1612

INSTRUCTIONS AND APPLICATIONS

Band-Pass Filter Set Type 1612

$^1/_3$ and $^1/_1$ Octave Band-Pass Filters.
22—45000 c/s Selective Frequency Range.
Standardized Weighting Networks "A", "B" and "C".
Transistor Coupled Output Stage.
Automatic Remote Filter Switching.

BRÜEL & KJÆR

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BB 1612

Band-Pass Filter Set

Type 1612

Reprint june 1965

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Introduction

Filters Handling Noise with Uniform Spectrum Density.

In investigations where narrow bands are to be selected from noise with uniform spectrum density (white noise) the use of band-pass filters is necessary. Ideally such filters should display zero attenuation within the pass-band and infinite attenuation elsewhere, i.e. filters which provide rectangular amplitude vs. frequency characteristics. Refer also Fig. 0.1. Such filters cannot be produced in practice by passive components but they should display characteristics as near as possible to that of the ideal filters, i.e. a flat pass-band and steps skirts.

Effective Bandwidth of a practical filter is equal to the bandwidth of an ideal filter which has uniform transmission in its pass-band equal to the maximum transmission of the specified filter and transmits the same power of white noise as the specified filter.

The effective bandwidth of a specified filter can be determined by firstly plotting the amplitude vs. frequency response of the filter in a graph with a linear ordinate showing the ratio, transmission at the particular frequencies to the maximum transmission, and with an abscissa showing the relative frequency $\frac{f}{f_0}$, where f_0 equals the center frequency of the filter. Refer also Fig. 0.1. Secondly, the ordinates of this characteristic are now squared and plotted in the same co-ordinates as above. Thirdly, the area so enclosed by the new characteristic and the zero line (hatched in Fig. 0.1) divided by maximum height of same area gives the effective bandwidth of the specified filter.

In many noise measurements it is convenient to know the correction factor in dB for the individual filters which have to be applied to the measured quantities due to the fact that the practical filters do not have a characteristic identical to the ideal filter. This correction factor can be derived from the effective bandwidth of the individual filters as this is a measure for the noise power the filter allows to pass.

$$\text{Correction Factor (dB)} = 10 \times \log \frac{\text{Effective Bandwidth}}{\text{Bandwidth of Ideal Filter}}$$

When relative noise measurements are made, it is also of great convenience to know how much this correction factor deviates from filter to filter. The

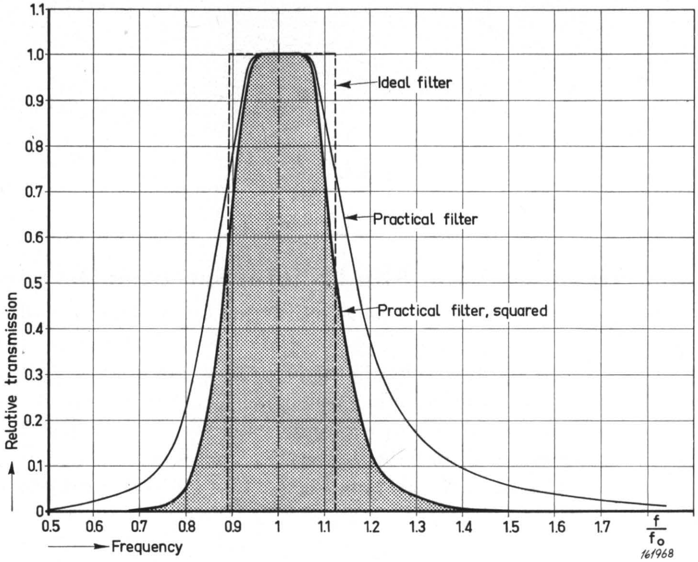

Fig. 0.1. Characteristics of an ideal and practical filter. Note both co-ordinates are linear.

deviation in the factor could, additionally, be referred to a filter in the middle of the range, for example at 1000 Hz (c/s).

If the deviation of the correction factor would be zero (which, of course, will be impossible for practical filters) and the filters in the range considered display constant relative bandwidth, the output noise level from the filters would increase by exactly 10 dB/decade $\simeq$ 3 dB/octave as the r.m.s. voltage white noise is proportional to the square-root of its effective bandwidth. The deviation in the correction factor of the individual filters will thus equal the deviation, which can be expected from this 3 dB/octave line.

Octave.

When dealing with acoustics, an octave is an expression of a relative measure of frequency, i.e. 1 octave above or below a certain frequency f_o means $2 \times f_o$ or $\frac{1}{2} \times f_o$ respectively.

Mathematically it is expressed by:

$$\frac{f}{f_0} = 2^n$$

where n may be positive, negative, a fraction or a number of octaves and f_o the frequency to which the frequency f is referred.

By taking the logarithm on both sides of the equation above, it is derived:

$$\log_{10} \frac{f}{f_0} = n \times 0.3010$$

from which f or n for a given n or f respectively can be calculated.
In Fig. 0.2 will be found a graph where n, positive and negative, is plotted versus relative frequency $\frac{f}{f_0}$.

Example:

$+\frac{3}{6}$ octave = + 0.5 octave

reads $\frac{f}{f_0} = 1.41$

$-\frac{1}{6}$ octave = — 0.17 octave

reads $\frac{f}{f_0} = 0.89$

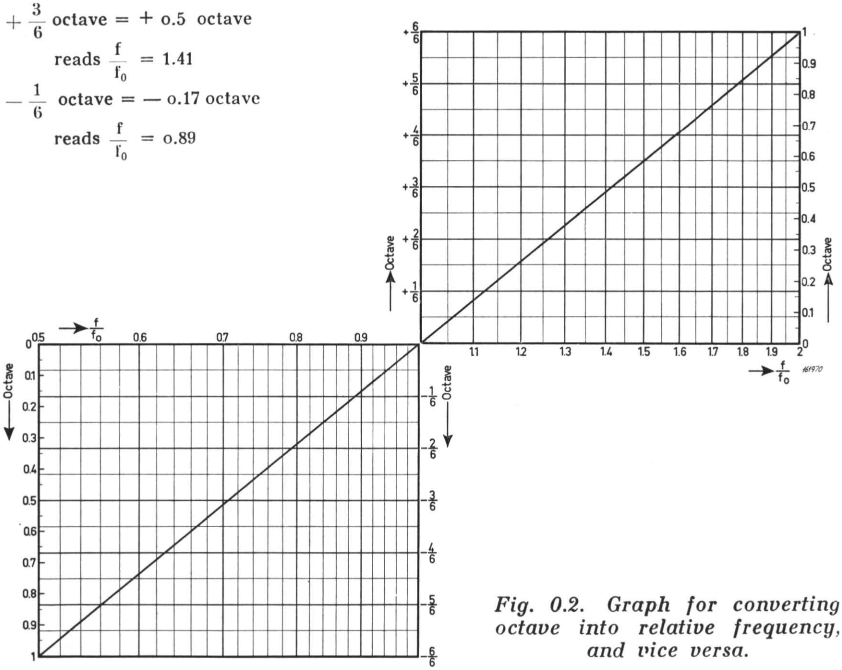

Fig. 0.2. Graph for converting octave into relative frequency, and vice versa.

Description

1. Description

General.

The Band-Pass Filter Set Type 1612 is intended for analysis, selective measurements and selection of noise signals in 1/3 or 1/1 octave bands covering the frequency range 22—45000 Hz (c/s). The Filter Set contains additionally four frequency weighting networks. The three of them are the "A" "B" and "C" networks the characteristics of which are in accordance with those proposed by I.E.C. for Precision Sound Level Meters. The fourth network gives a linear frequency response 20—45000 Hz (c/s). The filters and weighting networks can be selected successively by a 50 position selector, which is manual as well as remotely operable. An input transformer and an output transistor stage ensure proper matching to a wide range of source and load impedances respectively.

The frequency range of analysis can be extended to cover 11—45000 Hz (c/s) when the Filter Set is combined with the Extension Filter Set Type 1620.

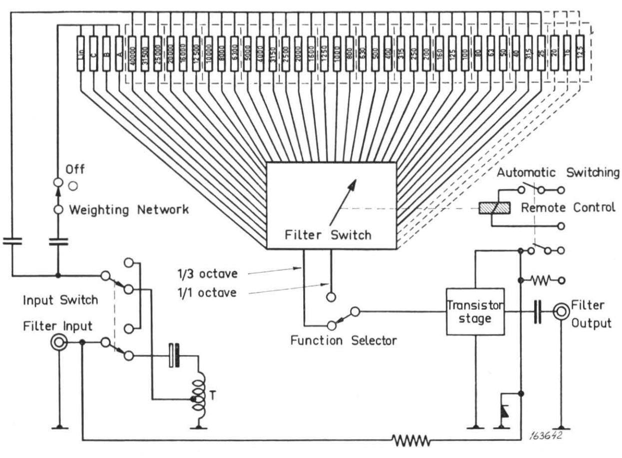

Fig. 1.1. Block diagram of Band-Pass Filter Set.

The Band-Pass Filter Set is designed to be combined with other B & K instruments, for example the Frequency Analyzer Type 2107, the Microphone Amplifier Type 2603 or Type 2604 and the Precision Sound Level Meter Type 2203. When combined with the two first of the four mentioned, an instrumentation is obtained which has data identical to the B & K A.F. Spectrometer Type 2112. In measurements where random noise is required as test signal the Filter Set can be combined with the B & K Random Noise Generator Type 1402. Noise bands of 1/3 or 1/1 octave widths can be supplied from such a combination. When employing the Filter Set together with the above mentioned instruments, except the Precision Sound Level Meter, the supply for the transistor output stage is derived from the associated instrument via the Filter Set input terminal.

Block Diagram. The basic design of the Band-Pass Filter Set is illustrated in Fig. 1.1. The input circuit (to the left in the figure) allows the input signal to be applied either directly to the filter or via an input transformer. The filters and weighting networks, the inputs of which are paralleled, are selected at the outputs by the filter switch. From this switch the signal passes the transistor stage to the output of the Filter Set.
The remote filter selection is provided by a built-in electro-mechanic device, which can be controlled by an external contact in series with a d.c. supply.

Input Circuit.

A selector and an input transformer constitutes the input circuit. The selector INPUT SWITCH has two positions. In the one position the signal is applied direct to the input of the filters and weighting networks. In the other position a step down transformer 10 : 1 is coupled in series with the filter and weighting network inputs. Inserting the transformer allows a higher source impedance up to 1000 Ω to be used in conjunction with the filters in relation to the 10 Ω required when the signal is applied direct. The 10 times (20 dB) lower sensitivity occuring when the transformer is switched in, must be taken into consideration during measurements. To keep the magnetic flux in the filter cores below the value of saturation the voltage on the filter inputs should not be higher than 1.4 volts peak. Consequently by inserting the transformer the peak voltage on the "Filter Input" terminal can be 14 volts.

Filters.

By a switch FUNCTION SELECTOR it is possible to select sets of filters, either with a bandwidth of 1/3 octave, or with a bandwidth of 1/1 octave. The center frequencies of both types of filters are placed in accordance to the ISO standards for acoustic measurements.

$^1/_3$ Octave Filters.

Design. The Filter Set is equipped with 33 filters having center frequencies as given in the table below from which also the filter bandwidth in cycles per second can be found.

Center Frequency Hz (c/s)	Bandwidth at 3 dB Hz (c/s) Approx.	Center Frequency Hz (c/s)	Bandwidth at 3 dB Hz (c/s) Approx.
25	5.8	1000	230
31.5	7.3	1250	290
40	9.2	1600	370
50	11.6	2000	460
63	14.5	2500	580
80	18.3	3150	730
100	23	4000	920
125	29	5000	1160
160	37	6300	1450
200	46	8000	1830
250	58	10000	2300
315	73	12500	2900
400	92	16000	3700
500	116	20000	4600
630	145	25000	5800
800	183	31500	7300
		40000	9200

A single filter consists of three resonant circuits coupled together as shown in Fig. 1.2. The first two circuits will give rise to a two-topped frequency response, as shown in Fig. 1.3 left. The third gives a single top which raises the valley between the two tops, so that a resultant curve having a relatively flat band-pass and steep sides as shown in Fig. 1.3 right is obtained. Because

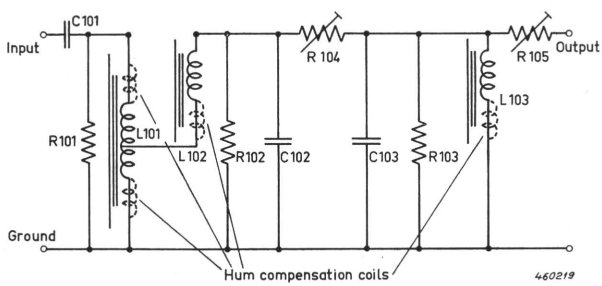

Fig. 1.2. Schematic diagram of a single 1/3 octave filter unit.

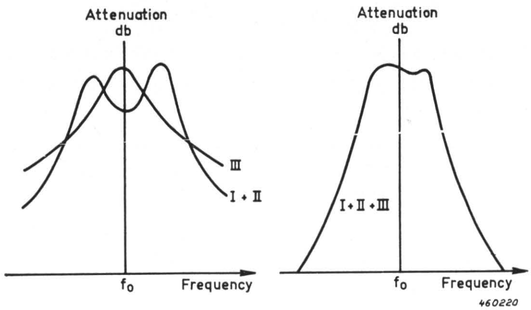

Fig. 1.3. Frequency characteristics illustrating the function of a 1/3 octave filter unit.

the two tops do not have the same height. The third resonant frequency must be placed unsymmetrically to obtain the desired band-pass, and the resultant response curve will have two humps, a broad one and a narrow one. **The input impedance response of the paralleled filters, will be a wave-shaped curve, varying between approximately 500 ohms and 2ooo ohms, so that the impedance is high at the center frequencies and low at the band limits (see also Fig. 1.4).**

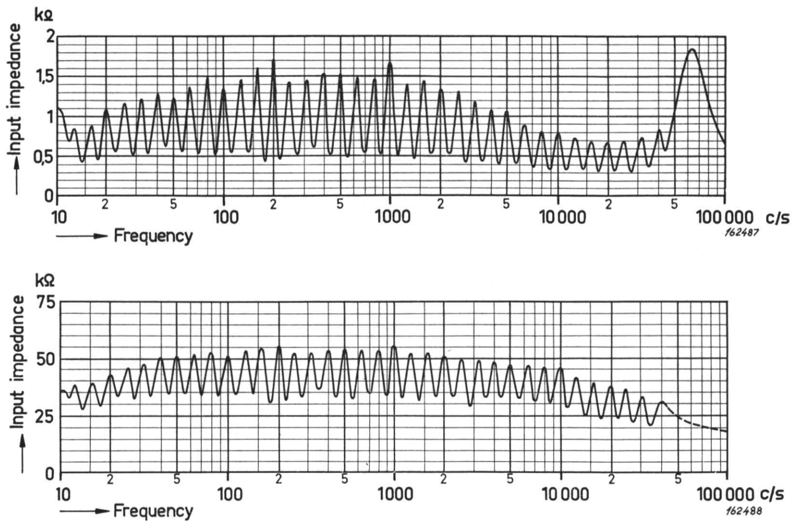

Fig. 1.4. Typical input impedance of Band-Pass Filter Set measured on FILTER INPUT. Extension Filter Set Type 1620 has been connected. FUNCTION SELECTOR on "1/3 Octave, 0 dB" and WEIGHTING NETWORK "On".
(a) INPUT SWITCH on "Direct"
(b) INPUT SWITCH on "Transformer"

The input voltage will therefore also vary up and down if the output impedance of the input amplifier it not made low. At a source impedance of approximately 10 ohms the voltage across the filters will only vary approximately 1.5 %.

To keep the transients in the filters to a minimum all the filter inputs are coupled in parallel. Furthermore, the filters are pre-loaded, and the change in load—when the Filter Switch connects the output amplifier to the different filters—is thus negligible.

Frequency Response. The frequency response of a filter is flat to within ± ½ dB over approximately ¼ octave. At the band limits, i.e. ⅙ octave from the center frequency, the attenuation is approximately 3 dB. See Fig. 1.5. However, due to the rather steep slope of the filter curves at these points, the frequency characteristics of two neighbouring filters cannot be expected to intersect exactly at the 3 dB point. This is easy to understand, because

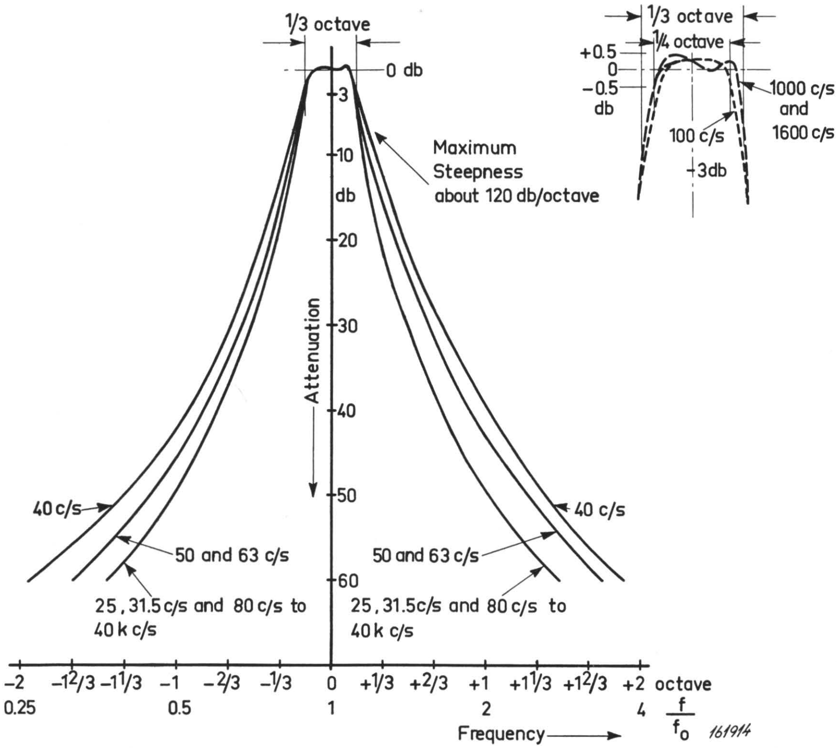

Fig. 1.5. Detailed 1/3 octave filter characteristic derived from sine-wave signals.

