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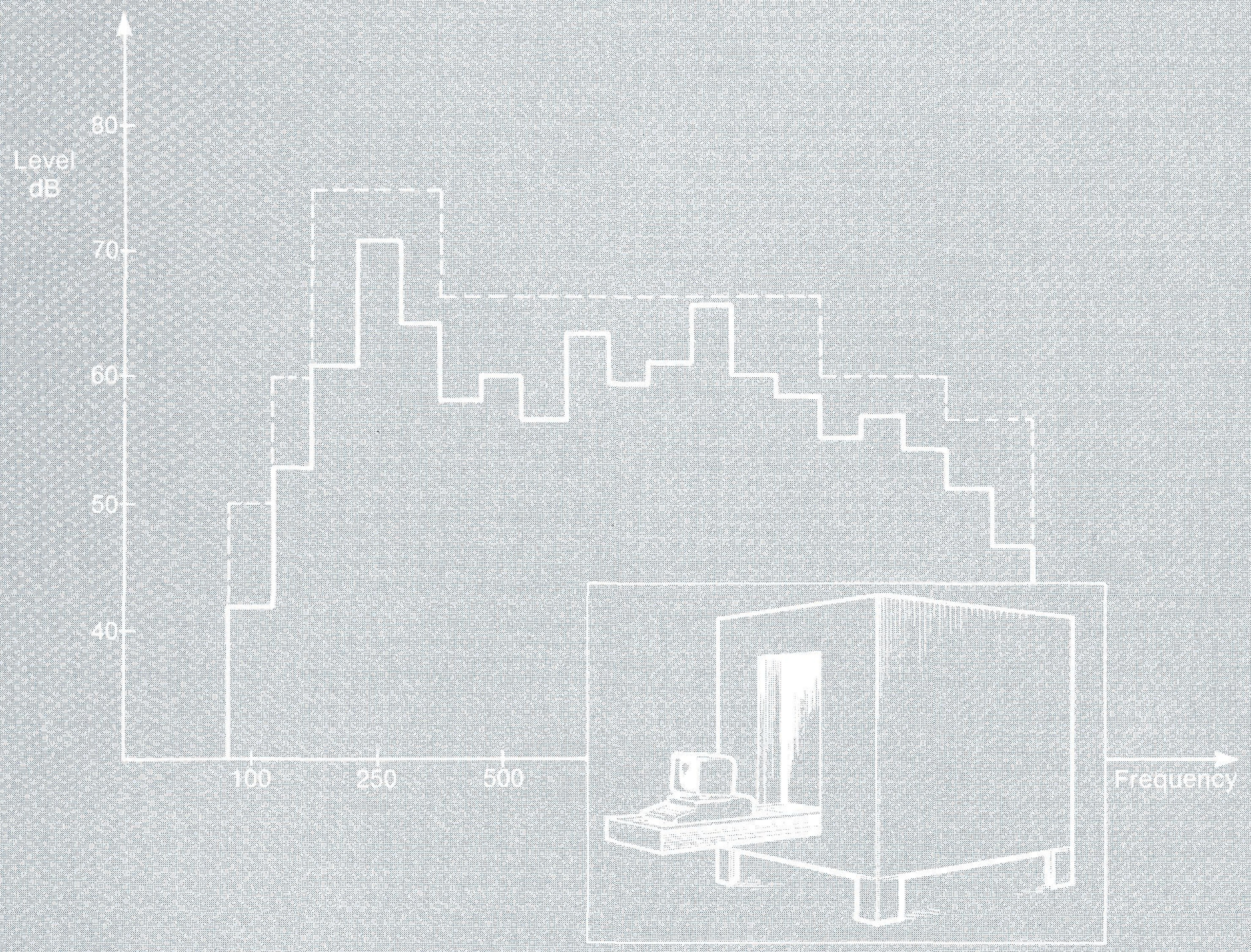
Production Testing of Noise from Business Machines



Brüel & Kjær

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Production Testing of Noise from Business Machines

by *Roger Upton,* B.Sc.

Introduction

The introduction of various national regulations either directly or indirectly limiting noise emissions from business machines, together with an increasing customer awareness of noise, is making noise an important parameter for business machine manufacturers. Where such noise emissions are to be measured for labelling purposes, absolute measurements are required which follow a published national or international standard. For production testing, however, comparative methods can usually be used, considerably simplifying the measurements. Further, where absolute measurements are preferred, the sound intensity method can be used to give precise measurements of sound power at or close to the production line.

