



Hydrophones

types 8101, 8103, 8104 and 8105

USES:

- Waterborne-sound measurements
- Calibration reference standard
- Ultrasonic measurements in liquids
- Cavitation measurements
- Laboratory and industrial measurements in liquids and gases
- As underwater projectors (8103, 8104 and 8105)
- Noise measurements in humid and polluted atmospheres

FEATURES:

- Frequency ranges from 0,1 Hz to 180 kHz
- Individually calibrated; traceable to NBS
- Flat frequency response over wide range
- Omnidirectional over wide frequency range
- Working pressure up to $4 \cdot 10^6$ Pa (40 atm. [400 m])
- Shielded-element construction
- Highly corrosion resistant
- Low-noise low-capacitance cable to MIL-C-915 (8101, 8104 and 8105)

ADDITIONAL FEATURES 8101:

- Built-in preamplifier with provision for insert voltage calibration
- Inherent noise level well below sea-state zero and close to Wenz's lowest ambient

ADDITIONAL FEATURES 8103:

- Very small size (50 × 9,5 mm)
- -3 dB limit in air at 15 kHz
- Double-shielded low-noise integral cable

ADDITIONAL FEATURES 8104:

- Calibration reference standard

ADDITIONAL FEATURES 8105:

- Omnidirectional over full frequency range
- Working pressure up to 10^7 Pa (100 atm. [1000 m])
- No metallic parts exposed
- -3 dB limit in air at 7 kHz

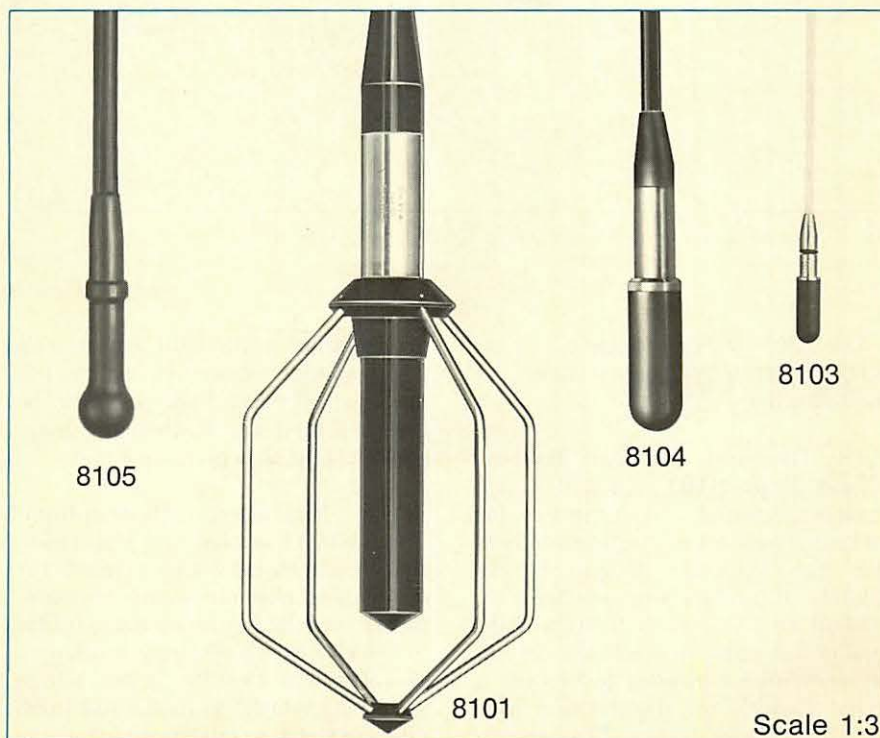
The B & K range of Hydrophones is a range of individually calibrated waterborne-sound transducers which have a flat frequency response and are omnidirectional over a wide frequency range. Their construction is such that they are absolutely waterproof and have good corrosion resistance. There are four types of B & K Hydrophone:

Type **8101** has a built-in amplifier which gives a signal suitable for transmission over long underwater cables.

Type **8103** is suitable for laboratory and industrial use and particularly for the acoustic study of marine animals or for cavitation measurements.

Type **8104** is ideal for calibration purposes.

Type **8105** is a robust spherical hydrophone usable down to 1000 m ocean depth with excellent directional characteristics, being omnidirectional over 270° in the x-z plane and 360° in the x-y plane.