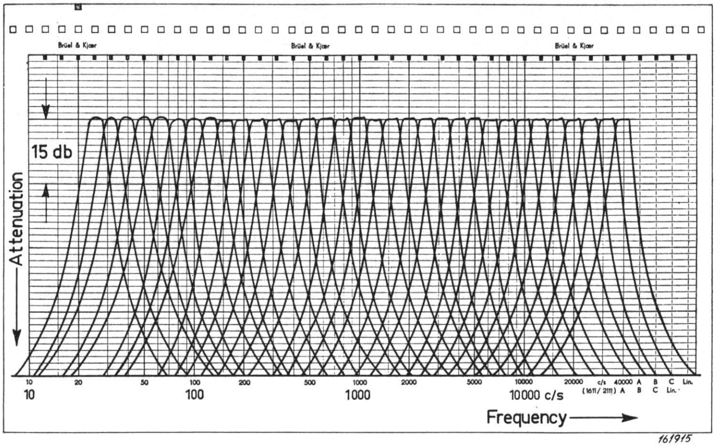

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Fig. 1.6. Complete set of filter characteristics when Filter Set is in 1/3 octave condition.

a displacing of the center frequencies of the two filters by only 1 % in opposite directions, will cause the intersection to take place at a point 1.7 dB higher or lower than the 3 dB point. If the width of one filter curve is changed by 1 %, the point of intersection is changed by o.2 dB.

The attenuation approximately at ± ⅓ octave from the center frequency is 20 dB, and at ± 1 octave 52 dB. It has been impossible to obtain sufficiently high quality factors for the coils at some frequencies below 80 c/s without lowering the stability or making the filters larger and heavier. The filter curves will therefore not be of the same quality at these frequencies, as there will be only top, and the "flat" part is about ⅙ octave wide. The attenuation of these filters is up to 4 dB at the band limits, from 14 to 20 dB at ± ⅓ octave, and from 42 to 50 dB at 1 octave away from the center frequency.

Effective Bandwidth. The effective bandwidth*) of the ⅓ octave filters is 9 % greater than the bandwidth of an ideal ⅓ octave filter which transmission in the pass band is equal to that of the Filter Set when in condition "Lin." (20—45ooo Hz (c/s)). Due to tolerances in the filter production, the mentioned correction of + 9 % to the bandwidth may be found to lie between 0 % and + 20 %.

In some measurements it may be necessary to make a correction to the measured values because of the 9 % greater bandwidth. The correction factor*) in dB then equals —o.4 dB. The deviation of this factor will, due

*) Vide also Introduction, para Filters Handling Noise with Uniform Spectrum Density.

to the production tolerances be ± 0.4 dB, which means that the greatest relative deviation will be within these limits.

Phase Response. Due to the nature of the filters they will cause a phase distortion, which is shown in Fig. 1.7, together with the amplitude response of the filter top. The hatched area indicates the limits within which the different filter curves for one apparatus are expected to lie.

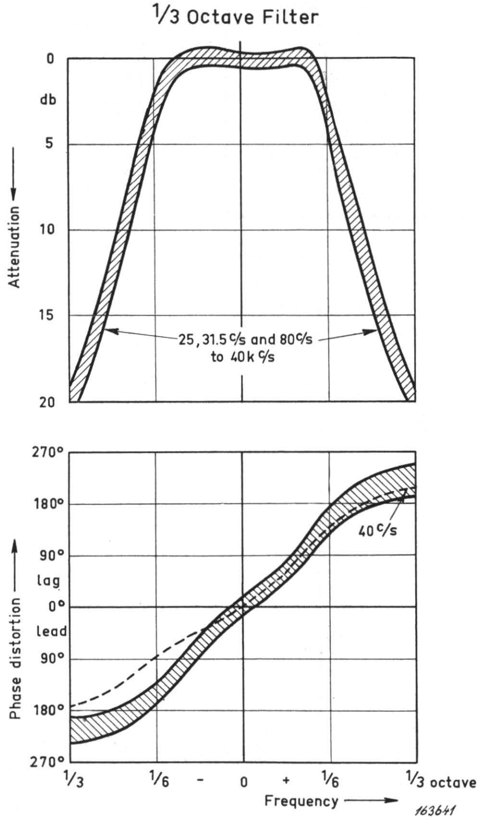


Fig. 1.7. Phase response of Filter set in 1/3 octave condition, shown together with the respective amplitude characteristics.

Hum Compensation. To reduce the induction of hum, in some of the low-frequency filters, occuring from magnetic fields created by nearby mains, transformers, or electrical machinery, the filters are provided with hum compensation coils as seen in Fig. 1.2. By this means a very low hum level is obtained.

$^1/_1$ Octave Filters.

Design. The $1/1$ octave filters are obtained by internally combining the $1/3$ octave filters in units of three in such a manner that the bandpass of the individual units will cover a complete octave. The center frequencies of the octave filters are given in the table together with the filter bandwidth.

Center Frequency Hz (c/s)	Bandwidth at 3 dB Hz (c/s) Approx.	Center Frequency Hz (c/s)	Bandwidth at 3 dB Hz (c/s) Approx.
31.5	22	2000	1410
63	45	4000	2810
125	89	8000	5600
250	177	16000	11200
500	353	31500	22300
1000	707		

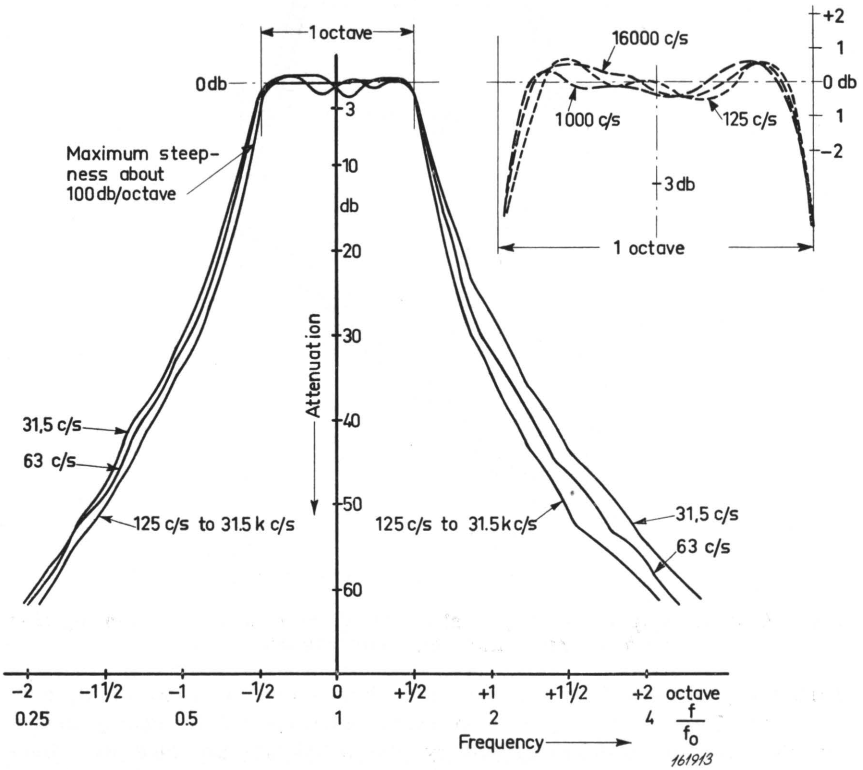


Fig. 1.8. Detailed 1/1 octave filter characteristics derived from sine-wave signals.

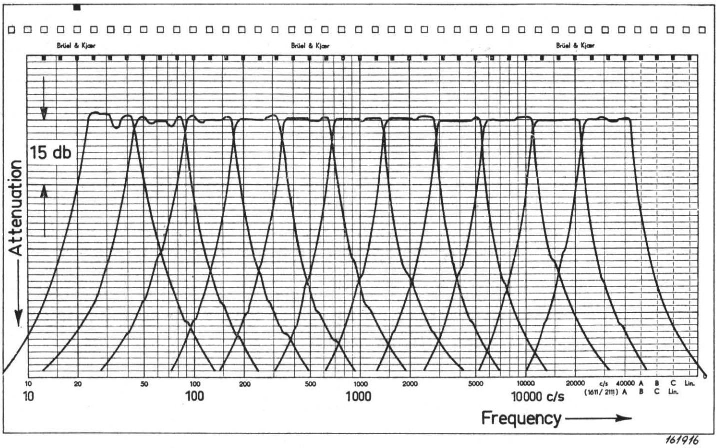


Fig. 1.9. Complete set of filter characteristics when Filter Set is in 1/1 octave condition.

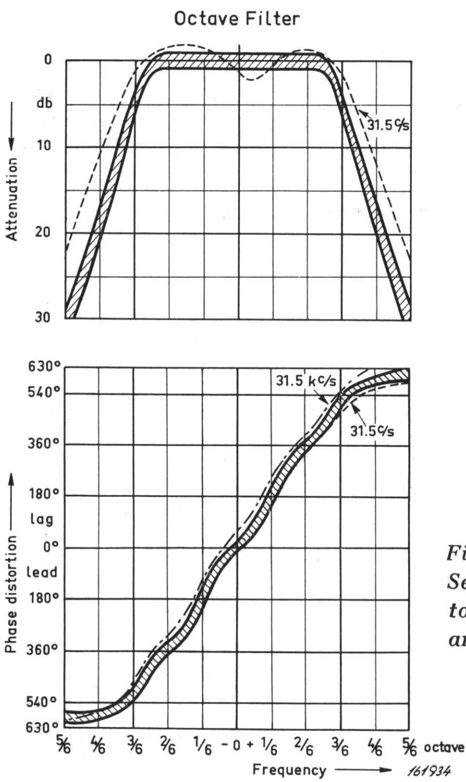


Fig. 1.10. Phase response of Filter Set in 1/1 octave condition, shown together with the respective amplitude characteristics.

Due to the circuit used for connecting three ⅓ octave filters to a ¼ octave filter a certain voltage drop is unavoidable. This voltage drop is made equal to 10 dB, which should be taken into account during measurements. The FUNCTION SELECTOR switch is therefore in position "Octave" also marked "10 dB".

Frequency Response. The filters are adjusted so that the deviations in the pass band between peaks and valleys are within ± 1 dB; for the 31.5 Hz (c/s) and 63 Hz (c/s) within ± 2 dB. At the band limits, i.e. ± ½ octave from the center frequency, the attenuation is approximately 3 dB, vide Figs. 1.8 and 1.9. The attenuation at ± 1 octave is approximately 35 dB, being somewhat less for the filters at the lower frequencies.

Phase Response. The phase response curves of the octave filters are shown in Fig. 1.10, together with the amplitude response of the filter top. The curves for the different filters are expected to lie within the hatched area.

Weighting Networks.

"A", "B" and "C". The three networks are mainly designed as illustrated in Fig. 1.11. The frequency response, related to each sinusoidal component of the signal is given in Fig. 1.12. In the table below will be found the respective tolerances.

For comparison the I.E.C. tolerances for ordinary Sound Level Meters are also given.

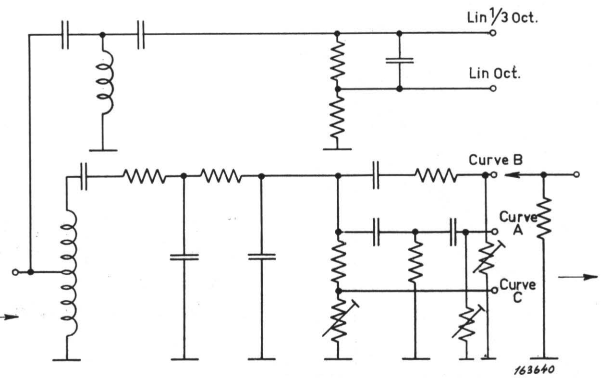


Fig. 1.11. Schematic diagram of weighting networks for sound level measurements.

When employing the weighting networks it should always be stated by the measured result which of the curves has been utilized during the investigation. Example: S.L. 86 dB (B).

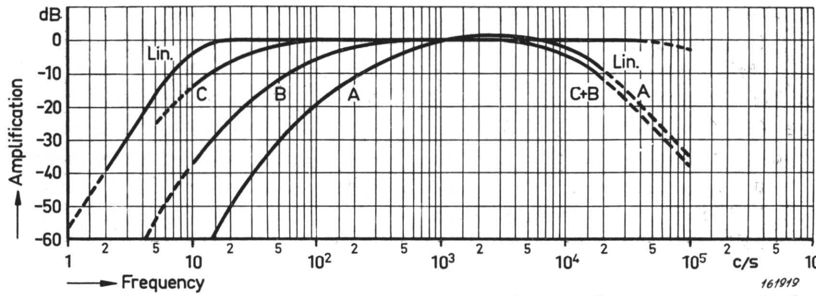


Fig. 1.12. Typical frequency characteristics "A", "B" and "C" for sound level measurements. Valid for the equipment (see text) furnished with one of the B & K Condenser Microphone Type 4131 or Type 4133. Curve also plotted for "Lin." (20—45000 Hz (c/s)) characteristic.

Frequency Hz (c/s)	10	20	40	80	160	315	630	1000	2000	4000	8000	12500	20000
Curve A	—70.5	—50.4	—34.5	—22.3	—13.2	—6.5	—1.9	0	+1.2	+1.0	—1.1	—4.2	—9.2 dB
Curve B	—38.5	—24.4	—14.2	—7.4	—3.0	—0.9	—0.1	0	—0.2	—0.8	—3.0	—6.0	—11.1 dB
Curve C	—14.5	—6.3	—2.0	—0.5	—0.1	0	0	0	—0.2	—0.8	—3.0	—6.0	—11.0 dB
Tolerance Precision Sound Level Meters	+5 —8	+5 —5	+2 —2	+1.5 —1.5	+1 —1	+1 —1	+1 —1	+1 —1	+1 —1	+1 —1	+1.5 —2	+3 —4	+3 dB —7 dB
Tolerance Ordinary Sound Level Meters	+5 —∞	+5 —∞	+3 —3	+2 —2	+2 —2	+2 —2	+2 —2	+1 —1	+2 —2	+3 —3	+4 —4	+5 —10	+5 dB —∞ dB

*) As discussed at the International Electrotechnical Commission (IEC) TC 29 in Helsinki 1961.

Low Frequency Cut-off. In various measurements it is convenient to cut off signals below 20 Hz (c/s). For this purpose a special weighting network "Lin." can be selected. The frequency characteristic can be seen in Fig. 1.12, where the cutting off, which is maximum 18 db per octave, is clearly seen.

In position "Octave, 10 dB" of the FUNCTION SELECTOR the output signal from both types of weighting networks are attenuated 10 dB equal to the signal derived in the pass band of the octave filters.

Selection of Filters and Weighting Networks.

The succesive switching of the filters and weighting networks is accomplished by the Filter Switch (see Fig. 1.1). The center frequency and respective type of weighting network are indicated on a large scale. The 1/3 octave filters and weighting networks are marked on the outer part, and the 1/1 octave filters on the inner part of the scale. The scale is calibrated from 12.5 Hz (c/s) to 40 kHz (kc/s), although the Spectrometer does not contain filters with center frequencies lower than 25 Hz (c/s). The additional calibration on the scale is based on the use of the Extension Filter Set Type 1620. Calibrations "A", "B" and "C" towards the end of the scale refer to the positions of the Filter Switch when the weighting networks are inserted between input amplifier and output amplifier. A final calibration "Lin" refers to the special weighting network making the frequency characteristic of the Filter Set flat from 20 to 45000 Hz (c/s).

Remote Control: The Filter Switch can be manually or automatically operated, the latter being achieved by a remotely controlled electro-magnetic drive unit. To obtain remote control an external DC supply (24 V, 180 mA) in series with a single-poled switch is required. The connections to be made to the jack REMOTE CONTROL can be seen in Fig. 1.13.

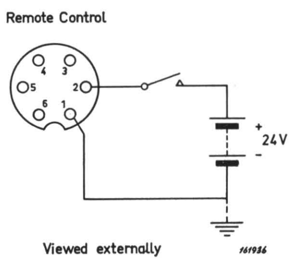


Fig. 1.13. Connections to socket REMOTE CONTROL for the remote control of Filter Switch.

NOTE: Take care that the + terminal of the external DC source is connected with pin 2 and the — terminal with pin 1. If inversely connected a spark-suppressor diode will be damaged.

When the switching action is controlled from the Level Recorder Type 2305 a special cable AQ 0002 has to be applied between the two instruments.

Extension Filters. The rotary switch has 50 positions. One complete revolution of the switch thus means 50 successive switchings. Only 37 positions of the 50 are employed for the connections to the built-in filters and weighting networks, 13 positions thus being unused. These 13 points are connected to a terminal strip at the back of the instrument chassis and can, when desired, be used for connection of additional external filters. Three of these points are already led to the seven-poled socket marked EXTENSION FILTER, to which the above mentioned Extension Filter Set Type 1620 can be connected. When Type 1620 is not used a special adapter is inserted in the EXTENSION FILTER jack, transforming the seven-poled jack into a 14 mm screened coaxial socket. The adaptor then provides a connection to the paralleled inputs of the filters and weighting networks.

Output Stage.

The output stage is equipped with two transistors in a common collector configuration giving an overall voltage gain of a little less than 0 dB. The purpose of the output stage is to ensure that a wide range of load impedances can be connected to the output FILTER OUTPUT without influencing the filter characteristics. The rated load resistance is 100 kΩ or higher but can be as low as 10 kΩ. Loading by 10 kΩ the amplitude vs. frequency characteristic of the output stage slopes off at the low frequencies, vide Fig. 1.15.

Output Stage Power Supply. The power supply for the transistors is maintained via the FILTER INPUT terminal in cases where the Filter Set is combined with the B & K Microphone Amplifiers Type 2603 or 2604, the Frequency Analyzer Type 2107, or the Random Noise Generator Type 1402. On these instruments, the terminal intended for connection of the Filter Set's FILTER INPUT supplies the signal superimposed on d.c. voltage of approximately 75 volts. This d.c. voltage is then utilized for powering the output stage.
If the Filter Set is not used in combination with the mentioned instruments the supply has to be taken from an external d.c. source, such as a battery. The Filter Set is delivered with a special battery supply cable furnished with a 6-pole plug and two snap locks. The snap locks suits battery types (9 Volts) equal to Burgess 2U6, Eveready 216 and Hellesens H 10. These batteries will when used with the Filter Set be drained by 1 mA

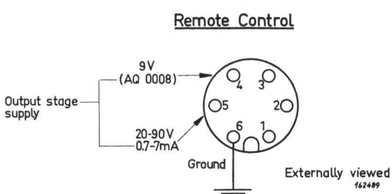


Fig. 1.14. Identification of the pins for external battery supply on the REMOTE CONTROL socket.

approximately and thus have a life of approximately 200 hours. The battery cable's plug has to be plugged into the socket REMOTE CONTROL placed at the rear of the Filter Set. A battery on/off switch is combined with the switch AUTOMATIC SWITCHING and in such a manner that when switching the latter to "On" the battery will also be switched "On".

