

Application Note

An Overview of Standards for Sound Power Determination

by Erik Cletus Petersen, Brüel & Kjær, Denmark

In Europe, a new "Machinery Directive" has been written, coming into force from 1/1/95 (see Appendix C). The purpose of this directive is to ensure the health of people using machines.

The directive states, among other things, that equipment sold in Europe must fulfil specified noise demands. The equipment covered by this directive is everything from jacks and garden tractors, to chain saws and plastic moulding machines.

What should be stated in the instruction manual for the equipment?

If the A-weighted sound pressure level is below 70 dB(A), this must be indicated ($L_p < 70 \text{ dB(A) re } 20 \text{ Pa}$).

Above 70 dB(A), the A-weighted sound pressure level should be stated.

If the sound pressure level exceeds 85 dB(A), the A-weighted sound power level should also be stated.

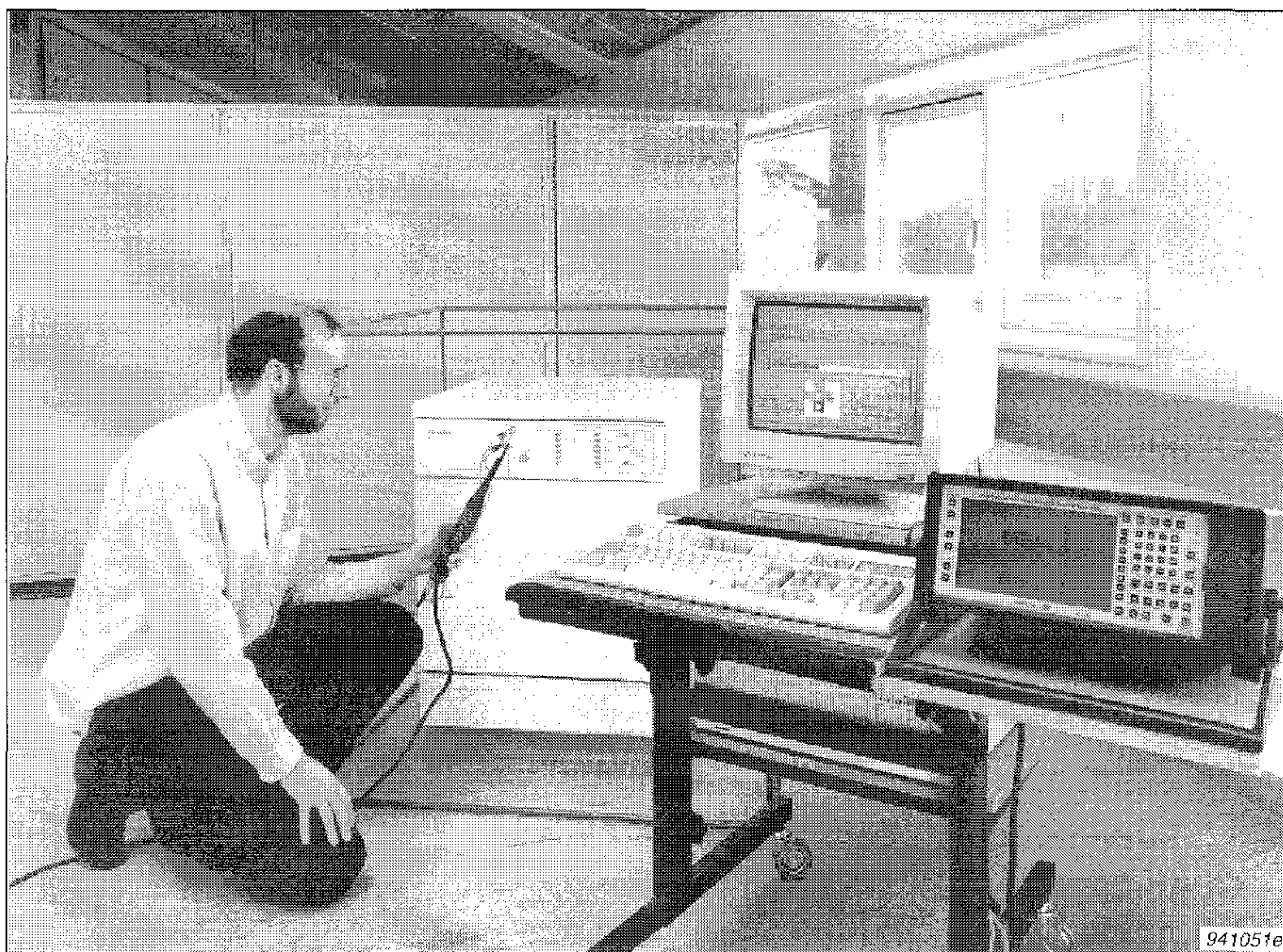
If the machine is very large, the sound power level is replaced by the sound pressure level measured at significant positions.

If the noise contains peaks exceeding 130 dB(C), this must also be stated.

Note that all sound pressure levels should be measured under "free field" conditions at the position of the operators head. If that is not defined, the sound pressure level must be measured at a distance of 1 metre from the surface of the machinery at a height of 1.6 metres from the floor.

Introduction

This application note is an introduction to the large number of international standards existing regarding sound power determination. The standards mentioned are mainly ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), ECMA (European Computer Manufacturers Association), DIN (Deutsches Institut für Normung e.V.), ANSI (American National Standards Institute) and



Measurement using Brüel & Kjær Sound Power Program Type 7679, which guides the user through the measurement according to the ISO 9614-2 standard

some of the European "Council Directives".

The standards can be divided into three main groups: Basic standards for performing the sound power determination, environment test standards which describe the operation conditions under which the sound power determination should be performed, and finally the standards which describe instrumentation to be used. Except for the environment standards, where a lot of different standards and council directives exist, all the important standards for sound power determination are covered by this application note.

Note: As a cross reference, Appendix A gives a list of the suggested instrumentation for different methods of sound power determination, and Appendix B lists all the standards covered in this application note.

Why measure?

To prevent people from getting hearing damage, all surrounding noise-emitting equipment should be made as silent as possible. This also makes the equipment more pleasant to operate.

The reason for stating the sound power is not only because legislation demands it, — it is customer driven. For an increasing number of customers, it is important to evaluate different products' noise specifications before they buy. Note that for most manufacturers it is important that their measurements are made according to an international standard. This gives a form of security, otherwise they might later be held responsible for their noise specifications by consumer organizations all over the world.

What to measure?

In the past, the sound pressure level was what people were used to measuring, but with more complicated noise problems, the use of sound power has become more and more popular.

Sound power is the acoustical energy per time unit, produced by a sound source [Watt].

A sound source radiates power and this creates sound pressure. Sound power is the cause. Sound pressure is the effect. Consider the following analogy. An electric heater radiates heat into a room and temperature is the effect. The temperature in the room is obviously dependent on the room itself, the insulation, and whether other sources of heat are present. For the same electrical power input, the heater radiates the same power, no matter what environment it is in. The relationship between sound power and sound pressure is similar. What we hear is sound pressure but it is caused by the sound power emitted from the source.

How should the measurement be made?

The sound power can be determined from sound pressure measurements. Unfortunately the room has an influence which affects the measurement.

The sound power can also be determined from sound intensity measurements. This method has the advantage that the room and stationary neighbouring sound sources theoretically do not influence the sound power determination.

It is important to keep in mind that sound power determination also includes the operational conditions of the noise source, under which the sound power is going to be determined.

What equipment should be used?

That depends on the method chosen, whether it is based on pressure or intensity. Pressure based equipment, such as sound level meters, is inexpensive, but it may require special rooms to obtain a sufficient accuracy, and then the total cost easily overtakes that of intensity based equipment.

Determination of Sound Power based on Sound Pressure Measurements

This method is governed by ISO 3741-47, ANSI S12.31-36 and DIN 45 635. There are two different methods for sound power determination based on pressure measurements; the direct method and the comparison method.

The direct method is primarily used in the free or semi-free field.

The principle of the direct method is that the sound source under investigation is placed in a known acoustic environment and then measurements of the spatially averaged sound pressure level are made with the sound source operating (see Fig.1 and 2). The background noise is also measured, and where necessary, a correction for the background noise is made. The sound power of the source is then calculated from the sound pressure measurements and a knowledge of the acoustic environment.

Two types of acoustic environment are used for such determination, namely, a diffuse sound field, as produced by a reverberation room, and a free sound field or a free sound field over a reflecting plane, as produced by an anechoic or semi-anechoic chamber, respectively.

The principle of the comparison method is that the sound source under investigation is placed in a known acoustic environment (diffuse sound field only), together with a known reference sound source (see Fig.9). First, the reference sound source is turned on and the spatially averaged sound pressure level is measured (see Fig.3). Then the reference sound source is interchanged with the source under investigation. Once again the spatially averaged sound pressure level is measured and since a relationship exists (the acoustic environment) between sound power and sound pressure, it is now very simple to calculate the sound power of the sound source under investigation.

