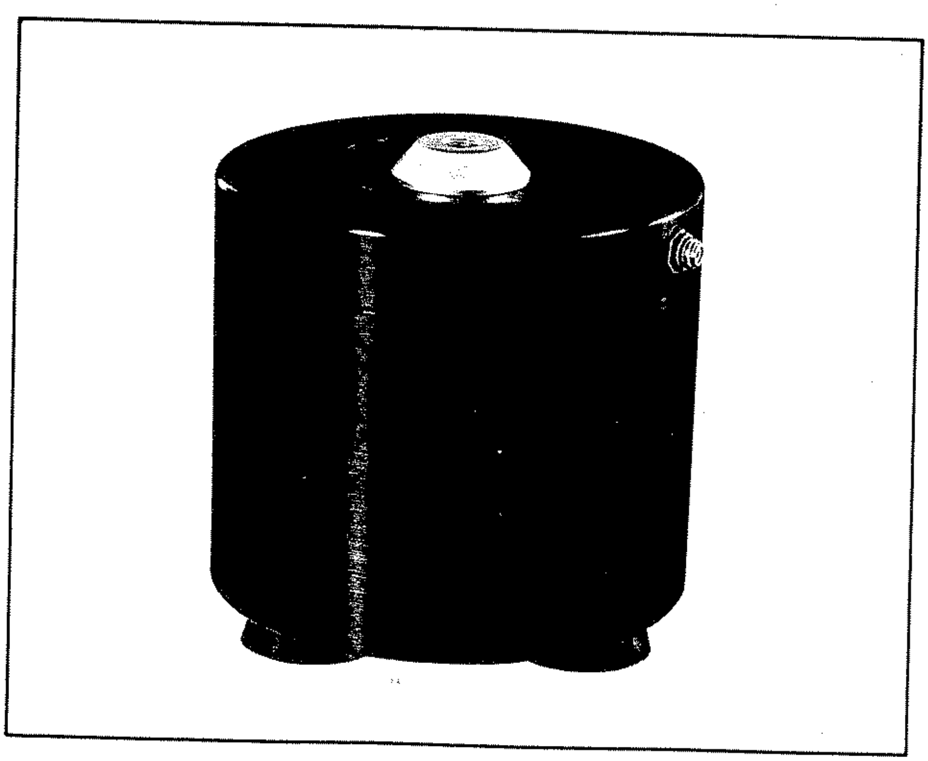
4810

Instruction Manual

Mini-Shaker Type 4810



A compact, permanent magnet, electrodynamic exciter with maximum force rating of 10 Newton (2,25 lbf) for transducer calibration, mechanical impedance measurements and testing of small objects at frequencies up to 18 kHz. Its moving coil has a nominal impedance at 500 Hz of 3,5 Ω with maximum current rating of 1,8 A RMS.

Brüel & Kjær

MINI–SHAKER TYPE 4810

Revision May 1987

CONTENTS

type 4810

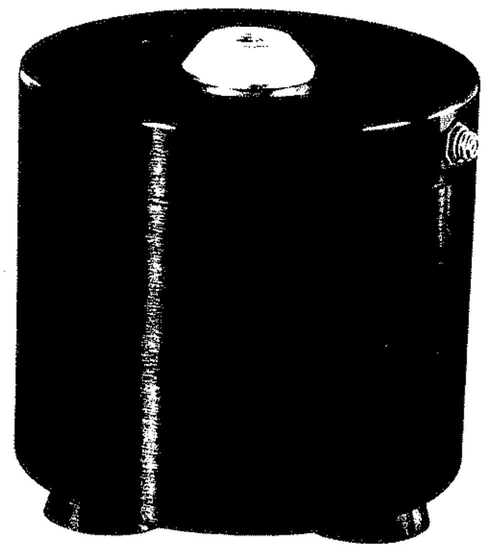
Mini-Shaker

FEATURES:

- Force rating 10 Newton (2,25 lbf) Sine Peak
- Frequency range DC to 18 kHz
- First axial resonance above 18 kHz
- Max. bare table acceleration 550 ms^{-2} (56 g)
- Rugged construction

USES:

- Calibration of accelerometers
- Vibration testing of small objects
- Educational demonstrations
- Mechanical impedance measurements



