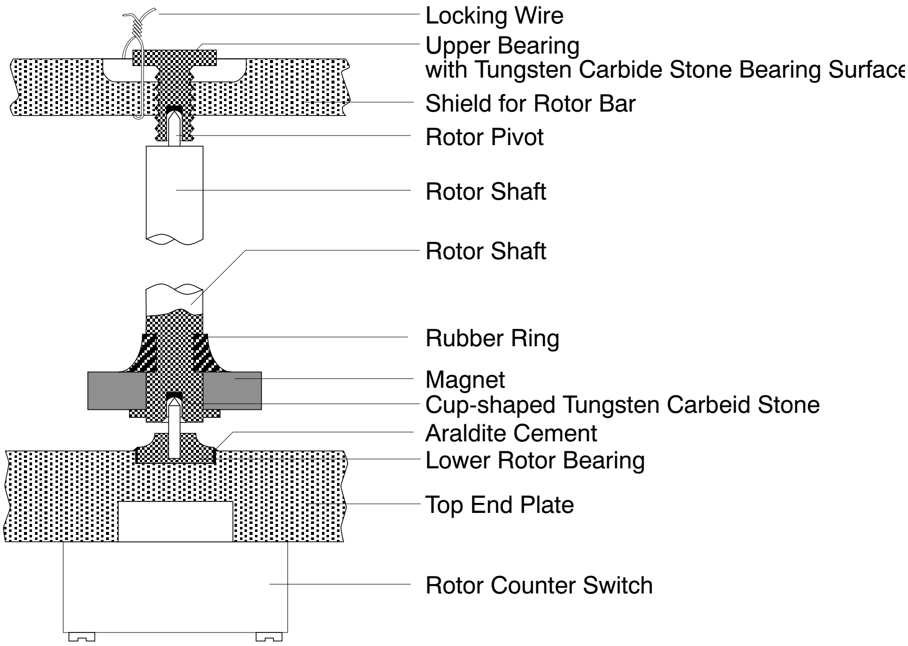


Fig. 3.02 Cross Section of Rotor Bearings

ceramic magnet at its lower end. As the magnet rotates, its field changes the magnetic resistor balance, thus generating two pulses for each revolution of the rotor.

Pressure sensor.

The sensing element in Pressure Sensor 3239A is the Sensonor Sensor SP81. The sensing element in the Pressure Sensors 3239B,C,D and E is the STS Model TD-15. These piezoresistive sensing elements features excellent stability and reliability. The sensing element is fitted into an acid-proof steel arm which is fastened to the top end plate of the RCM. The arm extends into the water and is exposed to the water pressure at its upper end. At the lower end the electronics that

interfaces the sensing element to Electronic Board 3045 are fastened to the arm. The electronics are molded in polyurethane. To prevent internal corrosion, the sensor tube is filled with silicone oil.
Several pressure ranges are available, 0-700 kPa, 0-3500 kPa, 0-7000 kPa, 0-14MPa, 0-20MPa, 0-35MPa and 0-60MPa for RCM 8. If an instrument with a pressure sensor is used at greater depth than the stated range, the sensor must be removed or sealed with a pressure stopper (Swagelok plug). If the sensor is not installed, Sealing Plug 1197 replaces it (refer also to note on page 3-09).

Temperature sensor.
The temperature sensing thermistor is housed in a stainless steel stud, figure 8.11, fitted on the top end plate and extending into the water. The thermistor, Fenwall GB 32JM19, is molded into the stud with polyurethane. The time constant for the temperature to reach 63% of a step change in temperature is about 12 seconds.
The reading N is a function of the thermistor resistance R as well as the chosen WR4 and the range reducing resistors, see figure 2.03:

Low and high range: $N = \left(\frac{WR4}{WR4 + R} - \frac{3}{8}\right) 4 \times 1023$

Wide range: $N = \left(\frac{WR4}{WR4 + \frac{R \times 10000}{R + 10000}} - \frac{3}{8}\right) \times 1023$

When Fenwal's data over nominal thermistor resistance versus temperature is inserted in the above formulas, the following tables can be calculated:

HIGH RANGE 10.08 to + 36.04°C. WR4 = 2200Ω , ± 0.1%

Temp.°C	10.08	11	12	13	14	15	16	17	18	19	20	21	22	
Calculated Reading N	0	37.25	78.16	119.19	160.32	201.47	242.66	283.83	324.92	265.94	406.84	447.57	488.1	

Temp.°C	23	24	25	26	27	28	29	30	31	32	33	34	35	36.04
Calculated Reading N	528.51	568.61	608.41	647.95	687.10	725.98	764.43	802.51	840.11	877.39	914.06	950.36	986.12	1023

LOW RANGE —2.46 to + 21.48°C. WR4 = 3825Ω, ± 0.1%

Temp.°C	–2.46	–2	–1	0	1	2	3	4	5	6	7	8	9	
Calculated Reading N	0	20.31	64.44	108.74	153.14	197.65	242.16	286.56	331.10	375.43	419.64	463.67	507.46	

Temp.°C	10	11	12	13	14	15	16	17	18	19	20	21	21.48	
Calculated Reading N	551.00	594.25	637.17	679.72	721.88	763.59	804.88	845.69	885.95	925.71	964.92	1003.54	1023	

WIDE RANGE —0.34 to + 32.17°C. WR4 = 2200Ω, ± 0.1% WR11 = 10000Ω, ± 0.1%

Temp.°C	0.34	0	2	4	6	8	10	12	14	16	18	20	22	
Calculated Reading N	0	9.49	65.68	123.61	183.16	244.19	306.43	369.78	434.00	498.86	564.18	629.74	695.32	

Temp.°C	24	26	28	30	32.17									
Calculated Reading N	0	760.74	825.74	890.17	953.82	1023								

In these tables readings are calculated with two decimals for interpolation purposes. As readings will be integer numbers, the actual reading will be the nearest integer.

For special application in arctic cold water a high resolution temperature range, –2.5 to + 5.6°C is available, giving a resolution of 0.008°C. This additional temperature measurement must take place in channel 4 which is normally used for pressure measurements. To obtain this special temperature range, pressure measurement must be sacrificed or placed in channel 2. (Consult Factory). Also, terminals 2 and 4 as well as 23 and 24 on the electronic board must be inter-connected. On instruments without a pressure sensor, the jumper between terminals 4 and 14 must be removed. The temperature range selector switch must be in position 1. A resistor, WR2B of 720Ω, must then be connected between terminals 34 and 14b, and another resistor, WR3B of 500Ω, between terminals 34 and 15b.

Low range configuration of the thermistor is used. The bridge is essentially as before. The resistors WR2B and WR3B limit the scanning range of the bridge to 3% of the bridge voltage.

In this case the reading, N, is given by the expression:

$$N = \left(\frac{WR4 \text{ x } 3000}{WR3B \text{ x } (WR4 + R)} + \frac{WR2B \text{ x } WR4 - R \text{ x } 3000}{WR2B \text{ x } (WR4 + R)} \right) \text{X } 1023$$

which gives the following tabulated relationship:

ARCTIC RANGE –2.64 to + 5.62°C

Temp.°C	–2.64	–2.5	–2.0	–1.5	–1.0	–0.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0	
Calculated Reading N	0	16.6	78.1	139.6	201.3	263.1	324.9	386.9	448.9	511	573.1	635.2	697.4	

Temp.°C	3.5	4.0	4.5	5.0	5.5	5.62								
Calculated Reading N	759.4	821.6	883.6	945.7	1007.6	1023								

The Iso curve thermistors are equal to within ± 0.1°C and the following nominal formula for the different ranges are calculated and are accurate to ± 0.15°C:

High: $T = 10.08 + 0.02464 \times N - 0.1549 \times 10^{-5} \times N^2 + 0.2214 \times 10^{-8} \times N^3$

Low: $T = -2.462 + 0.02277 \times N - 0.1344 \times 10^{-5} \times N^2 + 0.1937 \times 10^{-8} \times N^3$

Wide: $T = -0.3221 + 0.03587 \times N - 0.8388 \times 10^{-5} \times N^2 + 0.43 \times 10^{-8} \times N^3$

Arctic: $T = -2.635 + 8.154 \times 10^{-3} \times N - 1.601 \times 10^{-7} \times N^2 + 7.991 \times 10^{-11} \times N^3$

A formula derived from the calibration of the instrument prior to shipment will accompany the instrument. The accuracy of the calibration formula is 0.05°C.

Conductivity cell.

The conductivity cell, figure 3.03 and 8.12, is based on 2 tape wound toroids (Magnetic Metals, P/N 380µ 8602) with a common sea-water loop. As the signal induced in the secondary is very low, the conductivity cell is furnished with an amplifier built into the stem of the cell.

The toroids with their windings are embedded in polyurethane resin. In order to obtain a stable volume of the sea water loop, a glass tube is installed in the bore hole of the cell.

As the geometry of the cell's surroundings may affect the cell calibration, calibration should always be done with a cell and a rotor fitted onto an instrument. Small scars in the epoxy coating of parts near the cell may also affect the calibration. Therefore, such scars should be repaired by using a repair lacquer. A tin can with 50 grams of repair lacquer, part no 2579 is available. When the cell is not inserted, it is replaced by Sealing Plug 2176. The cell should always be installed with Type No/Serial No facing outwards. Refer also to note on page 3-10.

The total range of conductivity is determined by resistor WR5 only, see figure 2-04.

$$\text{Range mmho/cm} = \frac{1000}{WR5 + 1000} \times 90.5 \qquad (WR5 \text{ in } \Omega)$$

The factor 90.5 (Conductivity Cell 2994) depends on the geometry of the cell. The factor of individual cells is the same within ± 1%.

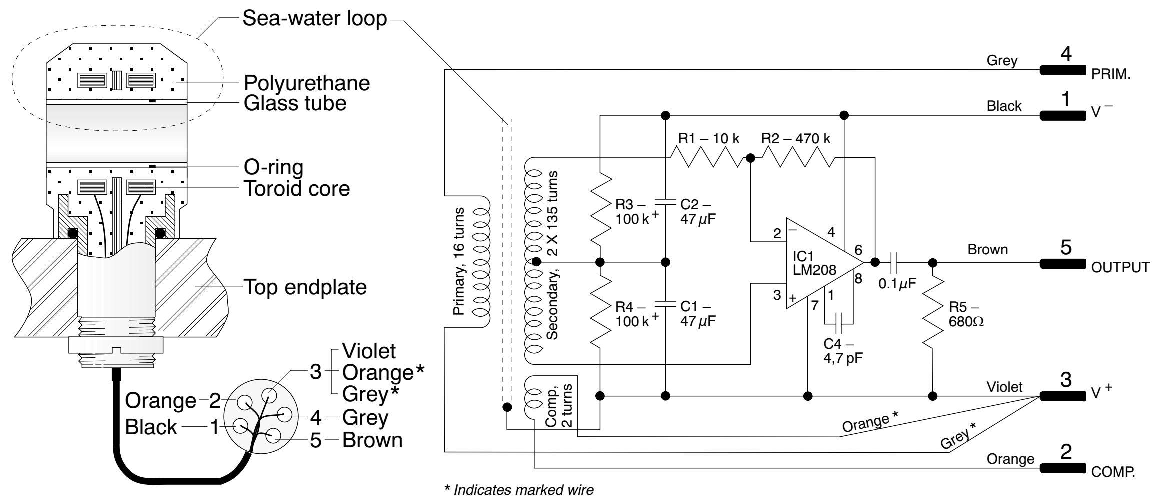


Fig. 3.03 Conductivity Cell 2994 Cross Section and Circuit Diagram

The lower point of the conductivity range is determined by resistor WR6 only, and is:

$$\frac{1000}{WR6} \times 95.5 \text{ mmho/cm} \qquad \text{(WR6 in } \Omega\text{)}$$

Example:	WR5 = 220Ω and WR6 = infinite (open)	Range: 0 to 74 mmho/cm
	WR5 = 1000Ω and WR6 = 3825Ω	Range: 24 to 68 mmho/cm
	WR5 = 6000Ω and WR6 = 3825Ω	Range: 24 to 36 mmho/cm

Compass.

The compass 1248 seen in figure 3.04 is read by applying a voltage of 6 volts to a built-in clamping coil through the terminals A and B. The clamping current is 15 mA.

The magnet assembly of the compass is normally free to swing on a conductive pivot connected to terminal 3. The bearing of the assembly consists of a cup-shaped Tungsten Carbide stone that is also conductive. When a clamping current is applied, the magnet assembly will tilt and cause a wiper to make contact with a potentiometer ring in the lid of the compass. Thereby the com-

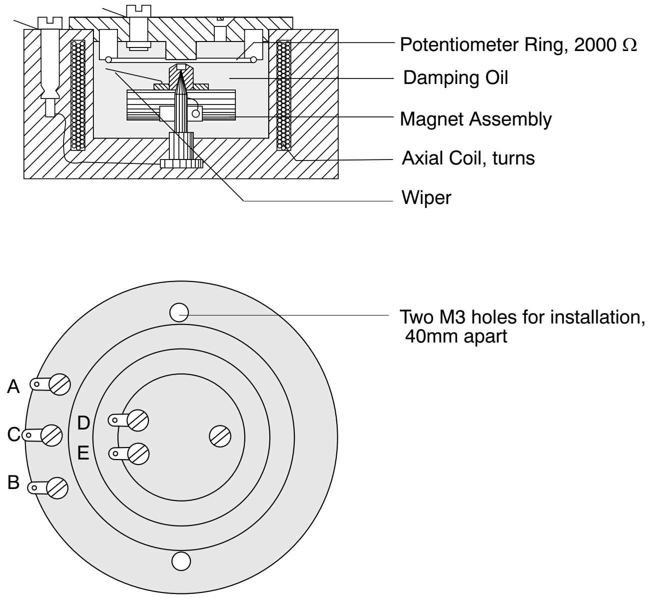


Fig. 3.04 Compass 1248

pass bearing can be read as a potentiometer setting. The potentiometer winding is accessible through terminals D and E. The compass can tolerate a tilt of about 12 degrees before the magnet assembly is jammed. If the compass suddenly is turned 90 degrees, it will take about 3.5 seconds before it gives true readings again.

As there may be small individual variations in the angle of the potentiometer ring relative to the fixed holes, the frame end plate of the instrument to which the compass is fastened, is furnished with oval holes so that the compass can be adjusted during calibration at the factory to give true readings for various directions of the instruments vane. Page 3-12

Acoustic transducer.

The design of the transducer is seen in figure 8.10. It is based upon a Channel Industries piezo-electric sphere ceramic part no. 390065, protected from the sea-water by a polyurethane molding. A small tuneable transformer is placed in the base of the transducer. The inductance of the secondary coil of this transducer will, together with the capacitance of the ceramic, form a resonating circuit resonating at 16384 Hz. Small individual variations of the capacitance of the ceramic is compensated for by adjusting the trimmer of the transformer which is accessible through the stem of the transducer. The transducer is aged at the factory and retrimming is seldom necessary. The capacitance temperature coefficient of the ceramic is sufficiently low as to allow the transducer to operate efficiently within the temperature range of 0 — 30°C.

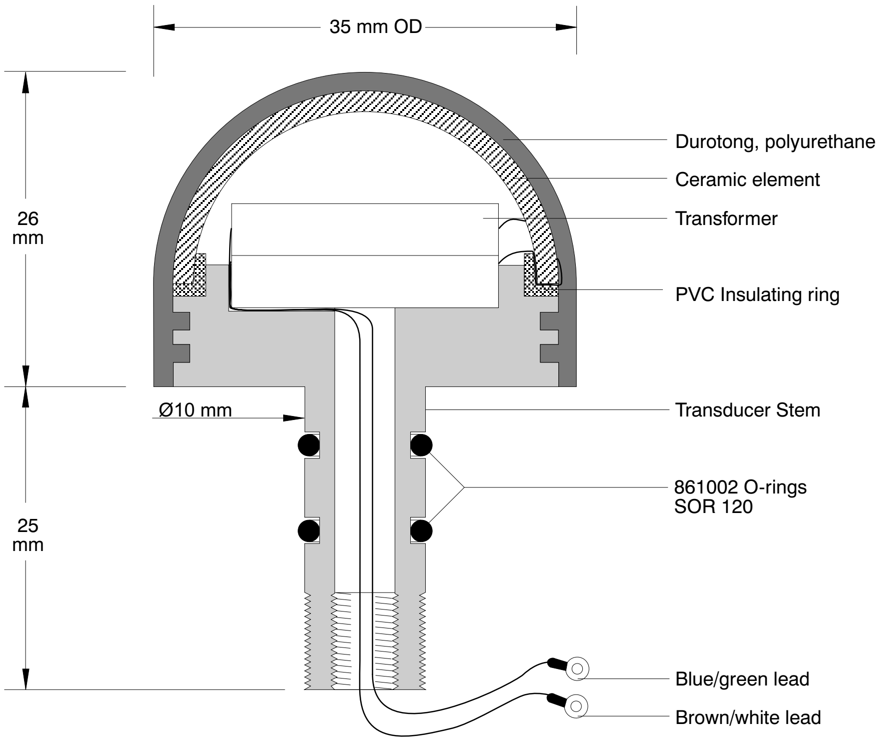


Fig. 3.05 Acoustic Transducer 3468

CHAPTER FOUR

OPERATING INSTRUCTIONS

Receiving a new instrument and taking it into use.