This application note describes some methods of production testing which can be used both for sampled and 100% testing in areas from incoming piece parts quality control, to the testing of finished items such as personal and desk-top computers and mainframe systems.

Comparative Testing of Noise Emissions

Noise measurements on business machines are governed by a number of national and international standards, such as DIN 45 635 pt. 19, ANSI S1.29 (soon to be superceded by ANSI S12.10), ECMA 74, and ISO/DIS 7779. These standards state how noise is to be measured from business machines when this information is to be used for labelling purposes, and describe common measurement methods which can be used the world over. However, these methods are seldom applicable to production testing since they involve complex procedures and specialised acoustic test facilities. In production testing, a fast, simple measurement is required, to which a pass/fail limit can be assigned. Further, the detailed information given by the standardised methods is rarely required. Hence, comparative testing can be used instead.

At first sight, a suitable means of production testing might seem to be the use of vibration measurements instead of noise measurements. The advantage here would be that vibration measurements would be almost immune to the background noise problems always present on a production line. However, vibration measurements present other problems, notably that the accelerometer positioning can be critical, and a means must be found of quickly mounting and dismounting the accelerometer while maintaining a stiff enough connection for the test. Further problems are presented in correlating the vibration measurements with equivalent noise emissions. Although this method has been used successfully for fairly simple items such as domestic refrigerator compressors, in the long run it is usually easier to measure the noise directly, even though this requires the construction of special test chambers to reduce the effects of background noise.

An example of a simple system for production testing of noise from business machines is shown in Fig. 1. Such a system would be useful for testing of relatively uncomplicated noise sources, such as floppy disc-drive motors. The test chamber itself can be designed to be quasi-reverberant or quasi-anechoic. Of the two, the quasi-reverberant type offers the advantage that reverberant build-up in the chamber increases the measured source noise with respect to the background noise. Whatever the type of