Using a rectified AC voltage for supplying the transistors, the smoothing is not critical. Even an unsmoothed voltage can be employed, as a R-C network for this purpose is built in. Due to the Zener diode stabilizing circuit, the voltage can have any value between 20 and 90 volts. The drain will be 0.7 and 7 mA respectively. The connections to be done to the REMOTE CONTROL socket can be seen in Fig. 1.14.

Overall Performance of Band-Pass Filter Set.

Transmission. The transmission loss from FILTER INPUT to FILTER OUTPUT terminals is 0 dB for voltages when the input transformer is not inserted. If the transformer is employed the transmission loss will be 20 dB. See Fig. 1.15.

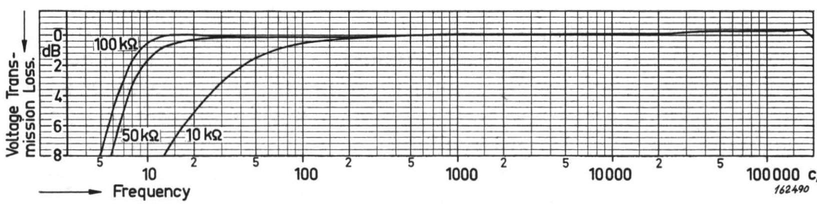


Fig. 1.15. Typical voltage transmission loss of Filter Set as a function of frequency.

INPUT SWITCH on "Direct" and FUNCTION SELECTOR to "1/3 Octave, 0 dB". In position "Transformer" of INPUT SWITCH 20 dB has to be added to the values read on the graph and additionally 10 dB should be added when FUNCTION SELECTOR is set to "Octave, 10 dB".

The transmission loss is given for 10, 50 and 100 kΩ load resistance on the FILTER OUTPUT terminal.

Nonlinear Distortion. This can arise from saturated filter cores, or from an overdriven or too heavy loaded output stage. When the input voltage on the FILTER INPUT terminal is below rated voltages, 1 and 10 volts respectively, and the load resistance on FILTER OUTPUT is higher than100 kΩ the nonlinear distortion will be lower than 0.1 % in the complete frequency range from 20 to 30000 Hz (c/s). This low distortion value is valid in both input conditions, "Direct" and "Transformer". Figs. 1.16 and 1.17.

Signal-to-Noise Ratio. The signal-to-noise ratio of the Filter Set is determined by the self-induced noise from the transistor output stage. For full drive of the stage, 1 volt output, the ratio will be better than 60 dB. The noise figure given here is measured by a wide band system with the frequency range 2—45000 Hz (c/s).

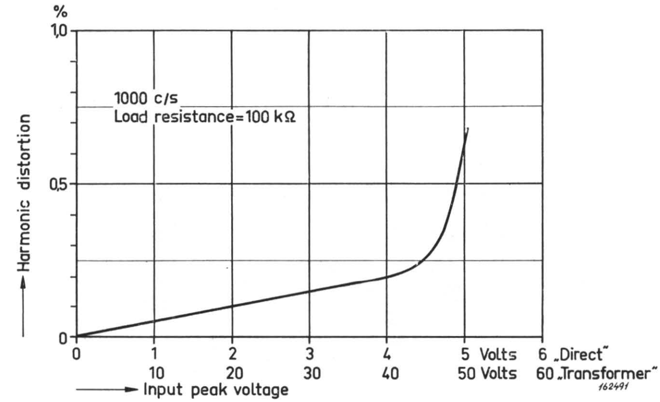


Fig. 1.16. Typical harmonic distortion of complete Filter Set in 1/3 octave condition, shown as a function of input peak voltage on FILTER INPUT. Valid of 1000 Hz (c/s) and 100 kΩ load on FILTER OUTPUT.

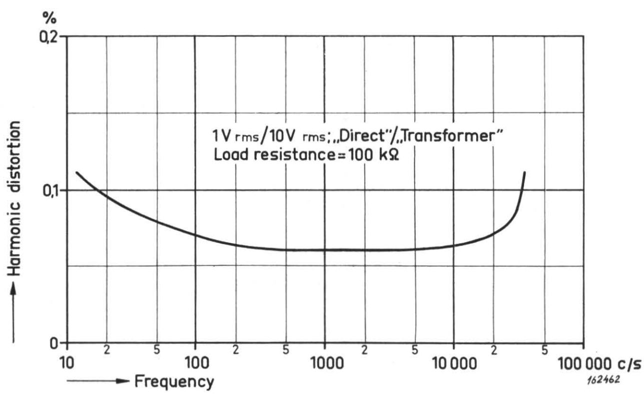


Fig. 1.17. Typical harmonic distortion of complete Filter Set in 1/3 octave condition illustrated as a function of frequency. Valid for 1 V r.m.s. ("Direct") and 10 V r.m.s. ("Transformer") on FILTER INPUT with 100 kΩ FILTER OUTPUT load.

2.
Control Knobs and Terminals

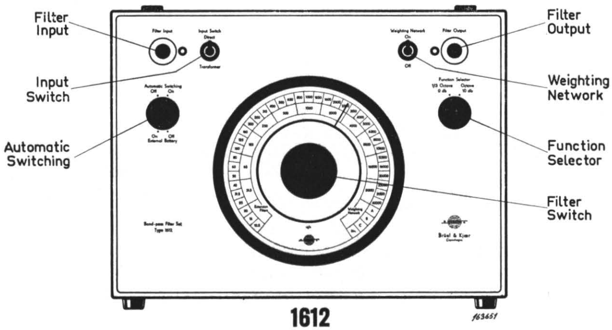


Fig. 2.1. Frontal view of Band-Pass Filter Set.

Front Plate

(refer Fig. 2.1).

INPUT SWITCH. "Direct". The signal on the FILTER INPUT is fed directly to the paralleled filter and weighting network inputs. The signal source impedance should be lower than 10 Ω.

"Transformer". The signal from the FILTER INPUT is passing the input transformer. The signal source impedance should be lower than 1000 Ω.

FILTER INPUT. Input Terminal.

AUTOMATIC SWITCHING, EXTERNAL BATTERY. "On". The connection of the electromechanical drive unit for filter switching is established with the REMOTE CONTROL. Additional, a battery, connected by the battery supply cable AQ 0008, is switched in.

"Off". The drive unit connection is disconnected and the battery is switched off.

FILTER SWITCH. For selection of the filters, weighting networks and possible connected extension filters.

WEIGHTING NETWORK. For switching on and off the four weighting networks "A", "B", "C" and "Lin.". The switching is accomplished at the network inputs.

FILTER OUTPUT. Output terminal.

FUNCTION SELECTOR. "1/3 Octave, 0 dB". The 1/3 octave filters and weighting networks, plus possible 1/3 octave extension filters, is selectable by the Filter Switch. The "0 dB" indicates that the pass band voltage transmission loss is "0 dB" when INPUT SWITCH is in position "Direct".

"Octave 10 dB". The octave filters and weighting networks, plus a possible octave extension filter, is selectable by the Filter Switch. The "10 dB" refers to an extra pass band voltage transmission loss of 10 dB.

Rear of Filter Set

REMOTE CONTROL. Plug for connections of remote control circuits and external battery supply.

EXTENSION FILTER. When the special adaptor (JP 0019) transforming the 7-pole socket into a 14 mm screened jack (inserted at delivery), is removed, the B & K Extension Filter Set Type 1620 can by its 7-pole plug be plugged into the Band-Pass Filter Set. The screened jack obtained with the adaptor in position is wired up with the filter and weighting network inputs.

NOTE When the Extension Filter Set is not connected, the special adaptor should always be inserted in the jack, as this grounds all the positions on the Filter Switch intended for the Extension Filter Set.

NOTE: When the Filter Set is set to "Direct" a d.c. voltage of approximately 75 volts is present on the screened jack, obtained by the adaptor JP 0019, in case the Filter Set is combined with one of the B & K Random Noise Generator Type 1402, Frequency Analyzer Type 2107, or the Microphone Amplifier Type 2603 or 2604.

Operation

3. Operation

The Filter Set is intended to be used in connection with the B & K Random Noise Generator Type 1402, Frequency Analyzer Type 2107, Microphone Amplifier Type 2603 or 2604 or Precision Sound Level Meter Type 2203, but is also well suited to be employed solely. When combined with the Frequency Analyzer Type 2107 or the Microphone Amplifier Type 2603 or Type 2604 a complete spectrometer is obtained which with respect to electrical specification is identical to the A.F. Spectrometer Type 2112. The operation procedure for such a combination will therefore be similar to that of the A.F. Spectrometer Type 2112, see below.

Band-Pass Filter Set Combined with Random Noise Generator Type 1402.

1/3 octave or 1/1 octave bands of noise will be present on the output terminals of the Random Noise Generator Type 1402 when the Band-Pass Filter Set is connected to the Generator's external filter terminals.

I. Manual Noise Band Selection.

I. Connect the Filter Set and Noise Generator as illustrated in Fig. 3.1.

II. Set the control knobs on Filter Set as follows:
1. INPUT SWITCH on "Direct".
2. WEIGHTING NETWORK to "Off".
3. FUNCTION SELECTOR to "1/3 Octave" or "Octave" as desired.
   Choose the desired noise band with the "Filter Selector".

III. Set the control knobs on the Noise Generator as follows:
1. METER TIME CONSTANT is set to a position where a stable deflection of the indicating meter pointer is achieved.
   NOTE: Using a high meter-time-constant value, the METER TIME CONSTANT may first be set to a low value and then to the position required. In this manner a faster reading is obtained.
2. EXTERNAL FILTER on "In".
3. FREQUENCY RESPONSE on "Weighted, —3 dB/octave".

IV. Turn OUTPUT LEVEL so that a suitable deflection on the indicating meter is obtained.

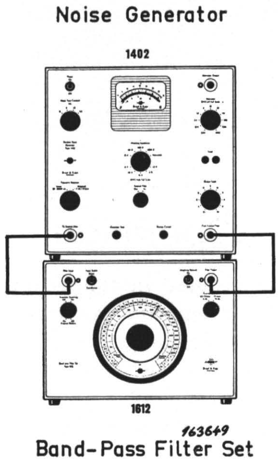


Fig. 3.1. Band-Pass Filter Set used as external filters for the Random Noise Generator Type 1402.

V. Two output terminals can be employed:

ATTENUATOR OUTPUT intended for high impedance loads (5000 Ω or higher)

LOAD intended for low impedance loads (6 Ω to 6000 Ω)

NOTE: The right terminal is grounded.

1. ATTENUATOR OUTPUT:
   Set MATCHING IMPEDANCE in position "Attenuator" and adjust to the appropriate signal level by OUTPUT LEVEL potentiometer and ATTENUATOR.
2. LOAD:
   Set MATCHING IMPEDANCE to a value as near as possible to that of the load impedance, and adjust to appropriate signal level by OUTPUT LEVEL potentiometer.

II. Automatic Noise Band Selection.

The procedure described above is followed throughout. Thereafter is continued with: "Automatic Filter Switching from Level Recorder", see the following.

Automatic Filter Switching from Level Recorder.

When the B & K Level Recorder Type 2305 is used in an integrated measuring system including the Band-Pass Filter Set the filters and weighting networks of the latter can be selected automatically in succession via the Level Recorder. The setting up and adjustment of the Recorder's single chart automatic stop and the synchronization of filter switching and recording paper calibration is as given below:

I. Measuring Arrangement.

Interconnect the Recorder 7-pole Remote Control socket with the Filter Sets' REMOTE CONTROL socket by using the remote control cable AQ 0002,*) see also Fig. 3.2.

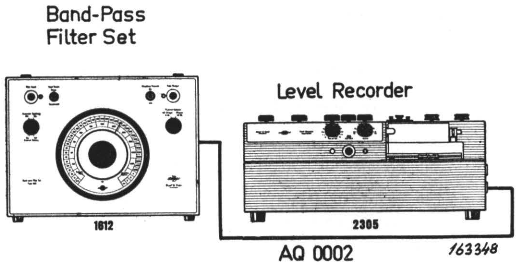


Fig. 3.2. Band-Pass Filter Set combined with Level Recorder Type 2305.

II. Adjustment of Level Recorder's Single Chart Automatic Stop.

1. Insert the desired type of frequency calibrated paper and mount pen or sapphire. If necessary, see instruction manual for the Level Recorder.
2. Set control knobs on Level Recorder:

    POTENTIOMETER RANGE dB" on "Stand by"
    POWER to "On"
    MOTOR to "On"
    PAPER DRIVE to "Stop" and "Forward"

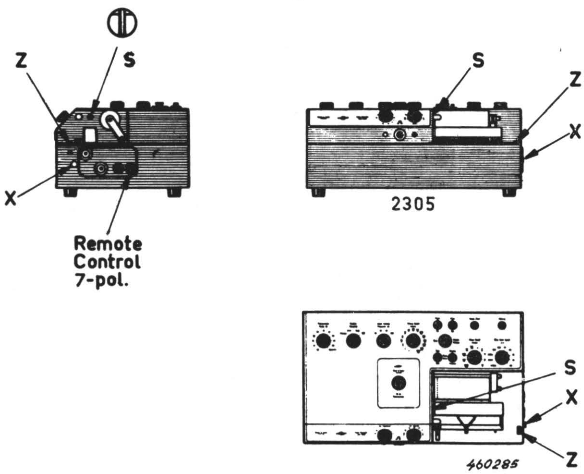


Fig. 3.3. Level Recorder with identification of: Synchronizing Gear Lever X, Screw S and Finger Wheel Z.

*) If desired the power for the output transistor in Type 1612 can also be supplied from the Level Recorder. This, however, requires a special cable and reconnection of the plugs (AQ 0002 can not be used).

PAPER SPEED to 10 mm/sec, small figures.

Gear Lever (Fig. 3.3) is pulled out to its outer position.

3. The toggle switch PAPER DRIVE is set to "Start", whereby the paper starts moving. If not, press the pushbutton "SINGLE CHART-CONT. RECORD. After one chart length or less the paper automatically stops.
4. Move the recording paper by means of the finger wheel Z shown in Fig. 3.3 until the writing stylus points at the "10" Hz (c/s) line.

III. Synchronization of Filter Switching and Recording Paper Preprint.

1. Turn the screw S (Fig. 3.3) with a screwdriver until the making cut in the screw is in its upper position.
2. Set PAPER DRIVE to "Stop".
3. Set AUTOMATIC SWITCHING on Filter Set to "Off".
4. Set Filter Switch to one step before "12.5" Hz (c/s, i.e. that which would be 10 Hz (c/s).
5. Set AUTOMATIC SWITCHING to "On".
6. Drive Level Recorder paper by operating the SINGLE CHART-CONT. RECORD push button to the exact point where the Filter Switch switches.

   NOTE: To find the exact point where the Level Recorder switches the Filter Switch it is recommended to set the PAPER SPEED to a low value. In this manner the paper is driven slowly until switching and then immediately stopped.
7. Move paper by finger wheel Z (Fig. 3.3) until the pen points half way between two squares indicating the ⅓ octave filter frequencies (placed on the top of the recording chart.)

   To obtain an easy reading move pen manually to the left hand side of paper (corresponding to full deflection).

   NOTE: To avoid effect of play between the gear wheels, the paper should always be shifted in a manner, so that it approaches the correct point in the reverse direction. If, for example, it has to be shifted corresponding to a higher frequency, i.e. forward direction, the paper is shifted a little beyond, and finally reversed to the desired point. If necessary, new trails can be carried out by driving to the following squares.
8. Check finally by driving the paper so far that the shifting takes place between the 80 Hz (c/s) and 100 Hz (c/s) filter. Here the switching should, when correctly adjusted, occur at the 90 Hz (c/s) line. Equal checks can be carried out at the 800—1000 Hz (c/s) and 8000—10000 Hz (c/s) filters.

   NOTE: The PAPER SPEED can, without altering the adjusted synchronization be changed during operation.
9. Set PAPER DRIVE to "Start". The paper runs now to the preselected single chart stop. The stop position may have changed a few millimetres on the paper owing to the synchronizing adjustment, but this has no practical influence.

The single chart automatic stop and the synchroization have now been accomplished. The combined Band-Pass Filter Set and the Level Recorder can then be inserted in the desired measuring arrangement.

Band-Pass Filter Set Combined with Microphone Amplifier Type 2603 or Type 2604.

Combining the Filter Set with one of the Microphone Amplifiers, spectrum analyses can be made reading the Amplifier's indicating meter. See procedure below. When the equipment is supplemented with the B & K Level Recorder Type 2305 the analysis can be recorded automatically, see paragraph "Automatic Recording of Sound Spectrograms" or "Automatic Recording of Voltage Analyses" below.
The operation procedure is identical for both Amplifier Type 2603 and Type 2604 with the exception that the switch for switching external filters in or out is termed FREQUENCY RESPONSE SWITCH for the Microphone Amplifier Type 2603 and WEIGHTING NETWORK for the Type 2604.

A.F. Spectrometer Analyses.

I. Measuring Arrangement.

1. Set up the Microphone Amplifier in the desired measuring arrangement, for example with a B & K Condenser Microphone in a sound analysis.

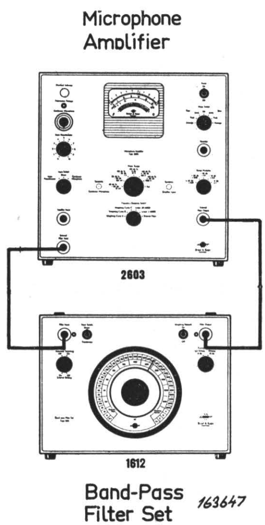


Fig. 3.4. Band-Pass Filter Set used as external filter for the Microphone Amplifier Type 2603 or Type 2604.

Set up and calibrate the arrangement as described in the instruction manual for the respective Microphone Amplifier.

2. Wire up Band-Pass Filter Set and Microphone Amplifier according to Fig. 3.4 with for example the Screened Connection Cables AO 0014.
3. Set FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK of Microphone Amplifier to "External Filter".
4. Set control knobs on Band-Pass Filter Set.
   INPUT SWITCH to "Direct".
   WEIGHTING NETWORK to "On".
   FUNCTION SELECTOR to "⅓ Octave" or "Octave" as desired.
   FILTER SWITCH to the filter at which the measurement should be carried out.

II. Measurements.

1. Apply the signal to be analysed to the arrangement.
2. Turn METER RANGE from the "Ref" position counterclockwise until the overload Indicator just shows overload. From this position turn one step clockwise. Indicator should now show no overload.
3. Set METER SWITCH to "R.M.S.", "Average" or "Peak". "Fast" or "Slow' as desired.
4. Set RANGE MULTIPLIER to obtain suitable indicating meter deflection, preferable between 10 and 20 dB on scale.