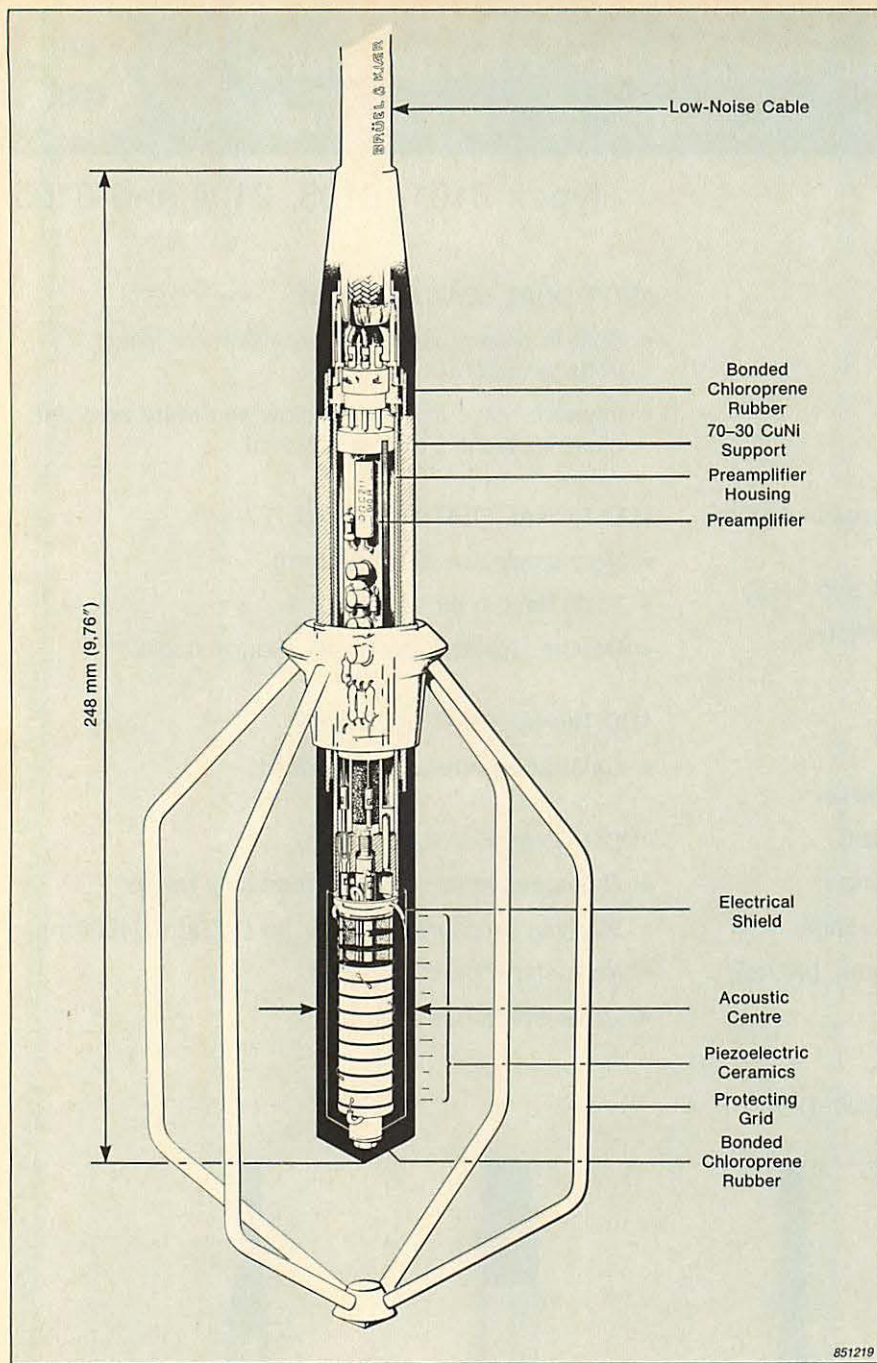


Fig. 1. Schematic drawing of hydrophone construction, Type 8101

The Brüel & Kjær range of waterborne-sound transducers consists of the following:

The **General Purpose Hydrophone Type 8101** is a wide-range waterborne-sound transducer for making absolute sound measurements over the frequency range 1 Hz to 120 kHz with a receiving sensitivity of $-184\text{ dB re } 1\text{ V}/\mu\text{Pa}$. A built-in high-quality low-noise preamplifier acts as an impedance converter to provide a signal suitable for transmission over long underwater cables. The built-in

preamplifier of the 8101 features an insert voltage calibration facility, but does not allow the hydrophone to be used as a projector. A schematic drawing of the 8101 is given in Fig. 1.

The **Miniature Hydrophone Type 8103** is a small-size high-sensitivity waterborne-sound transducer for making absolute sound measurements over the frequency range 0.1 Hz to 180 kHz with a receiving sensitivity of $-211\text{ dB re } 1\text{ V}/\mu\text{Pa}$. It has a high sensitivity relative to its size and good all-round characteristics which make

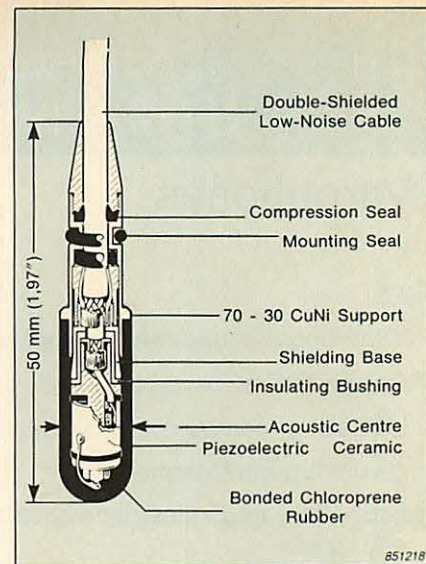


Fig. 2. Schematic drawing of hydrophone construction, Type 8103

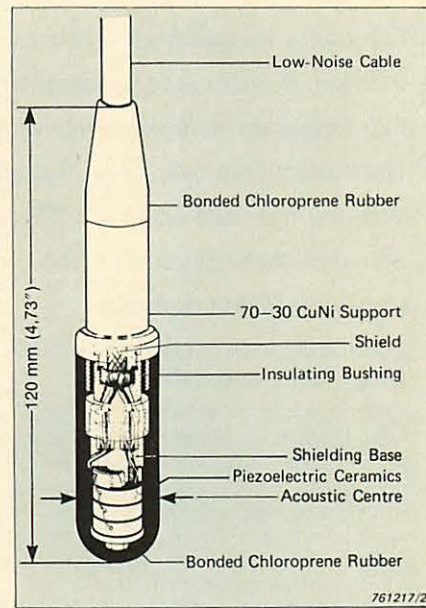


Fig. 3. Schematic drawing of hydrophone construction, Type 8104

it generally applicable to laboratory, industrial and educational use. The 8103's high-frequency response will be specially valuable when making acoustic investigations of marine animals and, for example, in the measurement of the pressure-distribution patterns in ultrasonic-cleaning baths. It is also particularly useful for cavitation measurements. Fig. 2 shows a schematic drawing of the 8103.