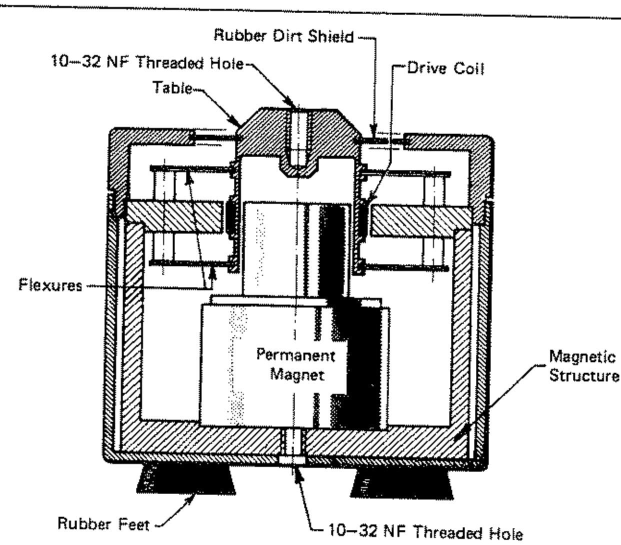


Fig. 1. Sectional drawing of the Mini-Shaker Type 4810

The Mini-Shaker Type 4810 is a small machine for the dynamic excitation of lighter objects, it is manufactured from quality materials to a high degree of precision and has proved to be a reliable and versatile tool in dynamic testing.

Type 4810 is well suited as the motive force generator in mechanical impedance measurements where only smaller forces are required.
It can also be used in the calibration of vibration transducers, both to determine their sensitivity by comparison with a standard accelerometer, and to determine their frequency response up to 18 kHz.

The Mini-Shaker is of the electrodynamic type with a permanent field magnet. A coil, which is an integral part of the table structure, is flexibly suspended in one plane in the field of the permanent magnet. An alternating current signal, provided by an external oscillator is passed through the coil to produce a vibratory motion at the table. A sectional drawing illustrating the method of construction is shown in Fig. 1.

The suspension system consists of radial flexure springs which restrict the moving element to almost perfectly rectilinear motion. Laminated flexure springs provide a high degree of damping to minimize distortion due to flexure resonances. The frequency response curves shown in Fig.2 show the highly damped flexure resonance around 50 to 60 Hz.

The object to be vibrated is attached to the table by means of a 10 — 32 NF screw; the thread size commonly used for mounting accelerometers. Performance limits which are defined by the maximum displacement (6 mm), maximum force (10 N or 7 N depending on frequency), and the first axial resonance of the moving element (above 18 kHz), are graphically shown in Fig.3.

Within these limits, the attainable acceleration can be determined by the expression.

$$a = \frac{F}{W}$$

where a = acceleration in ms^{-2} ($1\ ms^{-2} = 0{,}102\ g$)
F = shaker rated force in Newtons
W = exciter moving element weight + test object weight in kg

Examples of maximum test object weight for accelerations of 20 g and 5 g are drawn in on the curve.

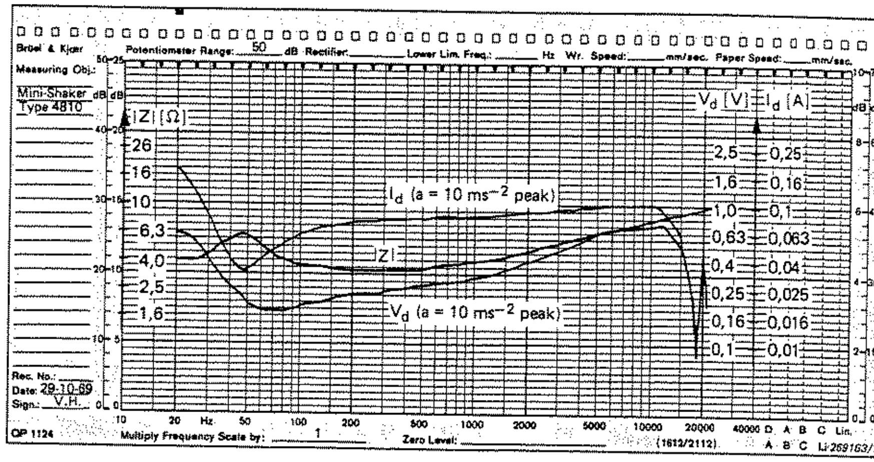


Fig.2. Frequency response of the 4810 for Impedance (Z), current (I) and voltage (V)