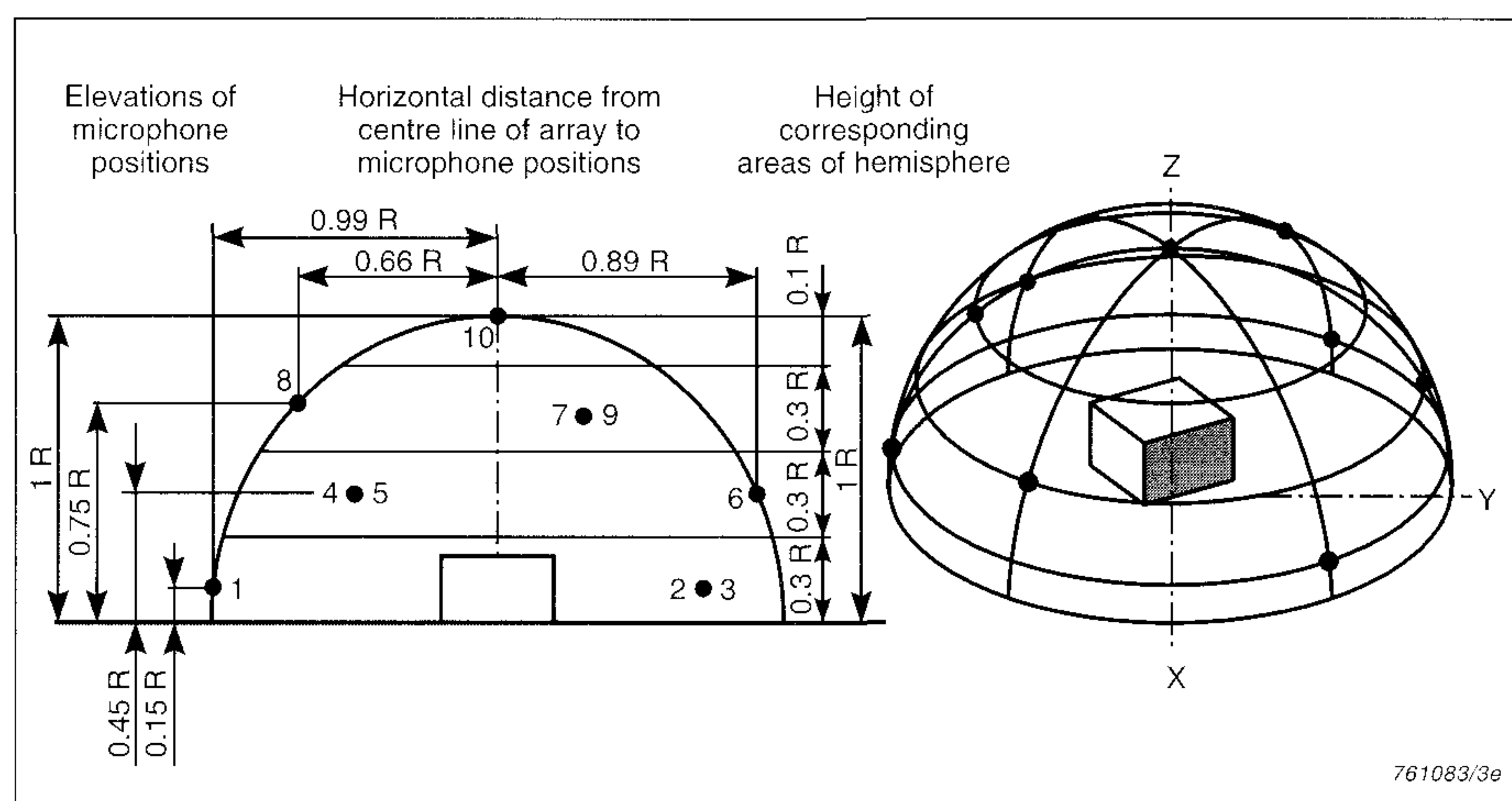


Fig.1 Microphone positions on equal areas on the surface of a hemisphere

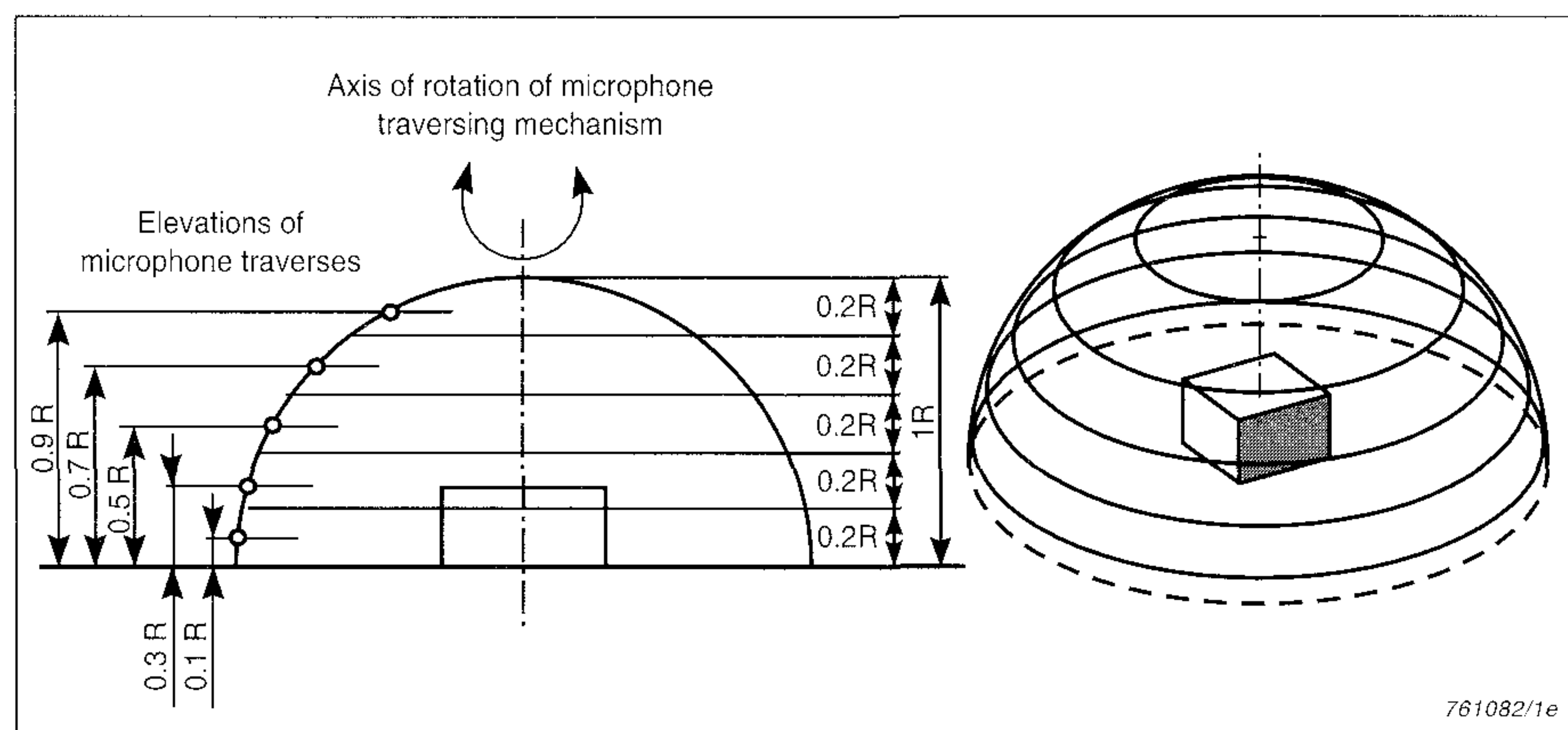


Fig.2 Coaxial circular paths for microphone traverses

$$L_W = L_p + (L_{Wref} - L_{pref})$$

As an introduction to the ISO 3741-47 / ANSI S12.31-36 standards, ISO 3740 / ANSI S12.30 gives a very good overview of the various methods (see Table 1).

Direct Method

1.1.1. Precision Methods of Sound Power Determination in a Reverberant Room

Precision methods (grade 1) of sound power determination in a reverberation room are governed by the standards ISO 3741, ISO 3742, ANSI S12.31, ANSI S12.32 and DIN 45 635-2. The measurement methods of ISO 3741 and ISO 3742 are the same. The difference between them being ISO 3741 and ANSI S12.31 are for broad-band noise sources, while ISO 3742, ANSI S12.32 and DIN 45 635-2 are for narrow-band noise sources and place more stringent requirements on the characteristics of the room. In the standards two methods are described, the direct method and the comparison method.

In the direct method, the sound power is calculated from the spatially averaged source, the background noise measurements and the physical parameters of the room (volume, surface area and reverberation time). Note that the reference sound source can be used to determine the acoustic properties of the room.

Instrumentation: *N* in appendix A

1.1.2. Engineering Methods of Sound Power Determination in a Reverberation Room

The engineering methods (grade 2) of sound power determination in a reverberation room are governed by ISO 3743, DIN 45 635-3 and ANSI S12.33. In these standards, the requirements for the reverberation room are “relaxed” with respect to ISO 3741/42 and ANSI S12.31/32. Further, the reverberation time of the room is characterised as a single number (the so-called nominal reverberation time of the room, see ISO 3743/ANSI S12.33 for details), rather than being variable with frequency. If the correction factor is unknown, a reference sound source can be used to determine the acoustic properties of the room. Note, however, that ISO 3743/ANSI S12.33 gives reduced ac-

International Standard	Classification of method	Test environment	Character of noise	Sound power levels obtainable
ISO 3741	Precision	Reverberation room meeting specified requirements	Steady, broad-band	In one or third octave bands. Optional: A-weighted
ISO 3742			Steady discrete frequency or narrow-band	
ISO 3743	Engineering	Special reverberation test room	Steady, broad-band, narrow-band discrete-freq.	A-weighted and in octave bands
ISO 3744		Outdoors or in large room	Any	A-weighted and in one or third octave bands
ISO 3745	Precision	Anechoic or semi-anechoic room		
ISO 3746	Survey	No special test environment	Steady, broad-band, narrow-band or discrete-freq.	A-weighted
ISO 3747		No special test environment; source under test not movable		

Table1

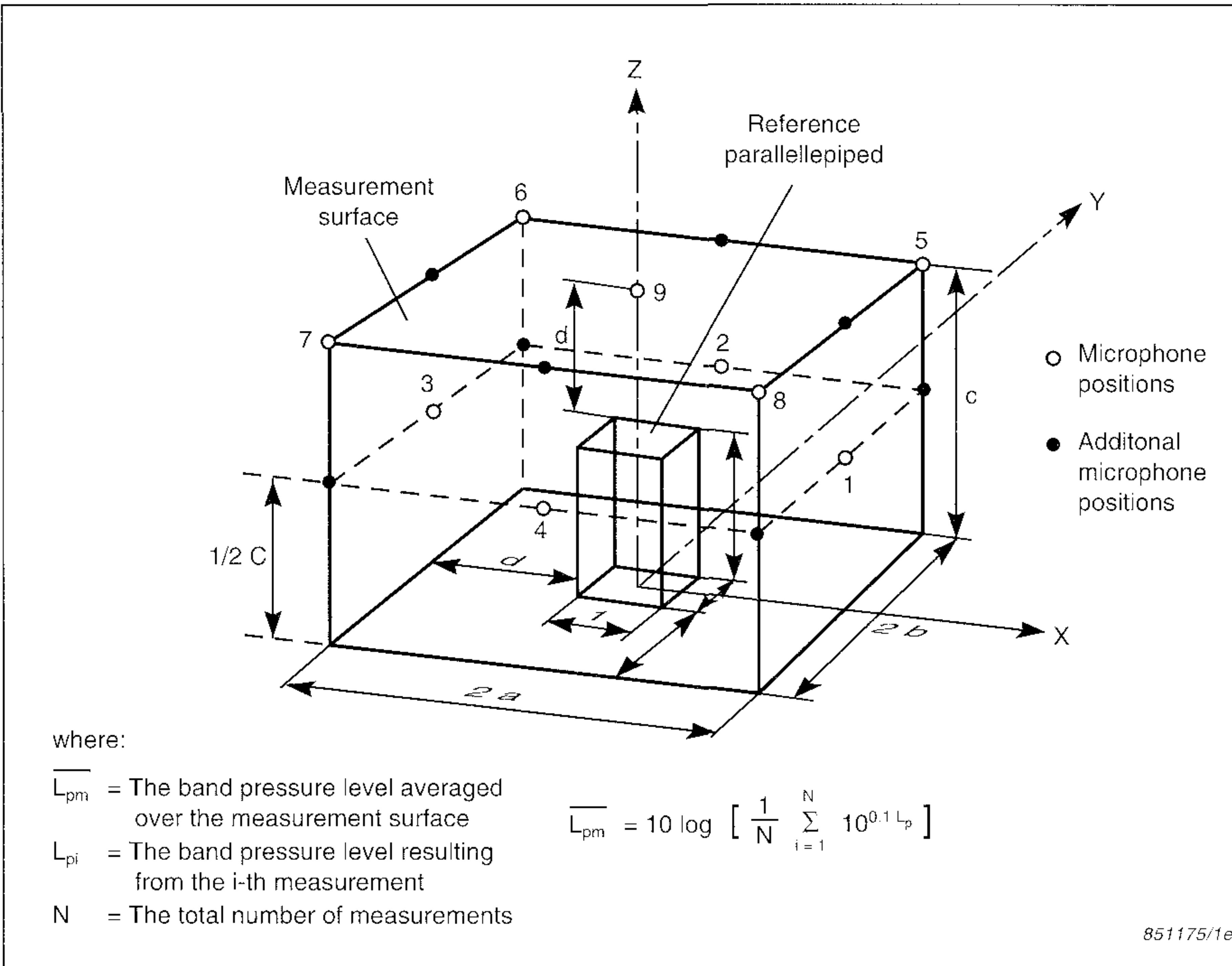


Fig.3 The parallelepiped or “shoebox” measuring surface used in ISO 3744

curacy with respect to ISO 3741/42 and ANSI S12.31/32.

