4294

Instruction Manual

Calibration Exciter Type 4294

The Calibration Exciter Type 4294 is a completely self-contained, pocket-sized, vibration reference source. It produces a reference acceleration level of $10\,ms^{-2}$ RMS at a frequency of 159,2 Hz (ω = $1000\,rads^{-1}$) and is intended for rapid calibration of vibration measurement, monitoring and recording systems utilising piezoelectric transducers and other vibration transducers.

Brüel & Kjær

CALIBRATION EXCITER
TYPE 4294

From serial no. 1028400

Revision April 1985

CONTENTS

type 4294

Calibration Exciter

USES:

- Quick, easy field calibration of vibration measurement and recording systems
- System fault finding and continuity checking
- Acceleration, velocity and displacement calibration

FEATURES:

- Convenient, hand-held vibration reference
- Integral accelerometer for servo-stabilisation of vibration amplitude
- Reference vibration level of 10 ms^{-2}
- Fixed operating frequency of 159,2 Hz corresponding to 1000 $rads^{-1}$
- Self-contained battery operation

The Calibration Exciter Type 4294 is a small, handy, completely self-contained vibration reference source. It is intended for rapid calibration and checking of vibration measurement, monitoring and recording systems utilising piezoelectric accelerometers as well as other types of vibration transducer having a maximum mass of 70 grams. The 4294 permits accurate adjustment of measuring instrumentation to indicate a standard acceleration level of 10 ms^{-2}, thus calibrating the system for correct measurement of other vibration levels.

The reference signal may additionally be used for velocity and displacement calibration, at 10 mms^{-1} and 10 μm respectively. Not only will a system calibration using the 4294 automatically take into account the influence of the connecting cables on the voltage sensitivity of the transducer but it will also provide a quick check on the correct function of the complete measurement system.

A sectional view of the Calibration Exciter's vibration head is shown in Fig.1. The Calibrator embodies an electromagnetic exciter driven by a stabilised oscillator at a frequency of 159,2 Hz (1000 $rads^{-1}$). Servo feedback via a small accelerometer on the underside of the vibration table is used to maintain a constant vibration level of 10 ms^{-2}. This enables transducers with masses of up to 70 grams to be calibrated without their mass influencing the reference level. To prevent overload, power for the calibrator is automatically disconnected in the event of a transducer mass of more than 70 grams being mounted on the table.

Use of the calibrator is very straightforward. The transducer is conveniently attached to the calibrator table using a 10-32 UNF steel stud

YQ 2962. Alternatively, the Mounting Disc DB 2529 supplied provides a convenient means of attaching transducers manufactured with 3 mm threads or those fitted with a Mounting Magnet UA 0642. The Mounting Disc also permits the attachment of transducers with either Beeswax or Cyanoacrylate adhesive. After connection of the transducer to an appropriate vibration level indicating instrument, the calibrator is actuated by depressing the small push-button on the side of its housing. The indicating instrument may be subsequently adjusted to read the relevant reference value (Fig. 2.). Following system adjustment the calibrator is switched off by depressing the push button a second time.

To prolong the useful life of its built-in battery, the 4294 automatically switches off after approximately two minutes. Sixty calibration periods of this duration are possible with a new battery.

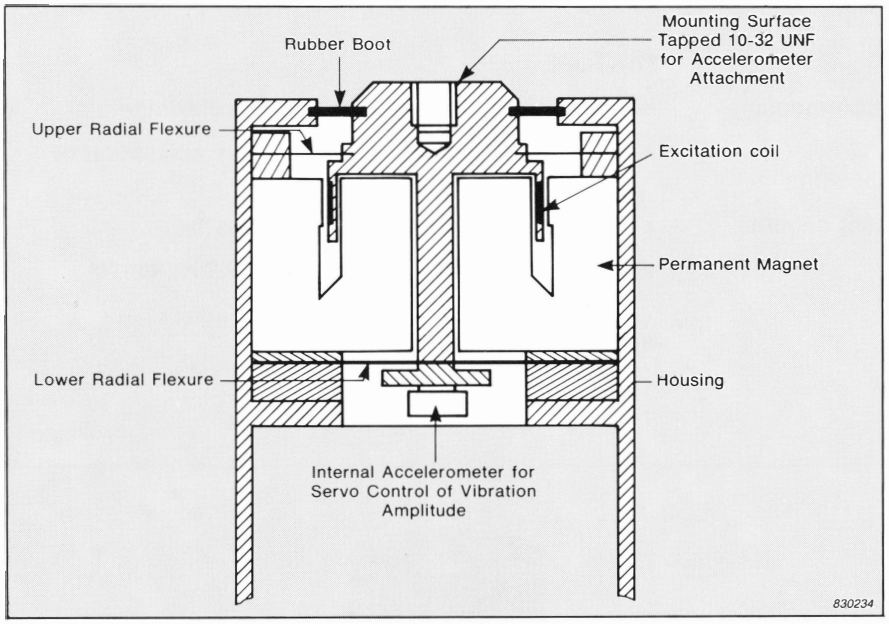


Fig. 1. Cross-Section of the Vibration System.

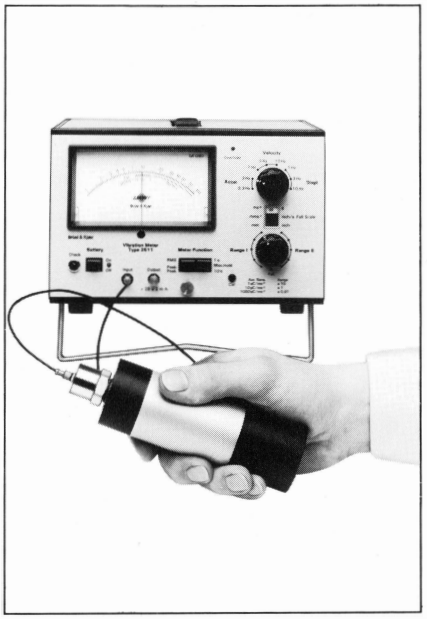


Fig. 2 Calibration of a 2511 Vibration Meter using the 4294.

