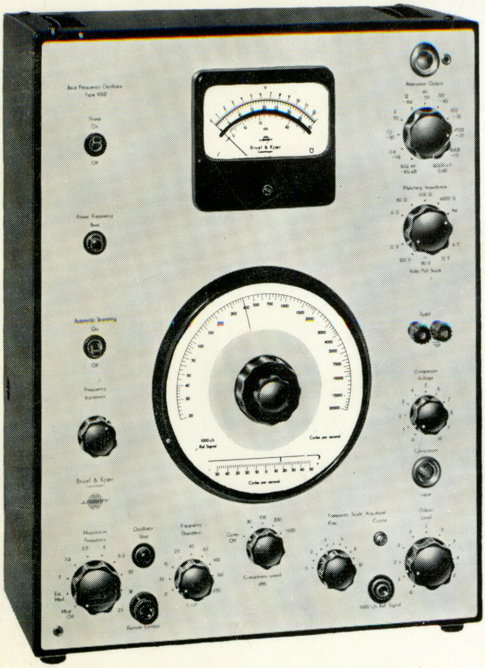
1022

INSTRUCTIONS AND APPLICATIONS

Beat Frequency Oscillator Type 1022



A beat frequency oscillator covering the range 20 to 20ooo c/s. The apparatus is designed to meet the numerous requirements of a signal source for audio frequency work. It is excellently suited both for electrical and electroacoustical measurements, as well as for acoustic research.

Accelerometers
Acoustic Standing Wave Apparatus
Artificial Ears
Artificial Voices
Audio Frequency Response Tracers
Audio Frequency Spectrometers
Audio Frequency Vacuum-Tube Voltmeters
Automatic A. F. Response and Spectrum Recorders
Band-Pass Filter Sets
Beat Frequency Oscillators
Complex Modulus Apparatus
Condenser Microphones
Deviation Bridges
Distortion Measuring Bridges
FM-Tape Recorders
Frequency Analyzers
Frequency Measuring Bridges
Hearing Aid Test Apparatus
Heterodyne Voltmeters
Level Recorders
Megohmmeters
Microphone Accessories
Microphone Amplifiers
Microphone Calibration Apparatus
Mobile Laboratories
Noise Generators
Noise Limit Indicators
Pistonphones
Polar Diagram Recorders
Preamplifiers
Precision Sound Level Meters
Recording Paper
Strain Gage Apparatus and Accessories
Stroboscopes
Variable Frequency Rejection Filters
Vibration Pick-ups
Vibration Pick-up Preamplifiers
Wide Range Vacuum Tube Voltmeters
Vibration Programmers
Vibration Control Signal Selectors
Vibration Control Generators
Vibration Meters

BRÜEL & KJÆR
NÆRUM, DENMARK. Teleph.: 80 05 00. Cable: BRUKJA. Telex: 5316. COPENHAGEN

B K

BB 1022 . 0300018

Beat Frequency Oscillator
Type 1022

Reprint July 1968

Contents

Description

General.

The Beat Frequency Oscillator Type 1022 is primarily designed for electrical and electro-acoustical measurements.

It works on the heterodyne principle using two high frequency oscillators, one of which operates on a fixed frequency, while the frequency of the other can be altered by a variable capacitor. The required audio frequency is then obtained as the difference between the two high frequencies and can be read off a large illuminated scale, the pointer of which is connected to the variable capacitor. The scale is logarithmic and graduated from 20 to 20ooo Hz. An INCREMENTAL SCALE is also provided, allowing exact frequency selection in the range — 50 to + 50 Hz around any setting on the main scale.

The zero-adjustment is controlled by obtaining a beat between the frequency of the mains voltage, and that of the oscillator voltage occuring when the oscillator is tuned to the frequency of the mains and the pressbutton marked POWER FREQUENCY BEAT on the front panel of the oscillator is pressed.

The variable capacitor has two control knobs, one of which is in a fixed position on the capacitor spindle and is used for quick setting to the desired frequency. The other will, when depressed, rotate the spindle with a ratio of 1 to 5 giving greater accuracy and fine selection of the frequency.

A worm gear permits the capacitor to be tuned automatically, for example, with the aid of the motor of the Level Recorder Type 2305. The mechanical connection to the Level Recorder is effected by means of a flexible shaft which can be screwed onto the bushing on the side of the Oscillator's cabinet. The worm gear can be engaged and released with the aid of a built-in electromagnetic clutch, operated from a switch on the front panel marked AUTOMATIC SCANNING, or by a remote control arrangement. The electromagnetic clutch is a friction-device allowing manual tuning of the variable capacitor even when the clutch is engaged.

Being also designed for use in room-acoustical measurements, the Beat Frequency Oscillator is equipped with frequency modulation, for which a reactance tube controlled by saw-tooth oscillations from a built-in oscillator is switched into the circuit of the fixed oscillator. Both the frequency and the amplitude of the saw-tooth oscillation are adjustable and may be read off two printed dials. Provision is also made for external modulation, whereby very wide limits of frequency modulation can be obtained.

By means of a compressor circuit, which can be controlled from an external voltage, it is possible to keep the voltage, current, or sound pressure constant during measurements when using the oscillator as a power source.

Description of the Oscillator and Mixer-Section.
Fig. 1.1 shows a block diagram of the complete Oscillator.
The fixed oscillator is tuned to 120 kHz and can be frequency modulated. The reactance tube circuit acts as a variable inductance and the modulation swing can be varied from 0 to ± 250 Hz by means of a switch on the front panel of the apparatus, marked FREQUENCY DEVIATION.
By means of the switch marked MODULATION FREQUENCY the frequency of the built-in saw-tooth oscillator may be chosen. Frequencies of 1—1.6—2.5—4—6.3—10—16 and 25 Hz are available. The oscillator is a blocking type, tuned to approximately 7 MHz, and the frequency of the saw-tooth oscillations is set by changing the grid resistor.

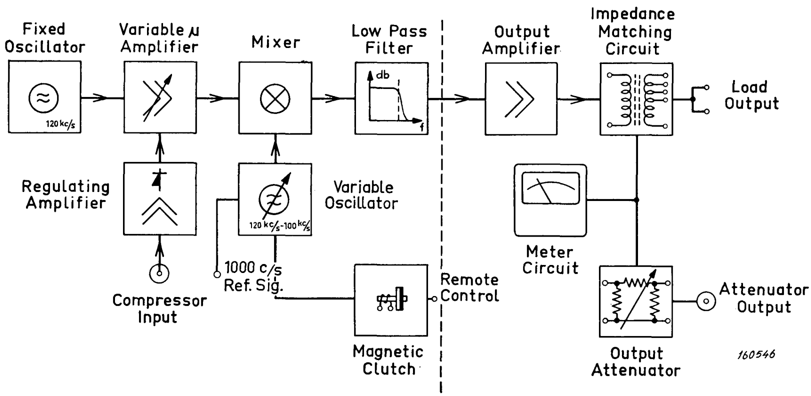


Fig. 1.1. Block Diagram of the Beat Frequency Oscillator 1022.

Provision is made for external modulation. The external generator should then be connected to two terminals of the socket on the front plate marked REMOTE CONTROL. For external modulation a voltage of approximately 3.5 volts is necessary when a modulation swing of ± 250 Hz is required.
When external modulation is employed the switch marked MODULATION FREQUENCY must be in position "Ext. Mod.", as in this position of the switch the reactance tube is on and the saw-tooth oscillator is off.
A variable capacitor inserted in the tuned circuit of the fixed oscillator, and operated by the knob marked FREQUENCY INCREMENT, permits exact frequency selection in the range ± 50 Hz for any setting on the main scale. Thus, using this capacitor, frequencies down to zero may be obtained, even though the main scale is only calibrated from 20 Hz to 20ooo Hz.
By means of a noiseless switch on the front panel, marked OSCILLATOR STOP, the voltage on the anode of the 120 kHz oscillator can be disconnected.

This switch is specially provided for reverberation measurements. The same method is used for remote control, the appropriate wiring of which can be seen by referring to the circuit diagram of the Oscillator.

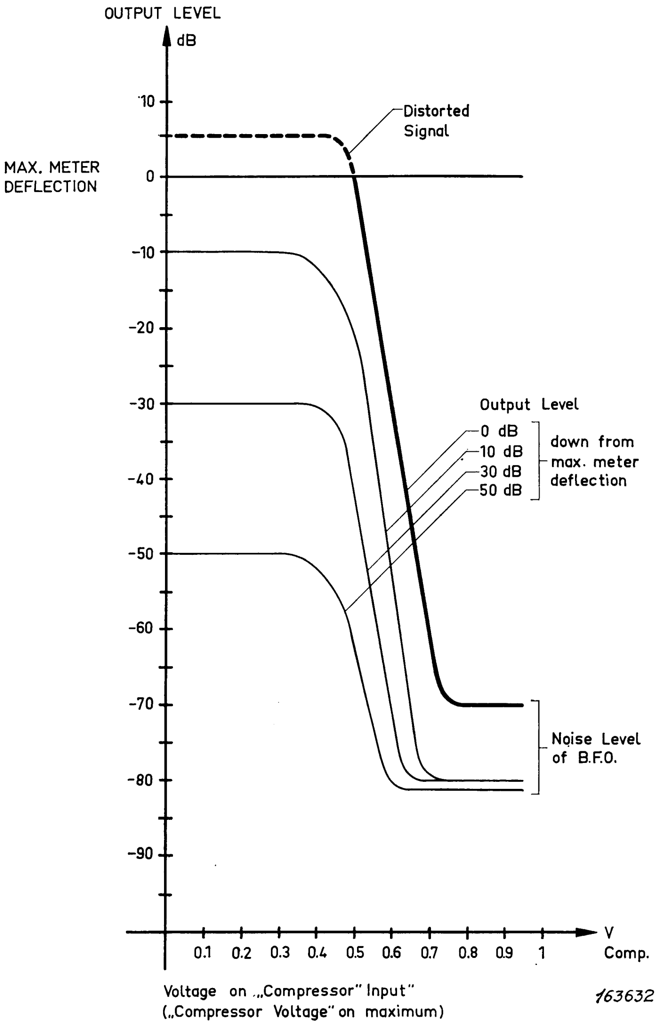


Fig. 1.2. Regulation characteristics for different positions of the potentiometer marked OUTPUT LEVEL.

The output voltage from the fixed oscillator is fed to the grid circuit of a pentode, the grid bias of which, is controlled, by means of a regulating amplifier. To obtain a higher degree of control the working-point of the pentode is chosen on the non-linear portion of the Ia-Eg characteristic, near cut-off.

The purpose of this circuit is to control automatically the output power of the Beat-Frequency Oscillator by an A.F. control voltage. For example, the voltage from a standard microphone placed in the sound field of a loudspeaker which is fed from the Oscillator. In this case the output power of the Oscillator will be so controlled that a constant sound pressure is maintained on the standard microphone.

The A.F. control voltage should be fed onto the screened socket marked COMPRESSOR INPUT on the front panel of the Oscillator. A variable potentiometer, marked COMPRESSOR VOLTAGE is inserted in the input circuit of the regulating amplifier and can be used as volume control for the output power from the Oscillator when automatic regulation is employed. Care must be taken, not to use a modulated DC voltage as regulation voltage, as the input circuit is directly coupled. The regulating amplifier has a linear frequency characteristic from 20 to 20000 Hz and should have an input signal of approximately 0.5 volt on the grid of the A.F. amplifier tube for full regulation. The input impedance, measured across the terminals of the socket marked COMPRESSOR INPUT is approximately 25 kΩ, and the maximum obtainable range of regulation is 50 dB.

The amplified A.F. control voltage is rectified in a full-wave rectifier, designed to give a DC output voltage proportional to the average value of the A.F.-control voltage.

By means of the switch marked COMPRESSOR SPEED on the front panel of the oscillator the regulation speed can be varied. Regulation speeds of 30—100—300 or 1000 dB/s may be chosen by changing the value of the resistor in the A-C filtering network for the rectified control voltage. When the switch COMPRESSOR SPEED is in position "comp. off." the output from the rectifier is short-circuited thereby disconnecting the automatic regulation circuit.

To make linear regulation of the output level possible, even when maximum output power is required from the Oscillator, the level of the high frequency voltage from the 120 kHz fixed Oscillator is raised approx. 10 dB when the automatic compression is switched in.

The anode-circuit of the pentode in the variable-μ amplifier is tuned to 120 kHz, forming a band-pass filter, the output of which is fed to the mixer. In the mixer tube, which is one half of a twin triode, the 120 kHz voltage is mixed with the output voltage from the variable oscillator. The frequency of the variable oscillator can be altered continuously from 120 to 100 kHz by means of a specially designed variable capacitor. This capacitor is made with a high degree of accuracy and a maximum deviation of 0.7 degrees from a logarithmic frequency curve is obtained. A worm gear, connected to the capacitor spindle, permits automatic tuning with the aid of an external motor, for example the motor in the Level Recorder Type 2305, and the worm gear can be set and released by means of a magnetic clutch. This is operated from a switch on the front panel of the oscillator, or it can be operated from an external switch or relay. Connection must then be made to the appropriate terminals of the socket marked REMOTE CONTROL on the front panel, and the control switch AUT. SCANNING for the magnetic clutch must be in position "off".

The end of the scale pointer spindle is provided with a 6 mm hole. The arrangement can be used for special purpose devices which are to be governed by the angular position of the frequency scale pointer.

By means of a pushbutton marked 1ooo Hz REF. SIGNAL, an extra capacitor is introduced in the tuning circuit of the variable oscillator.

There will be exactly 1ooo Hz at the output socket when the scale pointer is set to 1ooo Hz REF. SIGNAL and the pushbutton 1ooo Hz REF. SIGNAL is depressed.

The reason for setting the scale pointer at 1ooo Hz REF. SIGNAL is in order to be able to align the 1022 with the frequency calibrated paper, used on the Level Recorder Type 2305, as this paper is calibrated from 10 Hz. The distance between the calibration mark of 10 Hz and 20 Hz on the recording paper corresponds to the distance between 1ooo Hz REF. SIGNAL and 20 Hz on the oscillator.

By depressing the pushbutton it is now possible to check that the level of the middle frequencies is within the divisions of the paper.

The voltage developed across the grid of the variable oscillator is fed into the mixer tube and mixed with the voltage from the variable-μ amplifier. The mixer tube is of the triode type, whereby a low hum level is obtained in spite of the AC-heating of the filament.

A low-pass filter having a cut-off frequency of 50 kHz is inserted in the anode circuit of the mixer tube, thus passing only the lower frequency obtained by the frequency conversion, onto the grid of the first tube in the output amplifier section.

Partial Blocking of Frequency Range.

As previously mentioned, the frequency scale is logarithmic and calibrated 20—20ooo Hz. When the capacitor is set to frequencies above 20ooo Hz or below 20 Hz the fixed Oscillator can be blocked, and consequently no output voltage will be obtained. For automatic recording of frequency characteristics, i.e. when using the Level Recorder Type 2305, this is a great advantage as no unwanted curves will then appear on the corresponding section of the frequency calibrated paper.