Like ISO 3741/42, ISO 3743 and ANSI S12.33 describe both a direct method and a comparison method for determination of sound power.

The direct method of ISO 3743 and ANSI S12.33 is simplified with respect to the direct method of ISO 3741/42 and ANSI S12.31/32.

Instrumentation: *N* in appendix A

1.2.1. Precision Method of Sound Power Determination in an Anechoic or Semi-anechoic Chamber

The precision method of determination of sound power in an anechoic or semi-anechoic chamber is governed by ISO 3745, ANSI S12.35 and DIN 45 635-1. It requires measurement of the operating noise source and the background noise. This is done at a number of microphone positions on a spherical measurement surface around the noise source under investigation (anechoic chamber), or on a hemispherical measurement surface if the noise source is mounted on a reflecting plane (semi-anechoic chamber).

Instrumentation: L in appendix A

1.2.2. Engineering Method of Sound Power Determination in an Almost-free-field over a Reflecting Plane

The engineering method of sound power determination in an almost-free-field is governed by ISO 3744, ANSI S12.34 and DIN 45 635-1. This is a relaxation of ISO 3745 and ANSI S12.35 (hence reduced accuracy), in that it allows some deviations from true free-field conditions and the use of measurement surfaces other than the sphere and hemisphere. One such measurement surface is the parallel-piped, or "shoebox". Otherwise, the method is identical to ISO 3745 or ANSI S12.35. If the acoustic properties of the room are unknown, a reference sound source can be used to determine the correction factor.

Note the existence of a similar standard (draft) ISO 3748, which has never been finally approved (1994).

Instrumentation: J, K, L, M in appendix A

1.2.3. Survey Method of Sound Power Determination in an Almost-free-field over a Reflecting Plane

The survey method (grade 3) of sound power determination in an almost-free-field is governed by ISO 3746, ANSI S12.36 and DIN 45 635-1. These standards specify a survey method for measuring the overall weighted sound pressure levels at prescribed microphone positions around the noise source. The A-weighted sound power level is calculated from the measured values. This method can be applied in situ to sources which cannot be moved to a special test environment and the methods specified in ISO 3741-45 and ANSI S12.31-35 cannot, or should

not, be applied, since they require too much effort.

The noise source can emit any kind of noise: broad-band, narrow-band or discrete tones, and the measurement surface can be either a hemisphere or a "shoebox".

Instrumentation: O in appendix A

Comparison Method

2.1.1. Precision Methods of Sound Power Determination in a Reverberant Room

Precision methods (grade 1) of sound power determination in a reverberation room are governed by the standards ISO 3741, ISO 3742, ANSI S12.31, ANSI S12.32 and DIN 45 635-2. The measurement methods of ISO 3741 and ISO 3742 are the same. The difference between them being that ISO 3741 and ANSI S12.31 are for broad-banded noise sources, while ISO 3742, ANSI S12.32 and DIN 45 635-2 are for narrow-band noise sources and place more stringent requirements on the characteristics of the room. In the standards two methods are described, the direct method and the comparison method.

In the comparison method, the influence of the environment on the determination is measured using a reference sound source, e.g. Type 4204 (see Fig. 4). First, the spatially averaged sound pressure in the re-

verberation room is measured with the reference sound source operating, in order to obtain the room correction factor. The source noise can then be measured in the same way by replacing the reference with the unknown sound source.

Based on the sound power values from the calibration chart for the reference source, and the two spatially averaged sound pressure level spectra, it is possible to determine the sound power from the unknown sound source.

Instrumentation: K, M in appendix A

2.1.2. Engineering Methods of Sound Power Determination in a Reverberation Room

The engineering methods (grade 2) of sound power determination in a reverberation room are governed by ISO 3743, DIN 45 635-3 and ANSI S12.33. In these standards, the requirements for the reverberation room are "relaxed" with respect to ISO 3741/42 and ANSI S12.31/32. Further, the reverberation time of the room is characterised as a single number (the so-called nominal reverberation time of the room, see ISO 3743/ANSI S12.33 for details), rather than being variable with frequency. However, ISO 3743/ANSI S12.33 gives reduced accuracy with respect to ISO 3741/42 and ANSI S12.31/32.

ISO 3743 and ANSI S12.33 are similar to ISO 3741/42 in that they describe both a direct method and a

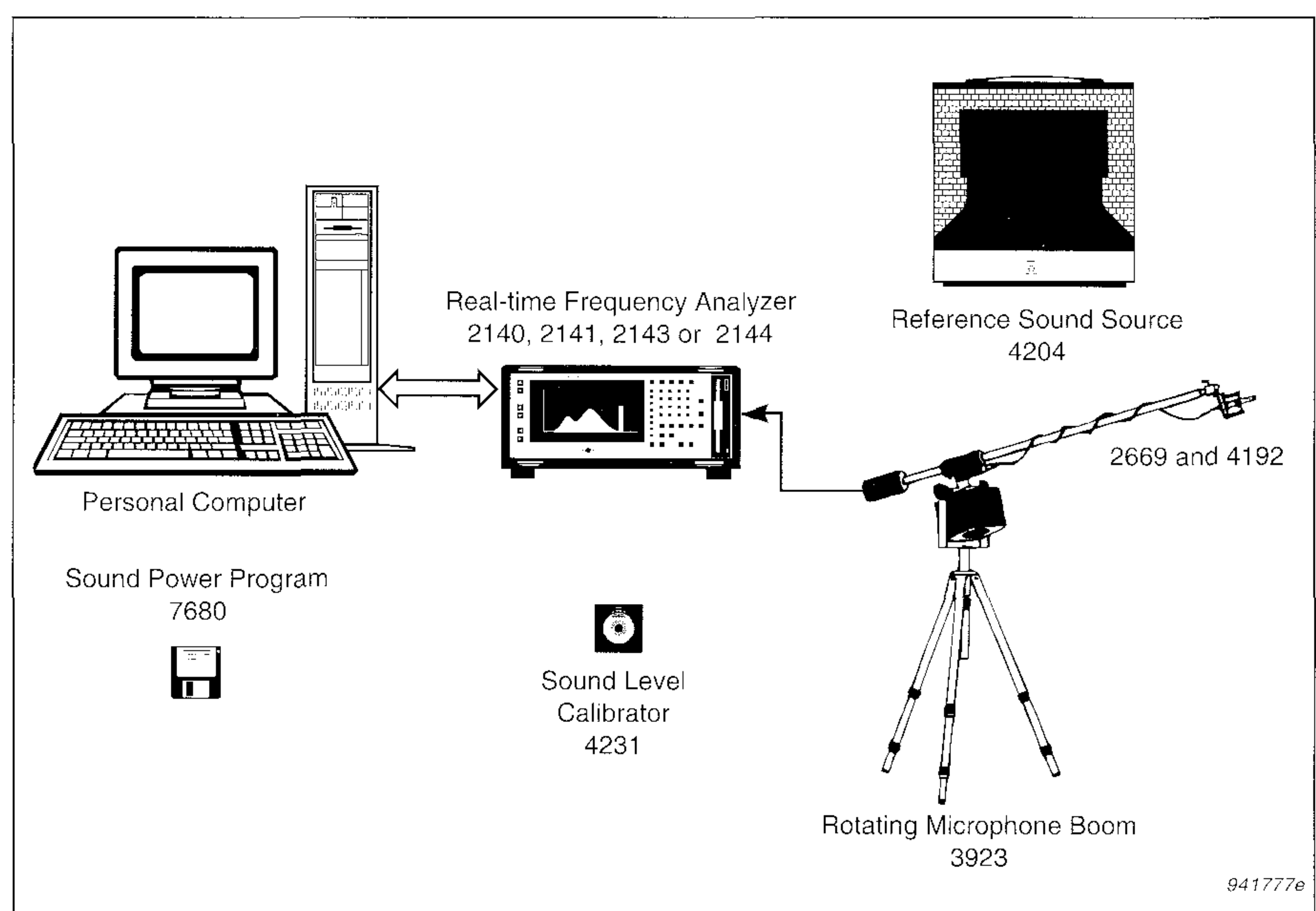


Fig.4 Complete system for sound power determination. The Type 7680 Program supports the comparison method in the reverberant field according to ISO 3741/43, and the direct method in almost-free-field conditions according to ISO 3744. For ISO 3744 the Reference Sound Source Type 4204 is used to determine the correction factor for the room

comparison method for determination of sound power.

The comparison method described in ISO 3743 and ANSI S12.33 is identical to the comparison method of ISO 3741/42 and ANSI S12.31/32.

Instrumentation: K, M in appendix A

2.1.3. Survey Method of Sound Power Determination using a Reference Sound Source

The survey method of sound power determination in accordance with the comparison method is governed by ISO 3747. The standard describes the procedure to be used for determining the overall A-weighted sound power levels of machines and equipment which cannot be moved from their installed locations for acoustical testing purposes. A reference sound source is used (see Fig. 5) which is placed in the immediate vicinity of the source under test.

It is not always simple to determine the magnitude of the environmental correction necessary, however, the comparison method takes it into account.

There are no restrictions on the test environment or the shape and size of the source. The noise emitted must be steady, broad-band, narrow-band or contain discrete frequencies.

Instrumentation: P, Q in appendix A

Determination of Sound Power based on Sound Intensity Measurements according to the Point Method

This method is governed by ISO 9614-1, ANSI S12.21 and NF S31-100. These standards specify a method for measuring the component of sound intensity normal to a measurement surface (see Fig. 6). The surface is chosen so as to enclose the noise source(s) of which the sound power level is to be determined. During the sound power determination, the intensity probe will be placed at a number of points (see Fig. 1 and 3). Each point is located on the measurement surface, representing a small partial area, in which the intensity flow is constant. The octave, third-octave or band-limited A-weighted sound power level is calculated from the measured values. The method is applicable to any source for which a physically stationary measurement

