# ALPHATRACKA MKII
# TRANSMISSOMETER
# 660nm (Red)
# HANDBOOK

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## IMPORTANT NOTICE

Chelsea Instruments Ltd has taken every reasonable precaution to ensure the accuracy of the information published in this handbook. However, it gives no undertaking that this information describes the suitability of the product, other than in general terms, for its use in the purchaser's application. It is the sole responsibility of the purchaser to ensure that the product meets the requirements of operation and environment and takes account of all safety aspects under the Health and Safety at Work Act 1974.

## WARRANTY

The Alphatracka is a complex scientific instrument and customers are advised that opening of the pressure housing can affect the warranty of the instrument. Chelsea Instruments Ltd will not accept responsibility for damage caused by flooding of the instrument after it has been opened up following despatch from our premises.

Chelsea Instruments Ltd will accept no liability or responsibility for the consequences arising from connections made to the instrument, undertaken by the customer or his agent or authorised representative.

This disclaimer does not affect your rights under the Consumer Protection Act legislation.

## WARNINGS
## RETAINED HIGH PRESSURE

**If any of the pressure housings has leaked during operation, under high pressure, it is possible for the pressure to be retained when the external pressure is released. If a pressure housing is to be opened under these circumstances, considerable hazard exists unless suitable precautions are taken and extreme care exercised.**

# 1 INTRODUCTION

## 1.1 Overview

Alphatracka MKII is an accurate transmissometer that measures the beam attenuation coefficient alpha(a) at 660nm. It can be used in a wide range of oceanographic systems to monitor suspended and dissolved materials. The optical housings are manufactured in titanium for its low weight and corrosion-free properties. They are mounted on a light robust titanium support frame which maintains the stability of the optical alignment during operational use. For optimum results in areas of differing amounts of total suspended matter, Alphatracka MKII is available in 5, 10 and 25cm path length versions. Alphatracka MKII can be mounted on a towed underwater vehicle or used in a moored or profiling system.

A modulated light source and a coherent detector give excellent rejection of interference due to ambient light up to full sunshine levels, even in the presence of wave glitter. The collimated light source and detection optics have minimal beam divergence and acceptance angle to reduce errors due to scattered light. The internal reference beam and ratiometric signal processing system combine to give an effective ageing rate of the source of <0.01 percent of full scale per 1000 hours usage. This provides long-term calibration stability and will obviate the need to correct for variations in source intensity during operational use.

Connection to the instrument is via a four way subsea connector; two ways are used for the supply of power (+7V to +18V dc.) and two ways for signal output. Output can be factory set for either 2.5V or 5.0V systems; it is normally set for 2.5V unless otherwise requested.

After manufacture, Alphatracka MKII is calibrated in pure water, as detailed in section 4.2. An air reading is also taken and recorded; this can be used to check that the windows are clean.

**NOTE: The construction of this instrument is such that optical alignment and calibration is maintained throughout its operational life, unless there is premature damage. If this occurs the instrument must be returned to Chelsea Instruments Ltd. for repair and calibration.**

The beam attenuation coefficient alpha(a) measured by Alphatracka MKII includes both absorption and light scatter losses, as discussed in section 1.3. Since the effects due to particle type and concentration vary from region to region, it would be prudent for
the user to build up a local data base and "calibrate" the instrument output against particle density in the survey area.

The design and manufacturing standards used to produce Alphatracka MKII give a high level of reliability and stability of calibration. The reliability of the instrument depends on the integrity of the optical set-up, so Chelsea Instruments Ltd. advise that the instrument be returned to their facility for all repair and adjustment. Any attempt by the user to open the instrument will most likely disturb the optical set-up and invalidate any warranty conditions.