The cut-off section can be made wider by adjusting the cam discs, connected to the rear end of the capacitor spindle. However, if the REMOTE CONTROL plug is removed there will be no blocking at any part of the scale.
In application where the B.F.O. is employed in conjunction with the B & K Level Recorder, and where automatic recording is required, the blocking arrangement can also be used for remote lifting of the Level Recorder's writing pen. This is a great asset in for example measurements where the compressor circuit of the B.F.O. is used. In this instance the pen-lifting arrangement of the Level Recorder can be controlled from the frequency blocking circuit by making the appropriate connections to the REMOTE CONTROL jack of the B.F.O. In cases where the entire frequency range (20—20000 Hz) of the B.F.O. is utilized, the normal frequency blocking, which functions outside the scale graduation, should be set out of operation. The writing pen of the Level Recorder can now be lifted from the paper outside the frequency range of interest and a proper working of the compressor also at the initial frequency (20 Hz) is ensured during the automatic scan. If the described method is not utilized, the following would take place: No signal will be present in the range 20000 Hz to 20 Hz (outside the scale graduation), i.e. the compressor of the B.F.O. will be in such a condition to give full output signal of the B.F.O. Consequently, when the scale pointer goes inside the scale graduation (20 Hz) full output level will be transmitted at 20 Hz, and after the chosen time delay (Compressor Speed) the signal level will be compressed to the proper (preset) value. A deflection on the recording paper which is not a response of the measured object would thus be recorded.

Description of the Output Amplifier Section.

The voltage from the low-pass filter is fed to the control grid of the first tube in the two-stage audio frequency output amplifier via a variable potentiometer. This potentiometer is operated by the knob marked OUTPUT LEVEL on the front panel of the Oscillator and is used for continuous adjustment of the output power.

The gain of the amplifier is stabilized by means of negative voltage feedback, and the anode circuit of the output tube is coupled to an auto-transformer for impedance matching.

Four different output impedances are available and can be chosen with the switch on the front panel marked MATCHING IMPEDANCE. The different positions of the switch are indicated by 6, 60, 600 and 6000 ohms respectively, and the output voltage is taken from the terminals marked LOAD. It should be noted that the output impedance of the Oscillator is only approximately 10—20 % of the indicated values, but when loading with impedances as marked, a maximum output power is obtained with a minimum harmonic content. Furthermore, correct loading ensures the output voltage to be practically independent of the frequency.

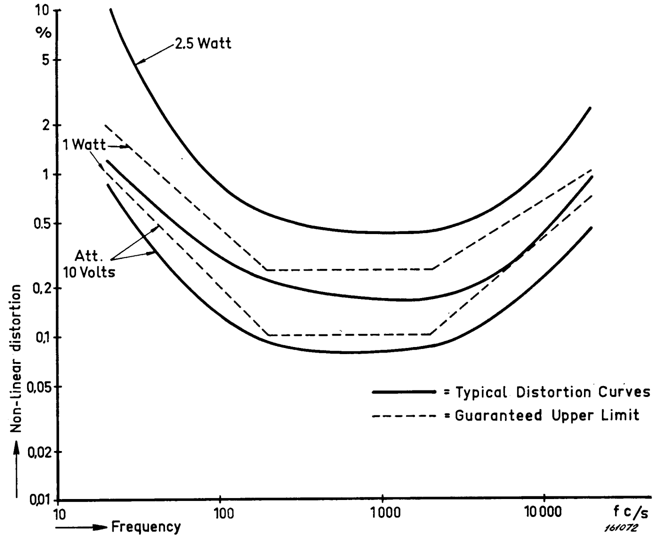


Fig. 1.3. Distortion curves for different loads. The curve marked "Att. 10 volts" is obtained from measurements taken on the ATTENUATOR OUTPUT terminals open circuit.

A fifth position of the switch MATCHING IMPEDANCE is marked "Att." and connects the output transformer to an attenuator, variable in steps of 10 dB from 120 μvolts to 12 volts, and is operated by the switch marked ATTENUATOR on the front panel. With the impedance switch in this position the output circuit is connected to the screened socket on top of the front panel, the output impedance being constant and approximately 50 ohms. The overall accuracy of the attenuator is approximately 2 %.

The voltage on the output terminals is indicated by a vacuum-tube voltmeter which measures the average value of the A.F. voltage. It is calibrated in r.m.s. values of a sinusoidal voltage, and the accuracy in the frequency range 20—20000 Hz is 1.5 % of full scale deflection.

In addition to the voltscales there is also a dB scale, and the scale is calibrated in such a way, that it is possible to read directly the level in dB re. 1 volt.

The sensitivity of the voltmeter is automatically changed when the position of the switch marked MATCHING IMPEDANCE is altered. Full deflection of the meter is indicated on the switch. When the MATCHING IMPEDANCE switch is in position "Att." the output voltage available from the Oscillator will depend on the position of the ATTENUATOR switch, in this case full deflection of the meter corresponds to the value indicated by the switch position.

In addition to the volt calibration on the switch ATTENUATOR OUTPUT there is also a dB calibration, and the calibration is, as mentioned above, given in dB re. 1 volt. An example will explain the use of the dB scale: If the OUTPUT LEVEL is adjusted in such a way, that 20 dB is read on the meter scale, and the switch ATTENUATOR OUTPUT is in the position — 30 dB then the signal level at the output socket will be 20 — 30 = — 10 dB re. 1 volt (0.316 V).
The signal-to-noise ratio of the Oscillator is greater than 70 dB for maximum output voltage. It is independent of the position of the attenuator, but somewhat dependent on the position of the potentiometer marked OUTPUT LEVEL. The best result is obtained when the voltmeter has a deflection around 20 dB.
Harmonic distortion is dependent on the setting of the OUTPUT LEVEL potentiometer. As long as the output is kept within the meter range, the distortion will be of the order indicated in Fig. 1.3.

Power Supply.

The Oscillator can be operated from a 240, 220, 150, 127, 115 or 100 volts AC power line, the power consumption being about 60 watts.
The proper voltage is selectable by a switch-fuse combination situated at the rear of the instrument. To select the voltage it is necessary to remove the fuse by turning the hexagonal disc head in the centre of the switch anticlockwise. Then turn the head of the voltage adjuster with a coin until the white mark is aligned with the required voltage. The fuse is then replaced.
It should be noted that if the apparatus is to be operated from a DC power line, or from an accumulator, a vibrator unit or a rotary converter is required.

Operation

General.

Ascertain that the Beat Frequency Oscillator is set to the appropriate power supply voltage by means of the selector at the rear of the instrument, and after connection to the power supply, the instrument can be switched on by the toggle switch marked POWER on the front panel. The dial lights in the meter, and frequency scale should come on immediately.

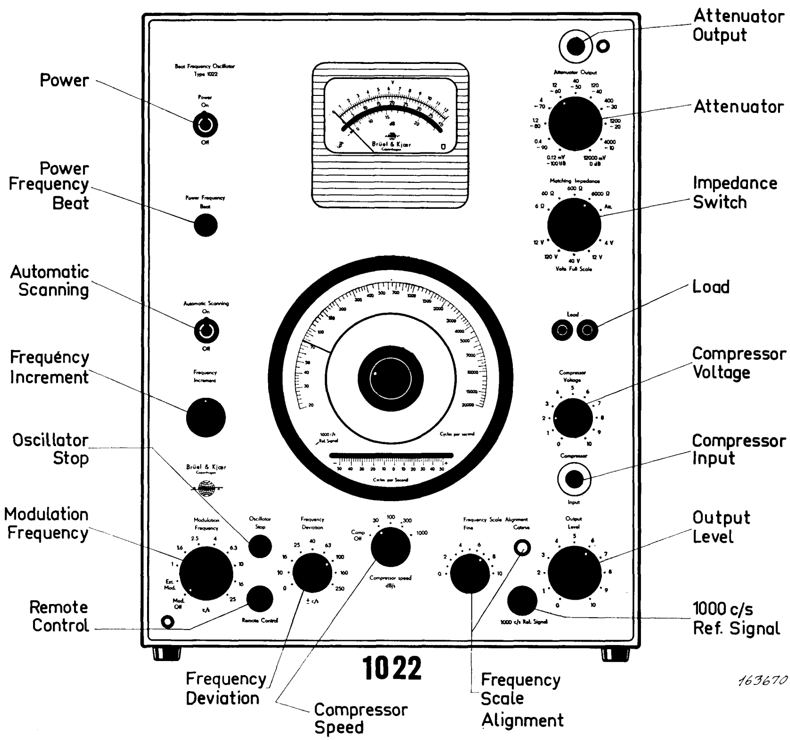


Fig. 2.1. Control knobs and markings of the Beat Frequency Oscillator Type 1022.

A. Calibration.

1. Snap the toggle switch marked POWER to "on" and allow two minutes warm up.
2. MODULATION FREQUENCY and COMPRESSOR SPEED to their "off" position.
3. Turn main scale pointer until it is on the frequency of the line voltage (e.g. 50 or 60 Hz), checking that the frequency incremental scale is on zero. If not, set by FREQUENCY INCREMENT knob to this point.
4. Set suitable deflection on the meter by tuning the knob marked OUTPUT LEVEL to higher than center scale reading.
5. Press POWER FREQUENCY BEAT button and hold to "in" position and at the same time rotate FREQUENCY SCALE ADJUSTMENT FINE slowly, until a large fluctuation registers, slows up, and practically ceases on the meter dial. If the scale is widely out of tune, two points may be found where this occurs, only one of which is correct and therefore a check as outlined in the following paragraph should be carried out, firstly releasing the POWER FREQUENCY BEAT button.
6. Turn the main scale pointer to twice the mains frequency (100 or 120 Hz) and if improperly tuned the meter needle will drop to zero indication.

   Then FREQUENCY SCALE ADJUSTMENT FINE must be re-aligned, but however, if the other zero point cannot be found and is outside the range of the FINE control, align the variable capacitor marked COARSE with a screwdriver to give a suitable setting, which should occur at some point between 4 and 6 on FREQUENCY SCALE ADJUSTMENT FINE.

B. Operation Using the Output Terminals Marked LOAD.

Apply the following procedure:—

1. Set-up and calibrate the oscillator as described in A.
2. Place the MATCHING IMPEDANCE switch in a suitable position for the application.

   N.B. Full deflection of the instrument meter corresponds to the voltage indicated by the switch position.
3. Connect the load to the output terminals marked LOAD.
   N.B. Right terminal is grounded.
4. Turn the pointer on the main frequency dial to the desired frequency, finely adjusting the Frequency Increment if necessary. (For automatic frequency sweep, see under E).
5. Select a suitable output voltage by turning the knob marked OUTPUT LEVEL.

C. Operation Using the Built-in Attenuator.

Apply the following procedure:—

1. Set-up and calibrate the oscillator as described in A.
2. Set the MATCHING IMPEDANCE switch in the position "Att.".
3. Select the appropriate voltage range by means of ATTENUATOR.
   N.B. Full deflection of the instrument meter corresponds to the voltage indicated by the switch position.
4. Connect the load to the screened output socket on the top of the instrument marked ATTENUATOR OUTPUT.
5. Proceed as in B. 4 and 5.

D. Frequency Modulation.

When a frequency modulated output signal is required, the following procedure should be adopted:—

1. Turn the knob marked MODULATION FREQUENCY to the required frequency.
2. Turn the knob marked FREQUENCY DEVIATION to zero.
3. Re-calibrate the Oscillator as described in A, omitting to turn MODULATION FREQUENCY to "off" position.
4. Set the FREQUENCY DEVIATION knob to the required bandwidth.
5. Proceed as described in B items 2 to 5, or C items 2 to 5, dependent on the requirement.

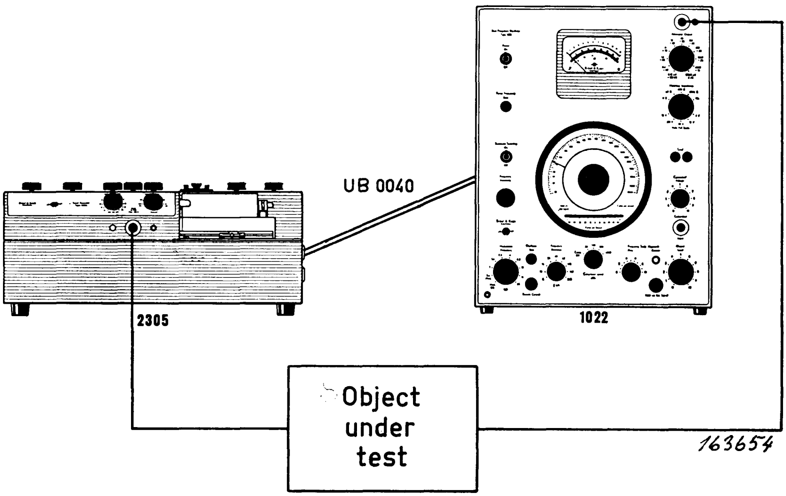


Fig. 2.2. Example of mechanically connecting the B.F.O. 1022 to Level Recorder Type 2305.

E. Automatic Recording.

By combining B.F.O. Type 1022 and Level Recorder Type 2305, or using Automatic Frequency Response Recorder Type 3308, it is possible to automatically record the frequency response of four terminal networks. When using B.F.O. Type 1022 and Level Recorder 2305, it is necessary to connect the two instruments mechanically by a Flexible Shaft UB 0040 as in Fig. 2.2 and to make the electrical connections also shown. Fig. 2.3 depicts the use of the Automatic Frequency Response Recorder Type 3308 with the required external connections.

For setting-up, calibrating and synchronising the combination shown in Fig. 2.2 the following procedure should be adopted:—

1. Ensure power supplies are correct and switch POWER toggles to the "on" position.
2. Calibrate the B.F.O. as described in A.

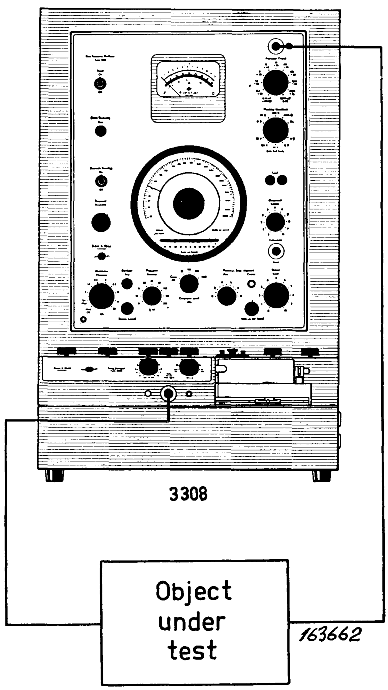


Fig. 2.3. External electrical connections when using Automatic Frequency Response Recorder Type 3308.

3. Connect the instruments as shown in Fig. 2.2. This is done by connecting a flexible driving cable (UB 0040) to the upper driving shaft of the Recorder DRIVE SHAFT I located at the right-hand side and to the front of the Level Recorder. Taking the other end of the cable, insert and screw into drive on left-hand side of B.F.O. (Check engagement by switching the Level Recorder START/STOP switch to "start" and the B.F.O. magnetic clutch to "on" and note if scale pointer rotates).