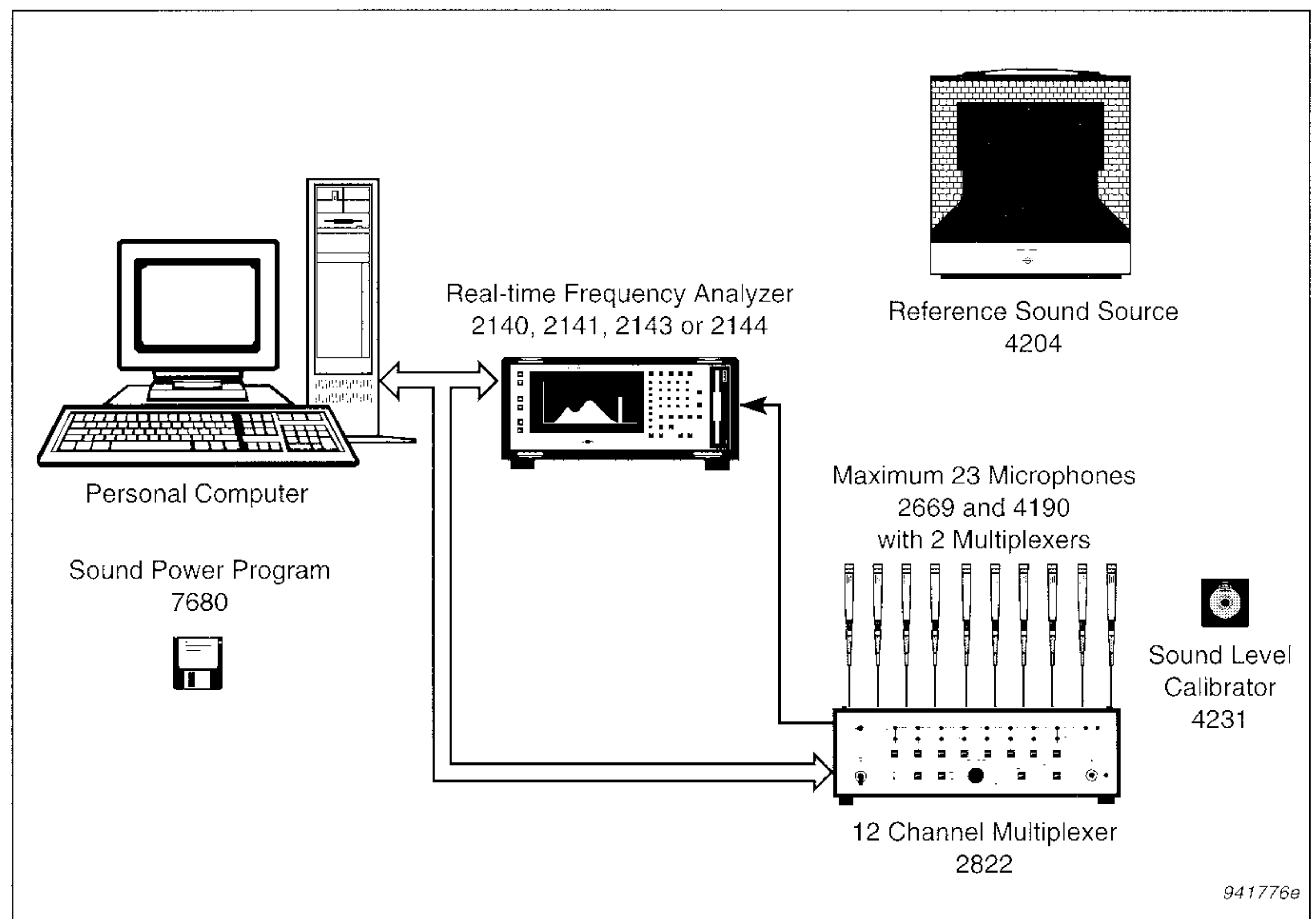


Fig.5 Complete system for sound power determination. The Type 7680 Program supports the comparison method in the reverberant field according to ISO 3741/43, and the direct method in free or almost-free-field conditions according to ISO 3744/45. Type 4204 is not required when measuring according to ISO 3745



Fig.6 Measuring sound power in-situ using Sound Power Program Type 5304, Dual Channel Real-time Frequency Analyzer Type 2144, Sound Intensity Probe Type 3548 and Sound Intensity Calibrator Type 3541

surface can be defined and the noise generated by the source is stationary in time. The source is defined by the choice of measurement surface. The method is applicable in situ, or in special purpose test environments.

A number of checks (field indicators) ensure the quality of the sound power contribution from each measurement point. This makes the determination rather complicated, unless a computer is used to perform all the calculations.

The ISO 9614-1 and ANSI S12.21 standards support precision and engineering grades, for octave and third-octave bands, and survey grade for overall A-weighted only.

The French standard NF S31-100 is a simplified version of the ISO and ANSI standards supporting precision and engineering grade only.

Instrumentation: E, G or I in appendix A

Determination of Sound Power based on Sound Intensity Measurements according to the Scan Method

This method is governed by ISO 9614-2, ANSI S12.12, ECMA 160 and INSTA 121. These standards specify a method for measuring the “spatial averaged” component of sound intensity, normal to a measurement surface. The surface is chosen so that it encloses the noise source(s) for which the sound power level is to be determined. During the sound power determination, the intensity probe traverses over the measurement surface (see Fig.2). To simplify the mechanical movement (the scanning), the measurement surface can be divided into a number of partial areas. The octave, third-octave or band-limited A-weighted sound power level is calculated from the measured values. The method is applicable to any source, in situ, or in special purpose test environments, for which a physically stationary measurement surface can be defined, and on which the noise generated by the source is stationary in time.

A number of checks (field indicators) ensure the quality of the sound power contribution from each measurement surface. This makes the determination complicated, unless a computer is used to perform all the

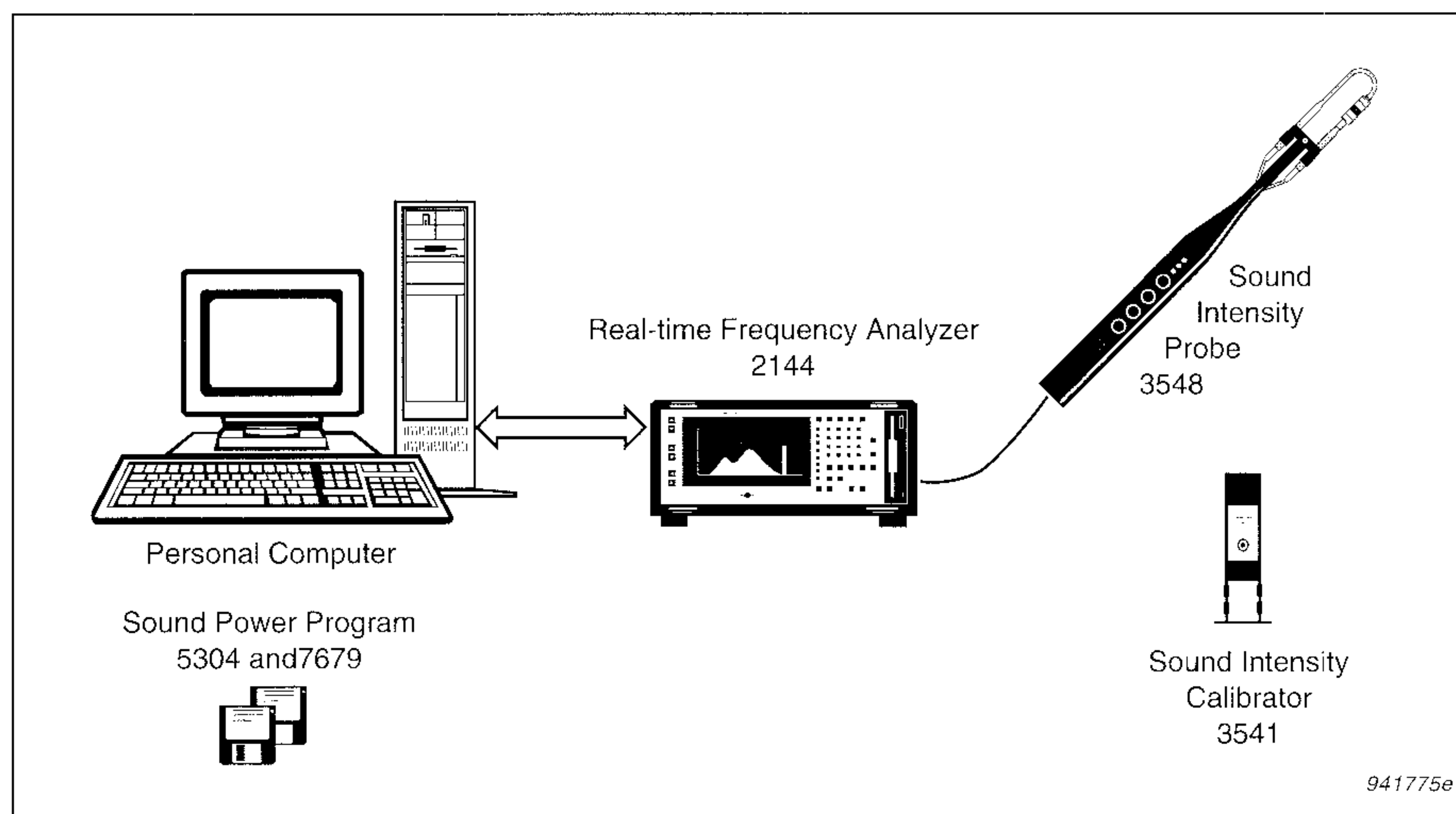


Fig.7 Complete system for sound power determination using sound intensity measurements. The Windows™ based PC software Type 5304 and 7679 makes sound power determination, according to ISO 9614 parts 1 and 2 (the point and scanning method), quick and easy

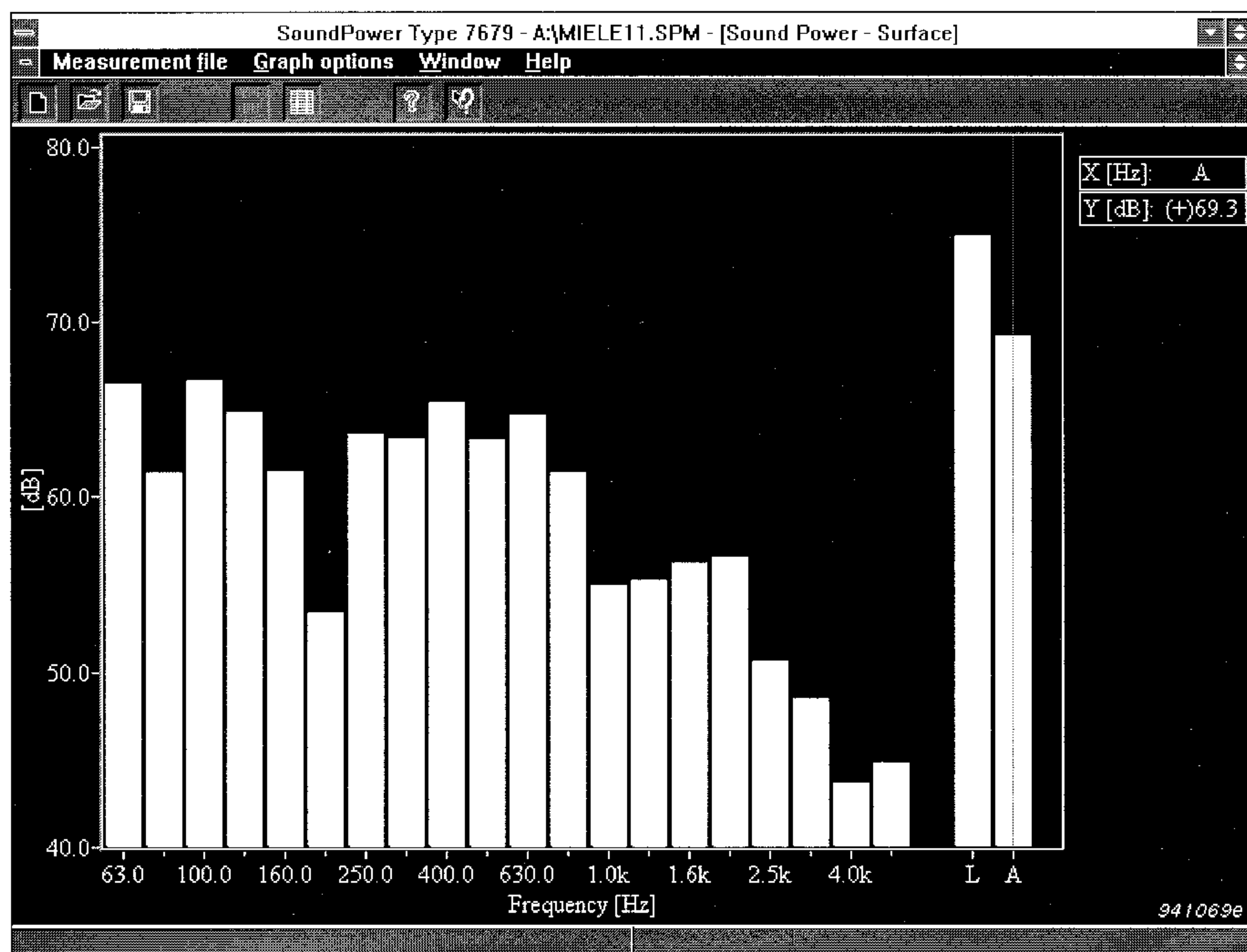


Fig.8 To fulfil the machine directive, only the A-weighted Sound Power Level, here 69.3 dB(A), is of interest, but the spectrum may give an idea of how to reduce the noise level