## 1.2 Specification

| | | | | |
|---|---|---|---|---|
| • Water path: | | 5, 10 or 25cm | | |
| • Overall length: | | 320, 370 or 520mm | | |
| • Diameter: | | 65mm | | |
| • Weight: | | 5cm | 10cm | 25cm |
| Standard and Deep Sea (Kg) | air | 3.55 | 3.6 | 3.75 |
| | water | 1.9 | 1.95 | 2.1 |
| • Material: | Standard/Deep Sea | Titanium | | |
| • Depth rating: | Standard | 2000 metres | | |
| | Deep Sea | 6000 metres | | |
| • Beam diameter: | | 15mm | | |
| • Beam Divergence: | | < 6 mrads. | | |
| • Acceptance Angle: | | < 16 mrads. | | |
| • Wavelength: | | 660nm (option 470nm, 565nm, 590nm) | | |
| • Source line half width: | | 20nm | | |
| • Optical Ports: | Standard | Synthetic Fused Silica | | |
| | Deep Sea | Sapphire | | |
| • Response time(63%): | | 0.2sec (nominal) | | |
| • Warm up time: | | 10 sec. | | |
| • Accuracy: | | < 0.3% full-scale | | |
| • Output (Factory Set): | | Zero to +2.5V d.c. (or zero to +5.0V d.c. option) | | |
| • Temperature coefficient: | | < 0.05% full-scale / $^{o}C$ | | |
| • Zero offset: | | 0 to +0.4% full-scale | | |
| • Power supply: | | +7V to + 18V d.c. (nominal 20 mA) | | |
| • Transient Surge from start-up: | | 50mA for 100ms. | | |

## 1.3 Technology

- Light Loss

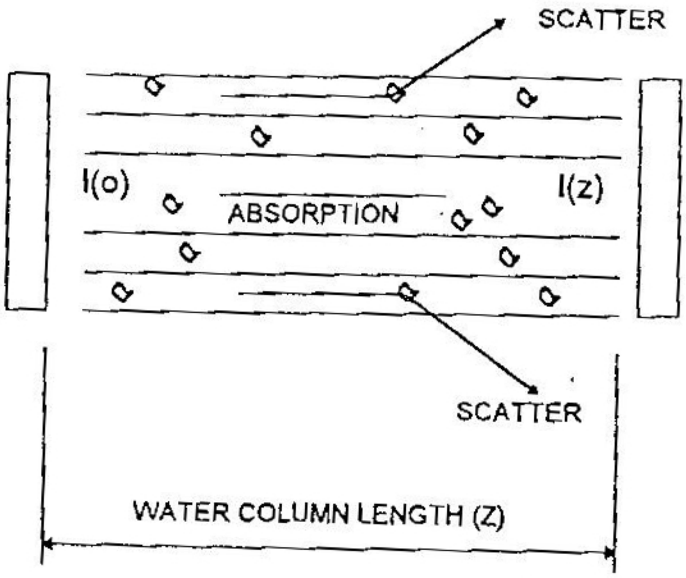


**Fig.No.1.1 Light Loss Pattern**

For a well collimated monochromatic beam travelling through a water column containing particles, light loss is either by absorption into other forms of energy, or scatter outside of the collimated beam. The amount of light loss depends upon the length of the water column(z) and the coefficients of absorption [Beta(b)] and scatter [Gamma(g)].

These coefficients have units of m-1 and are independent of the length of the water column; however, the total light loss is dependent upon the length of the water column, so it is always related to the path length.

Light loss due to absorption is given by:

$$I(z) = I(o)e^{-bz} \quad \text{(b = coefficient of absorption)}$$

and light loss due to inelastic scatter, (i.e. no loss of energy, only change of direction) is given by:

$$I(z) = I(o)e^{-gz} \quad \text{(g = coefficient of scatter)}$$

Total light loss is the sum of that by both absorption and scatter, so the beam attenuation coefficient alpha(a) = b + g.

Therefore:

$$I(z) = I(o)e^{-az} \quad \text{(a = beam attenuation coefficient)}$$

Light Transmission T(z) is given by:

$$T(z) = \frac{I(z)}{I(o)} = e^{-az}$$

- Beam Attenuation Coefficient

The beam attenuation coefficient alpha(a) is contributed to by three factors; firstly that due to the basic water sample(Aw), secondly that due to suspended particles(Ap), and thirdly that due to organic decay (humic acids)(Ah). At 660nm (red) as used by Alphatracka MKII, the attenuation due to humic acids (yellow) is so small that it can be safely ignored for most purposes.