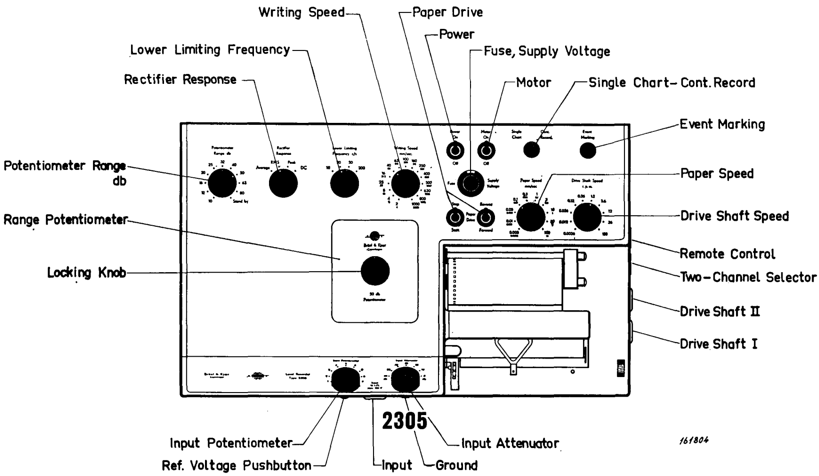


Fig. 2.4. Level Recorder Type 2305 viewed from above.

4. Switching PAPER DRIVE to "stop", continue with the following procedure referring to Fig. 2.4.
5. Load the Level Recorder with the desired recording paper. (Follow instructions in Level Recorder Manual).
6. Select and insert required Range Potentiometer. (N.B. Place POTENTIOMETER RANGE dB switch to "standby" when changing potentiometers).
7. Switch POTENTIOMETER RANGE dB until figure corresponds to the Range Potentiometer being used, i.e. "10", "25", "50" or "80".
8. By means of the switch RECTIFIER RESPONSE, select R.M.S. or if specially required one of the other three positions Average, Peak, or D.C.
9. Turn the LOWER LIMITING FREQUENCY switch to the cut-off value (10, 20, 50 or 200 Hz).
10. Set WRITING SPEED to required position.
(Full explanations of items 8, 9 and 10 can be obtained from the Level Recorder Manual).

11. Place REVERSE/FORWARD switch to "forward".
12. Select PAPER SPEED to a suitable speed, e.g. 10 mm/sec.
13. Pull gear-lever marked X to the outer position. (See Fig. 5.1).
The actual paper drive speed now corresponds to the *small numbers* marked around the PAPER SPEED knob.
14. Two types of recording can be made:—
(a) Single chart recording (automatic recording over a length of 250 mm paper only),
(b) Continuous recording over any length of paper.
(a) **Single Chart Recording:**
Set the PAPER DRIVE toggle switch to "start" commencing the paper to run, which will continue until the built-in automatic stop switch declutches the drive mechanism (less than one chart length).
Reset recording paper by finger wheel Z (Fig. 5.1) until the stylus rests on the 10 Hz line.
A chart of 250 mm length will now run off when the SINGLE CHART — CONTINUOUS RECORDING pushbutton is pressed and released again immediately afterwards. (It is possible to stop the recording at any time by setting the PAPER DRIVE toggle switch to "stop").
(b) **Continuous Recording:**
The operator should follow the instructions outlined under (a), i.e. SINGLE CHART RECORDING, except that to start the recording it is necessary to press the SINGLE CHART — CONTINUOUS RECORDING push-button and turn it clockwise. Recording will now automatically take place until the push-button is released again and the PAPER DRIVE, START-STOP toggle switch is set to "stop".
Note: Whenever the PAPER DRIVE, START-STOP toggle switch is in the "stop" position the paper drive is completely controlled by the SINGLE CHART — CONTINUOUS RECORDING push-button.
15. In order to synchronise the units, stop the paper so that the stylus rests on the 10 Hz line.
16. Adjust the commencing of the reference line on the paper to a suitable level, any necessary fine adjustment being made with the Input Potentiometer.
17. Set the pointer of the B.F.O. on 1000 Hz REFERENCE SIGNAL and engage the magnetic clutch by use of the clutch switch. The units should then be synchronised.
18. Push the 1000 Hz REF. SIGNAL button. The B.F.O. then generates a signal of 1000 Hz enabling the operator to select a reference signal

which is in the middle of the range. (This makes certain that when taking a recording of frequency characteristics, where the lowest attenuation is around 1000 Hz, that the deflection of the stylus lies within the scale limits of the paper during the recording).

Continuous Recording with ten Times Enlarged Paper Speed.

The following method is adopted: Set the "1 : 10 Synchronizing Gear Lever" in its inner position (released). The actual paper drive speed then corresponds to the *large numbers* marked around the PAPER SPEED knob. Recording on frequency calibrated paper is not possible in this position.

The start and stop of the recording will in this case be completely controlled by means of the PAPER DRIVE, START-STOP toggle switch.

F. Automatic Regulation of the Output Power.

By means of the compressor circuit it is possible to regulate the output from the oscillator. When a constant output voltage is required, the output voltage from the Oscillator is used as a control voltage. A constant current is obtainable if the voltage drop across a resistor connected in series with the load, is used as the control voltage, and a constant sound pressure is maintainable with the aid of a regulating microphone. The microphone is then placed in the sound field from a loudspeaker which is driven by the Oscillator, and the microphone output voltage used as control voltage. (It is essential that the frequency characteristic of the microphone is linear).

Proceed as follows:—

1. Calibrate the Oscillator as described under Calibration, see under A.
2. Set the MATCHING IMPEDANCE switch in the desired position.
3. Connect the load to LOAD terminals or to the screened output socket on the top of the instrument, see B or C.
4. Feed the control voltage to the COMPRESSOR INPUT terminal. If necessary use an amplifier which has a linear frequency characteristic for the amplification of the control signal, approximately 0.5 volt being required for full utilization of the compressor.
5. Set COMPRESSOR VOLTAGE and OUTPUT VOLTAGE to maximum (fully clockwise).
6. Feed the voltage to be measured to the recording instrument, e.g. the Level Recorder Type 2305.
7. Set the COMPRESSOR SPEED switch in one of the positions: 30, 100, 300 or 1000 dB/sec.
8. Regulate the desired output voltage by turning COMPRESSOR VOLTAGE knob counterclockwise.

Note: When the Beat Frequency Oscillator is used in conjunction with the Level Recorder Type 2305 the writing speed of the Level Recorder should be kept below the regulation speed of the compressor.

It is also possible to obtain different regulation characteristics dependent on the position of the potentiometer marked OUTPUT LEVEL. This can be seen from Fig. 1.2.

Remote Control.

In the main description of the apparatus several forms of remote control are mentioned. To carry out any one of these methods use must be made of the REMOTE CONTROL jack on the front panel, the appropriate connections being made to the pins of the six poled socket. Fig. 2.5 shows the different pins on the socket.

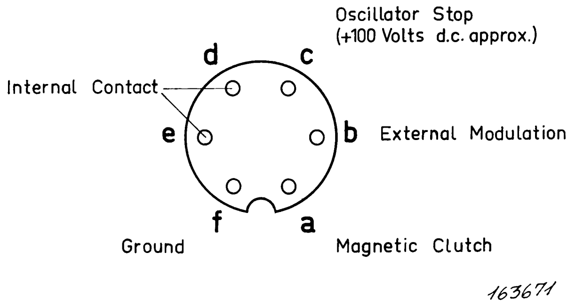


Fig. 2.5. REMOTE CONTROL jack, viewed looking towards front panel.

Remote control of the magnetic clutch can be obtained by making or breaking a connection between a and f, providing the clutch control switch AUTOMATIC SCANNING is at the position "off".

For external modulation one may connect the external generator between chassis and terminal b, having the MODULATION FREQUENCY switch set to position "Ext. Mod.", but it is also possible to use f as chassis connection.

For remote interruption of the output signal (stopping of the fixed oscillator) the terminal c should be connected to terminal f (ground). This arrangement is used, for instance, when reverberation measurements are carried out automatically by employing the B & K Level Recorder Type 2305. A special switch in the Recorder then connects terminal c to ground when the radiated signal has to be interrupted.

Terminals d and e are in connection with an internal contact used for interrupting the signal output when the frequency scale pointer is outside the scale.

Note: When delivered from the factory, each B.F.O. is supplied with a 6-poled plug containing the necessary connections for the function of the internal contact.

Trouble Shooting.

If the B.F.O. is not working properly when switched on, check the following:—

1. That scale-pointer is not situated in the uncalibrated section of the main dial, i.e. between 20000 Hz and 20 Hz.
2. That scale-pointer is not on a section chosen for "partial blocking of frequency range", see pages 9 and 10.

Accessories

Output Transformer TU 0005.

This transformer is designed to allow symmetrical output from the attenuator output of the B.F.O. 1022. (Symmetry better than 0.1 %). The output impedance is 600 Ω and the distortion 0.5 % at 20 Hz with maximum output voltage from the B.F.O. (12.5 V). The accuracy of the Transformer is $\pm$ 0.2 dB in the frequency range 10 Hz to 35 kHz. In addition a core material has been chosen for the transformer, which makes it possible to "preload" the secondary winding with a current of 100 mA without causing additional distortion for frequencies above 300 Hz. The transformer ratio is $\sqrt{10:1}$.
The voltage transmission loss of the transformer when loaded by 600 Ω is approximately 16 dB.

Applications

The field for use of the Beat Frequency Oscillator Type 1022 is so extensive that only a few of the possible applications are illustrated in the following pages, these being classified into there sections, showing the instrument being used as a power source for:—

(A) Electronic Measurements
(B) Acoustical Measurements
(C) Mechanical Measurements.

GROUP A. ELECTRONIC MEASUREMENTS

Measurement of Frequency Response of Four-Terminal Networks.
The object to be tested, e.g. a filter, transmission line, transformer etc. is fed from the Beat Frequency Oscillator Type 1022 output. Then point-by-point

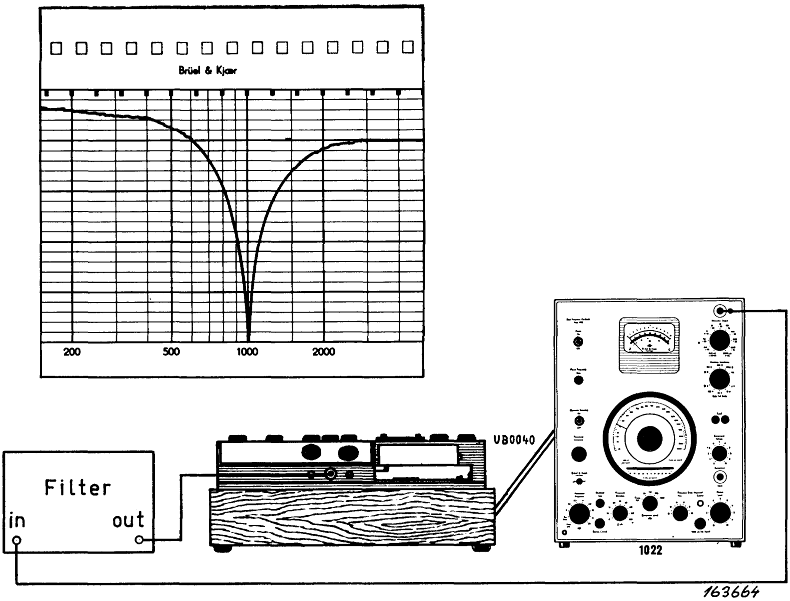


Fig. 3.1. Measurement of frequency response of four-terminal A.F. network.

measurements can be taken by means of the Audio Frequency Voltmeter Type 2409 (or 2410) or Microphone Amplifier Type 2603 or 2604.

If an automatic recording of the frequency response is wanted, the Level Recorder Type 2305 should be used. The mechanical coupling between the motor in the Level Recorder and the tuning capacitor of the B.F.O. is effected with a Flexible Shaft UB 0040 which is delivered with the B.F.O.

The measuring arrangement which is employed to obtain the frequency characteristic of an A.F.-filter is shown in Fig. 3.1.

Should the compressor circuit be used to regulate the output signal from the Oscillator it is advisable to verify that the voltage at the COMPRESSOR INPUT is approximately to required o.5 volt. When it is intended to use the equipment for automatic recording of frequency characteristics, the input of the Level Recorder may first be connected to the input of the compressor, and a recording of the compressor input voltage made for the complete frequency range in which measurements are to be taken. With the compressor working correctly the resultant recording should be a straight line. If this is the case the input to the Level Recorder can then be disconnected, and the desired measurements carried out.

A.C. Bridge Measurements.

By employing the B.F.O. Type 1022 and a Frequency Analyzer Type 2107 as an indicating instrument selective measurements of components in an A.C. bridge can be obtained.

The only requirement the bridge must satisfy is that one diagonal point can be grounded as shown in Fig. 3.2. This requires the bridge to be supplied from the B.F.O. via a screened transformer e.g. TU 0005, the B.F.O. being grounded at one terminal.

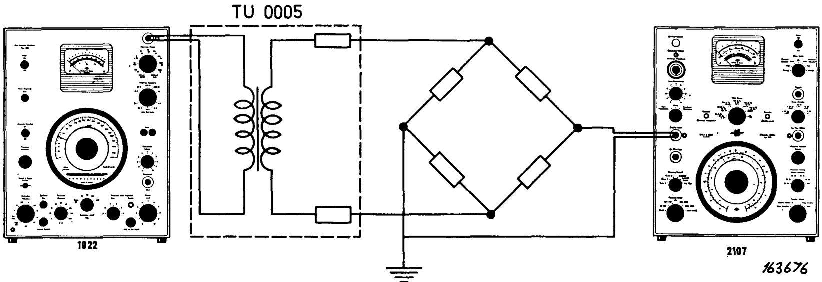


Fig. 3.2. The B.F.O. Type 1022 used as voltage source for AC Bridge Measurements. The Output Transformer TU 0005 provides a symmetrical output from the B.F.O.

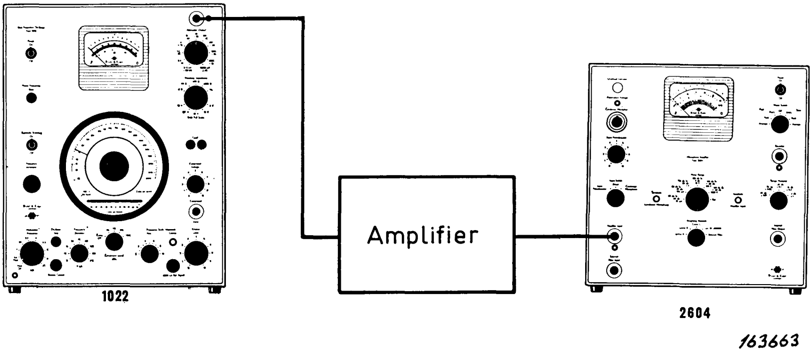


Fig. 3.3. Measurement of gain in an AF amplifier.