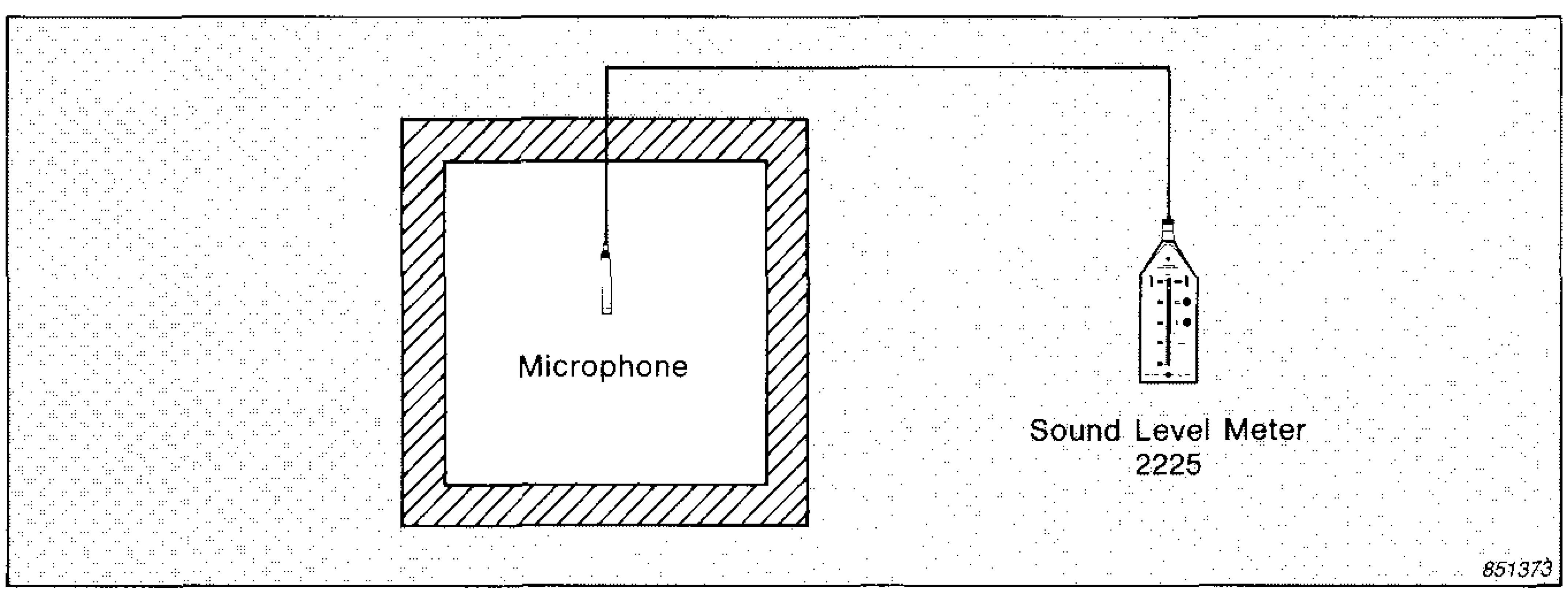

Fig. 1. Use of a test chamber and a sound level meter for production testing

chamber used, a design parameter should be that the difference between the source noise and the background noise, measured in the chamber, be at least 10 dB, whereby background noise effects can be safely ignored.

The sound level meter is used to measure the A-weighted sound pressure level at a single, fixed, microphone position in the chamber. The pass/fail limits are set by building up a correlation between sound pressure measurements in the chamber and sound power measurements in a standardised acoustic test facility. It is important that the test object is always placed in the same position in the chamber, and this can be ensured by use of a test jig. Care should be taken to ensure that the test jig is acousticaly "dead", that is, that no resonances are excited which would contribute to the measured sound pressure levels.