The instrument is shipped in 2 cases, see figures 8.05 and 8.06. The vane assembly consists of 3 main parts, the vane plate with balance weights, the gimbal housing and the tail fins. These parts are assembled as shown in figure 8.01. The necessary preparation is to attach the tail fins to the vane as shown in the figure.

The recording unit is equipped with batteries when shipped and the DSU clock is set to GMT. The only preparation needed is to check that the time interval switch is set to the desired interval, and to switch on the main switch. Before doing this, it is recommended that the unit be checked for possible shipping damage. This check can best be performed by following the procedure given in the check-out list, Form No. 303, see figure 8.20.

If the unit passes the check-out procedure, the instrument should be prepared for deployment as follows:

1) Open the recording unit by unscrewing the 2 C-clamps at the top end plate and lift the unit out of the pressure case.
2) Set the time interval switch to the desired interval.
3) Check that the temperature range selector switch is in the desired position.
4) Switch on the main switch, the instrument immediately starts, and the DSU records time information and 1 measurement cycle of the 6 channels. The LCD display of the DSU will show 00012 (6 words for the time information and 6 for sensor channels). The quartz clock in the DSU is set to GMT at the factory.
5) Put the instrument back into the pressure case and tighten the C-clamps until the top end plate rests against the edge of the pressure case. Avoid overtightening as this will damage the o-ring and C-clamp.
6) Ensure that a protective cap is fitted to the electrical terminal.

The recording unit is now ready to be fastened to the vane assembly and be deployed. Any recording unit can be used with any vane assembly. The balance of the instrument can be checked by hanging the instrument by the spindle rod. The unit should then hang with the vane in a horizontal position. If necessary, adjust balance by loosening the fastening screws of the balance weights and sliding the weights forwards or backwards as needed and then retighten the screws. The instrument will balance equally in air and water.

Retrieval of instrument and removing DSU.

When an instrument is retrieved after a period of recording, it should first be rinsed in fresh water. The unit can then be opened. After opening, the following procedure must be carried out (read the whole procedure before stopping the instrument):

1) Wait until the clock triggers the instrument and until the instrument has finished the recording cycle (observe the DSU display).

2) Write the time of last record on the label.

3) Turn off the main switch.

4) Remove the DSU from the recording unit by releasing the 2 snap-on locks at the lower end of the instrument, pulling out and then pressing down the DSU to release it from the connector on the top. Refer to chapter 5 for reading of the DSU.

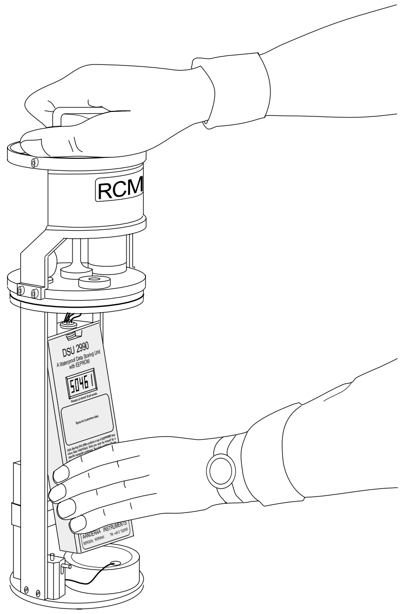


Fig. 4.01 Installation/Removal of DSU 2990

Comments on Check-out list.

Rotor threshold check.
This check can best be done by walking at normal speed carrying the recording unit in one hand with the handle parallel to the direction of movement. If the rotor turns, the threshold speed is normal.

Conductivity Cell test.
Can best be done with the Resistor Set 2653 as a sea-water loop. This set is supplied with the instrument and contains, embedded in a casting, one 100Ω and one 1000Ω resistor and are valid for the range 0 – 74 mmho/cm. The correct readings of the cell with these 2 loops is shown in the calibration sheet accompany the instrument. For the range 24 – 68 mmho use 2653A, 50 and 100 ohms. For the range 24 – 36 mmho use 2653B, 82,5 and 110 ohms.

Acoustic Oscillator test.
The test can be done in several ways. If a hydrophone receiver is available, the test can be done in air by monitoring whether correct data is received over a 6 meter distance.

Testing the Compass Function.

Note!

When testing the compass function, it is practical to inhibit the vector averaging process of RCM 7. This is done by interconnecting terminals 20 and 22 with a wire strap. When these two terminals are connected, the compass will be read momentarily once the instrument is triggered, whether by the built-in clock or manually. The channel 5 output is as described in chapter 2 (page 2-09).

The number of rotor revolutions is sampled every 60 seconds. When 0.5 minute sampling interval is used, the sample is taken at the end of each interval. The following formula is used for calculating speed in cm/s:

Speed (cm/s) = A + B x N, where

A = 1.1 (fixed value worked out from rotor calibration)

B= 46.5 x 1/2 x 1/INT x 1/60 x P

P= The overflow protection factor (3/4 x INT)

In the above formula.:

46.5: cm of waterway per rotor revolution INT: recording interval in minutes

(The value of B = 0.290625 if the sampling interval is set to 10 minutes.)

When the interval switch is in the position "MS" (manual start), the output value corresponds to the total number of half revolutions of the rotor from one triggering to the next.5)

Fresh battery.

Recommended battery is Lithium Battery 7.2V, 14 Ah, part no. 3382. Other types of batteries may be used provided they are non-magnetic. The battery capacity will allow storage of a full DSU 2990 (65500 words) at all available sampling intervals.

The table below will show how much data the battery is able to store in an RCM 7/8 using the expanded DSU 2990E (at 0°C).

DSU 2990E and Lithium Battery 3382, 7.2V, 10-14 Ah (Depending on type of load)

Interval	0.5 min	1 min	2 min	5 min	10 min	20 min	30 min	60 min	120 min
Words	262100	262100	262100	262100	185000	167100	153000	123600	75000
Days	15	30	60	148	214	386	531	858	1041

When installing a battery always check that battery terminals are well seated and give good contact.

CHAPTER FIVE

READING OF DSU AND DATA PROCESSING

Stored data is read by connecting the Data Storage Unit (DSU) 2990 via a DSU Reader 2995, to the RS-232C port of a computer, see figure 5.01. A suitable program must control the read-out process. The operating manual for the DSU Reader, Technical Description No. 145, provides the user with sufficient information to write his own read-out program.
The DSU Reader 2995 converts the 0 to -5V serial signals associated with the DSU to dual-polarity signals in accordance with the RS-232C standard. In addition it supplies the -6V control voltage for powering the DSU during the read-out process. The DSU is connected to the DSU Reader 2995 by a standard Connecting Cable 2842C. A computer interfacing cable, 3016C, with a 6-pin 2828 Plug at one end and a 9-pin D-connector at the other, connects the DSU Reader to the PC’s serial input port.

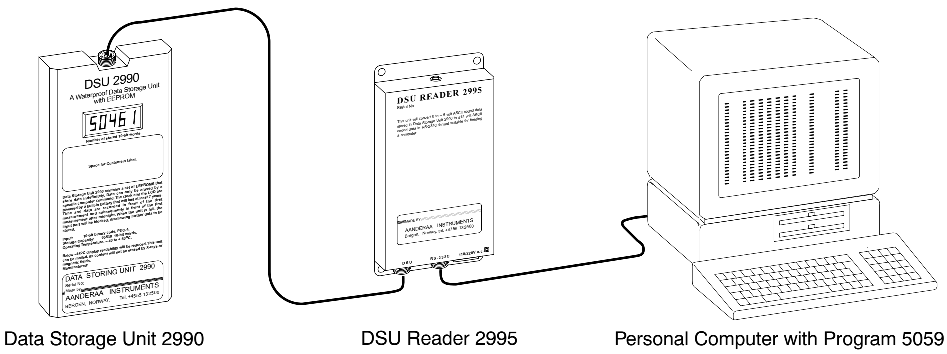


FIG. 5.01 Data Reading

The DSU will examine bytes received from the computer and execute the command routines. In case of an invalid command, it will return to the stand-by mode. Altogether eleven command codes are valid for communication with the DSU. Beside the commands for controlling the data read-out, which will not erase the stored data, commands are also given for display and setting the real-time clock and for erasing the content of the DSU. With the exception of the ‘ERASE’ commands, all commands are single characters.

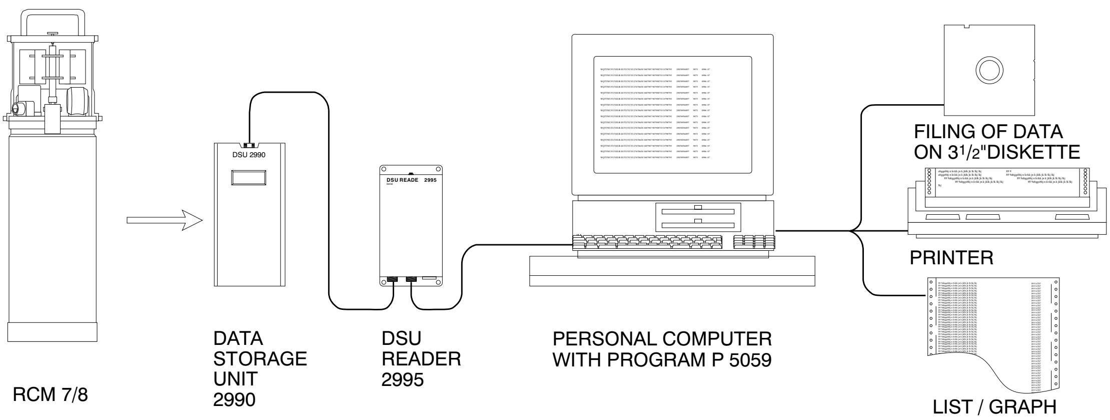


FIG. 5.02 Data Reading System

Data Reading Program 5059

The Data Reading Program DRP 5059 is a totally new Win32 based program, designed using the most modern software technology presently available. Emphasized has been put on ease of use together with versatile, graphical user interface and system flexibility.
Minimum requirements are:
Pentium 166 Processor (recommended), 16MB RAM for Windows 95 and 98, 32MB RAM for Windows NT, 10MB Hard Disk. It can be used with Windows ©95, build 1111, Windows ©98 and Windows NT™ Sp3. The program replaces the Data Reading Program 4059. The program will not work with Windows 3.1 or 3.11, and customers working in these environments should still use the 4059 program.
It is a component based program, built using a large set of independent binary components that become a part of your operating system instead of building the application into one huge executable file. As such, each component becomes available to any application that can make use of it.
The advantage of using this technique is that only one copy of the component resides on your disk although several applications may use it. This yields less chance for bugs or errors and it improves productivity through reuse of programming effort. An example of such a component is the AAICOMServer used to set up the serial (COM) ports and download the DSU. Used in the Display Program 3710, it has proven its reliability. Perhaps the most important feature is the possibility to design your own custom analysis tool components. The DRP 5059 incorporates a special hook-in mechanism for ActiveX components. The hook-in interface provides your ActiveX component with access to the database and to a window in which you can show the analysis result.
In most cases, you will probably be satisfied with the tools shipped with the program from the factory. These tools comprise graphing features, statistical analysis and signal analysis. Analyze the exported ASCII files from the database in other products such as Microsoft Excel.
The Data Reading Program 5059 is a multi-document application. A document always links to a measurement session. A measurement session usually consists of the data that is stored in a single Data Storage Unit (DSU).
A DSU connects to a document via a COM port. Several documents can open at the same time. Each document uses a separate COM port, so to work with two DSUs at the same time, two COM ports must be available.
The COM port is, however only needed during the actual DSU download (reading) session and not while working with a previously downloaded DSU file or an imported ASCII file.
The Data Reading Program 5059 is a new, multifunction handling and data processing program. It contains:
A Template Library of standard instruments, stations and sensors from Aanderaa Instruments, a Custom Library to store customers' own product specifications and a Tooling section for different data handling functions as well as a faster data transfer mode. Two sample *.dsu files, located in the samples directory, allows for experimenting with the program without having to download a DSU item.

To download a complete version of the Data Reading Program 5059, see our web pages on the internet. The program grants a 30 day trial period during which time all functionality is available.
After the trial period the program reverts into a non- licensed, limited capability version. By purchasing a license key from the manufacturer, or one of our representatives, the full functionality will be retained. The size of this file is 3253KB

CHAPTER SIX

CALIBRATION

General.

Each RCM 7/8 is calibrated at the factory prior to shipment. Normally it does not have to be re-calibrated for several years unless changes have been made to the instrument, i.e. replacement of defective sensors or change of sensor range. However, to ensure maximum accuracy, the calibration should be checked once a year.

The calibration procedures described in this chapter are those in use by the manufacturer. During calibration, instruments are connected to a printer through the electrical terminal on the top end plate for direct read-out of the measured parameters.

The relationship between sensor raw data readings (N) and the various quantities in physical units, is given as a power series of third degree. For some users and some applications, a simpler, linear relation would be preferable. The coefficients A, B, C and D of the power series is therefore given in a form that also covers the best linear fit to the sensor characteristic.

$$A + B \times N + C \times N^2 + D \times N^3$$

Temperature.

The ISO-curve type thermistor used in this sensor has well defined characteristics where the coefficients C and D make no significant difference to the individual sensor. Thus factory calibration of individual sensors is restricted to measurements at two different temperatures from which the values of A and B are calculated.

These measurements are performed with the instruments immersed in a temperature stabilized bath which is stirred to avoid temperature gradients. The temperature is measured by a platina thermometer (Automatic Systems Laboratories, model F25) which is frequently checked against an Equiphase Cell*, *Trademark of Trans-sonic, Inc., Burlington, Massachusetts,* establishing the triple point of water (0.0098 °C).
During calibration, the instrument must be allowed sufficient time for proper temperature stabilization. This is indicated by a steady temperature reading for about four or five samples (2 minute sampling interval).

Pressure.

The pressure sensor is a linear sensor. Calibration is performed using deadweight testers covering the range 0 to 600 kg/cm2. Several readings are taken throughout the range (7-11 points). Two of these are used for the calculation of the coefficients A and B. The other readings serve as check points. The sensor is only accepted if all the readings are within the accuracy limits as compared to the linear characteristic.

Current direction.

The compass calibration is no actual calibration as the coefficients given in the calibration formula are fixed, but a checking procedure to ensure that the compass readings are within the limits of tolerance (± 5°). The readings are checked for every 15th degree magnetic, and the compass is then adjusted (turned) so that the error in reading extends equally to either side of the nominal calibration curve. During this adjustment procedure the vector-averaging function is inhibited by strapping the terminals 20 and 22 on the electronic board.

Current speed.