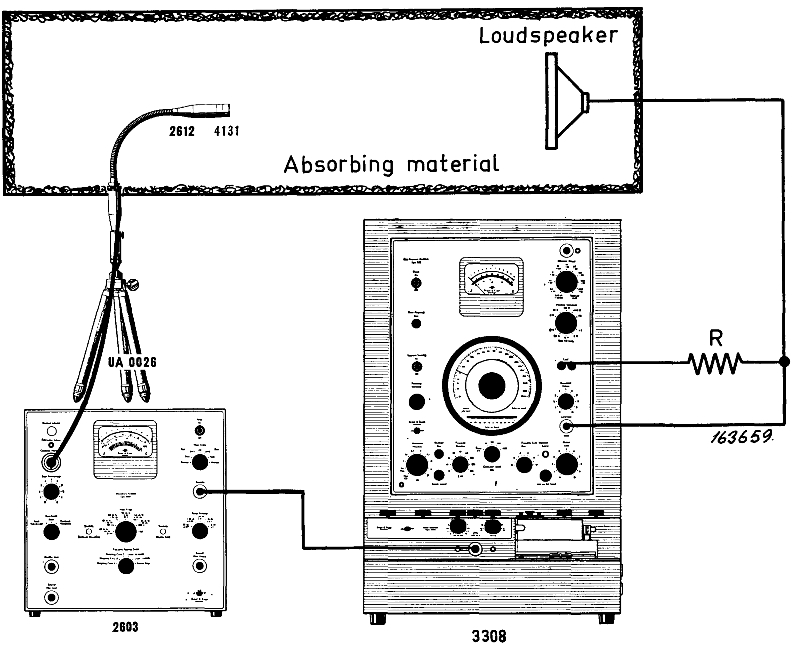


Fig. 3.4a. Measuring arrangement used for recording the frequency characteristic of a loudspeaker.

Due to the selectivity of the Frequency Analyzer it is well-suited as an indicating instrument in a bridge circuit. The decibel scale on the instrument meter will often prove useful when it is desired to measure the quality of different components placed within the bridge.

Measurement of Gain in A.F. Amplifiers.

The measurement of distortion and frequency response of A.F. amplifiers may be carried out in the same manner as for four-terminal networks, the description for the arrangement being given in the initial paragraph to this section.

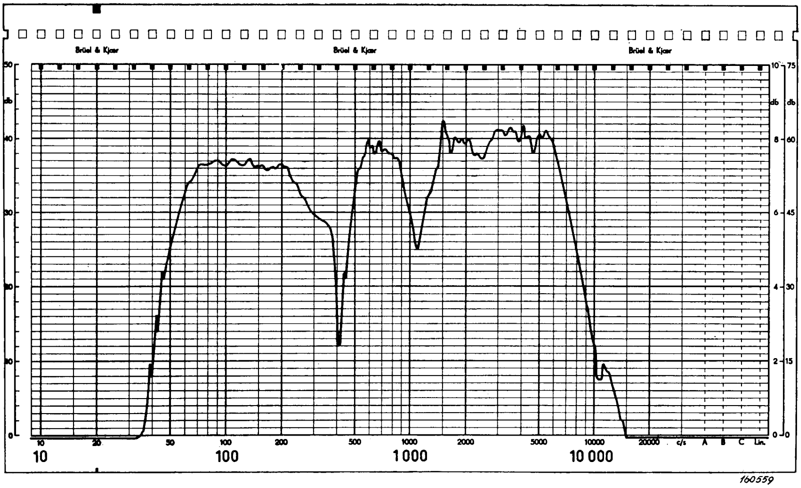


Fig. 3.4b. Recording of the frequency characteristic of loudspeaker mounted in a cabinet. (The measurement was not carried out in a completely dead room, and the effect of reflections can be seen from the recording).

Frequently it is important to check the linearity of an amplifier i.e. to measure the gain for different values of input voltage. As the attenuator circuit of the Beat Frequency Oscillator Type 1022 is very accurately calibrated it is an extremely useful instrument in carrying out gain measurements.

The output voltage from the amplifier under test should be measured with an Audio Frequency Voltmeter Type 2409 (or 2410), or a Microphone Amplifier Type 2603 (or Type 2604) an example of the arrangement being given in Fig. 3.3.

GROUP B. ACOUSTICAL MEASUREMENTS

Frequency Response Recording of Loudspeakers.

Loudspeaker tests may be carried out either in an anechoic chamber, or in the open air. In the open air, noise is generally present, and a completely sound absorbent room should preferably be used.

The loudspeaker under test should be fed with a constant voltage or current, the latter producing a mechanical force of constant amplitude which is applied to the diaphragm.

Fig. 3.4a shows a set-up for recording the frequency characteristic of a loudspeaker. The loudspeaker is fed from the B.F.O. section of the Automatic Frequency Response Recorder Type 3308 via a series resistor the voltage drop across which is led to the Compressor Input of the B.F.O. A constant current will therefore be obtained in the circuit when the voltage across the resistor is approximately o.5 volt.

The output voltage from the Condenser Microphone Type 4131 is fed to the Level Recorder in the Automatic Frequency Response Recorder via an Amplifier. This amplifier can be a Microphone Amplifier Type 2603 (or 2604) or a Frequency Analyzer Type 2107 or 2112. The Amplifier should be switched to have a linear frequency characteristic.

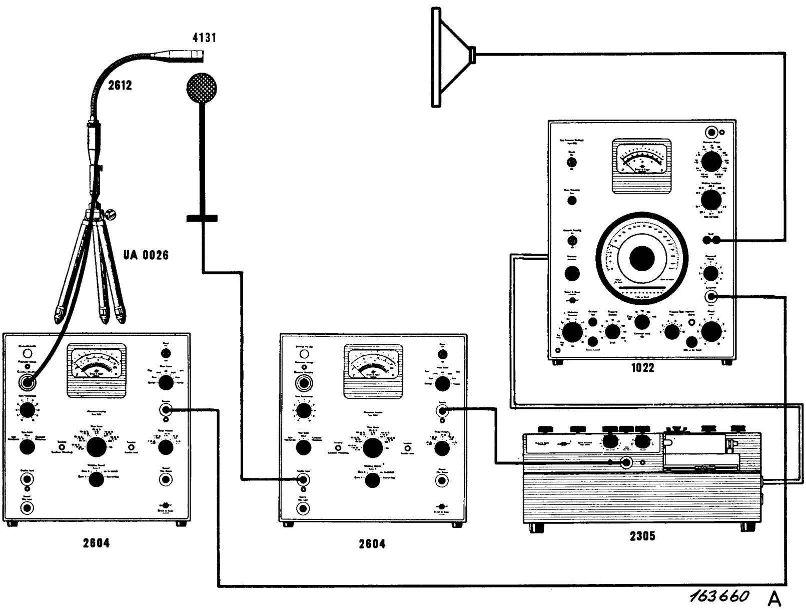


Fig. 3.5a. Measuring set-up for automatic recording of the frequency response of microphones.

An advantage gained by employing a Frequency Analyzer as an amplifier is that distortion measurements can be carried out with the same measuring set-up. Fig. 3.4b shows a recording obtained with the described set-up.

Recording of the Frequency Response of Microphones.

Fig. 3.5a shows a typical arrangement for automatically recording the frequency response of a microphone.

In the set-up depicted, the microphone to be tested is connected to the Level Recorder Type 2305, via a Microphone Amplifier Type 2604, the originating sound source being a loudspeaker which is fed from the B.F.O. Type 1022. As the sound pressure in front of the microphone under test has to be kept constant, it is necessary to place it relatively close to another microphone (in this case a Condenser Microphone Type 4131) which is coupled to a second Microphone Amplifier Type 2604, the output of which is fed to the COMPRESSOR INPUT of the BFO ensuring a constant sound source. It is

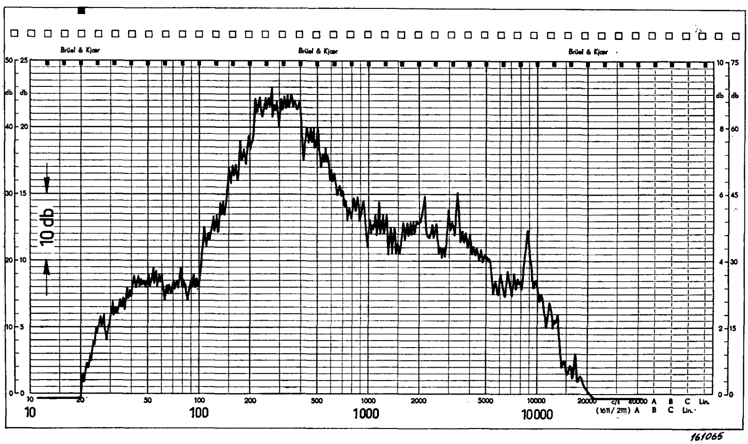


Fig. 3.5b. Recording made with the set-up shown in Fig. 3.5a.

essential that the two microphones are symmetrically placed in the radiated sound field and the correct compressor speed selected. The acoustical delay time required for the sound to travel from the loudspeaker to the microphone must be small in comparison to the time constant determining the compressor speed. Under normal circumstances these conditions are easily fulfilled.

To give reliable measurements the room to be used need not be fully anechoic as the regulating effect of the compressor will compensate for any minor reflections set-up. However, for correct operation of the regulation circuit,

the reverberation time of the room must not be too long and a low scanning speed should be used for the frequency sweep.
In Fig. 3.5b will be seen a recording showing the frequency response of a microphone recorded by employing the previously outlined system.

Recording the Frequency Characteristic of Hearing Aids and Earphones.
A recommended set-up for the testing of the above units is displayed in Fig. 3.6a. By this method it is possible to automatically record the frequency characteristics of the components under well-defined acoustical conditions.
The B.F.O. 1022 feeds the earphone under test which is placed in the

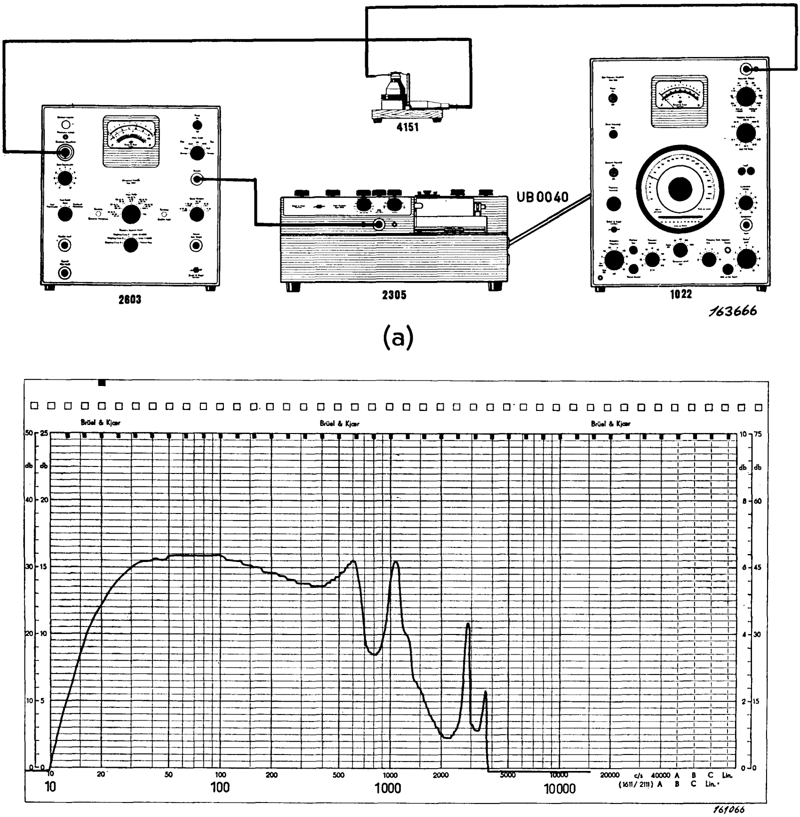


Fig. 3.6.
(a) Measuring arrangement.
(b) Recording of the frequency characteristic of an earphone.

Artificial Ear Type 4151. Different types of couplers are available for the ear. A DB 0138 2 cm^3 which conforms to ASA Z 24.9. 1949 and the new IEC standards is suitable for measurements on insert type of earphones. For headsets and similar external earphones a 6 cm^3 can be supplied e.g. DB 0160 (N.B.S. type) or DB 0161 (A.S.A. type).
A B & K Condenser Microphone 4132 is placed in the coupler and measures the S.P.L. produced by the earphone. The output from the Microphone is fed to the input of the Amplifier Type 2603 and the amplified signal led to a Level Recorder Type 2305 to obtain a graphic recording, see also Fig. 3.6b.

Checking of Hearing Aids.
An arrangement for the checking of Hearing Aids is illustrated in Fig. 3.7a. This set-up makes it possible to automatically record the frequency character-

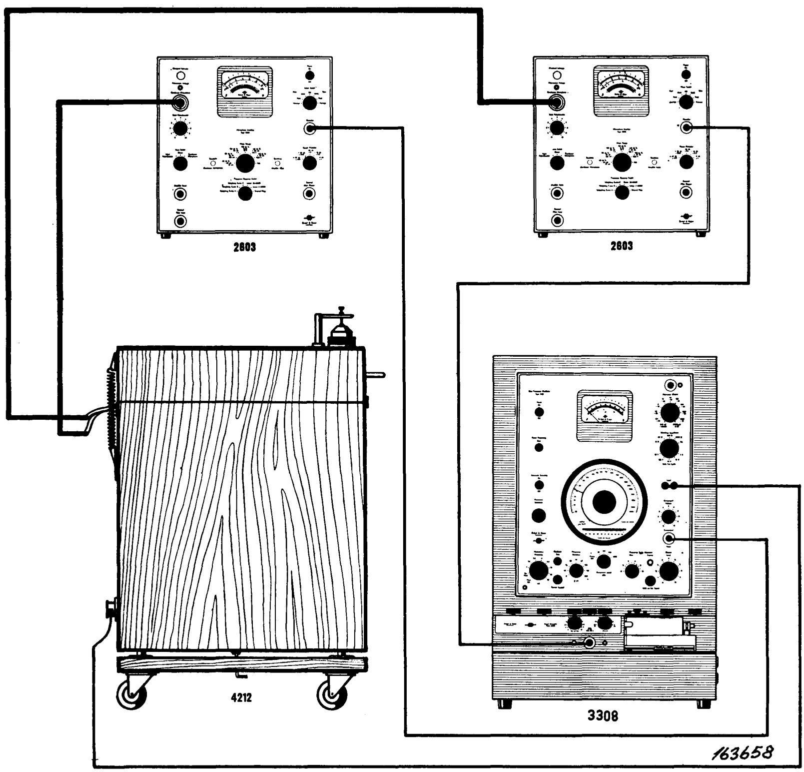


Fig. 3.7a. Arrangement for automatically checking the frequency characteristic of a hearing aid.

istic of a complete hearing aid, under what are approximately free field conditions.