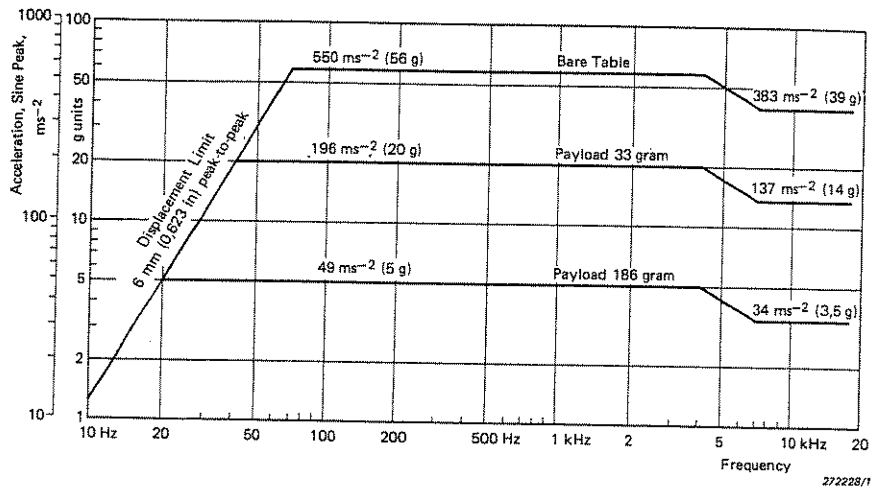


Fig.3. Sine performance curves for the 4810

In order to attain full rated output force from the 4810 it should be driven by Power Amplifier Type 2706. This is a power amplifier specially designed to drive small vibration exciters and has a current limiter to prevent overdriving the 4810. The Mini-Shaker can also be driven at a lower level by Sine Generator Type 1023. This has an output of 7,0 W which will drive the Mini-Shaker to a rated force of approximately 3,9 N (0,9 lbf) peak.

Specifications 4810

Frequency Range:
DC to 18 kHz

First Major Armature Resonance:
Above 18 kHz

Force Rating (Peak):
10 Newton (2,25 lbf) 65 Hz to 4 kHz
7 Newton (1,5 lbf) 65 Hz to 18 kHz

Max. Bare Table Acceleration (Peak):
$550\ ms^{-2}$ (65 Hz to 4 kHz)
$383\ ms^{-2}$ (4 kHz to 18 kHz)
($1\ ms^{-2} = 0{,}102\ g$)

Max. Displacement (Peak-to-Peak):
6 mm (0,236 in)

Dynamic Flexure Stiffness:
2 Newton/mm (11,5 lbs/in)

Dynamic Weight of the Moving System.
18 grams

Magnetic Field:
Permanent magnet

Max. Input Current:
1,8 A. RMS

Coil Impedance:
3,5 Ω at 500 Hz

Connection:
Microsocket NF 10 — 32

Table Size:
14 mm (0,55 in) diameter

Fastening Thread:
NF 10 — 32

Weight:
1,1 kg (2,4 lb)

Dimensions:
Diameter: 76 mm (3 in)
Height: 75 mm (2,9 in)

Accessories Available:
Cable for connection of Mini-Shaker to Power Amplifier AO 0069
Mounting Accessories (includes isolated studs YP 0150 and non-isolated studs YQ 2960) UA 0125

2. OPERATION

2.1. MOUNTING PROCEEDURE FOR THE 4810

The 4810 can be used in an upright position on its three rubber feet, for accelerometer calibration and testing small test-objects. If a more secure mounting arrangement is required, then it can be fastened to a workbench by using the 10-32 UNF threaded hole at the centre of its base, or the 3 mm screws securing its three rubber feet.

2.2. MOUNTING PROCEEDURE FOR TEST OBJECTS

The vibration table of the 4810 has a single fixing hole at its centre. This has a 10-32 UNF reinforced helical steel thread and is 10 ± 0,1 mm (0,4 ± 0,004 in) deep. For fixing accelerometers and vibration-test objects to the table, the 10-32 UNF steel mounting studs YQ 2960 are available. For breaking ground loops, the 10-32 UNF insulated studs YP 0150 and insulating mica-washers YO 0534 (ø 15 – ø 5 mm) or YO 0746 (ø 25 – ø 5 mm) are available. The correct mounting torque is 1,76 Nm (15 lbin).