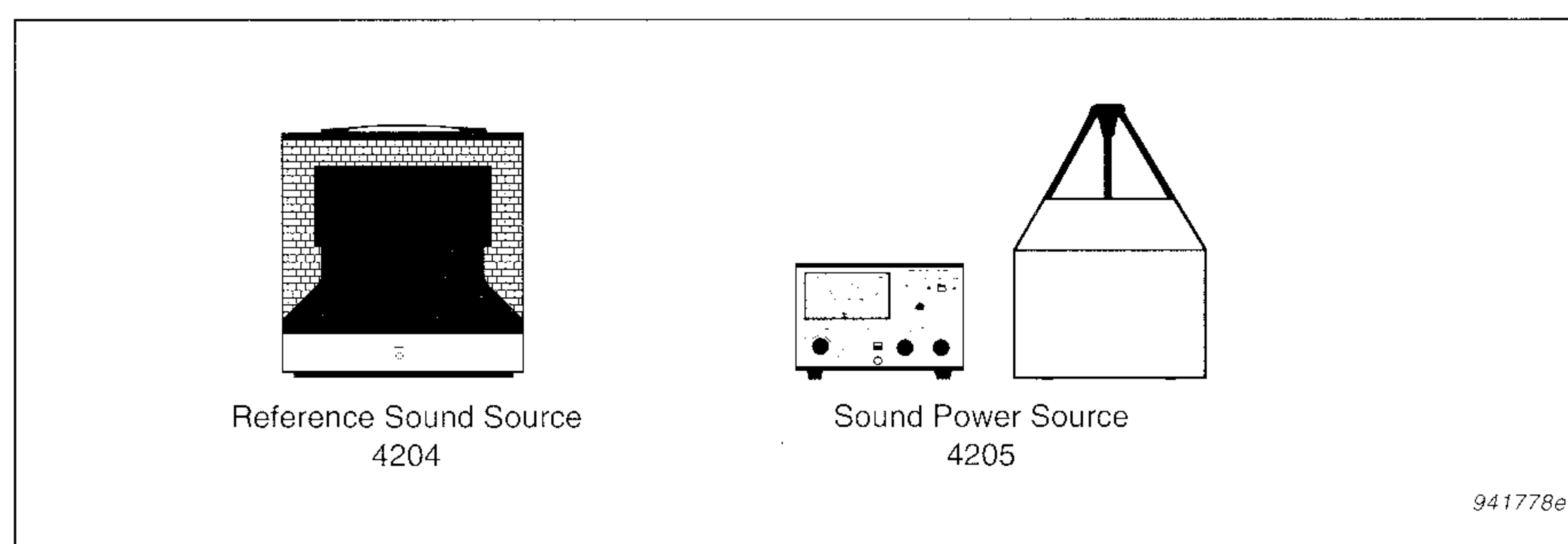


Fig.9 Reference Sound Source Type 4204 and Electroacoustic Calibrated Source Type 4205

calculations. Due to the physical properties of the spatially averaged scanning, the field indicators are not as complicated to fulfil as the ones needed for the point method. This makes the measurement much easier to perform (see Fig. 8).

The ISO 9614-2, ANSI S12.12 and ECMA 160 standards support engineering grade for octave and third-octave bands, and engineering and survey grade for overall A-weighted only.

Instrumentation: F, H in appendix A

The Nordic standard INSTA 121 is a simplified version of the ISO, ANSI and ECMA standards. The measurements and sound power determination are made in the same way, but the field indicators are limited to a single test of adequate instrumentation capability. This makes sound power determination simple to perform, even without a computer.

Instrumentation: A, C or D in appendix A

Note that a proposal was made in 1994 for the scanning method: Determination of sound power levels of noise sources using sound intensity, ISO 9614-3, precision method.

Instruments used for Determination of Sound Power

The sound power standards refer to a number of instrumentation standards governing sound intensity analyzers and intensity probes. The instrumentation standards specify standardized filter curves, measurement and display set-up parameters and tolerances.

IEC 225 and ANSI S1.11 define the octave, half-octave and third-octave band filters for analysis of sound and vibration. Tolerances are also given. In 1966, the first edition was published. The tolerances outside the pass-band (filter skirts) were set high to make up for the analogue electronics used at that time. In 1986 came a revised version of the ANSI standard. The definitions of the filter curves are the same, but the tolerances have been decreased, making measurements less dependent on the chosen filter manufacture.

Note that IEC 225 is under revision (1994) to adopt some of the tolerances from the 1986 ANSIS1.11 standard.

IEC 651 and ANSI S1.4 describes a "normal" exponential averaging sound level meter, where IEC 804 governs the linear averaging.

Regarding sound power, the specification of the overall A-weighted filter is probably the most important.

IEC 1043 and ANSIS1.12 instrumentation standards describe the minimum demands for sound intensity probes and analyzers. This is to ensure the accuracy of the measurement of sound intensity applied to the determination of sound power in accordance with ISO 9614/ANSI S12.21 and S12.12. To meet the requirement of that standard, instruments are required to analyze the sound intensity in octave or third-octave bands, and optionally to provide overall A-weighted band levels. It is also required to measure sound pressure level, in addition to sound intensity level, to facilitate the use of the field indicators described in ISO 9614/ANSI S12.21 and S12.12. The IEC/ANSI instrumentation standard describes two degrees of accuracy: class 1 and class 2. Class 1 is needed

to fulfil ISO 9614/ANSI S12.21 and S12.12 precision and engineering measurements, where class 2 is intended for survey measurements.

Other Standards

To determine the sound power level of a noise source, there are a number of different standards (described above) to choose between (often referred to as "Basic Standards" or just B-Standards). The proper sound power standard to choose, depends on the acoustic environment and the equipment available.

Operational Conditions

Choosing one of the above described standards is very often not enough. Take for instance a chain-saw. All the sound power standards describe how to determine the sound power, but they do not say anything about the operational conditions. (See Fig. 10.)

For various types of equipment special standards exist, describing the conditions under which the equipment should be tested. This is to ensure an equal comparison between competitive products on the market. They are very often referred to as



Fig.10 Set-up for sound power determination of a Nilfisk industrial vacuum cleaner (Courtesy of Fisker & Nielsen A/S)

“Noise Test Codes” or just C-Standards.

Traditionally, standardization in acoustics has occurred internationally. The machinery directive, however, calls for European Standards and for purely formal reasons, it has been necessary to establish a European committee. They have decided to implement international standards in their original form. This is recognizable in the way European standards are numbered: the EN number is found by adding 20000 to the ISO number!

Most of the specific C-Standards are at the moment European, since there are no ISO counterparts for the many specific types of machine. Since 1957 several European committees have prepared a large number of specific safety standards: Council Directive 79/113 (year/number) EEC applies to a broad range of machinery used in work on civil engineering and building sites, 89/514 covers earth-moving machines, 84/534 covers tower cranes, 84/535 and 85/407 refer to welding generators, 84/536 and 85/408 refer to power generators and 84/538, 87/252, 88/180, 88/181 are all in reference to lawnmowers. See Fig. 11.

In a couple or years(!) when the European standardization work of C-Standards is concluded, they will be internationally approved and then only the ISO standards will exist.

A careful examination of all existing C-Standards is beyond the scope of this application note, but the following standards are mentioned just as examples:

Business Equipment

ISO 7779/ECMA 74 specifies a method for the measurement of airborne noise emitted by computers and business equipment (Fig. 12). Until now, a wide variety of methods has been applied by individual manufactures and users to satisfy particular equipment or application needs. See Fig. 13.

These diverse practices have, in many cases, made comparison of noise emission difficult. This standard simplifies such comparisons and is the basis for declaration of noise emission levels of computers and business equipment. See Table 2.

In order to ensure accuracy, validity and acceptability, the standard is based on ISO 3741/42/44/45.

Air Terminals

ISO 5135 defines requirements for acoustic testing in reverberation rooms of air terminal units, dampers and valves used in air diffusion and air distribution systems. It is based on the use of ISO 3741/42. The standard describes the acoustic test facilities, instrumentation and procedures to be used for precision grade determination of sound power levels, in octave or third-octave bands, of a noise source having a volume preferably less than 1% of the volume of the reverberation room.

Chain-saws

ISO 7182 specifies a method for measuring the overall A-weighted and octave band sound pressure levels, at the operator's position, of noise emitted by portable, hand-held, combustion engine chain-saws for use primarily in forests. This standard does not cover sound power determination, therefore it is important to fulfil the European Machinery Directive (see ISO 9207).

ISO 9207 specifies a method for determining the sound power level of chain-saws. The standard provides all the information necessary to make, under standardized conditions, the determination, declaration and verification of sound power levels of hand-held chain-saws, primarily used in forests (see Fig. 14). Preferred methods for determination of sound power levels according to this standard are engineering methods (grade 2). See Table 3.

Sound Insulation

ISO 140-10 and NORDTEST 1065-92 specify a laboratory sound intensity scanning method of measuring airborne sound insulation for small building elements. This method also establishes directions regarding reporting and applying such test data. The measurements are made under diffuse field conditions. The Nordtest standard is a simplified version of the ISO standard as it assumes that there is no flanking transmission, hence, the measurements made are simpler.

Noise declaration

ISO 4871 is a standard under revision (1994). This standard, which applies to machinery and equipment:

- gives information on the declaration of noise emission values

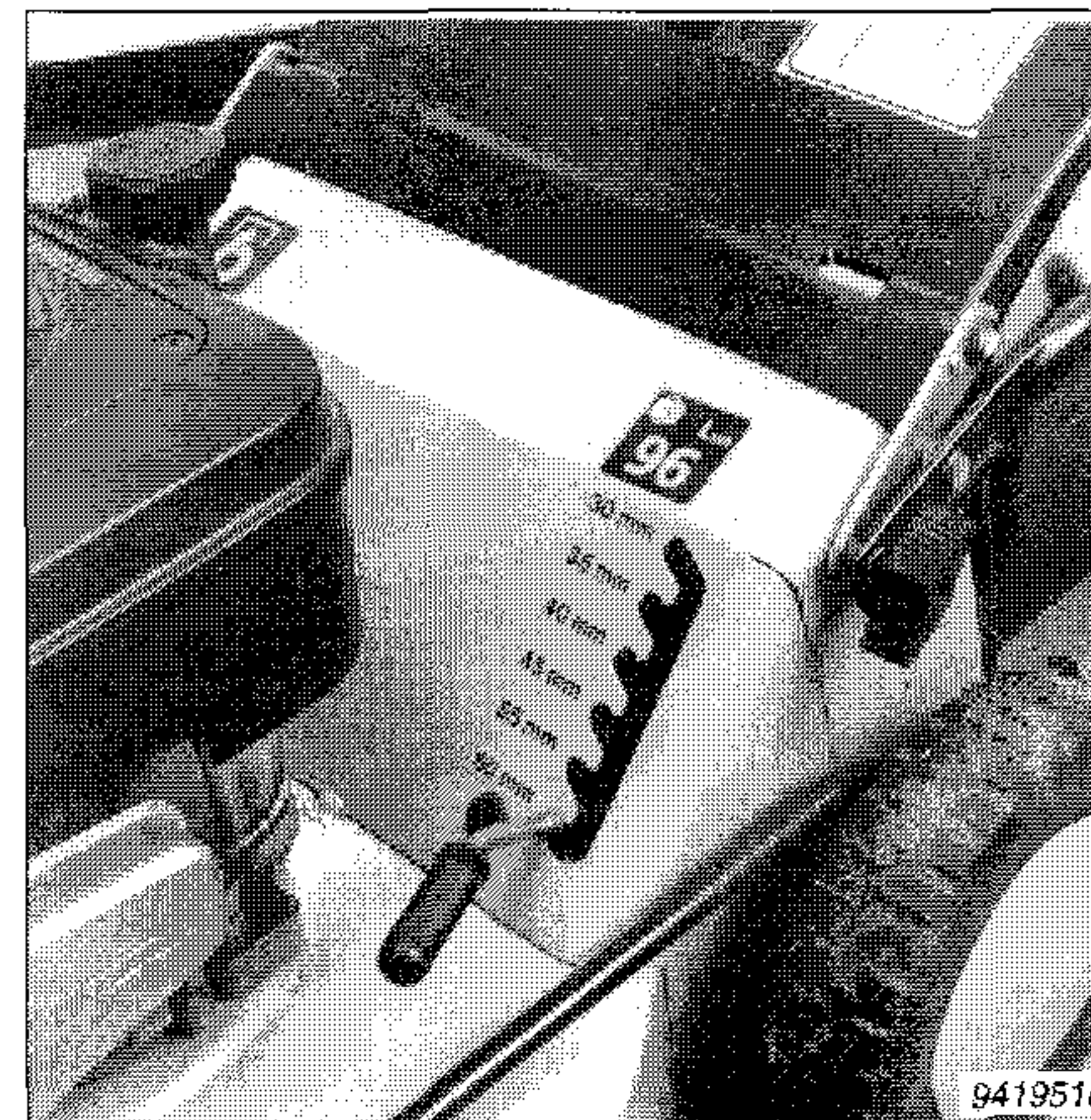


Fig. 11 EEC Machine Directive Label indicating the maximum sound power level guaranteed by the manufacturer of the lawnmower

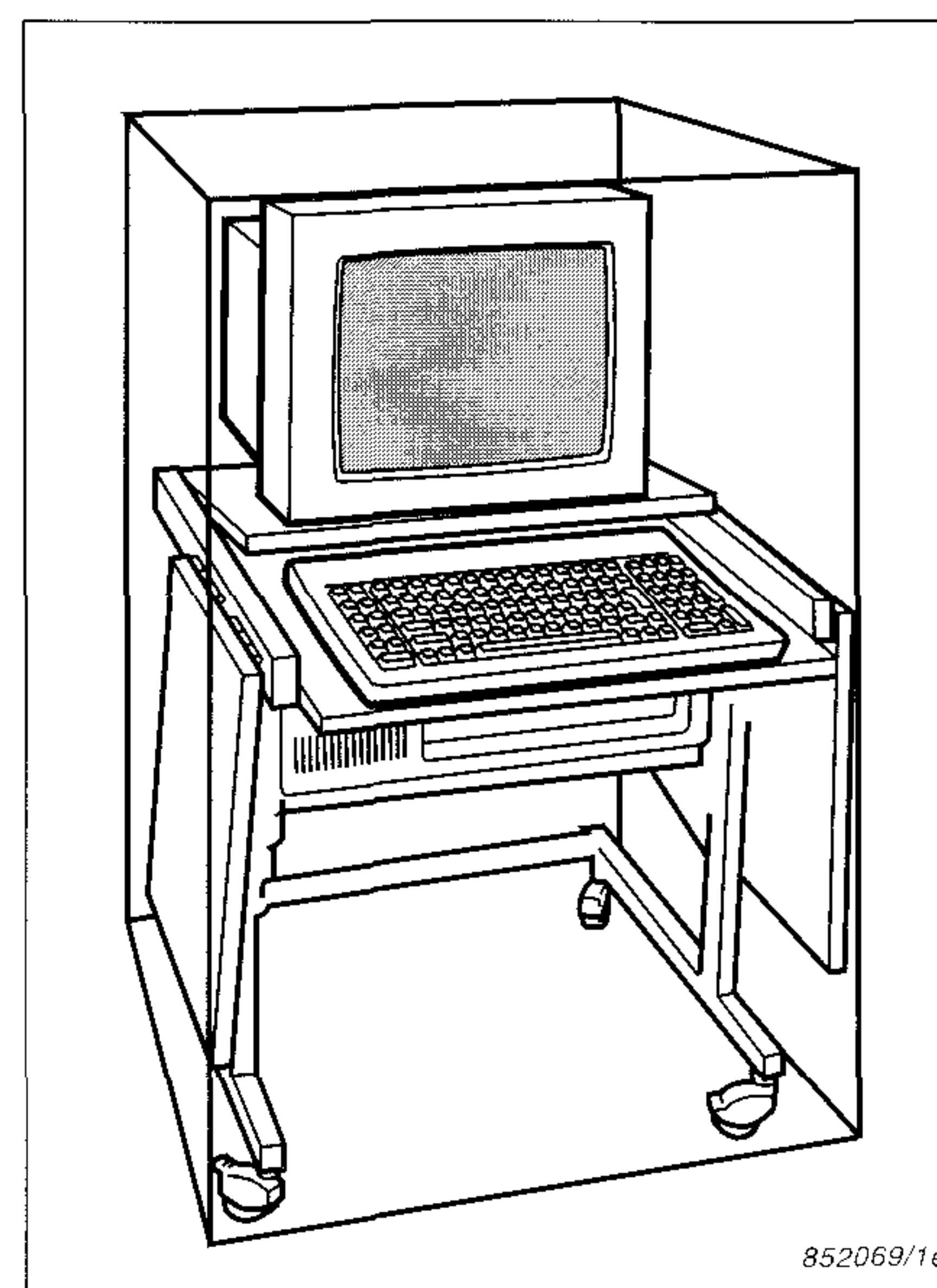


Fig. 12 Measurement surface surrounding a personal computer

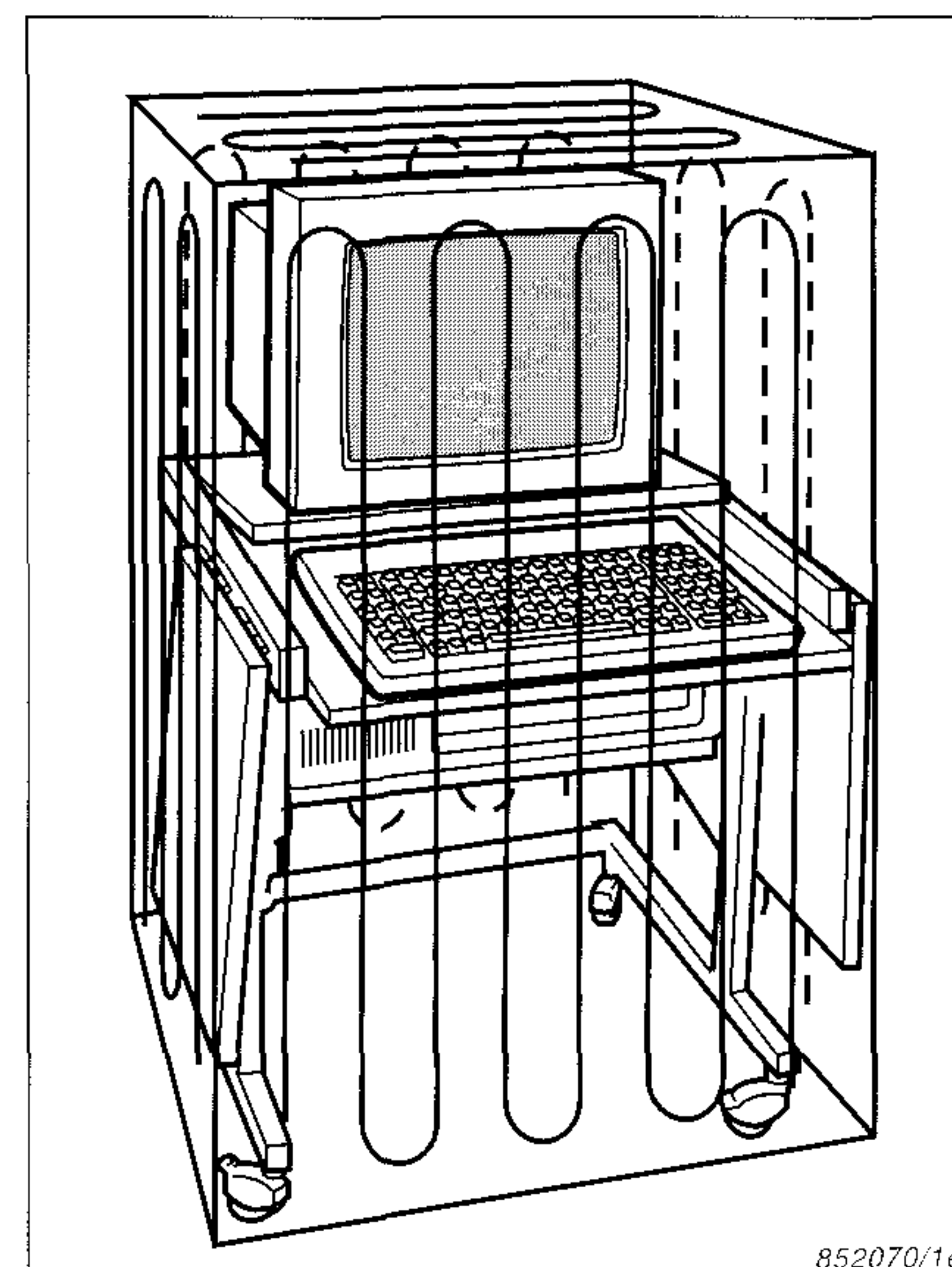


Fig. 13 Measurement of sound power on a personal computer showing the intensity probe's path over the measurement surface

- describes acoustical and product information to be stated in technical documents supplied to users by the manufacturer
- specifies the method for verifying the declared noise emission values stated by the manufacturer.

The values to be used for the declaration of noise emission are the overall A-weighted sound power level, and the A-weighted emission sound pressure level, at operator or bystander positions. The declared values are the statistical upper limits corresponding to the stated or labelled value defined in ISO 7574.

Together with ISO 3740-47 and ISO 11200-11204, a complete system of standards is available which provide a basis for establishing a specific machine noise measurement (noise test code) for almost any situation.

ISO 7574 part 1 and 4 define terms relating to methods for determining and verifying the stated (e.g. labelled) values of the noise emitted by machinery and equipment. Part 2 gives methods for stating values for the individual machines (manufacture), and part 3 gives methods for verifying stated (labelled) values for batches of machines.

DIN45 635

DIN 45 635 is a German standard which contains several hundred parts. Part 1 to 3 are B-Standards written in line with the ISO 374x family, see above, but the rest are Noise Test Codes for various types of machinery. The numbering is not consecutive, so numbers between 8 and 3400 are usual. From Beuth Verlag GmbH, Berlin 30, it is possible to obtain the parts of the standard, and also an overview. Each part covers a single subject e.g. part 13 covers vacuum pumps, part 21 electric tools and part 1654 woodworking, edge glueing, banding and trimming machines.

