B & K INSTRUMENTS:

ACOUSTICAL....
Condenser Microphones
Piezo-Electric Microphones
Microphone Preamplifiers
Microphone Calibration Equip.
Sound Level Meters
(general purpose-precision-
and impulse)
Standing Wave Apparatus
Tapping Machines
Noise Limit Indicators

ELECTROACOUSTICAL....
Artificial Ears
Artificial Mouths
Artificial Mastoids
Hearing Aid Test Boxes
Telephone Measuring Equipment
Audiometer Calibrators
Audio Reproduction Test Equip.

STRAIN....
Strain Gauge Apparatus
Multipoint Panels
Automatic Selectors
Balancing Units

VIBRATION....
Accelerometers
Accelerometer Preamplifiers
Accelerometer Calibrators
Vibration Meters
Magnetic Transducers
Capacitive Transducers
Vibration Exciter Controls
Vibration Programmers
Vibration Signal Selectors
Mini-Shakers
Complex Modulus Apparatus
Stroboscopes

GENERATING....
Beat Frequency Oscillators
Random Noise Generators
Sine-Random Generators

MEASURING....
Measuring Amplifiers
Voltmeters
Deviation Bridges
Megohmmeters

ANALYZING....
Band-Pass Filter Sets
Frequency Spectrometers
Frequency Analyzers
Real-Time Analyzers
Slave Filters
Psophometer Filters
Statistical Analyzers

RECORDING....
Level Recorders
(strip-chart and polar)
Frequency Response Tracers
Tape Recorders

BRÜEL & KJÆR

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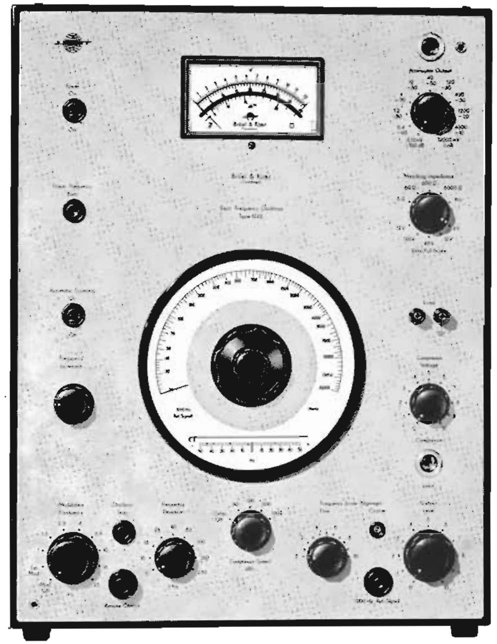
1022

Instructions and Applications



Beat Frequency Oscillator Type 1022

A signal generator covering the range of 20–20,000 Hz and designed especially for acoustic and electro-acoustic measurements. Logarithmic sweep and automatic drive for recording of frequency response curves. The output signal can be frequency modulated and controlled by a compressor loop.

30-0154

BRÜEL & KJÆR

THE BEAT FREQUENCY OSCILLATOR

TYPE 1022

March 1970

CONTENTS

Dimensions:

Ext. dials and knobs	Height	Width	Depth	Weight
Type 1022 A	48 cm 19 inches	38 cm 15 inches	20 cm 8 inches	15 kg 33 lbs
Type 1022 B	50.5 cm 20 inches	40 cm 16 inches	27.3 cm 11 inches	19 kg 42 lbs
Type 1022 C	53.2 cm 21 inches	48.2 cm 19 inches	20.5 cm 8 inches	19 kg 42 lbs

Accessories Supplied

1 Power Cord
1 Flexible Drive Shaft UB 0041
1 Remote Control Plug JP 4722
3 Fuses VF 0009
2 Scale Lamps VS 1271
2 Scale Lamps VS 1273

Accuracy of Attenuators

Over full frequency range	2%

Power Requirements

Mains supplies of 100–115–127–150–220–240 Volts AC and 50 to 400 Hz.

Power consumption:	Without load	20 Watt
	With 2.5 W load	26 Watt

Cabinets:

With the mechanical design of all B & K apparatus, it is very easy to interchange the instruments with the various cabinets. The instruments 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 1022A

The B.F.O. is in a metal case.

Type 1022B

Similar to Type 1022A 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 1022C

Similar to Type 1022A, 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).

1. INTRODUCTION

The Beat Frequency Oscillator Type 1022 is a precision signal generator using solid state circuitry throughout. It covers the range 20–20,000 Hz and is designed for acoustical, vibrational and electrical measurements.

The 1022 works on the heterodyne principle using two high frequency oscillators one of which operates at a fixed frequency while the frequency of the other can be varied. The required audio frequency is then obtained by mixing these frequencies to produce a beat frequency.

The instrument contains several features that aid experimental work. A regulator stage is provided so that for instance constant sound pressure or vibration level may be maintained.

The output signal can be automatically frequency modulated by an internal generator to produce a warble tone for use during reverberation measurements. Alternatively the output signal can be externally modulated to allow wider choice of modulation frequency and frequency deviation.

The output attenuator has a range of 100 dB in 10 dB steps and the output impedance can be varied to give maximum power (2.5 W) in a load of 6-60-600 or 6000Ω.

The 1022 may be swept continuously through its frequency range by means of an external motor drive. Alternately, parts of the frequency range may be blocked with adjustable cams to suit any particular sweep program. If it is driven by the Level Recorder 2305 it can also be automatically synchronized with frequency calibrated paper.

Outputs of 100–120 kHz variable and 120 kHz fixed frequencies are available for use as control frequencies for the Heterodyne Slave Filter 2020.

Remote control facilities are provided to start and stop the scanning and the oscillator and for instance to lift the pen on the Level Recorder when the oscillator is sweeping outside the frequency range of interest.

2. CONTROLS

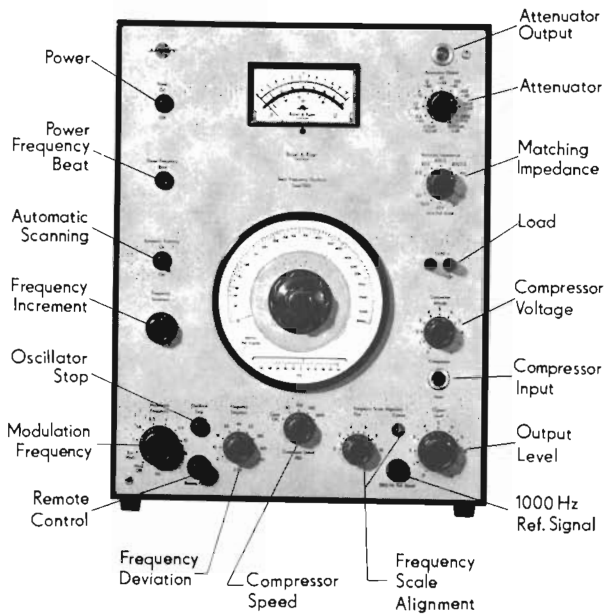


Fig.2.1. Front Panel

FRONT PANEL

POWER:	On/off switch for mains supply.
POWER FREQUENCY BEAT:	Pushbutton. When depressed and held in, a beat between the power supply frequency and the output frequency of the B.F.O. can be observed on the meter. By this means the output frequency can be calibrated with the main frequency scale.

Frequency Modulation

Internal: Variable in steps, 1–1.6–2.5–4–6.3–10–16–25 Hz.

Oscillator Stop

By silent push-button or by remote control.

Attenuator Output

Maximum Output Voltage	12 V

Load Output

Maximum Power Output	2.5 W
Minimum permissible load impedances are marked at the Matching Impedance switch positions. They are:	6 Ω 60 Ω 600 Ω 6000 Ω

120 kHz and 100–120 kHz Outputs

Output Level approx.	200 mV
Output Impedance	100 Ω

Compressor Input

Input Impedance approx.	25 kΩ
Maximum input level	50 V

Remote Control Socket

For the requirements of this socket, see Remote Control, Operation chapter.

7. SPECIFICATIONS

Frequency Range 20–20.000 Hz.

Frequency Scales

Main Scale: Logarithmic over 3 decades.

Incremental Scale: Range of – 50 to + 50 Hz of main scale setting.

Frequency Characteristics (without compressor loop)

Attenuator Output:	Better than ±0.3 dB
Load Output (with 1 watt load):	Better than ±0.5 dB

Distortion

Frequency Hz	20	200	2000	20,000
Attenuator Output (∼10 V output)	0.2%	0.1%	0.1%	0.2%
Load Output (1 watt load)	0.3%	0.15%	0.15%	0.4%

Automatic Output Regulation

The built-in compressor amplifier maintains regulation up to 55 dB and will maintain a constant voltage, current or sound pressure level to within 1.5 dB over the whole frequency range. Linearity of the frequency characteristic is better than ±0.3 dB.

Regulation speed variable in steps: 30–100–300–1000 dB/sec.

Frequency Deviation

Internal: Variable in steps, 0 ±10 ±16 ±25 ±40 ±63 ±100 ±160 ±250 Hz

External: With external generator continuously variable from 0 to ±300 Hz. Maximum Modulation Sensitivity 5 mV/Hz (at 250 Hz frequency deviation).