Therefore:

$$a = Aw + Ap$$

Beam attenuation due to suspended particles(Ap) is dependent upon the optical characteristics of the particles. This varies from region to region, but not to any great extent within a specific survey area. Thus Alphatracka MKII can be used to determine particle concentrations.

At up to moderate concentrations, the relationship between particle concentration and percentage light transmission T(z) can be assumed to be linear with an off-set due to the loss in the basic water sample(Aw).

The beam attenuation coefficient due to suspended particles(Ap) depends upon the specific characteristics of each particle(Ap1) and the quantity(N) per unit volume of water sample.

Therefore:

$$a = Aw + N(Ap1)$$

From the previous page we have Light Transmission(Tz):

$$T(z) = e^{-az}$$

so we now have:

$$T(z) = e^{-(Aw+N(Ap1))z}$$

$$= e^{-Awz} e^{-N(Ap1)z}$$

The light loss for Alphatracka MKII due to water is $e^{-Awz}$ which can be set as a constant(Tw). This gives:

$$T(z) = Tw\ e^{-N(Ap1)z}$$

Taking the logarithm of each side gives:

$$\text{Log } T(z) = \text{Log } Tw\ (-N(Ap1)z)$$

Therefore, as both Tw and (Ap1)z are constant, the logarithm of the light [illegible] (Tz) is proportional to the particle concentration.

# 2 TECHNICAL DESCRIPTION

## 2.1 Construction

Alphatracka MKII consists of a Transmitter/Reference Assembly and a Detector Assembly aligned and spaced apart by a robust open support frame. Fig.No.2.1. shows the main components.

- Transmitter/Reference

The Transmitter/Reference Housing is sealed by an end cap which supports a four way subsea connector for power input and the signal output. Inside the housing is a LED light source and a reference diode mounted within the transmission cone of the LED. Adjustment is included to allow precision factory adjustment of the beam alignment and collimation which is then set and sealed. The collimated beam leaves the housing through a sealed window. The circuitry for controlling the drive to the LED and feedback from the reference diode, is mounted on two surface mount PCBs.

- Detector

The Detector Housing is also sealed by an end cap. Inside the housing is the signal photodiode, which is mounted in an adjustable sleeve to allow positioning. The collimated beam enters the housing through a sealed window onto the focusing lens. The circuitry associated with the signal photo diode is mounted on a single surface mount PCB, mounted within the housing.

- Support Frame

A Titanium open support frame provides a robust mounting for both of the optical housings, and fixes the spacing between the two optical systems. The robust but light construction ensures that the precise factory alignment and calibration is maintained during operational use, baffles are provided to assist ambient light rejection.

## 2.2 Optical Layout

The LED light source assembly is mounted on three screws; this provides kinematic adjustment of the LED to position it at the focal point of the collimating lens. The light cone from the LED is collimated into a 15mm dia. parallel beam with minimal divergence. It leaves the housing via a fused silica window.

Mounted close to the LED is a reference diode which monitors the LED output; this is used as feedback into the signal processing circuitry and enables Alphatracka MKII to achieve excellent long-term calibration stability.

The collimated beam enters the Detector Assembly through a fused silica window onto a focusing lens. The signal photo diode assembly has a screw thread on the outer diameter which allows it to be positioned correctly.

The optical system is accurately set-up during manufacture and all components are sealed in position before calibration. The basic light path is shown in Fig.No.2.1.