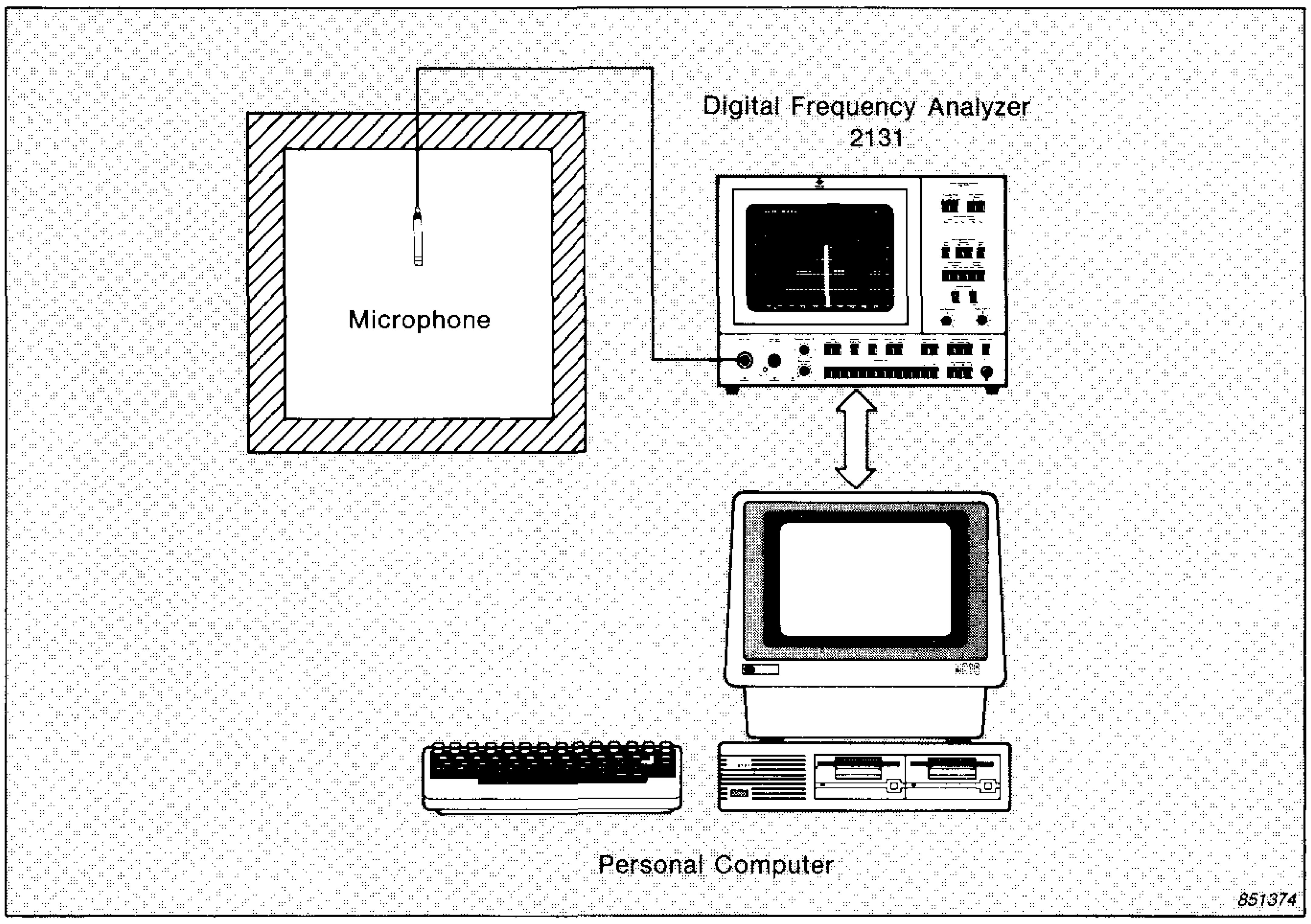

Fig. 2. Production testing system using a real-time analyzer

In the example shown in Fig. 1, the sound level meter used is one which can easily be operated by production line personnel. The measurement is based on the concept of the "1-minute L_{eq}", whereby the sound pressure measured in the chamber is averaged over a period of one minute. In this measurement, the need for "eyeball-averaging" of a fluctuating sound pressure level is eliminated, the sound level meter giving a single number which can be compared with the pass/fail limit. Where, however, a measurement time of one minute is too long, a more sophisticated sound level meter can be used to allow measurements of L_{eq} over time periods shorter than one minute.

As mentioned previously, the system described in Fig. 1. is suitable for testing of relatively simple objects, with few noise sources. Here, the A-weighted noise level is often sufficient to make the pass/fail decision. For more complex objects, however, an octave or 1/3 octave analysis of the noise might be necessary. For instance, in a personal computer, there can be several noise sources, such as the cooling fan(s), the disc drive(s), the visual display unit, etc.. A system for testing such objects, using a real-time 1/3 octave analyzer, is shown in Fig. 2.

Octave or 1/3 octave analysis of noise emissions places more stringent requirements on the design of the test chamber, since the design goal of at least 10 dB difference between the source noise and the background noise in the chamber now applies to each octave of 1/3 octave. Achieving this can be difficult, especially at low frequencies. Typical methods include the use of double-walled chambers with vibration isolation between the inner and outer chamber, a separate door to each chamber, and both absorption materials and an airgap between the inner and outer chambers. Chambers designed according to these principles have proved more than sufficient in providing the required background noise attenuation.

Use of an octave or 1/3 octave analysis of the noise from the test object obviously complicates the test when compared with using a simple sound level meter. However, it is now the computer which makes the pass/fail decision. Further, the computer can be used to prompt the operator during the test. Typical test times using such systems are one or two minutes, including loading the test object into the test chamber and removing it again, and such test chambers have been built to operate directly on the production line. The principle of the test method is exactly as described before, except that the correlation between the sound pressures measured in the chamber and sound powers measured in a standardised acoustic test facility are made on an octave or 1/3 octave basis.

Production Testing using Sound Intensity

The test methods described in the previous section apply mainly to smaller, high volume business machines. Also, the physical dimensions of the test chambers involved allows their easy incorporation into the production line. For instance, a chamber for noise testing of a personal computer might have a maximum physical dimension of the order of two to three metres. However, as the test objects become larger, these methods become less practical, since the test chambers required begin to resemble full-scale reverberation rooms or anechoic chambers. Further, there is the problem of physically moving the test object in and out of the test chamber. In such circumstances, it becomes advantageous to change the entire test method, and to base it on sound intensity rather than sound pressure. This method also gives absolute measurements of sound power.

Sound intensity is a vector quantity which describes the amount and the direction of flow of acoustic energy. It is directly connected with sound power, and another name for it is sound power flux. One of its primary advantages in the measurement of sound power is that accurate measurements can be made even when the background noise is 10 dB or more **higher** than the source noise, while such measurements based on sound pressure require that the background noise be at least 6 dB and preferably 10 dB **below** the source noise. Hence, sound intensity presents an ideal method of measuring sound power in areas of high background noise such as on production lines.

The principle of sound power measurement based on sound intensity is illustrated in Fig. 3. The sound intensity is integrated over a measurement surface totally enclosing the test object. Since sound intensity is a vector quantity, it can distinguish between sound energy leaving the measurement surface, and sound energy entering it. It follows that when the integration over the measurement surface is complete, any effects due to noise sources external to the surface will have cancelled out, (assuming that there is no absorption inside the measurement surface), leaving behind the intensity due to the noise source inside the surface. Since sound intensity is sound power flux or sound power flow per unit area, only an area correction is needed to arrive at the sound power of the source, this having been measured without the need for special acoustic test facilities.