The reason for making all these parts was that international standards did not exist and/or german industry often prefers to use national standards.

Note: It is recommended you contact your local standardization office, as they will be able to supply not only the international standards but also domestic standards.

Product: Computer Model ABC Declared Noise Emission	Operating	Idle
L_{WAd} L_{PAm} (bystander position)	7.1 B 57 dB	7.0 B 56 dB

Table 2 Example of declared noise emission values from ECMA Standard

Operating condition	L_{pm} in dB	L_w in dB
Idling		
Full load		
Racing		

Table 3 Acoustical data to be reported according to ISO 9207

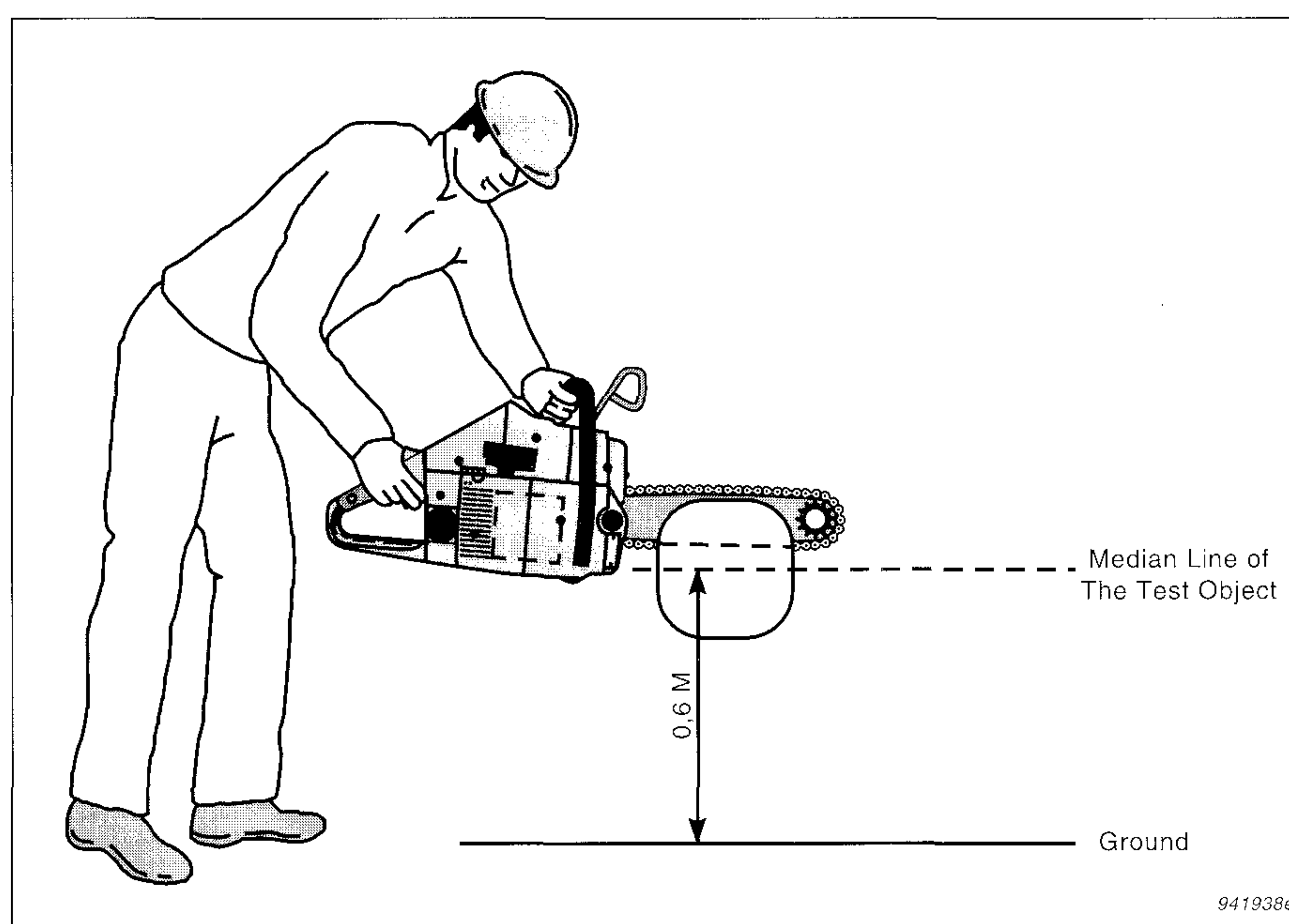


Fig. 14 Position of chain saw during measurement to ISO 9207, is called a noise test code. ISO 9207 describes the measurement conditions and recommends the standard, according to which a measurement should be performed

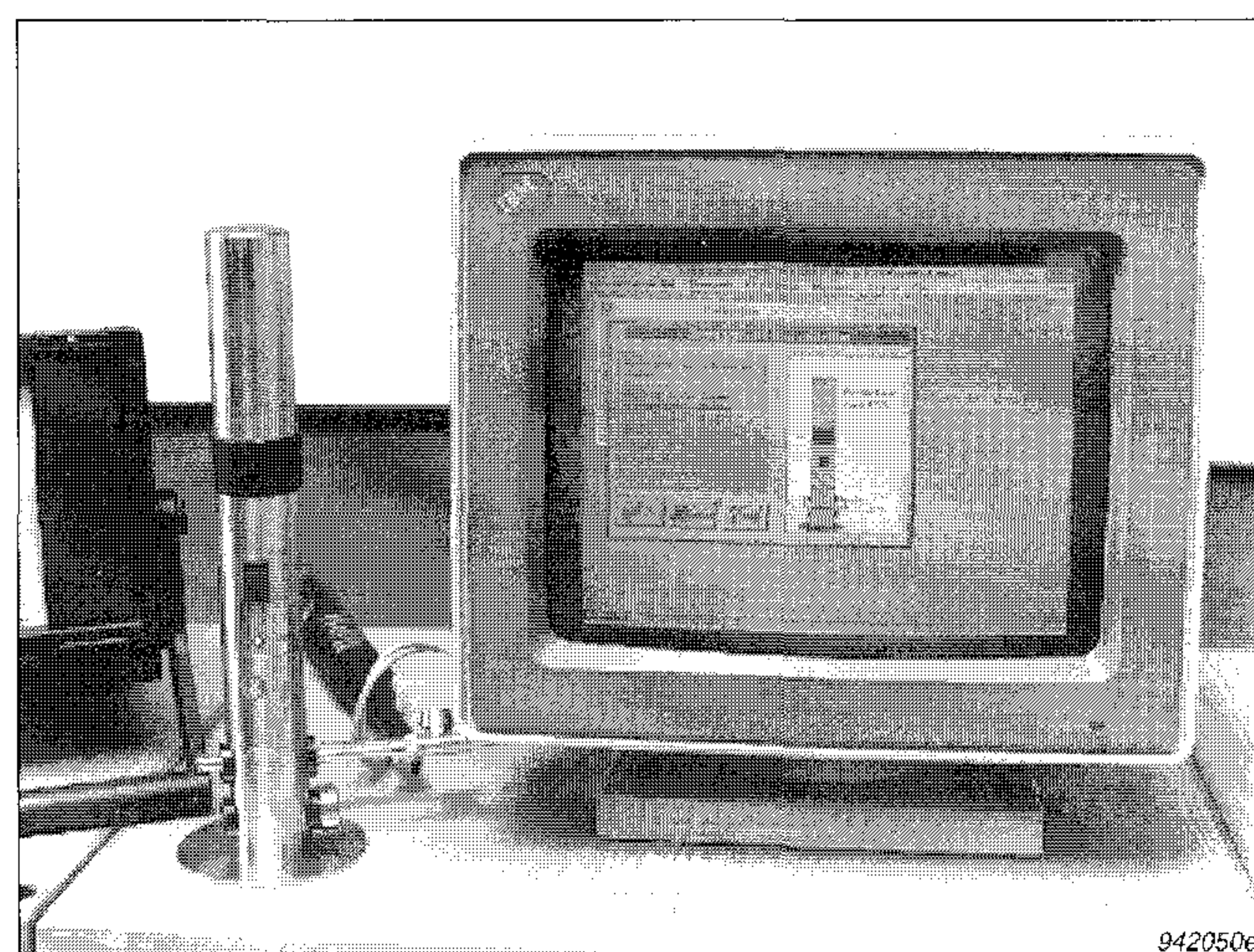


Fig. 15 An example of Calibration

Appendix A

Instrumentation

- A** Type 3554 Sound Intensity System
(contains Type 4437 + 3547 + 4231 + DP0888 + WT9347 + WT9378)
2×AO 0265 IEEE 488 Standard Digital Interface Cable
PC with IEEE interface running Windows™
- B** Type 3562 Sound Power System
(contains Type 2144 + 3548 + 3541 + 7679)
- C** Type 3563 Sound Intensity Mapping System
(contains Type 2133 + 3545 + ZH0354 + 3541)
- D** Type 2144 Portable Real-time Frequency Analyzer
Type 3548 Sound Intensity Probe
Type 3541 Sound Intensity Calibrator
- E** Type 3563 Sound Intensity Mapping System
contains Type 2133 + 3545 + ZH0354 + 3541)
Type WT9378 Mapping and Sound Power Program
AO 0265 IEEE 488 Standard Digital Interface Cable
PC with IEEE Interface running Windows™
- F** Type 3562 Sound Power System
(contains Type 2144 + 3548 + 3541 + 7679)
AO 0265 IEEE 488 Standard Digital Interface Cable
PC with IEEE
- G** Type 3554 Sound Intensity System
(contains Type 4437 + 3547 + 4231 + DP0888 + WT9347 + WT9378)
AO 0265 IEEE 488 Standard Digital Interface Cable
PC with IEEE interface running Windows™
- H** Type 3563 Sound Intensity Mapping System
(contains Type 2133 + 3545 + ZH0354 + 3541)
Type 7679 Sound Power Program
AO 0265 IEEE 488 Standard Digital Interface Cable
PC with IEEE interface running Windows™
- I** As set-up **F** plus
Type 5304 Sound Power Program
- J** Type 2143/44 Portable Real-time Frequency Analyzer
Type 2669B Falcon™ Microphone Preamplifier
Type 4192 Falcon™ Condenser Microphone Cartridge
Type 3923 Rotating Microphone Boom
Type 4231 Sound Level Calibrator
AO 0265 IEEE 488 Standard Digital Interface Cable
PC with IEEE interface running Windows™
- K** As set-up **J** plus
Type 4204 Reference Sound Source
- L** Type 2143/44 Portable Real-time Frequency Analyzer
Type 2822 Microphone Multiplexer
10×Type 2669B Falcon™ Microphone Preamplifier
10×Type 4192 Falcon™ Condenser Microphone Cartridge
Type 4231 Sound Level Calibrator
Type 7680 Sound Power Program
AO 0087 BNC Coaxial Cable
- M** As set-up **L** plus
Type 4204 Reference Sound Source
- N** Type 2123/33 Real-time Octave and Fractional Octave Digital Frequency Analyzer
Type 2669B Falcon™ Microphone Preamplifier
Type 4192 Falcon™ Condenser Microphone Cartridge
Type 3923 Rotating Microphone Boom
Type 4231 Sound Level Calibrator
Type 4204 Reference Sound Source
AQ 0034 Remote Control Cable
- O** Type 2236 Precision Integrating Sound Level Meter
Type 4231 Sound Level Calibrator
- P** As set-up **O** plus
Type 4204 Reference Sound Source
- Q** Type 2260 Investigator™ Modular Precision Sound Analyzer
Type 4231 Sound Level Calibrator
Type 4204 Reference Sound Source