Specifications 4294

VIBRATION SYSTEM:
Electromagnetic exciter with internal built-in piezoelectric accelerometer (shear type) for servo regulation of vibration amplitude.
Frequency: 159,2 Hz ±1% (1000 $rads^{-1}$)
Acceleration: 10 ms^{-2} (RMS) ±3%
Velocity: 10 mms^{-1} (RMS) ±4%
Displacement: 10 μm (RMS) ±5%
Transverse amplitude: less than 5% of main axis amplitude.
Distortion: less than 5% for 10 to 70 gram load and less than 3% for 20 to 60 gram load
Warm-up Time: less than 5 seconds.

TRANSDUCER MOUNTING:
Maximum Load: 70 grams.
Mounting Thread: 10-32 UNF

TEMPERATURE RANGE:
+10 to +40°C (50 to 104°F) for 10ms^{-2} reference within ±3%
-10 to +55°C (14 to 131°F) for 10ms^{-2} reference within ±5%

HUMIDITY: Up to 90% RH (non-condensing) at 30°C

POWER REQUIREMENTS:
Built-in Battery: One 9 V Alkaline Battery QB 0016 (IEC type 6LF22)

Battery Life: Approximately 60 calibrations each lasting 2 minutes with automatic switch-off at the end of each calibration.

DIMENSIONS:
Length: 150 mm (5.9 in)
Diameter: 52 mm (2.05 in)

WEIGHT:
500 grams including battery and leather case

ACCESSORIES INCLUDED:
1 × Leather Case ..... KE 0217
1 × 9 V Battery ..... QB 0016
1 × 10-32 UNF Steel Stud ..... YQ 2962
1 × Mounting Disc Adaptor ..... DB 2529

2. OPERATION

2.1. ENVIRONMENT AND HANDLING

The Calibration Exciter Type 4294 is designed for use in environments having a temperature within the range -10 to +55°C (+14 to +131°F) and relative humidity up to 90% RH (at 30°C and non-condensing). Whenever possible it should be used with its leather case fitted (see Fig.2.1) to protect it from mechanical damage as well as from contamination from grease and dirt.

Fig. 2.1. Calibration Exciter Type 4294 installed in its Leather Case

2.2. BATTERY INSTALLATION AND REPLACEMENT

For powering the 4294 the use of a long life alkaline battery QB 0016 (IEC type 6LF22) is recommended. The battery fits into the battery holder which is accessible after unscrewing the base of the Type 4294 (see Fig.2.2). To prevent damage take care not to cross the screw thread on reassembly.

Fig. 2.2. 9 V Battery installed in the Calibrator

To maximise battery life the Type 4294 is automatically switched off after approximately 2 minutes. Using the battery QB 0016 approximately sixty calibrations, each of 2 minutes' duration, are possible. Following this useage, the operating period will rapidly decrease indicating that the battery needs to be replaced. However, the 4294 may be used right up to the moment its battery is fully depleted without it influencing the accuracy of the reference level generated.

2.3. MOUNTING OF TRANSDUCER

The 4294 is designed for use with all B&K transducers with a maximum weight of 70 grams. These may be mounted directly on to the vibration table using a 10-32 UNF steel stud YQ 2962, or alternatively mounted with the aid of the Mounting Disc DB 2529. The different mounting options are illustrated in Fig.2.3.

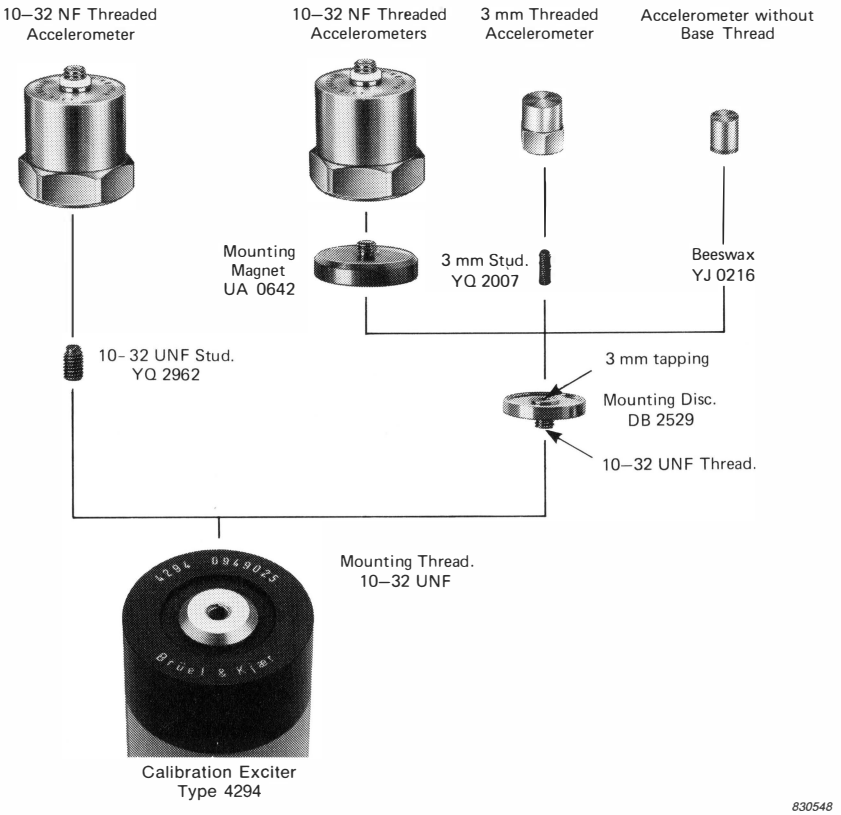


Fig. 2.3. Transducer Mounting Options

The Mounting Disc permits the attachment of transducers by several methods. Small transducers fitted with 3 mm threads may be attached using a 3 mm steel stud YQ 2007. Alternatively, a Mounting Magnet UA 0642 or Beeswax YJ 0216 may be employed to attach transducers to the Mounting Disc. During calibration the transducer should be at approximately the same temperature as the Type 4294 for optimum accuracy.