To prevent damage to the 4810, always use a torque wrench for fixing accelerometers and test objects to the vibration table; ensure that the mounting stud does not bottom in the fixing hole. Also, ensure that the test object is mounted with its centre of gravity in line with the centre of the vibration table. Otherwise, unbalanced loads may cause the drive coil of the table to rub against the pole piece of the 4810.

When a test object is mounted on the vibration table, it will exert a force on the table creating a static displacement. If the displacement is too large, the test object should be suspended using resilient straps, so that the full mass of the test object does not bear directly on the table.

2.3. CONNECTING A POWER AMPLIFIER

Figure 2.1 shows the range of signal generators and the power amplifier which can be used to control the 4810.

The Sine/Noise Generator Type 1049, the Vibration Exciter Control Type 1050, and the Sine Generator Type 1051 can each control the 4810 via the Power Amplifier Type 2706. The power amplifier is specially designed to drive small vibration exciters and is sufficient to drive the mini-shaker to its full output force of 10 N (2,25 lbf). It has a current limiter which must be set to 1,8 A to prevent damage to the 4810.

The power input socket of the 4810 can be connected to the output socket of the 2706, using the cable kit AO 0069, which consists of cable AO 0038 plus adaptor JP 0145 and adaptor JP 0150.

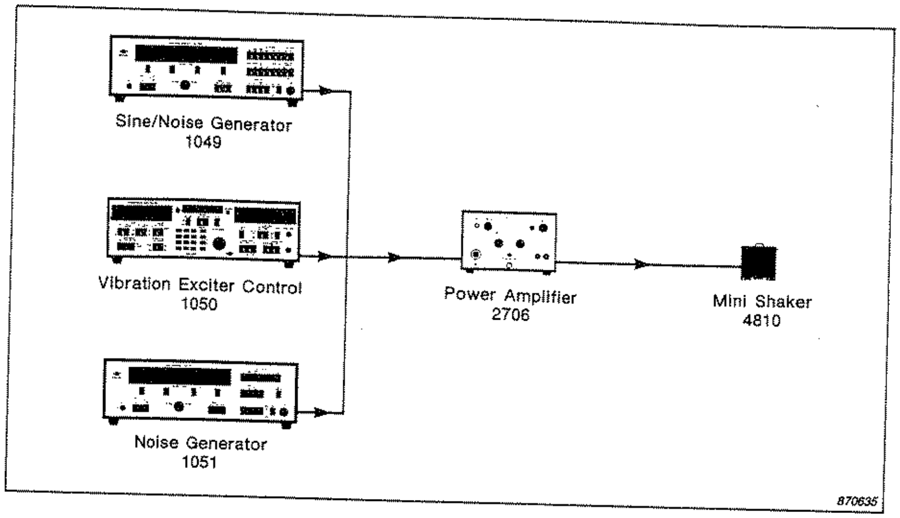


Fig. 2.1. Signal generators and power amplifier for use with Mini-Shaker 4810

3. OPERATING CHARACTERISTICS

3.1. CONSTRUCTION

A sectional view of the Mini-Shaker Type 4810 is shown in Fig. 3.1.