Appendix B

Determination of Sound Power based on Sound Pressure Measurements:

ISO 3740	Guidelines for the use of basic standards and for the preparation of noise test codes
ISO 3741	Precision method for Broad-band sources in reverberation rooms
ISO 3742	Precision method for discrete frequency and narrow band sources in reverberation rooms
ISO 3743	Engineering methods for special reverberation test rooms
ISO 3744	Engineering method for free-field conditions over a reflecting plane
ISO 3745	Precision method for anechoic and semi-anechoic rooms
ISO 3746	Survey method
ISO 3747	Survey method using a reference sound source
ANSI S12.30	Revised version of ANSI S1.30. Equivalent to ISO 3740
ANSI S12.31	Revised version of ANSI S1.31. Equivalent to ISO 3741
ANSI S12.32	Revised version of ANSI S1.32. Equivalent to ISO 3742
ANSI S12.33	Revised version of ANSI S1.33. Equivalent to ISO 3743
ANSI S12.34	Revised version of ANSI S1.34. Equivalent to ISO 3744
ANSI S12.35	Revised version of ANSI S1.35. Equivalent to ISO 3745
ANSI S12.36	Revised version of ANSI S1.36. Equivalent to ISO 3746
DIN 45 635-1	Similar to ISO 3744/45/46
DIN 45 635-2	Similar to ISO 3741/42
DIN 45 635-3	Similar to ISO 3743

Determination of Sound Power based on Sound Intensity Measurements:

According to the point method:

ISO 9614-1	Determination of sound power levels of noise sources using sound intensity – Measurements at discrete points, grade 1, 2 and 3
ANSI S12.21	Similar to ISO 9614-1
NF S31-100	French standard, grade 1 and 2

According to the scan method:

ISO 9614-2	Determination of sound power levels of noise sources using sound intensity – Measurements by scanning, grade 2 and 3
ANSI S12.12	Similar to ISO 9614-2
ECDMA 160	Using computer equipment, similar to ISO 9614-2
INSTA 121	Determination of sound power levels of noise sources using sound intensity – Scanning method for use in situ

Instruments used for Determination of Sound Power:

IEC 651	Sound Level Meters
ANSI S1.4	Equivalent to IEC 651
IEC 804	Integrating – averaging Sound Level Meters
IEC 1043	Instruments for the measurement of sound intensity – Measurements with pairs of pressure sensing microphones
ANSI S1.12	Equivalent to IEC 1043
IEC 225	Octave, half-octave and third-octave band filters intended for the analysis of sound and vibration. 1966, and under revision (1994) inspired by ANSI S1.11-1986
ANSI S1.11	1966 edition equivalent to IEC 225-1966. New version in 1986

Other Standards:

ISO 7779/ECMA 74	Measurement of airborne noise emitted by computer and business equipment
ISO 5135	Determination of sound power levels of noise from air terminal devices, air terminal units, dampers and valves by measurements in a reverberation room
ISO 7182	Measurements at the operator's position of airborne noise emitted by chain saws
ISO 9207	Manually portable chain-saws with internal combustion engine – Determination of sound power levels
ISO 140-10	Measurement of sound insulation in buildings and of building elements – Measurement of sound insulation of small building elements
Nordtest 1065-92	Small building elements: Sound insulation, intensity scanning under laboratory conditions
ISO 4871	Declaration and verification of noise emission values of machinery and equipment
ISO 7574	Statistical methods for determining and verifying stated noise emission values of machinery and equipment (part 1–4)
DIN 45 635	This German standard contains several hundred parts. Parts 1 to 3 are B-Standards, see above, but parts 8 to 3400 (or higher) are Noise Test Codes for various types of machinery.

Appendix C

The Machinery Directive

In Europe, a new "Machinery Directive" has been written, coming into force from 1/1/95. The purpose of this directive is to ensure quality and the health of people using machines and also to ensure free trade over the borders. This appendix gives a brief introduction to the contents of Machinery Directive 89/392/EEC and the updates 91/368/EEC, 93/44/EEC and 93/68/EEC. Note that Brüel&Kjær cannot be held responsible for any misinterpretation of the following text.

Directives vs. Standards

Most engineers are familiar with standards. Standards can be international or domestic, but commonly they are written by engineers and technicians associated with industry or technical high schools, to be used by the same group of people in the same environment. The Directives are, on the other hand, completely different. They are written by lawyers, to be used by government authorities giving uniformity in all EU member states. Therefore the directives do not give any technical solutions, only what is needed when selling a product.

It is important to notice that when a directive has been written, it will never be changed.

Directives are updated by issuing new directives to be appended. Regarding the Machinery Directive, we recommend that you obtain the commented version of the directive, which can be bought either direct from the "Office for the EU official publications, L-2985 Luxembourg" (price: ECU 15), or from a local supplier (more than 30 countries all over the world).

Contents of the directive

The Machinery Directive consists of 14 articles and 7 appendices. The directive defines which machines and safety components it covers, especially dangerous machines, and the exceptions, e.g. ships, railways, airplanes and vehicles used for passenger trans-

port. Furthermore, manufacturers are allowed to exhibit equipment which does not fulfil the directive if it is written on the machine.

If a machine does not fulfil the requirements given by the directive, government authorities must prohibit the use of the machine in the EU country. As a guarantee that the machine fulfils the directive, it must be labelled with the "CE" mark, unless it is sold second-hand.

Note that components for a larger machine do not need to be CE marked. The manufacturer just has to state that used in a specified configuration, the complete assembly can be CE marked. To fulfil the safety requirements, this directive calls on a number of other directives, e.g. EMC- and mains-supply directives. As documentation, the manufacturer has to state, that the equipment is produced in harmony with the standards mentioned in

the statement. Furthermore, a technical dossier containing drawings, calculations, test results and product description, must be kept by the manufacturer. The safety of the operator is emphasized in a number of subjects, and one of them is the contents of the instruction manual. For Brüel&Kjær this is of interest because sound and vibration levels must be stated.

Possibility of sanctions

There has been a lot of talk about the risk of and government sanction against installing machines or equipment covered by the Machinery Directive which is not CE labelled. Well, the worst thing that can happen is either that government authorities closes down the factory until the illegal equipment is gone or that your insurance company will not cover the damages your illegal equipment may have caused!

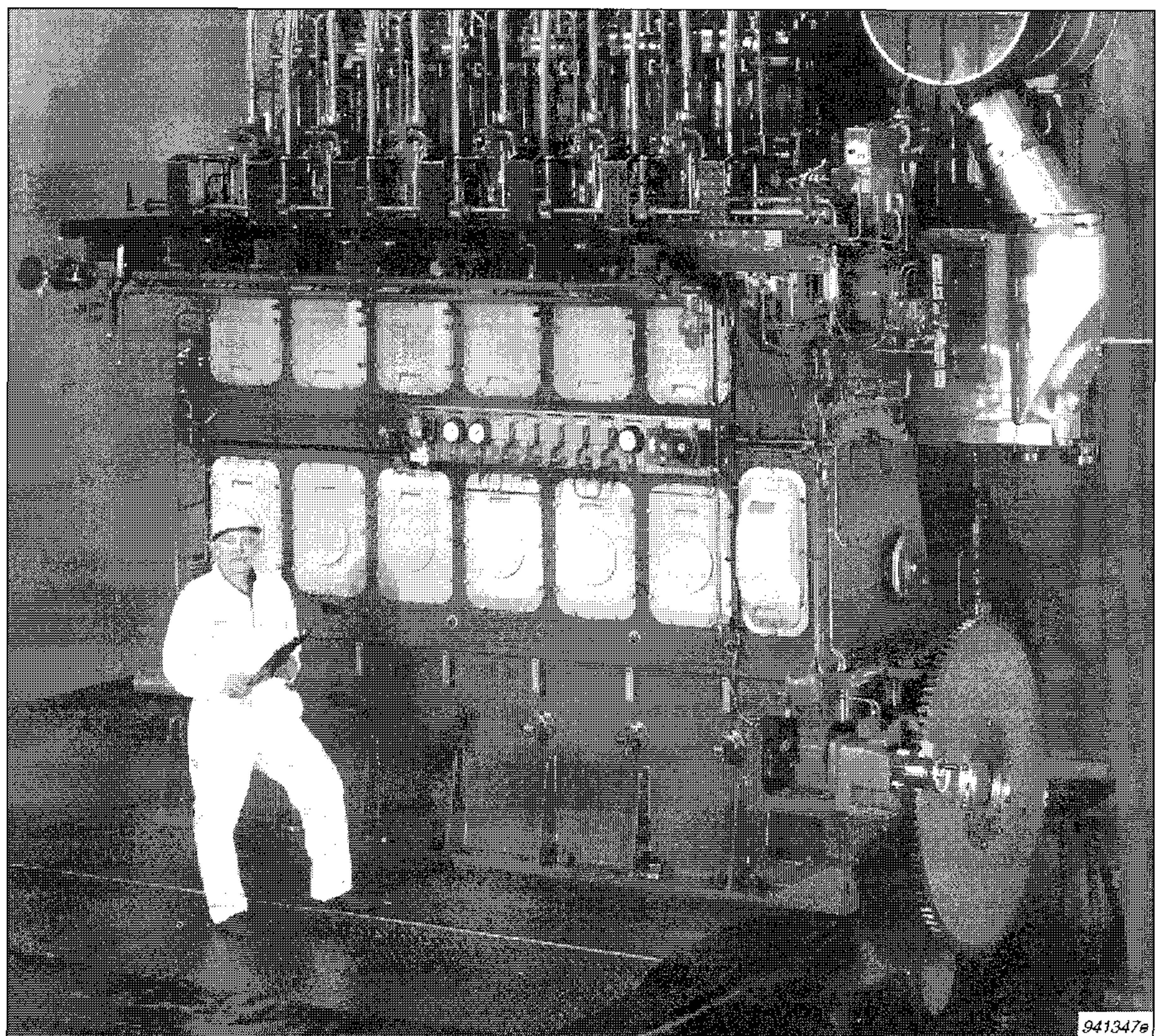


Fig.16 A wide range of machinery must fulfil the "Machinery Directive" to be marked and sold in the EU

Brüel & Kjær

WORLD HEADQUARTERS: DK-2850 Nærum · Denmark · Telephone: +45 42 80 05 00 · Telex: 37316 bruka dk · Fax: +45 42 80 14 05

Australia (02) 450-2066 · Austria 00 43-1-816 74 00 · Belgium 016/44 92 25 · Brazil (011) 246-8166 · Canada: East (514) 695-8225 West (604) 591-9300 · China 10-8419 625
Czech Republic 02-67 021100 · Finland (0)1481577 · France (1)64 57 20 10 · Germany 06151/8149-0 · Great Britain (081)954-2366 · Holland 03402-39994
Hong Kong 2548 7486 · Hungary (1)215 83 05 · Italy (02) 57 60 41 41 · Japan 03-5420-7302 · Republic of Korea (02) 554-0605 · Norway 66 90 44 10 · Poland (0-22) 40 93 92
Portugal (1)38 59 256/38 59 280 · Singapore 735 8933 · Slovak Republic 07-49 78 90 · Spain (91) 368 10 00 · Sweden (08) 711 27 30 · Switzerland 01/940 09 09
Taiwan (02) 713 9303 · Tunisia (01) 750 400 · USA (800) 332-2040
Local representatives and service organisations worldwide