AUTOMATIC SCANNING:	Connects the variable capacitor of the B.F.O. to a worm drive which can be connected to and driven by an external motor.
FREQUENCY INCREMENT:	Allows exact variation of the output frequency within – 50 to +50 Hz of that indicated by the main frequency scale.
OSCILLATOR STOP:	Pushbutton to interrupt the oscillator. It is fitted for reverberation measurements and is noiseless.
MODULATION FREQUENCY:	Selects frequency of modulation. Choice of 1–1.6–2.5–4–6.3–10–16–25 Hz or external modulation.
REMOTE CONTROL:	Six-pin socket for connection of various forms of remote control and external frequency modulation. For connections see Operation chapter paragraph G.
FREQUENCY DEVIATION:	Modulates the frequency of the fixed oscillator and hence the output frequency by 0 to ±250 Hz.
COMPRESSOR SPEED:	Selects the time constant in the regulation circuit. Gives regulation speeds of 30–100–300–1000 dB/sec.
FREQUENCY SCALE ALIGNMENT:	Fine and Coarse potentiometers to adjust the output frequency to coincide with that indicated on the main scale.
1000 Hz REF.SIGNAL:	When this button is depressed and the main frequency scale is set to "1000 Hz, Ref.Signal" an output reference signal is produced.
OUTPUT LEVEL:	Potentiometer giving continuous adjustment of output signal when the compressor circuit is not in operation.

COMPRESSOR INPUT: For connection of the signal from the regulating transducer when automatic regulation of the B.F.O. output is required. Input impedance 25 kΩ. Maximum range of regulation 50 dB.

COMPRESSOR VOLTAGE: Logarithmic potentiometer for control of the output voltage of the instrument, when compressor loop is applied.

LOAD: Output terminals of variable output impedance. Controlled by Matching Impedance knob. The right-hand terminal is grounded.

MATCHING IMPEDANCE: 6–60–600–6000Ω indicates the minimum load impedance for each switch position. Another position feeds the output through the Attenuator.

ATTENUATOR: When "Matching Impedance" is set to "Att" the output signal can be attenuated in ten accurate steps of 10 dB. The other values indicated by the knob positions refer to the RMS voltage (mV) available at full scale meter deflection.

ATTENUATOR OUTPUT: Output signal fed through this socket when "Matching Impedance" set to "Att". A grounding socket is placed beside it.

MECHANICAL DRIVE CONNECTION: Located on both sides of the instrument are sockets for the connection of an external mechanical drive for automatic frequency sweep. The shaft connection fits the Flexible Drive Shaft UB 0041 which forms the mechanical link between the B.F.O. and the Level Recorder 2305.

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 ±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.

Note: For correct synchronization of paper and sweep speed the synchronizing Gear Lever X on the 2305 (Fig.6.2.) should be in its outer position and the knobs PAPER SPEED and DRIVE SHAFT SPEED should be set as in TABLE I

PAPER SPEED mm/sec.	DRIVE SHAFT SPEED rpm.
0.0003	0.036
0.001	0.12
0.003	0.36
0.01	1.2
0.03	3.6
0.1	12
0.3	36
1.0	120

TABLE I

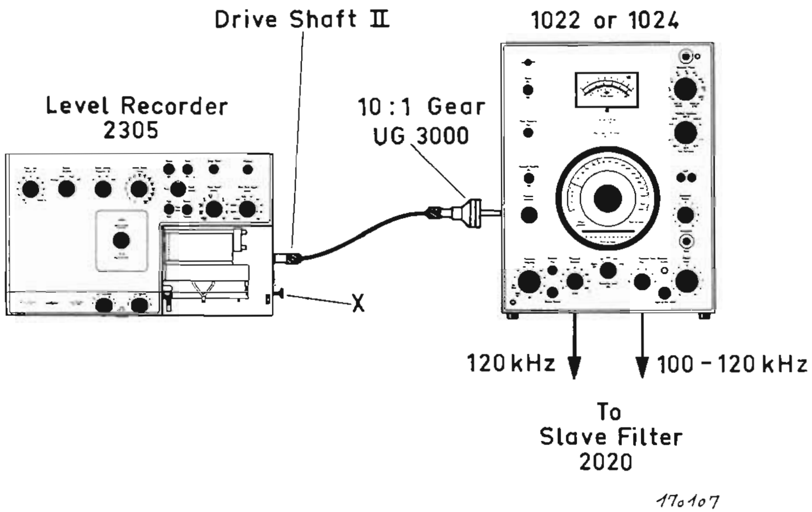


Fig.6.2. Connection of Gear UG 3000

REAR PANEL

100 – 120 kHz AND 120 kHz:

These sockets supply control voltages for use with the Heterodyne Slave Filter 2020. The output impedances are 100Ω and output levels approximately 200 mV.

3. TECHNICAL DESCRIPTION

A block diagram of the 1022 is shown in Fig.3.1.

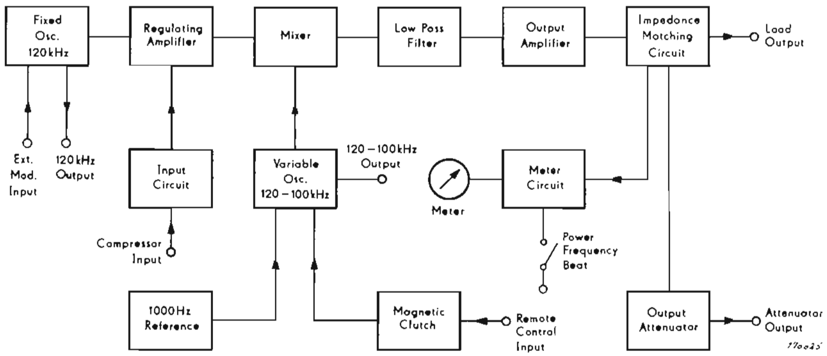


Fig.3.1. Block Diagram

The fixed oscillator is a tuned LC type and works at 120 kHz. Incorporated in the tuned circuit is a variable capacitor which is operated by the Frequency Increment knob. This allows exact frequency selection within ±50 Hz about any setting on the main scale. In addition this capacitor permits frequencies down to 10 Hz to be obtained at the risk of slightly more distortion.

An output to supply a reference signal or a control signal for the Heterodyne Slave Filter 2020 is provided. The output impedance of the 120 kHz output socket is 100Ω and the signal level is of the order of 200 mV.

The fixed oscillator can be frequency modulated to produce a warble tone. The oscillator is connected directly to a reactance circuit to enable external modulation of the signal, but in the case of internal modulation a relaxation type of oscillator employing a unijunction transistor to control the reactance circuit is also used.

6. ACCESSORIES

10:1 GEAR UG 3000

When making narrow band frequency analyses of a spectrum that has narrow resonances it is important to have a slow and constant sweep speed. Clearly if the sweep speed varied, the narrow filter might jump past one of the resonances.

The 2020 is driven electrically from the 1022 which is in turn driven by a flexible shaft from the Level Recorder 2305. Hence for narrow band analyses the 10:1 Gear UG 3000 is recommended (Fig.6.1.). Generators 1022 or 1024 connect directly to this gear, which is driven from DRIVE SHAFT II of the 2305 Level Recorder via the Flexible Shaft UB 0041, as shown in Fig.6.2. Thus the mechanical loading on the Flexible Shaft is considerably reduced and the sweep speed regulation is improved by a factor of 10 or more.

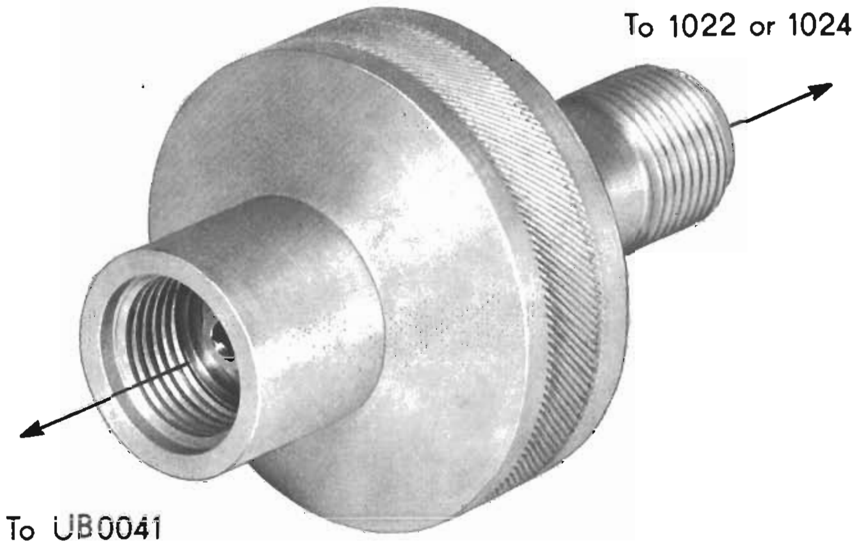


Fig.6.1. The 10:1 Gear UG 3000

To measure the strain on the test object a resistance strain gage should be used and a Strain Gage Apparatus 1516 will be found ideal as the measuring bridge. The output voltage from the Strain Gage Apparatus can be fed directly to a Level Recorder with linear potentiometer for 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. 5.21.

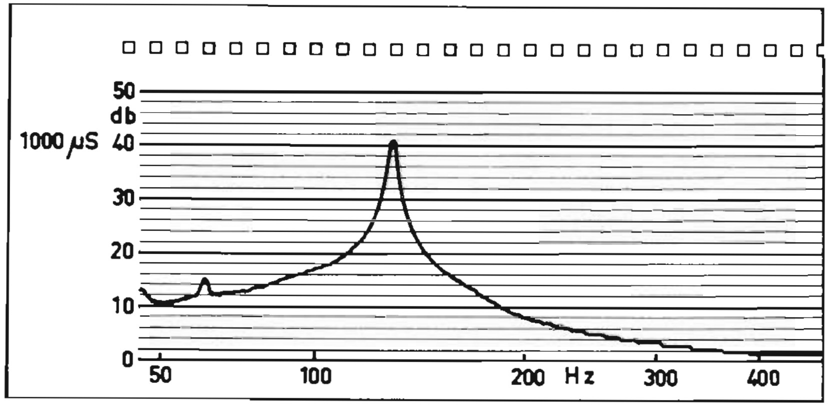


Fig.5.21. Recording of mechanical strain in a bar. Instrumentation set-up as in Fig.5.20.