2.4. BASIC SYSTEM CALIBRATION

The following procedure may be used for quick, accurate adjustment and calibration of vibration measurement systems for a reference acceleration level of 10 ms^{-2} RMS (14,14 ms^{-2} Peak). Calibration using reference values of velocity or displacement is also possible and is mentioned in step 6 below.

1. Attach the system transducer to the vibration table (finger-tight is sufficient) of the Calibrator using either a 10-32 UNF Stud YQ 2962 or the Mounting Disc DB 2529. See section 2.3.

2. Connect the transducer to the vibration measurement system using a suitable low noise cable, e.g. that supplied with the transducer. Where a preamplifier having adjustable sensitivity conditioning is employed, the transducer sensitivity specified on the calibration chart should be dialled-in prior to setting the measuring range of the readout instrument.

3. Switch on the preamplifier and indicating instrument and select the acceleration measurement mode plus the highest indicating range on the appropriate instruments.

4. Press the button on the side of the Calibrator to vibrate the transducer. The transducer is now subjected to a sinusoidal acceleration of 10 ms^{-2} RMS (±3%) at a frequency of 159,2 Hz (i.e. ω = 1000 $rads^{-1}$).

5. Switch the range controls of the preamplifier and/or indicating instrument to obtain an on-scale meter indication without the overload lamps of the instruments lighting.

   The indicating instrument should now indicate a reference acceleration level of 10 ms^{-2} RMS. If not, adjust the sensitivity potentiometer of one of the instruments until the correct reference level is indicated. Once correctly set avoid further adjustment of the sensitivity potentiometer, as the calibration will be lost.

   Note: If an indicating instrument with peak indicating mode is employed, then it should be adjusted to indicate a reference level of 14,14 ms^{-2} Peak.

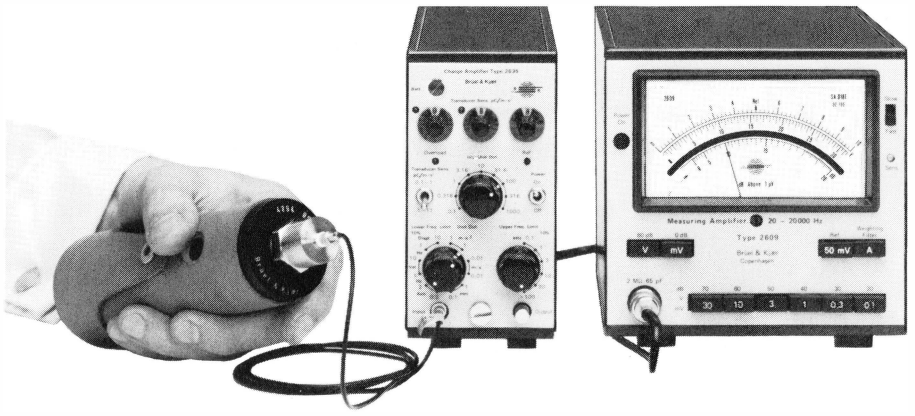


Fig. 2.4. Calibration of vibration measurement system

6. For velocity and displacement calibration of the vibration measurement system, the preamplifier/measuring instrument should be equipped with integration networks. The appropriate measurement mode should therefore be selected prior to switching on the Calibrator. The relevant calibration levels are as follows:

   Velocity: 10 mms^{-1} RMS or 14,14 mms^{-1} Peak $\pm 4\%$
   Displacement: 10 μm RMS or 14,14 μm Peak $\pm 5\%$

2.5. TRANSDUCER SENSITIVITY CHECK

For determination of the actual sensitivity of transducers, calibrated preamplifier and indicating instrumentation is required. Although not intended for absolute sensitivity measurement, the following procedure provides an approximate sensitivity check, sufficient for determining whether an transducer functions correctly and has not been damaged during previous use.

1. Attach the system transducer to the vibration table of the Calibrator (finger-tight is sufficient) using either a 10-32 UNF Stud YQ 2962 or the Mounting Disc DB 2529. See section 2.3.

2. Connect the transducer to the vibration measurement system using a suitable low noise cable, e.g. that supplied with the transducer. If a voltage preamplifier is employed then it is important that the particular cable supplied with the transducer is used, otherwise the voltage sensitivity of the transducer will be affected.

3. In the case of a vibration meter, RMS indication of acceleration plus an appropriate measurement range should be selected. If a conditioning preamplifier featuring direct dial-in of charge or voltage sensitivity is employed, then the relevant sensitivity specified on the transducer calibration chart should be dialled-in prior to setting the range of the calibrated indicating instrumentation.

4. Switch on the preamplifier, indicating instrument and calibrator in that order. The transducer is now subjected to a sinusoidal acceleration of 10 ms^{-2} RMS $\pm 3\%$.

5. A calibrated vibration meter will display the transducer output directly in terms of acceleration, enabling the transducer sensitivity to be determined using the following relation:

$$S_c = \frac{A_i \cdot S_0}{A_0}$$

Where:

S_c is the calculated transducer sensitivity in pC/ms^{-2} or mV/ms^{-2} depending on whether the vibration meter has a voltage or charge preamplifier input;

S_0 is the nominal transducer sensitivity for which the vibration meter is calibrated;

A_i is the meter acceleration indication in ms^{-2};

A_0 is the reference acceleration level. For the 4294 this is 10 ms^{-2}.

