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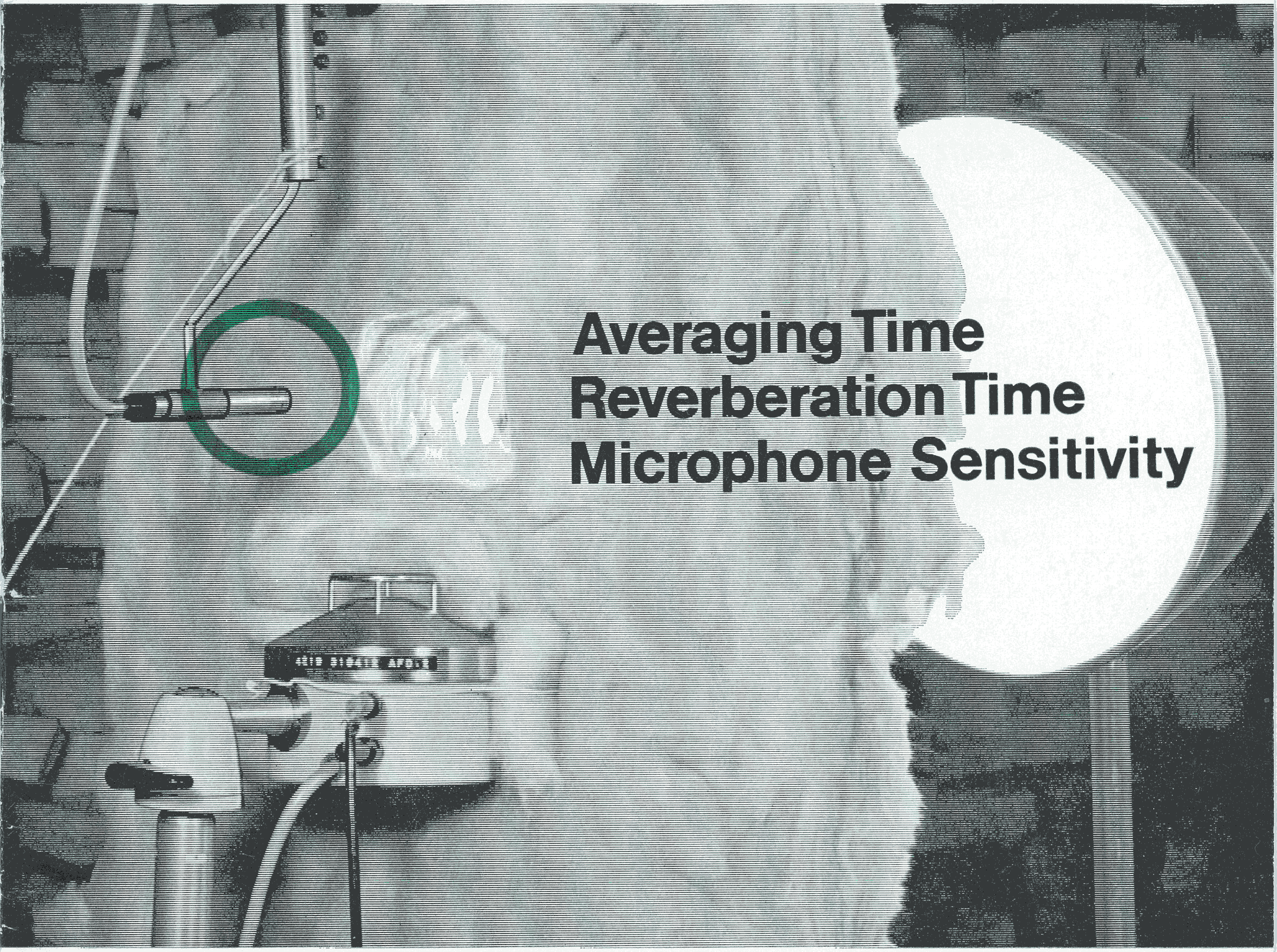

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TECHNICAL REVIEW

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Contents

Measurements of averaging times of Level Recorders Types 2305 and 2307

by

H. P. Olesen and K. Zaveri

ABSTRACT
The influence of different Level Recorder settings and potentiometers on the averaging times of Level Recorders have been discussed. A measuring system for determining the averaging times has been outlined and the spread of results obtained has therefore been illustrated as a nominal curve with tolerance limits for normal Level Recorder settings.

SOMMAIRE
Cet article discute l'influence des différents réglages et des potentiomètres sur le temps d'intégration des Enregistreurs de Niveau. Un système de mesure permettant la détermination des temps d'intégration est décrit. A partir de la dispersion des résultats obtenus, on a déterminé une courbe nominale et les limites de tolérance pour des réglages normaux des Enregistreurs de Niveau.

ZUSAMMENFASSUNG
Der Einfluß unterschiedlicher Pegelschreibereinstellungen und Meßpotentiometer auf die effektive Mittlungszeit von Pegelschreibern wird untersucht. Eine Meßanordnung zur Bestimmung der Mittlungszeit wird beschrieben, und die Streuungen der erhaltenen Resultate werden in Form einer Nominalwertkurve mit Toleranzgrenzen für normale Pegelschreiber dargestellt.

Introduction
Comprehensive measurements of the averaging times of the Level Recorder Type 2305 were carried out by Broch and Wahrman in 1961 and the results were presented as a number of curves which could be used as guides for Level Recorder settings, ref. (2).

Since then some attempts have been made to check the original measurements and to determine the averaging times for different potentiometers, as the 1961 investigation was only carried out with 10 dB potentiometers.

Since this has led to some confusion, as regards which figures to use, the present paper proposes standard Level Recorder settings for a given averaging time. In addition the measurement procedure used is described in some detail in order to allow the user to check the averaging time of his recorder if he chooses to use other Level Recorder settings.

The measurement arrangement

The measurements were carried out by feeding a band-limited white noise signal to the Level Recorder and transforming the pen fluctuations proportionally to an electrical signal by means of an Analog Voltage Read-out Type ZR 0021 attached to the Level Recorder. The electrical signal was amplified by an experimental AC preamplifier with a very low lower limiting frequency and RMS detected by a device which allowed measurements to very low frequencies. (See Fig. 1).

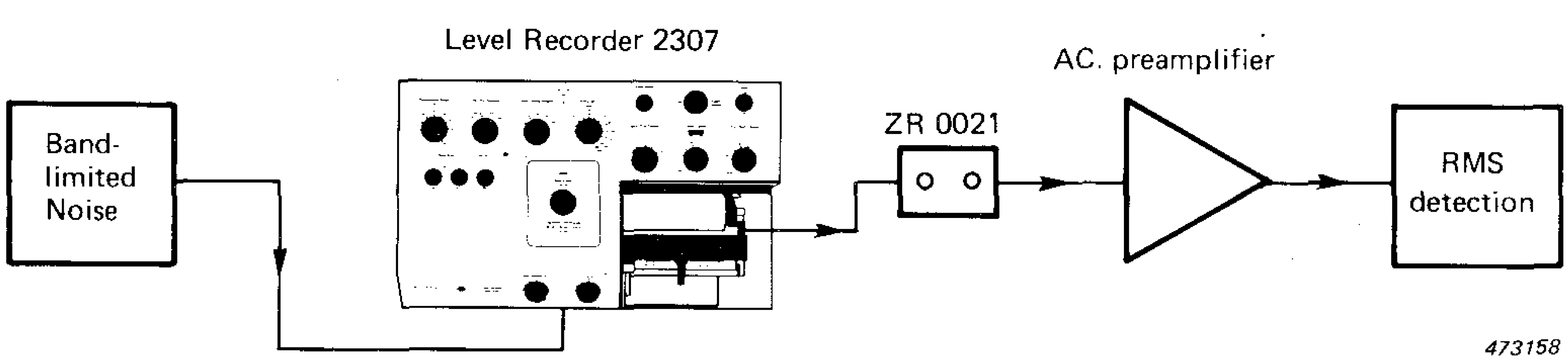

Fig. 1. Basic measurement arrangement

For a logarithmic potentiometer the measured RMS value can be considered to be proportional to the relative amplitude error ϵ_2. For small fluctuations the amplitude error equals half the energy error ϵ_1 and can be expressed in terms of bandwidth and averaging time as derived in the references

$$\epsilon_2 = \frac{\epsilon_1}{2} = \frac{1}{2\sqrt{BT}} \quad \text{i.e. } T = \frac{1}{4B\epsilon_2{}^2}$$

where B is the noise bandwidth
and T is the averaging time

A numerical example of the calibration procedure and of the calculation of the averaging time for a single measurement is given below. The output voltage from ZR 0021 was adjusted to change 1 V DC for a change of 10 dB in pen position (50 dB potentiometer and 50 mm paper). With a noise signal input of 30 Hz bandwidth at 1000 Hz centre frequency to the Level Recorder, which was set at a writing speed of 8 mm/s, the measured RMS value at the ZR 0021 output was 61 mV. This corresponded to 0,61 dB_{RMS} or a ratio of R = antilog (0,61/20) = 1,0728. This gives a relative error of $\epsilon_2 = 0{,}0728$ and the averaging time can then be calculated from

$$T = \frac{1}{4B\epsilon_2^2} = \frac{1}{4 \times 30 \times 0{,}0728^2} = 1{,}57 s$$

In order to determine ϵ_2 accurately enough, it is necessary to measure the very low frequency components of the pen fluctuations. This is particularly important at low pen speeds, and hence, the first measurements were carried out by means of tape recorder transformation of the measured fluctuation signal before its RMS value was measured. By this method frequencies down to 0,05 Hz were detected. Later the measurement system was extended downwards in frequency to be limited by the RC lower limiting frequency of 0,002 Hz of the AC preamplifier and by a detection time constant of 300 s of the meter circuit of a Measuring Amplifier Type 2607. The meter circuit alone, has virtually DC response when the capacitor C 1212 (0,68 F) on circuit board ZL 0027 is short circuited as shown in Fig.2a and provides full meter deflection for an input voltage of 5 V_{RMS} . This creates the need for gain in a separate amplifier which is therefore provided by the AC preamplifier. The signal from the AC preamplifier is connected to pin 1 of circuit board ZL 0012 of the Measuring Amplifier Type 2607. Care should, however, be taken, as no overload protection is provided at this point. A diagram of the preamplifier is given in Fig.2b together with its connection to the meter section of 2607. Measurements can also be carried out using the Frequency Analyzers Types 2114 and 2120 since they incorporate measuring circuits similar to those of Type 2607. The band limited noise signal could be taken from several different instrument combinations to provide different bandwidths. In the experiments described here, a Sine Random Generator Type 1024 and a Band Pass Filter Set Type 1614 were used to provide both relatively broad bandwidth signals and narrower noise bands at the same centre frequency. However, as the centre frequency of the signals do not influence the measurements, broad band random noise may also be obtained by one of the Random Noise Generators Types 1402 or 1405 in conjunction with the Band Pass Filter Set Type 1614. To filter the noise signal the Frequency Analyzers Types 2120 and 2121 can also be used. However, for each filter used, considerations should be given to the noise bandwidth as discussed later.