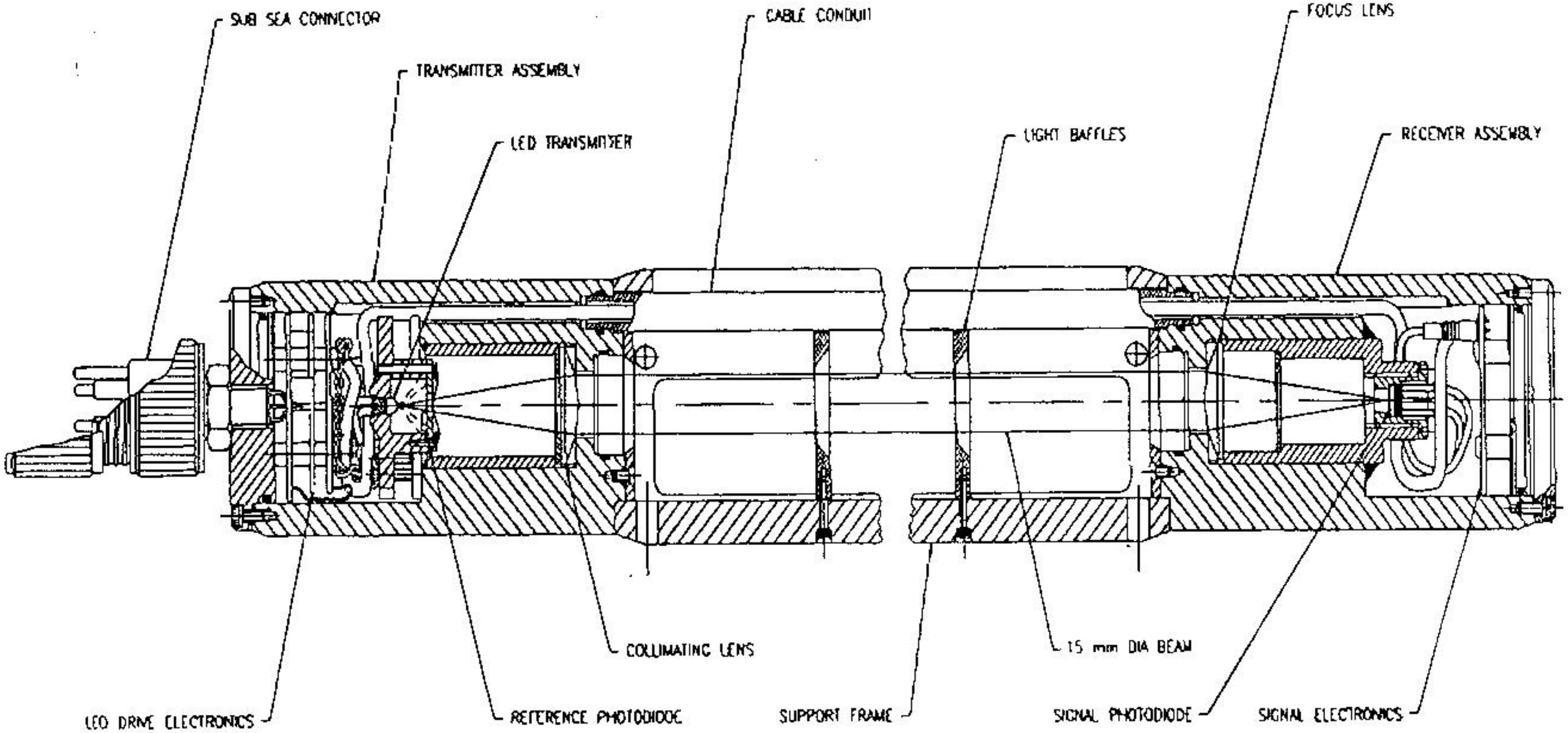


Fig.No. 2.1 Alphatracka MkII
GA & Optical Layout

## 2.3 Control Electronics

A diagram of the basic electronic modules is shown in Fig.No.2.2.

The electronics are mounted on three surface mount PCBs, two controlling the LED transmitter and reference photodiode and one controlling the signal photodiode. A screened cable connects the two transmitter PCBs to the detector PCB, via a Titanium tube running along the titanium support frame defining the optical path.

The LED transmitter is driven by a modulated source and viewed by a reference photo diode. The signal channel uses a carrier frequency of 340Hz which is suitable to give effective rejection of wave glitter when operating near the surface.

A digitally controlled servo loop balances appropriate fractions of the signals received by the reference and signal photo diodes. The user output voltage is, in principle, independent of LED output ageing and LED temperature coefficient effects.

The resulting stable performance of AlphaTracka is obtained by locking the optical and electrical characteristics together in a null seeking servo loop. This interaction between a precision optical system and sophisticated electronics does mean that the instrument should be returned to the factory for any repairs that require the instrument to be opened up. If, due to operational conditions, it is not possible to return damaged equipment to the factory for repair, refer to Section 3.3.