6. If a calibrated voltmeter together with a fixed sensitivity preamplifier is employed for transducer calibration, the transducer sensitivity may be calculated using the following relation:

$$S_c = \frac{V_0}{A_0 \cdot P_s}$$

where:

S_c is the calculated transducer sensitivity in pC/ms^{-2} or mV/ms^{-2};

P_s is the preamplifier sensitivity in units of mV/pC or mV/mV;

V_0 is the voltage output from the preamplifier measured in millivolts when the transducer is vibrated at the reference acceleration;

A_0 is the reference acceleration level. For the 4294 this is $10\,ms^{-2}$

7. If a calibrated voltmeter together with a conditioning amplifier is employed to measure the transducer charge sensitivity, then an arbitrary mV/unit out range may be selected on the preamplifier. Multiplication of this mV/unit out setting by the reference acceleration level gives the correct voltmeter reading. It is then a simple step to adjust the transducer sensitivity dials on the conditioning amplifier so that the correct voltage reading is displayed by the voltmeter. The dials on the preamplifier will then indicate the transducer sensitivity, S_c

8. Any significant departure of the calculated value of S_c from that shown on the transducer calibration chart is indicative of a faulty transducer.

3. SERVICE AND REPAIR

The 4294 is designed and constructed to provide the user with many years of reliable operation. However, should a fault occur which impairs its correct function then its internal battery should be removed to prevent the risk of further damage. For repair consult the separate Service Instruction Manual available for the 4294 or contact your local B&K service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.

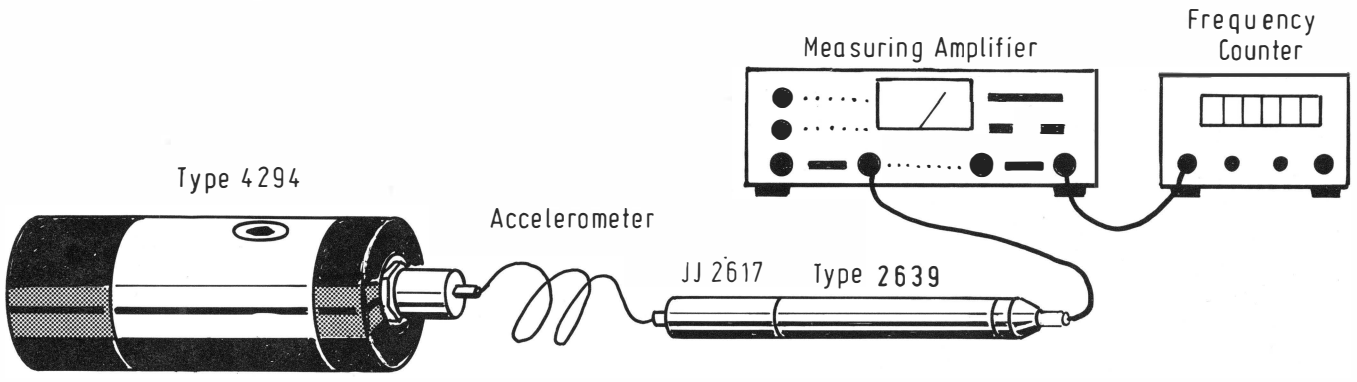
BRÜEL & KJÆR
Nærum-Denmark

Service Instruction **4294**

Calibration Exciter

Valid from serial no. 1028400

0037–438



Trouble Shooting

If any faults should occur please check the instrument according to the procedure outlined below.

When a fault has been traced and corrected the voltages and adjustments influenced by the correction must be re–checked. The complete instrument should then be tested according to the "Checking Procedure"to make sure that all basic functions are operative.

The tolerances given in these notes are intended for use as a guide for adjustments.

Before correcting any apparent deviation make sure that the measuring instrument has tolerances small enough not to affect the measurements.

Spare Parts

Please state the serial no. of the Exciter when ordering spare parts.

Replacement of Parts

Due to the high requirement for frequency- and temperature stability only spare parts recommended by the factory should be used.

Checking Procedure

Mount an Accelerometer on the Type 4294. (Max load 70 g) Connect the Accelerometer to a Preamplifier (Type 2639) through an adaptor JJ 2617. Connect the Preamplifier to a Measuring Amplifier (Type 2636) and the output of the Measuring Amplifier to a Frequency Counter.

Notice! No Polarization Voltage.

Calibrate the Measuring Amplifier by means of the built in Reference voltage.

Activate the Exciter and note the meter reading.

Check that the noted reading corresponds to the voltage noted in the Calibration Chart for the Accelerometer.
Tolerance: ± 5% (mV/ms^{-2} × 10).

Check the freguency of the Calibrator signal: 159,2 Hz ± 1%.
If necessary adjust P1 on ZE 0438 in the Exciter.