The calibration of the current speed sensor depends mainly on the rotor geometry, and as there is practically no difference between individual rotors, the need for individual calibration is regarded unnecessary. To ensure threshold is below specified maximum, the following check is carried out; A thin cord is hung over a polished 3 mm diameter pin and attached to a weight of 1.35 g, see figure 6.01. The force of this weight should be sufficient to start the rotor, and the test should

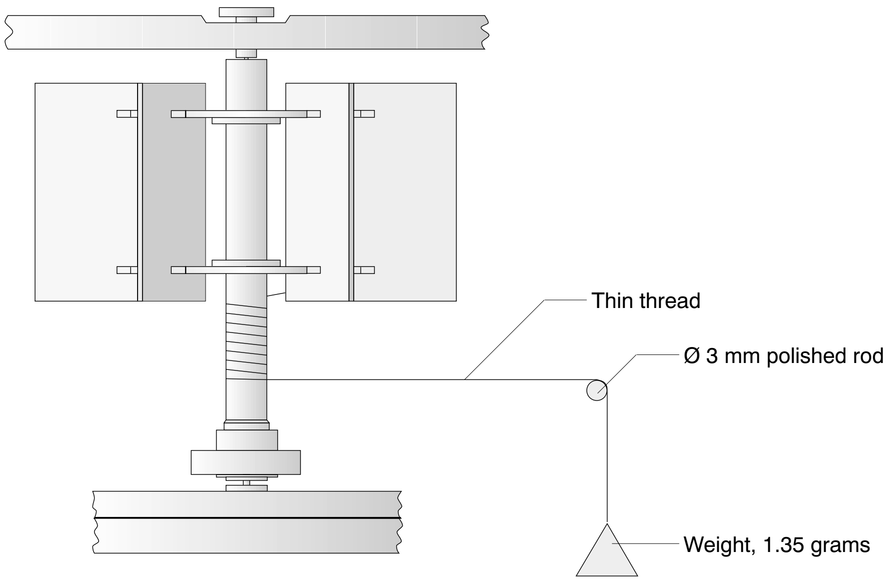


Fig. 6.01 Rotor Threshold Check

be carried out for several points on one revolution of the rotor. If the force is insufficient to start the rotor at any point, action should be taken to eliminate the cause. This check will indicate that threshold speed is below the specified maximum of 2.0 cm/s.

Conductivity.

The conductivity cell is best calibrated using a sea-water bath of known conductivity.

Calibration at the factory is performed by the use of a reference conductivity cell, which has a measuring range of 15 mS/cm. The reading of this cell is used to calculate the conductivity of the bath (the reference cell is checked once a year against water samples).

A quick check of the cell performance can be done by using a "sea-water loop" through the bore of the cell. "Sea-water loops" of 100 and 1000 ohms are supplied with the instrument and the readings with these loops in the bore of the cell are given in the calibration sheet accompanying the instrument.

CALCULATION OF SALINITY

The 5059 DSU reader software will calculate the salinity in a seperate virtual channel. The salinity calculations will appear in the engineering units file as a seperate column. The formula used is presented below :

Input parameters

* CND : Conductivity : [mS/cm].
* T : Temperature : [°C]. (ref. IPTS-68).
* P : Presssure : [dbar].

Output parameters

* Sal : Salinity : [PPT] (ref PSS-78)

Functions

$R_{T35}(T) = ((((1.0031E-9)\cdot T-6.9698E-7)\cdot T+1.104259E-4)\cdot T+2.00564E-2)\cdot T+0.6766097$

$C(P) = (((3.989E-15)\cdot P-6.370E-10)\cdot P+2.070E-5)\cdot P$

$B(T) = ((4.464E-4)\cdot T+3.426E-2)\cdot T+1$

$A(T) = -(3.107E-3)\cdot T+0.4215$

Formulas

D T = T - 15

$$R = \frac{CND}{42.914 mS/cm}$$

R=1 when T=15°C, P=0, Sal=35PPT

(Conversion from conductivity in mS/cm to relative conductivity R)

$$RT = \sqrt{\frac{R}{R_{T35}\cdot\left(1+\frac{C}{A\cdot R+B}\right)}}$$

$$Sal = ((((2.7081\cdot R_T - 7.0261)\cdot R_T+14.0941)\cdot R_T+25.3851)\cdot R_T-0.1692)\cdot R_T+0.0080+$$
$$\left(\frac{\Delta T}{1+0.0162\cdot\Delta T}\right)\cdot(((((0.0636-0.0144\cdot R_T)\cdot R_T-0.0375)\cdot R_T-0.0066)\cdot R_T-0.0056)\cdot(R_T+0.0005)$$

REFERENCES :

Also located in Unesco report No. 37 1981 practical salinity scale 1978 : E.L. Lewis IEEE Ocean eng. Jan 1980.

CHAPTER SEVEN

MAINTENANCE

General.

The RCM 7 requires a minimum of maintenance. Apart from keeping the outside of the instrument clean, changing worn bearings, zinc anodes and corroded parts, only the following yearly maintenance is required:

Yearly maintenance.

1) Refill silicone oil in the pressure sensor (when fitted) by use of a hypodermic syringe. Use silicone oil of 60000 centistoke e.g. Dow Corning Silicone Oil DC200, Aanderaa part no 260017.

2) Change lower rotor bearing (pivot) if worn. Refer to rotor threshold check in chapter six. The lower rotor bearing rests in a 2 mm deep recess at the center of the top end plate. It can be removed with a pair of pliers. The new bearing should be fastened with Araldite glue after cleaning the recess.

3) Corroded parts should be replaced by new when necessary. Always fill crevices between metal surfaces and threaded screw holes with Tectyl 506 to avoid crevice corrosion.

4) Check or re-calibrate according to the recommendations given in chapter six of this manual.

The manufacturer always keeps a stock of spare parts, accessories and comsumable parts for quick delivery. Orders may be placed by telex, telefax, telephone or by mail.

Replacement of parts.

All parts of the instrument are uniformly made, a feature that allows change of parts without influencing the calibration or performance, e.g. if a failure should occur in the electronic board, a new board can be ordered and installed without any adjustments or re-calibration of the sensors. In the same way, calibration for a sensor is valid regardless of which current meter it is installed in. This allows for factory supply of calibrated sensors for installation by the customer.

Factory service.

Factory service is offered for maintenance, repair or calibration of instruments or parts. When returning instruments or parts for service, use the "Instrument Service Order" form no 135. Normal turn-around time is four weeks, but on request the service department will make every possible effort to meet customers´ requirements.