# 3 ELECTRICAL INTERFACING

## 3.1 Interconnections

The signal and power interconnections are shown below and the subsea connector pin outs detailed in Fig.No.3.1.

| REAR BULKHEAD TERMINAL | SIGNAL | REAR END CAP PIN |
|---|---|---|
| 1 | PWR + | 1 |
| 2 | SIG Lo | 2 --) SIG Lo and PWR - |
| 3 | SIG Hi | 3 ) are internally |
| 4 | PWR - | 4 --) connected and must remain so. |

It is important to note that Power Low (PWR-) and Signal Low (SIG Lo) are connected internally inside Alphatracka MKII and this link must NOT be broken. This means that the normal good practice of using a differential or instrumentation amplifier to receive the output voltage should be observed. Since most chart recorders and data loggers use this type of input, this should not be a problem.

Since the output resistance of Alphatracka MKII can be considered zero for practical purposes, it is only the cable resistance which is likely to determine the minimum permissible input resistance of the data recording or display device. If the input resistance is at least 10,000 times the cable resistance (i.e. a total of both conductors), there will be less than 0.01% shift in calibration at the recorder. Since most modern recording or display devices have an input resistance of at least 1 megohm, this means that cable resistance below 100 ohms are of negligible concern.

If it is necessary to 'pot down' the output voltage to a lower level to accommodate a more sensitive recording device, this should be done at the receiving end so that the higher level signal is transmitted through an environment which may be noisy. The potential divider should have a total resistance at least that in accordance with the discussion in the previous paragraph, and it is good practice to put a suitable capacitor across the lower leg to filter out interference. If the associated time constant is less than 0.05 sec, it will have little effect on the settling rate seen at the recorder.

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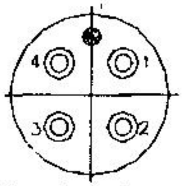
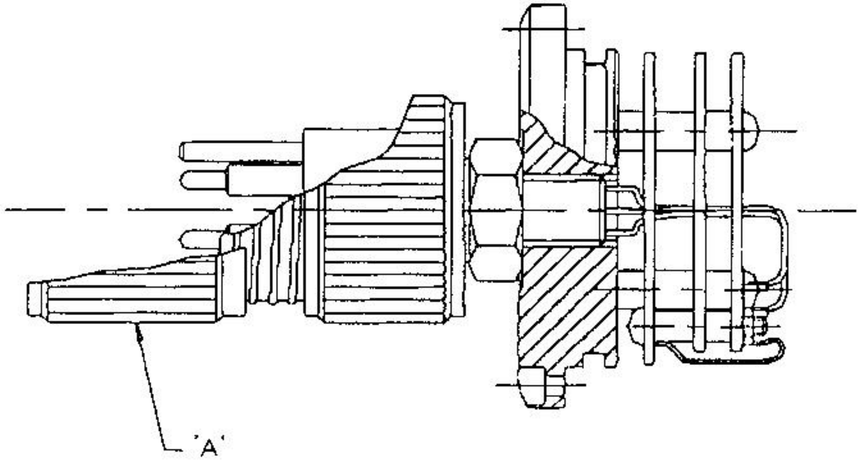
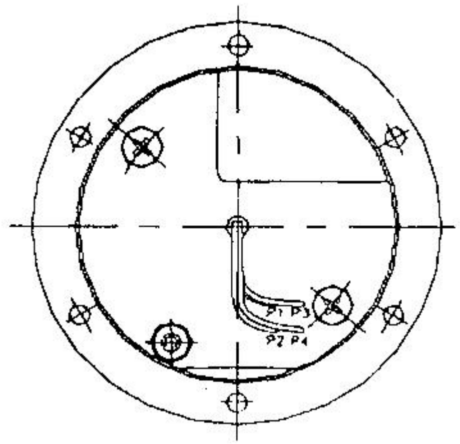



VIEW ON BULKHEAD CONNECTOR PINS.




INTERCONNECTIONS

| DESIGNATION | 8H-4-MP PIN/WIRE No. | REF 2 PCB PIN No. |
|---|---|---|
| PWR- | 4 | P2 |
| SIG OUT | 3 | P3 |
| SIG GRO | 2 | P4 |
| PWR+ | 1 | P1 |

NOTE:- MATING CONNECTOR IMPULSE IL-4-FS.
FIT LOCKING SLEEVE BEFORE MOULDING CONNECTOR TO OTHER END OF FLYING LEAD.