The reactance circuit is needed to control the actual frequency deviation (modulation swing) of the fixed oscillator by producing an inductive reactance across the oscillator's tuned collector. The deviation can be varied linearly from 0 to ± 250 Hz where the sensitivity is approximately 5 mV/Hz.

A saw-tooth generator determines the frequency of modulation i.e. the rate of change of the frequency swing of the oscillator. Frequencies of 1–1.6–2.5–4–6.3–10–16–25 Hz are available. Provision is also made for modulation by an external generator. Alternative modulation frequencies or wave shapes can then be chosen and frequency swings of up to ± 300 Hz obtained (but the modulation sensitivity varies).

The signal from the fixed oscillator is passed to a regulating amplifier which controls the output level. The regulating amplifier is used to perform the oscillator stop and dead zone blocking. A compressor amplifier can be switched in to control the regulating amplifier so that constant output level is obtained. When the instrument is being used for instance to power a loudspeaker, the compressor circuit can be used with a microphone to maintain a constant sound pressure level.

The compressor circuit consists of an amplifying stage and a full-wave averaging rectifier stage. The signal from the rectifying stage is then used to vary the gain of the regulating amplifier. A variable potentiometer (Compressor Voltage) in the input circuit of the regulating amplifier can be used to control the output power from the instrument when automatic regulation is used.

The speed with which the variation in output level is regulated back to normal depends on the setting of the Compressor Speed knob, but also depends to a certain extent on the amount of the deviation from the normal level. Compressor speeds of 30 – 100 – 300 – 1000 dB/sec. are available and are determined by the integration time constant of the rectifying circuit.

The input impedance of the Compressor Input is approximately 25 kΩ and the maximum range of regulation is 50 dB. Regulation characteristics for different positions of the Output Level potentiometer are shown in Fig.3.2.

The variable oscillator is of similar design to the fixed one except that it has a variable capacitor in its tuned circuit to vary the oscillation frequency between 100 and 120 kHz. A worm gear, connected to the capacitor

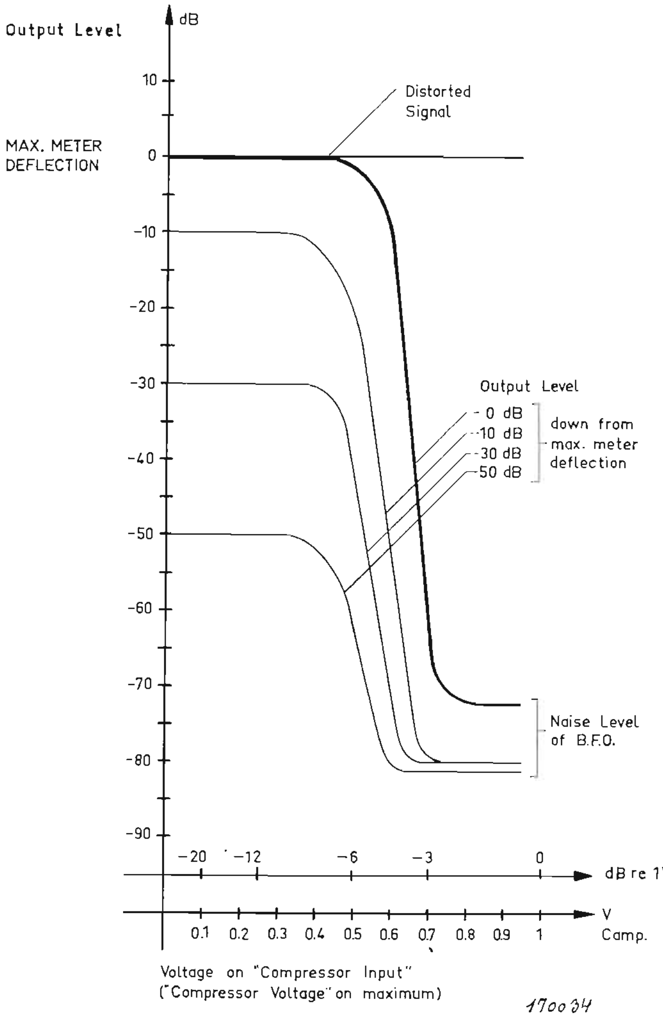


Fig.3.2. Regulation characteristics for different positions of Output Level potentiometer

spindle, permits automatic tuning with the aid of an external motor such as that of the Level Recorder 2305. A magnetic clutch, which can be remotely controlled, is used for connection of the external drive to the capacitor spindle.

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.

The illustration in Fig.5.20. 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.

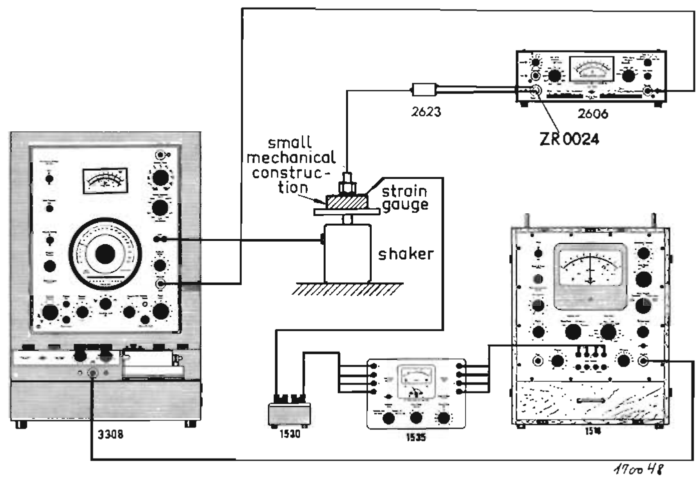


Fig.5.20. Set–up for the measurement of vibration in small specimens.

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 Preamplifier 2623 and a Measuring Amplifier 2606 to the compressor input of the B.F.O.

By using the Measuring Amplifier 2606 the acceleration can be read directly, so the force on the test object can be calculated knowing its mass.

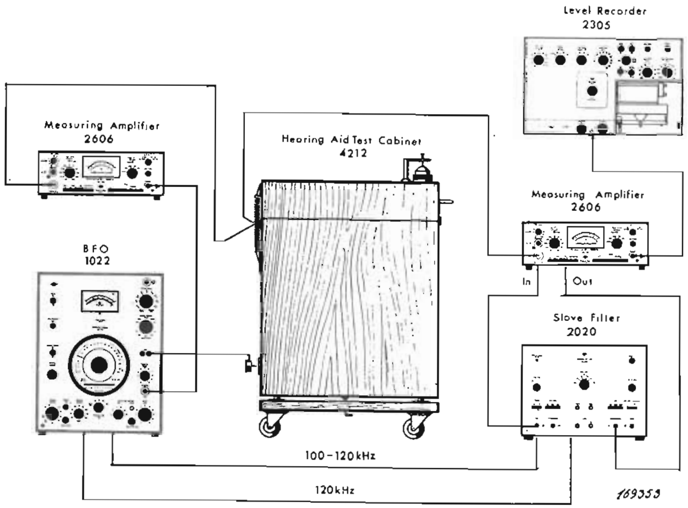


Fig.5.19. Set-up for automatic recording of hearing aid harmonics

The percentage harmonic distortion can now be calculated and is defined by:

$$\frac{Pr}{P} \times 100\%$$

Where "Pr" is the RMS harmonic sound pressure level excluding fundamental and "P" is the overall RMS sound pressure level.

Alternatively this can be expressed by:

$$\text{Harmonic Distortion} = \left(\frac{P_2{}^2 + P_3{}^2 + P_4{}^2 + \cdots\cdots}{P_1{}^2 + P_2{}^2 + P_3{}^2 + P_4{}^2 \cdots\cdots} \right)^{\frac{1}{2}} \times 100\%$$

where P_1 = amplitude of fundamental sound pressure
P_n = amplitude of the n th harmonic.

Note: When the "Rejection" output is used for harmonic analysis the compressor feedback voltage can be taken from the "Output" of the same instrument, since both "Rejection" and "Output" circuits function simultaneously.

When the capacitor is set to frequencies above 20 kHz or below 20 Hz the signal from the fixed oscillator is blocked so that no output voltage is obtained. This has the advantage that when automatic recordings are being taken with the Level Recorder 2305, no unwanted curves appear on the paper. The cut-off section can be made wider by means of the adjustable cams fixed on the capacitor spindle (Fig.4.5). The Remote Control plug is also needed to make certain connections inside the instrument. By this method the overall frequency range of the apparatus can be reduced to about one octave. In applications where the 1022 is used with the Level Recorder 2305 the adjustable cams can be made to operate the pen lift. .

A 1000 Hz reference signal can be supplied at the output sockets when the Reference Oscillator is connected and the scale pointer is set to the position 1000 Hz Ref.signal. The use of this reference signal can be seen in the operation chapter.

The signals from the fixed and variable oscillators are mixed and then passed to a low-pass filter. The filter has a cut-off frequency of 50 kHz and is used primarily to eliminate any 100 — 120 kHz or 220 — 240 kHz components.