CHAPTER EIGHT

ILLUSTRATIONS

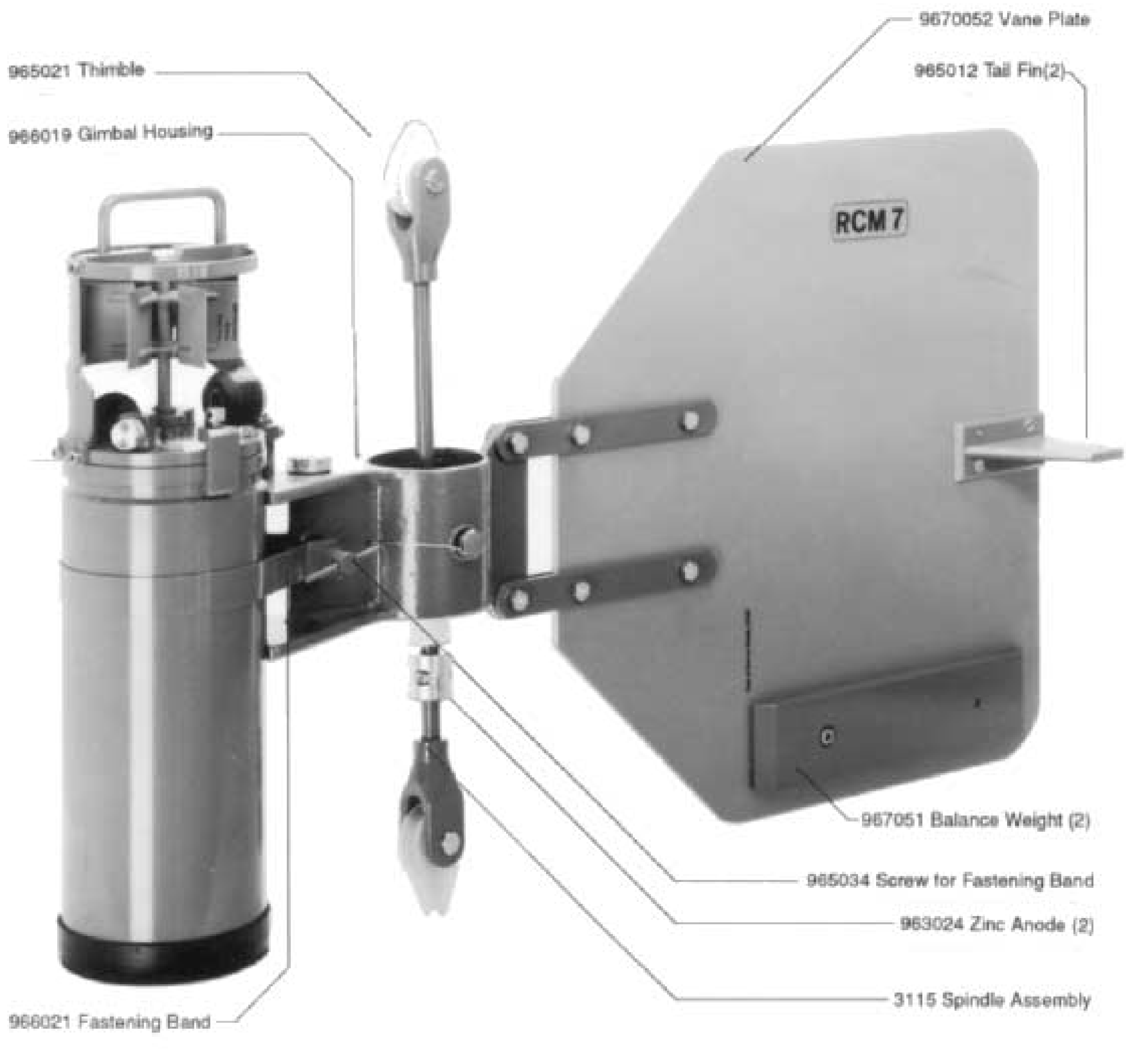


Fig. 8.01 Assembled Current Meter RCM 7

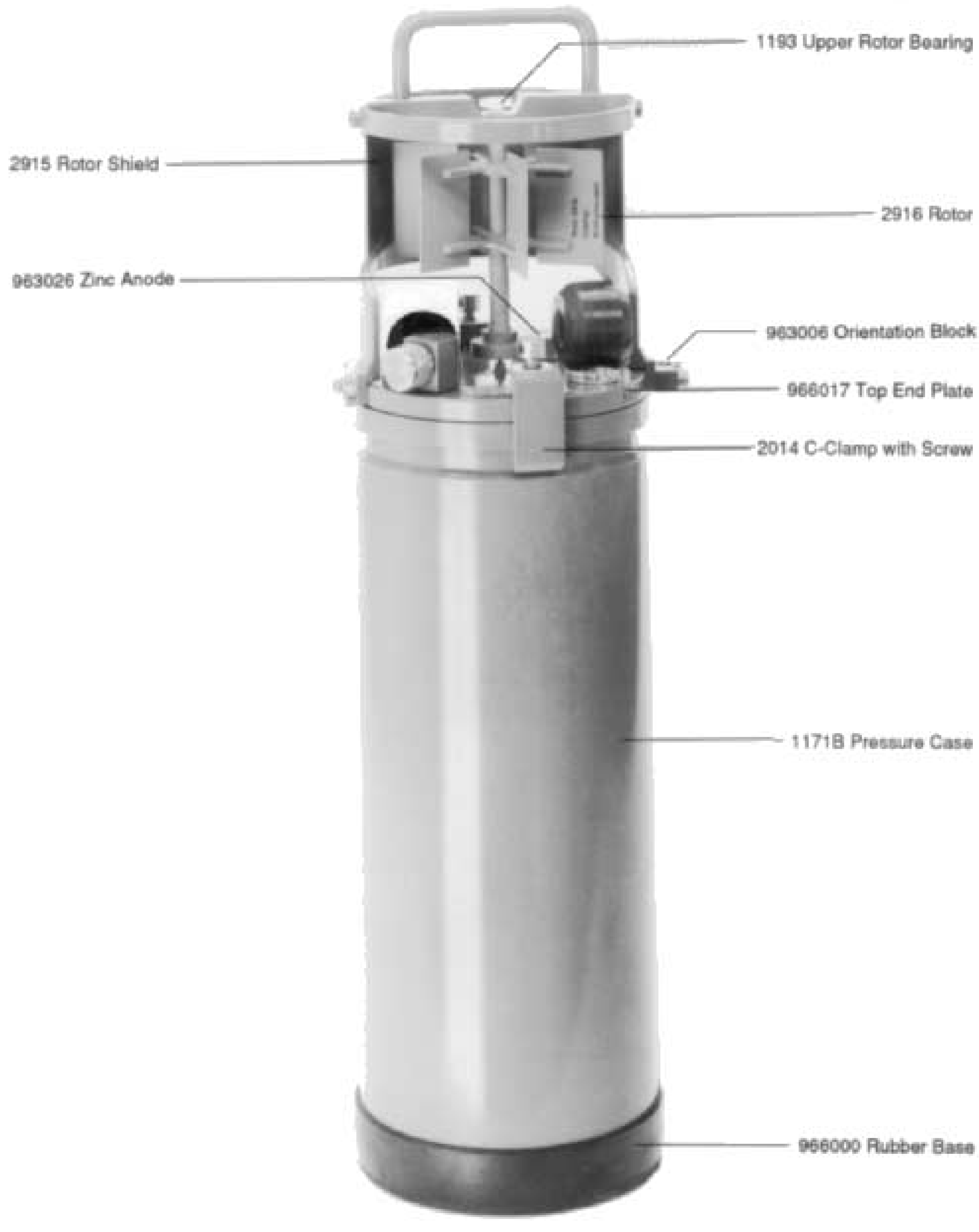


Fig. 8.02 Recording Unit RCM 7

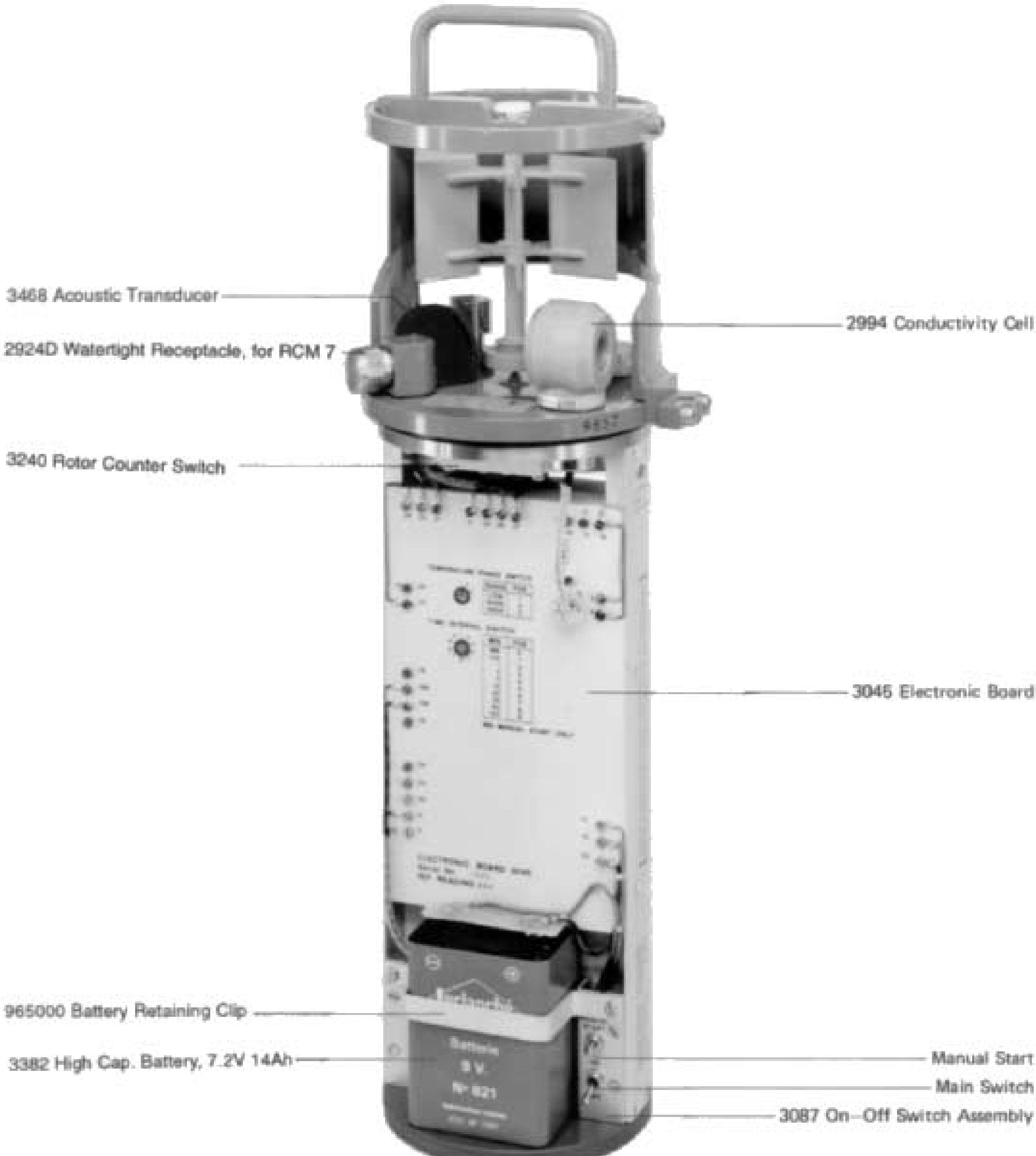


Fig. 8.03 Recording Unit, Electronic Board Side

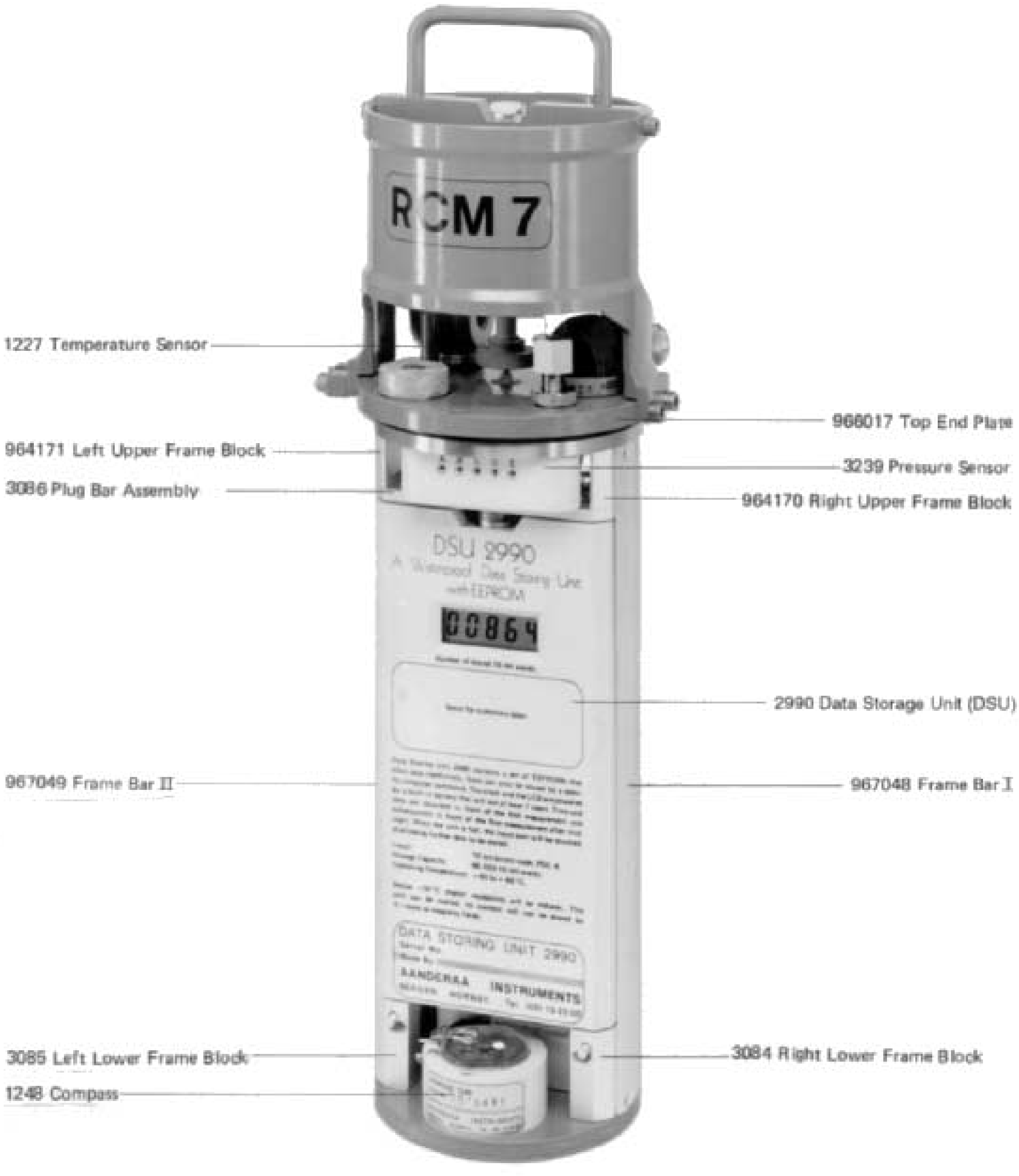


Fig. 8.04 Recording Unit, Data Storage Unit (DSU) Side

Fig. 8.05 Recording Unit as shipped

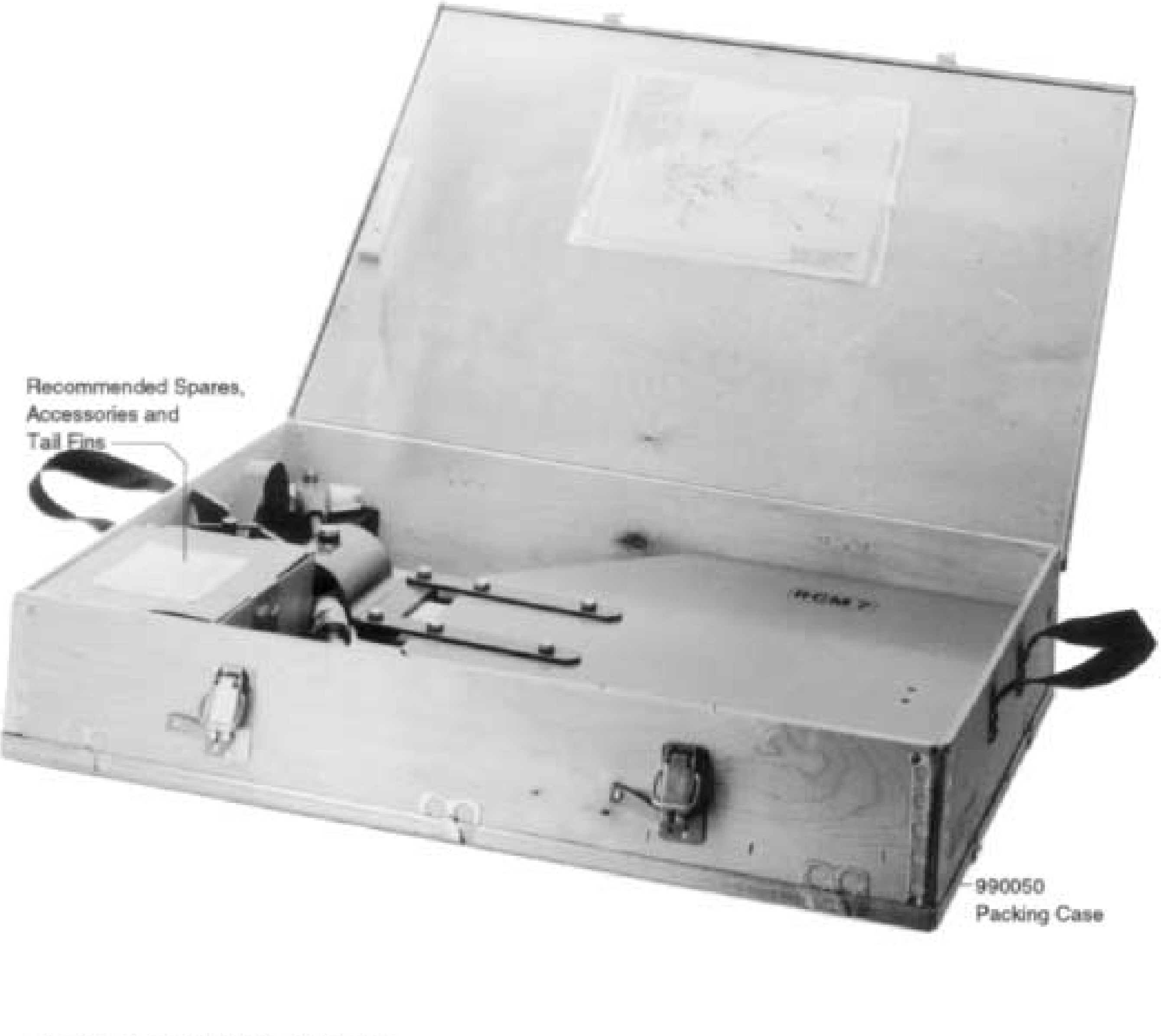


Fig. 8.06 Vane Assembly as shipped

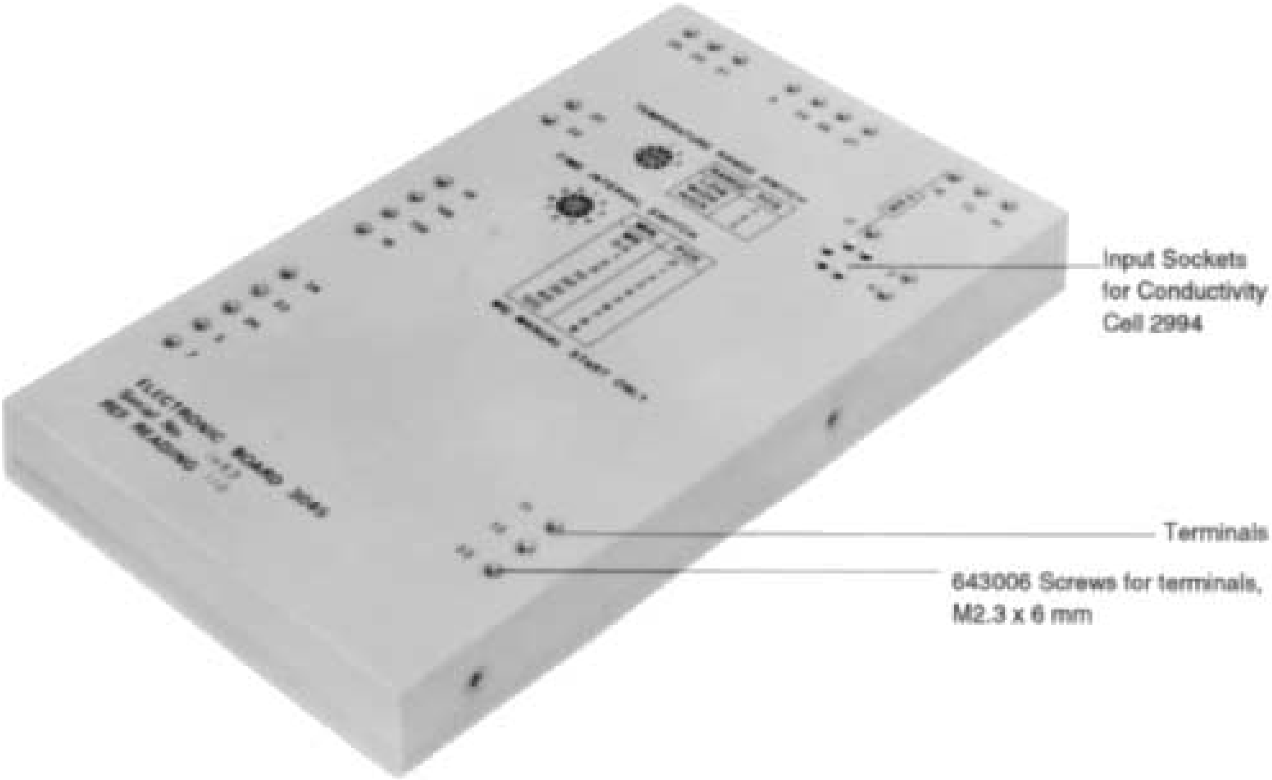


FIG. 8.07 Electronic Board 3045

Fig. 8.08 Data Storage Unit 2990 (DSU)