The signal level within the chosen filter, and referred to the input of the measuring arrangement is read according to the same method as explained in the instruction manual for the Microphone Amplifier.

Automatic Recording of Sound Spectrograms.

A. SET UP, CALIBRATION AND ADJUSTMENT OF EQUIPMENT

I. Measuring Arrangement.

Connect Microphone Amplifier, Filter Set and Level Recorder as shown in Fig. 3.5. The REMOTE CONTROL socket on the rear of the Filter Set should be connected to the seven-poled REMOTE CONTROL socket of the Level Recorder by using the cable AQ 0002.

II. Calibration of Combination Microphone Amplifier and Filter Set.

1. Set control knobs of Microphone Amplifier:

INPUT SWITCH:	"Direct"
METER SWITCH:	"Ref."
METER RANGE:	"Fast", "RMS"
RANGE MULTIPLIER:	"× 1, 0 dB"
FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK:	"External filter"

2. Set control knobs of Filter Set:

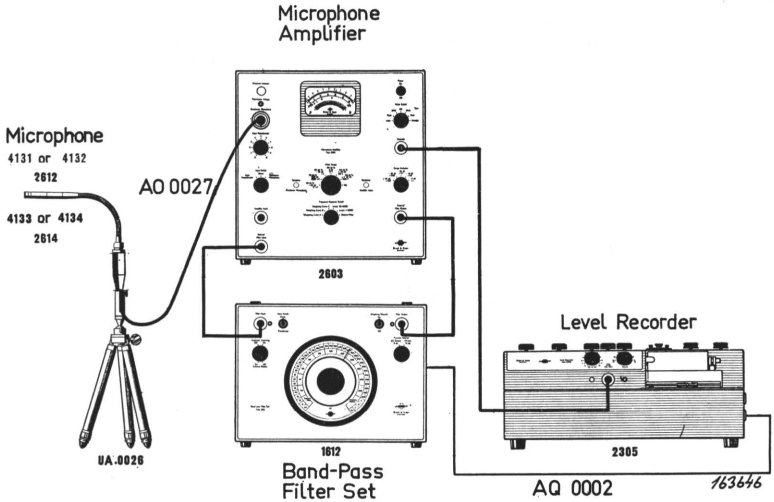


Fig. 3.5. Measuring arrangement for automatic recording of sound spectrograms.

INPUT SWITCH:	"Direct"
WEIGHTING NETWORK:	"On"
FUNCTION SELECTOR:	"⅓ Octave - 0 dB"
AUTOMATIC SWITCHING:	"Off"
SCALE POINTER:	"Linear"

3. The meter should now show a deflection to the red mark on the scale. Possible deviations being corrected by the screwdriver operated potentiometer marked SENSITIVITY — AMPLIFIER INPUT on the front panel of Microphone Amplifier.

III. Calibration of Level Recorder.

1. Potentiometer 50 dB employed. For potentiometers with other ranges refer para B, page 39.
2. Set control knobs as follows:—

   POTENTIOMETER RANGE to "50"
   RECTIFIER RESPONSE to "R.M.S."
   LOWER LIMITING FREQUENCY to "20"
   WRITING SPEED: 50 mm paper: 500 mm/sec, large figures.*)
   100 mm paper: 1ooo mm/sec, small figures.*)

*) By this combination of LOWER LIMITING FREQUENCY and WRITING SPEED setting, the Level Recorder is operating in an abnormal condition and therefore tends to overswing as visible on the recording in Fig. 3.6. The abnormal condition is used only during synchronization to give an unambiguous indication of the filter switching point.

PAPER DRIVE to "Stop" and "Forward"
SINGLE CHART-CONT. RECORD in its upper position
POWER to "On"

Allow a few minutes for warming up, then switch

MOTOR to "On"
INPUT ATTENUATOR to "10"

3. By the INPUT POTENTIOMETER the deflection of the stylus is adjusted to full deflection minus 4 dB. (Using 50 dB Range Potentiometer, 50—4 = 46 dB).

IV. Adjustment of Single Chart Automatic Stop:—

1. Insert the desired type of frequency calibrated paper and mount pen or sapphire. If necessary, see the instruction manual for Level Recorder Type 2305.
2. Pull the Gear Lever X (Fig. 3.3) (ratio 1 : 10) to its outer position. The Lever is marked X in Fig. 3.3.
3. Set the PAPER SPEED to 10 mm/sec, small figures.
4. The toggle switch PAPER DRIVE is set to "Start", whereby the paper starts moving. If not, press the pushbutton SINGLE CHART-CONT, RECORD. After one chart length or less the paper automatically stops.
5. Move the recording paper by means of the finger wheel Z (Fig. 3.3) until the pen points at the "10" Hz (c/s) line.

V. Synchronization between Level Recorder and Band-Pass Filter Set.

The switching moment of the Filter Switch on the Band-Pass Filter Set can now be synchronized with the paper movement.

1. Turn the screw S shown in Fig. 3.3 with the aid of a screwdriver, until the marking cut in the screw is in its upper position.
2. When proceeding from above set control knobs on the Microphone Amplifier and Band-Pass Filter Set as:

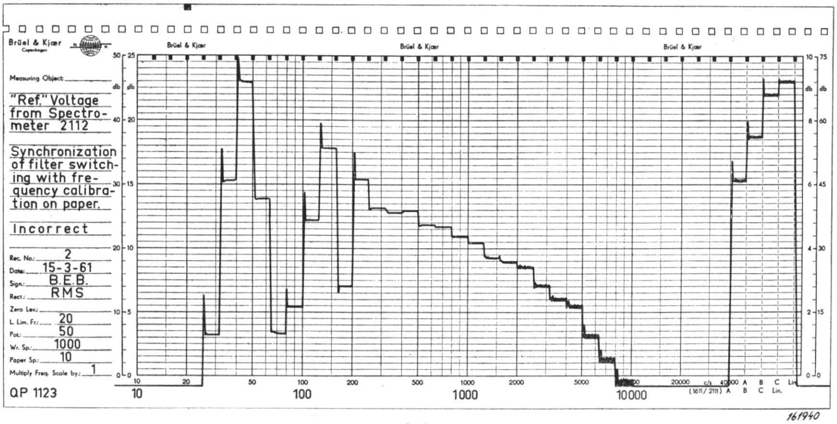
   Microphone Amplifier:

   FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK to "External Filter"

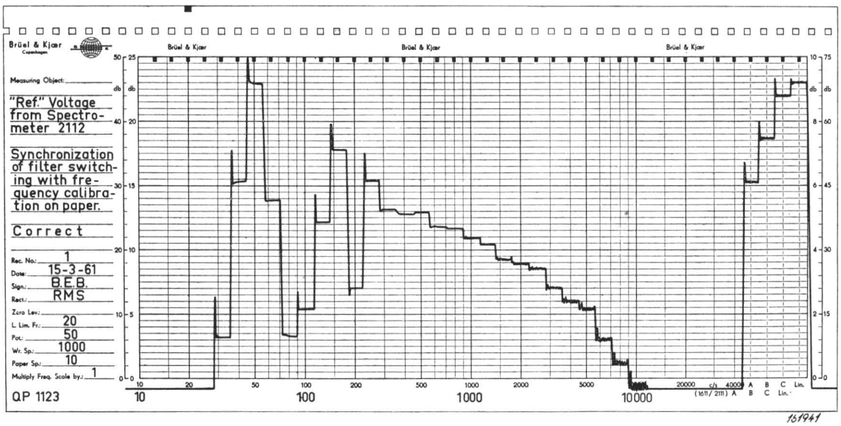
   Filter Set:

   INPUT SWITCH to "Direct"
   WEIGHTING NETWORK to "On"
   FUNCTION SELECTOR to "⅓ Octave 0 dB"
   AUTOMATIC SWITCHING to "Off"
   Filter Switch to one step before (counter-clockwise) the position "12.5"
   AUTOMATIC SWITCHING to "On"
3. The control knobs on the Level Recorder have to be moved as follows:

   Set PAPER DRIVE to "Stop".
   Press pushbutton marked SINGLE CHART-CONT. RECORD.



(a)



(b)

Fig. 3.6. Synchronization between recording paper and filter switching. (Concerning the overswing on the recording refer the footnote on page 33).
(a) Incorrect.
(b) Correct.

The paper starts moving, and then the reference voltage commences to be recorded.

The pushbutton should be released when the paper has moved to about the "200" — "300" Hz (c/s) line.

4. Correct synchronization is obtained when the switching over from the "80" Hz (c/s) to the "100" Hz (c/s) filter takes place on the line "90" Hz (c/s), refer Fig. 3.6a and b.

   To ensure that synchronization is achieved within the proper ⅓ octave filter the component of the power supply fundamental frequency should be represented as the highest value on the spectrogram within the filter covering this fundamental. From Fig. 3.6b it is seen that the fundamental (here 50 Hz (c/s)) is the highest value and rests within the filter concerned. In the case of a 60 Hz (c/s) power supply frequency the highest value would be contained within the 63 Hz (c/s) filter.

5. If the synchronization is incorrect, the paper should be shifted by the finger wheel Z.

   NOTE: To avoid the effect of play between the gear wheels, the paper should always be shifted in a manner, so that it approaches the correct point in the reverse direction. If, for example, it has to be shifted corresponding to a higher frequency, i.e. forward direction, the paper is shifted a little beyond, and finally reversed to the desired point.

   To be able to see how far the paper has to be shifted, it is recommended to draw a line by means of the stylus, when the paper has stopped. By using this line, the paper is now shifted the required distance to give correct synchronization, this being easily seen from the previous recording. To draw the line, the stylus is given a deflection which may be obtained by pressing the knob "100 mV. Ref." on the Level Recorder. Should the paper have to be shifted equal to a lower frequency the respective distance may be marked on the paper beforehand.
6. To check the synchronization, run the recording to about the "2000" — "3000" Hz (c/s) line. When synchronized correctly the switching from the "800" Hz (c/s) to the "1000" Hz (c/s) filter should now take place at the "900" Hz (c/s) line. If this is not the case, run the paper to the following charted portion and repeat from item IV. 3.
7. PAPER DRIVE is set to "Start", whereby the paper moves to the pre-selected single chart stop.

VI. Calibration According to the Selected Microphone.

The measuring arrangement has now to be calibrated to the Micro phone employed. This can be done by:—

Microphone 4131 or 4132 employed.
Employment of the reference voltage in the Microphone Amplifier and the correction factor "K" valid for the respective Microphone.

1. Check the microphone polarization voltage. Further instructions concerning this is given

Microphone 4133 or 4134 employed.

1. Check the microphone polarization voltage. Further instructions concerning this is given in the instruction manual for the Microphone Amplifier.
2. Apply the Condenser Microphone as shown in Fig. 3.5. Allow a few minutes to warm up.

Microphone 4131 or 4132 employed.

in the instruction manual for the Microphone Amplifier.

2. Apply the Condenser Microphone as shown in Fig. 3.5. Allow a few minutes to warm up.
3. The control knobs of the Microphone Amplifier should be operated as follows:—
   INPUT SWITCH to "Condenser Microphone"
   FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK to "External Filter".
   The other control knobs are kept as described above.
4. The control knobs of Filter Set:
   INPUT SWITCH: "Direct"
   WEIGHTING NETWORK: "On"
   FUNCTION SELECTOR: "1/3 Octave, 0 dB"
   AUTOMATIC SWITCHING: "On"
   SCALE POINTER: "Linear"
5. The deflection on the indicating meter should now be adjusted to the red mark plus the correction factor "K" of the Microphone. This being done by means of the potentiometer SENSITIVITY, CONDENSER MICROPHONE situated on the front.

Example 1.
"K" = 1.5 dB.
The pointer has to be adjusted to 16 dB + 1.5 dB = 17.5 dB
16 dB corresponds to the red mark.

Example 2.
"K" = — o.3 dB
The pointer has to be adjusted to 16 dB — o.3 dB = 15.7 dB

Microphone 4133 or 4134 employed.

3. The control knobs of the Microphone should be operated as follows:—
   INPUT SWITCH to "Condenser Microphone"
   FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK to "External Filter".
   The other control knobs being kept as described above.
4. The control knobs of Filter Set:
   INPUT SWITCH: "Direct"
   WEIGHTING NETWORK: "On"
   FUNCTION SELECTOR: "1/3 Octave, 0 dB"
   AUTOMATIC SWITCHING: "On"
   SCALE POINTER: "Linear".
5. Adjust the deflection of the indication meter pointer to the red mark on the scale by turning the screwdriver-operated potentiometer SENSITIVITY CONDENSER MICROPHONE.
6. Increase the sensitivity of the Level Recorder by means of the INPUT POTENTIOMETER, and, if necessary, by the INPUT ATTENUATOR to:—
   the correction factor "K" dB — 10 dB,
   where "K" is the correction factor of the Microphone.

▼

Example 1.
"K" = 13.3 dB
The sensitivity of the Level Recorder should be increased by:—
13.3 dB — 10 dB = 3.3 dB

Example 2.
(50 db Range Potentiometer).
"K" = 16 dB
The sensitivity of the Level Re-

Microphone 4133 or 4134 employed.

corder should be increased by:—
16 dB — 10 dB = 6 dB

The stylus should then in reality rest at 46 dB + 6 dB = 52 dB.

This is of course not possible as the full deflection is equal to 50 dB.

A way of increasing the sensitivity could be:—

(a) Decrease sensitivity by INPUT POTENTIOMETER on Level Recorder
10 dB — 6 dB = 4 dB

(b) Increase sensitivity 10 dB by INPUT ATTENUATOR
The total increase is then
— 4 dB + 10 dB = 6 dB.

The measuring arrangement has now been calibrated so that an absolute reading of the S.P.L. value present on the microphone diaphragm, can be carried out on the spectrogram. Further information is given in a following paragraph "Reading of Absolute Value of the Spectrogram".

VII. Adjustment to the Signal.

Sound to be analysed is exposed to the Microphone.

1. The control knobs RECTIFIER RESPONSE, LOWER LIMITING FREQUENCY, WRITING SPEED and PAPER SPEED on the Level RECORDER are set to positions, whichever are desired for the measurements.

   NOTE: By choosing the positions of LOWER LIMITING FREQUENCY and WRITING SPEED the stability and overswing of the Recorder should be taken into account. For more details, refer to the manual for the Level Recorder Type 2305.

2. Keeping other control knobs in positions as outlined above, set knobs on Microphone Amplifier to:

METER RANGE and RANGE MULTIPLIER:	Are set so that a suitable deflection of the writing stylus is obtained. (40—45 dB for 50 dB Range Potentiometer employed). To give highest signal/noise ratio the "Range Multiplier" should be in a position as near "× 1, 0 dB" as possible.
METER SWITCH:	"Off" (recommended at low frequencies or/and high amplitudes).

VIII. Recording.

On proceeding from "Adjustment to the Signal" the recording can be started when:—

1. FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK is set to "External Filter".

2. The FUNCTION SELECTOR of the Filter Set is set to "⅓ Octave, 0 dB" or "Octave 10 dB", whichever is desired for the measurement.
3. The pushbutton SINGLE CHART - CONT. RECORD." is operated, allowing the recording to start.
4. Additionally, it is recommended to write down on the recording paper the positions of METER RANGE, RANGE MULTIPLIER and FUNCTION SELECTOR controls.

B. EMPLOYMENT OF DIFFERENT POTENTIOMETERS

When using other than a 50 dB Potentiometer during measurement, the following should be taken into account:—

I. Item A II through A IV is firstly carried out with a 50 dB Range Potentiometer for synchronization.

II. Apply for desired Range Potentiometer and calibrate the deflection of the Level Recorder stylus as follows:—

1. POTENTIOMETER RANGE to the Potentiometer employed.*)
2. WRITING SPEED on:—
   160 mm/sec for 50 mm paper (large figures)
   315 mm/sec for 100 mm paper (small figures)
3. PAPER DRIVE to "Start" and "Forward".
4. INPUT ATTENUATOR is set to:—

Range Potentiometer	INPUT ATTENUATOR
10 dB	"30"
25 dB	"30"
75 dB	"0"
10— 35 mV	"50"
10—110 mV	"40"

5. By the Level Recorder INPUT POTENTIOMETER the deflection of the stylus is adjusted to:—

Range Potentiometer	Deflection of Stylus
10	10-4 = 6 dB
25	25-4 = 21 dB
75	75-19 = 56 dB

	50 mm	*100 mm paper*
10— 35 mV	20 mm	40 mm deflection on stylus scale
10—110 mV	26.5 mm	53 mm deflection on stylus scale

Then continue with item A V through A VI.1.

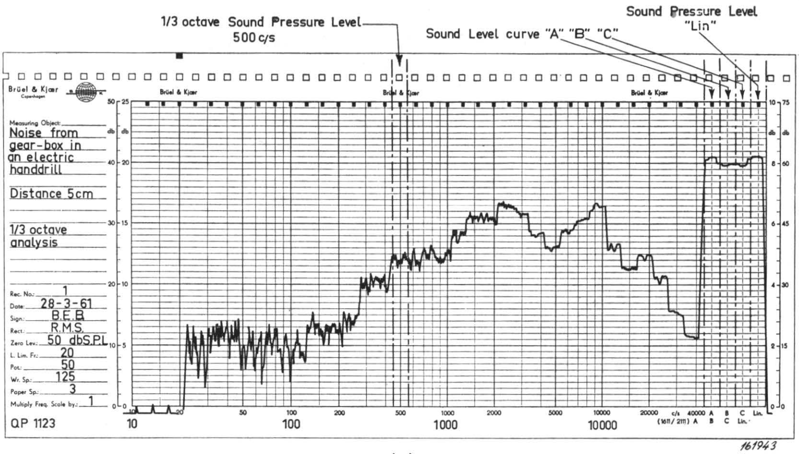
---

*) By employing a linear Range Potentiometer 10—35 mV or 10—110 mV (ZR 0001 or ZR 0002 respectively) the resolving power of the recording system of the Level Recorder is not the same at minimum deflection as it is at maximum. Therefore a particular position of POTENTIOMETER RANGE will not be optimum for all degrees of deflection.
It is recommended to set POTENTIOMETER RANGE to "12" when using a 10—35 mV Potentiometer and "16" when a 10—110 mV Potentiometer and further to combine WRITING SPEED and LOWER LIMITING FREQUENCY setting so that unstability and overshoot of the recording system is avoided in the range of deflection wanted.