In the measurements of averaging time it is possible to use ZR 0021 for both 50 mm and 100 mm paper on the Level Recorder Type 2307

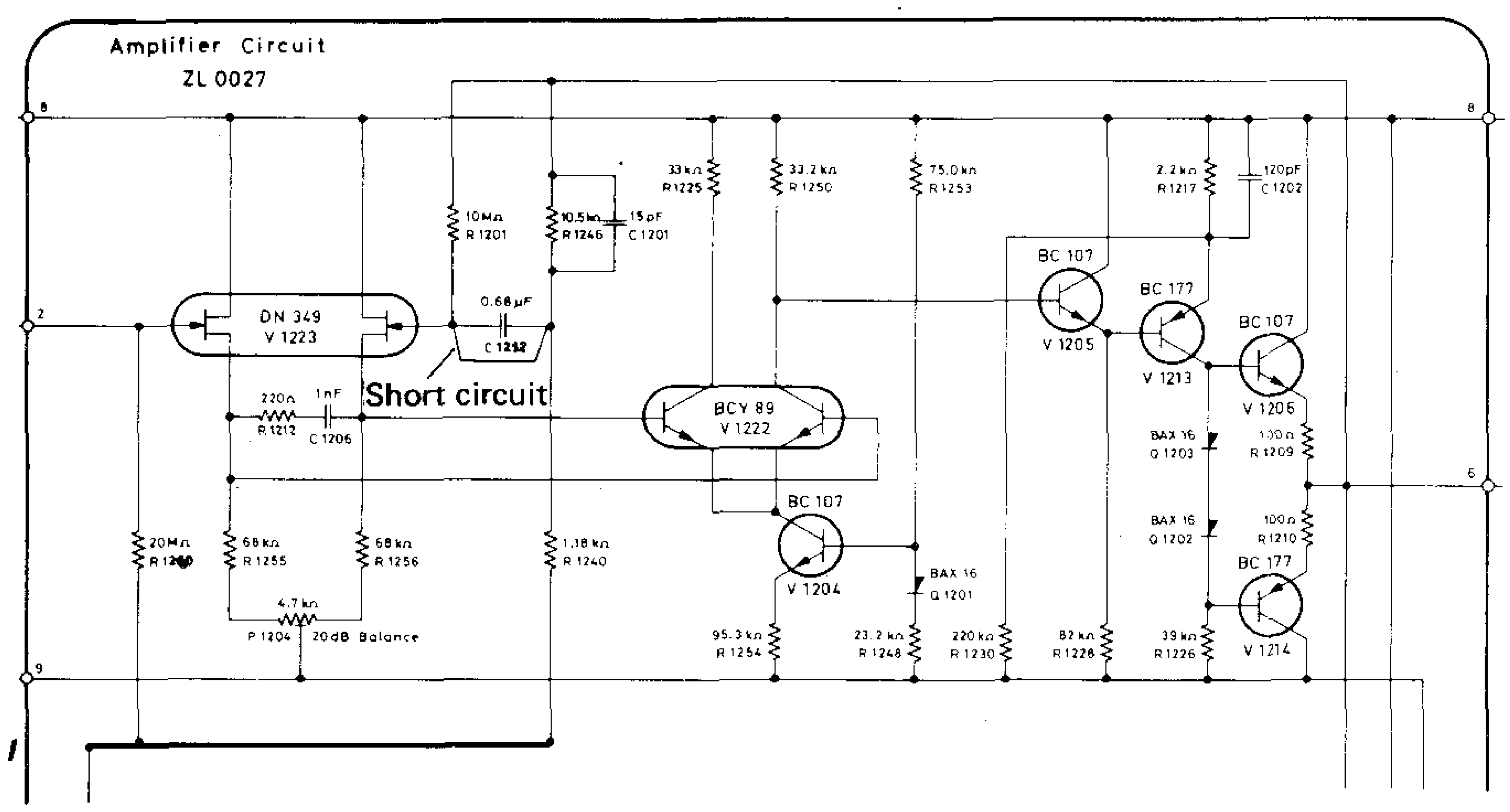

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Fig.2.a. The short circuit over the capacitor C 1212 in ZL 0027

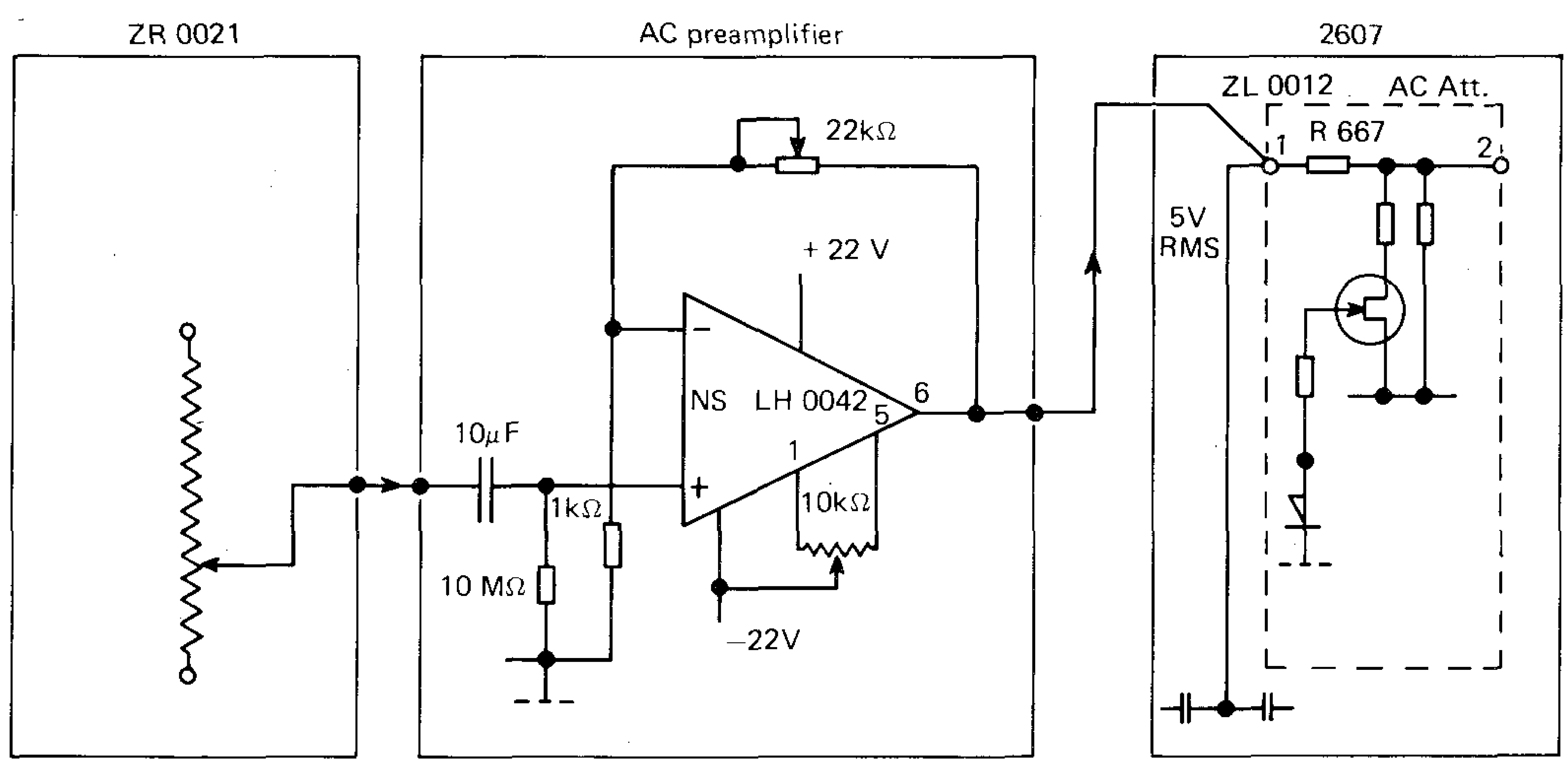

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Fig.2.b. The AC-preamplifier connected to ZR 0021 and 2607

whereas only 50 mm paper may be used with the ZR 0021 on the Level Recorder Type 2305.

Measurement results

A large number of measurements indicated that if "normal" conditions were maintained the results would be near the line given by the averaging times T= 0,01 s for pen speed 1000 mm/s and T= 5 s for pen speed 2 mm/s (50 mm paper). See curve 1 in Fig.3. The "normal" conditions referring to different parameters are discussed below.

Measurement frequency range

The measurement frequency range should extend to very low frequencies (this condition only refers to the correct measurement of the averaging time and not to the Level Recorder itself).