Fig. 8.09 Rotor Counter 3240

Fig. 8.10 Pressure Sensor 3239

Fig. 8.11 Temperature Sensor 1227

Fig. 8.12 Conductivity Cell 2994

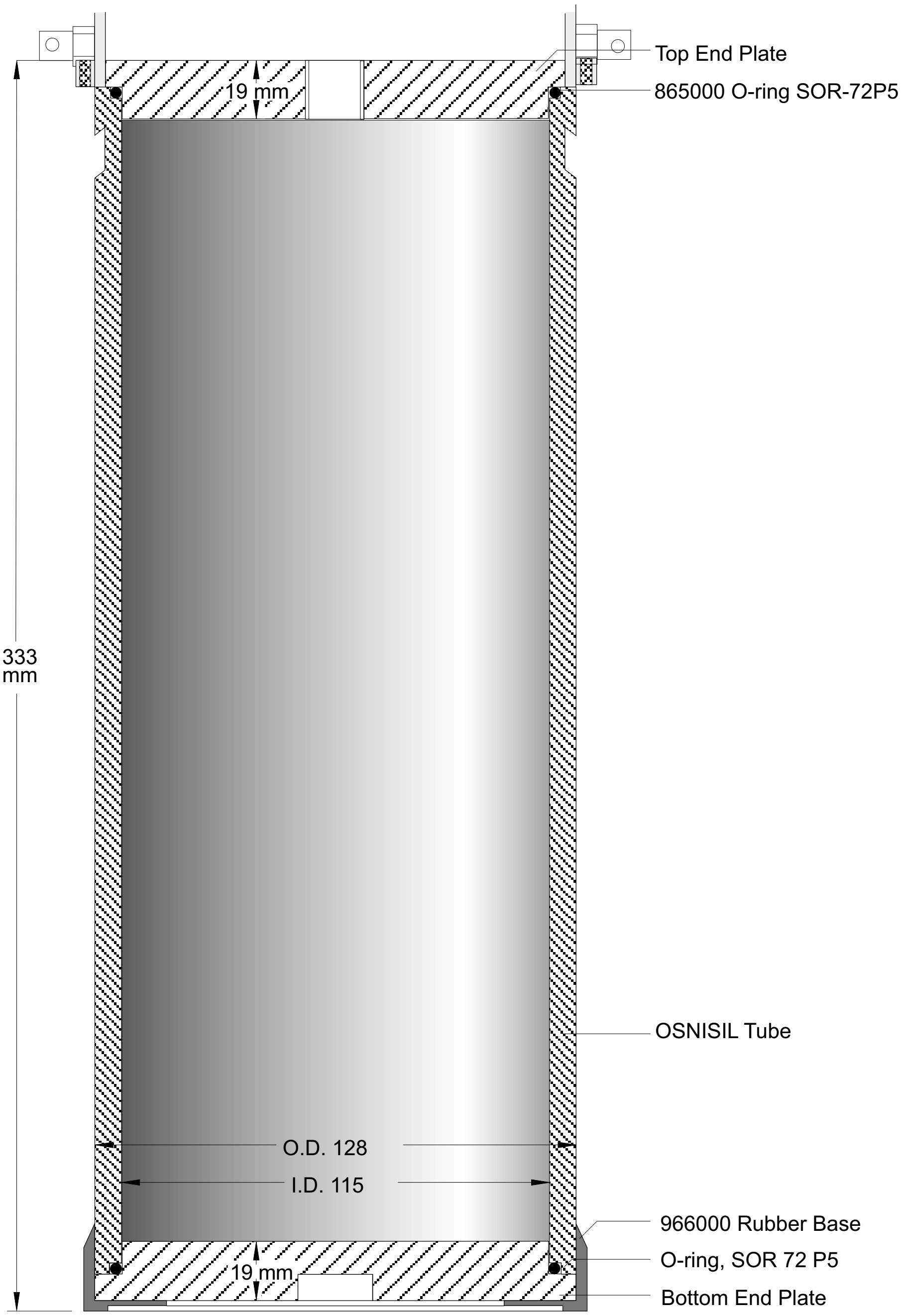


Fig. 8.13 Pressure Case 1171B with Top End Plate installed

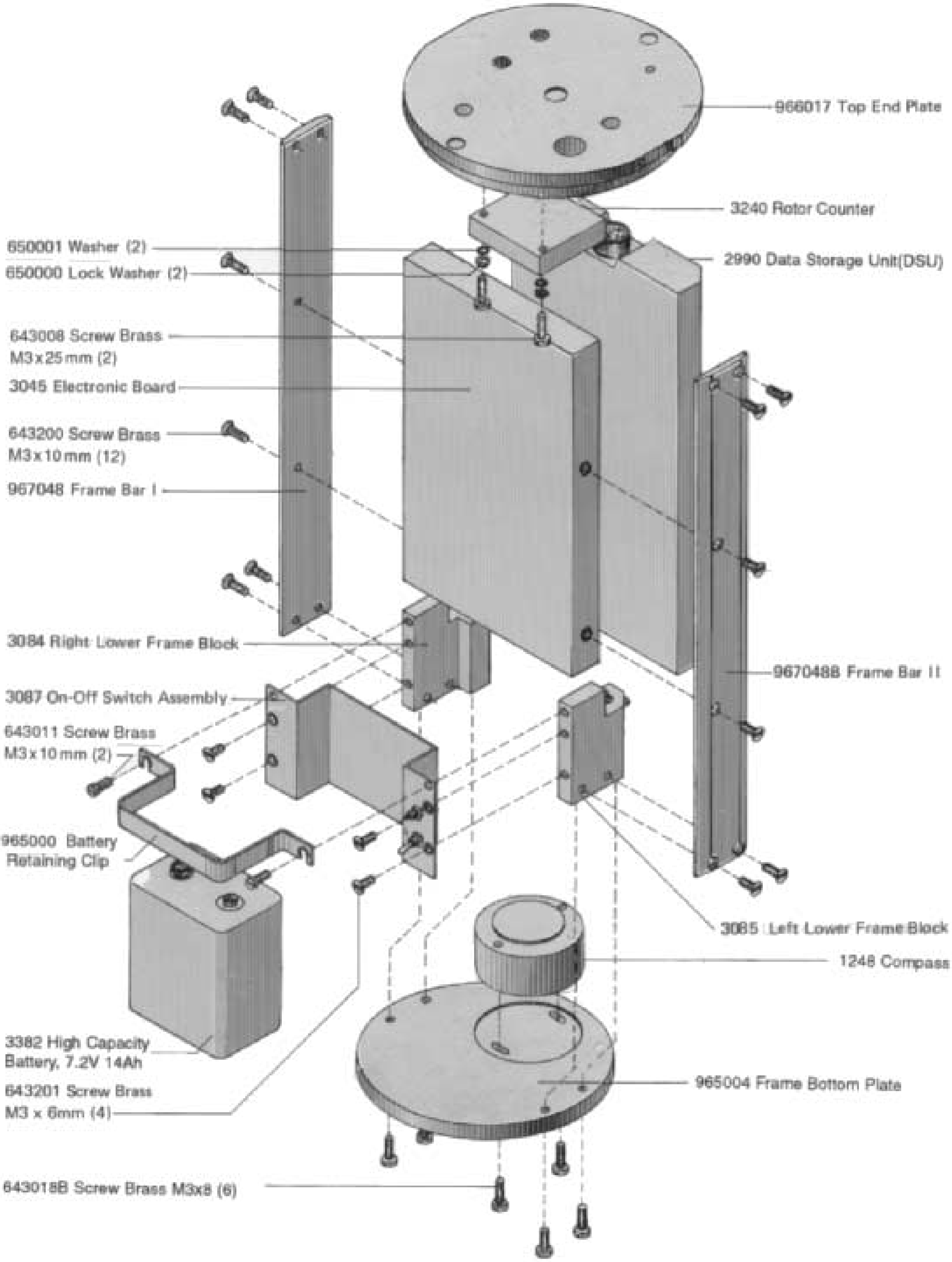


Fig. 8.14 Recording Unit, Lower Section (V-3509)

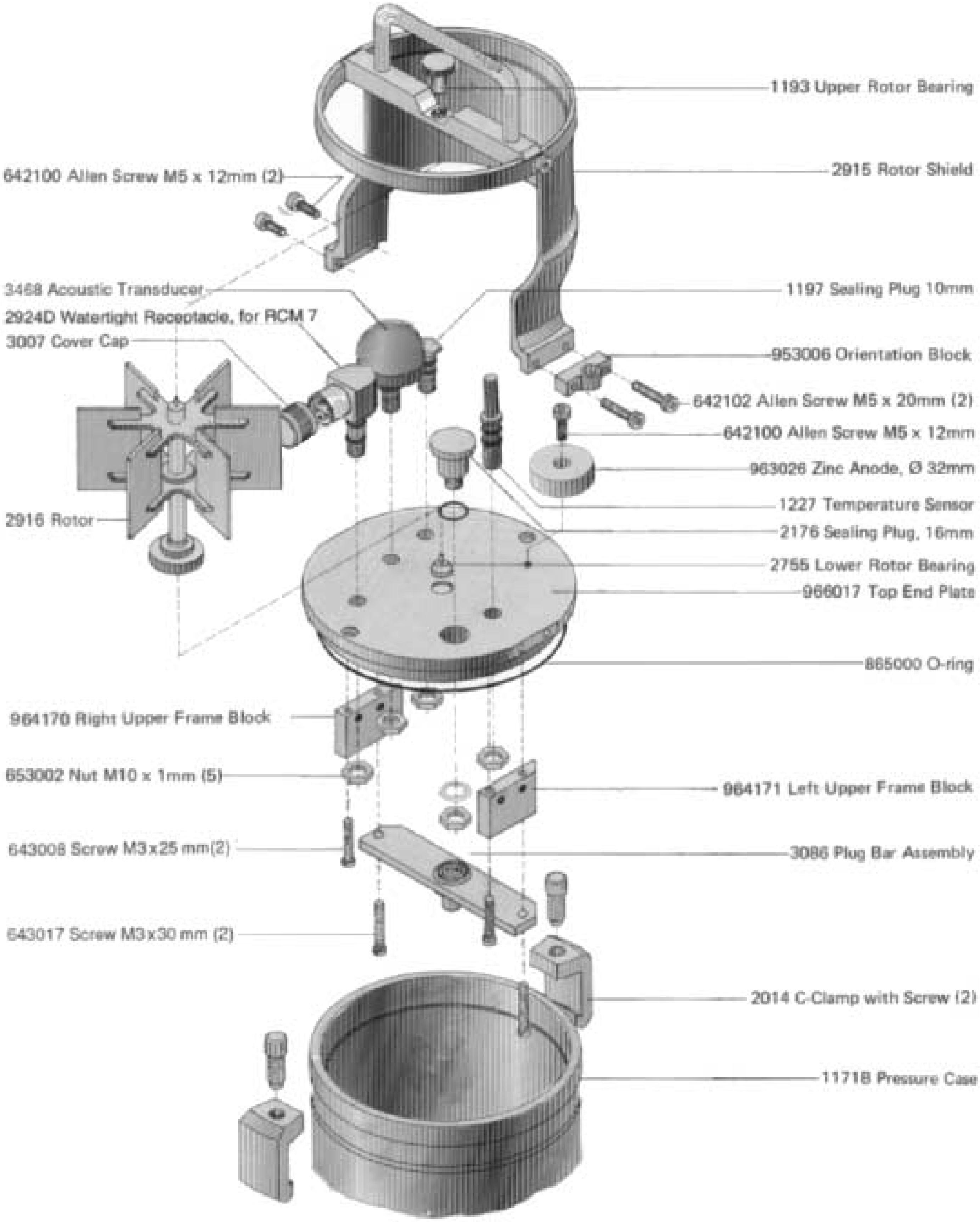


Fig. 815. Recording Unit, Top Section (V-3508A)

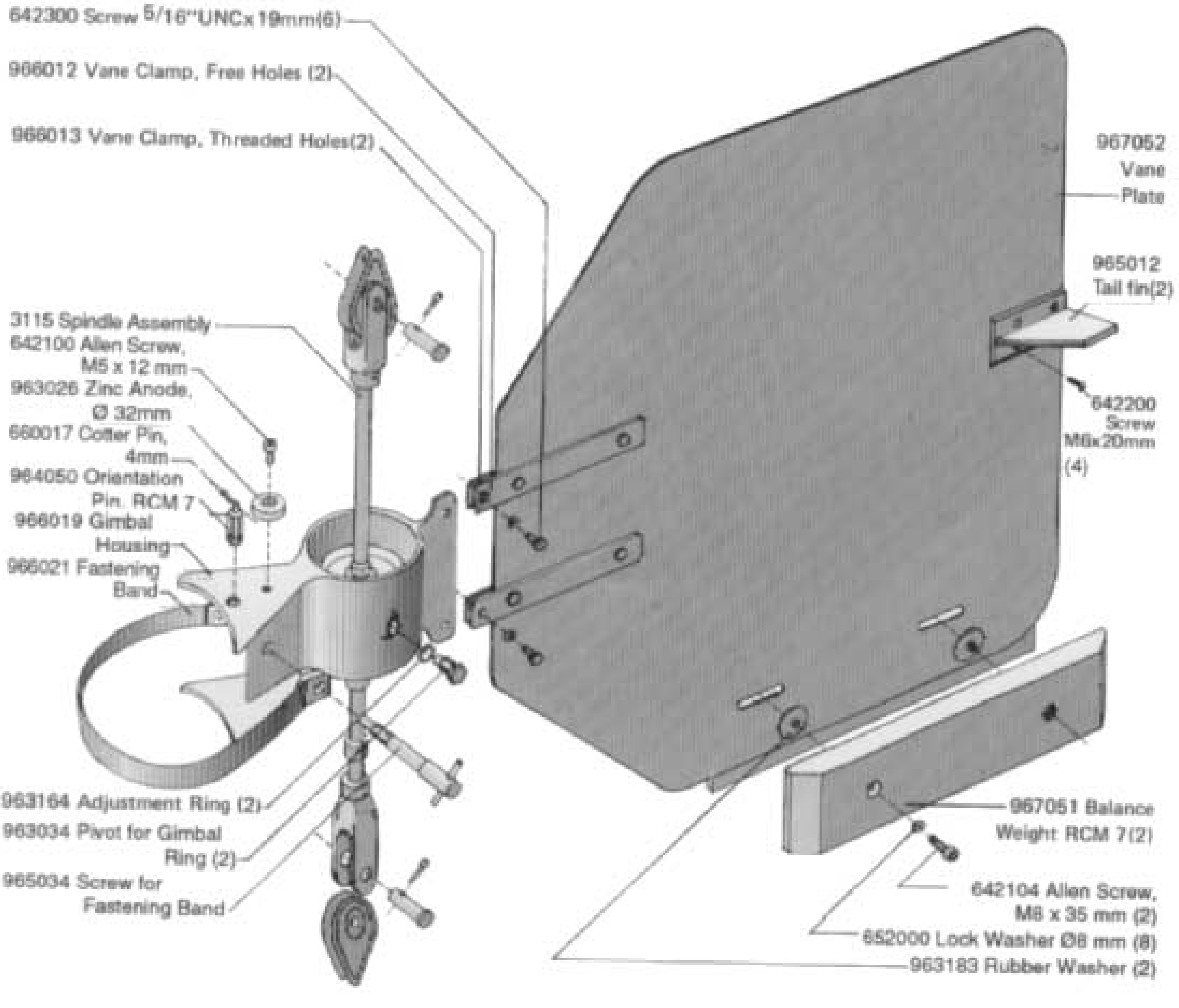


Fig. 8.16 Vane Asembly 3114 (V-3511A)

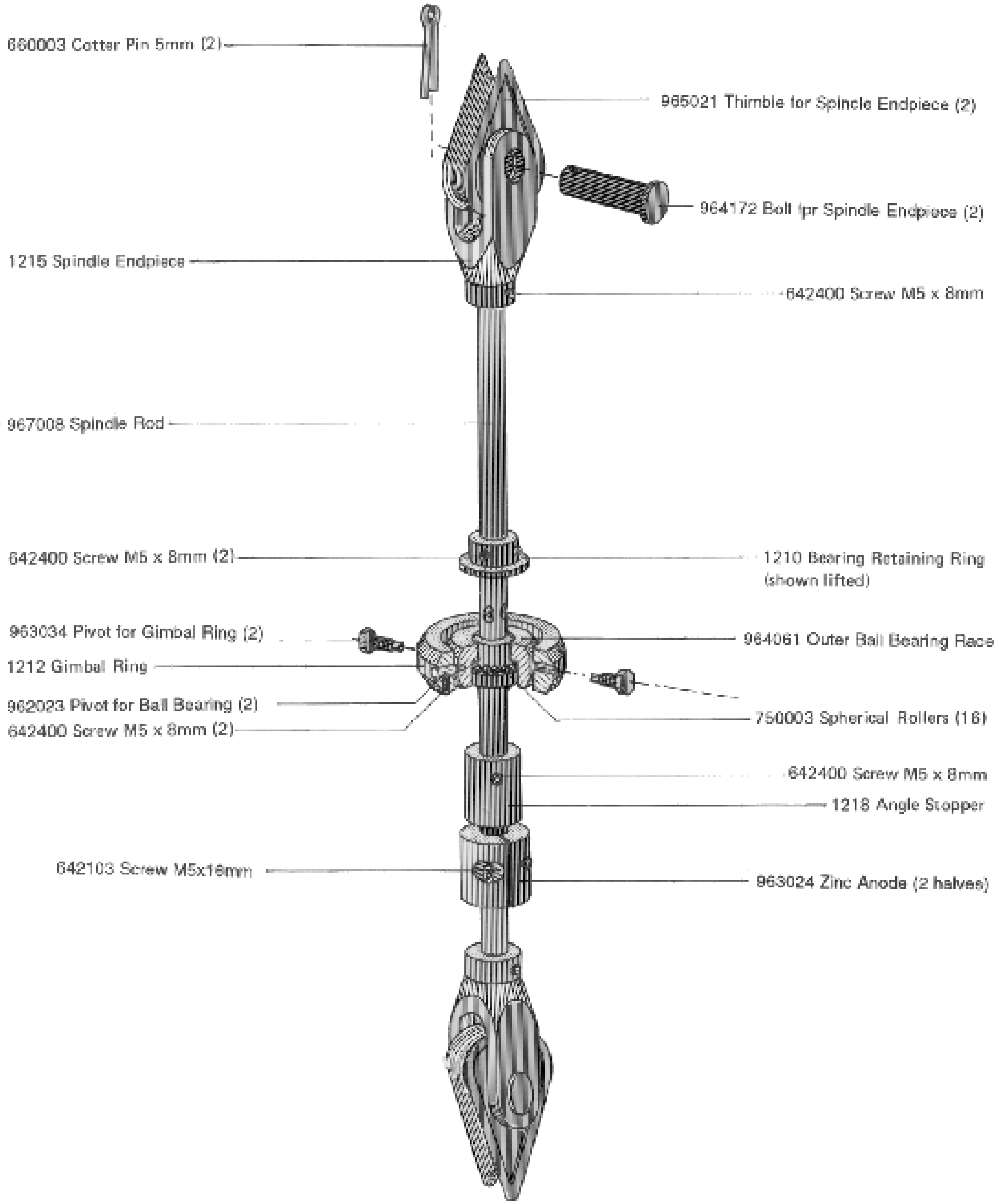


Fig. 8.17 Spindle Assembly 3115 (V-4289N)