Fig.No.3.1 Connector Pinout

## 3.2 Interface Maintenance

The very stable performance of Alphatracka MKII relies on precise interaction between the optical system and the sophisticated electronics. This means, that to meet the warranty conditions, the instrument must be returned to the factory for any repairs that require the instrument to be opened up.

It is appreciated however that there can be operational conditions that make it impossible to return damaged equipment to the factory for repair. For this reason the following information is supplied, without prejudice to the warranty conditions.

The output driver operational amplifiers Q9A & B are the 'industry standard' OP-97 and these are surface mounted on the underside PCB PC5499 facing the subsea connector. Q9A drives the 2.5V output and Q9B drives the 5.0V output.

In system usage, instrument packages are usually damaged by either excess supply voltage or by injecting currents into output stages. If the output voltage of Alphatracka MKII is 'stuck' above +5V or below -4V, it is possible that Q9A or Q9B has been damaged by such mistreatment. In this case, users could replace both Q9A and Q9B; this will not shift the output voltage by more than 0.15 millivolts, which is quite insignificant.

If spare operational amplifiers are not available, it is possible that either Q9A or Q9B is still functional. Thus if the instrument was working on the 2.5V range when damaged, Q9A could be discarded and Q9B substituted for it; if on the 5V range, discard Q9B and try Q9A in its place. In neither case will the calibration shift by more than 0.15 millivolts by this substitution.

# 4 DEPLOYMENT and CALIBRATION

Alphatracka MKII has been designed to make it both electrically and optically rugged. However it is important to observe the following points if satisfactory data is to be obtained.

## 4.1 Deployment

- To ensure that the optical system is not strained during deployment, four M4 mounting holes have been supplied in the Support Frame. The position of these can be seen in Fig.No.4.1. and they must be used to mount Alphatracka MKII to the deployment system.

  NOTE: Only mount Alphatracka MKII using the fixing holes supplied; on no account clamp by the end housings as optical misalignment will almost certainly occur.

- Alphatracka MKII may be mounted either vertically or horizontally. If mounted vertically for long periods, and in a static position, beware of a build-up of deposits on the lower window.

- The deployment system must provide support for the connecting cable, and the cable be routed and clamped such that there is not any strain on the connector.

- Before mating the connector, ensure that the two halves are clean and then lightly lubricate the contacts with petroleum jelly or silicone oil. Do not over lubricate as this can cause the connector to become dis-connected during operational use.

- After each deployment, wash the complete instrument in clean fresh water to remove all traces of salt and debris. Lightly dry the instrument, taking care not to scratch either of the two windows (see below). The calibration of the instrument relies on the integrity of the optical system.

- It is important to keep the windows clean. This must be done using soft, clean, lint free cloth, and plenty of distilled water. If there are stubborn deposits, a small amount of detergent can be added.

An air reading can be taken, and compared with that obtained at the time of manufacture, to confirm the condition of the windows. This is **NOT** a calibration; see section 4.2.

**NOTE: Your attention is drawn to the warning in section 4.2. regarding the condition of reference water samples. Their condition deteriorates very quickly and decrease in instrument output is more likely due to changes in the water sample than in instrument malfunction.**