The filtered signal is then fed to the output amplifier. This will give an output power of 2.5 W nominal load (i.e. the load indicated on the Matching Impedance switch). The output amplifier is current limited to protect the transistors.

Finally the output signal is fed to an auto transformer for impedance matching with the load. The markings 6–60–600–6000Ω around the Matching Impedance Switch indicate the minimum load impedances that should be used for each switch position. The signal can also be passed to an output attenuator which allows output signals to be selected between 120 μV and 12 V, (full scale deflection), in accurate 10 dB steps. The overall accuracy of the attenuators is 2%. The voltage at the output terminals is indicated by a transistor voltmeter which measures the average value. It is calibrated in RMS values of a sinusoidal voltage and the accuracy over the frequency range 20–20,000 Hz is 1.5% at full scale deflection. Additionally, there is a dB scale which gives dB values re 1 volt. It should be noted that when the Attenuator Output is used, the output voltage only equals the corresponding meter deflection when the impedance of the load connected to the terminal is high compared with the 50Ω attenuator impedance.

The sensitivity of the voltmeter is automatically changed when the position of the Matching Impedance switch is altered. Full scale meter deflection in volts is indicated for each switch position. The Attenuator switch is similarly marked and in addition has dB values re 1 volt.

The signal-to-noise ratio of the instrument is better than 70 dB for maximum output voltage. It is independent of the position of the attenuator, but somewhat dependent on the position of the Output Level potentiometer. The optimum setting is when the voltmeter indicates 20 dB.

The amount of harmonic distortion also depends 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.3.3.

The 1022 can be operated from 100, 115, 127, 150, 220, 240 Volts AC and 50 to 400 Hz mains supplies and the maximum power consumption is of the order of 26 W with full load.

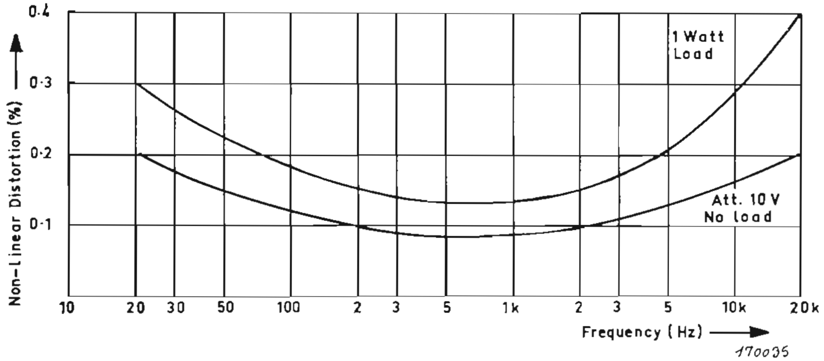


Fig.3.3. Distortion curves for different loads

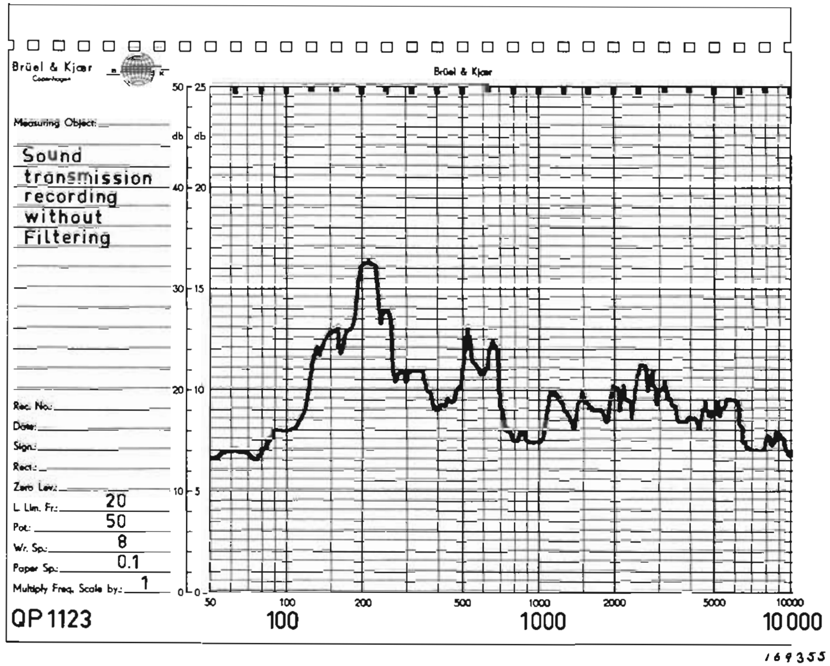


Fig.5.18. Sound transmission recording without filtering

An instrument set up for the automatic recording of hearing aid harmonics is shown in Fig.5.19.

The test environment is provided by the Type 4212 Hearing Aid Test Box, which gives practically free-field conditions over the frequency range 150 Hz to 5 kHz. The receiver of the hearing aid under test is excited by a loudspeaker inside the anechoic chamber of the test box. Sound pressure at the position of the receiver is maintained constant by a regulating condenser microphone which provides feedback to the compressor circuit of the oscillator supplying the loudspeaker signal. The hearing aid output is coupled to an artificial ear as required by the IEC (Recommendation 118). The artificial ear contains a pressure response microphone which detects the output from the earphone. Using the Slave Filters "Output" (L.F.) and "Rejection" outputs the respective frequency and harmonic analysis spectrograms can be recorded on the same frequency calibrated chart using the Level Recorder.

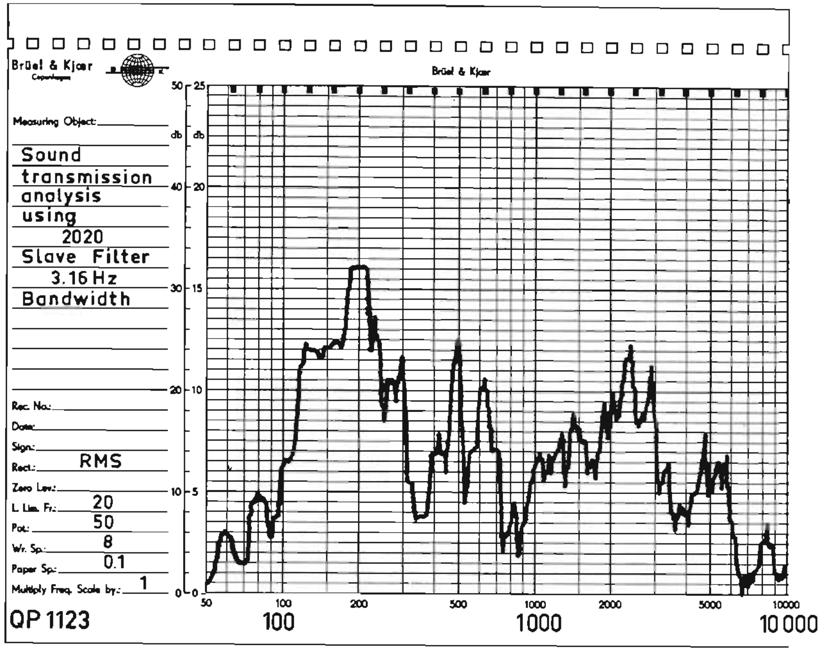


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Fig.5.17. Sound transmission analysis using a Heterodyne Slave Filter 2020 with 3.15 Hz bandwidth

Experimental results obtained for a receiving room where a high level of background noise was present are shown in Fig.5.17. and 5.18. The results obtained using the 2020 (Fig.5.17.) show a considerable improvement in signal to noise compared to those obtained with no filter (Fig.5.18.).

Note: To ensure that the compressor circuit is controlled from the fundamental of the sound source, another 2020 could be used with the 2606 in the compressor loop.

Automatic Recording of Harmonics in Hearing Aids

Another use of the Heterodyne Slave Filter with the 1022 is shown below. The 2020 can be used for frequency rejection whereby it will reject frequencies by over 40 dB over a 3.15 Hz bandwidth.

4. OPERATION

PRELIMINARY ADJUSTMENTS

Before the instrument is used check the voltage selector on the rear panel is set to the correct line voltage. If not, remove the central fuse and adjust with a small coin or screwdriver.

A. CALIBRATION

1. Switch on and allow 1 minute to warm up.

2. Set MODULATION FREQUENCY and COMPRESSOR SPEED to "Off".

3. Set main scale pointer to the frequency of the mains supply (e.g. 50 or 60 Hz) checking that the frequency increment scale is set to zero.

4. Set the meter deflection to higher than centre scale reading with OUTPUT LEVEL knob.

5. Press POWER FREQUENCY BEAT button and hold "in". At the same time slowly adjust the FREQUENCY SCALE ALIGNMENT FINE knob until a large fluctuation registers, slows up, and practically ceases on the meter dial.

6. Set main scale pointer to 20 Hz and subtract 20 Hz with FREQUENCY INCREMENT knob. If the meter deflection drops to zero then the B.F.O. is calibrated. If not, continue to point 7.

7. If the meter deflection does not drop to zero, adjust FREQUENCY SCALE ALIGNMENT COARSE with a screwdriver until the meter deflection does.

8. Reset the main scale pointer to the frequency of the mains supply. Reset frequency increment scale to zero. Make a final adjustment with FREQUENCY SCALE ALIGNMENT FINE to obtain the exact position of "slow beat" as in point 5. The B.F.O. is then calibrated.

B. OPERATION USING LOAD TERMINALS

1. Set up and calibrate the Oscillator as above in A.

2. Select suitable matching impedance for the load using MATCHING IMPEDANCE switch.

3. Connect load to LOAD terminals.

4. Turn pointer on main frequency dial to desired frequency, finely adjusting with FREQUENCY INCREMENT knob if necessary.