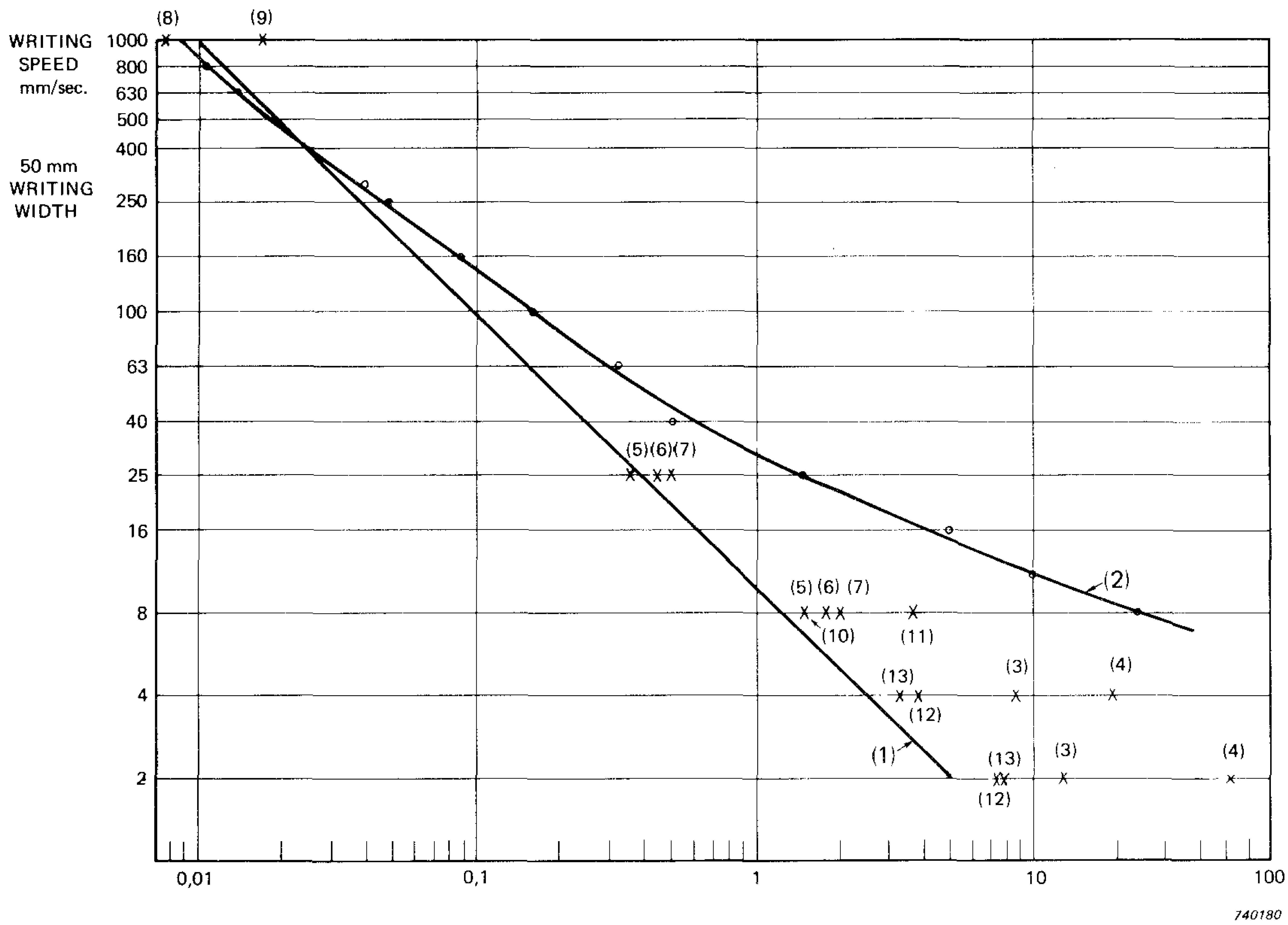

Fig.3. Measured averaging times

If the RMS detection of the pen deflection is limited by the lower limiting frequency of the measurement system RMS values measured will be too low resulting in too high a value for the calculated averaging time, especially for low writing speeds. Note the slope and the bend of curve 2 in Fig.3 which displays the results obtained with a lower limiting frequency of 2 Hz for the measuring system. The bend of the curve is typical of a low frequency cutoff.

Lower Limiting Frequency

For any given writing speed the lower limiting frequency of the Level Recorder should be chosen such that stable operation is ensured (see Fig.4). Varying the lower limiting frequency in the stable operation region does, however, influence the averaging time. The changes are found to be relatively small and do not consistently increase or decrease for increasing or decreasing lower limiting frequency. The points 5, 6 and 7 in Fig.4 give an example of increasing averaging time for increasing lower limiting frequency setting of the Level Recorder. These measurements were carried out with a 50 dB potentiometer on a signal of 30 Hz bandwidth and with lower limiting frequency settings of 2 Hz, 10 Hz and 200 Hz respectively.

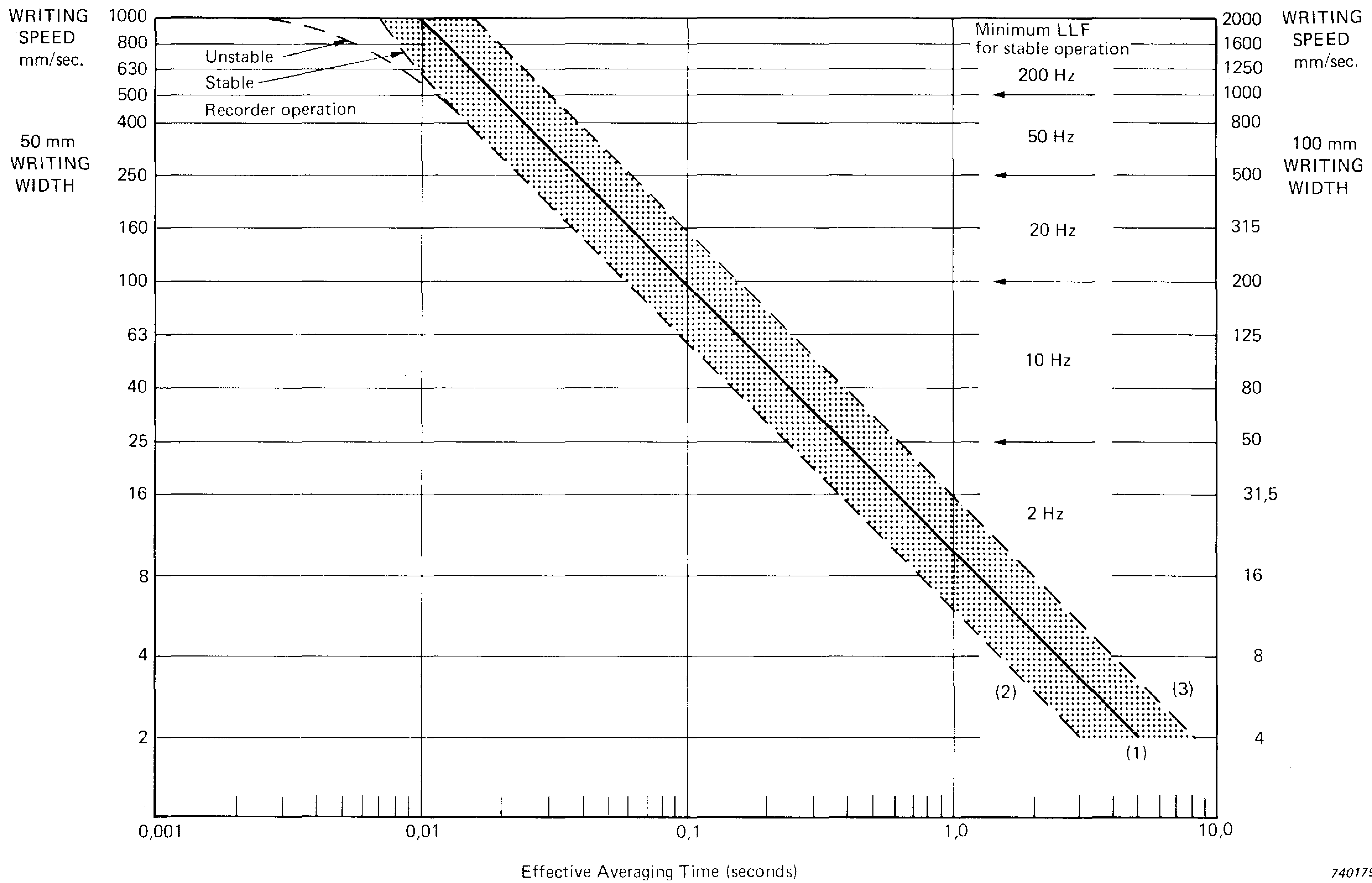

Fig. 4. Averaging times with tolerance limits

Pen Fluctuations
Since the writing system can be considered a linear circuit for small pen fluctuations only, they must be kept under 6 — 8 mm and 14 — 16 mm peak-peak for 50 mm and 100 mm paper respectively. If the pen fluctuations are increased beyond these limits, errors are introduced by the speed limiting circuits in the Level Recorder tending to increase the averaging time. Furthermore, for large fluctuations in dB (50 dB and 75 dB potentiometers) the simple relationship between amplitude fluctuation and averaging time is no longer valid. The increase of averaging time with increasing pen fluctuations is demonstrated by points 8 and 9 on Fig.3 which show the measured averaging times for 707 Hz and 30 Hz bandwidths respectively with a 50 dB potentiometer. Points 10 and 11 show the values of averaging times for the same bandwidths measured at a writing speed of 8 mm/s and with a 10 dB potentiometer.

In order to keep the pen deflections of reasonable magnitude within the above mentioned limits the 50 dB and 10 dB potentiometers were used for high and low writing speeds respectively. This is because a 50 dB potentiometer for a relatively wide noise bandwidth at low writing speeds would yield very small pen fluctuations for which the ZR 0021 potentiometer would provide insufficient resolution and thereby, too high averaging times would be calculated. On the other hand, a 10 dB potentiometer would give too large fluctuations for the same bandwidths at high writing speeds whereby the limits of pen deflection would be exceeded.

The potentiometer range setting
The potentiometer range attenuator should be in the appropriate position for the potentiometer used. (75 dB, 50 dB, 25 dB or 10 dB).

The averaging time can be increased by setting the "Potentiometer Range" attenuator to a higher setting than indicated by the used potentiometer. The points numbered 3 on Fig.3 are obtained with a signal of 30 Hz bandwidth, with a 10 dB potentiometer and the "Potentiometer Range" knob set at 10 dB. The points numbered 4 are obtained for similar conditions except that the "Potentiometer Range" knob is set at 50 dB. This trend is in agreement with Fig.15 of Ref. (2).

Points 3 and 4 although they show very high averaging time are included here only to show the effect of "Potentiometer Range" attenuator setting. The reason why the averaging times are so high is because 30 Hz bandwidth gives very large pen deflection. By using a 300 Hz and 707 Hz bandwidth for the same LLF the points 12 and 13 respectively are obtained and are found to lie very much closer to the curve 1 of Fig.3.