PARTS LIST

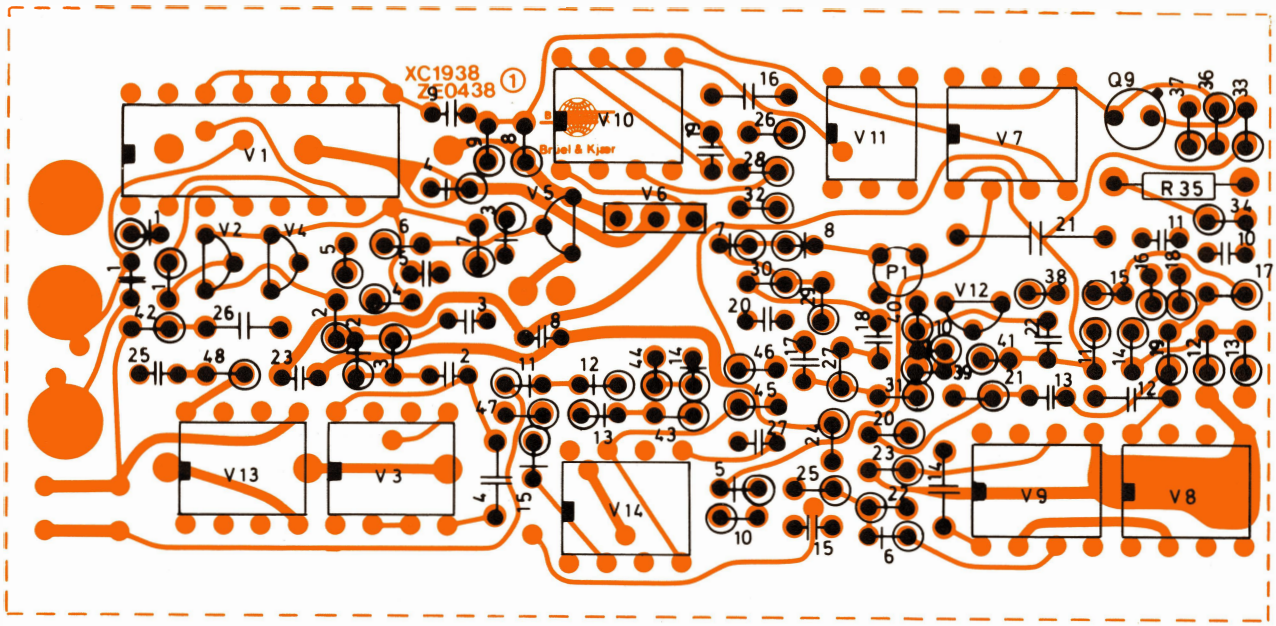
C 1	Ceramic			220 nF/50 V	CK 5221
C 2	Tantalum			10 µF/16 V	CF 0059
C 3	-			1,0 µF/35 V	CF 0062
C 4	Ceramic			10 nF/30 V	CK 4101
C 5	Polystyrene	1%		1,0 nF/63 V	CT 1132
C 6	Eletrolytic			470 µF/10 V	CE 0305
C 7	-			1000 µF/6 V	CE 0210
C 8	Tantalum			22 µF/16	CF 0031
C 9,10	-			1,0 µF/35 V	CF 0062
C 11	-			10 µF/16 V	CF 0059
C 12	Ceramic			2,2 nF/400 V	CK 3221
C 13	Tantalum			1,0 µF/35 V	CF 0062
C 14	Ceramic			1,0 nF/400 V	CK 3101
C 15	-			100 nF/32 V	CK 5100
C 16	-			47 nF/16 V	CK 4471
C 17	Polystyrene	1%		1,6 nF/63 V	CT 1181
C 18,19	-	-		820 pF/250 V	CT 1121
C 20	Tantalum			1,0 µF/35 V	CF 0062
C 21	Polyester			33 nF/250 V	CS 0419
C 22	Tantalum			22 µF/16 V	CF 0031
C 23	Ceramic			100 nF/32 V	CK 5100
C 24	Elektrolytic			220 µF/10 V	CE 0306
C 25	Tantalum			10 µF/16 V	CF 0059
C 26	Ceramic			47 nF/16 V	CK 4471
C 27	Tantalum			4,7 µF/35 V	CF 0051
C 28	Ceramic			10 nF/30 V	CK 4101
P 1	Cermet		lin.	100 KΩ	PG 4105

Q 1-3	Si.	IN4148		75 V/75 mA	QV 0216
Q 4	Ze.	MZ2361		1,28–1,42 V/0,25 W	QV 1337
Q 5	Ge.	AA119		45 V/100 mA	QV 0079
Q 6	Si.	IN4148		75 V/75 mA	QV 0216
Q 7,8	Ze.	BZX79		2,5–2,9 V/0,25 W	QV 1356
Q 9	-	ICL8069		1,16–1,28 V/0,1 W	QV 0041
Q 10-13	Ge.	AA119		45 V/100 mA	QV 0079
Q 14	Si.	IN4148		75 V/75 mA	QV 0216
Q 15	Ge,	AA119		45 V/100 mA	QV 0079