The **Standard Measuring Hydrophone Type 8104** is a wide-range waterborne-sound transducer

for making absolute sound measurements over the frequency range 0,1 Hz to 120 kHz with a receiving sensitivity of $-205\text{ dB re } 1\text{ V}/\mu\text{Pa}$. It can also be used as a sound transmitter (projector) which makes it ideal for calibration purposes by the reciprocity method, by the calibrated-projector method, or by the comparison method. The 8104 is shown schematically in Fig. 3. **Note:** Standard Measuring Hydrophones Types 8100 and 8104 are now available under one type number, Type 8104. Apart from accessories the two were identical.

The **Spherical Hydrophone Type 8105** is a small waterborne-sound transducer for making absolute sound measurements over the frequency range 0,1 Hz to 160 kHz with a receiving sensitivity of $-205\text{ dB re } 1\text{ V}/\mu\text{Pa}$. It is rugged, being capable of withstanding pressures of up to 10^7 Pa (100 atm.; 1000 m (3250 ft.) ocean depth). The Hydrophone Type 8105 has excellent omnidirectional characteristics: it is omnidirectional over 360° in the x - y plane and 270° in the

x - z plane. The Type 8105 is shown schematically in Fig. 4.

Construction

The four B&K hydrophones are piezoelectric transducers, i.e., they use piezoelectric ceramics as sensing elements. The piezoelectric sensing element and its internal supporting structure are permanently bonded into sound-transparent polychloroprene rubber. The support body of the hydrophone is made from a 70-30 Copper-Nickel alloy, which has extremely high corrosion resistance to virtually all hostile environments, and very good anti-fouling properties when immersed in seawater. The Type 8105 has no metal parts exposed.

The internal support is mechanically and electrically isolated from the metal housing, being coupled only by synthetic rubber. This provides vibration isolation of the sensing element. The hydrophones are equipped with an integral cable, the shield of which is connected to the internal support, thus providing electrical shielding for

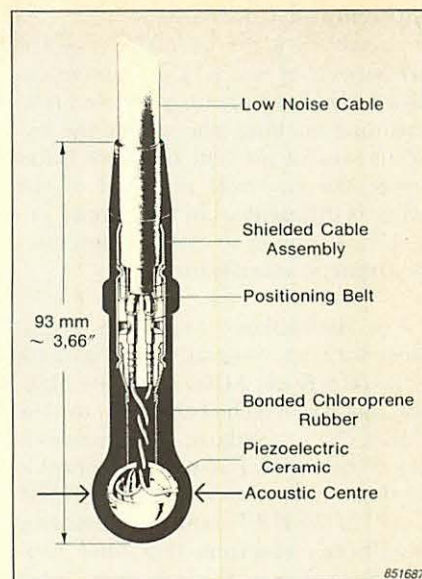


Fig. 4. Schematic drawing of hydrophone construction, Type 8105

the sensing element. Note that the Type 8103 has its internal support and metal housing connected at the plug end of the cable.