C. EVALUATION OF SOUND SPECTROGRAMS

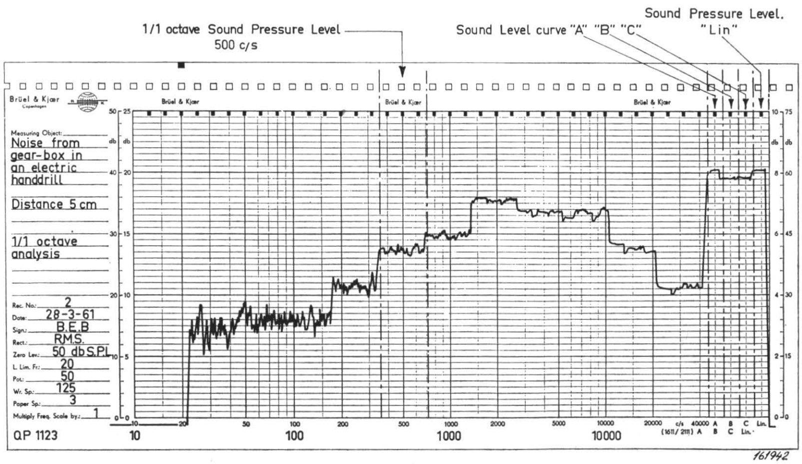
Sound Pressure Level (S.P.L.) value is indicated when the Filter Switch on the Filter Set is in position "Lin.", see Fig. 3.7a and b.

When the Filter Set is switched to analyse with ⅓ Octave Filters, the Sound Pressure Level within ⅓ octave is measured only, and is indicated when the Filter Switch is in any of the positions from "25" to "40ooo". See Fig. 3.7a. When the Filter Set is used with Extension



(a)

Fig. 3.7. Example of recorded spectrograms. The Sound Pressure Level and Sound Level are indicated.
(a) ⅓ octave analysis.



(b)

(b) 1/1 octave analysis.

Filter Set Type 1620, or ZS 0146, the ⅓ Octave S.P.L. value is obtained, when the filter switch is in any of the positions "12.5" to "40ooo". When switching the Filter Set to Octave Filters, the Sound Pressure Level with a bandwidth of 1 octave is only measured. See Fig. 3.7b.

Sound Level is measured when the Filter Switch on the Filter Set is in one of the positions "A", "B" or "C" and the FUNCTION SELECTOR in "⅓ Octave, 0 dB" or "Octave, 10 dB". See also Fig. 3.7a and b. When the measuring arrangement is calibrated as described in the previous paragraphs the above mentioned levels can all be found from the recorded spectrogram, vide the following paragraph.

D. READING OF VALUES FROM THE SPECTROGRAM

When the calibration procedure is carried out as described above in item A I and II the absolute value in S.P.L. or S.L. on the diaphragm of the Microphone can be read on the spectrogram by following the procedure given below.

Microphone 4131 or 4132 employed.

1. 50 dB Range Potentiometer applied:—

   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   — 30 dB

Example 1.

Deflection of the stylus: 46 dB
Position of METER RANGE:
"60 dB S.L."
Position of RANGE MULTIPLIER:
"0 dB × 1"
Position of FUNCTION SELECTOR:
"⅓ Octave, 0 dB"
46 dB + 60 dB + 0 dB + 0 dB — 30 dB = 76 dB S.P.L. or S.L.

Example 2.

Deflection of the stylus: 10 dB
Position of METER RANGE:
"80 dB S.L."
Position of RANGE MULTIPLIER:
"— 10 dB × o.3"

Microphone 4133 or 4134 employed.

1. 50 dB Range potentiometer applied:—

   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   — 20 dB

Example 1.

Deflection of the stylus: 46 dB
Position of METER RANGE:
"60 dB S.L."
Position of RANGE MULTIPLIER:
"0 dB × 1"
Position of FUNCTION SELECTOR:
"⅓ Octave, 0 dB"
46 dB + 60 dB + 0 dB + 0 dB — 20 dB = 86 dB S.P.L. or S.L.

Example 2.

Deflection of the stylus: 10 dB
Position of METER RANGE:
"80 dB S.L."
Position of RANGE MULTIPLIER:
"— 10 dB × o.3"

Position of FUNCTION SELECTOR:
"Octave, 10 dB"
10 dB + 80 dB — 10 dB + 10 dB — 30 dB = 60 dB S.P.L. or S.L.

Microphone 4131 or 4132 employed.

2. 10 dB Range Potentiometer applied:—
   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   + 10 dB
3. 25 dB Range Potentiometer applied:—
   The value in dB on the Spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   — 5 dB
4. 75 dB Range Potentiometer applied:—
   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   — 40 dB

Position of FUNCTION SELECTOR:
"Octave, 10 dB"
10 dB + 80 dB — 10 dB + 10 dB — 20 dB = 70 dB S.P.L. or S.L.

Microphone 4133 or 4134 employed.

2. 10 dB Range Potentiometer applied:—
   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   + 20 dB
3. 25 dB Range Potentiometer applied:—
   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   + 5 dB
4. 75 dB Range Potentiometer applied:—
   The value in dB on the spectrogram
   + the number of dB S.L. indicated by METER RANGE
   + the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
   — 30 dB

NOTE: For 75 dB Range Potentiometers the calibration is different from that which is valid for the three other Range Potentiometers, refer "Automatic Recording of Voltage Analysis", para B on page 45, which is also used for sound spectrogram recordings

Due to the risk of overdriving, the voltage from the output RECORDER of the Microphone Amplifier should not exceed 45 V peak.

Derivation of above formulae.
The calculation of the formulae used for the different Range Potentiometers, item 1, 2, 3, and 4 above, can be seen from the general formula:—

Microphone 4131 or 4132.
The value in dB on the spectrogram
+ the number of dB S.L. indicated by METER RANGE
+ the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
— dB deflection stated for calibration of the Level Recorder*)
— 4 dB + 20 dB

Example:
75 dB Range Potentiometer.
The value in dB on the spectrogram
+ the number of dB S.L. indicated by METER RANGE
+ the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
— 56 dB — 4 dB + 20 dB
The last line in the formula being — 40 dB, refer item 4 above.

Microphone 4133 or 4134.
The value in dB on the spectrogram
+ the number of dB S.L. indicated by METER RANGE
+ the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
— dB deflection stated for calibration of the Level Recorder*)
— 4 dB + 20 dB + 10 dB

Example:
50 dB Range Potentiometer
The value in dB on the spectrogram
+ the number of dB S.L. indicated by METER RANGE
+ the sum of numbers of dB indicated by RANGE MULTIPLIER and FUNCTION SELECTOR
— 46 dB — 4 dB + 20 dB + 10 dB
The last line in the formula being — 20 dB, refer item 1 above.

*) Refer "Automatic Recording of Sound Spectrograms", para A III item 3, or para B II item 5.

Automatic Recording of Voltage Analysis.

A. SET UP AND CALIBRATION

I. Measuring Arrangement.
Connect the instruments as shown in Fig. 3.8.

II. The procedure outlined in "Automatic Recording of Sound Spectrograms" should be followed from item II through V.

NOTE: The procedure is described using a 50 dB Range Potentiometer in the Level Recorder. If Potentiometers with other data are desired refer para "Employment of Different Potentiometers" on page 39.

III. Adjustment to the Signal.

1. The control knobs RECTIFIER RESPONSE, LOWER LIMITING FREQUENCY, WRITING SPEED and PAPER SPEED on the Level Recorder are set to positions, whichever are desired for the measurement in question.

   NOTE: By choosing the positions of LOWER LIMITING FREQUEN-

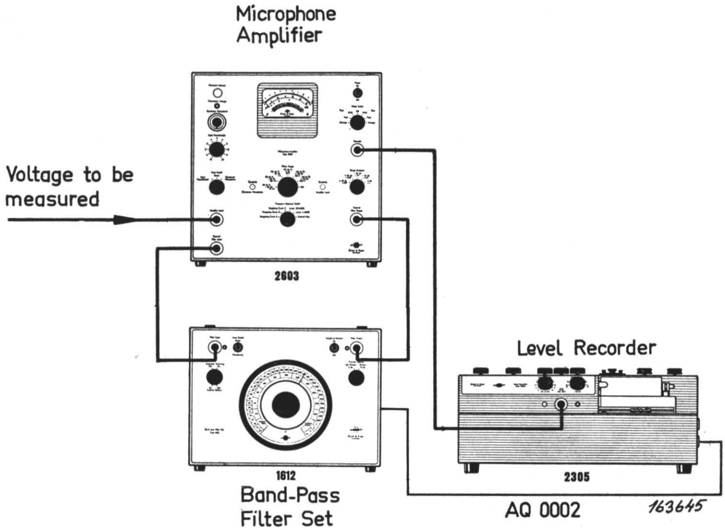


Fig. 3.8. Measuring arrangement for automatic recording of voltage analyses.

CY and WRITING SPEED the stability and overswing of the Recorder should be taken into account. For more details, refer to the manual for the Level Recorder Type 2305.

2. The voltage to be measured is applied to the AMPLIFIER INPUT on the Microphone Amplifier. Keeping control knobs in position as outlined above, change the following on the Microphone Amplifier to:—

METER RANGE and RANGE MULTIPLIER:	Are set so that a suitable deflection of the writing stylus is obtained (40—45 dB for 50 dB Range Potentiometer employed). To give the highest signal/noise ratio the RANGE MULTIPLIER should be in position as near "× 1, o dB" as possible.
METER SWITCH:	"Off"

IV. Recording.

On proceeding from "Adjustment to the Signal" the recording can be started when:

1. FREQUENCY RESPONSE SWITCH respective WEIGHTING NETWORK is set to "External Filter".
2. The FUNCTION SELECTOR of the Filter Set is set to "⅓ Octave, or "Octave, 10 dB", whichever is desired for the measurement.

   NOTE: In octave analysis it is recommended to compensate for the 10 dB extra attenuation by increasing the amplification of the output amplifier the same amount, the RANGE MULTIPLIER is thus turned one step counter-clockwise. By doing so the dynamic range of the Microphone Amplifier is fully utilized.

3. The pushbutton SINGLE CHART-CONT. RECORD is operated, allowing the recording to start.
4. It is recommended, additionally, to write down on the recording paper the positions of the METER RANGE, RANGE MULTIPLIER and FUNCTION SELECTOR controls.

B. READING OF ABSOLUTE VALUES FROM THE SPECTROGRAM

I. When the equipment is calibrated as outlined in para A, item II, page 43*), the reading from the spectrogram can be done as given below:

1. Logarithmic Range Potentiometer 10, 25 and 50 dB employed.

The absolute value of the signal applied to the AMPLIFIER INPUT of the Microphone Amplifier is read in dB re. 10 V as:—

The value in dB on the spectrogram + the sum of numbers of dB indicated by METER RANGE, RANGE MULTIPLIER and FUNCTION SELECTOR — dB range of Potentiometer employed (10, 25 or 50 dB), re. 10 V.

Example:

50 dB Potentiometer
Deflection of the stylus: 46 dB
METER RANGE: "+ 20 dB"
RANGE MULTIPLIER: "—10 dB"
FUNCTION SELECTOR: "1/3 Octave, 0 dB"
46 dB + 20 dB — 10 dB + 0 dB — 50 dB = + 6 dB re. 10 V = 20 V

Example:

25 dB Potentiometer
Deflection of the stylus: 13 dB
METER RANGE: "—40 dB"
RANGE MULTIPLIER: "0 dB"
FUNCTION SELECTOR: "Octave, 10 dB"
13 dB — 40 dB + 0 dB + 10 dB — 25 dB = — 42 dB re. 10 V = 20 mV.

2. Logarithmic Range Potentiometer 75 dB employed.

The absolute value read in dB re. 10 V is:—

The value in dB on the Spectrogram + the sum of numbers of dB indicated by METER RANGE, RANGE MULTIPLIER and FUNCTION SELECTOR — 60 dB, re. 10 V.

NOTE: To avoid overdriving of the output amplifier in the Microphone Amplifier, the output voltage should not exceed 45 V peak. When for instance recording a sine wave in position R.M.S. the deflection of the stylus should not exceed 70 dB.

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*) i.e. para A item III.3 page 34 or para B item II page 39.

Example:

75 dB Potentiometer
Deflection of the stylus: 60 dB
METER RANGE: "0 dB"
RANGE MULTIPLIER: "— 10 dB"
FUNCTION SELECTOR: "1/3 Octave, 0 dB"
60 dB + 0 dB — 10 dB + 0 dB — 60 dB = — 10 dB, re. 10 V = 3.16 V.

3. Linear Range Potentiometer 10—35 mV and 10—110 mV.

The absolute value can be read as follows:

First, a value z is introduced, which is derived from:—

z = mV or Volt indicated by position of METER RANGE × factor indicated by RANGE MULTIPLIER × factor indicated by FUNCTION SELECTOR.

NOTE: RANGE MULTIPLIER in position "o.3" or "o.03", factor equals o.316 or o.0316 respectively
FUNCTION SELECTOR in position "1/3 Octave, 0 dB" factor equals 1
FUNCTION SELECTOR in position "Octave, 10 dB" factor equals 3.16

Second, by using this value z the reading on the spectrogram is derived by the aid of the following table, in which can be read the voltages that give zero deflection and full deflection respectively, together with how much 10 mm and 20 mm interval on the paper equal in mV or volt:—

Level Recorder Stylus Deflection (Stylus Scale)	Linear Range Potentiometer 10—35 mV		Linear Range Potentiometer 10—110 mV		
	Paper Width		Paper Width		
	50 mm	100 mm	50 mm	100 mm	
Zero	$\frac{z}{3.16}$	$\frac{z}{3.16}$	$\frac{z}{10}$	$\frac{z}{10}$	mV or V
Full	$\frac{z}{3.16} \times 3.5$	$\frac{z}{3.16} \times 3.5$	$\frac{z}{10} \times 11$	$\frac{z}{10} \times 11$	mV or V
10 mm interval	$\frac{z}{3.16} \times 0.5$		$\frac{z}{10} \times 2$		mV or V
20 mm interval		$\frac{z}{3.16} \times 0.5$		$\frac{z}{10} \times 2$	mV or V

NOTE: From the table it will be seen that z should be chosen so that it contains figures 316 or 1 for 10—35 mV and 10—110 mV Range Potentiometer respectively to give a plain figure in mV or volt.

Example: 10—35 mV Range Potentiometer.

METER RANGE "10 mV"
RANGE MULTIPLIER "o.3"

FUNCTION SELECTOR "1/3 Octave, 0 dB"

$z = 10 \text{ mV} \times 0.316 \times 1 = 3.16 \text{ mV}.$

Zero deflection $= \frac{3.16}{3.16} = 1$ mV for 50 and 100 mm width paper.

Full deflection $= \frac{3.16}{3.16} \times 3.5 = 3.5$ mV for 50 and 100 mm width paper.

10 mm on 50 mm paper and
20 mm on 100 mm paper $\left.\right\} \frac{3.16}{3.16} \times 0.5 = 0.5$ mV.

Example: 10—110 mV Range Potentiometer.

METER RANGE "1 V"
RANGE MULTIPLIER "0.03"
FUNCTION SELECTOR "Octave, 10 dB"

$z = 1 \text{ Volt} \times 0.0316 \times 3.16 = 0.1 \text{ Volt}.$

Zero deflection $= \frac{0.1}{10} = 0.01$ Volt for 50 and 100 mm width paper.

Full deflection $= \frac{0.1}{10} \times 11 = 0.11$ Volt for 50 and 100 mm width paper.

10 mm on 50 mm paper and
20 mm on 100 mm paper $\left.\right\} \frac{0.1}{10} \times 2 = 0.02$ Volt.

II. Setting of Microphone Amplifier for Zero or Full Stylus Deflection Reference Reading.

If it is required to record voltages in dB above or below a certain reference value, the voltage equal to 0 db deflection or full deflection respectively of the stylus is found by means of the tables given below. The equipment has to be calibrated as outlined in para A.

Voltage on AMPLIFIER INPUT of Microphone Amplifier Referred to zero Deflection on Recording Paper	**The Sum of dB Indicated by METER RANGE, RANGE MULTIPLIER and FUNCTION SELECTOR**			
	Logarithmic Range Potentiometer			
	10 dB	25 dB	50 dB	75 dB
10 μV		Cannot be adjusted for the μV, mV or V given.	—70 dB	—60 dB
31.6 -	—100 dB		—60 -	—50 -
100 -	—90 -		—50 -	—40 -
316 -	—80 -		—40 -	—30 -
1 mV	—70 -		—30 -	—20 -
3.16 -	—60 -		—20 -	—10 -
10 -	—50 -		—10 -	0 -
31.6 -	—40 -		0 -	+10 -
100 -	—30 -		+10 -	+20 -
316 -	—20 -		+20 -	+30 -
1 V	—10 -		+30 -	+40 -
3.16 -	0 -		+40 -	
10 -	+10 -			
31.6 -	+20 -			
100 -	+30 -			

Voltage on AMPLIFIER INPUT of Microphone Amplifier Referred to full Deflection on Recording Paper	**The Sum of dB Indicated by METER RANGE, RANGE MULTIPLIER and FUNCTION SELECTOR**
	Logarithmic Range Potentiometer 10, 25 and 50 dB
100 μV	—100 dB
316 -	—90 -
1 mV	—80 -
3.16 -	—70 -
10 -	—60 -
31.6 -	—50 -
100 -	—40 -
316 -	—30 -
1 V	—20 -
3.16 -	—10 -
10 -	0 -
31.6 -	+10 -
100 -	+20 -
316 -	+30 -
1000 -	+40 -

75 dB Range Potentiometer: Full deflection cannot be obtained when utilizing the calibration stated beforehand.

4.
Accessories and Combined Units

Extension Filter Set Type 1620.

When analyses of frequencies below 22 Hz (c/s) have to be carried out, the Extension Filter Set Type 1620 can be used in conjunction with the Band-Pass Filter Set. The Extension Filter Set contains both 1/3 and 1/1 octave filters extending the selective range of the Filter Set down to 11 Hz (c/s).

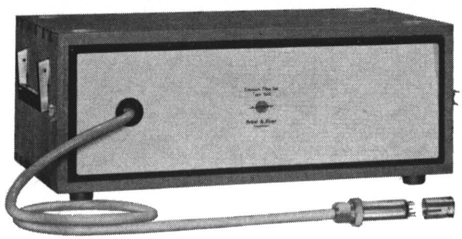


Fig. 4.1. Extension Filter Set Type 1620.

1/3 Octave Filters. The Extension Filter Set is furnished with three filters of 1/3 octave bandwidth (3 dB), having center frequencies of 12.5, 16 and 20 Hz (c/s). In Fig. 4.2 a graph is given where typical filter characteristics are shown. The tolerances in the pass-band are within those stated for the 1/3 octave filters in the Band-Pass Filter Set.