5. Select required output voltage using OUTPUT LEVEL knob.

C. OPERATION USING ATTENUATOR OUTPUT

1. Set up and calibrate the Oscillator as above in A.

2. Set MATCHING IMPEDANCE switch to "Att".

3. Select appropriate voltage range with ATTENUATOR knob.

4. Connect load to ATTENUATOR OUTPUT.

5. Turn pointer on main frequency dial to desired frequency, finely adjusting with FREQUENCY INCREMENT knob if necessary.

6. Select required output voltage using OUTPUT LEVEL knob.

Note: The meter reading is correct only when the impedance of the load is high compared to the 50Ω attenuator impedance.

D. FREQUENCY MODULATION

When a frequency modulated output signal is required:

1. Set knobs:

MODULATION FREQUENCY	required value
FREQUENCY DEVIATION	zero

2. Calibrate the Oscillator from point A. 3. above.

3. Set FREQUENCY DEVIATION knob to required bandwidth.

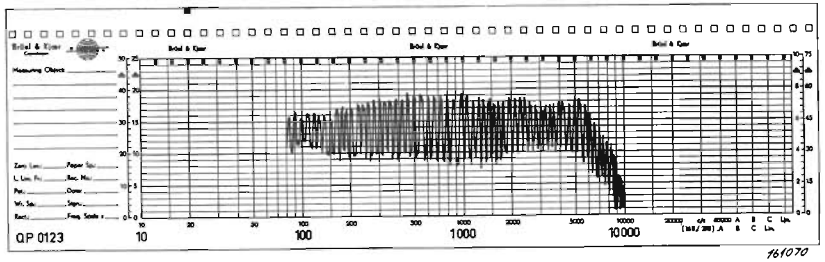

*Fig.5.15. Reading obtained with a set-up as in Fig. 5.14.
50 dB range potentiometer used in Level Recorder*

A set up is shown in Fig.5.16. where a compressor loop is used to keep the sound level constant. The feedback signal is amplified by a Measuring Amplifier 2606. Another 2606 is used in conjunction with the 2020 to analyze the attenuated signal in the receiving room. The analyzed signal is then recorded on frequency calibrated paper using a Level Recorder 2305 and thus provides a direct measure of the sound insulation qualities of the room at any frequency in the measuring range.

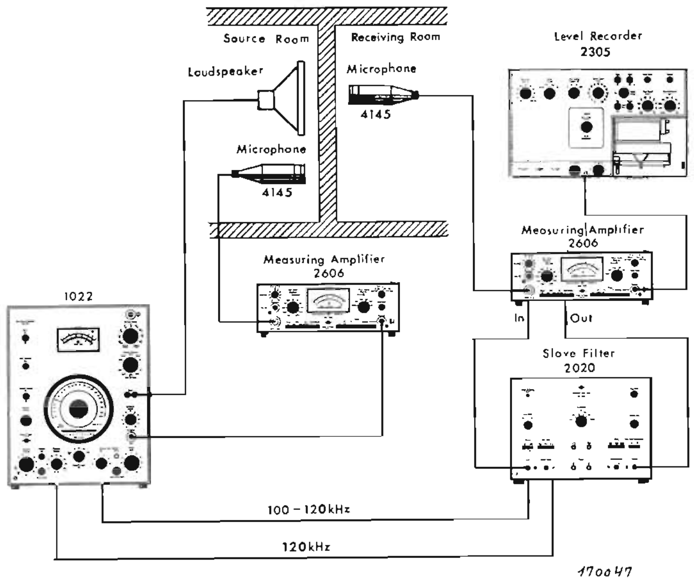

Fig.5.16. Set-up for measurement of airborne sound insulation using a Heterodyne Slave Filter 2020

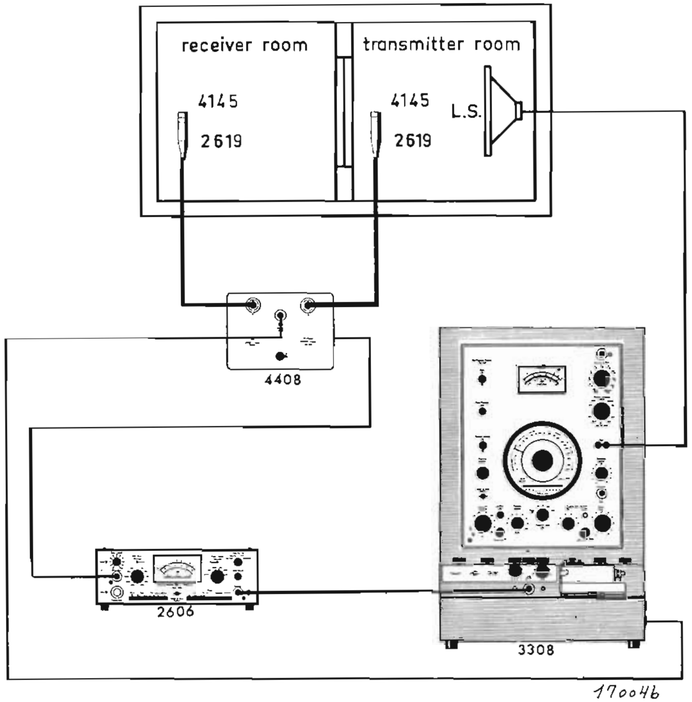

Fig.5.14. Set-up for measurement of the sound insulation properties of a wall

ing Amplifier 2606, 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. Such a recording is shown in Fig.5.15. The sound absorbed by the receiving room must be taken into account.

The main problems in the transmission and reception of airborne sound are the power available from the source and the signal to noise ratio of the receiver. Both these problems can be eased if a narrow band noise source and a narrow band receiver are used.

The Heterodyne Slave Filter 2020 has very narrow bandwidths and is ideal for such measurements. It can also be directly controlled by the 1022.

4. Proceed from point B. 2 or C. 2 as required.

E. AUTOMATIC REGULATION OF OUTPUT POWER

By means of the compressor circuit it is possible to regulate the output from the oscillator. When a constant voltage is required, the output voltage from the oscillator should be used as a control voltage. (Fig.4.1a.). A constant current is obtainable if the voltage drop across a resistor in series with the load is used as the control voltage (Fig.4.1b.). Similarly a reference microphone can be used to control sound pressure or an accelerometer can be used to control vibration level. Examples can be seen in the Applications chapter.

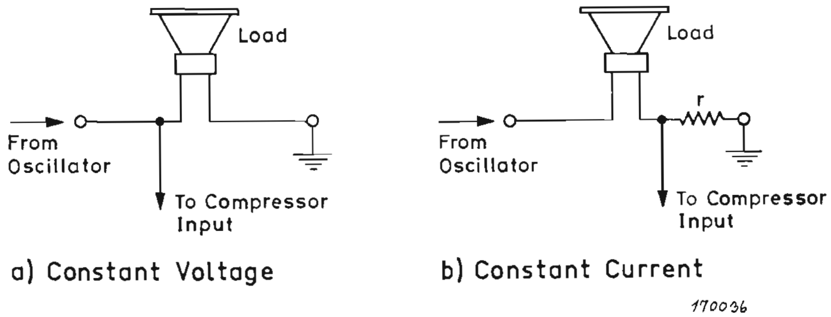

Fig.4.1. Constant voltage and constant current compressor loops

To use the compressor loop proceed as follows:

1. Set up and calibrate the Oscillator as described above in A.

2. Set the MATCHING IMPEDANCE switch to the desired position.

3. Connect the load to LOAD terminals or to the ATTENUATOR OUTPUT at 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. (See Fig.3.2).

5. Set COMPRESSOR VOLTAGE and OUTPUT LEVEL to maximum (fully clockwise).

6. Feed the voltage to be measured to the recording instrument, e.g. the Level Recorder 2305.

7. Set COMPRESSOR SPEED to required value.

8. Regulate the desired output voltage by turning COMPRESSOR VOLTAGE knob counter-clockwise.

Note: When the Beat Frequency Oscillator is used in conjunction with the Level Recorder 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.3.2.

F. AUTOMATIC RECORDING

By combining the 1022 with a Level Recorder 2305 or using an Automatic Frequency Response Recorder 3308, it is possible to automatically record the frequency responses of four terminal networks.

The following procedure should be adopted:

1. Set up and calibrate the oscillator as above in A.

2. Connect the instruments as shown in Fig.4.2. The flexible driving shaft (UB 0041) should be connected to the upper driving shaft of the Recorder, DRIVE SHAFT I (Fig.4.3.). The other end should be connected to the drive socket on the left hand side of the 1022 (Check engagement by switching on the Level Recorder and the magnetic clutch of the 1022 and note if the scale pointer rotates).

3. Set PAPER DRIVE to "Stop, Forward".

4. Select and insert required Range Potentiometer.
   (NB: Place POTENTIOMETER RANGE knob to "Standby" when changing potentiometers).

5. Set POTENTIOMETER RANGE knob to correspond to the Range Potentiometer being used.

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.5.13.