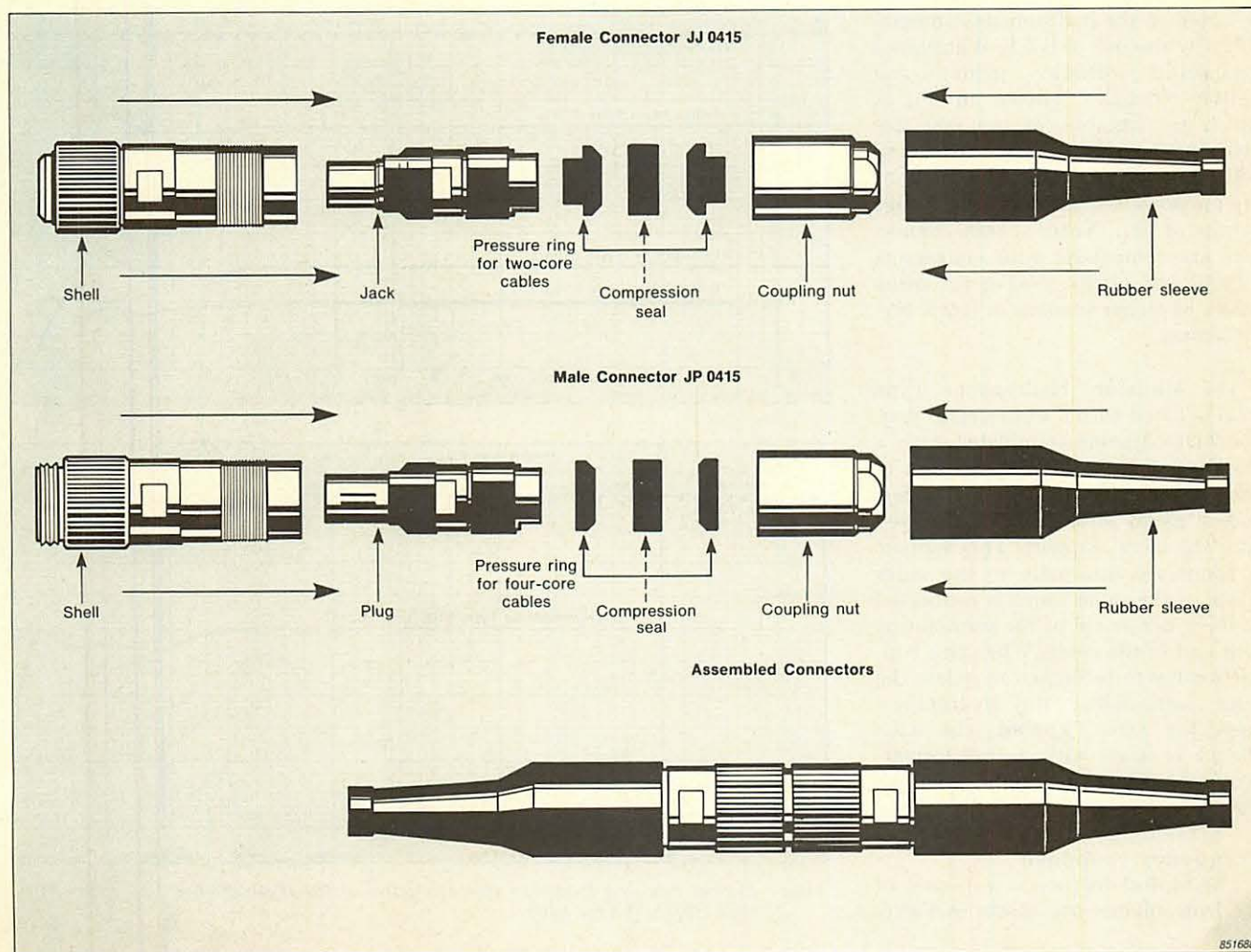


Fig. 5. Exploded view of B&K Waterproof Connectors JP0415 and JJ0415

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Cables and Connectors

Special care has been taken in the production of B & K hydrophone cables in order to obtain good electrical shielding enabling the use of the hydrophones in air and in water tanks where the electrical potential of the water is different from the ground potential, as well as in cases of high electromagnetic interference.

The Hydrophone Type 8101 is supplied with an integral 10m low-noise cable (B & K no. AC0038) of the highest quality which conforms to the MIL-C-915 standard. This cable is fitted with a B & K 7-pin plug suitable for direct connection to the PREAMP. socket of the B & K range of measuring amplifiers, spectrometers and frequency analyzers. Hydrophones Types 8104 and 8105 also have integral 10m cables (AC0034) to the MIL-C-915 standard but these are fitted with BNC plugs.

For use at greater depths (up to 1000m with the 8105), MIL-C-915 standard extension cables of up to 300m are available to order. These can be fitted to the hydrophone's integral cable by the use of B & K Waterproof Connectors JP0415 (male) and JJ0415 (female), shown in Fig. 5, which are suitable for use with the Hydrophones Types 8101, 8104 and 8105. Pictorial assembly instructions are provided with each male or female connector set. **Note:** These connectors are compatible with connectors JP0205 and JJ0205 used on extension cables of earlier versions of B & K Hydrophones.

The Miniature Hydrophone Type 8103 is fitted with a 6m integral double-shielded cable terminated with a B & K miniature plug JP0056 and in cases of high electromagnetic interference a metal screen can be clamped onto the metal support. This support is connected internally to the outer shield of the cable which is connected to the inner shield of the terminating plug end of the cable. When this connection has to be broken to isolate the fluid surrounding the hydrophone from the signal ground, the 8103 should be used with a transformer-coupled output preamplifier such as the Type 2626.

Frequency response

The typical frequency responses of the hydrophones are shown in Fig. 6.

These are measured in a water tank in free-field conditions achieved by means of pulse techniques using a Gating System Type 4440.

Calibration

Each B & K Hydrophone is submitted to an extensive ageing and temperature stabilizing procedure before being individually calibrated. Individual calibration data and frequency response curves are supplied with each hydrophone. The receiving sensitivity calibration of the B & K Hydrophones is traceable to the National Bureau of Standards (Washington D.C.).

A convenient calibration check at low frequencies can be performed using the B & K Hydrophone Calibrator Type 4223. This provides a rapid and easy method for air calibration of sound measuring systems terminating in B & K Hydrophones. Being battery powered, the 4223 can be used both in the laboratory and in the field.

The principle of operation of the 4223 is the production of a sound pressure in the coupler cavity by four pistons which oscillate back and forth in phase. A frequency of 250 Hz is produced which is electronically maintained within $\pm 2\%$.

Fig. 7 shows sectional drawings of the Calibrator. The couplers supplied with the Calibrator are shown fitted with their respective B & K Hydrophones. The sound pressure levels produced in the coupler volumes are 157, 166, 162 and 151 dB re $1 \mu\text{Pa}$ for the 8101, 8103, 8104 and 8105, respectively. Note that the sound pressure level in the coupler volume can be monitored with a $1/2$ " microphone (see inset of Fig. 7), thus enabling the calibration to be traceable to NBS.

A barometer is supplied with the 4223 giving the atmospheric pressure correction in dB in the range $0.79 \cdot 10^5$ to $1.05 \cdot 10^5 \text{ Pa}$ (790 to 1050 mbar).