The hearing aid earphone under examination is placed on the ear of the Hearing Aid Test Box Type 4212, which consists of an external artificial ear, a regulating microphone, a built-in loudspeaker, the latter two of which are enclosed in a small anechoic chamber. The chamber is effectively insulated against both airborne and impact noise, allowing measurements to be taken down to 50 dB re. 2×10^{-4} μbar approximately.

The hearing aid and the regulating microphone are placed symmetrically in the sound field. The regulating microphone is connected to the Microphone Amplifier Type 2603, which amplifies the signal and then applies it to the Compressor input of the B.F.O. Type 1022. This combination enables the sound pressure level on the hearing aid to be kept constant without influencing the practically free sound field conditions.

The B.F.O. Type 1022 supplies the required power for the loudspeaker in the chamber, while a B & K Condenser Microphone, which is placed in the Artificial Ear, is used for the measurement of the acoustic output from the hearing aid. The microphone is connected to a Microphone Amplifier Type 2603, and the amplified voltage is led to the input of a Level Recorder Type 2305.

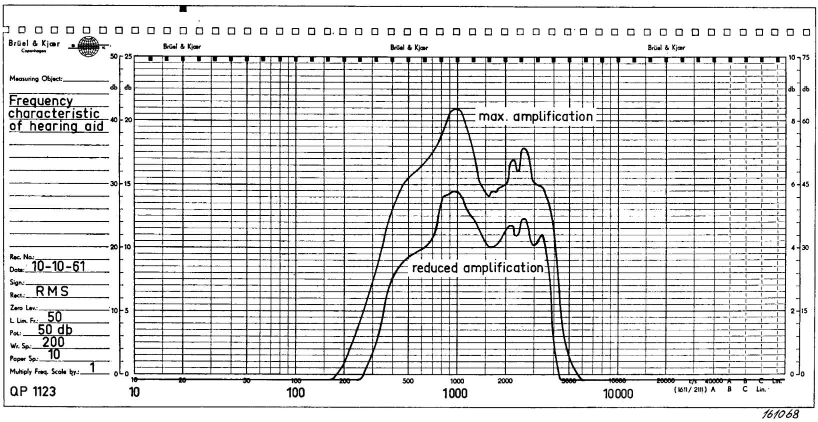


Fig. 3.7b. Recording by 3.7a. Taken for different settings of the hearing aid volume control.

Fig. 3.7b shows typical characteristics of a hearing aid device automatically recorded with the arrangement described in 3.7a. (N.B. Recordings are taken for two different settings of the hearing aid volume control).

Measurements on Air Filters, Carburettor Inlets, etc.

To carry out measurements on the above and other such items as mufflers, silencers, etc. it is necessary to provide a high but constant sound level source. This can be readily obtained by using the Constant Sound Pressure Source Type 4211 in conjunction with the B.F.O. 1022. The B.F.O. 1022 gives high regulation of the signal (by the use of the compressor circuit), even when operating at maximum rated power.

An arrangement utilising the Type 4211 in conjunction with the combined B.F.O. 1022, Level Recorder 2305, (i.e. Automatic Frequency Response Recorder Type 3308 is shown in Fig. 3.8, the item under test being an air filter. Fig. 3.9 shows the resultant curves which give an indication of the

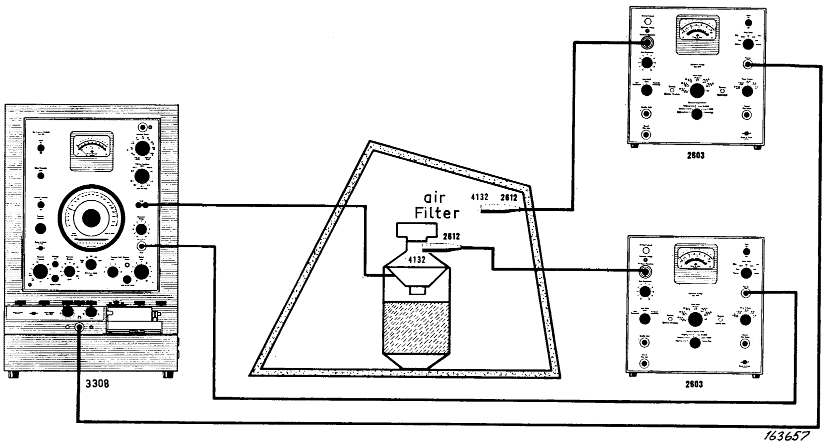


Fig. 3.8. Arrangement for determining the sound attenuation in an air filter.

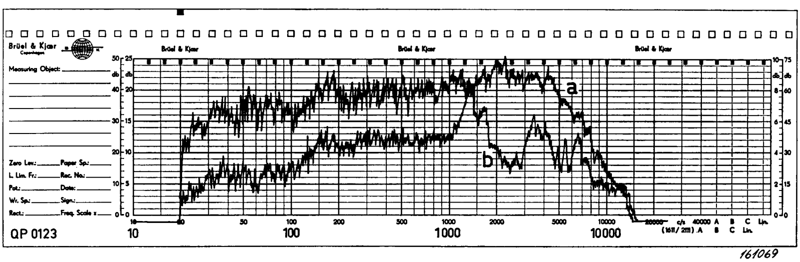


Fig. 3.9. Determination of the air filters sound attenuation. Curve (a) Measurement without air filter. Curve (b) Measurement with air filter mounted on top of the constant sound pressure source 4211.

attenuation of sound waves in the air filter. Curve A is measured with the Sound Pressure Source 4211 open and Curve B with the filter mounted on the Source opening. The sound pressure level at the air filter input in both cases being 110 dB with reference to 2×10^{-4} μbar, and to avoid directional influences the measurements were carried out in a highly reflective hard-walled chamber.

In many instances there will be a requirement to find the most suitable position to mount absorbent material in order to silence the object on test. When this situation arises measurements should be carried out under "free field conditions" or in an anechoic chamber allowing the directional pattern of the unit under examination to be obtained.

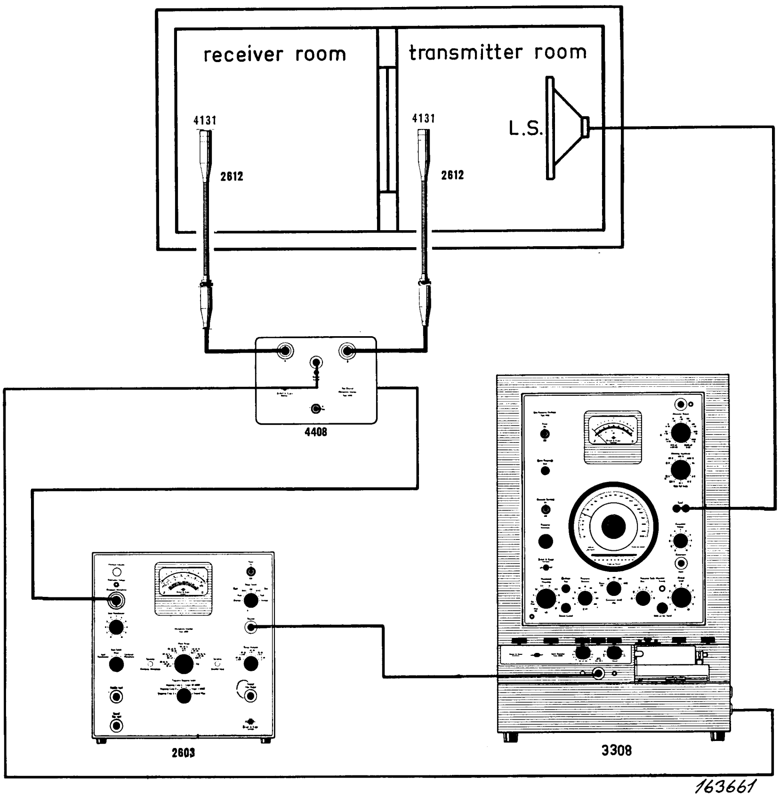


Fig. 3.10a. Measuring arrangement for automatic reading of the sound insulation properties of the wall.

Testing the Qualities of Airborne Sound Insulation.

A means of automatically carrying out this test is shown in Fig. 3.10a. The wall under test is placed between two rooms, which are termed "the transmitting room" and "the receiving room" respectively.

In each of the two rooms separated by the wall is placed a Type 4131 microphone individually coupled to a Cathode Follower Type 2612. Two extension cables connect the microphone units with the Two-Channel Microphone Selector Type 4408. The Microphone Selector is remotely controlled by the two-channel switching device, which is "built-in" to the Level Recorder portion of the Automatic Frequency Response Recorder Type 3308. In this case the Recorder is using a 50 dB Range Potentiometer and the necessary sound is generated by the B.F.O. 1022 section of the Type 3308 in conjunction with a loudspeaker. The Beat Frequency Oscillator should be frequency modulated and the loudspeaker (or loudspeakers) placed so that a sound field, as diffuse and isotropic as possible, is built up.

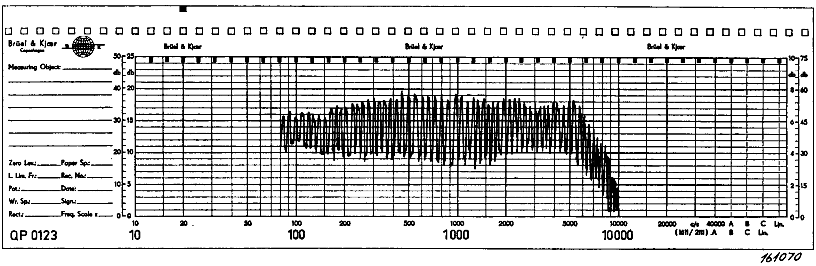


Fig. 3.10b. Recording obtained with a measuring set-up as in Fig. 3.10a. N.B. 50 dB Range Potentiometer is used in Level Recorder.

By means of the Microphone Selector which is connected to the Microphone Amplifier Type 2603, the different sound levels picked up in the two rooms are taken alternately and amplified before being fed to the Level Recorder. The result is that two independent curves are automatically reproduced on the recording paper, enabling the sound level difference between the two sides of the wall to be read off in decibels. The sound absorption of the receiving room must be taken into account.

Measurement of Reverberation Time.

One of the more important factors in determining the acoustic qualities of a room is the measurement of the room's reverberation time. The Beat Frequency Oscillator includes special functions, such as the compressor circuit and the possibility of frequency modulation, which makes it very

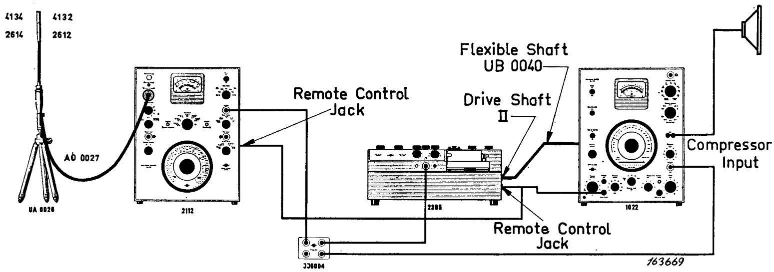


Fig. 3.11. Measuring equipment for the automatic recording of reverberation Time. Compressor of the B.F.O. employed.

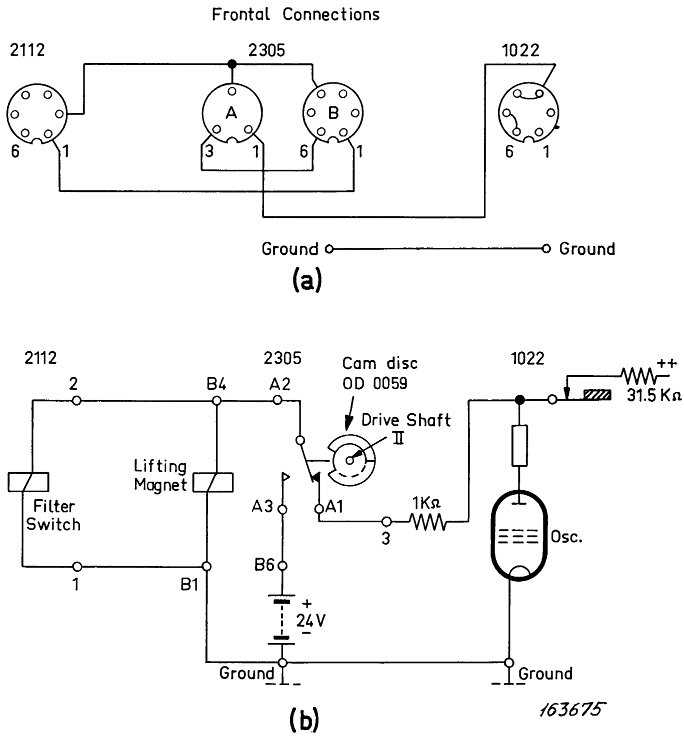


Fig. 3.12. Connection between instruments.
(a) Connections between remote control jacks.
(b) Electrical circuit of the remote arrangement.

suitable for this type of measurement. The compressor circuit serves to keep the sound radiated in the room at a constant value throughout the frequency range of the measurements. Frequency modulation of the signal radiated in the room ensures that a great number of eigentones of the room are excited in the frequency band covered by the frequency modulated signal. The resultant recorded decay curves will in this manner appear with a smooth slope. That would not be the case when a pure sine-wave signal is radiated in the room, as distinct standing waves would arise. The frequency modulation is easily adjusted in frequency swing and modulation frequency by the controls FREQUENCY DEVIATION and MODULATION FREQUENCY respectively.

Various measuring arrangements for reverberation measurements can be set up where the B.F.O. is an integrating part. Here will be discussed an arrangement which works automatically and where the measured decays are recorded by the B & K Level Recorder Type 2305. The set-up is illustrated in Fig. 3.11. The B.F.O. Type 1022 and the loudspeaker constitute the transmitting part, whereas one of the B & K Condenser Microphones, the Audio Frequency Spectrometer Type 2112 and the Level Recorder Type 2305 make up the receiving part. As the amplifier for the Microphone is chosen the Spectrometer which makes a selective reception in 1/3 or 1/1 octave bands possible, thereby reducing the influence of the room's background noise. A sufficient dynamic range is in this manner obtained when measurements are carried out in rooms where the background noise cannot be removed. The measuring arrangement shown allows decay curves of the reverberation to be recorded automatically throughout the frequency range 25 Hz to 20ooo Hz with intervals of 1/3 octave. All the decays are registered on a frequency calibrated part of recording paper being only 250 mm in length (refer Fig. 3.14). If greater spacing between the individual decay curves is required, the recording has to be made on non-frequency calibrated paper. Below is given a brief description of the principal working of the two types of measurements.

Frequency Calibrated Paper. 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 in the B.F.O. To ensure that only the part of the measurement is recorded which is of interest, the writing pen should lift from the paper in the interval between two decays, and as selective reception is utilized, the filters in the Spectrometer should be switched in successively. The disconnecting of the sound source, the lifting of the pen and the switching of the filters in the Spectrometer 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. 3.12. The connections to the respective Remote Control Jacks are shown in Fig. 3.12a, while Fig. 3.12b gives the electrical circuits for the remote controlling arrangement.

Overlapping junction.