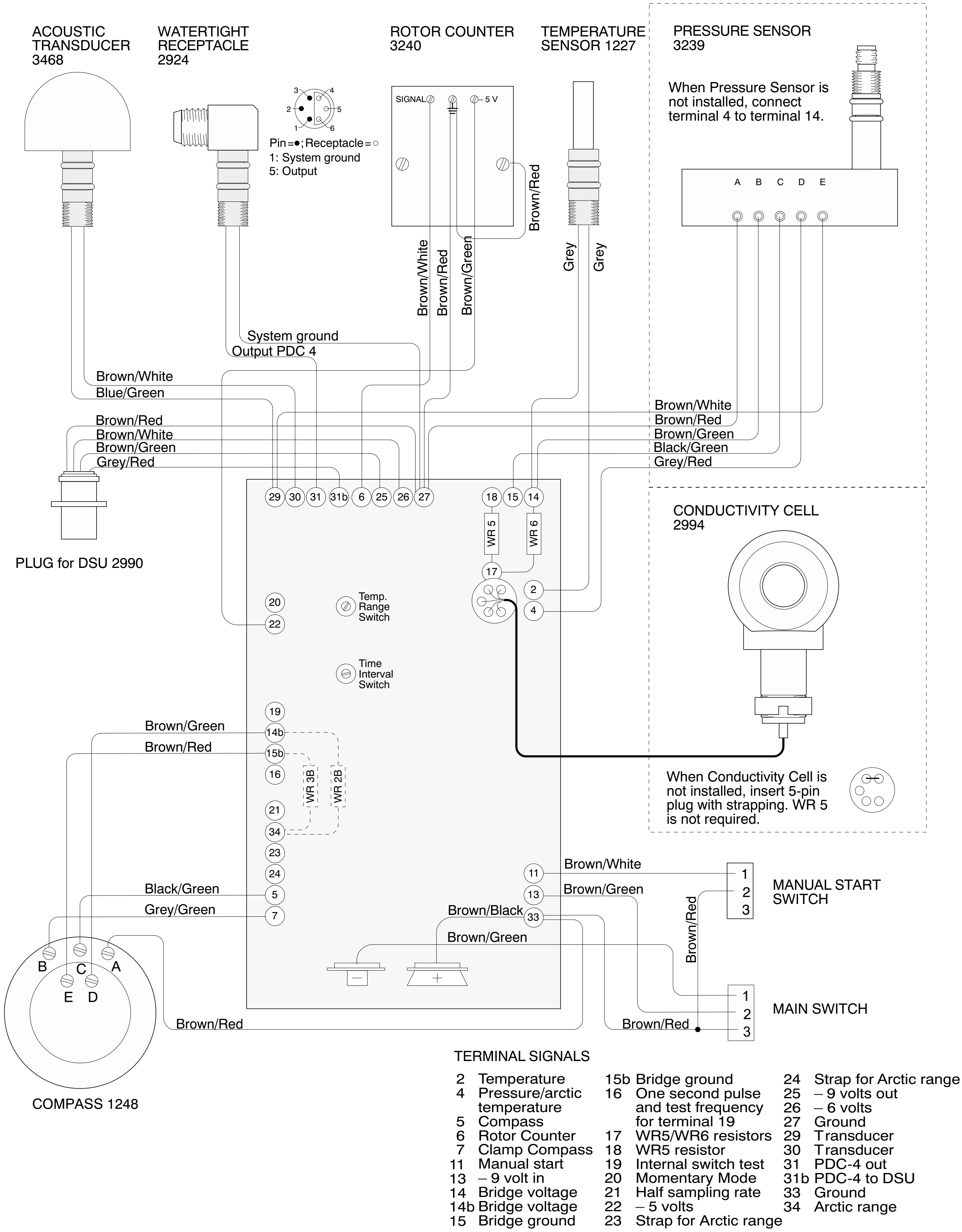


Fig. 8.18 Wiring Diagram (V-5686J)

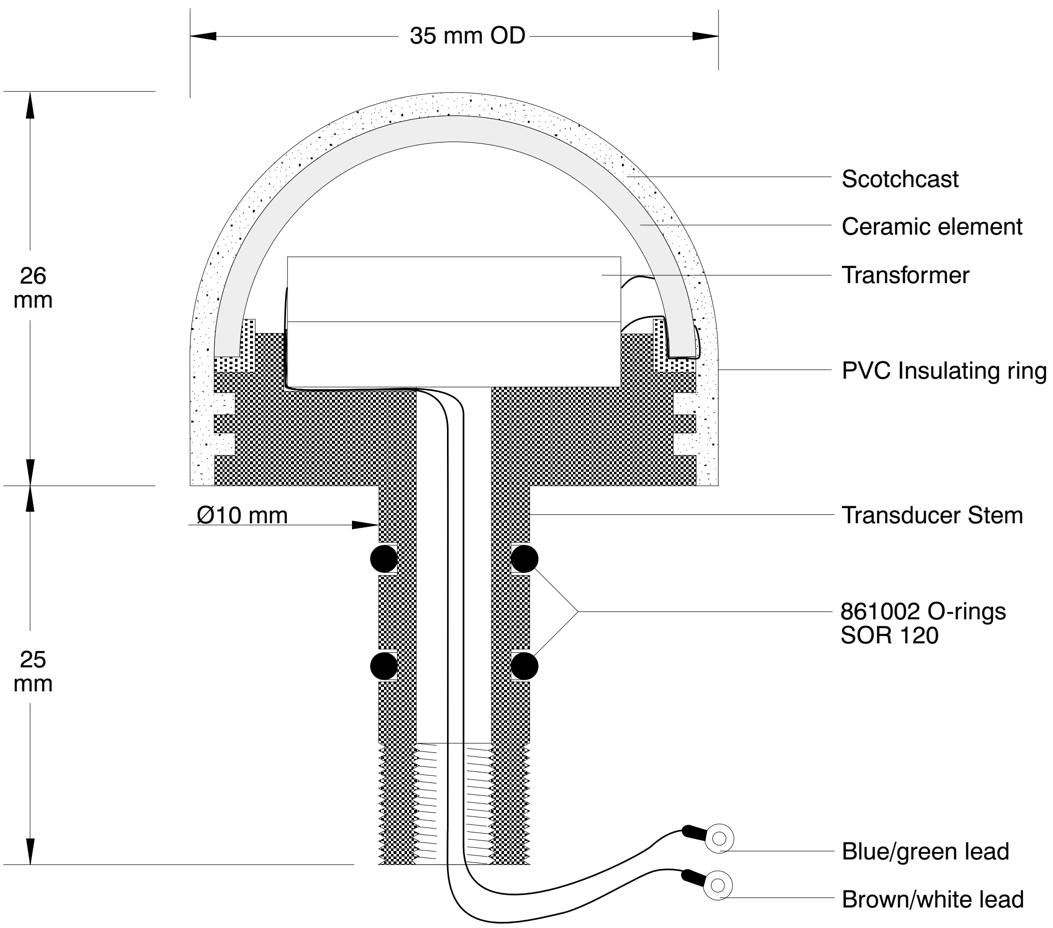


Fig. 8.19 Acoustic Transducer 3468

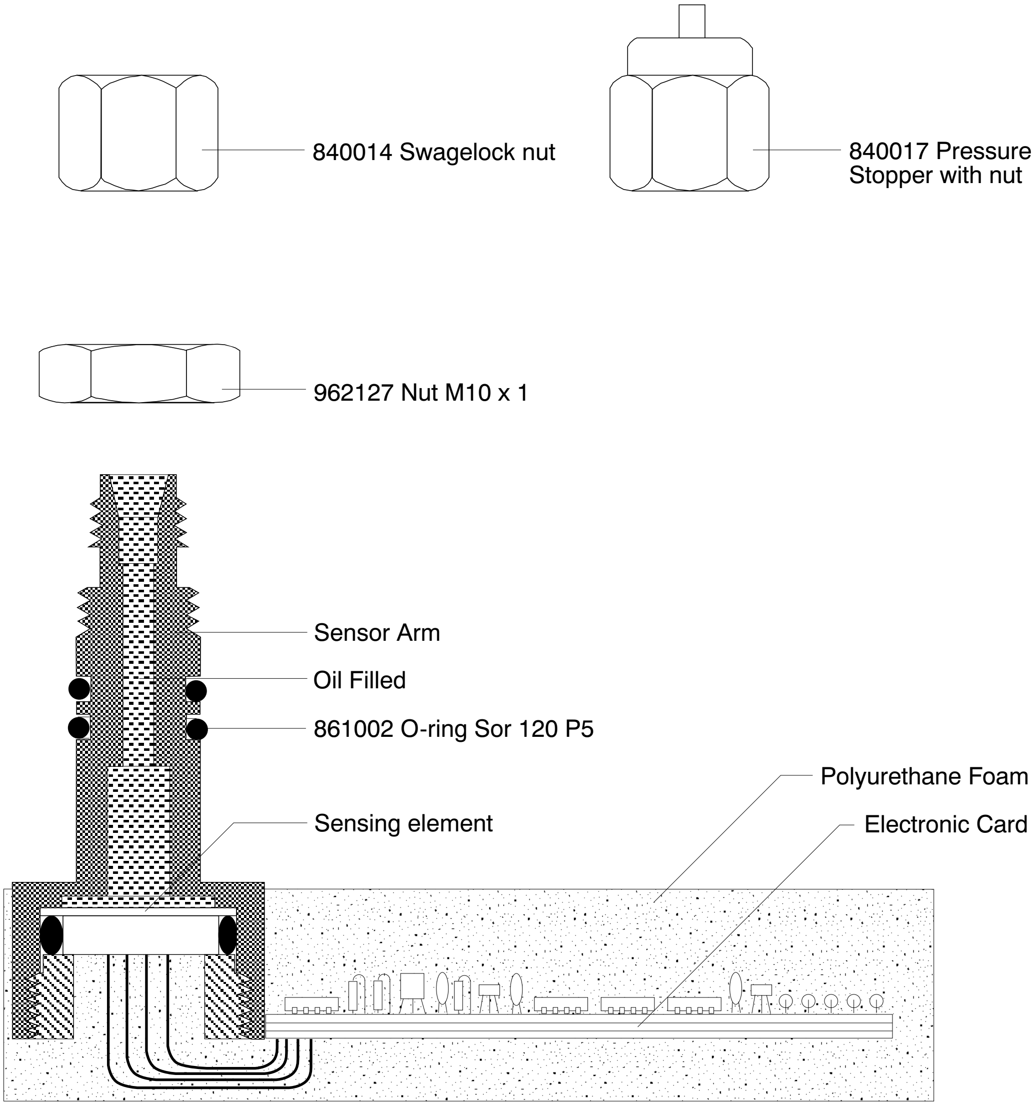


Fig. 8.20 Pressure Sensor 3239

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Test and Specification Sheet

RCM ....

Serial No. ....

Component Specifications (for sensors and coefficients, see Calibration Sheet)

Component	Serial No.	Remarks
Electronic Board 3045		Reference reading:
Data Storage Unit 2990		
Rotor Counting Switch 3240		
Acoustic Transducer 3468		

External Materials:

Pressure Case: OSNISIL Copper alloy (97.77% Cu, 1.73% Ni, 0.5% Si) and stainless acid proof steel (57.2% Fe, 17.5% Cr, 12.5% Ni, 2.7% Mo, maximum 0.06% C).
Vane Plate: 8 mm PVC.
Other Plastic Parts: Polyamid and Polystyrene.
Other Metal Parts: Stainless acid proof steel or JNM 1 bronze (84% Cu, 6% Sn, 5% Pb, 5% Zn).

Surface Treatment, External Parts:

All Metal Parts: Olive green epoxy coated.
O-Ring Surfaces: Uncoated. If bronze, nickel plated.
Rotor: Coated with Hempel Hard Racing antifouling paint.

Visual and Mechanical Checks:

Epoxy coating intact .... ☐
Zinc anode installed .... ☐
Rotor axial play (0.1–0.5 mm) .... ☐
Rotor threshold check .... ☐
Wire Harness and Screws .... ☐
Check of operation at 0°C (all channels tested, data stored in DSU 2990. 16 hour test run with 5 min.sampling interval) .... ☐
Clock function: checked at .... minute intervals. .... ☐
Acoustic Transducer output, comparative test in air .... ☐

Date .... Sign ....

Performance Tests Prior to Shipment, Selector Switch in position "Manual Start":

Maximum current consumption ....mA
Current consumption between measurements ....µA
First run, with ....Ω in sea water loop and orientation block facing East. Second Run, with ....Ω in sea water loop and orientation block facing West and after the rotor has been turned .... revolutions.

Readings:

Channel No.	1	2	3	4	5	6
First Run						
Second Run						

Pressure Sensor oil filled .... ☐
O-Ring inspected, cleaned and greased .... ☐
Erased DSU 2990 installed .... ☐
Vane assembly .... ☐
Fresh battery installed, Type: .... Open loop voltage .... Voltage with 100Ω load .... ☐
Inspection stamp .... ☐

Form No. 296
August 1999

Date .... Sign ....

Fig. 8.21 Test and Specification Sheet RCM

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Check-out List RCM 7 and 8

Serial No:....................

Visual and Mechanical Checks:

1.Epoxy coating intact (especially near Conductivity Cell)........ ☐
2.No corrosion, O-ring groove Pressure Case........ ☐
3.No corrosion, other parts........ ☐
4.No marine fouling........ ☐
5.Zinc anode installed........ ☐
6.Rotor end play (0.1 - 0.5 mm)........ ☐
7.Pressure Sensor oil filled........ ☐

Performance Test: (to be carried out with test battery and Seico Printer or Deck Unit 3127 connected and with interval switch in "MANUAL START" (MS).
First run, with 100Ω in sea-water loop and orientation block facing East. Second run, with 1000Ω in sea-water loop, orientation block facing West and after rotor has been turned.................... revolutions.

1st Test Run

Ch. No.	Reading	Reading O.K
1		
2		
3		
4		
5		
6		

2nd Test Run

Ch. No.	Reading	Reading O.K
1		
2		
3		
4		
5		
6		

Comments:

To decide whether a reading is O.K. compare with calibration sheet.

Clock function: Power switched on........... hour....... minutes
First triggering .... hour........ minutes
Second triggering .... hour........ minutes

Acoustic Oscillator O.K. ☐

Date:.................... Sign:..

Deployment Preparations:
Fresh main battery installed: Type:.. Open loop voltage:..
Voltage with 100Ω load:.................... DSU erased: ☐ DSU installed: ☐ DSU labeled ☐
Time of first measurement .... day: month:............year:............ hour:............ minute:............ GMT ☐ LT ☐
O-ring inspected, cleaned and greased: ☐
C-clamps tightened: ☐
Install Cover Cap 2924: ☐

Date:.................... Sign:..

Retrieval Phase:
Recording Unit cleaned and rinsed in fresh water
Time of last measurement: day: month:............ year:............ hour:............ minute:............ GMT ☐ LT ☐

State of Recording Unit: - ....

Form No 303
August 1999

Date: /

Sign:..

Fig. 8.22 Check-out List

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Calibration Sheet
RCM......................................
Serial No. ....

Calibration points Original (to accompany instrument)

Ch. No.	Parameter	Sensor	Range	Calibration points and corresponding readings			Unit
1	Reference			Fixed reading, N:			
2		Sensor		Cal. point Reading, N Cal. point Reading, N Cal. point Reading, N			
3	Conductivity	Cell 2994 No.		Cal. point Reading, N			mmho/cm
4		Sensor		Cal. point Reading, N			
5	Direction	Compass 1248 No.		Cal. point Reading, N			degrees magn.
6	Speed	Rotor 2916		Individual units not calibrated			

Conductivity Cell, reading with sea-water loop:

ohm, N =

ohm, N =

Information about calibration is given in Chapter 6 in the Operating Manual for RCM 7/8 (TD No. 159).

Coefficients

Value of parameter in given unit = $A + BN + CN^2 + DN^3$

Ch. No.	Parameter	A	B	C	D	Unit
1	Reference					
2						
3	Conductivity[1])					mmho/cm
4						
5	Direction					degrees magn.
6	Speed					cm/sec.

[1]) Cell form factor: K = cm-1

Place .... Date ....19................

Signature ....