2305 compared to 2307

Though slightly higher averaging times were observed for the Level Recorder Type 2307 than for Type 2305 at high writing speeds the results clearly justify the use of the same nominal curve 1 of Fig.3.

Conclusions

Measurement results (though illustrated here by only a few examples) show a large spread in averaging time depending on various parameters of the Level Recorder and signal characteristics. Crest factors of signals (which we have not investigated) as well as noise bandwidths, discussed later, may also influence the values of averaging times. Although only small variations in results have been found for different B & K level recorders, deviations caused by production tolerances should neither be overlooked. It therefore seems reasonable to present averaging times for normal Level Recorder settings as a nominal curve which is a straight line in a double logarithmic plot (curve 1 in Figs.3 & 4). However, as the results show a spread in averaging times, they are given as a band of possible values shown by the shaded area of Fig.4. The curve to the left (curve 2) is the curve given by Broch and Wahrman, Ref. (2), which is considered the limiting curve for zero pen fluctuations. The curve to the right (curve 3) is considered as the limiting curve for max. allowed pen deflections. (Approximately 6 — 8 mm peak-peak on 50 mm paper and 14 — 16 mm peak-peak on 100 mm paper).

The numerical values of the nominal curve which could be used for most measurement purposes are given in Table 1 for both 50 mm and 100 mm recording paper. However, to obtain as good agreement as possible it is advisable to choose writing speeds and thereby averaging times so that pen fluctuations are somewhat less than the limits given in Table 2 for different potentiometers.

As no changes are introduced in the moving system of the Level Recorders by interchange of potentiometers, the nominal curve would be valid for all logarithmic potentiometers provided the limits of Table 2 are observed. For linear potentiometers, however, a slightly different measurement and calculation procedure of the averaging time would be required. In this case the measured RMS value of fluctuation should be calibrated in volts and divided by the mean RMS value of the recording in order to obtain ϵ_2.

Writing speed mm/s		Averaging time s
100 mm paper	50 mm paper	
2000 1600 1250	1000 800 630	0,01 0,0125 0,016
1000 800 500	500 400 250	0,02 0,025 0,04
315 200 125	160 100 63	0,063 0,1 0,16
80 50 31,5	40 25 16	0,25 0,4 0,63
16 8 4	8 4 2	1,25 2,5 5

Table 1. Averaging times for Normal Recorder settings

For applications where it is of importance to know the averaging time with greater accuracy it is suggested that the averaging time be determined for the Level Recorder settings (including the potentiometer and potentiometer range setting) that would be used during the measurements. Consideration should also be given to the signal characteristics.

	Potentiometers			
	75 dB	50 dB	25 dB	10 dB
Max. peak-peak fluctuation dB	6 — 8	6 — 8	3 — 4	1,2 — 1,6

Table 2. Max. peak-peak fluctuations in dB of recording

The signal bandwidth should be taken as noise bandwidth since there might be over 10% deviation from half power bandwidth or —3 dB bandwidth in some filter types and as low as 1% in others.

In determining the averaging times, the bandwidth of the noise signal should be chosen so that approximately the same amount of fluctuations are experienced. The pen should be in contact with the paper as with a free pen slightly different results might be obtained. No appreciable difference has been observed (by visual means) in the recordings with or without the ZR 0021 contact connected although one might expect the contrary to occur.

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A simple Equipment for direct Measurement of Reverberation Time using Level Recorder Type 2305

by

Tamás Pritz dipl. eng.)*

ABSTRACT

An arrangement which gives a direct indication on a digital time meter reduces the need for determination of reverberation time from sound decay recordings which are rather time consuming. The results are in good agreement with those obtained from the decay recordings.

SOMMAIRE

Un système donnant une indication directe par affichage numérique réduit la nécessité de déterminer le temps de réverbération à partir des courbes de décroissance enregistrées, ce qui prend en général beaucoup de temps. Les résultats obtenus sont en bon accord avec les temps de réverbération déterminés à partir des courbes.

ZUSAMMENFASSUNG

Es wird eine Meßausrüstung beschrieben, die es ermöglicht, die Nachhallzeit eines Raumes direkt an einem Zeitzähler digital abzulesen ohne die zeitaufwendige Aufzeichnung von Nachhallkurven. Die Ergebnisse sind in guter Übereinstimmung mit denen, die über den Weg der Aufzeichnung gewonnen wurden.

The measurement of reverberation time can usually be made in a traditional manner, by means of a Level Recorder, not considering the new Reverberation Processor Type 4422. The reverberation time can be determined based on the reverberation decay curves drawn on the recording paper. Therefore, the measurement provides the reverberation time in an indirect way. The determination of reverberation time from the recorded decay curves is highly time absorbing and dependent on the individual — especially in the case of irregular reverberation processes.

A simple equipment has been planned and constructed for the direct measurement of reverberation time, with which the measurement can be made quickly and objectively. The principle of the measurement is that with a Digital Time Meter we measure the time during which the sound pressure in a room decreases 30 dB after the sound source has

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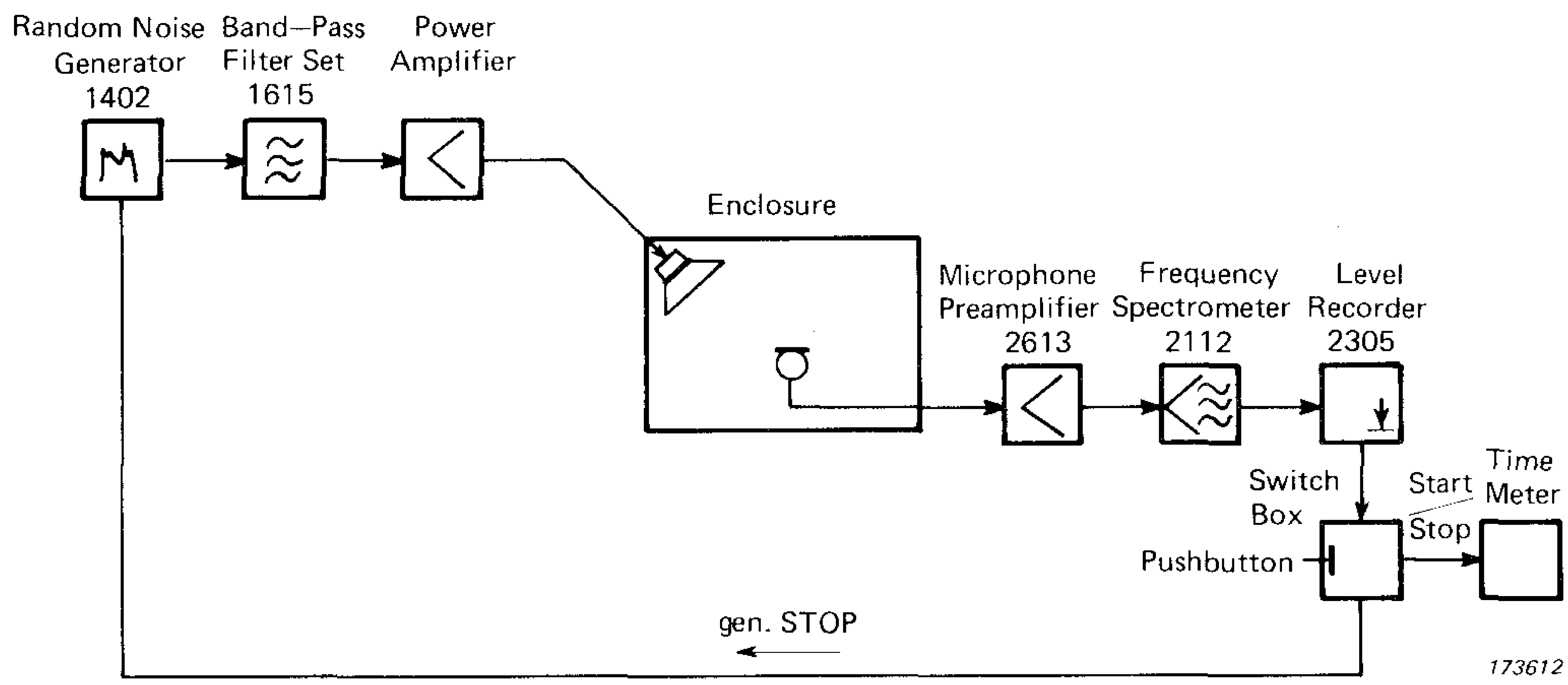

Fig. 1. *Arrangement for direct measurement of reverberation time*

been switched off. The reverberation time is twice the value of the measured time. The measuring arrangement of the reverberation time is shown in Fig.1.

The measurement is done in the following manner: When the gen. STOP impulse switches off the Random Noise Generator, a START impulse is received simultaneously by a Time Meter. When the sound pressure in the room decreases by 30 dB, a STOP impulse is received by the Time Meter, halting the measurement of time. Thus, half of the reverberation time can directly be read off from the Time Meter.