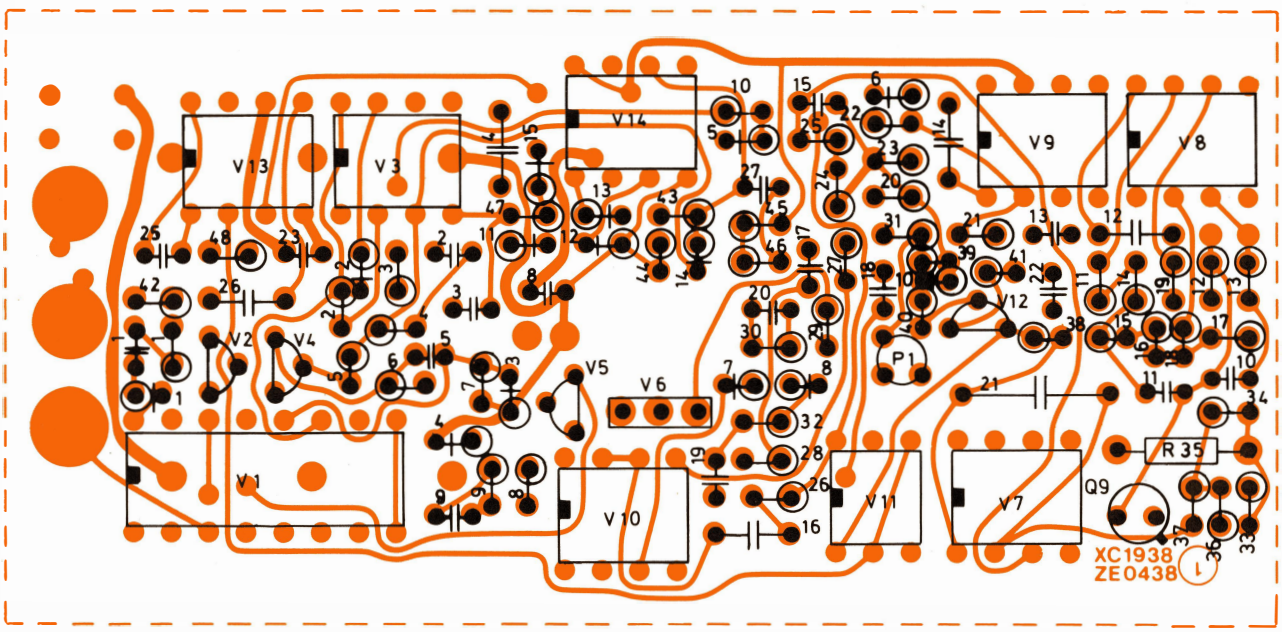
R 1,2	Carbon	1/4 W	5%	100 kΩ	RB 5100
R 3	-	-	-	10 MΩ	RB 7100
R 4	-	-	-	10 kΩ	RB 4100
R 5	-	-	-	56 kΩ	RB 4560
R 6	-	-	-	1,0 kΩ	RB 3100
R 7	-	-	-	100 kΩ	RB 5100
R 8	Metal	-	1%	31,6 kΩ	RF 4316
R 9	-	-	-	10,0 kΩ	RF 4100
R 10	-	-	-	49,9 kΩ	RF 4499
R 11,12	-	-	-	10,0 kΩ	RF 4100
R 13	Carbon	-	5%	8,2 MΩ	RB 6820
R 14	Metal	-	1%	1,00 kΩ	RF 3100
R 15	-	-	-	3,01 kΩ	RF 3301
R 16	-	-	-	4,64 kΩ	RF 3464
R 17	NTC	0,5 W		150 kΩ	RN 0024
R 18	Metal	1/4 W	5%	8,20 MΩ	RB 6820
R 19	-	-	1%	1,00 MΩ	RF 6100
R 20,21	-	-	-	100 kΩ	RF 5100
R 22	-	-	-	90,9 kΩ	RF 4909
R 23	-	-	-	200 kΩ	RF 5200
R 24	-	-	-	499 kΩ	RF 5499
R 25	-	-	-	825 kΩ	RF 5825
R 26	-	-	-	100 kΩ	RF 5100
R 27	-	-	-	866 kΩ	RF 5866
R 28	-	-	-	806 kΩ	RF 5806
R 29,30	-	-	-	100 kΩ	RF 5100
R 31	-	-	-	590 kΩ	RF 5590
R 32	-	-	-	200 kΩ	RF 5200
R 33	-	-	-	5,26 kΩ	RF 3536
R 34	-	-	-	20,0 kΩ	RF 4200
R 35	Factory Adjusted				
R 36	-	-	-	10,0 kΩ	RF 4100
R 37	-	-	-	1,0 MΩ	RF 6100
R 38	-	-	-	392 Ω	RF 2392
R 39,40	Carbon	-	5%	100 kΩ	RB 5100
R 41	-	-	-	1,0 kΩ	RB 3100
R 42	Metal	-	1%	10,0 Ω	RF 1100
R 43	-	-	-	100 kΩ	RF 5100
R 44	-	-	-	499 kΩ	RF 5499
R 45	-	-	-	29,4 kΩ	RF 4294
R 46	-	-	-	10,0 kΩ	RF 4100
R 47	-	-	-	49,9 kΩ	RF 4499
R 48	-	-	-	1,21 kΩ	RF 3121

V 1	2×J-K Master–Slave F/F	CD4027BCN	VD 2016
V 2	Si.	BC546	VB 0590
V 3	Timer	NE555V	VD 0062
V 4	Si.	BC546	VB 0590
V 5	Si.	BC556	VB 0124
V 6	Voltage regulator 5 V	LM330T	VE 0216
V 7	Op.Amp.	LM358N	VE 0134
V 8	Op.Amp.	CA3130AE	VE 0170
V 9	Op.Amp.	CA3130E	VE 0086
V 10	Op.Amp.	TL062CP	VE 0136
V 11	FET–Optokobler	HIIFI	VD 0109
V 12	Si. coupler	BC546	VB 0590
V 13	Op.Amp.	LM386N–3	VE 0162
V 14	Op.Amp.	LM358N	VE 0134

1–pin–socket	JJ 0069
1–pin–plug	JP 0167
Switch	NT 0176
Battery 9 V	QB 0016
Printed Circuit Board	XC 1938
Printed Circuit Board with comp.	ZE 0438