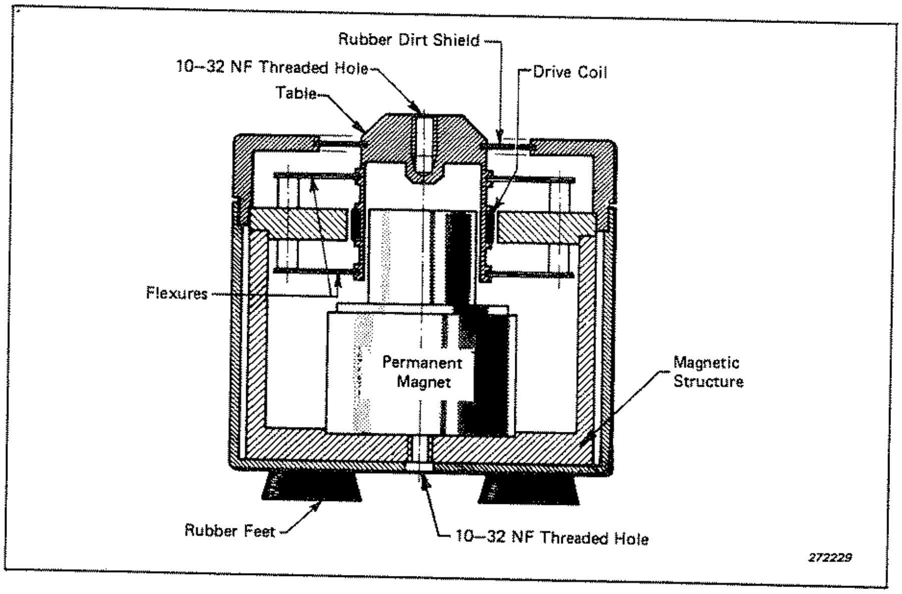


Fig. 3.1. Mini-Shaker Type 4810

3.1.1. Magnetic assembly

The 4810 uses a columax-alloy permanent magnet which is epoxy-bonded to the base of a low-carbon steel structure. A high purity, cylindrical, iron pole-piece projects from the magnet up through the centre of the flange, creating a circular air gap in which a 1 T (10^4 G) magnetic field is produced. The magnetic field above the table top is insignificant and therefore will not normally harm sensitive equipment used near to the mini-shaker.

3.1.2. Moving element

The moving element is a thin hollow cylinder which is connected at the top end to the vibration table, and at the other to the drive coil. It is designed to give the best possible coupling between the force generated by the drive coil and the test object on the vibration table. For maximum bare-table acceleration and for a high resonance-frequency, the moving element is machined from a lightweight aluminium solid. The vibration table has been hardened using an electrochemical hardening process.

The drive coil has been wound on to the core element such that it is always in the magnetic field. It has a nominal impedance of 3,5 Ω at 500 Hz. The maximum drive current rating is 1,8 A RMS.

The moving element is supported in the field gap of the magnet assembly by radial flexure springs. These springs are made of two layers of spring steel plate separated by rubber. This construction provides a high degree of damping, which helps minimize distortion due to flexure resonances.

The maximum displacement limit of the moving coil element is 6 mm (0,234 in) peak to peak. If the mini-shaker is driven beyond its capabilities, an audible bumping sound will result, warning the operator that the drive level should be reduced immediately.

3.2. FREQUENCY RESPONSE AND RESONANCES

Figure 3.2 shows a plot of the frequency response of the 4810. The current I_d, voltage V_d and the impedance $|Z|$ (in A, V and Ω respectively) are plotted against frequency for a constant acceleration of 10 ms^{-2}.

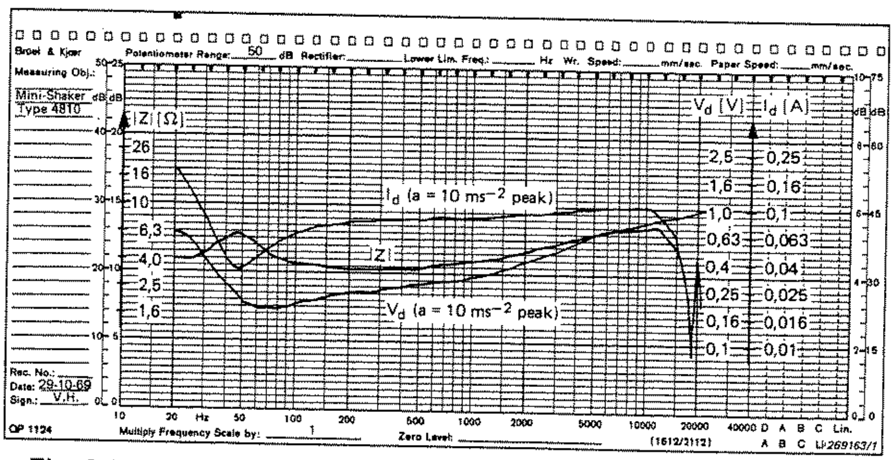


Fig. 3.2. Typical frequency response of the Mini-Shaker Type 4810

The frequency response shows a peak in the impedance and a trough in the current at approximately 50 Hz, indicating the suspension resonance between the element and its fastening. There is a second trough in the current curve at approximately 18 kHz, corresponding to the first major axial resonance of the moving element.