An important detail of the circuit, generating the START and STOP impulses for the Time Meter, as well as the gen. STOP impulse for the Random Noise Generator, is the Contact Device. This Contact Device is fixed on the top of the Writing Arm of the Level Recorder. The Contact Device consists of three contacts made of copper foil, as can be seen in Fig.2. The distance between the two upper contacts is set to be 30 dB,

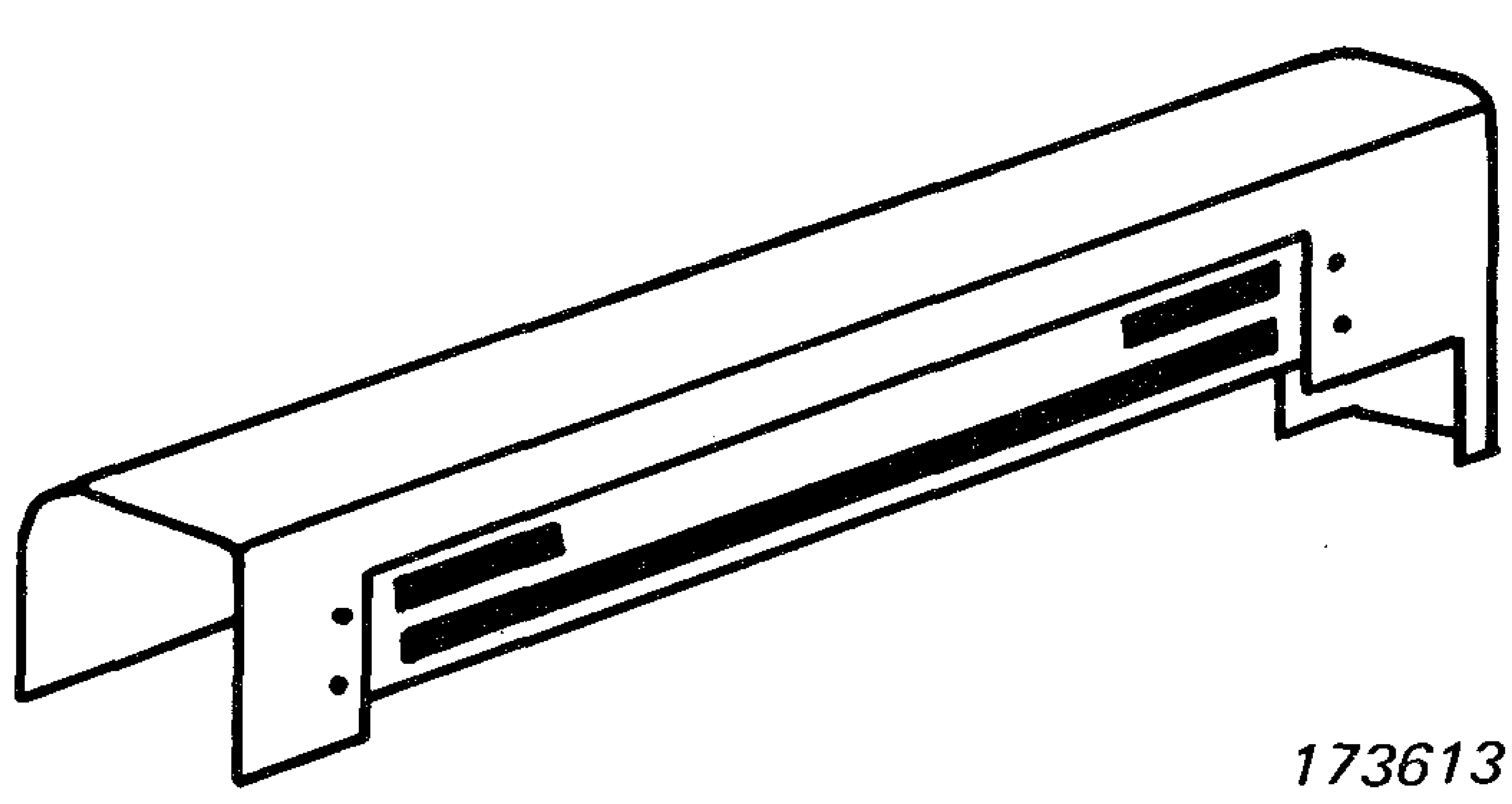

Fig. 2. *The contact device*

for a 50 dB Potentiometer in the Level Recorder. The Contact Slider Type OD 0130 — a component of the Statistical Distribution Analyser Type 4420 — moves together with the Writing Stylus. The Contact Slider grazes the foil contacts and links up the lower and upper contacts, whereby the STOP and START impulses are generated.

The Measurement Procedure

The detailed scheme of the electronic circuit is shown in Fig.3. To explain the function of the circuit, we have to consider that state where the Random Noise Generator is in operation and the sound pressure is stationary in the room. At this point, the Contact Slider should be between the upper contacts marked by c_1 and c_2, but nearer to c_1. The relays marked N and S are in a released state. The Pushbutton is not depressed and the Time Meter is on zero.

By adjusting the Input Potentiometer of the Level Recorder the Contact Slider is made to approach contact c_1. At the moment when the Contact Slider touches contact c_1, the relays marked S and N are in operation. The time of operation for delays S and N are identical.

The relay contact n of relay N short-circuits the Noise Generating Circuit, and the loudspeaker is shut off. Simultaneously the Time Meter receives a ground impulse through the Pulsing Circuit from relay contact s_1 of relay S. As a result of this the Time Meter begins operation. In the meanwhile, according to the decrease of the sound pressure in the

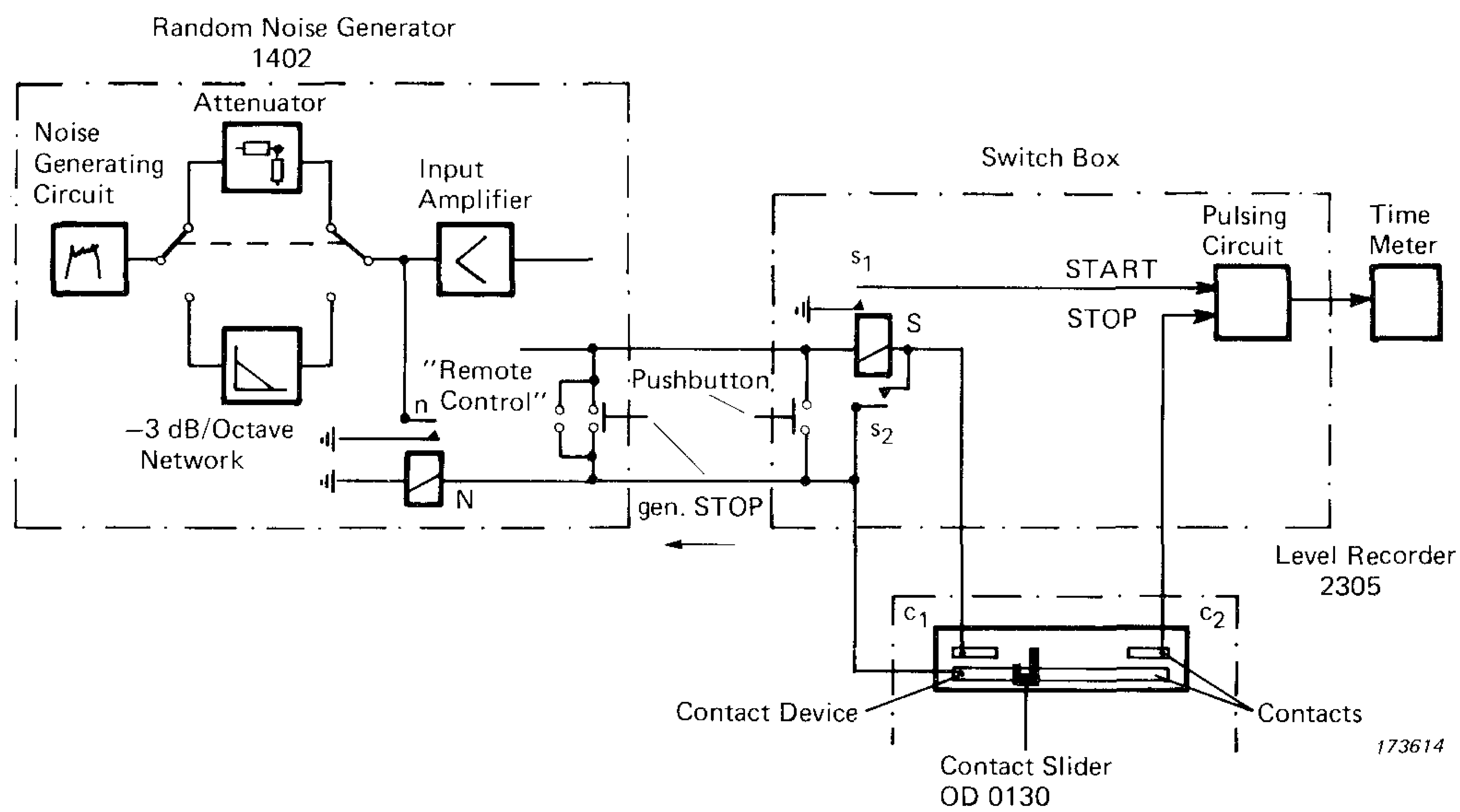

Fig.3. A schematic view of the electronic circuits for direct measurement of reverberation time

room, the Contact Slider leaves contact c_1, and relay N would be released. This is prevented by the fact that relay contact s_2 of relay S secures a holding circuit for relay N. When the Contact Slider reaches contact c_2, the Time Meter receives a STOP impulse through the Pulsing Circuit from the lower contact of the Contact Device. As a result, the Time Meter stops the counting and we can directly read off half of the reverberation time. Before starting the next measurement, the Time Meter has to be set on zero. By pressing the pushbutton of the generator, relay S is short-circuited, and is released. While the Pushbutton is pressed, relay N is also in operation. Releasing the Pushbutton, the circuit of relay N brakes, and the loudspeaker begins operation, and the measurement can be carried out as shown above. The advantage of this measuring method is that the reverberation time decay can also be drawn by the Level Recorder, simultaneously with the direct measurement.