Octave Filter. When the Band-Pass Filter Set is set to 1/1 octave analysis, the 1/3 octave filters in the Extension Filter Set are combined to constitute one 1/1 octave filter with a center frequency of 16 Hz (c/s). The tolerances in the pass-band are within those given for the lower 1/1 octave bands in the Band-Pass Filter Set.

Mounting and Connection. The Extension Filter Set is built up in drawers and mounted on a chassis. It is available in a mahogany cabinet. It can be connected to the Band-Pass Filter Set terminal EXTENSION FILTER by means of a multi-cored screened cable terminated with a 7-poled plug. The adaptor, which is normally mounted in the EXTENSION FILTER, should then be removed and replaced by the seven-poled plug of the connection cable.

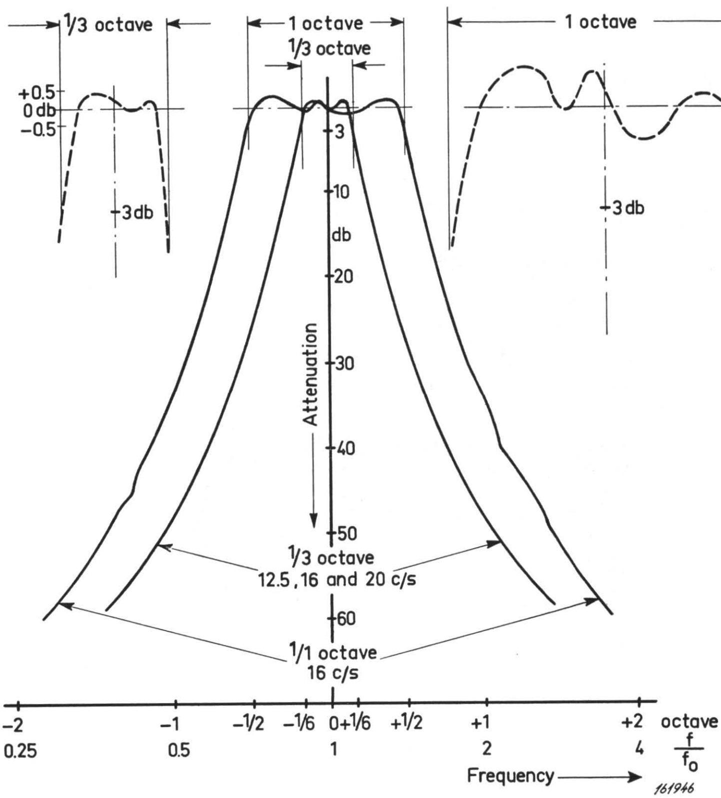


Fig. 4.2. Typical Extension Filter characteristics as derived from sine-wave signals.

NOTE: A d.c. voltage of approximately 75 Volts is present on the terminal EXTENSION FILTER, obtained with the adaptor in place, when the Band-Pass Filter Set is used as external filter for the B & K Random Noise Generator Type 1402, Frequency Analyzer Type 2107 or Microphone Amplifier Type 2603 or Type 2604. This DC voltage is blocked by condensers in the Extension Filter Set Type 1620 but should be taken into consideration if using other external filters.

Connecting Cable AQ 0002.

This Cable is intended to be used when the Filter Switch of the Band-Pass Filter Set has to be automatically controlled from the B & K Level Recorder.

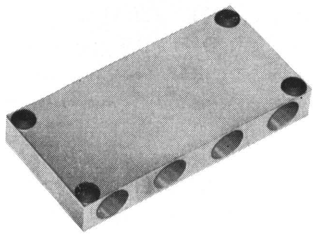


Fig. 4.3. Connection Box JJ 0004.

Screened Connection Box JJ 0004.

When more complex measuring arrangements are built up of B & K instruments it is often necessary to make multiple connections. For this purpose the Connection Box is a very useful accessory. The Box contains four screened sockets which are all connected in parallel (in multiples). These terminals match the normal B & K Screened Connecting Cables.

Combined Units.

The Band-Pass Filter Set Type 1612 can be supplied mounted in a rack together with the Frequency Analyzer Type 2107 and the Level Recorder Type 2305.

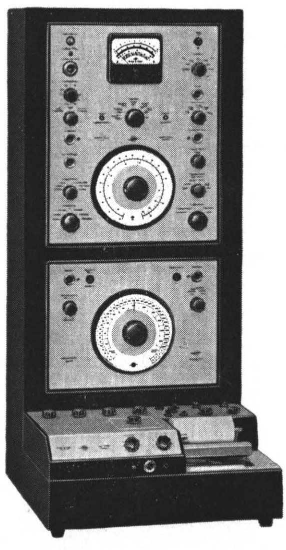


Fig. 4.4. Type 3333.

The output impedance at the EXT. FILTER INPUT socket and the input impedance at the EXT. FILTER OUTPUT socket of the Frequency Analyzer are matched to the Band-Pass Filter Set so that this can be used directly as an external filter to the Frequency Analyzer. External connections between Filter Set and Frequency Analyzer must be made, and the INPUT SWITCH of Band-Pass Filter Set must be set to "Direct".
When the switch WEIGHTING NETWORK of the Frequency Analyzer is in the position "External Filter", and the knob FUNCTION SELECTOR is switched to "Selective Section Off", the combined instruments are equal to the Spectrometer Type 2112.
If a broad-band signal is to be analyzed, it is thus possible to make coarse analysis (1/1 octave or 1/3 octave) when using the instruments as a spectrometer. When it is found necessary to make a "fine" analysis in one or more of the different band-passes of 1/1 octave or 1/3 octave, this can then be made by normal use of the Frequency Analyzer Type 2107.
The frequency characteristic of the Frequency Analyzer, when the switch FUNCTION SELECTOR is in the position "Freq. Analysis", can be adjusted by the knob marked FREQUENCY ANALYSIS OCTAVE SELECTIVITY. The frequency characteristic for maximum selectivity is shown in Fig. 4.5a.

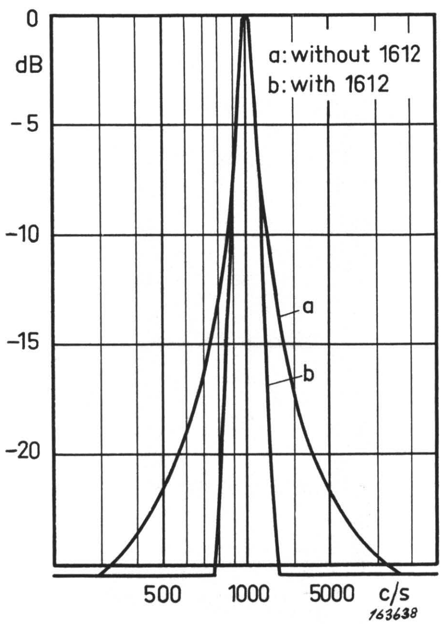


Fig. 4.5. Frequency characteristic for maximum selectivity.

It can be seen from the figure that the attenuation just around the pass-band is very high. However, further away from the passband the attenuation slope is no longer so steep. If, for some reasons, it is desired to produce a very narrow passband with very high attenuation also further away from the center frequency it is possible to combine the attenuation characteristics of the 2107 Analyzer with the 1/3 octave condition of the Band-Pass Filter Set, see also curve b Fig. 4.5.
It is also possible to drive automatically the frequency tuning of the Analyzer Type 2107 from an external motor. By driving the tuning mechanism from the motor in the Level Recorder Type 2305 the frequency spectrum of the Analyzer input signal can be recorded automatically on pre-printed, frequency calibrated recording paper Type QP 1130. As the FREQUENCY RANGE switch of the Type 2107 is automatically operated so that it switches from one range to the next for each full turn of the frequency scale pointer, complete automatic recording over the entire frequency range of the Analyzer is possible.

Applications

5.
Applications

Sound and Vibration Spectrograms.

One of the most important applications of the Band-Pass Filter Set is its use in an integrated equipment for automatic recording of sound or vibration spectrograms. The Band-Pass Filter Set is then inserted as external filter in for example one of the B & K Microphone Amplifiers Type 2603 or 2604, and the B & K Level Recorder Type 2305 is employed for recording and automatic control. Completing the equipment with a suitable B & K sound or vibration transducer, spectrograms of one or the other type can be carried out.

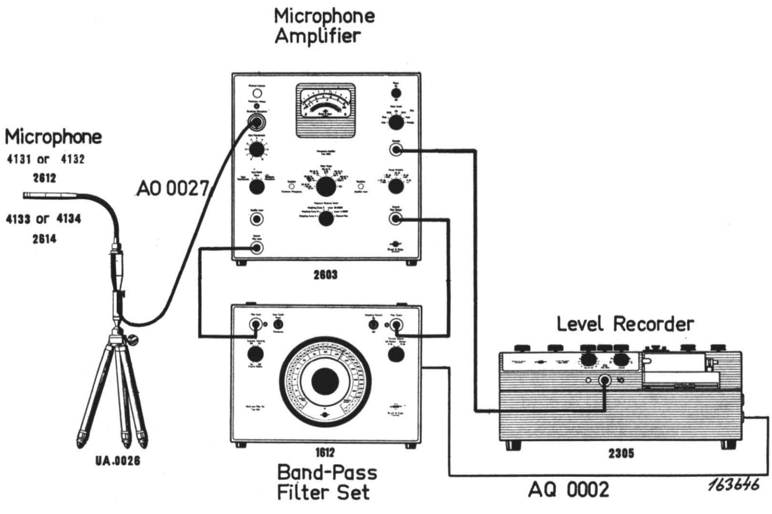


Fig. 5.1. Equipment for recording sound spectrograms automatically

Sound.

When using a measuring arrangement as illustrated in Fig. 5.1 sound spectrograms can be recorded automatically on amplitude/frequency calibrated recording paper. Usually employed as transducer is one of the B & K Condenser Microphones Type 4131, 4132, 4133 or 4134 with associated Cathode Follower Type 2612 or 2613 respective 2614 or 2615.

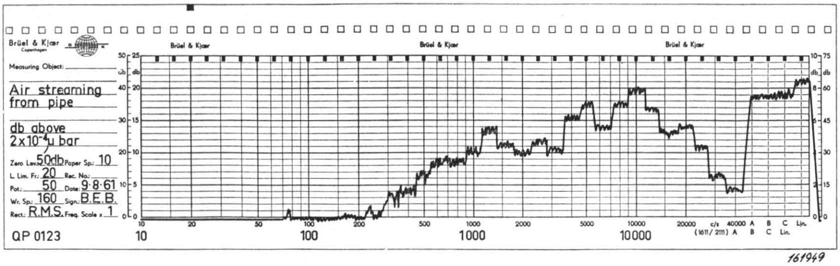
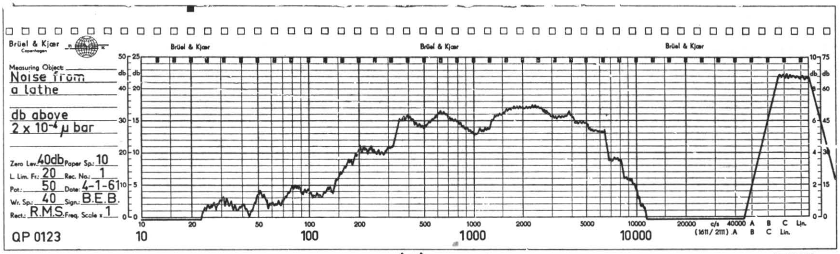
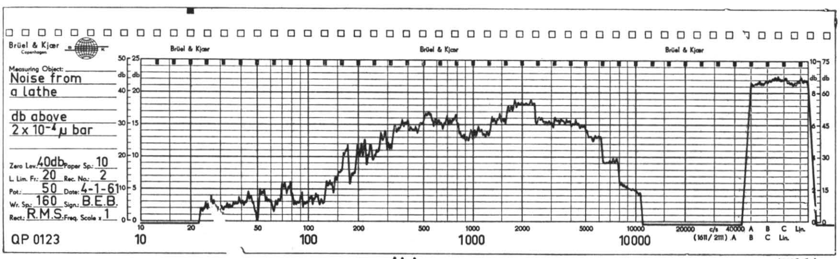


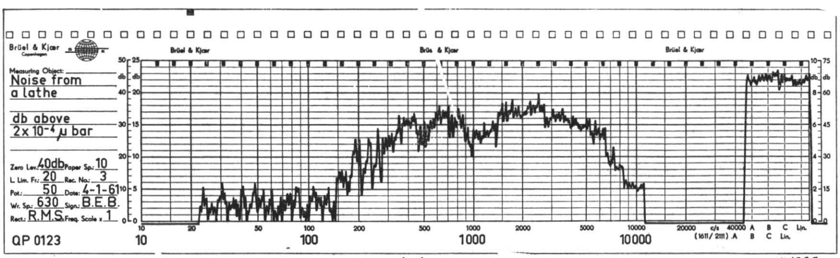
Fig. 5.2. Noise spectrum produced by stream of air, ⅓ octave analysis.



(a)



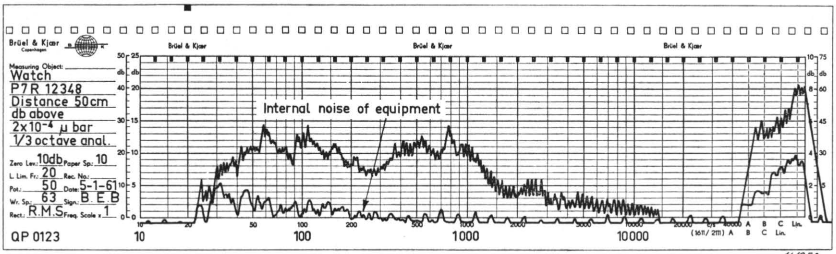
(b)



(c)

Fig. 5.3. ⅓ octave spectrograms of noise radiated from a lathe.
(a) Level Recorder writing speed 40 mm/sec.
(b) Level Recorder writing speed 160 mm/sec.
(c) Level Recorder writing speed 630 mm/sec.

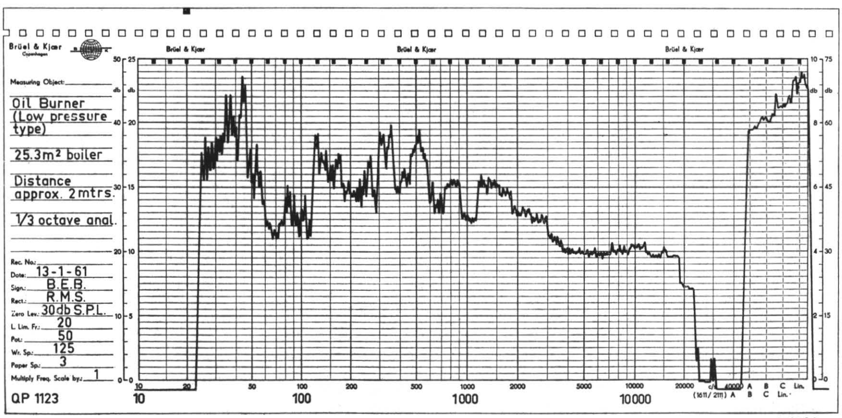
Some typical spectrograms are shown in the following.
Fig. 5.2 shows a characteristic spectrum of the sound produced by air streaming out of a system of pipes. As can be seen this type of noise consists almost entirely of high frequencies.
Fig. 5.3 shows the spectrogram of the noise radiated from a lathe. The three different curves are recorded with different writing speeds on the Recorder. It is seen that the curve is considerably smoother when a low writing speed is employed. With a high writing speed all the small variations in the sound pressure level become quite pronounced.



161950

Fig. 5.4. Noise spectrum in ⅓ octaves obtained from a watch. The lower curve gives the internal noise of the measuring equipment.

Fig. 5.4; in this case the equipment has been operating just above its own noise level, i.e. above the lowest level at which measurements can be taken. The curve beneath the noise level of the watch is a recording of the internal noise of the complete measuring system.



161826

Fig. 5.5. Spectrogram of noise from an oilburner. ⅓ octave analysis.

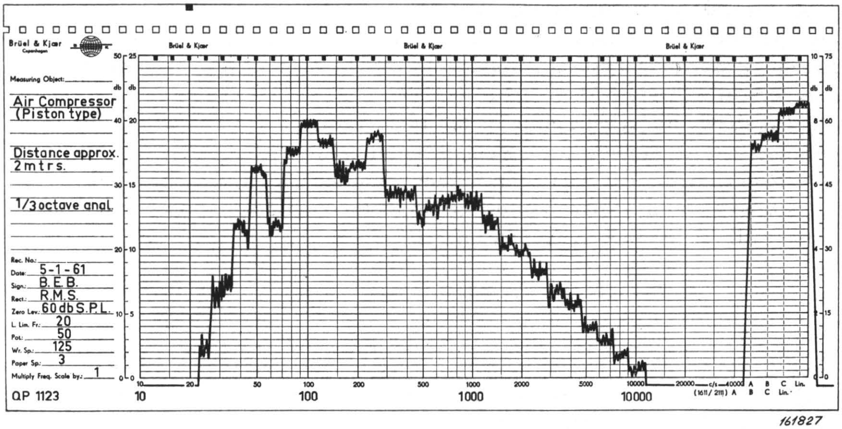


Fig. 5.6. ⅓ octave analysis of noise radiated from an air-compressor.

Vibration.

With the measuring arrangement shown in Fig. 5.7 the acceleration signal from a sewing machine is analysed in 1/3 octaves. Used as transducer is the B & K Accelerometer Type 4308 the signal of which is applied to the Vibration Pick-up Preamplifier Type 1606 which further is connected to the input "Condenser Microphone" of the Microphone Amplifier. In vibration, measurements, the low frequencies are often of great interest, therefore the Extension Filter Set Type 1620 has been added to the Band-Pass Filter

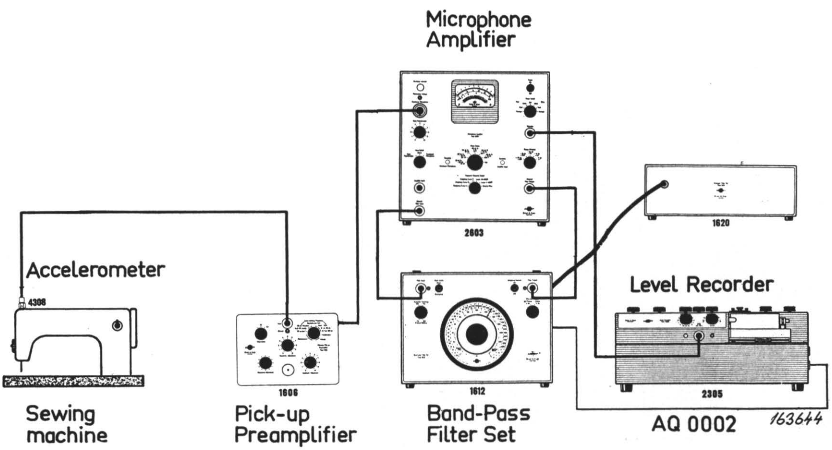


Fig. 5.7. Equipment for automatic recording of vibration spectrograms.