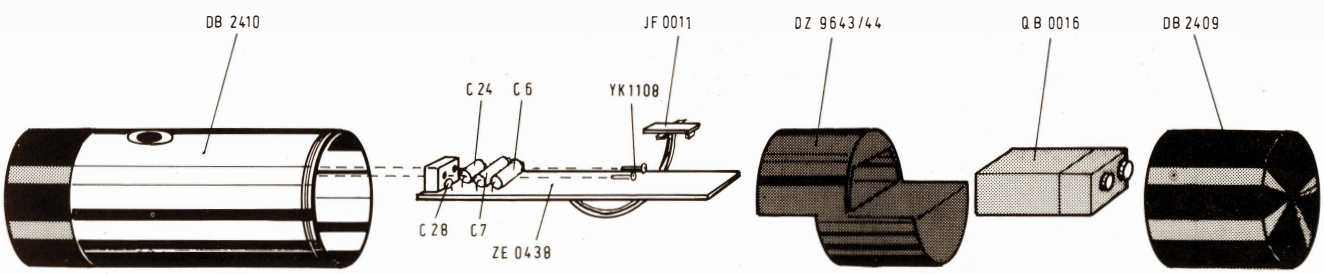


Viewed from the solder side

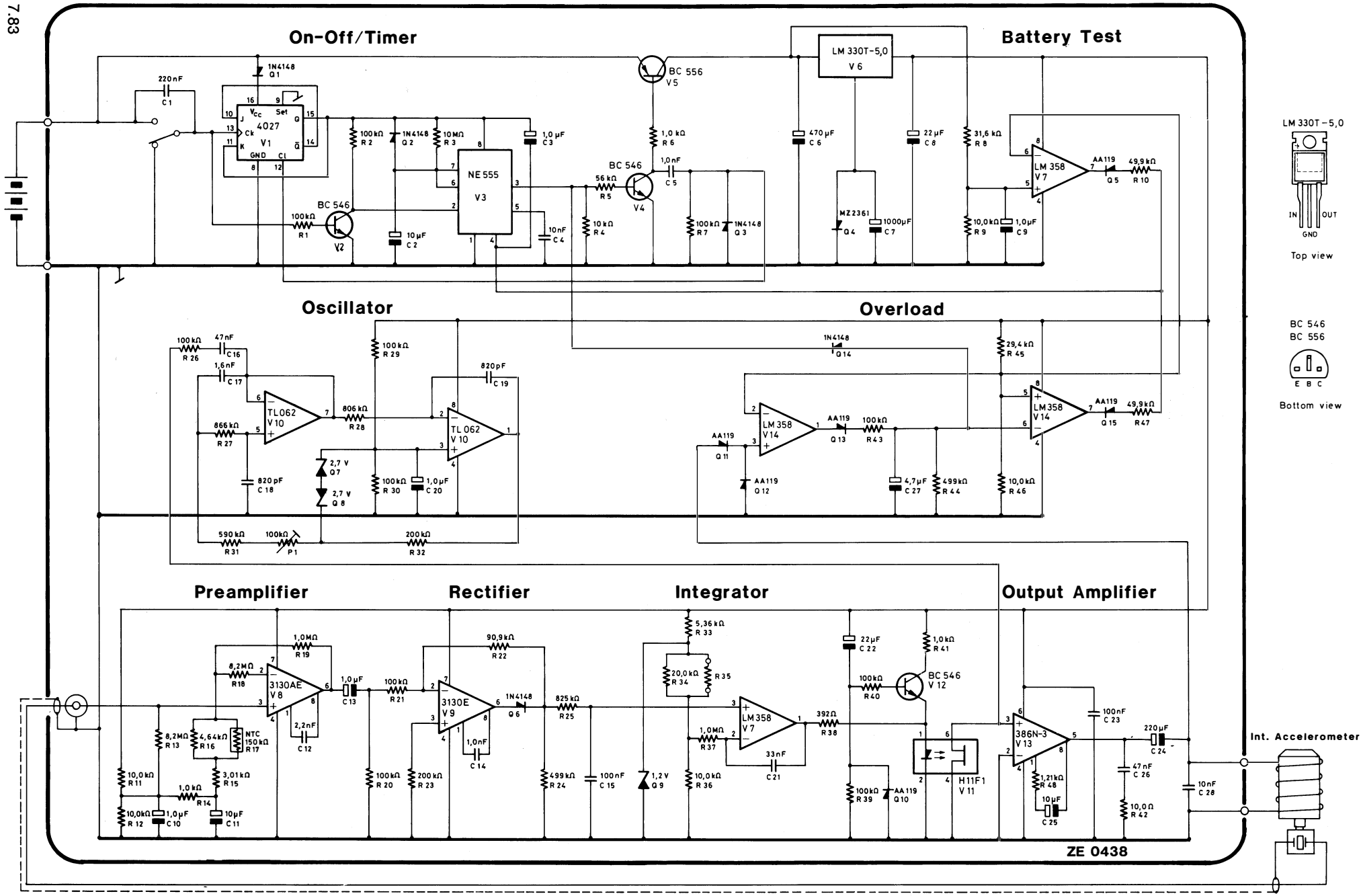


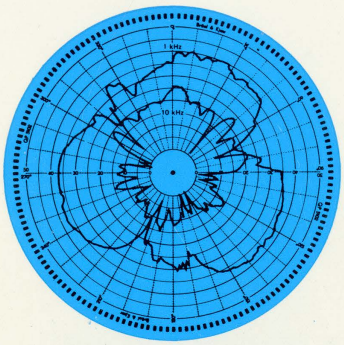
Viewed from the component side

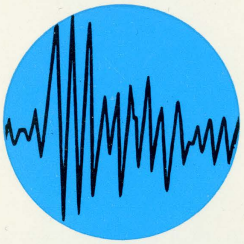
C Q R

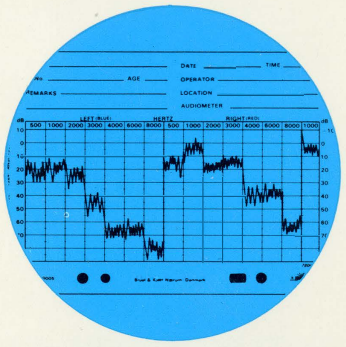


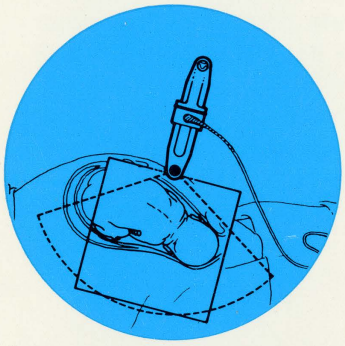
ZE 0438

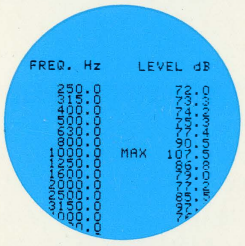

On-Off/Timer
Battery Test
Oscillator
Overload
Preamplifier
Rectifier
Integrator
Output Amplifier
LM 330T-5,0
V 6
BC 556
V5
1N4148
Q1
220nF
C1
4027
V1
NE 555
V3
BC 546
V2
V4
100kΩ R2
1N4148 Q2
10MΩ R3
1,0µF C3
1,0 kΩ R6
1,0nF C5
56kΩ R5
10 kΩ R4
100kΩ R7
1N4148 Q3
10µF C2
10nF C4
100kΩ R1
470µF C6
22µF C8
MZ2361 Q4
1000µF C7
31,6 kΩ R8
10,0kΩ R9
1,0µF C9
LM 358 V7
AA119 Q5
49,9kΩ R10
100kΩ R26
47nF C16
1,6nF C17
TL062 V10
866kΩ R27
820pF C18
806kΩ R28
100kΩ R29
820pF C19
2,7 V Q7
2,7 V Q8
100kΩ R30
1,0µF C20
590kΩ R31
100kΩ P1
200kΩ R32
1N4148 Q14
29,4kΩ R45
LM 358 V14
AA119 Q11
AA119 Q12
AA119 Q13
100kΩ R43
4,7µF C27
499kΩ R44
10,0kΩ R46
AA119 Q15
49,9kΩ R47
1,0MΩ R19
8,2MΩ R18
3130AE V8