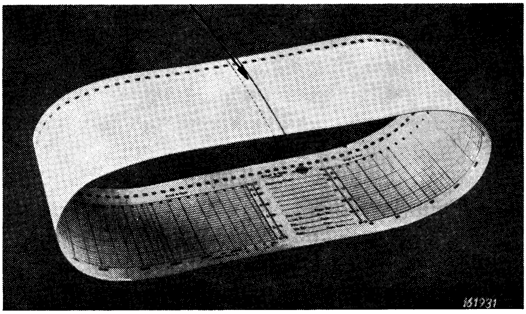


Fig. 3.13. Making up of paper loop.

When placing a loop of 50 mm paper width (Fig. 3.13) in the Level Recorder with 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 placed with a spacing of 1/3 octave as shown in Fig. 3.14. By cohesively synchronizing the paper movement with the frequency scanning of the B.F.O., with the filter switching on the Spectrometer and with the switching of moment of the sound, the starting points of the decay curves will correspond to the center frequency of the respective filters, represented by small squares on the top of the preprint of the recording paper QP 0423, see Fig. 3.14. It is possible, to a certain degree, to keep the

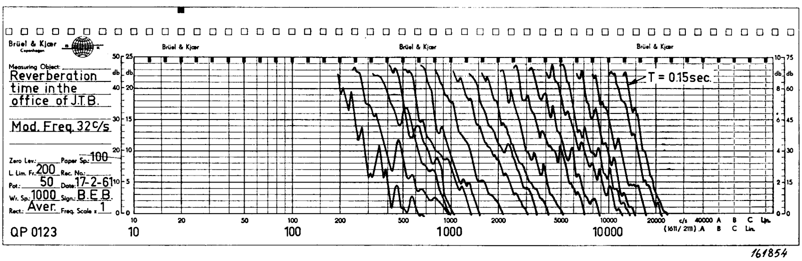


Fig. 3.14. Example of recording of decay curves. Compressor arrangement used.

sound pressure level at the point of measurement independent of loudspeaker and room response by utilizing the compressor circuit of the B.F.O. as indicated in Fig. 3.11. This method ensures that all the decay curves commence at the same level on the recording paper.

Non-Frequency Calibrated Paper. When a larger spacing than 5 mm between the decay curves is desired (vide example in Fig. 3.15), 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

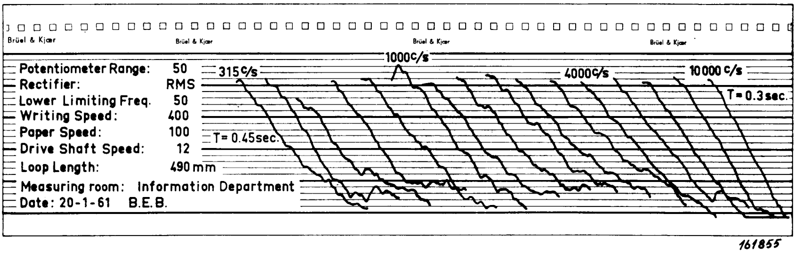


Fig. 3.15. Decay curves at 10 mm intervals recorded on a loop of 490 mm.

carried out on the lined recording paper, e.g. QP 0402, 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.

If only a few reverberation curves are to be taken, the situation may not warrant the use of automatic measuring, in these circumstances use should be made of the pressbutton marked OSCILLATOR STOP on the B.F.O. Also when it is desired to record the decay curves with a spacing less than 1/3 octave, the described function of the automatically working arrangement cannot be used immediately. The manually or remotely operated OSCILLATOR STOP may then be utilized.

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 on top of 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. 3.16.

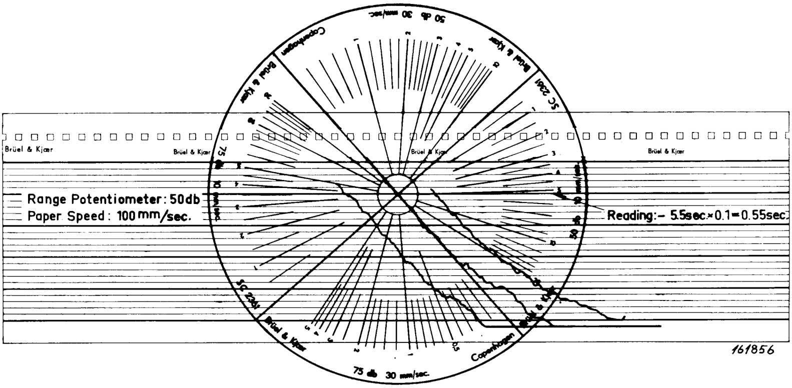


Fig. 3.16. Use of Protractor SC 2361. Ten times higher paper speed used than stated on the protractor "50 dB, 10 mm/sec". Reading then divided by 10, i.e. o.55 sec.

2. Reverberation time in seconds is then read on the scale at the point through which the horizontal line passes. Vide Fig. 3.16.

The decay curves should preferably be approximated into a straight line 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, see also Fig. 3.16.

Absorption Measurements of Sound Insulation Material.

The B.F.O. Type 1022 in conjunction with the Standing Wave Apparatus Type 4002, enables the sound absorbing proporties of different materials to be evaluated and their sound absorbent coefficients to be determined.

A lay-out is shown in Fig. 3.17, the B.F.O. Type 1022 feeding the loudspeaker which is mounted in the end of the tube of the Standing Wave Apparatus Type 4002. Included in the apparatus is a probe type microphone which is mounted on a trolley, allowing the open end of the probe to be stationed at any point along the central axis of the tube. The output of the microphone unit is connected to the input of the Frequency Analyzer Type 2107 or the Audio Frequency Spectrometer Type 2112. The Analyzer Type 2107 can be continuously tuned through the band 20 to 20ooo Hz with a constant percentage bandwidth, the 3 dB bandwidth being variable in steps from 6 % to 29 %. On the other hand the Spectrometer 2112 has 33 1/3 octave and

1/1 octave filters with center frequencies from 25 Hz to 40 kHz, and 31.5 Hz to 31.5 kHz respectively. Both equipments have meter scales which directly indicate the sound absorption coefficient.

The material to be tested is placed in the termination end of the Standing Wave Apparatus and when the set-up is operated, due to the sound reflection from the sample, standing waves are produced in the tube. If the termination

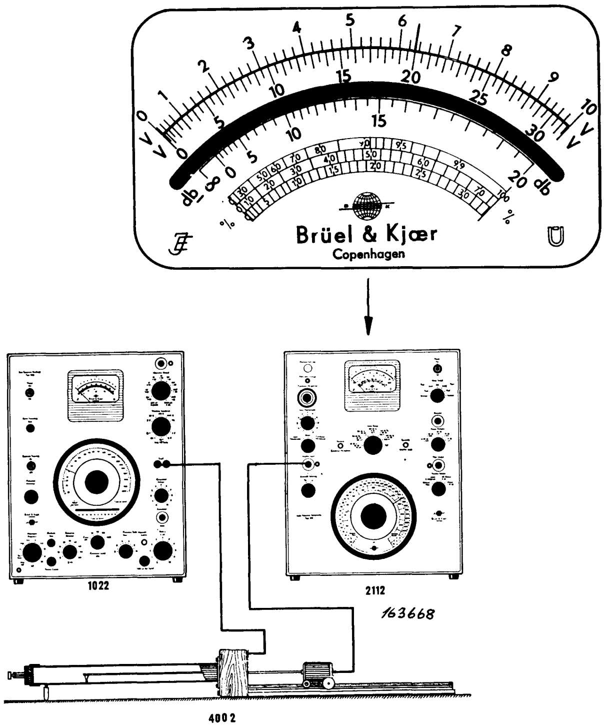


Fig. 3.17. Absorption measurements on sound insulating material by means of standing wave. Apparatus Type 4002. Spectrometer Type 2112 and B.F.O. Type 1022.

of the tube was made to consist of a totally rigid material, a complete reflection of the sound wave with minima equal to zero would be obtained. On replacing the rigid termination with an absorbent material only part of the wave will be reflected and the minima will no longer be zero. Thus by measuring the ratio between the maximum and minimum sound pressures the absorption co-efficient of the sample for 0 degree incidence sound can be found.

GROUP C. MECHANICAL MEASUREMENTS

Strain Measurements on Vibrated Objects.

In the measuring of mechanical strain on objects under vibration, it is essential that the vibration acceleration is kept constant within the range of frequencies at which measurements are being taken and that inherent resonances in the system have no effect on the magnitude of the driving force.

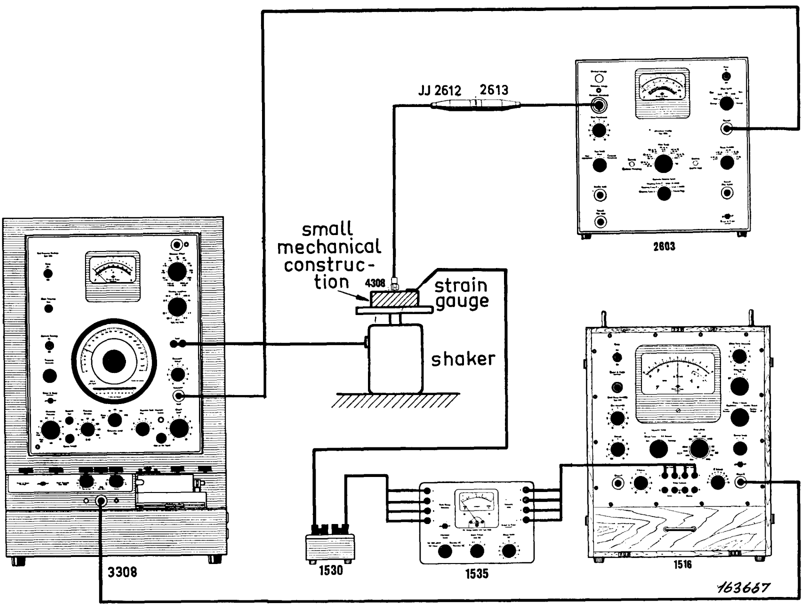


Fig. 3.18a. Arrangement for measurement of vibration in small mechanical constructions.

The illustration in Fig. 3.18a shows a test rig for strain measurements of small mechanical constructions, the B.F.O. 1022 section of the Automatic Frequency Response Recorder Type 3308 feeding the shaker, the object under test being placed on the shaker table.

To keep the acceleration constant a controlling system is utilized. This system consists of an Accelerometer mounted on top of the test object. As the acceleration has to be constant and under control the output voltage is connected via a Cathode Follower Adaptor JJ 2612, Cathode Follower 2613, ad a Microphone Amplifier 2603 to the compressor input of the B.F.O. The filter switch on the Type 2603 should be set to position "Linear".

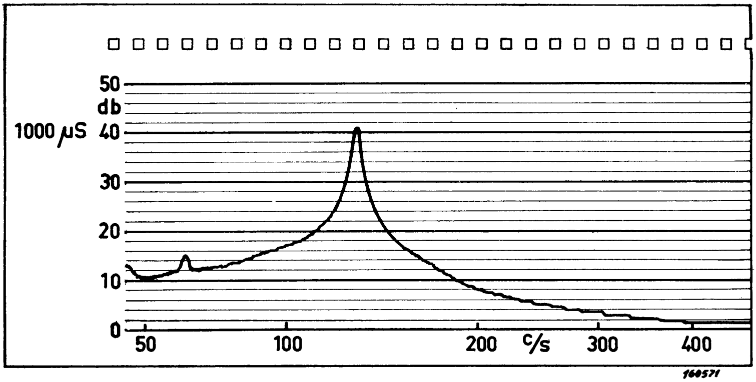


Fig. 3.18b. Recording of the mechanical strain of a bar. Measured with an arrangement as shown in Fig. 3.18a.

By using the built-in meter on the Amplifier Type 2603, the output voltage of the Accelerometer can be observed and the acceleration calculated from the Accelerometer's sensitivity curve. From this the driving force can be calculated, using Newton's equation $F = m \times a$, where F = the driving force, m = the mass, and a = the acceleration.
To measure the mechanical strain in the object under test a Strain Gage is used. This is a pick-up device which is comprised of a looped resistance (or resistances) sandwiched between insulating material which is cut in the form of a strip, and which can be glued on to the test object. The object when subjected to mechanical strain is distorted and this will alter the Gage resistance, the variation being registered by a sensitive measuring bridge arrangement, e.g. the Strain Gage Apparatus Type 1516. (For further information refer to manual).
The output voltage from the Strain Gage Apparatus is then fed to the input of the Level Recorder of the Type 3308, to give an automatic recording. An example of such a recording, taken on a thin metal bar, showing the mechanical strain and indicating its resonant frequency, is shown in Fig. 3.18b.

Instrument Combinations

The B.F.O. Type 1022 is delivered in a metal case but should a mahogany cabinet be preferred, then this alteration can be carried out very simply.

1. Remove the four special threaded retainers, located at the back of the case and the rubber feet.
2. Place instrument and metal case into the mahogany cabinet.
3. Replace the threaded retainers and the rubber feet, which now require longer fixing screws.

If it is required to have the equipment rack mounted then a special frame is necessary. In this case the instrument + cabinet is secured to the frame by four screws. This whole assembly is then mounted in a 19″ standard rack. Finally if it is preferred to use a B & K combination mounting unit then the instrument in a metal case is placed in the mounting unit and secured by four screws, but care must be taken to connect the instrument to ground. The apparatus is isolated from the mounting unit, but, however, the Level Recorder Type 2305 is the only instrument, which is in direct connection with the chassis of the combination mounting unit.

The Beat Frequency Oscillator Type 1022 can be delivered in the following combinations:

Combined Inst.	Sep. Inst.
Type 3308 =	1022 + 2305
Type 3329 =	1022 + 2603 + 2305
Type 3331 =	1022 + 2107 + 2305
Type 3332 =	1022 + 2112 + 2305

and the type Nos. stand for:
1022: Beat Frequency Oscillator.
2305: Level Recorder.
2603: Microphone Amplifier.
2107: Frequency Analyzer.
2112: Audio Frequency Spectrometer.

For a comprehensive technical description of the Spectrometer, the Microphone Amplifier, the Frequency Analyzer and the Level Recorder, reference should be made to their respective manuals. However, a brief outline of their basic principles is given in the following paragraphs.

The Audio Frequency Spectrometer.

The basic design of the Spectrometer is shown in Fig. 4.1. The input amplifier section consisting of three stages is supplied with a large amount of negative feedback, thus ensuring that a low source impedance (approx. 12 ohms) is coupled to the filter system.

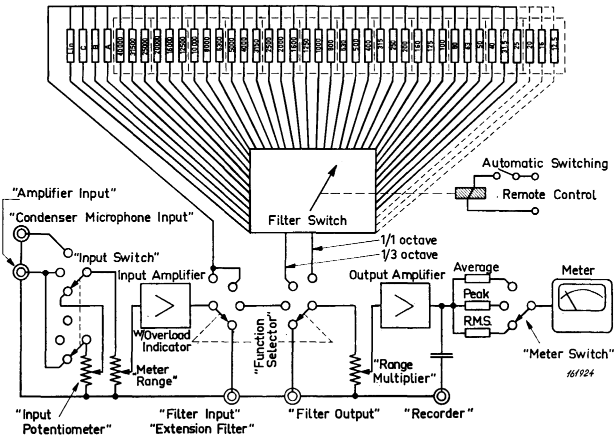


Fig. 4.1. Block diagram of the Spectrometer.