3.3. FORCE RATING AND OPERATIONAL LIMITS

The force required to vibrate a mass m with an acceleration a is given by Newton's second law of motion:

$$F = ma$$

By including the effective mass m_e of the moving element, and rearranging, we obtain:

$$a = \frac{F}{m + m_e}$$

From which the maximum acceleration of the mini-shaker with any payload can be calculated.

Example: The Mini-Shaker Type 4810 has a moving element with an effective mass m_e equal to 0,018 kg, and a maximum force rating equal to 10 N. The maximum acceleration produced when loaded by a 0,1 kg mass is given by:

$$a = \frac{F}{m + m_e}$$

$$= \frac{10}{0,1 + 0,018}$$

$$= 84,7\,ms^{-2} \quad (8,6\,g)$$

The maximum acceleration for other loads can be calculated in the same way, or determined from the performance curves shown in Fig. 3.3.

At frequencies above 70 Hz, the limits are based solely on the amount of force available. However, in order to produce a given acceleration level, the displacement must increase as the frequency decreases. Consequently, at frequencies up to 70 Hz, the mini-shaker is confined to its 6 mm (0,236 in) maximum displacement limit to avoid any damage.

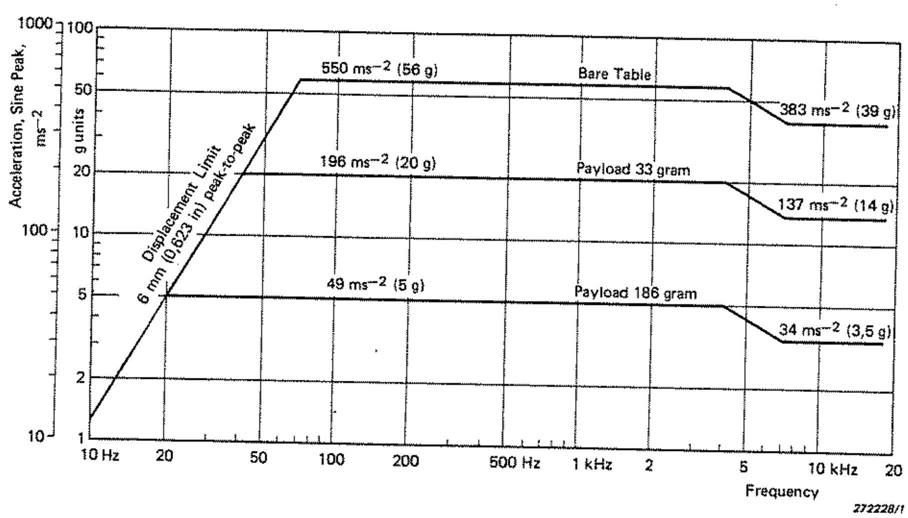
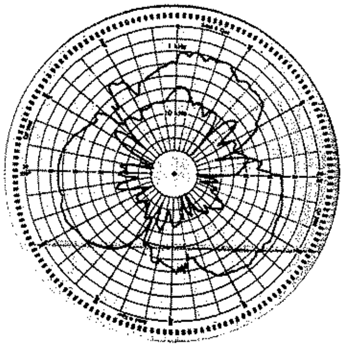
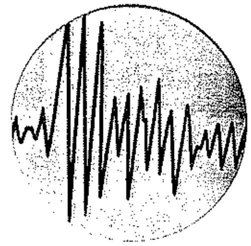
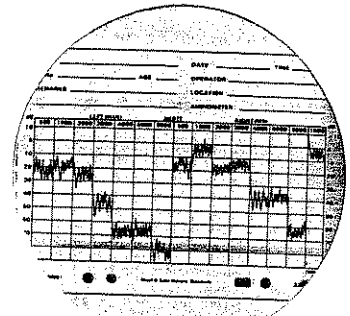


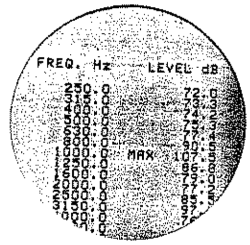
Fig. 3.3. Operational limits for sinusoidal excitation of the Mini-Shaker Type 4810