2,2nF C12
1,0µF C13
8,2MΩ R13
4,64kΩ R16
NTC 150kΩ R17
10,0kΩ R11
3,01kΩ R15
1,0kΩ R14
10,0kΩ R12
1,0µF C10
10µF C11
90,9kΩ R22
100kΩ R21
3130E V9
1,0nF C14
1N4148 Q6
825kΩ R25
100kΩ R20
200kΩ R23
499kΩ R24
100nF C15
5,36kΩ R33
20,0kΩ R34
R35
1,0MΩ R37
10,0kΩ R36
1,2 V Q9
LM 358 V7
33nF C21
392Ω R38
22µF C22
1,0kΩ R41
100kΩ R40
BC 546 V12
100kΩ R39
AA119 Q10
H11F1 V11
386N-3 V13
100nF C23
220µF C24
1,21kΩ R48
10µF C25
47nF C26
10,0Ω R42
10nF C28
ZE 0438
LM 330T-5,0
IN
OUT
GND
Top view
BC 546
BC 556
E B C
Bottom view
Int. Accelerometer

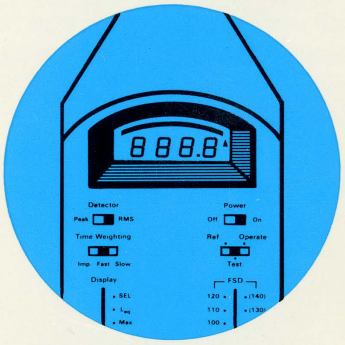


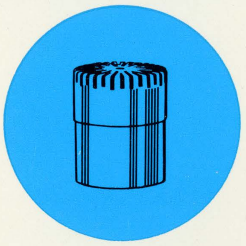


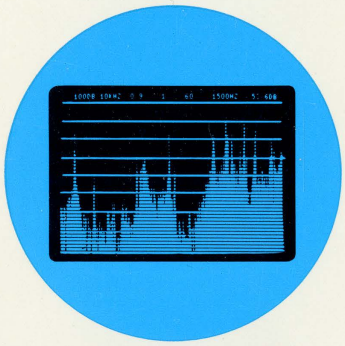


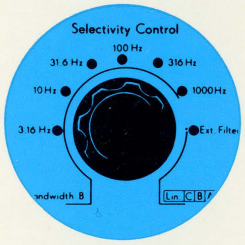


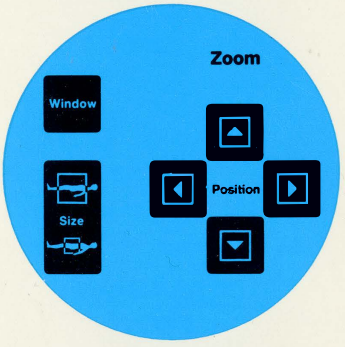


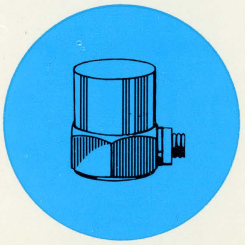


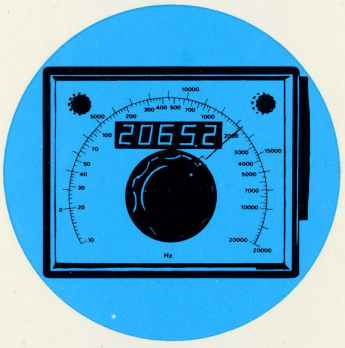


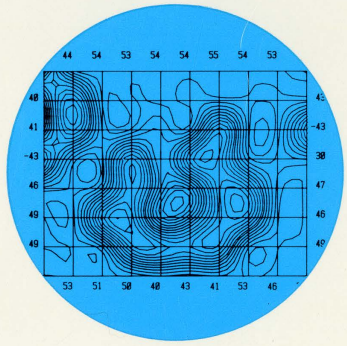


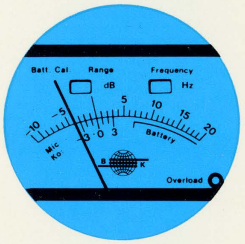


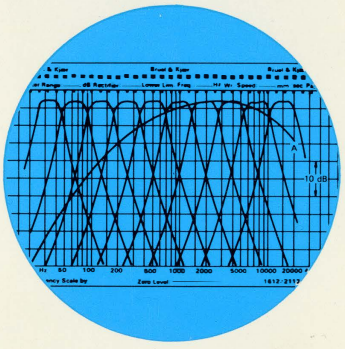


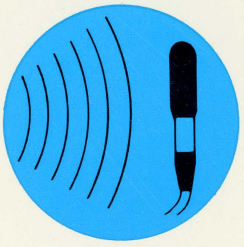












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