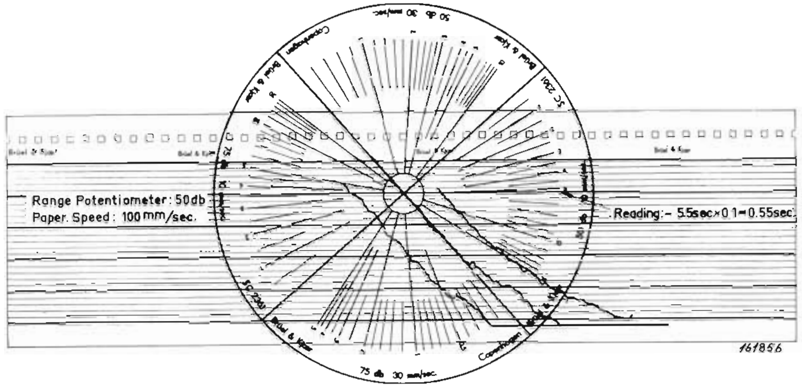

Fig.5.13. Use of Protractor SC 2361, ten times higher paper speed used than on the proctractor (50 dB 10 mm/sec.). Reading then divided by 10 i.e. 0.55 sec.

Airborne Sound Insulation

A means of automatically carrying out this test is shown in Fig.5.14. The wall under test is placed between two rooms, which are termed "the transmitter room" and "the receiver room" respectively.

In each of the two rooms separated by the wall is placed a Type 4145 Condenser Microphone individually coupled to a Preamplifier Type 2619. Two extension cables connect the microphone units with the Two-Channel Microphone Selector 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 3308. A 50 dB Range Potentiometer can be used, the 1022 should be frequency modulated and the loudspeaker (or loudspeakers) placed so that a sound field, as diffuse and isotropic as possible, is built up.

By means of the Microphone Selector which is connected to the Measur-

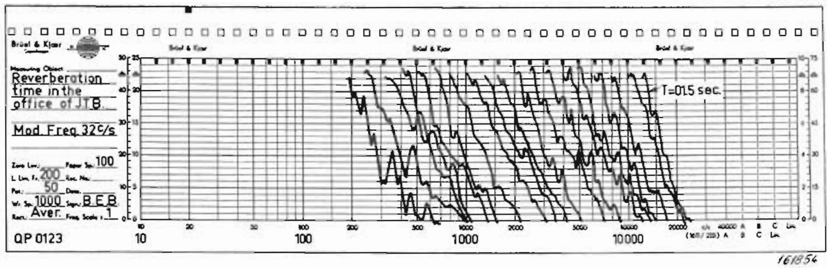

Fig.5.11. Recording of decay curves, compressor loop used

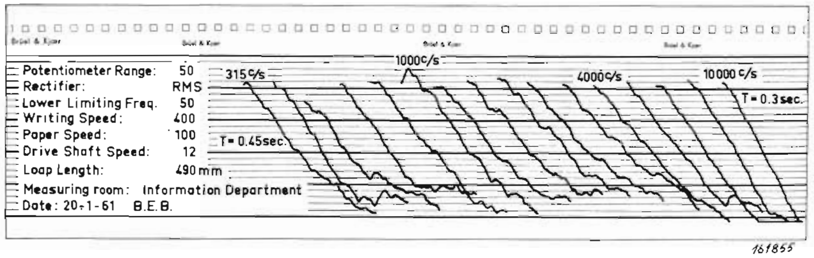

Fig.5.12. Decay curves at 10 mm intervals recorded on a 490 mm loop

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. See Fig.5.13.

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

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.

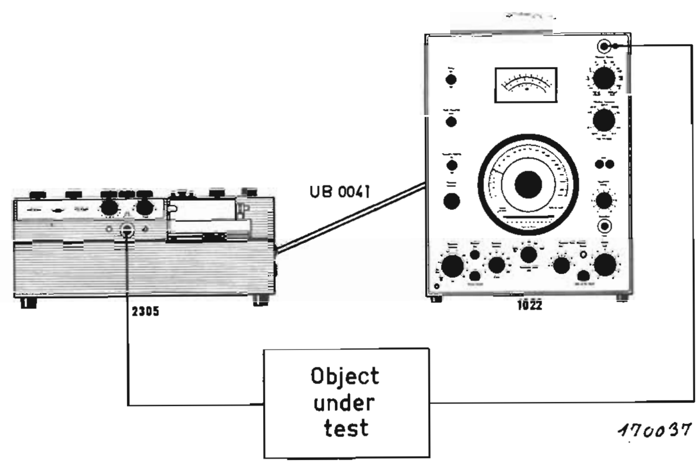

Fig.4.2. Basic set-up for automatic recording

6. Select RECTIFIER RESPONSE
   LOWER LIMITING FREQUENCY
   WRITING SPEED
   PAPER SPEED eg 10 mm/sec.

7. Pull gear-lever marked X to the outer position. (See Fig.4.3.).
   The paper drive speed now corresponds to the *small numbers* marked around the PAPER SPEED knob.

8. 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 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.4.3.) until the stylus rests on the 10 Hz line.
   A chart of 250 mm length will now run off when the SINGLE CHART – CONT. RECORD pushbutton is depressed for a short time and then released. (It is possible to stop the recording at any time by setting the PAPER DRIVE switch to "stop").

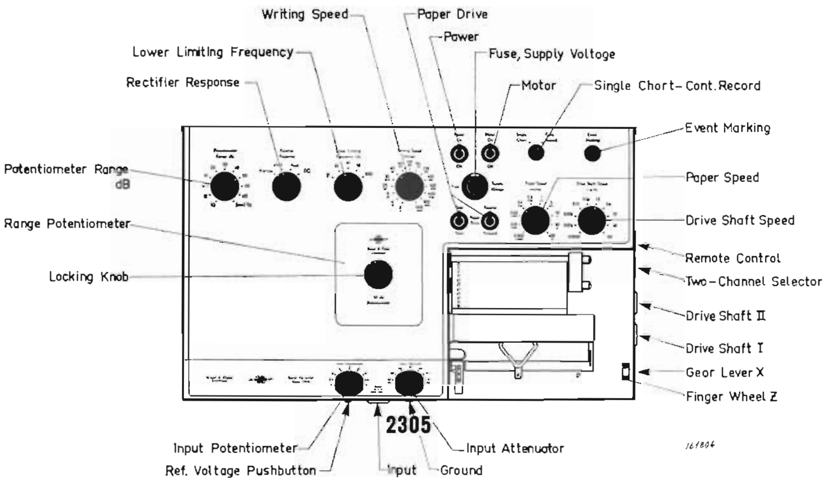

Fig.4.3. Level Recorder 2305

(b) *Continuous Recording:*
The operator should follow the instructions outlined under (a), Single Chart Recording except that to start the recording it is necessary to press the SINGLE CHART – CONT. RECORD push-button and turn it clockwise. Recording will now automatically take place until the push-button is released again and the PAPER DRIVE switch is set to "stop".

Note: Whenever the PAPER DRIVE switch is in the "stop" position the paper drive is completely controlled by the SINGLE CHART – CONT. RECORD push-button.

9. In order to synchronise the units, stop the paper so that the stylus rests on the 10 Hz line.

10. Depress 100 mV reference button on Level Recorder and use INPUT POTENTIOMETER to adjust stylus to a suitable level on the recording paper.

11. Set pointer of 1022 to 1000 Hz REF. SIGNAL and engage magnetic clutch by use of clutch switch. The units will then be synchronised so that the distance between the 10 and 20 Hz marks on the paper

Frequency Calibrated Paper

When 50 mm wide paper is made into a paper loop 495 mm long as in Fig.5.10. (i.e. two chart lengths minus 5 mm where 5 mm is the distance between two holes) it is possible to obtain curves spaced 1/3 octave apart and synchronised with the frequency calibrated paper as shown in Fig.5.11. The centre frequency of a particular filter is represented by the small black squares at the top of the paper (QP 0424). It is possible to keep the sound pressure level fairly constant by means of a compressor circuit as shown in Fig.4.1. so ensuring that the decay curves commence at the same level.

Overlapping junction.

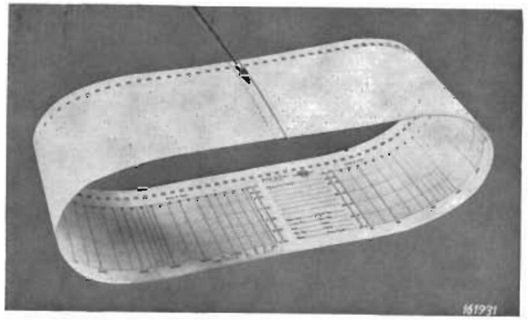

Fig.5.10. Making up of paper loop

Non-frequency Calibrated Paper

When more spacing than 5 mm is required between decay curves the paper loop can be made 490 mm long to give 10 mm spacing as in Fig.5.12. In such circumstances, however, only the lined paper QP 0402 can be used and it is necessary to keep check of the frequency at which each particular curve is taken.

Waxed paper and a stylus is preferable for reverberation measurements due to the high paper speeds needed. If only a few reverberation curves are needed automatic recording may not be necessary. The Oscillator Stop push-button can then be used and the filter switching done by hand.