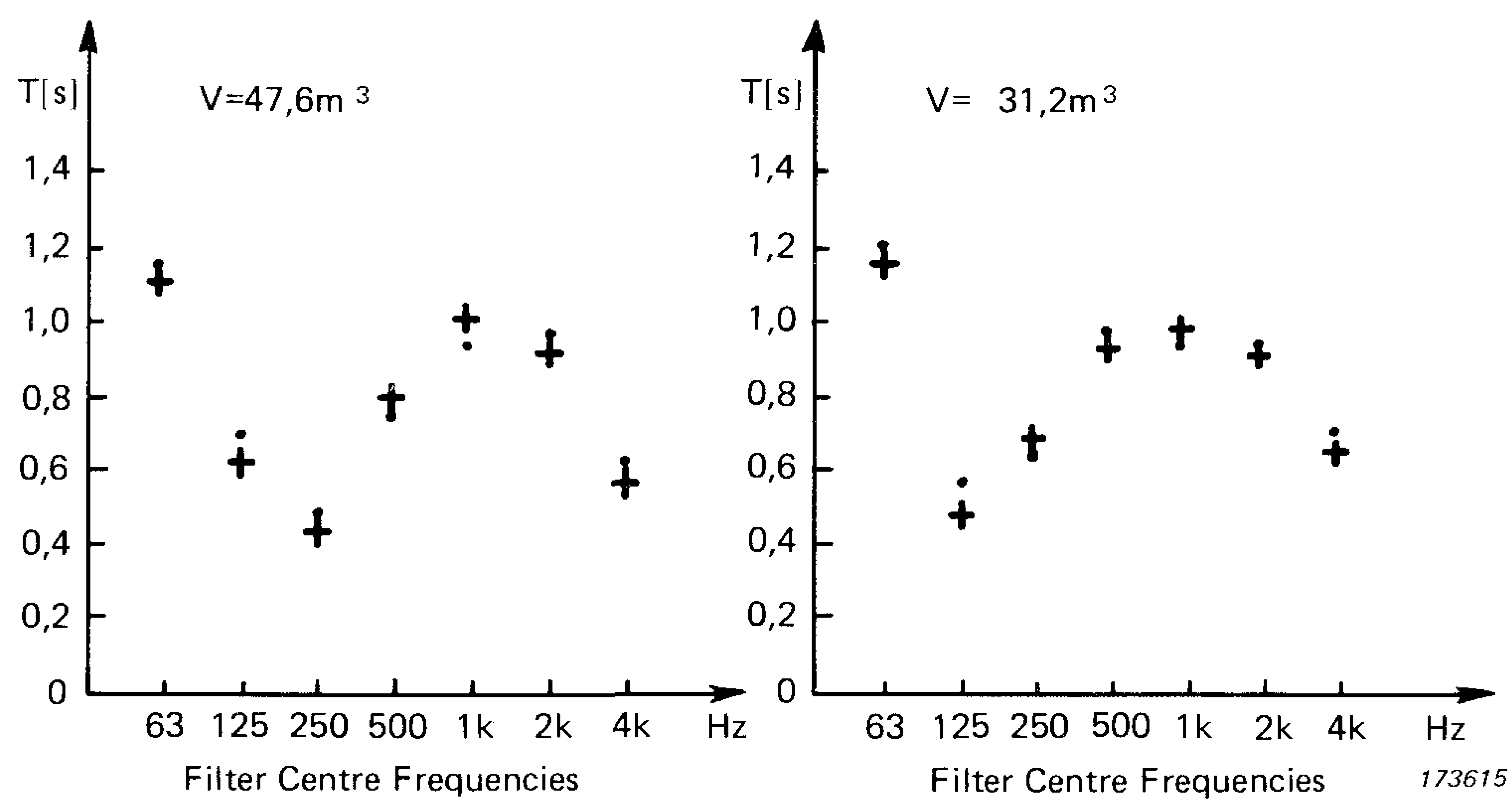

Fig.4. Measured reverberation time
● Direct method
+ Traditional method

The reverberation times of two rooms have been measured by the direct and the traditional methods. The values of the measured reverberation times are shown in Fig.4. The results obtained by the two different measuring methods are quite similar.

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Brief Communication

The intention of this section in the B & K Technical Reviews is to cover more practical aspects of the use of Brüel & Kjær instruments. It is meant to be an "open forum" for communication between the readers of the Review and our development and application laboratories. We therefore invite you to contribute to this communication whenever you have solved a measurement problem that you think may be of general interest to users of B & K equipment. The only restriction to contributions is that they should be as short as possible and preferably no longer than 3 typewritten pages (A4).

Influence of Sunbeams striking the Diaphragms of Measuring Microphones

by

Erling Frederiksen

Introduction

During acoustic measurements in open air, microphones sometimes encounter sumbeams striking on their surface. The energy density of the sunbeams would, as a consequence, heat the microphones resulting in a possible change of microphone sensitivity. Experiments were therefore carried out under simulated conditions to investigate the change in microphone sensitivity between sunshine and clouded weather.

Measurement Procedure

In the space the energy density of the sunbeams is approximately 1360 W/m^2, however, when they pass the atmosphere the density is reduced depending on the weather conditions. On a day with clear sunshine the energy density has at Brüel & Kjær been measured to about 70% of the level in the space, though, even light clouds can reduce the level to 50% or lower.

On account of the practical difficulties in achieving free-field conditions outdoors, as well as unstable weather conditions in Copenhagen, the experiments have been performed in an anechoic chamber with the aid of a 1000 W electric bulb, used as the energy source.

The power radiation for the measurements was measured by means of a small black plate (50 mm x 50 mm). On one side of the plate an electric heating element was mounted while on the other side a normal silicon diode.

The plate was placed in the radiation field to be measured and the leakage current through the diode was observed. The power beam was then stopped and electric power was supplied to the heating element until the same leakage current was obtained. The electric power supplied which is easily measurable, is assumed then to be equal to the power received from the beam source.

The power at the diaphragm position was measured to be 0,8 kW/m^2 or approx. 60% of space density.

Before the measurements were performed, the change in sound pressure level at the microphone position was checked with the light on and off, and was found to be less than 0,02 dB. Fig.1 shows the set-up used.

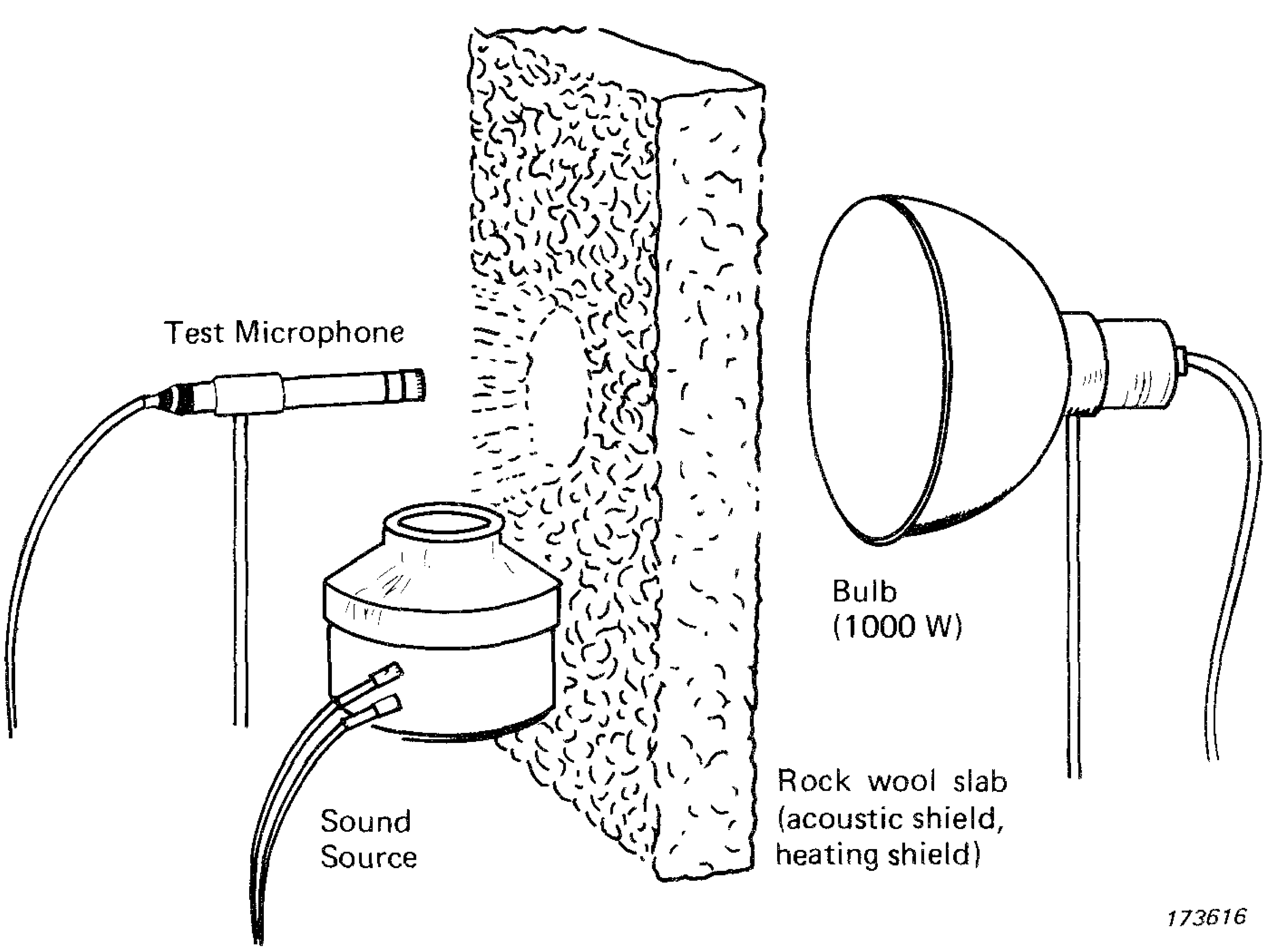

Fig. 1. The measurement arrangement

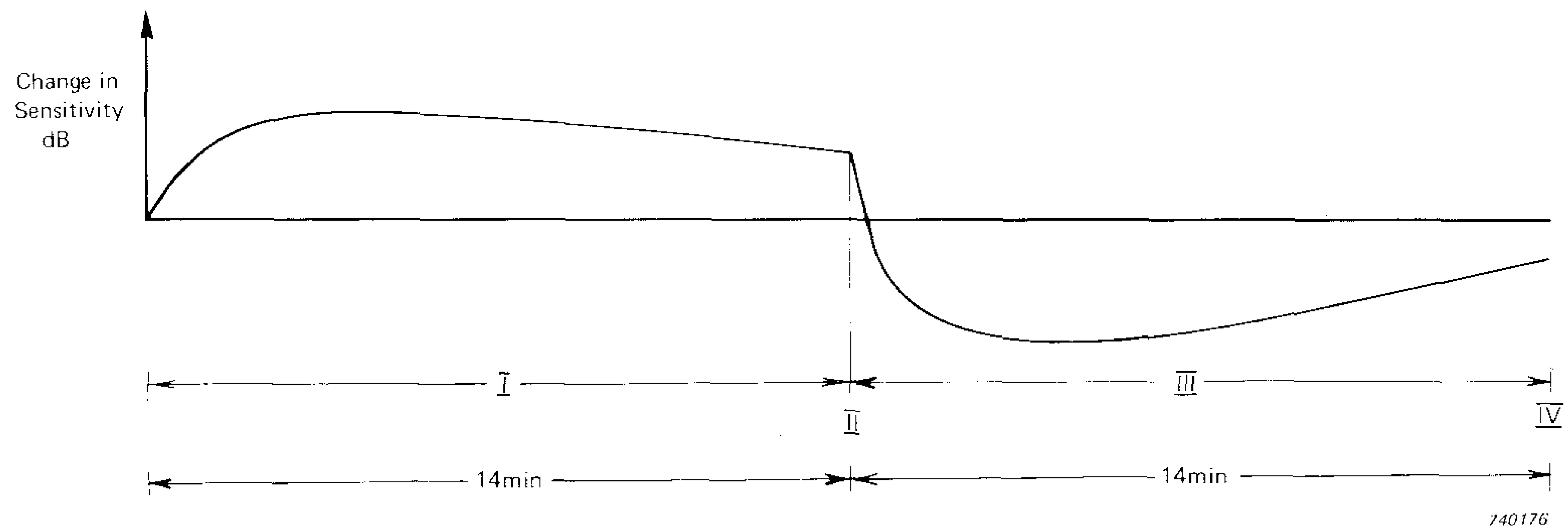

Fig.2. The microphone sensitivity as a function of time during power and powerless periods

The output signals from various microphones were observed during 14 minutes with the bulb on, followed by 14 minutes with the bulb off.