The filter system is made up of 33 band-pass filters and three weighting networks. The center frequencies of the filters being: 25 — 31.5 — 40 — 50 — 63 — 80 — 100 — 125 — 160 — 200 — 250 — 315 — 400 — 500 — 630 — 800 — 1000 — 1250 — 1600 — 2000 — 2500 — 3150 — 4000 — 5000 — 6300 — 8000 — 10000 — 12500 — 16000 — 20000 — 25000 — 31500 — 40000 when switched for 1/3 octave analyses, and: 31.5 — 63 — 125 — 250 — 500 — 1000 — 2000 — 4000 — 8000 — 16000 — 31500 in the case of octave analysis. Switching from filter to filter is accomplished by a rotary switch in the output circuit, and a large illuminated scale is used for filter identification. The output amplifier, similar to the input, contains three stages also supplied with a large amount of negative feedback. The metering circuit connected to the output amplifier can be switched to measure half the peak to peak, average or RMS value of the input signal.

The linear frequency range covered is 2 Hz to 40000 Hz and the three weighting networks conform to the IEC-proposed standards for precision sound level measurements.

The Microphone Amplifier.

The block diagram of the Microphone Amplifier is shown in Fig. 4.2, and the amplifier consists of two independent amplifier sections which may either be connected in cascade or have a filter system interposed between them. The power supply contains the necessary rectifiers and filters for the operation of the amplifiers and can supply the external B & K Condenser Microphone or Preamplifier in use.

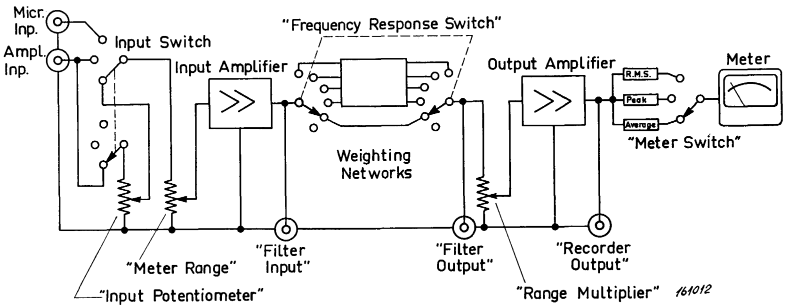


Fig. 4.2. Block diagram of the Microphone Amplifier.

The first two stages of the input amplifier consist of resistance-capacitance coupled triodes, while the third stage is built as a cathode-follower. A great amount of negative feed-back is introduced to stabilize the amplifier and to ensure a low source impedance of approximately 12 Ω, at the FILTER INPUT terminal.

The output amplifier consists of three stages and shows an input impedance of 1.46 MΩ. The output circuit of the output amplifier is connected both to the output terminal marked RECORDER and to the rectifier and meter circuit. The RECORDER terminal is provided for connection to level recorder, headphones, oscillograph, etc. Additionally it can be connected to the compressor input of the Beat Frequency Oscillator Type 1022. The output impedance at the terminal is 50 Ω.

The input and output amplifier sections can, as mentioned, be cascaded, this being accomplished by means of a switch on the front panel. By this means a high gain amplifier with a linear frequency characteristic in the range from 2 Hz—40 kHz is obtained. The switch also enables a series of built-in weighting networks, which conform to IEC proposed standards, to be inserted between the amplifier sections, or in turn the amplifier sections to be isolated from each other and connected to terminals provided for external filters.

The Level Recorder.

The Level Recorder has been designed to record signal levels in the frequency range 10 Hz to 200ooo Hz as well as d.c. The operation of the instrument is based on the servo-principle. Fig. 4.3 shows a block diagram of the instrument.

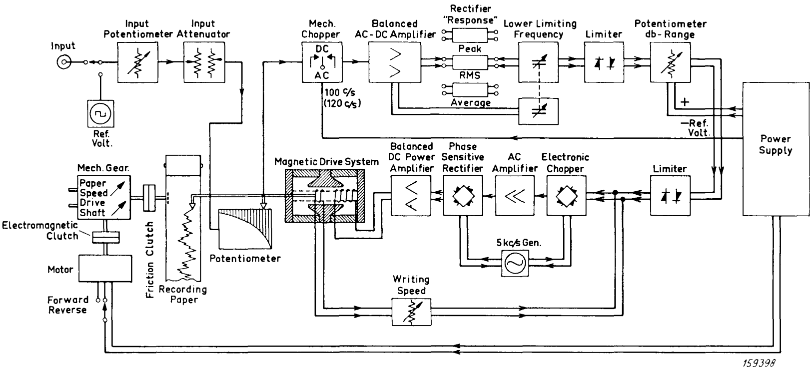


Fig. 4.3. Block diagram of the Level Recorder.

Fundamentally the Recorder consists of an interchangeable range potentiometer; a direct coupled amplifier; the special B & K rectifier circuit which gives RMS, Average or Peak detection of the input signal, a DC chopper amplifier and an electro-mechanical writing system.

When the magnitude of the voltage applied to the input terminals is changed a current will flow through the driving coil of the writing system thus moving the stylus, which is mechanically coupled to the range potentiometer. By the movement of the stylus the voltage delivered from the potentiometer to the AC amplifier will be altered until a stable condition is regained. In this way it is possible to obtain different ranges of voltage variations which can be recorded, by employing different range pontentiometers. Logarithmic range potentiometers are available for voltage level ranges of 10, 25, 50 or 75 dB. Two linear potentiometers cover the ranges 10 to 35 mV and 10 to 110 mV respectively.

The recorder is capable of writing on two different widths of recording paper, 50 mm and 100 mm. To change from one width to the other it is only necessary to release a snap-lock arrangement on the moving arm which holds the stylus.

The writing speed is determined by the amount of damping applied to the writing system which is selectable by the rotary switch "Writing Speed". This is variable in 15 spot settings shown by the figures outside the switch.

The large figures denote the settings for 50 mm paper while the small figures are for recordings on paper of 100 mm width.

Recording Paper.

Different types of pre-printed recording paper to be used on the Level Recorder in conjunction with the Beat Frequency Oscillator Type 1022 and Spectrometer Type 2112 combination are available, the paper being manufactured with a printed logarithmic frequency scale covering the range from 10 Hz to 40ooo Hz.

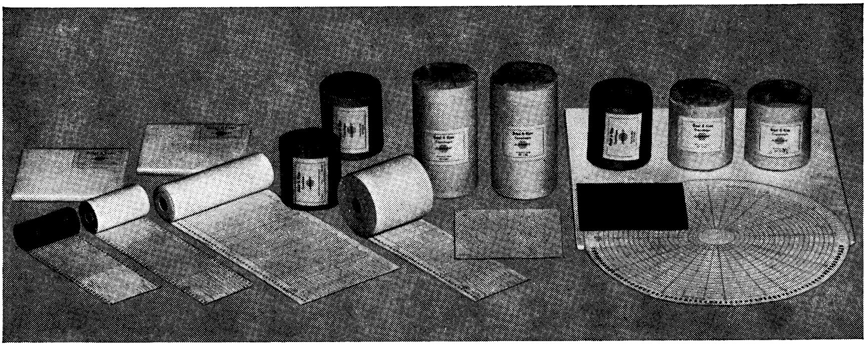


Fig. 4.4. The various types of preprinted recording paper.

Two main types of paper, having various features, and which come in two widths, can be supplied. Also included in the range is a polar diagram recording paper to be used when the Level Recorder is required for this application (see Level Recorder Manual). Two types of writing are catered for, either ink or stylus, the applicable surfaces being treated accordingly. White paper for ink writing is available, with pre-printed lines or outlines of frequency diagrams and is obtainable in the widths of 100 mm or 50 mm. The polar diagram type comes in packs of 100 sheets and has a 100 mm radius. The waxed paper comes only in 50 mm widths and is intended for use with a sapphire stylus. The white waxed paper consists of coated transparant paper and exhibits printed lines or frequency diagrams as the case may be. Waxed paper is particularly useful when high writing speeds have to be used, giving a very clear definition of the recording. When using these papers the sapphire stylus will leave a thin transparant line on the waxed paper, the latter being specially made to enable blue prints to be taken. It is not necessary to double-copy the latter, as the scales being printed in black will show up if a direct blue print is taken from it.

OPERATION OF THE INSTRUMENT COMBINATIONS

General.

If the instruments are mounted in a rack, all electrical and mechanical connections are made internally. When the instruments are used in individual cabinets, interconnection must be made via control Cable AQ 0002 for remote control from Level Recorder to Spectrometer and a flexible shaft UB 0040 for the mechanical tuning arrangement for B.F.O. Type 1022. The logarithmic frequency scale of the B.F.O. 1022 allows it to be completely synchronized with the Spectrometer.

Synchronization.

To fully synchronize the three units the following sequence of operation is recommended. Switch on the power of each instrument and connect the RECORDER terminal of the Spectrometer to the INPUT terminal of the Level Recorder, then calibrate as follows:—

B.F.O. 1022 Section.

Calibrate the B.F.O. as in "Calibration" under Operation on page 14.

Spectrometer.

1. The control knobs should be set as follows:—

INPUT SWITCH:	"Direct"
METER RANGE:	"Ref."
METER SWITCH:	"Fast", "RMS"
RANGE MULTIPLIER:	"× 1, 0 dB"
FUNCTION SELECTOR:	"Linear, 2—40ooo Hz"

   Control knobs not mentioned may be in any position.

2. The meter should now show a deflection to the red mark on the scale. Possible deviations being corrected by the potentiometer marked SENSITIVITY — AMPLIFIER INPUT on the front panel, with the aid of a screwdriver.

Level Recorder.

(N.B. In this case a 50 dB potentiometer is used. For other ranges refer manual for Level Recorder Type 2305).

Set control knobs to the following positions:—

1. POTENTIOMETER RANGE dB to "50".
2. RECTIFIER RESPONSE to "RMS".
3. LOWER LIMITING FREQUENCY to "20".
4. WRITING SPEED:
   50 mm paper: 250 mm/sec. (large figures).
   100 mm paper: 500 mm/sec. (small figures).
5. PAPER DRIVE to "stop" and "forward" positions.
6. MOTOR to "on".
7. Set INPUT ATTENUATOR to "10".

8. Using the INPUT POTENTIOMETER adjust stylus to full deflection —4 dB (e.g. using 50 dB Range it will be 50 dB —4 dB = 46 dB).
9. Insert the desired type of frequency calibrated paper .(If necessary refer Level Recorder Manual).
10. Pull the Synchronizing Gear Lever (1 : 10) marked "X" in Fig. 5.1 to outer position.
11. With a screwdriver turn the screw "S" on Fig. 5.1 until marking cut is in vertical position.
12. Set the PAPER SPEED to 10 mm/sec. (small figures). The spring loaded knob is operated by lifting, turning and dropping to correct position.

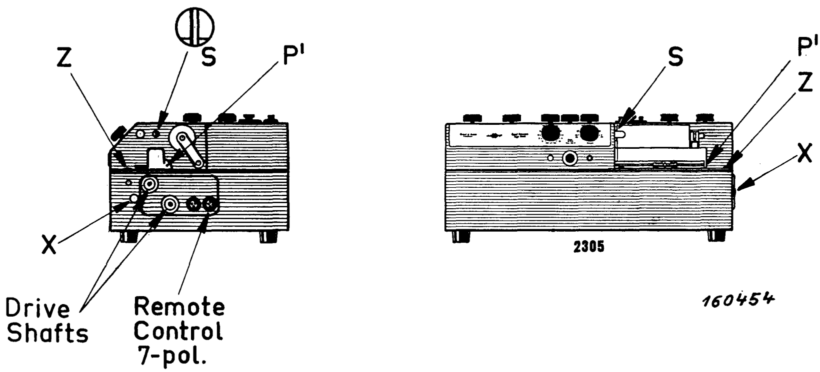


Fig. 5.1. Front and side views of Level Recorder.

13. The toggle switch PAPER DRIVE is set to "start" whereby the paper should start moving. If not, press the pushbutton SINGLE CHART — CONTINUOUS RECORDING and release it again, the paper will move and after a chart length or less automatically stop.
14. Move the recording paper by means of the finger wheel "Z" shown in Fig. 5.1 until stylus rests on 10 Hz line.

At this stage final synchronization of the units takes place by firstly syn chronizing the Spectrometer and Level Recorder sections as follows:—
Set the control knobs of the Spectrometer to:—

1. FUNCTION SELECTOR to "1/3 Octave — 0 dB".
2. FILTER SWITCH to one step before (counter-clock-wise) the position "12.5".
3. AUTOMATIC SWITCHING to "on".

Then the control knobs of the Level Recorder to:—

1. PAPER DRIVE to "stop".

2. Press pushbutton marked SINGLE CHART and hold in. (Paper will move and the reference voltage commences to record). Release pushbutton when paper has moved to about the "200" Hz line.
3. Units are correctly synchonized when switching from the 80 Hz to the 100 Hz filter takes place on the 90 Hz line.
4. As a means to see how far the paper has to be shifted, it is recommended to draw a line, by means of the "100 mV Ref." button on the front plate of the Recorder, at the point where the paper has stopped. By using this line as a reference the paper can be shifted the appropriate distance to give correct synchronization.
5. To check the synchronization, run the recording until the pen is stopped on for example the 2ooo Hz line. When correctly synchronized, the switching of the 800 Hz to the 1ooo Hz filter should now take place at the 900 Hz line. If this is not the case repeat from item 2.
6. Finally reset the Writing Speed on 250 mm or lower if the large figures are being used, and to a figure of 500 mm or less if using the small figures.

To complete the synchronization sequency the B.F.O. Type 1022 must be synchronized with the frequency calibration on the paper.

1. Rotate main scale of B.F.O. manually until it corresponds to the frequency denoted by the stylus, firstly moving it to a higher frequency and then rotating it back until it arrives on the desired frequency. This will take up any possible backlash with the gears of the B.F.O.
2. Move the switch AUTOMATIC SCANNING of the B.F.O. to the "on" position.
   All units should now be in complete synchronization and on switching the toggle switch of the PAPER DRIVE on the Recorder to "start", the combination will operate in complete unison.

EXAMPLES OF APPLICATIONS

Applications for the combined B.F.O. 1022 and Level Recorder 2305 have been described, and illustrated, under this heading in the earlier phase of this manual. Now one important use for the treble combination, B.F.O. + Level Recorder + Spectrometer (i.e. the AF Response and Spectrum Recorder Type 3332) will be described, followed by another example using the Spectrometer and Level Recorder with the exclusion of the B.F.O. 1022 section.

Automatically Recording Harmonics.