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

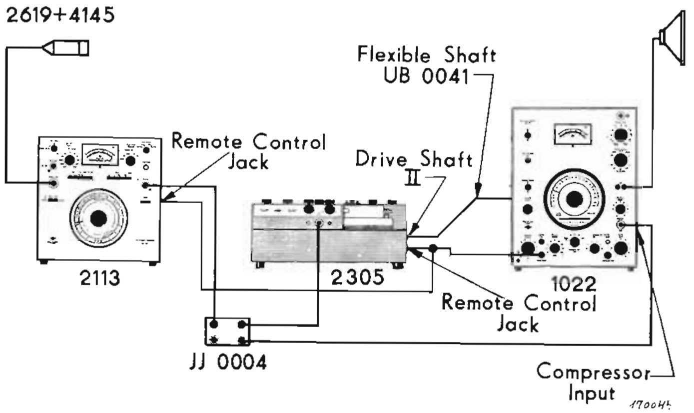

Fig.5.8. Set-up for the automatic recording of reverberation time

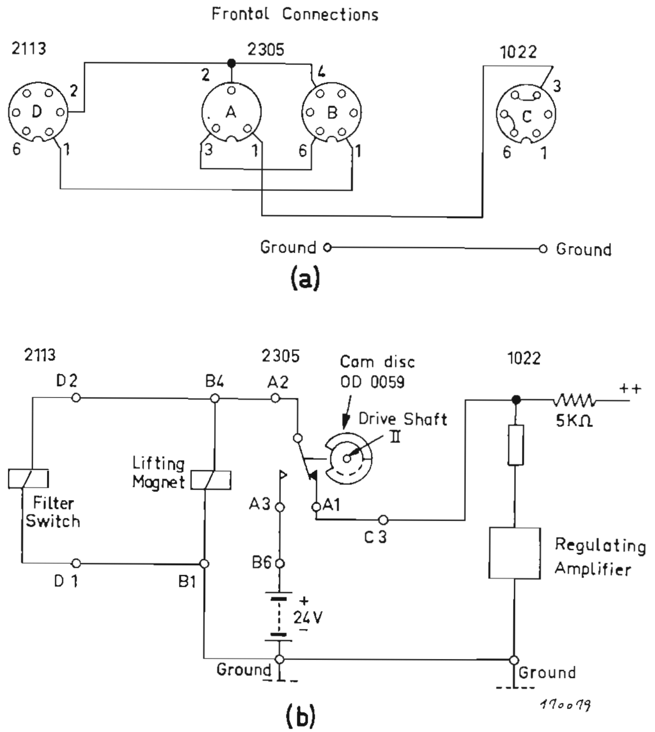

Fig.5.9. Electrical connection of instrumentation for automatic recording of reverberation time
a) Connections between remote control plugs
b) Electrical circuit for remote control

corresponds to the distance between the 1000 Hz REF. SIGNAL and 20 Hz marks on the 1022.

12. Depress 1000 Hz REF. SIGNAL button and adjust the output level from the 1022 and/or the INPUT ATTENUATOR of the Level Recorder so that the stylus deflects to somewhere in the middle of the paper.

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 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 switch.

G. REMOTE CONTROL

Several forms of remote control are possible with the 1022. A diagram showing the connections of the Remote Control plug is shown in Fig.4.4.

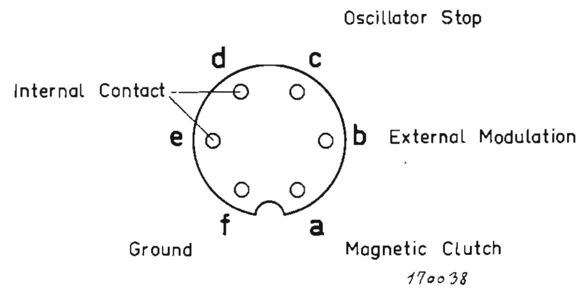

Fig.4.4. Remote Control Plug viewed externally

Magnetic clutch

Frequency scanning can be stopped and started by making or breaking a connection between terminals a and f providing the clutch control switch AUTOMATIC SCANNING is off.

External Modulation

Set MODULATION FREQUENCY switch to Ext. Mod. Connect the external generator between the chassis and terminal b. Terminal f can be used as chassis connection.

Oscillator Stop

For remote interruption of the output signal (stopping of the fixed oscillator) terminal c should be connected to terminal f (ground). When reverberation measurements are made automatically using the Level Recorder 2305, a switch in the Level Recorder can be used to ground terminal c. See Applications. Room Reverberation Time.

Terminals d and e

These terminals are connected to an internal contact which is used for interrupting the output signal when the instrument is being swept through the dead zone 20 kHz to 20 Hz.

Note

When delivered from the factory, the Oscillator is supplied with a 6-poled plug containing the necessary connections for dead zone blocking.

H. PARTIAL BLOCKING OF FREQUENCY RANGE

The initial and/or the final part of the frequency range can be blocked by means of the cams mounted on the spindle of the capacitor (Fig. 4.5.). With full use of the cams the frequency range can be reduced to approximately one octave in any part of the frequency range.

The blocking range is adjusted as follows:

1. Disconnect the instrument from the power supply line.

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.5.7. is a recording showing the frequency response of a microphone recorded by employing the previously outlined system.

Measurement of Reverberation Time

One of the more important factors that determines the acoustical quality of a room is its reverberation time and the 1022 has been designed with certain special features to aid such measurements. The compressor circuit serves to keep the sound level in the room constant with frequency while frequency modulation of the signal ensures that standing waves and interference phenomena are avoided. The latter feature helps to produce smooth slopes to recorded decay curves whereas if pure sine waves were radiated in the room, standing waves might produce uneveness.

Various set-ups can be used to measure reverberation time using the 1022 as an integral part. An arrangement whereby the decay curves are recorded automatically using the Level Recorder 2305 is discussed here. The set-up can be seen in Fig.5.8. The Frequency Spectrometer 2113 is chosen as amplifier for the microphone since selective reception in 1/3 or 1/1 octave bands will reduce background noise and increase the dynamic range of the decay curves.

Decay curves throughout the complete audio range can be recorded automatically at 1/3 octave intervals using this combination of equipment and can be made on both frequency calibrated or nonfrequency calibrated paper. In order to record the decay of sound in the room the sound source must be disconnected at definite intervals by means of the oscillator stop. Only the decay curve is required so the pen should be lifted from the paper between decay curves and, as selective reception is used, the filters of the Spectrometer also need to be switched between curves. The oscillator stop, pen lift and the filter switching can all be performed simultaneously by remote control from the two-channel selector of the Level Recorder. The necessary connections between the different instruments are shown in Fig. 5.9 a. whilst the electrical circuit produced can be seen in Fig.5.9 b.

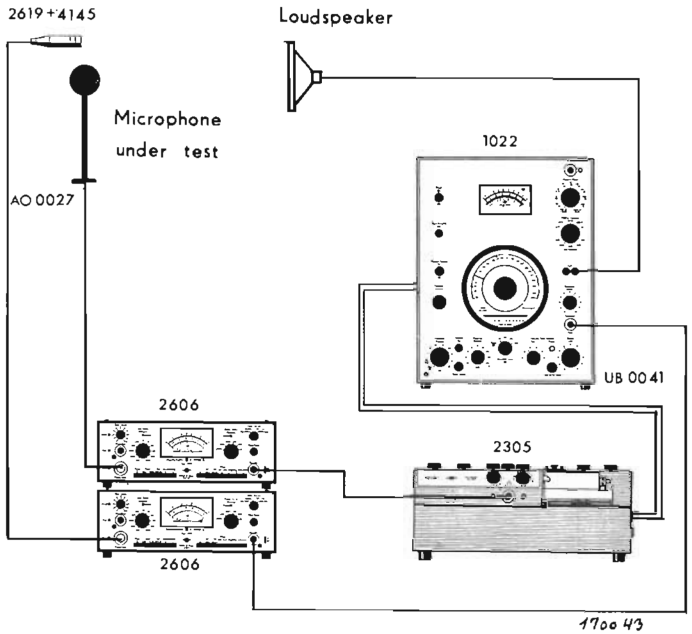

Fig.5.6. *Set-up for the automatic recording of the frequency response of microphones*

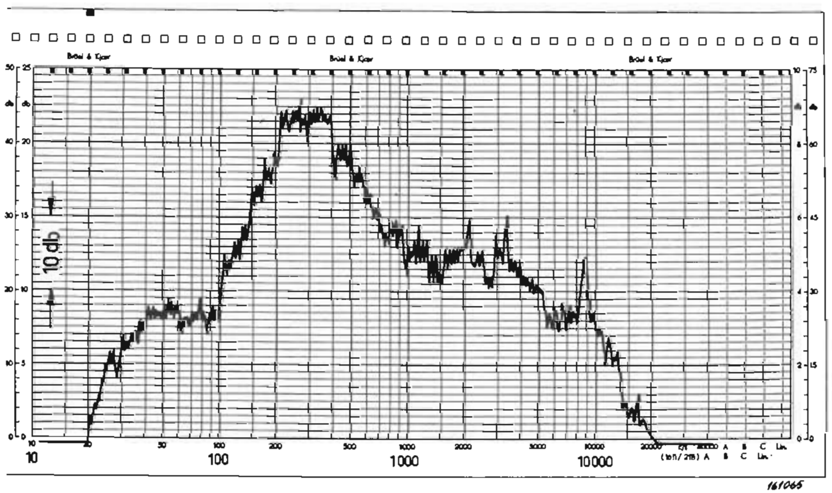

Fig.5.7. *Recording made with the set-up shown in Fig.5.6.*

2. Remove rear panel.

3. Loosen knurled lock-nut (Fig.4.5.) sufficiently for the outer and inner cams to be moved relative to the one in the middle.

4. Set the pointer of the main scale to the lowest frequency of the desired frequency range.

5. Turn the inner cam to the right (seen from behind) until the contact is activated.

6. If necessary tighten the lock-nut a little so that the cam is not displaced when the main scale pointer is moved.

7. Set the pointer of the main scale to the highest frequency within the desired frequency range and turn the outer cam to the left until the contact is activated. Be careful that the inner cam does not move.