Fig.2 shows a typical curve of the change in sensitivity obtained. The maximum changes for five different microphones are given in the table below:

	Measurement Conditions	Microphone Type Number				
		4133	4134	4149	4144	4117
I	Max. change in power period (dB)	<0,02	<0,02	<0,02	+0,035	–0,035
II	Change at end of power period (dB)	<0,02	<0,02	<0,02	+0,035	–0,035
III	Max. change in powerless period (dB)	–0,035	–0,025	–0,04	<0,02	–0,04
IV	Change at end of powerless period (dB)	<0,02	–0,02	–0,025	<0,02	<0,02

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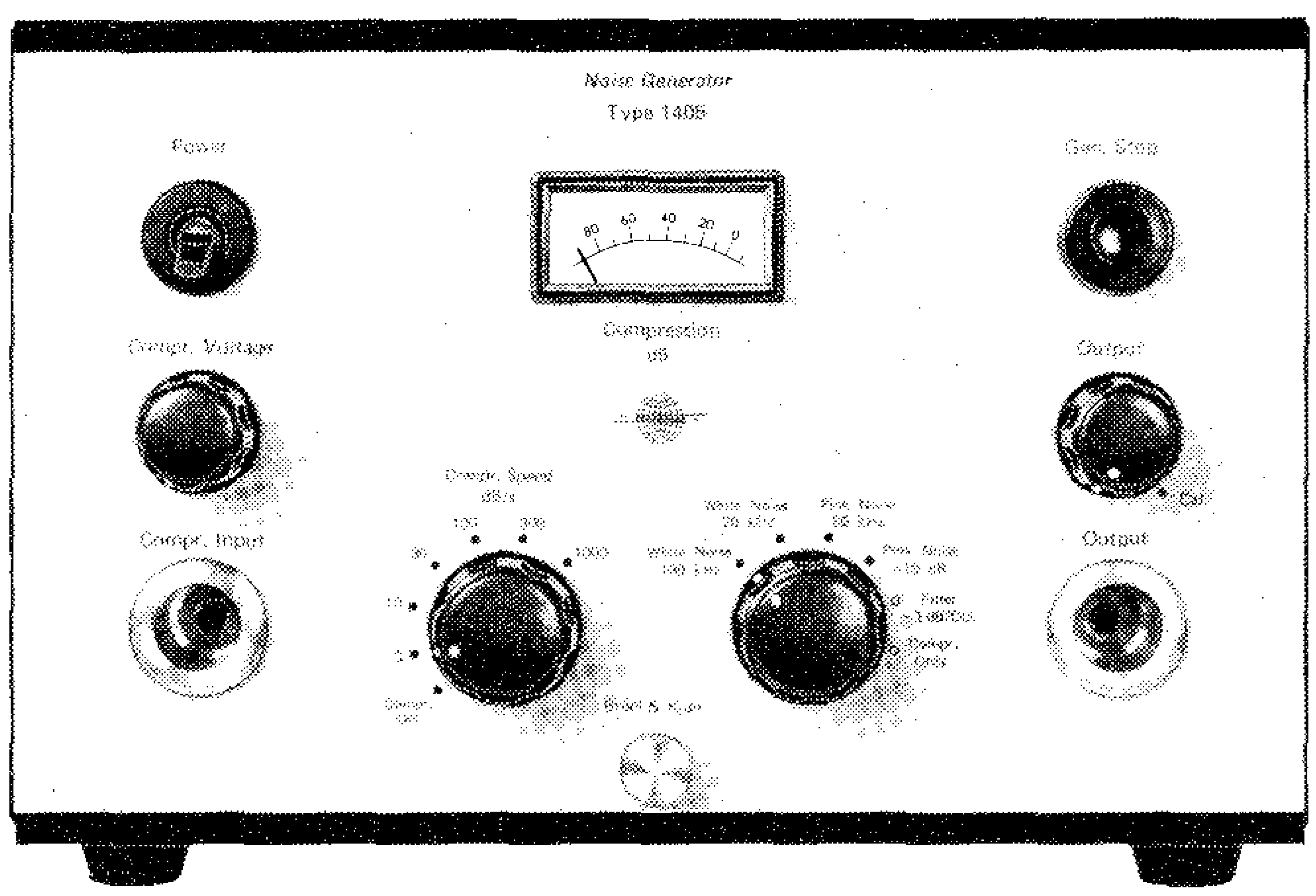
Table 1. The change of microphone sensitivity during period of observation

It should be noted, that the values quoted in the table **include** the change in sound pressure level between the light on, and off, mentioned above. Although the changes in microphone sensitivity are very small for different conditions of radiation it should, however, be noted that a change of radiation intensity will produce a transient signal which may disturb measurements. The main cause of this signal is the rapid heating or cooling of the air in the back volume of the microphone, the diaphragm of which will be displaced by the resulting pressure change until equality is restored by air flow through the equalisation vent of the microphone.

The results were obtained with no protection of the microphone diaphragms. The standard protection grid, it might be mentioned, reduces the intensity of the sunbeams by 60% and a 6 mm thick piece of the foam normally used for windscreens attenuates the intensity by more than 70%.

News from the Factory

Noise Generator Type 1405



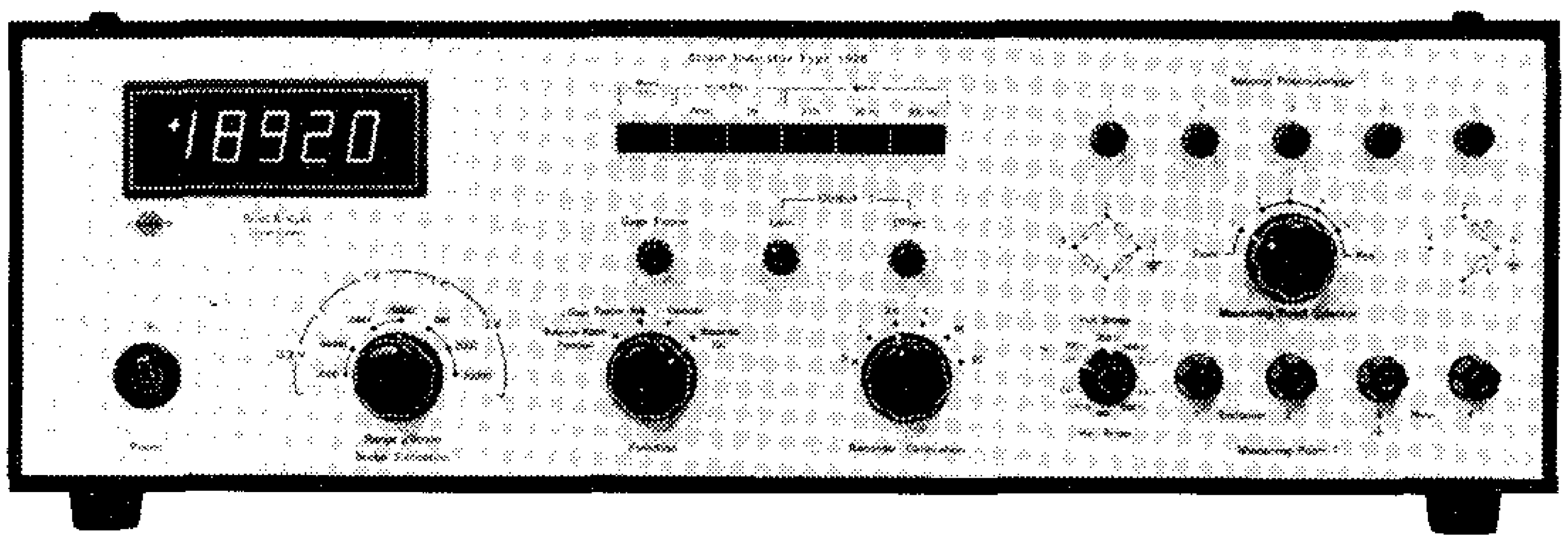
The new noise generator supplies well defined white noise with a uniform spectral density of 10^{-4} V^2/Hz for use in applications such as vibration analysis with shakers, reverberation measurements, frequency response of electronic devices, cross-talk measurements etc.

The generator has six working modes

1. Output of white noise from 20 Hz to 100 kHz
2. Output of white noise from 20 Hz to 20 kHz
3. Output of pink noise (white noise decreasing at 3 dB/octave) from 20 Hz to 50 kHz
4. Same as 3) but at 10 dB lower level (for use with 1/3 octave Filter Set Type 1616)
5. Use as —3 dB/octave filter (for example for use as automatic bandwidth compensation)
6. Use as compressor amplifier.

The compressor has six working speeds of 3, 10, 30, 100, 300 and 1000 dB/s and a control range > 80 dB. The signal to hum ratio is better than 90 dB while other notable features are calibrated output 3,16 V RMS (continuously adjustable down to 0 V), manually or remotely operated generator stop function and mains or battery operation.

Strain Indicator Type 1526



Static and dynamic strains upto a frequency of 300 Hz can be read directly by the newly developed digital Strain Indicator Type 1526.