Form No 320
August 1999

Fig. 8.23 Calibration Sheet

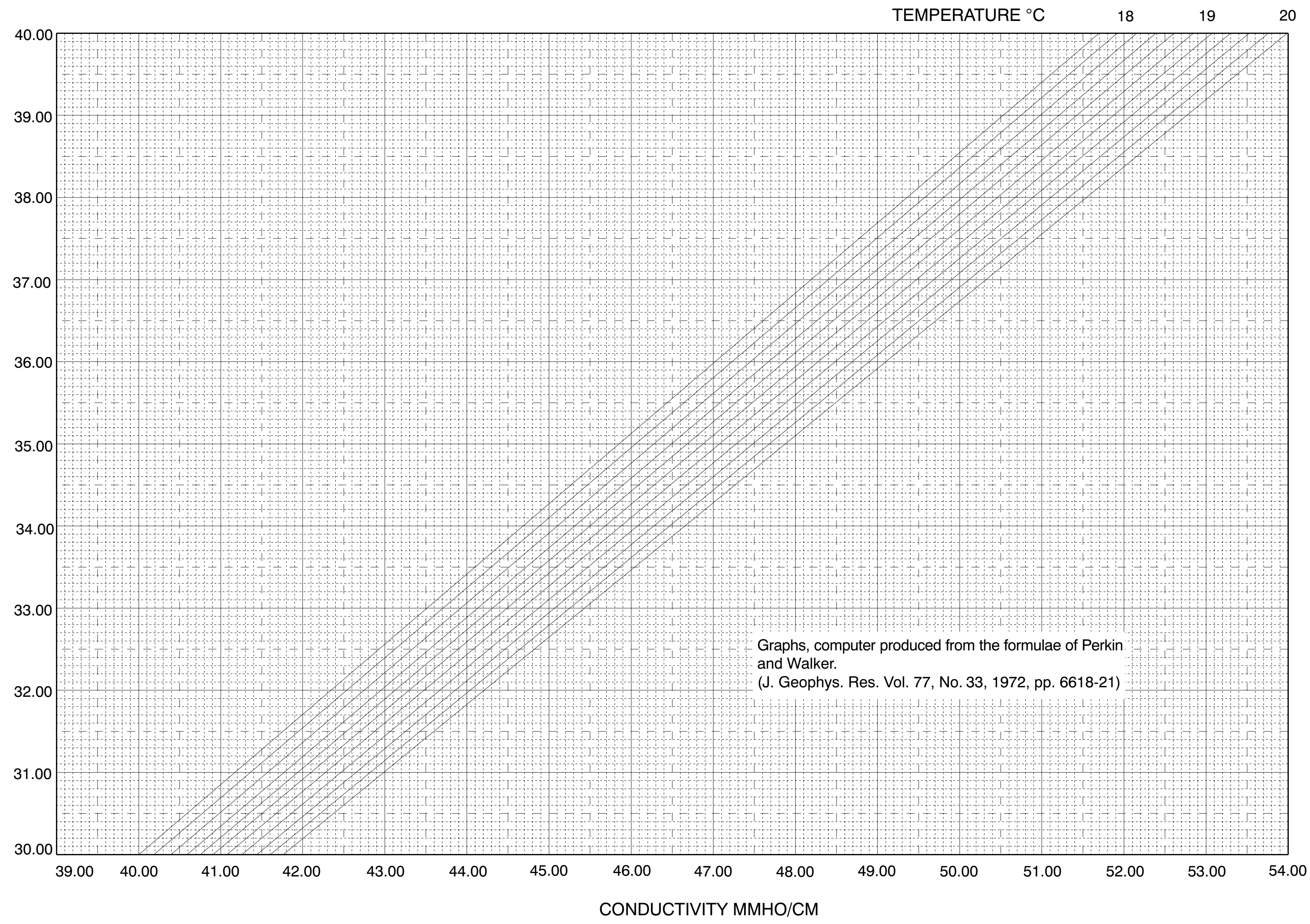


Fig. 8.24 Salinity Conversion Graph 18 – 20°C

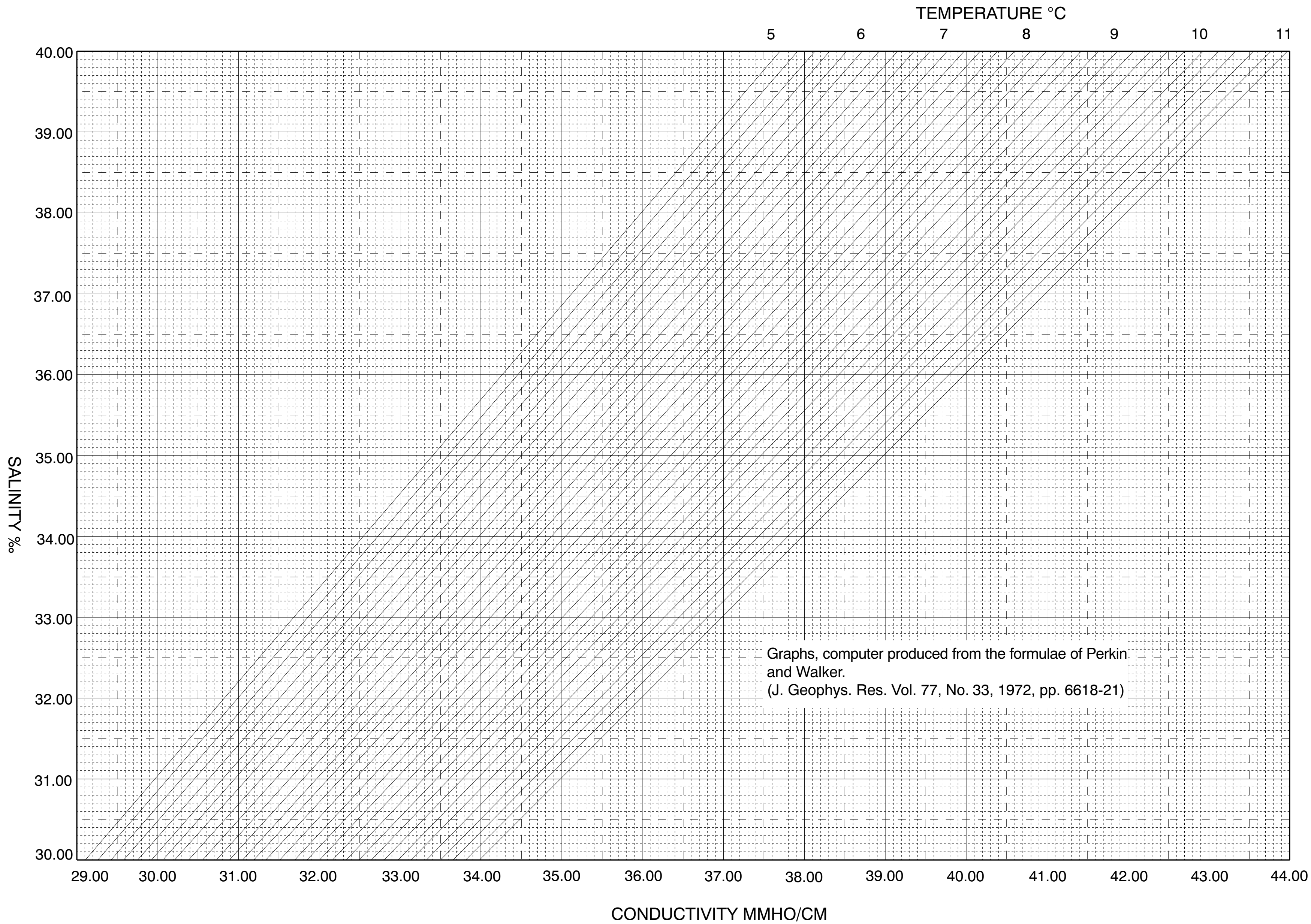
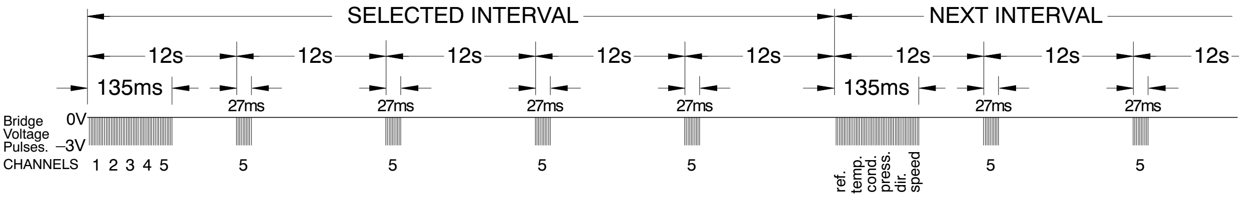


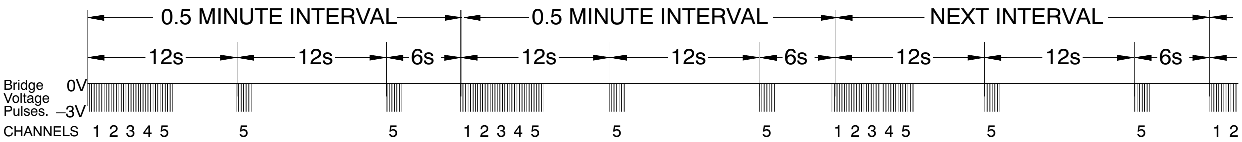
Fig. 8.25 Salinity Conversion Graph 5 – 11°C

TIMING DIAGRAMS FOR RCM 7 — SIGNAL AT TERMINAL 14

TIMING DIAGRAM, FROM 1 TO 10 MINUTE SELECTED INTERVAL



TIMING DIAGRAM FOR 0,5 MINUTE SELECTED INTERVAL



TIMING DIAGRAM FROM 20 TO 60 MINUTE SELECTED INTERVAL

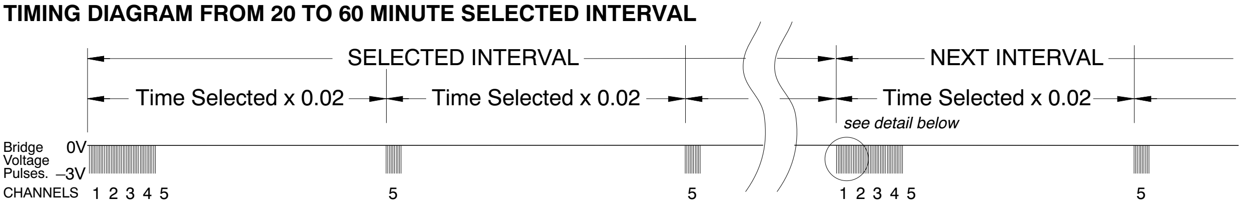


DIAGRAM SHOWING BRIDGE VOLTAGE PULSES (10 FOR EACH CHANNEL)

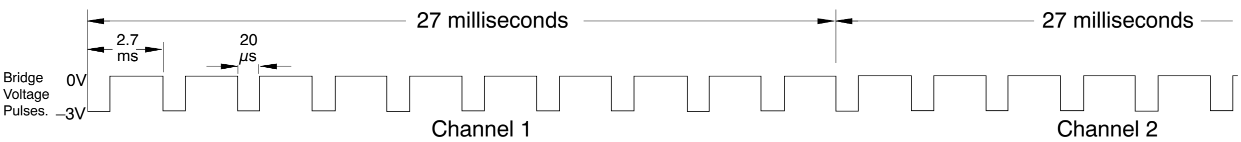


Fig. 8.26 Timing Diagrams, RCM 7 – Vector Averaging

TIMING DIAGRAM FOR "RCM 4 MODE" (vector averaging inhibited)

SIGNAL AT TERMINAL 14

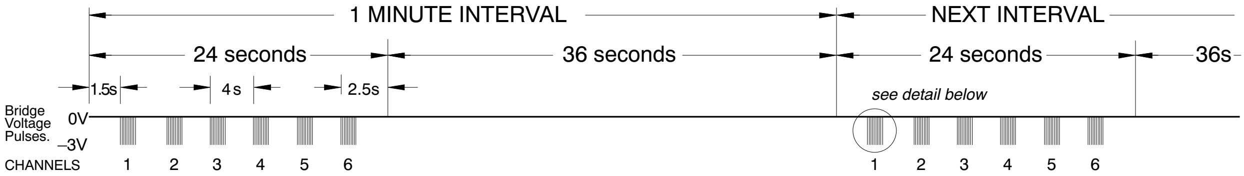


DIAGRAM OF ONE RECORD – SIGNAL AT TERMINAL 31

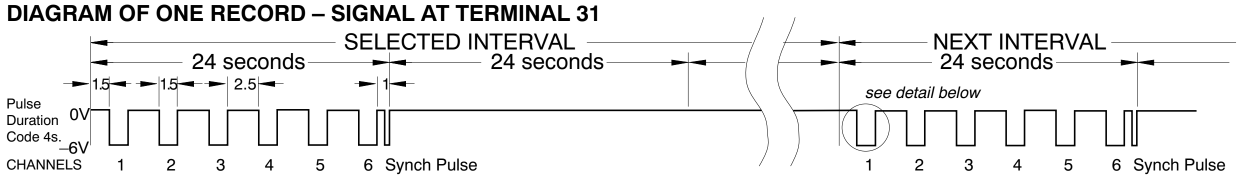


DIAGRAM OF – 6 VOLTS OUTPUT – SIGNAL AT TERMINAL 26

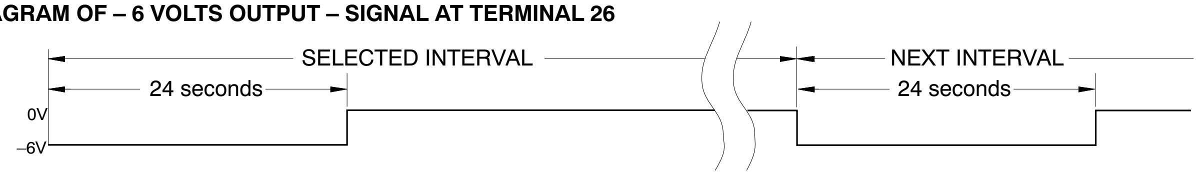


DIAGRAM OF 1 CHANNEL SHOWING SINGLE PDC-4 SIGNALS (10 FOR EACH CHANNEL)

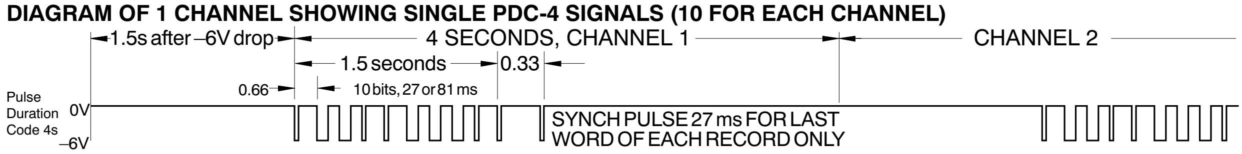


DIAGRAM SHOWING BRIDGE VOLTAGE PULSES (10 FOR EACH CHANNEL)

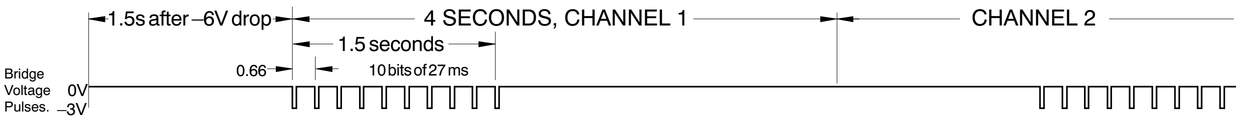


Fig. 8.27 Timing Diagrams, “RCM-4 Mode”

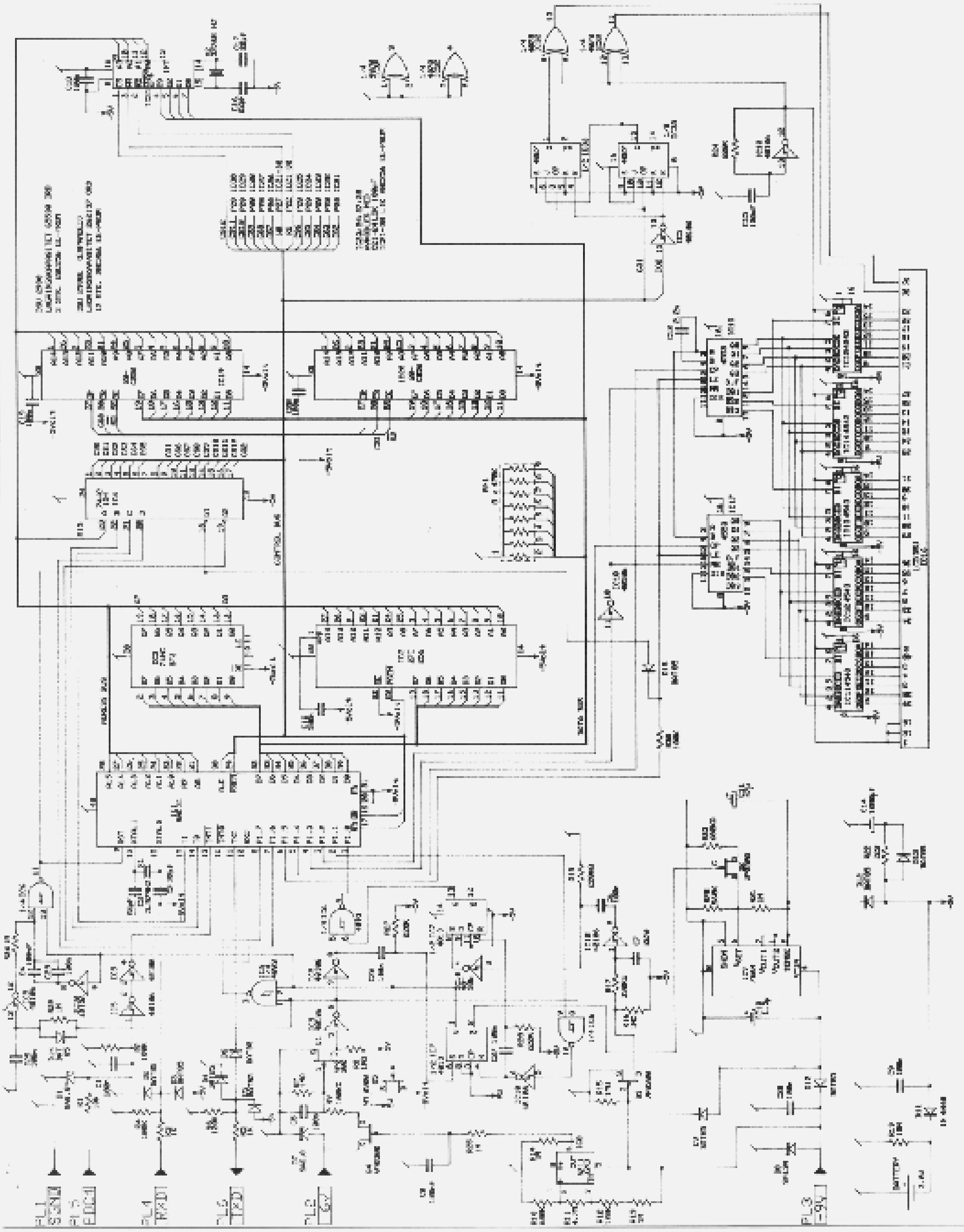


Fig. 8.28 Circuit Diagram, Data Storage Unit 2990 (V-3581E)