8. The cam in the middle should be rotated so that it does not interfere with the frequency range in use.

9. Tighten the lock-nut, still being careful that the cams do not move.

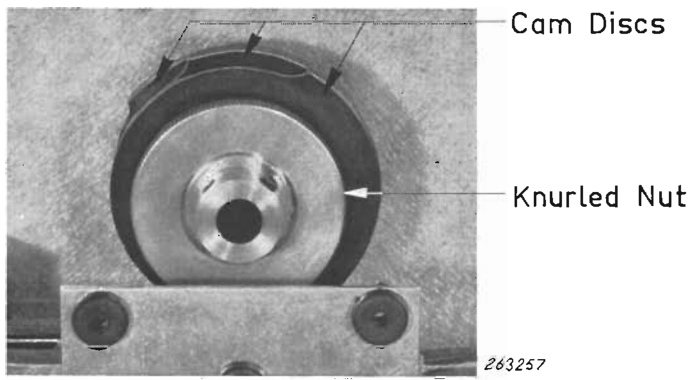

Fig.4.5. *The adjustable cams*

I. USE WITH 2020

To drive the 2020 from the 1022 it is necessary only to connect up the 120 kHz and 100–120 kHz sockets on the rear of the oscillator to the corresponding sockets on the rear of the 2020. For further details of operation see the instruction manual of the 2020.

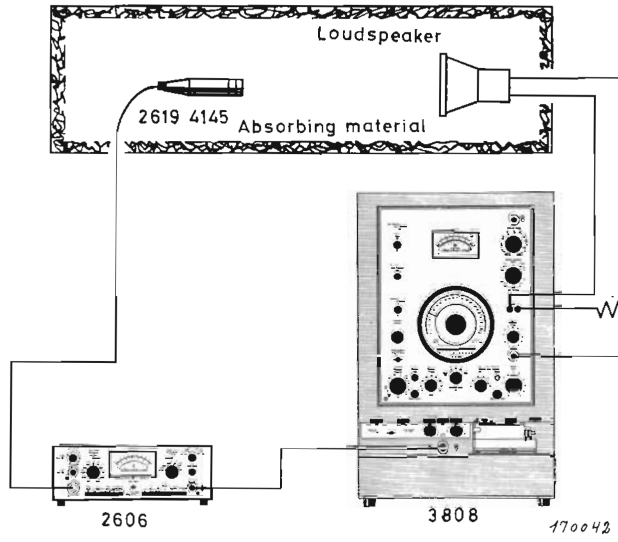

Fig.5.4. Set-up for recording of frequency characteristics of a loudspeaker

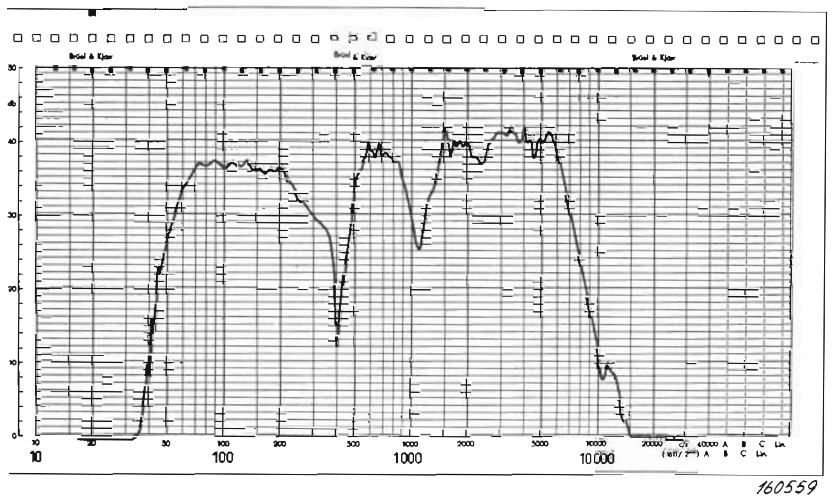

Fig.5.5. Frequency characteristics of a loudspeaker. (The measurement was not carried out in a completely dead room and the effect of reflections can be seen)

B. ACOUSTICAL MEASUREMENTS

Frequency Response of Loudspeakers

To obtain the true frequency response of a loudspeaker an anechoic chamber is essential. Whenever a frequency response is made in an ordinary room it should only be regarded as an "installation" or "on site" test since a combination of loudspeaker and room characteristics will be obtained.

The loudspeaker under test should be fed with constant voltage or constant current. (See Operation E). A constant current arrangement produces a constant force on the diaphragm. Such an arrangement is shown in Fig. 5.4. Here the loudspeaker is fed from the B.F.O. section of an Automatic Frequency Response Recorder 3308 via a series resistor. The voltage drop across the resistor is then fed to the compressor input of the B.F.O. A constant current will then be obtained in the circuit when the voltage drop across the resistor is approximately 0.5 volt.

A Condenser Microphone 4145 should be used for picking up the sound produced and its output fed to the Level Recorder of the 3308 via a Microphone Amplifier 2603, Measuring Amplifier 2606, Frequency Spectrometer 2113 or a Measuring Amplifier 2606 with a Heterodyne Slave Filter 2020. An advantage gained by using frequency selective recording is that much of the background noise can be removed from the signal. Fig.5.5. shows a recording made with the set-up in Fig.5.4.

Frequency Responce of Microphones

Fig.5.6. 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 2305, via a Measuring Amplifier 2606, the sound source being a loudspeaker which is fed from the 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 with a flat frequency characteristic (e.g. a Condenser Microphone 4145) which is coupled to a second Measuring Amplifier 2606, the output of which is fed to the Compressor Input of the 1022 so ensuring a constant sound source. It is essential that the two microphones are symmetrically placed in the radiated sound field and the correct compressor speed selected. The acoustic delay time required for the sound to travel from the loudspeaker to the microphone

5. APPLICATIONS

The field of 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 three sections:

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

A. ELECTRONIC MEASUREMENTS

Measurement of Frequency Response of Four-Terminal Networks

The object to be tested, e.g. a filter, transmission line, transformer etc. can be fed from the 1022 and point-by-point measurements taken by means of the Audio Frequency Voltmeter 2409, Microphone Amplifier 2603 or Measuring Amplifier 2606. If an automatic recording of the frequency response is wanted, the Level Recorder 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 0041 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.5.1.

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 0.5 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.

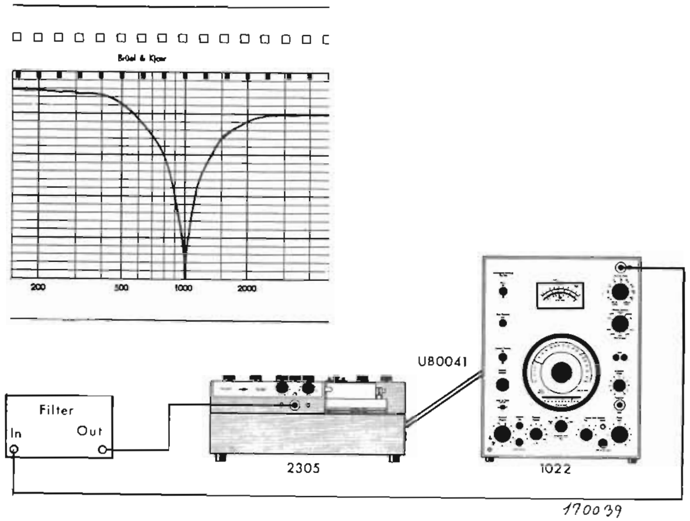

Fig.5.1. *Measurement of frequency response of four-terminal network*

A.C. Bridge Measurements

By employing the 1022 with a Frequency Analyzer 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 is grounded as shown in Fig.5.2. This requires the bridge to be supplied from

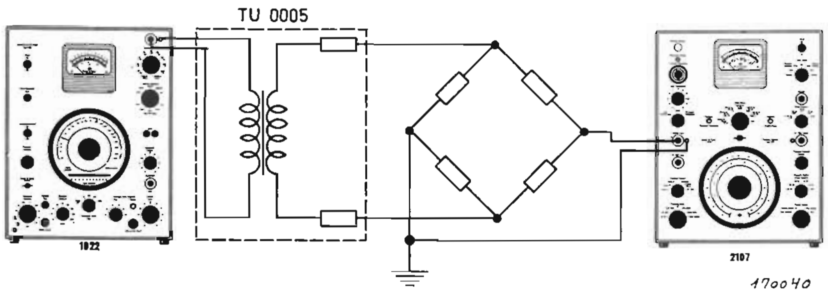

Fig.5.2. *The 1022 used as a voltage source for AC bridge measurements. The Output Transformer TU 0005 provides a symmetrical output.*

the B.F.O. via a screened transformer e.g. TU 0005, the B.F.O. being grounded at one terminal.

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.

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 1022 is very accurately calibrated it is an extremely useful instrument in carrying out these measurements.

The output voltage from the amplifier under test should be measured with an Audio Frequency Voltmeter 2409 or a Microphone Amplifier 2603 or a Measuring Amplifier 2606 an example of the arrangement being given in Fig.5.3.

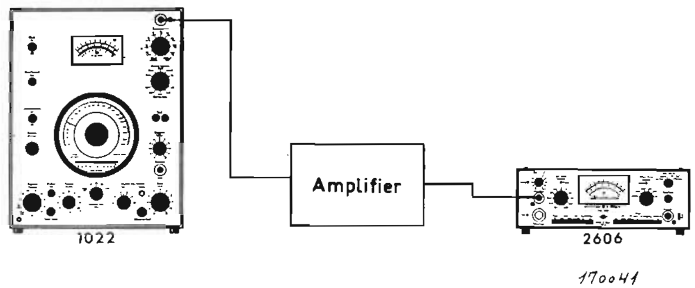

Fig.5.3. *Measurement of gain in an AF amplifier*