Problems encountered with DC systems such as thermocouple effects and magnetic and electric noise are eliminated, on account of the use of a carrier frequency system which also permits the use of low bridge excitation voltages of 3 V, 1 V, and 0,3 V. Hence the low heat dissipation makes the instrument ideal for measurements on epoxies, glass and other low thermal conductivity materials. The five measuring channels which can be individually calibrated can accept strain gauges in the range 50 to 2000 Ω in half or full bridge configuration. The use of the demodulator principle permits resistive and capacitive balance to be achieved by just a single potentiometer.

With the aid of the function selector, the digital display would give directly, in turn, instantaneous values of strain (0,1 — 2000 $\mu\epsilon$), gauge factor (in the range 1,00 to 10,00) and the bridge balance reading. Under overload conditions, the display flashes on and off.

The "maximum hold" function captures max. levels of transients, and is also useful in separating the static and dynamic signals when both are present. A set of low pass filters of 3 Hz, 30 Hz and 300 Hz are provided to remove undesired dynamic signals. Three outputs are available, a normal analog output, an output with adjustable offset and gain for use with Level Recorders, and a B C D output for digital peripherals. A plug-in calibration bridge is included as an accessory offering 1% accuracy when the instrument is used as a transducer read out.

General Purpose Vibration Meter Type 2511

The new portable Vibration Meter Type 2511 is versatile and suitable for both laboratory and field work.

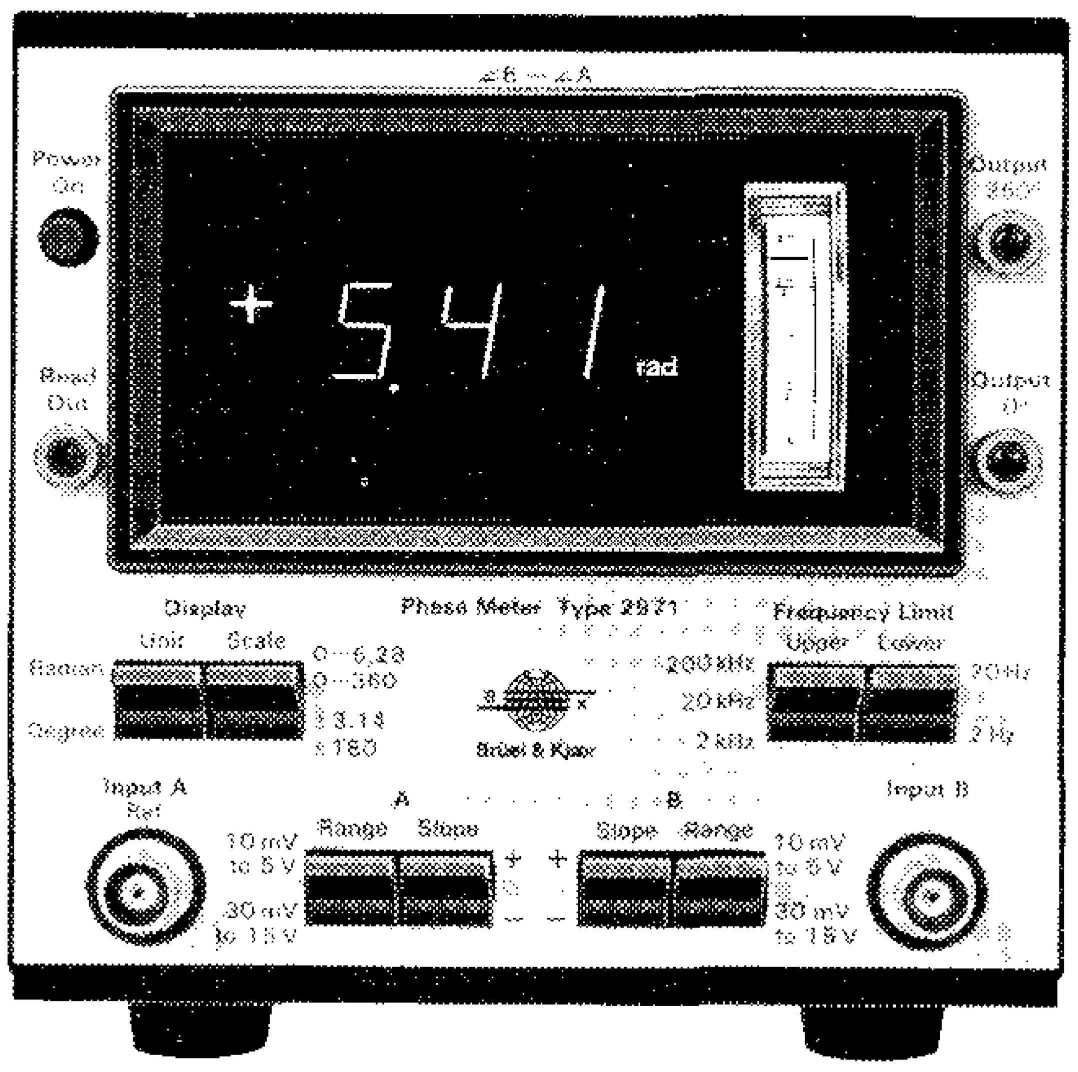
Accelerations of mechanical shocks and vibration can be measured in the frequency range 0,3 Hz to 3,6 kHz (to 12 kHz with Accelerometer Type 4343) in both Metric and British units, however the frequency limits for velocity and displacement measurements depend on the integrating circuits. RMS and peak detectors are incorporated, both of which can also be used in the "Hold" function by which the maximum vibration level of a transient can be captured.

High pass 1 Hz, 3 Hz and 10 Hz filters are provided as well as low pass filters of 1 kHz and 15 kHz. BNC input and output sockets make connection of external filters possible whereby a narrow band frequency analysis is feasible.

A meter calibrator is built-in, while power to the instrument can be supplied either by built-in batteries or externally by power supplies Types 2805 or 2808.

Finally AC, DC Lin, and DC Log recorder outputs are available for recording vibration levels on Level Recorders.

Phase Meter Type 2971



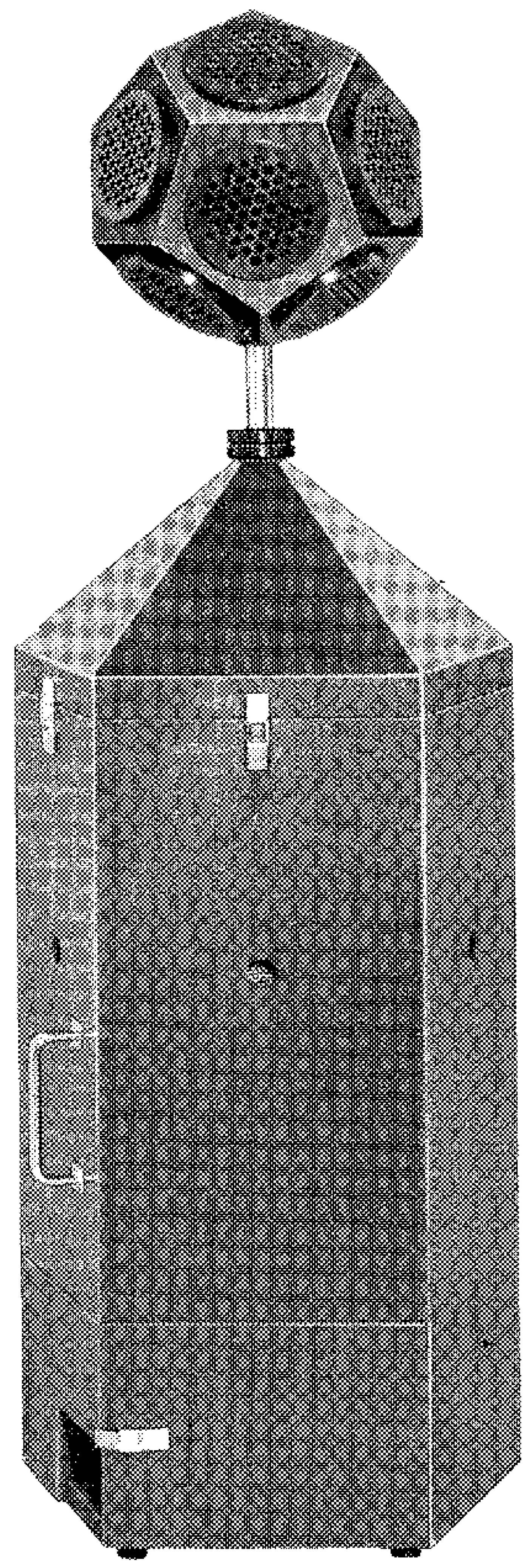
The Phase Meter Type 2971 measures the phase angle between two alternating voltages of the same frequency in the frequency range 2 Hz — 200 kHz. The large digital display shows the amplitude of the phase angle in degrees or radians and also indicates whether the unknown signal leads or lags behind the reference signal. An analog edgewise meter which also displays the phase angle in radians gives a convenient survey of phase changes during response measurements.

"Out of dynamic range" indicators on both the signal channels facilitate use of the instrument, while the adjustable polarity of trigger slope makes measurements possible on unsymmetrical signals, a feature very important for mechanical measurements.

A DC output is available for X-Y or level recorders as well as a digital output for tape punch.

The phase meter is not only useful in phase measurements of electrical components such as filters, amplifiers, transformers etc. but is ideal for mechanical dynamic measurements for example dynamic elasticity, balancing, mechanical mobility etc. Together with the Digital Delay Unit Type 5675 the complete phase characteristics of loudspeakers can be obtained.

Isotropic Sound Source Type 4241



The frequent need in building acoustics of a sound source radiating equally in all directions has resulted in the development of the Isotropic Sound Source Type 4241. The instrument contains a high frequency and a low frequency unit to obtain a wide frequency range 10 Hz — 4 kHz. The directional characteristic is spherical within 3 dB for frequencies below 3000 Hz.

The maximum obtainable sound pressure level is more than 90 dB re. 2×10^{-5} Pa at a distance of 1 m from the centre of the instrument under free-field conditions while the maximum acoustic radiated power is more than 0,01 watt.

A B & K Power Amplifier Type 2706 is mounted at the bottom of the mahogany case which is able to drive the sound source at maximum ratings.

The size and weight of the instrument make it ideal for both laboratory and field use.

Typical applications of the instrument are in building acoustic research, reverberation and insulation measurements as well as educational acoustic experiments.

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