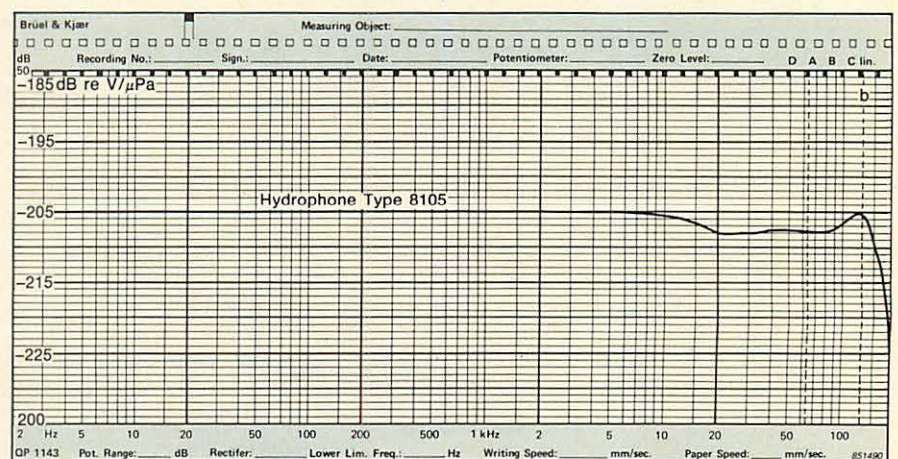
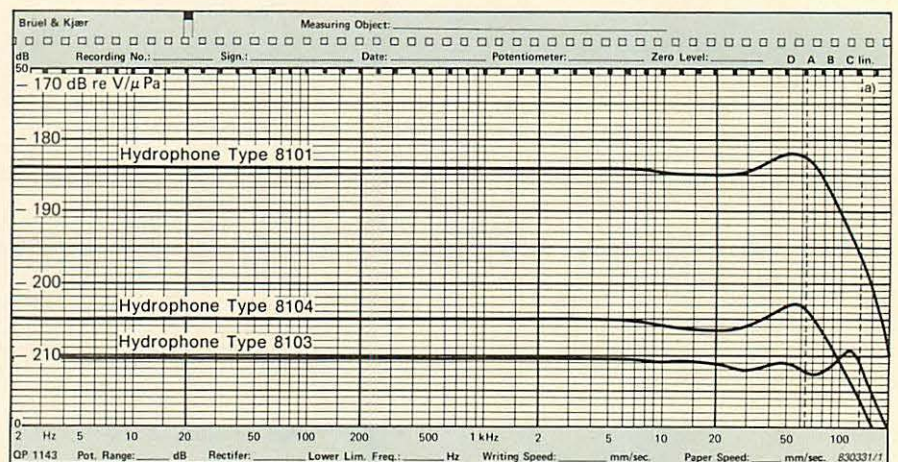


Fig. 6. Typical receiving frequency characteristics of the Hydrophones: (a) Types 8101, 8103, 8104; (b) Type 8105

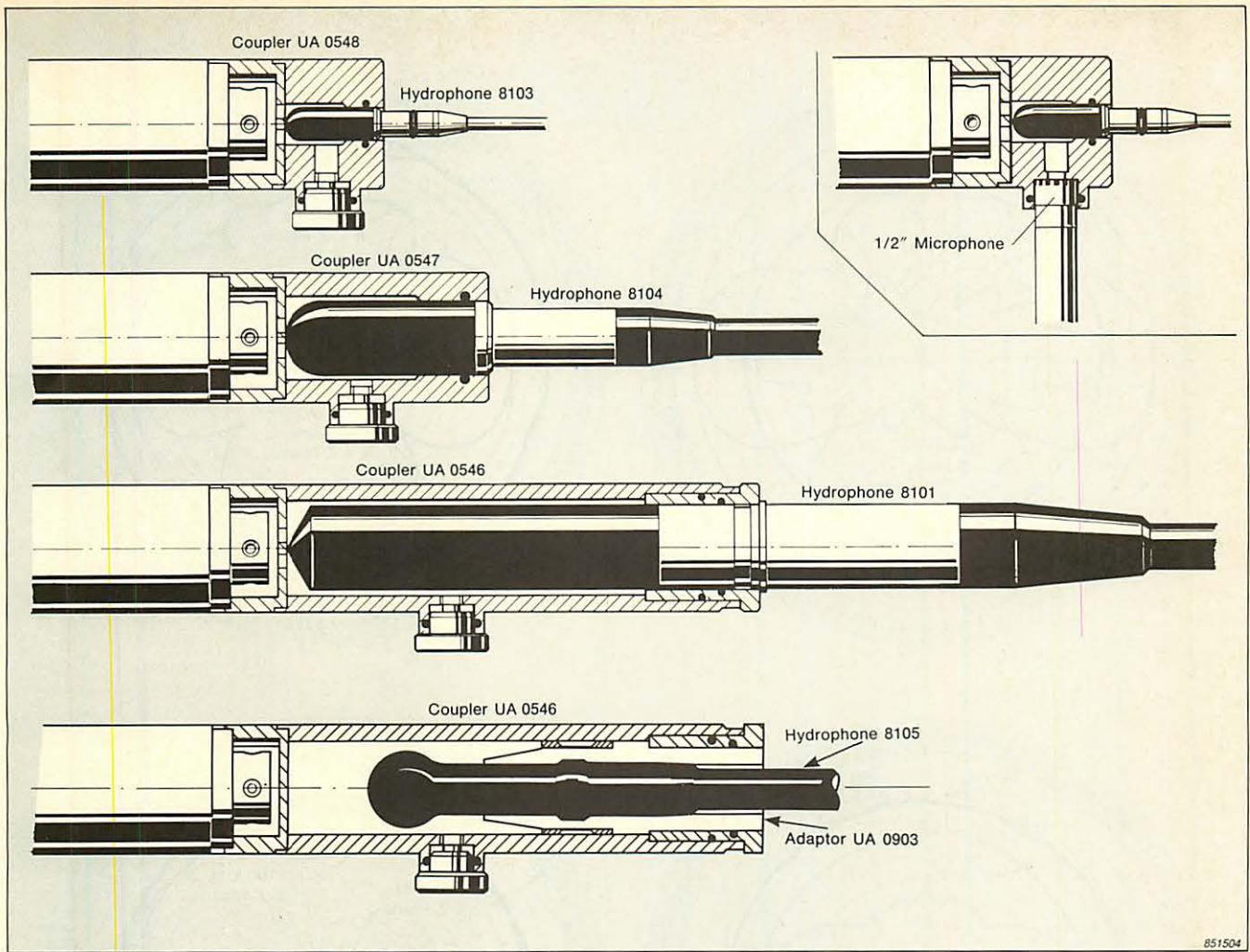


Fig. 7. Mounting of B&K Hydrophones and their respective couplers onto the Calibrator Type 4223. The inset shows a 1/2" microphone inserted into a coupler for monitoring the sound pressure level

Directivity patterns

The hydrophones have very good omnidirectional characteristics. The typical directivity patterns of the hydrophones in water are shown in Fig. 8. These polar directivity patterns have been measured in free-field conditions achieved by means of gating techniques in a water tank. This method requires a standard hydrophone as a projector and the unknown hydrophone as the receiver whose polar directivity pattern is to be determined.