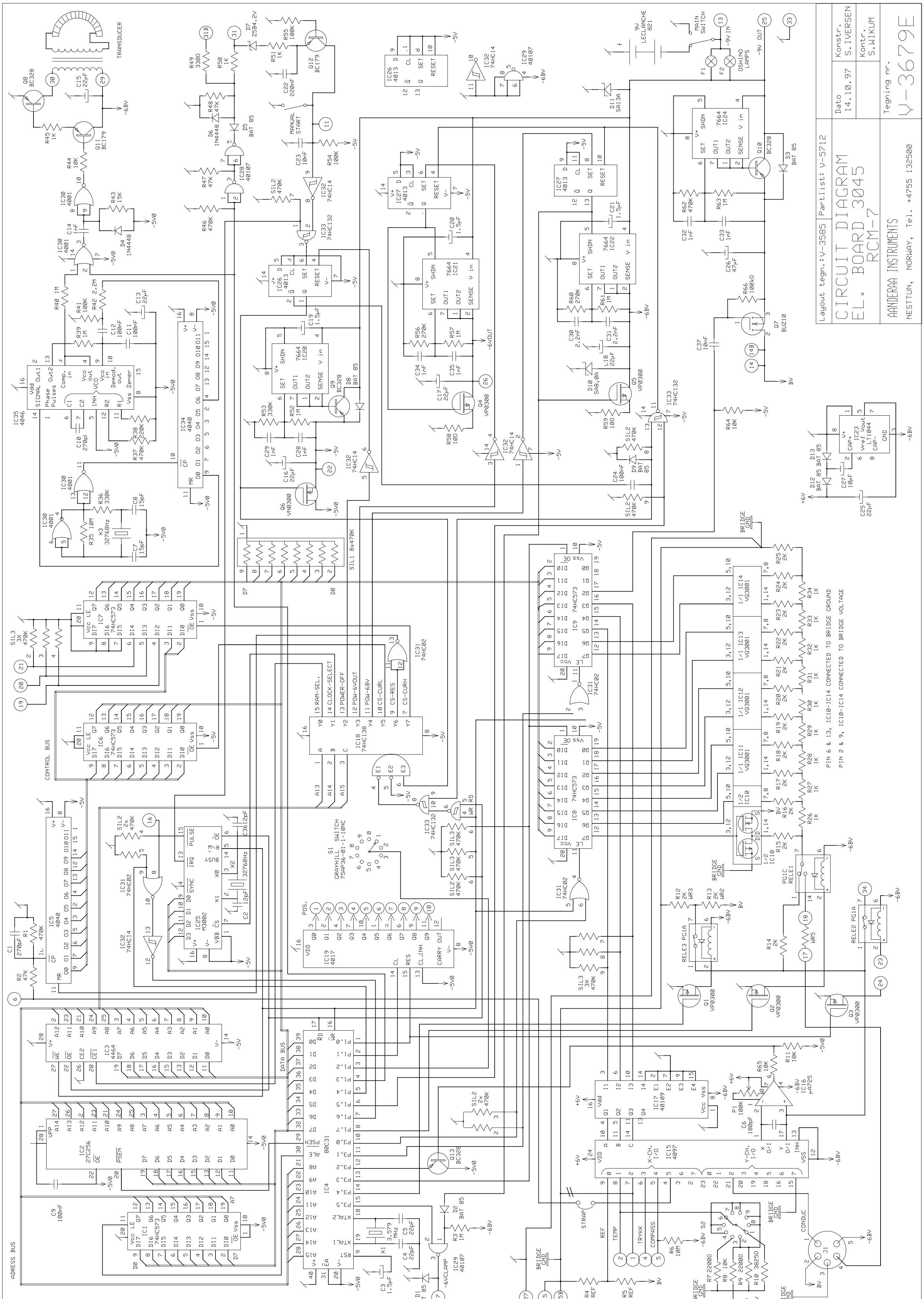


Fig. 8.29 Circuit Diagram, RCM 7–(V-3679)

CHAPTER NINE

RECORDING CURRENT METER MODEL 8

Introduction.

Chapters 1–8 are also valid for the deep-water version, RCM 8. This version has the same features as the RCM 7 except for the physical dimensions of the pressure case and the top end plate, see figure 10.01. These parts are strengthened to meet the requirements of a depth capability of 6000 meters. It also has a heavier balance weight to counteract the heavier case. Pressure Sensor 3249 is employed for the RCM 8. It has a longer arm than Pressure Sensor 3239 to fit the top end plate of RCM 8. This chapter only describes the specifications and parts specific to the RCM 8.

Specifications.

Depth capability:			6000	meters
Net weight,	Recording Unit,	in air:	15.2	kg
		in water:	10.9	kg
	Vane Assembly,	in air:	14.1	kg
		in water:	11.8	kg
Gross weight,	Recording Unit:		20.5	kg
	Vane Assembly:		22.0	kg
Dimensions,	Recording Unit, height:		520	mm
	Pressure Sensor 3249:		0-9000	PSI

Description.

Figure 10.01 shows the pressure case with top end plate. In order to withstand the pressure of up to 600 kg/cm2, the thickness of the top and bottom end plates has been increased to 30 mm. Two O-rings, one on the top end plate and one on the bottom end plate, are located in circular grooves to give proper sealing against the inside of the pressure case. The bottom end plate is press fitted to the tube.

As the inside height of the RCM 8 is the same as for the RCM 7, the pressure tube is made 14 mm longer to compensate for the increased thickness of the end plates, and the groove for the C-clamp is reduced to two small grooves to obtain better mechanical strength.

The top end plate, seen on figure 10.02, requires specially designed fastening nuts for the temperature sensor, acoustic transducer, electrical terminal and sealing-plug.

Due to the greater weight of the instrument housing, a heavier balance weight (2.0 kg) is needed on the vane assembly to maintain static balance of the instrument. The longer pressure case also requires a 37 mm longer orientation pin on the gimbal housing.

Parts, specifically for the RCM 8.

966027	Top End Plate, RCM 8
2175B	Pressure Case, RCM 8
962026	Nut for 10 mm Plug/El. Terminal 2924 and sensors
865001	O-ring for Pressure Case, SOR-71
965032	Orientation Pin, RCM 8
967055	Balance Weight, RCM 8 (2)
3249	Pressure Sensor

CHAPTER 10

ILLUSTRATIONS

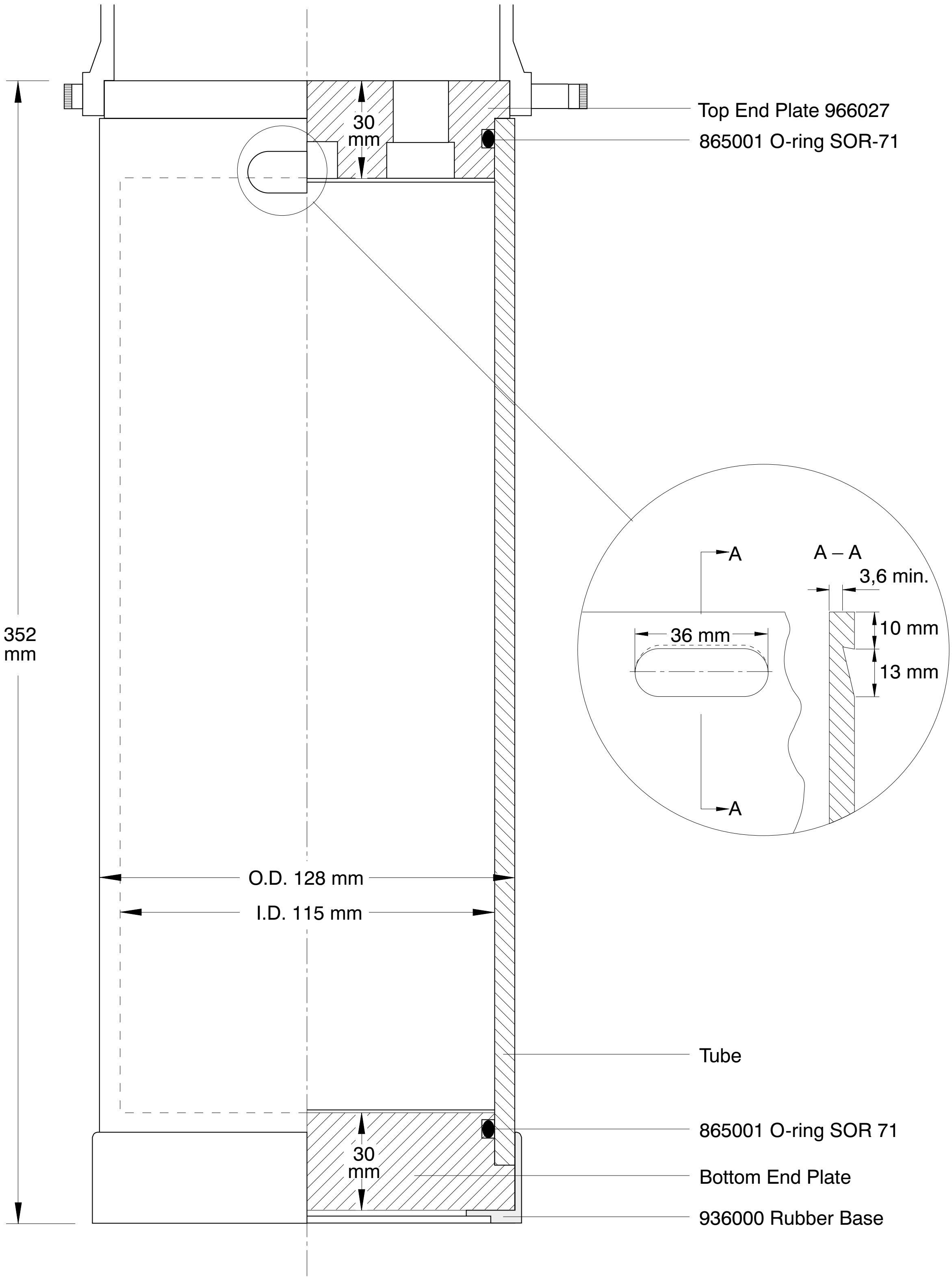


Fig. 10.01 Pressure Case and Top End Plate for RCM 8

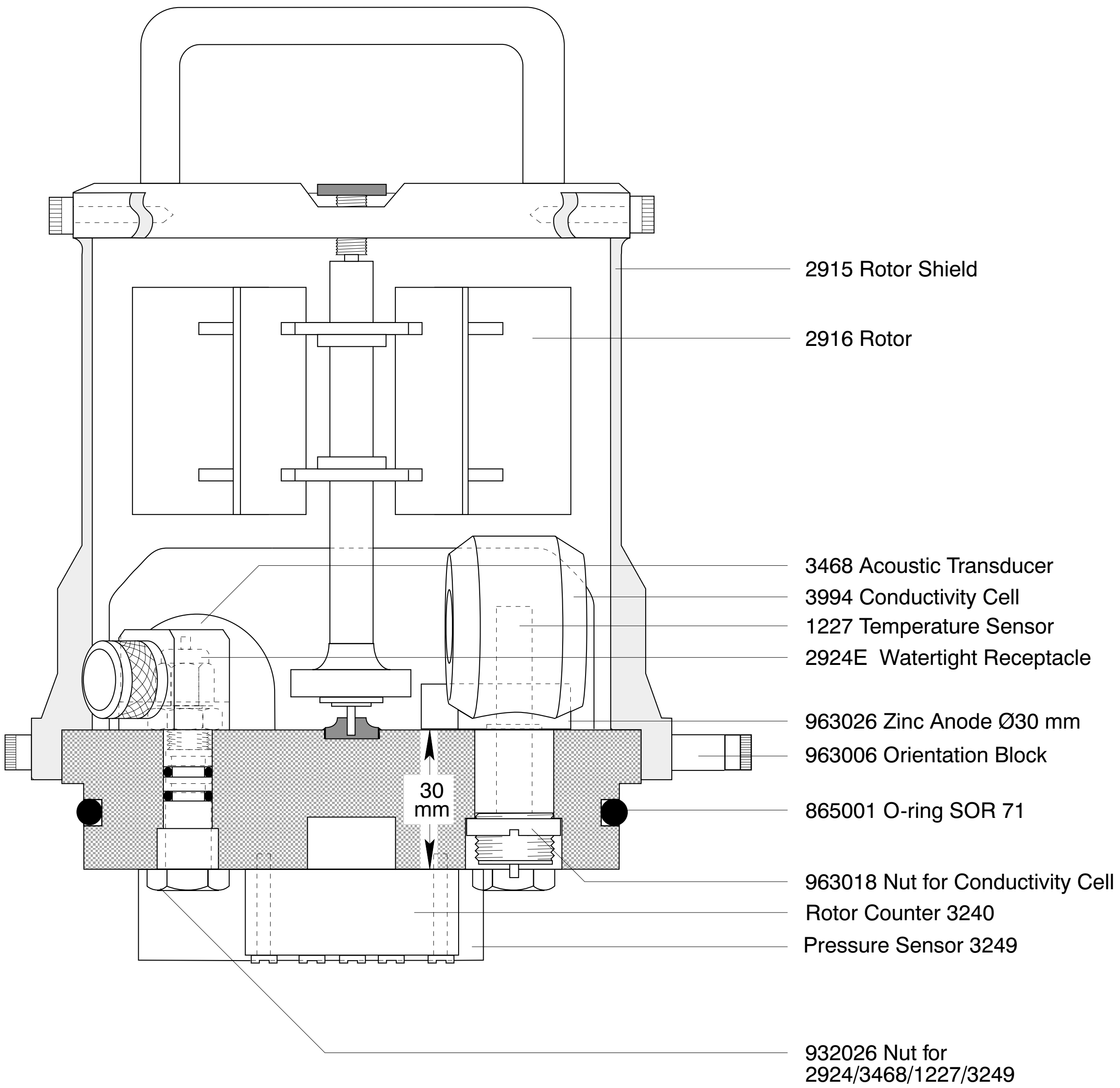


Fig. 10.02 Top Section of RCM 8

APPENDIX

List of significant changes.

1) Page 2-05, 3-06:	On instruments where both a special temperature measurement and a pressure measurement is required, the temperature must be measured in channel 4 and the pressure in channel 2. Please consult factory for more specific information.
2) Page 3-03:	Electronic Boards with serial number 1169 or above will give current direction with zero current speed.
3) Page 3-04:	DSU 2990 with serial number 2700 and above, uses EEPROMs with embedded batteries. Earlier versions features static CMOS RAMs and a replaceable battery.
4) Page 3-04	DSU 2990 with serial number 2165 and above, features an electronic shut-off in case of low battery voltage to prevent data errors.
5) Page 7-02:	Electronic Boards 3045 with serial numbers up to and including 1504 perform differently in "Manual Start" mode. The channel 6 output in these boards is related to the rotor revolutions in the following manner: 1 rotor revolution = 5.33 counts 10 rotor revolutions = 53.30 counts 100 rotor revolutions = 533.00 counts
6) Page 3-11:	From October 1993 the instruments are delivered with Acoustic Transducer 3468 which has a better performance than the 2568 modell.