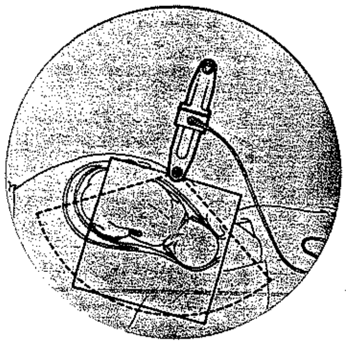
4810

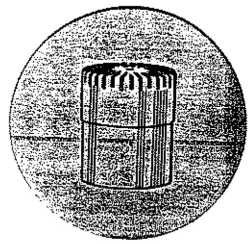


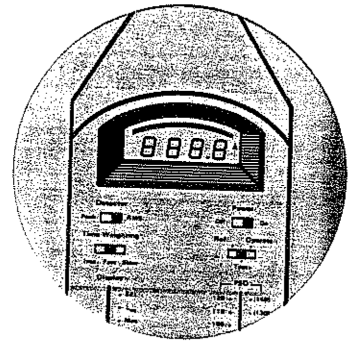


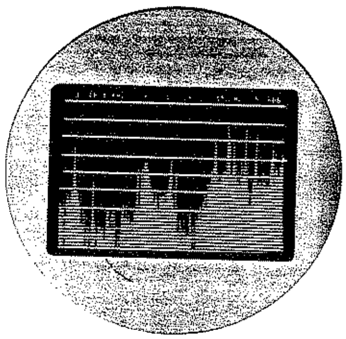


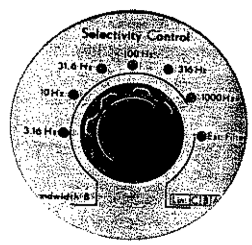


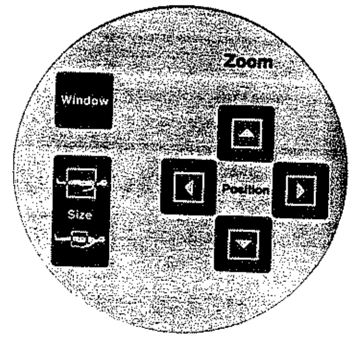


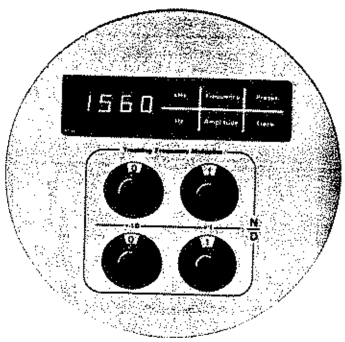


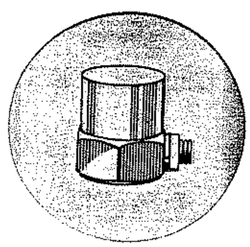


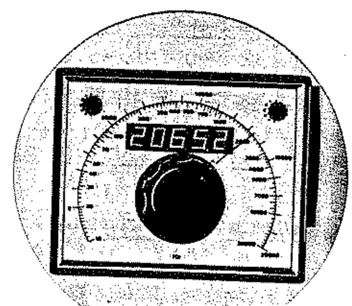


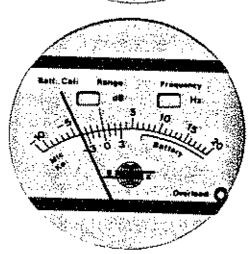


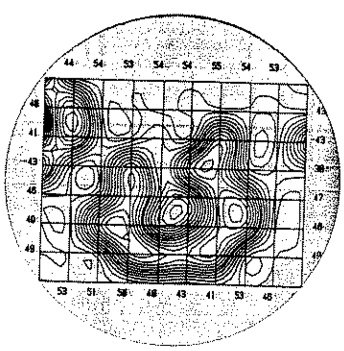


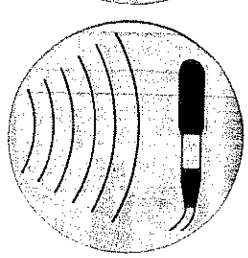


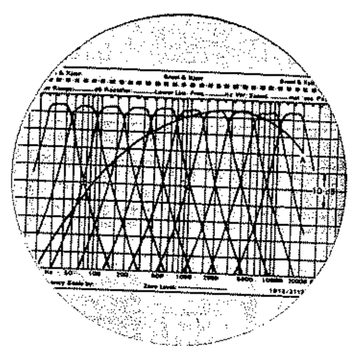












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