Fig. 9 shows a typical arrangement which permits automatic plotting of the polar calibration charts. The output of the Sine Random Generator Type 1027 is gated into a series of tone bursts by the Gating System Type 4440 and amplified, if necessary, by a Power Amplifier Type 2713 to give a suitable signal level. It is transmitted to a Standard Measuring Hydrophone Type 8104 that operates as a projec-

tor, emitting a series of pulses under water. An Oscilloscope, triggered by the 4440, can be used to display the received signal and to monitor the measuring gate position.

The receiver Hydrophone (a Type 8104 is shown) is mounted on a Turntable Type 3922 so that the polar characteristics can be charted. The receiver signal is amplified and, if needed, filtered to remove low frequency components before it is passed to the Oscilloscope and the 4440.

A suitable delay is arranged to match the dimensions of the tank in use, so that the measuring gate is open only while the direct signal is being received, and closed when the reflected signals arrive. The figure also shows a typical emitted burst, the received signal complete with echoes, and the measuring gate signal showing the position of the measuring period.

A similar set-up can be used to determine the sensitivity of the unknown hydrophone.

Use as projectors

The piezoelectric effect of the sensing element is reversible, i.e., mechanical excitation causes an electrical output, and conversely, an applied alternating voltage causes corresponding mechanical excitation. Therefore, the Hydrophones Types 8103, 8104 and 8105 (but not the Hydrophone Type 8101 because of its built-in preamplifier), can be used as sound transmitters (projectors), for both measurement and reciprocity calibration. Transmitting responses to voltage for the Hydrophones Types 8103, 8104 and 8105 in water are shown in Fig. 10. Note the 12dB/octave slope which is typical for piezoelectric hydrophones.

When hydrophones are used as projectors, the driving signal requires

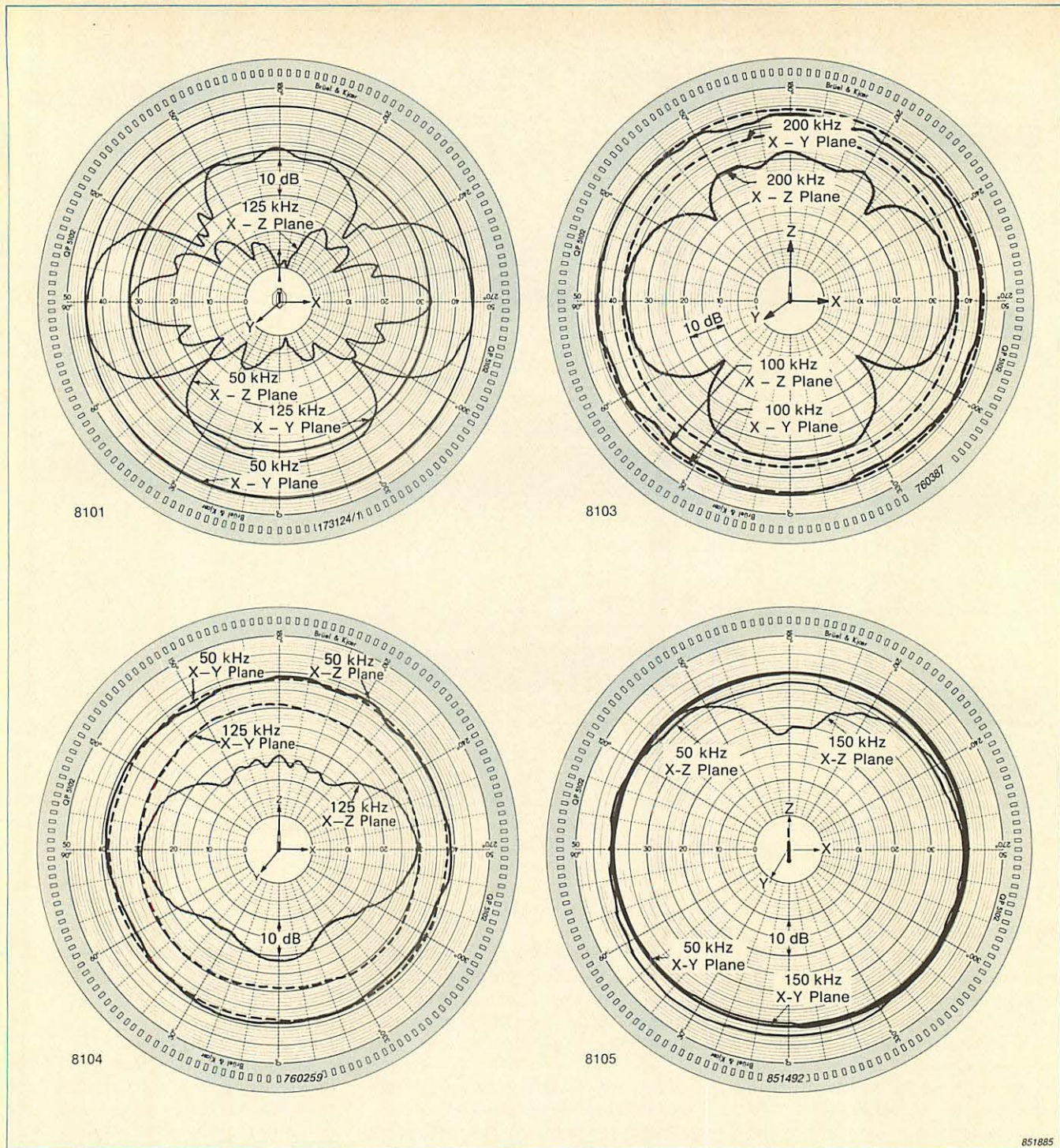


Fig. 8. Typical directivity patterns of the Hydrophones Types 8101, 8103, 8104 and 8105