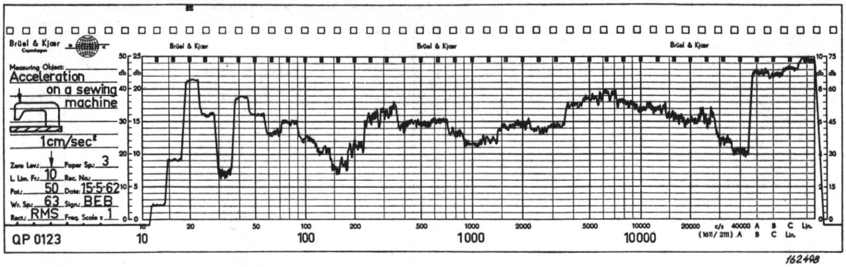


Fig. 5.8. The Extension Filter Type 1620 has been utilized. ⅓ octave acceleration spectrum measured on a sewing machine.

Set, making analyses down to 11 Hz (c/s) possible. In Fig. 5.8 is reproduced a recorded spectrogram as attained with the arrangement described above. The accelerometer has been placed vertically as sketched in the head of the chart.

Another type of vibration analysis is shown by the 1/3 octave spectrogram in Fig. 5.9 where the effectivness of a motor foundation isolation has been measured as a function of frequency.

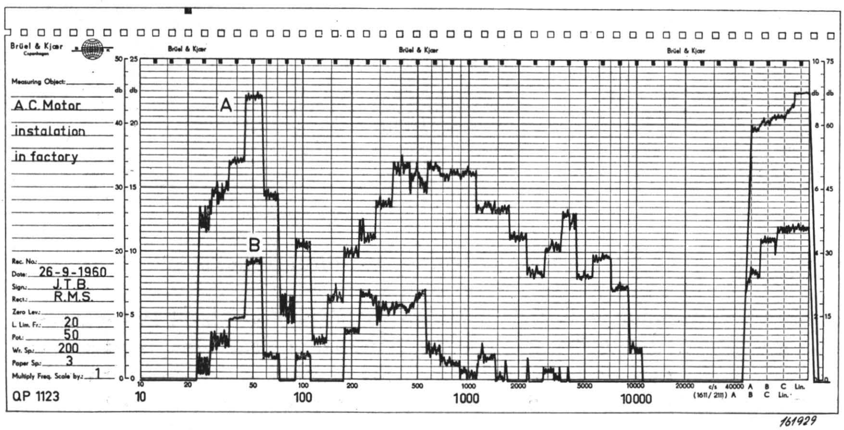


Fig. 5.9. Vibration isolation measurement as a function of frequency of a motor foundation.

Airborne Sound Insulation Measurements by Random Noise.

When measuring the sound insulation of a partition between two rooms an arrangement as illustrated in Fig. 5.10 can be used. The output signal from the Noise Generator Type 1402 is applied to the loudspeakers in the "transmitter" room via a power amplifier. A power amplifier may be

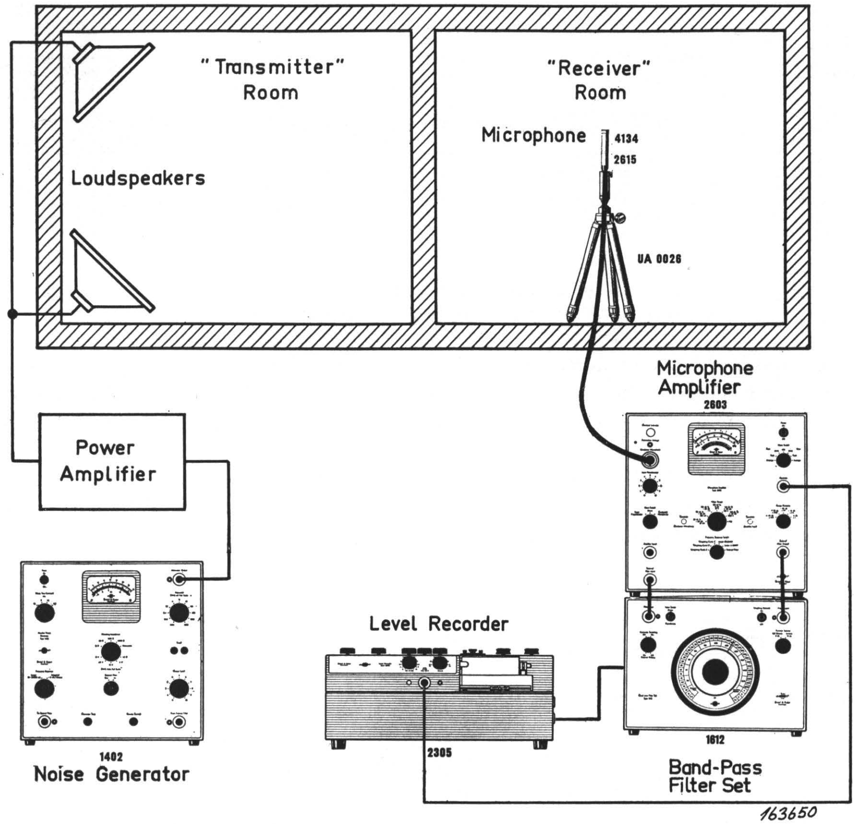


Fig. 5.10. Sound insulation measuring equipment.

necessary to produce a sufficiently high sound pressure level in rooms with perceptible background noise. The receiving equipment consists of a B & K Condenser Microphone (here, the Type 4134 is used), the Microphone Amplifier Type 2603 combined with the Band-Pass Filter Set and the Level Recorder Type 2305. With the combination Microphone Amplifier Band-Pass Filter Set the signal from the Microphone can be measured in bands of 1/3 or 1/1 octaves. The Level Recorder records the analysed signal automatically on preprinted frequency calibrated charts.

From the difference in dB between the sound pressure levels measured in the transmitter room and receiver room the insulation property of the partition can be calculated provided adequate correction is made for the absorption in the receiver room. From the recorded curves in Fig. 5.11 the difference in sound pressure levels can be read in dB.

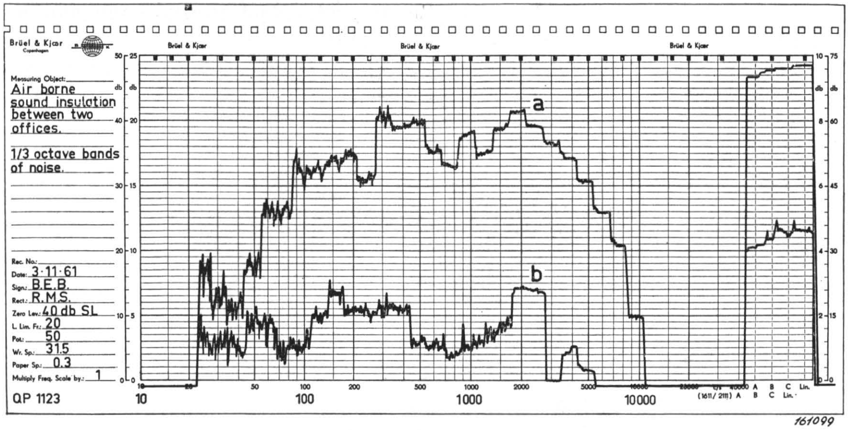


Fig. 5.11. Recorded sound pressure level versus frequency in ⅓ octave. The curves are recorded successively.
(a) "Transmitter" room.
(b) "Receiver" room.

The Level Recorder Type 2305 has a facility allowing it to automatically stop after moving the paper one chart length in either the forward or reverse direction. Also, when the paper has been reversed by one chart length, a new recording can be taken without losing the synchronization between the paper movement and the switching moment of the filters. It is thus seen that the second recording shown in Fig. 5.10 is easily taken on the same chart as the first.

Measurements of Impact Sound Transmission.

The sound insulation of a floor against impact sounds is estimated by placing a standardized impact sound generator on the floor and measuring the sound intensity L in the room below in various frequency bands. In Fig. 5.12 is sketched a measuring arrangement where the B & K standardized impact sound generator, Tapping Machine Type 3204, makes up the transmitting part. The receiving part consists of a B & K Condenser Microphone connected to a Microphone Amplifier Type 2603 which has the Band-Pass Filter Set as external filters. For the purpose of recording the measurements automatically the arrangement is completed by the B & K Level Recorder Type 2305. The data will then be presented as a function of frequency on an amplitude/frequency calibrated chart.
In the ISO standard R 140 (1960) for these measurements, it is recommended to analyse with 1/1 octave filters for the estimation of the sound pressure. If the analysis is carried out with a filter comprising a narrower band than 1/1 octave an appropriate correction has to be made.

From the spectrogram in Fig. 5.13 the impact sound transmission can be read directly as it is recorded in octave bands.

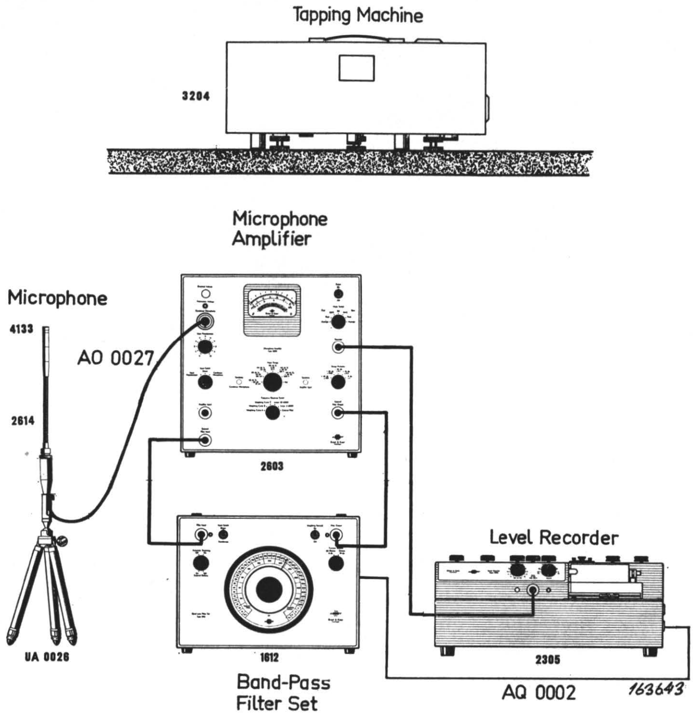


Fig. 5.12. Equipment for measuring of floor impact sound insulation.

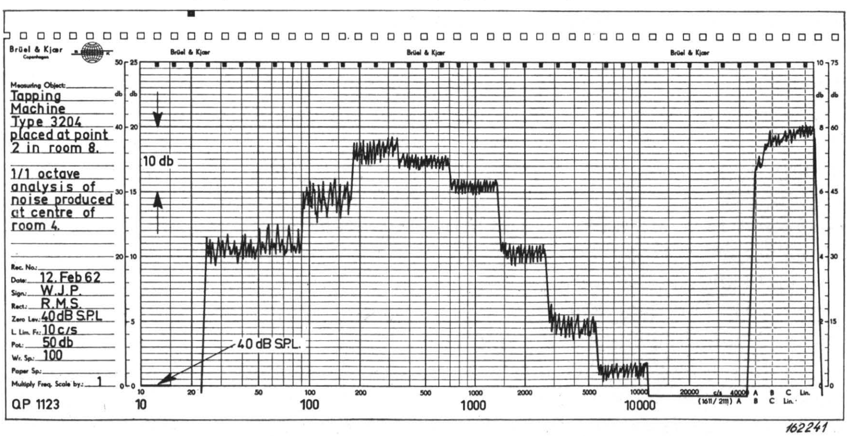


Fig. 5.13. 1/1 octave spectrogram of impact sound.

Loudspeaker Frequency Response Measurements by Bands of Random Noise.

To measure loudspeaker frequency response under realistic conditions the exciting signal may be of a statistical character simulating speech and music. A suitable signal can be bands of random (white) noise having a Gaussian magnitude distribution.

In Fig. 5.14 is illustrated an arrangement by which a loudspeaker response can be measured using this type of noise as test signal. The signal applied to the loudspeaker is generated from the B & K Random Noise Generator Type 1402 combined with the Band-Pass Filter Set. By using the Band-

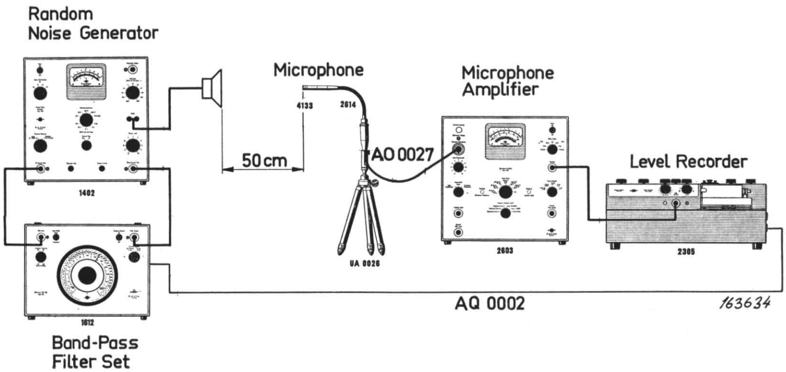


Fig. 5.14. Measuring arrangement for measuring loudspeaker frequency responses by narrow bands of random noise.

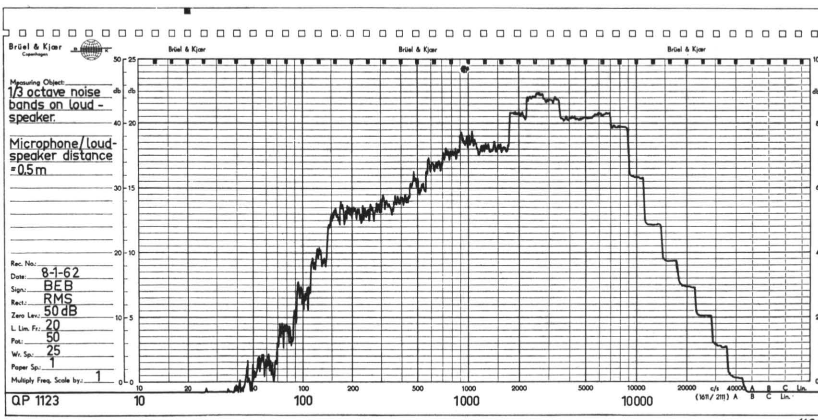


Fig. 5.15. Frequency response of a loudspeaker as measured by ⅓ octave bands of noise.

Pass Filter Set as external filters for the Random Noise Generator, 1/3 or 1/1 octave bands of noise can be supplied from the Generator. The receiving part of the arrangement is formed by the B & K Condenser Microphone Type 4133/2614, the Microphone Amplifier Type 2603, and the Level Recorder Type 2305. The automatic filter switching of the filters in the Band-Pass Filter Set is controlled from the Level Recorder. The loudspeaker has been driven under constant voltage conditions and without any baffle.
In Fig. 5.15 the automatically recorded frequency characteristic is reproduced. It should be mentioned that the measurements were carried out in an ordinary room.

Analysis by Precision Sound Level Meter.

If the Band-Pass Filter Set is used in combination with the B & K Precision Sound Level Meter Type 2203 sound or vibration analyses in 1/3 or 1/1 octave bands can be made manually or recording can be carried out automatically by completing the instrumentation with the B & K Level Recorder Type 2305.
Using the instrumentation required for manual analysis, an equipment entirely independent of mains supply is attained, which makes it excellent for field measurements. It should be mentioned that by employing the Level Recorder for automatic recording the 9 volt needed to power the Band-Pass Filter Set can be supplied by the Level Recorder's 24 volt DC on pin 6 of the Remote Control socket.
The special screened connection cable AO 0007 for wiring up the Precision Sound Level Meter and the Filter Set is delivered on request.

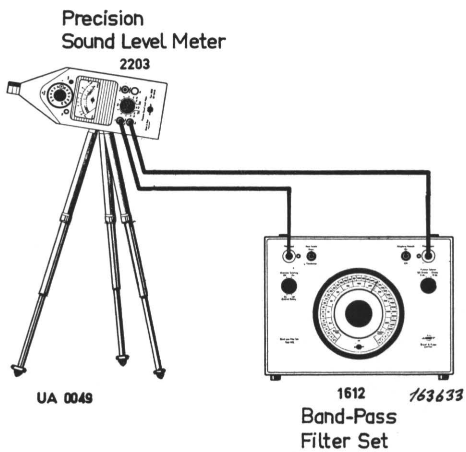


Fig. 5.16. Band-Pass Filter Set used as external filters for the Precision Sound Level Meter Type 2203.

Measurement of Reverberation Time.

The Band-pass Filter Set and the B & K Level Recorder constitute very important parts in equipment intended for determination of reverberation time as the measurements can be carried out selectively. This reduces the influence of background noise, while the sound decay in the room under examination is rendered as a slope on paper recorded by the Level Recorder. Several methods of exciting the room can be used depending on the number of measurements to be carried out. If only a few measurements are made, a pistol shot or something similar is the simplest form of sound source.

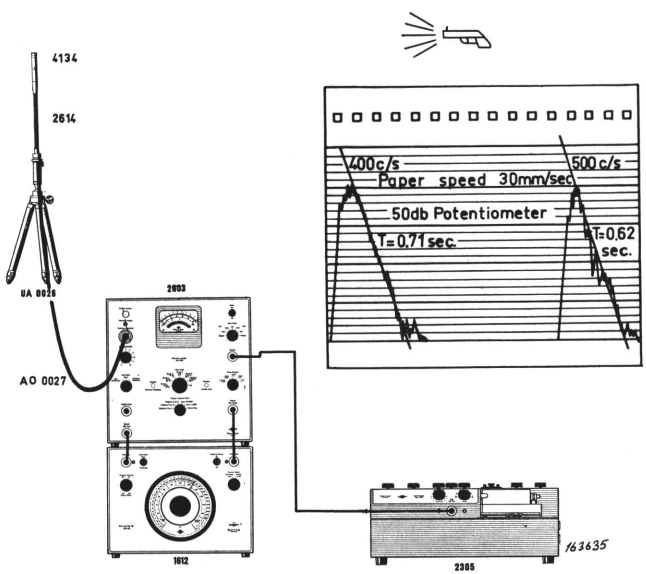


Fig. 5.17. Measuring arrangement for recording reverberation time. Pistol used as sound source.