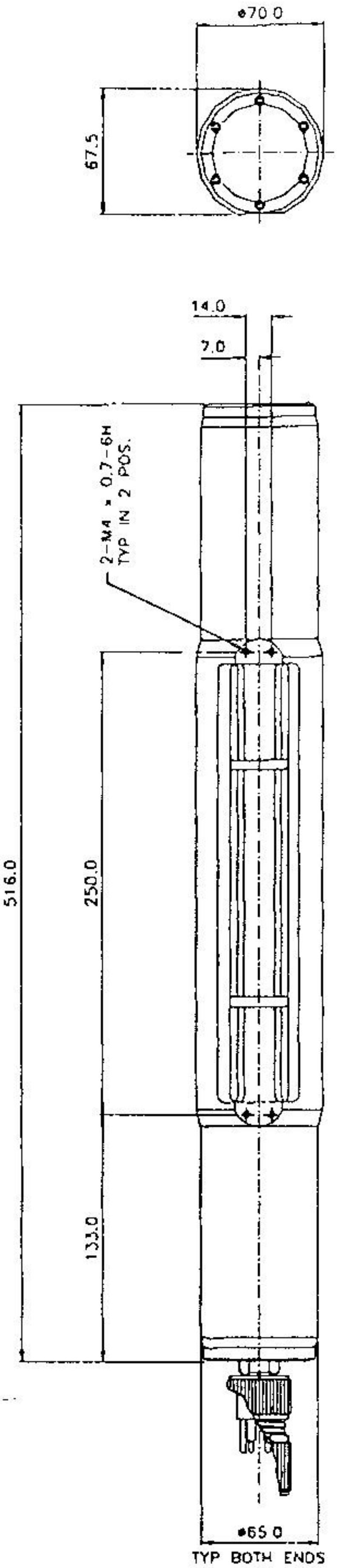



**Fig.No. 4.1 Mounting Holes for deployment**

## 4.2 Calibration

**Note: The beam attenuation coefficient in pure water at 660nm has been determined as 0. 4$m^{-1}$ ± 15%, Raymond Smith and Karen Baker - Applied Optics Vol. 20 (1981). For a 25cm water column transmissometer this gives a transmission of 90.5 ± 1.4%.**

- The nominal calibration parameters for a 25cm Alphatracka MKII are as follows:

| | Output Voltage Option 2.5V | 5.0V |
|---|---|---|
| 90.5% ± 1.4% Transmission pure water. | 2.1V | 4.2V |

Alphatracka MKII is calibrated at the factory at 20°C in distilled water with an electrical conductivity less than one microSiemen/cm and filtered to better than 5 microns. The output voltage, measured under these conditions, is recorded on the calibration certificate.

**NOTE: Great care is needed when preparing pure water samples for use as a calibration reference. Due to bacterial and algae growth the sample quickly deteriorates and the transmission level drops; even though there is not any apparent visual effect. Any observed reduction in instrument output is more likely to be due to this deterioration than instrument malfunction. It is advisable to compare the output from two instruments when carrying out a calibration.**

- It is possible that the user will encounter water which is purer than that used during the calibration. In this situation Alphatracka MKII will give a higher output voltage which may be substituted for the pure water voltage on the calibration record.
- The design of the light source with its internal reference beam and ratiometric signal processing system compensate for changes in source intensity, so adjustment is not required during normal operational use.
- V(offset) is measured prior to delivery and recorded on the calibration certificate. It can be checked by blocking the receiving window completely and checking the signal output.
- An air reading is also taken prior to delivery and entered on the calibration certificate. This can be repeated before each deployment to confirm that the windows are clean. This is NOT a calibration but is a convenient way to confirm the operation of the instrument. The windows must be clean and dry as any small deposit or fluid will modify the voltage output.
- Possible sunshine effects can be checked by blocking off the transmission window and comparing the readout with that obtained for V(offset).

## 4.3 Calculation of Beam Attenuation Coefficient

- The light transmission T(z) for a measured output is:

$$T(z) = \frac{(Vmeasured - Voffset)}{Vfullscale - Voffset)}$$

From section 1.3 we have:

$$T(z) = \frac{I(z)}{I(o)} = e^{-az}$$

Therefore:

$$\frac{-\log T(z)}{z} = a \quad \text{(units } m^{-1}\text{)}$$

$$a\,(m^{-1}) = -\log \frac{[(Vmeasured - Voffset)]}{[(Vfullscale - Voffset)]} \times \frac{1}{z}$$

For a 25cm Alphatracka MKII z = 0.25 so:

$$a\,(m^{-1}) = -\log \frac{[(Vmeasured - Voffset)]}{[(Vfullscale - Voffset)]} \times 4$$

- The interpretation of results must take into account the optical characteristics of the suspended particles in the area of operation. The ratio of suspended particle mass to beam attenuation must be determined experimentally.

- There is a small error due to the component of forward scattered light measured by the detector, which causes an over estimation of transmission. The Mie theory may be applied, using the value of detector acceptance angle given in section 1.3, to calculate the scatter error.