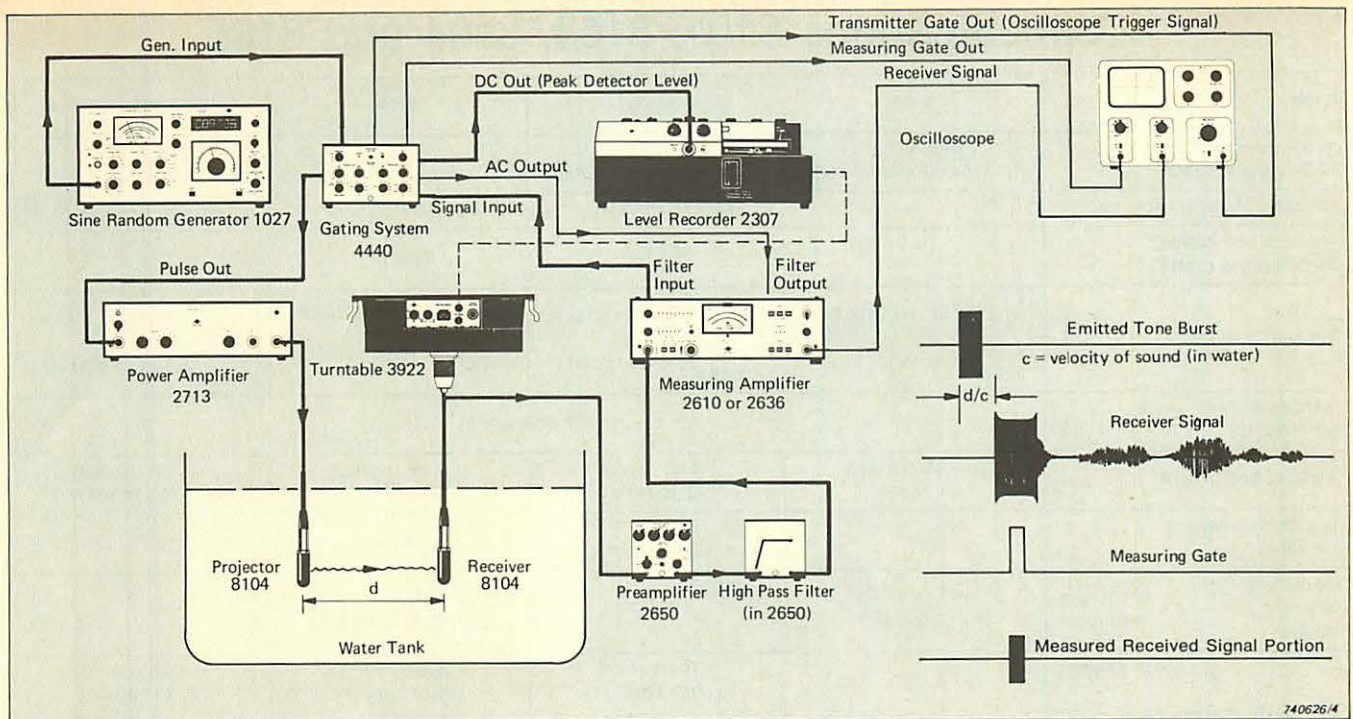
power amplification. The B&K Power Amplifier Type 2713 has been especially designed for driving the Hydrophones Types 8103, 8104 and 8105 used as projectors, but is also useful for driving other highly reactive loads. The 2713 is a low-noise 100VA power amplifier with a frequency range extending from 10 Hz up to 200 kHz, and a gain continuously adjustable be-

tween 0 and 60dB over six 10dB ranges. It also features selectable maximum output voltage limits as well as extensive protective functions to prevent damage to both the amplifier and the transducer.

Measurements

Before measurements are taken, the high-impedance output signals from

the Hydrophones Types 8103, 8104 and 8105 should be routed through a signal-conditioning amplifier. Although the entire B&K range of accelerometer preamplifiers is suitable, the use of the Conditioning Amplifiers Types 2626, 2635 or 2650 is particularly recommended. These preamplifiers feature a dial-in sensitivity adjustment to give convenient output values



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Fig. 9. Arrangement for obtaining polar directivity patterns of hydrophones in small water tanks

(for example 0,1 or 1 V/Unit) and have a wide frequency range, and adjustable low-pass and high-pass filters. Note that the 2635 is portable, being battery powered. For technical details of these preamplifiers, the reader is referred to their respective product data sheets.

The Hydrophone Type 8101 features a built-in preamplifier which acts as an impedance converter. The output signal does not require further conditioning and the 8101 can be directly plugged into the Preamplifier socket of the B & K range of measuring amplifiers, frequency analyzers and real-time analyzers which supply the necessary voltages.