When utilizing this method the receiving part of the equipment should always contain a selective instrument such as the Band Pass Filter Set which enables measurements to be carried out at different frequencies. In Fig. 5.17 can be seen a measuring arrangement together with an example of two recorded decay curves. The receiving part of the measuring set-up consists of one of the B & K Condenser Microphones, the signal from which is applied to the Band Pass Filter Set and a linear Amplifier, and further to the Level Recorder Type 2305 which then records the output signal from the Amplifier.

When many measurements have to be carried out, for example in a concert hall, measuring equipment which works automatically will undoubtedly be

the most rational solution. In such an arrangement the gun has to be substituted by a sound source which can be conveniently controlled.
Two different methods of signal generation are suitable for this:

1. A frequency-modulated (warbled) oscillator (1022), or a narrow band noise generator (1024), as shown in Fig. 5.18.
   or
2. A wideband random noise generator (1402) and a Band-pass Filter Set (1642), shown in Fig. 5.19, which together provide bands of noise.

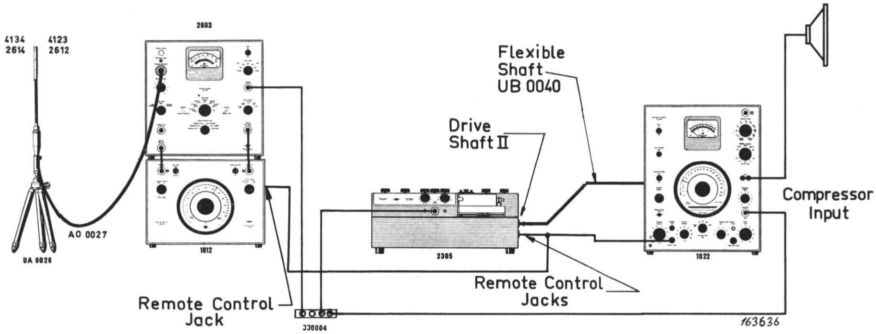


Fig. 5.18. Measuring arrangement for automatic recording reverberation time.

Using a Frequency-modulated Oscillator or Narrow Band Noise Generator. A suitable measuring arrangement is shown in Fig. 5.18.
In this instance, although not strictly necessary, it is recommended to employ the technique of selective signal reception, which ensures a much larger dynamic range for the decay curves owing to a reduction in the systems noise level.

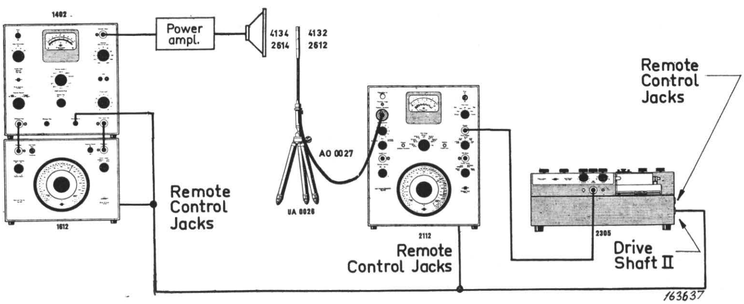


Fig. 5.19. Measuring arrangement for automatic recording of reverberation time, carried out by a random noise generator and a band-pass filter set.

Frequency Calibrated Paper. The measuring arrangement shown in Fig. 5.18 allows decay curves with a spacing of ⅓ octave to be recorded automatically in the frequency range 25 Hz (c/s) to 20 kHz (kc/s). All the curves will be presented on a frequency calibrated chart with a length of 250 mm. The transmitting part of the equipment consists of the B & K Frequency Oscillator (B.F.O.) Type 1022 or 1024 and one or two loudspeakers. The receiving part is comprised of one of the B & K Condenser Microphones, the Band Pass Filter Set Type 1612 + the Microphone Amplifier Type 2603 and the Level Recorder Type 2305. The signal frequency from the Oscillator should either be frequency modulated, the frequency and swing of the modulation being easily selected by two control knobs on the B.F.O. Type 1022, or narrow bands of noise from the Oscillator Type 1024 should be employed. In this manner a smooth reverberation curve will be recorded for each frequency at which measurements are carried out.

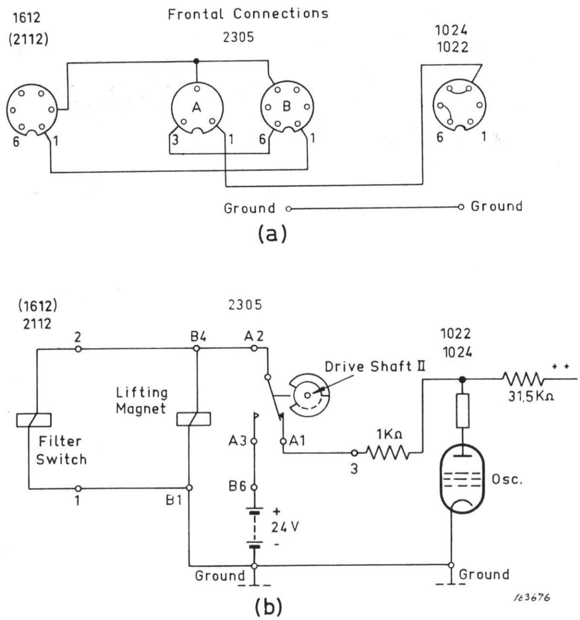


Fig. 5.20. Connection between instruments. a) Connection between remote control jacks. b) Electrical circuit.

For recording the decay of the sound in the room the sound source has to be disconnected at definite intervals. This is achieved by stopping the oscillator. To ensure that only the part of the measurements, which is of interest, is recorded, the writing pen should lift from the paper in the interval between two decays, and when selective reception is utilized, the filters in the Band Pass Filter Set should be switched in successively. The disconnecting of the sound source, the lifting of the pen and the switching of the filters in the Filter Set can all be automatically controlled by a special switch in the Level Recorder. (The Two-Channel Selector). The necessary connections between the different instruments are shown in Fig. 5.20. The connections to the respective Remote Control Jacks are shown in Fig. 5.20a, while Fig. 5.20b gives the electrical circuits for the remote controlling arrangement.

Overlapping junction

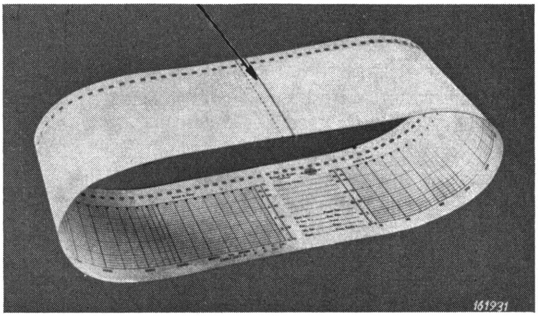


Fig. 5.21. Construction of paper loop. The dotted line illustrates the necessary overlap at the junction.

By loading the Recorder with a loop of 50 mm width paper, Fig. 5.21, having a length of 495 mm (i.e. two chart lengths minus 5 mm; 5 mm being the distance between two perforated holes) it is possible to have the curves for the different frequencies spaced by ⅓ octave as shown in Fig. 5.22. Since the paper movement is synchronized with the frequency scanning of the Generator, with the filter switching on the Spectrometer, and with the instant of switching off the sound, the starting points of the decay curves will correspond to the center frequency of the respective filters as represented by small squares on the top of the preprinted recording paper QP 0123, see Fig. 5.22. It is possible, to a certain degree, to keep the sound pressure level at the point of measurement independent of loudspeaker and room response

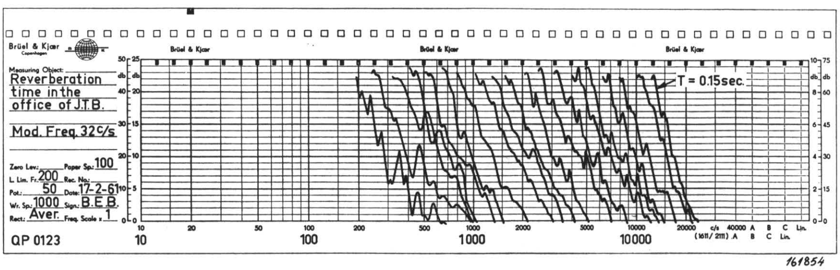


Fig. 5.22. Reverberation decay curves with a spacing of 1/3 octave (5 mm) Compressor arrangement used.

by utilizing the compressor circuit of the Generator as indicated in Fig. 5.18. This method ensures that all the decay curves commence at the same level on the recording paper.

Non-Frequency Calibrated Paper.

When a spacing larger than 5 mm between the decay curves is desired (vide example in Fig. 5.23), the recording paper loop used in the Recorder has to be made accordingly shorter as the length of this determines the spacing. For example, a loop length of 490 mm gives 10 mm spacing between the curves. In such instances the recording has to be carried out on the lined recording paper, e.g. QP 0102, and it is necessary to "mark" one or more frequencies on the paper. The marking can be readily done by means of the Level Recorder's "Event-Marker" arrangement.

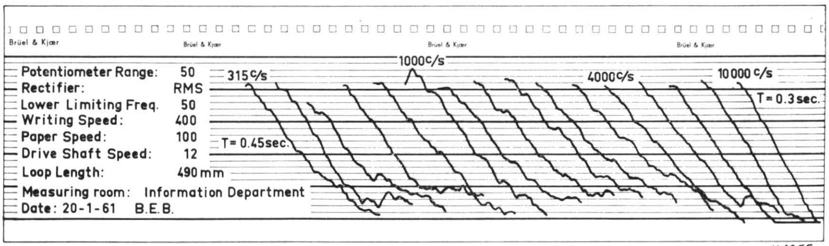


Fig. 5.23. Reverberation decay curves with a spacing of 10 mm. Compressor arrangement used.

Using a Wideband Random Noise Generator.

In this case bands of noise with constant percentage bandwidths are generated, and it is recommended to use a selective receiver which ensures a large dynamic range. However, it is also possible to dispense with the selective receiver, but then a greater power amplifier must be used, to obtain sufficient signal power from the loudspeaker to make the background noise insignificant. The electrical "transmitting" part of the system consist of a Band-Pass Filter Set Type 1612 together with a Noise Generator Type 1402 as shown in Fig. 5.19. The impedances at the input and output terminals of the Filter Set automatically match the B & K Noise Generator. By employing the Filter Set noise bands of 1/3 or 1/1 octave widths can be selected. It should be noted here, that when noise bands having constant percentage bandwidths are being used, such as 1/3 or 1/1 octave bands, the power output will increase proportional to frequency. If it is desired to utilize the same power output in each band it is then necessary to "shape" the input spectrum to the filters so that it drops off with frequency at a rate of 3 dB/octave. This is provided for in the Noise Generator Type 1402 in that it can be switched to either produce a flat ("white") spectrum or a spectrum with a slope of

—3 dB/octave. When reverberation measurements (or sound insulation measurements) are made in great assembly-halls, in factories, schools, or other "public places" it may be necessary, even if bands of noise are used for the measurements, to employ a power amplifier. The —3 dB/octave condition of the Noise Generator then allows the amplifier to be used with maximum efficiency during all the measurements. When it is desired to use frequency calibrated paper and automatic recording, the necessary connections between the different instruments are shown in Fig. 5.24.
The lengths of the paper in the Level Recorder are the same as used in the set-up with frequency-modulated signals as sound generator.

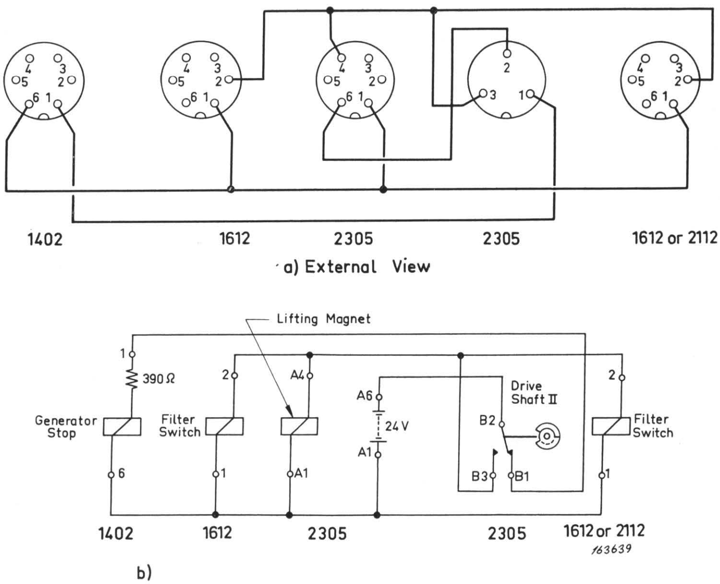


Fig. 5.24. (a) Connection between remote control jacks.
(b) Electrical circuit.

Use of the Protractor SC 2361.
The Protractor has been designed to facilitate the determination of reverberation time from recorded decay curves on the 50 mm width paper. It is divided into four sections marked "75 dB 10 mm/sec.", "75 dB 30 mm/sec.", "50 dB 10 mm/sec.", and "50 dB 30 mm/sec.".
When one of these four combinations of "Range Potentiometer" and "Paper Speed" has been employed during the measurements, the reverberation time can be read directly in seconds.

1. The Protractor is held so that the printing is readable. The proper section is chosen and its left limiting line (thick diagonal) is placed

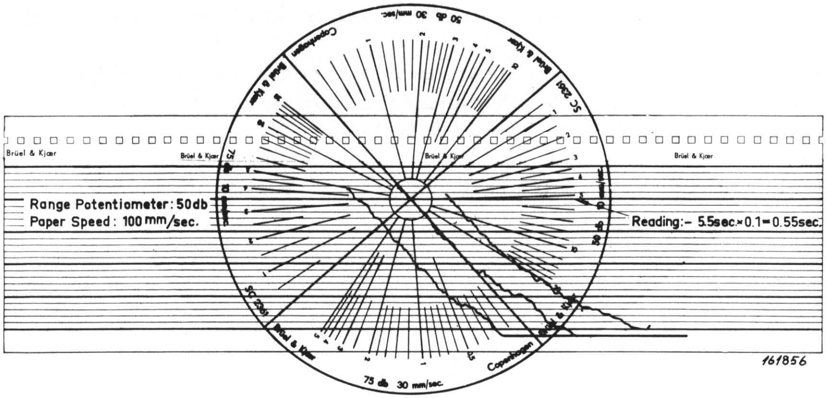


Fig. 5.25. Use of the Protractor SC 2361.

on the portion of the recorded decay curve to be measured, and in such a manner that the centre of the Protractor coincides with one of the horizontal lines on the recording paper. Refer Fig. 5.25.

2. The reverberation time in seconds is then read on the scale at the point through which the horizontal line passes. Vide Fig. 5.25.

The decay curves should preferably be approximated into straight lines making it easier to determine the average slope.

If paper speeds other than 10 and 30 mm/sec. have been used, the determined reverberation times should be multiplied or divided by factors of 10.

Example.

50 dB Range Potentiometer.

Paper Speed 100 mm/sec.: Use the section "50 dB 10 mm/sec.", and divide the measured result by 10.

If the decay curves are recorded on 100 mm paper width, the results measured by the protractor have to be multiplied by 2.

CABINET

With the mechanical design for most B & K apparatus, it is very easy to house the instruments unit into the various cabinets. The equipment is delivered in metal cases as standard fittings, but should it be prefered to have the instrument housed in a mahogany cabinet, then this can be carried out very easily.

1. Remove the four specially threaded retainers at the back of the instrument and the rubber feet.
2. Place it with metal case into the mahogany cabinet.

3. Replace threaded retainers and rubber feet, which now require longer fixing screws.

If it is required to have the apparatus rack mounted then a special frame is necessary. In this case the instrument + metal case is secured to the frame by four screws. This whole assembly is then mounted in the rack.

Finally if it is prefered to use B & K mounting unit then the apparatus in metal case is placed into the rack, and again secured by the four screws.

Specification

Frequency Range: Selective 22—45000 Hz (c/s).
11—45000 Hz (c/s) when Extension Filter Set Type 1620 is applied.

Band-Pass Filters: In accordance with ISO standard,

Center Frequencies: 1/3 octave, 25—40000 Hz (c/s) (33 filters).
1/1 octave, 31.5—31500 Hz (c/s) (11 filters).

Selectivity*): 1/3 octave filters, approximately 50 dB at 1 octave from center frequency,
1/1 octave filters, approximately 35 dB at 1 octave from center frequency.

Deviation in Band-Pass.: In relation to the "Lin." characteristic and at rated load impedance, within
± 0.5 dB for 1/3 octave, and
± 2 dB for 1/1 octave filters, ± 2 dB for the 31.5 and 63 Hz (c/s) filters.

Weighting Networks:

"A", "B", "C": According to the proposed IEC Standards for Precision Sound Level Meters (Helsinki 1961).

"Lin.": Gives linear range 20—45000 Hz (c/s).
Cutting off below 20 Hz (c/s) with a maximum slope of 18 dB per octave.

Input Source Impedance:

Direct: 0—10 Ω.

Transformer: 0—1 kΩ.

Rated Load Impedance: 50 kΩ—∞, 22—45000 Hz (c/s).
100 kΩ—∞, 11—45000 Hz (c/s).

Voltage Attenuation, Overall: 0 dB in position "Direct", 20 dB in position "Transformer" } + 10 dB in position "Octave"

Maximum AC Input Voltage: 10 volts in position "Transformer".
1 volt in position "Direct".

*) See also Figs. 1.5 and 1.8.

Distortion: Lower than 0.1 % (20—20000 Hz (c/s)) with a load impedance larger than 100 kohms and the input voltage below that of "Maximum Input Voltage".*)

Signal/Noise Ratio: (2—45000 Hz (c/s)): Better than 60 dB at Maximum Input Voltage.

Supply for Filter Switch Remote Control:
(if separate) 24 V DC, 180 milliamps.

Supply for Transistor Stage:
(if separate) 9 V DC, 0.7 mA or 20—90 V DC, 0.7—7 mA respectively.

Accessories Included:
3 screened plugs JP 0018
1 Battery supply cable AQ 0008
1 control cable AQ 0002

Cabinet: Mahogany with handles and lid.
Metal case.

1612**) mounted into	Height	Width	Depth
Alluminium alloy cabinet	28 cm 11 inches	38 cm 15 inches	20 cm 7.9 inches
Mahogany case	30.5 cm 12 inches	40.5 cm 16 inches	27.2 cm 10.7 inches
Frame for 19″ rack	35.2 cm 13.9 inches	48.2 cm 19 inches	20.3 cm 8inches

*) See Figs. 1.16 and 1.17 on page 23.
**) Without dials and knobs.

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