The Type 3332 combination is well-suited for the automatic recording of harmonic distortion, as the Spectrometer can be switched to select any specific harmonic component of the fundamental in use, up to and including

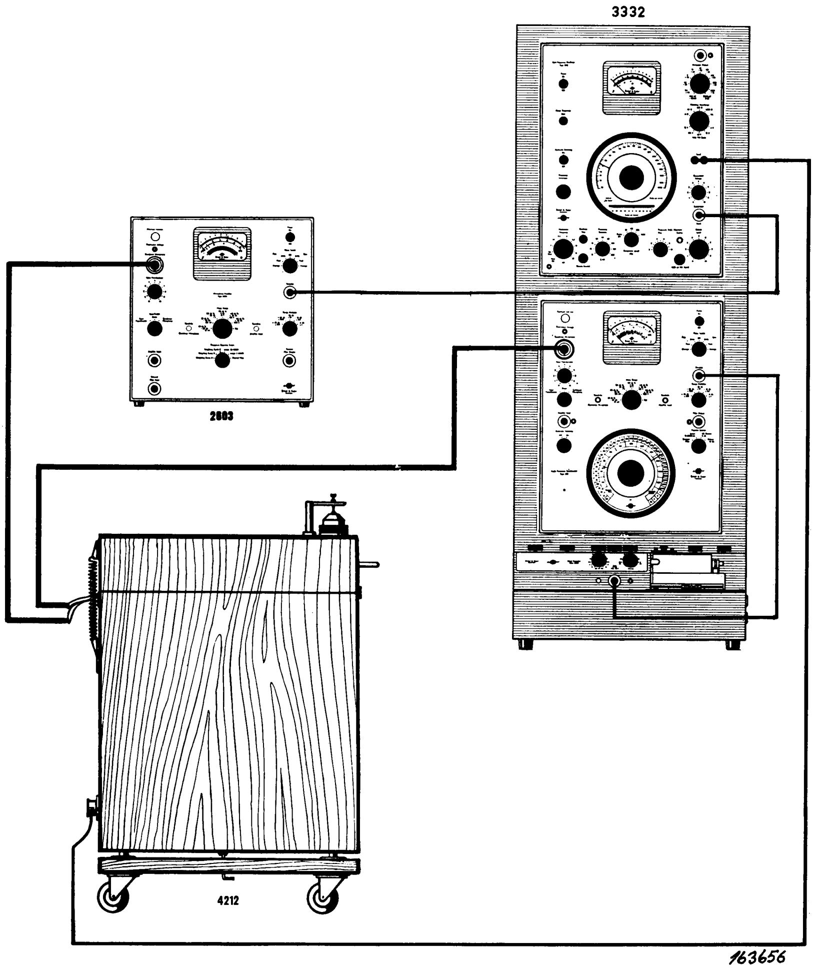


Fig. 6.1a.
Measuring arrangement to measure harmonic distortion in hearing aids.

the 5th. In Fig. 6.1 the illustration shows an arrangement for the investigation of harmonic distortion in hearing aids.
As the distortion produced in the electronic assembly of such a unit (i.e. the amplifier only) is small, in comparison to distortion produced by the electro-acoustical transducing stage, this portion must also be included in the examination.
Basically the set-up is the same as described under "Checking of Hearing Aids", page 29, with the exception that the output of the Artificial Ear on

the Hearing Aid Test Box Type 4212, is fed to the input of the Spectrometer, instead of to the Microphone Amplifier Type 2603. When synchronization of the units as described on page 47 has been carried out, the measurements can commence.

In the case where the harmonics of a four-terminal network are to be automatically recorded, the synchronization of the units should have been completed and the Single Chart recording method should be utilized.

The harmonics are measured by setting the filter switch on the Spectrometer so that it runs ahead of the frequency scanning of the B.F.O., the selected frequency difference being in accordance with the harmonic which is going to be measured.

By means of the Reverse/Forward switch the recording is returned by the single chart length already run off; and the process repeated until all the required harmonics are recorded on the same chart as the fundamental.

The dips seen on the curve are due to the shape of the Spectrometer filter, and the manner of scanning the frequency range. When properly synchronized the "open" dips will occur with a depth that corresponds to around 3 dB.

During measurements the sensitivity of the Spectrometer or the Level Recorder should not be altered. If, however, circumstances require an

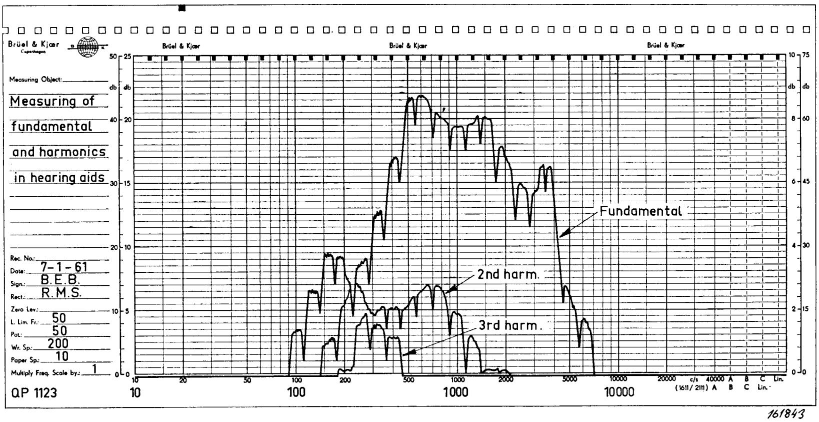


Fig. 6.1b. Recording obtained with set-up as shown in Fig. 6.1a.

alteration to be made e.g. to obtain a clear recording of some of the harmonics, the gain of the Spectrometer can be increased by means of the RANGE MULTIPLIER switch. (The METER RANGE switch should not be used as it will tend to overdrive the amplifier stages). When using the RANGE MULTIPLIER for this means, it must of course be taken into account in the evaluation of the final results.

Vibration Measurements.

By using an accelerometer with a Vibration Pick-up Preamplifier, or one of the Microphone Cathode Followers, vibrations in buildings, machinery, ships,

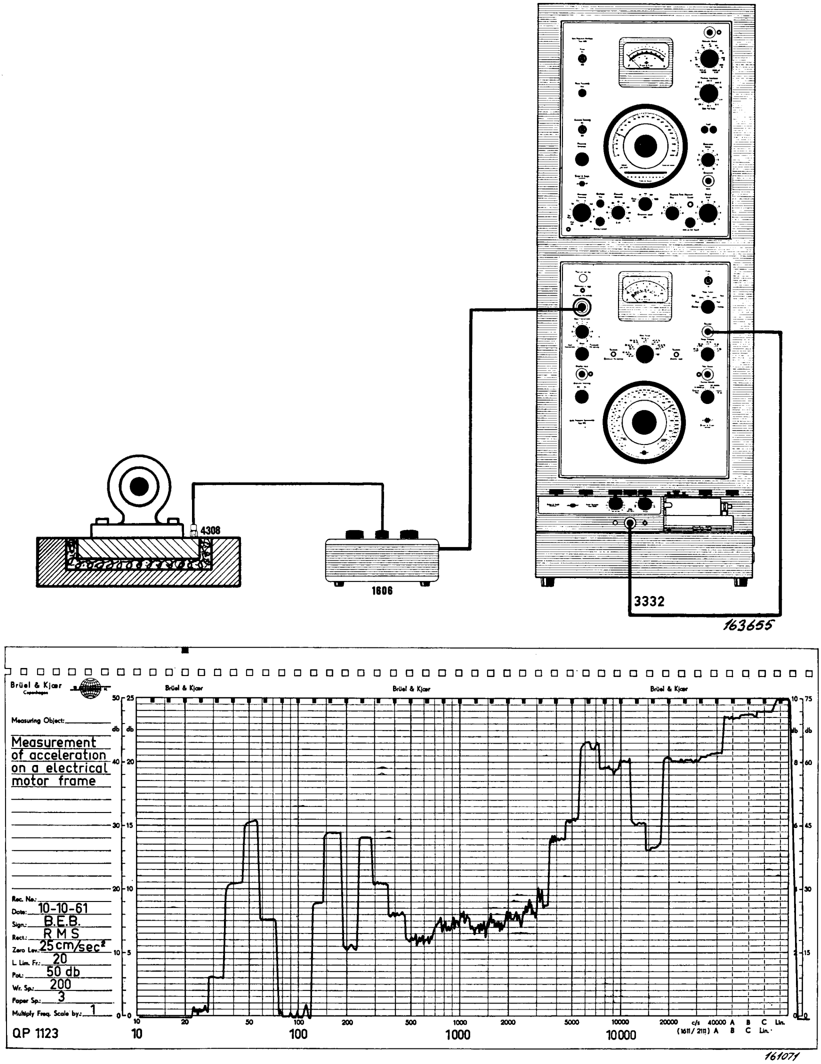


Fig. 6.2.

(a) Set-up for vibration measurements on a motor installation.

(b) Recording obtained with measuring set-up as shown in Fig. 6.2a.

etc., can be measured. In Fig. 6.2a a layout is shown, where the Type 3332 is being used to automatically record vibration measurements taken on the base of an electrical motor, the Spectrometer allowing an analysis of the vibrations to be made. The output from the Accelerometer is fed via the Preamplifier 1606 to the CONDENSER MICROPHONE input of the Spectrometer. Information on the calibration of the arrangement is given in the manual for the Type 1606.

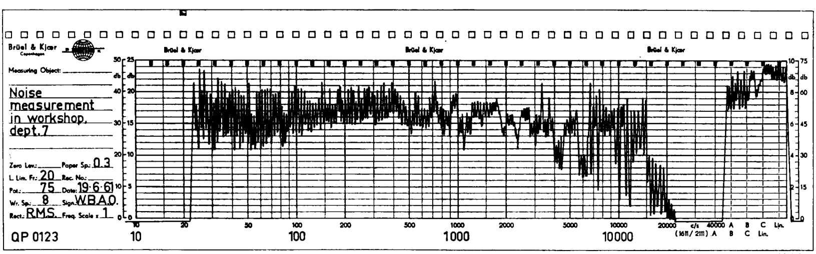
Fig. 6.2b. shows a recording of the vibrations from a synchronous motor which uses a 50 Hz mains supply. In this recording a 50 dB Range Potentio-**meter was used in the Level Recorder, 0 dB reference being equal to an acceleration of 25 cm/sec^2.**

Noise Measurements.

Noise within factories, offices, cities, airports, etc. varies with the time of day. Therefore it is a firm requirement that recordings of the noise should be carried out over a considerable period of time as a single recording taken at a particular instant would provide incorrect information.

Fig. 6.3 shows a recording taken of the noise level in a mechanical workshop over a selected period of time by using one of the Weighting Networks in the Spectrometer. As can be seen the noise level varies considerably with time and a reliable analysis cannot be obtained by only taking a few measurements. It is therefore necessary, when doing such a test, to record continuously and then to statistically assess the final result.

To measure, analyse and record such noise the Spectrometer + Level Recorder (i.e. the receiving part of the AF Response and Spectrum Recorder Type 3332) in combination with a B & K Condenser Microphone can be used.



161953

Fig. 6.3. Recording of the noise level in a mechanical workshop over a period of time.

Specification

Frequency Range: 20—20ooo Hz.

Frequency Scales:

Main Scale: Logarithmic from 20—20ooo Hz.

Tolerance ± o.7 degrees of theoretical logarithmic curve. Vernier driven.

Increment Scale: Range — 50 to + 50 Hz of main scale reading. Both scales illuminated.

Frequency Accuracy:

Main scale: 1 % ± 1 Hz.

Increment scale: ± o.5 Hz.

Outputs:

Matching: Switchable matching impedance for 6, 60, 600 or 6ooo ohms load.

Max. power output 2.5 watts approx.

Attenuator: Variable in steps of 10 dB (within ± o.2 dB) from 125 μV to 12.5 V. Continuously variable by potentiometer within each step.

Frequency Characteristic: In frequency range 20 to 20ooo Hz.

Better than ± o.3 dB on ATTENUATOR OUTPUT.

Better than ± o.5 dB on LOAD 1 watt loaded.

Voltmeter: Vacuum-tube voltmeter. Moving-coil. Illuminated mirrored scale. Accurate, better than 1.5 % of full-scale deflection. Perfectly safeguarded against overload.

Distortion:

Frequency in c/s	20	200	2ooo	20ooo
ATTENUATOR terminal. No load with 10 V output approx.	1.0 %	o.1 %	o.1 %	o.7 %
LOAD terminal. (Loaded 1 watt)	2.0 %	o.3 %	o.3 %	1.2 %

Hum and Noise: 70 dB below max. output.

Automatic Output Regulator:

The built-in compressor amplifier maintains regulation up to 45 dB, and a constant voltage current, or sound pressure to within 2 dB in frequency range 20—20ooo c/s. Linearity of the frequency characteristic is better than ± o.3 dB. Input impedance 25 kohms. Regulation speed variable in steps: 30 — 100 — 300 and 1ooo dB/s.

Frequency Deviation variable in steps: 0 ± 10 ± 16 ± 25 ± 40 ± 63 ± 100 ± 160 ± 250 Hz.

Frequency Modulation: Selectable modulation frequency by built-in saw-tooth oscillator of 1 — 1.6 — 2.5 — 4 — 6.3 — 10 — 16 and 25 Hz.

Oscillator Stop: Push-button Oscillator Stop for noiseless switching in reverberation measurements. Remote control available.

Frequency Scan: Worm gear in oscillator permits variable capacitor to be driven from motor of Level Recorder Type 2305. Connection achieved by flexible shaft. Magnetic clutch for set and release of drive. Clutch can be remotely controlled. Accurate synchronization with Level Recorder Frequency Calibrated Paper.

Power Supply: 100 — 115 — 127 — 150 — 220 — 240 Volts AC. 50—400 Hz.

Power Supply: 100 — 115 — 127 — 150 — 220 — 240 Volts AC. 50—400 c/s. Power consumption approximately 60 watts.

Cabinets:
With the mechanical design of all B & K apparatus, it is very easy to interchange the instruments with the various cabinets. The equiments are delivered in metal cases as standard fittings which can be mounted in any desired way i.e. — mahogany cabinet or frame for 19″ standard rack.

Type 1022 A.
The B.F.O. is in a metal case and is intended for laboratory use.

Type 1022 B.
Similar to Type 1022 A but the instrument and the metal case are housed in a mahogany cabinet with cover. In this cabinet it is easy to transport the instrument.

Type 1022 C.
Similar to Type 1022 A, but it is supplied in a frame ready for mounting the instrument in a 19″ standard rack. The instrument is delivered together with a chain wheel which can be coupled with the chain drive supplied with 2305 C. (The Level Recorder used for 19″ standard rack mounting).

Dimensions:

Ext. dials and knobs	Height	Width	Depth	Weight
Type 1022 A	48 cm 19 inches	38 cm 15 inches	20 cm 8 inches	17.5 kg 38.6 lbs
Type 1022 B	50.5 cm 20 inches	48 cm 19 inches	27.3 cm 11 inches	22 kg 48.5 lbs
Type 1022 C	53.2 cm 21 inches	48.2 cm 19 inches	20.5 cm 8 inches	21.8 kg 48.2 lbs

ORBOE PRINT . COPENHAGEN . DENMARK
July 1968