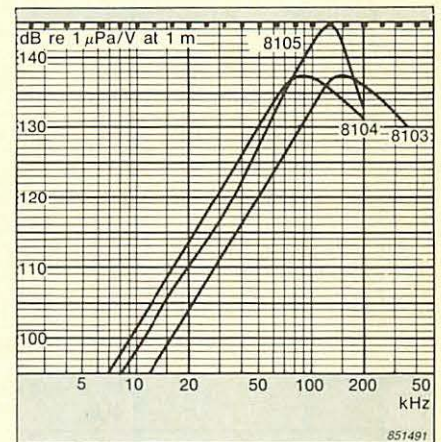


Fig. 10. Typical transmitting response to voltage of Types 8103, 8104 and 8105

Specifications Built-in Preamplifier 8101

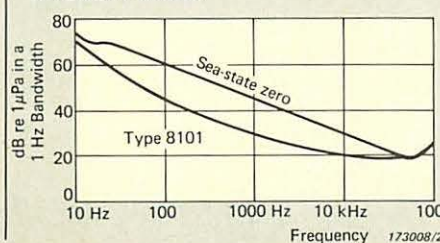
GAIN:
0 dB

FREQUENCY RANGE:
< 0,5 Hz to 300 kHz

INPUT IMPEDANCE:
1000 MΩ || 10 pF

MAXIMUM INPUT SIGNAL:
12 V supply: 2,5 V RMS (~3850 Pa)
24 V supply: 5,0 V RMS

INHERENT NOISE:



MAXIMUM OUTPUT SIGNAL:
12 V supply: 2,5 V RMS or 10 mA
24 V supply: 5,0 V RMS or 20 mA

OUTPUT IMPEDANCE:
< 50 Ω

POWER REQUIREMENT:
+12 to 24 V DC, 12 to 24 mA

Specifications 8101, 8103, 8104 and 8105

Type	8101	8103	8104	8105
Voltage sensitivity, nominal: (with integral cable)	630 $\mu\text{V}/\text{Pa}^*$ (-184 dB re 1 V/ μPa)	30 $\mu\text{V}/\text{Pa}^*$ (-211 dB re 1 V/ μPa)	56 $\mu\text{V}/\text{Pa}^*$ (-205 dB re 1 V/ μPa)	
Charge sensitivity, nominal:	—	$1,2 \times 10^{-7}$ pC/ μPa^*	$4,2 \times 10^{-7}$ pC/ μPa^*	$4,0 \times 10^{-7}$ pC/ μPa^*
Capacitance, typical: (with integral cable)	—	3850 pF	7800 pF	7200 pF
Frequency range:	(+1,5 dB) (-2,5 dB) 0,1 Hz to 60 kHz (+2 dB) (-10 dB) 1 Hz to 120 kHz	(+0,5 dB) (-3,5 dB) 0,1 Hz to 100 kHz (+2 dB) (-10 dB) 0,1 Hz to 180 kHz	(± 2 dB) 0,1 Hz to 80 kHz (+2 dB) (-10 dB) 0,1 Hz to 120 kHz	(+0,5 dB) (-4 dB) 0,1 Hz to 100 kHz (+2 dB) (-10 dB) 0,1 Hz to 160 kHz
Horizontal directivity: ● (at 100 kHz)	± 2 dB (typical)			
Vertical directivity: ●	± 2 dB (typical) at 15 kHz	± 4 dB (typical) at 100 kHz	± 2 dB (typical) at 50 kHz	± 2 dB (typical) over 270° at 100 kHz
Leakage resistance: (at 20°C)	— > 2500 M Ω			
Operating temperature range:	Short-term Continuous -10°C to + 60°C (14°F to 149°F)	-40°C to + 120°C (-40°F to 248°F) -40°C to + 80°C (-40°F to 176°F)		
Sensitivity change with temperature	Charge:	$\leq +0,03$ dB/°C (+0,017 dB/°F)	$\leq +0,03$ dB/°C (+0,017 dB/°F)	$\leq +0,03$ dB/°C (+0,017 dB/°F)
	Voltage:	0 to -0,03 dB/°C (0 to -0,017 dB/°F)	$\leq -0,03$ dB/°C (-0,017 dB/°F)	$\leq -0,04$ dB/°C (-0,022 dB/°F)
Max. operating static pressure:	252 dB = 4×10^6 Pa = 40 atm. = 400 m ocean depth			260 dB = $9,8 \times 10^6$ Pa = 100 atm. = 1000 m ocean depth
Sensitivity change with static pressure:	$\leq -3 \times 10^{-7}$ dB/Pa (-0,03 dB/atm.)			
Allowable total radiation dose:	5×10^7 Rad.			
Dimensions: Length:	248 mm (9,76")	50 mm (1,97")	120 mm (4,73")	93 mm (3,66")
Body dia:	24 mm (0,95")	9,5 mm (0,37")	21 mm (0,83")	22 mm (0,87")
Width across the cage:	132 mm (5,21")			
Weight: (including integral cable)	3 kg (6,6 lb)	170 g (0,37 lb)	1,6 kg (3,5 lb)	
Integral cable:	10 m waterblocked low-noise shielded cable to MIL-C-915 with 7-pin B & K plug	6 m waterproof low-noise double-shielded teflon cable with standard miniature coaxial plug	10 m waterblocked low-noise shielded cable to MIL-C-915 with BNC plug	
Accessories included:	Individual calibration chart and calibration data			
	Removeable protective cage 1 Adaptor DB 2609	Mahogany case		
Accessories available:	Waterblocked low-noise shielded extension cable to MIL-C-915 available to any length up to 300 m AC 0038 Underwater connectors: Male JP 0415 Female JJ 0415		Waterblocked low-noise shielded extension cable to MIL-C-915 available to any length up to 300 m AC 0034 Underwater connectors: Male JP 0415 Female JJ 0415	

* Nominal value, each hydrophone is supplied with its own calibration data

● See polar directivity diagrams given in Fig.7