A system for the semi-automatic measurement of sound power based on sound intensity is shown in Fig. 4. It

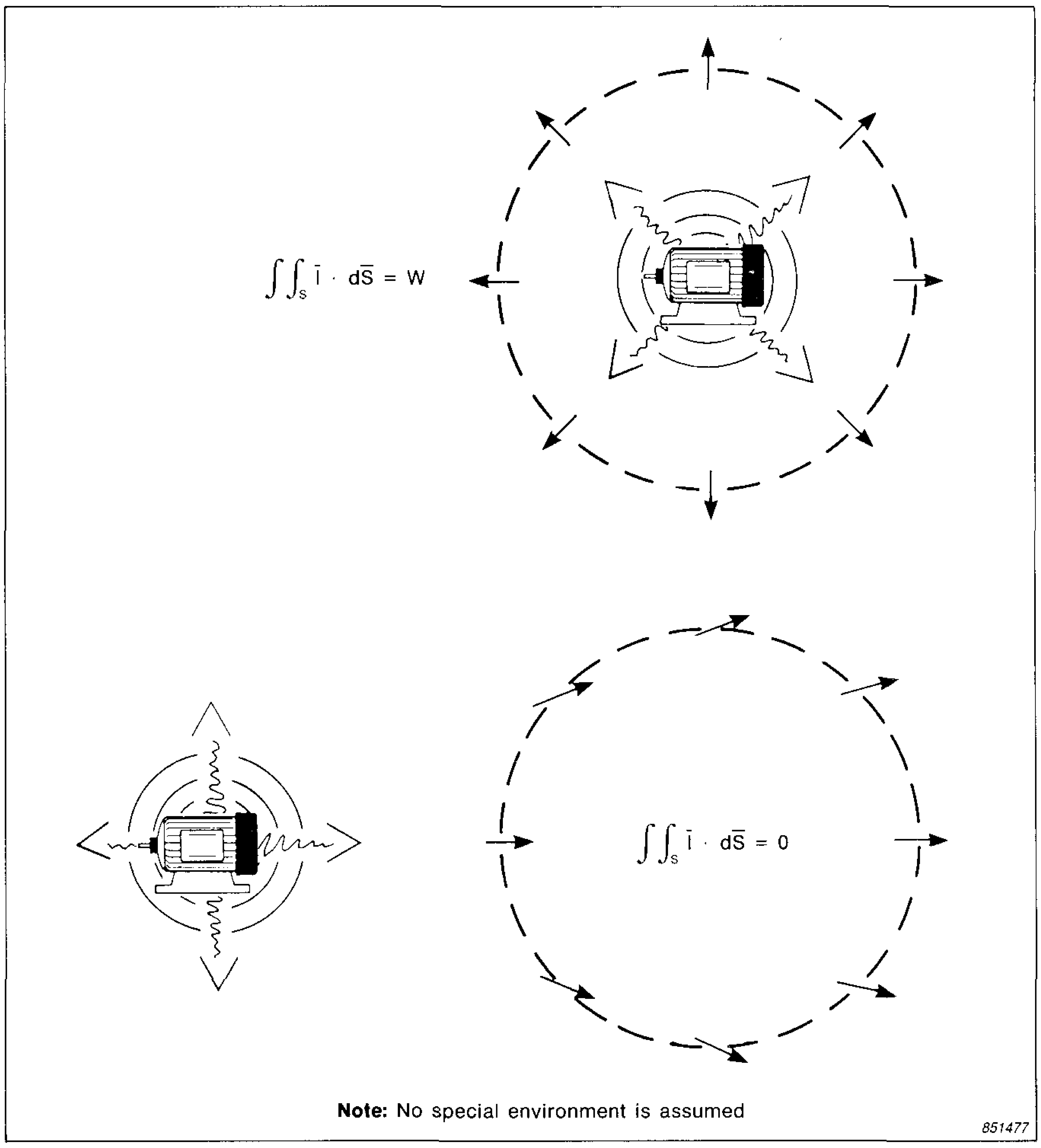

Fig. 3. Principle of measurement of sound power based on sound intensity

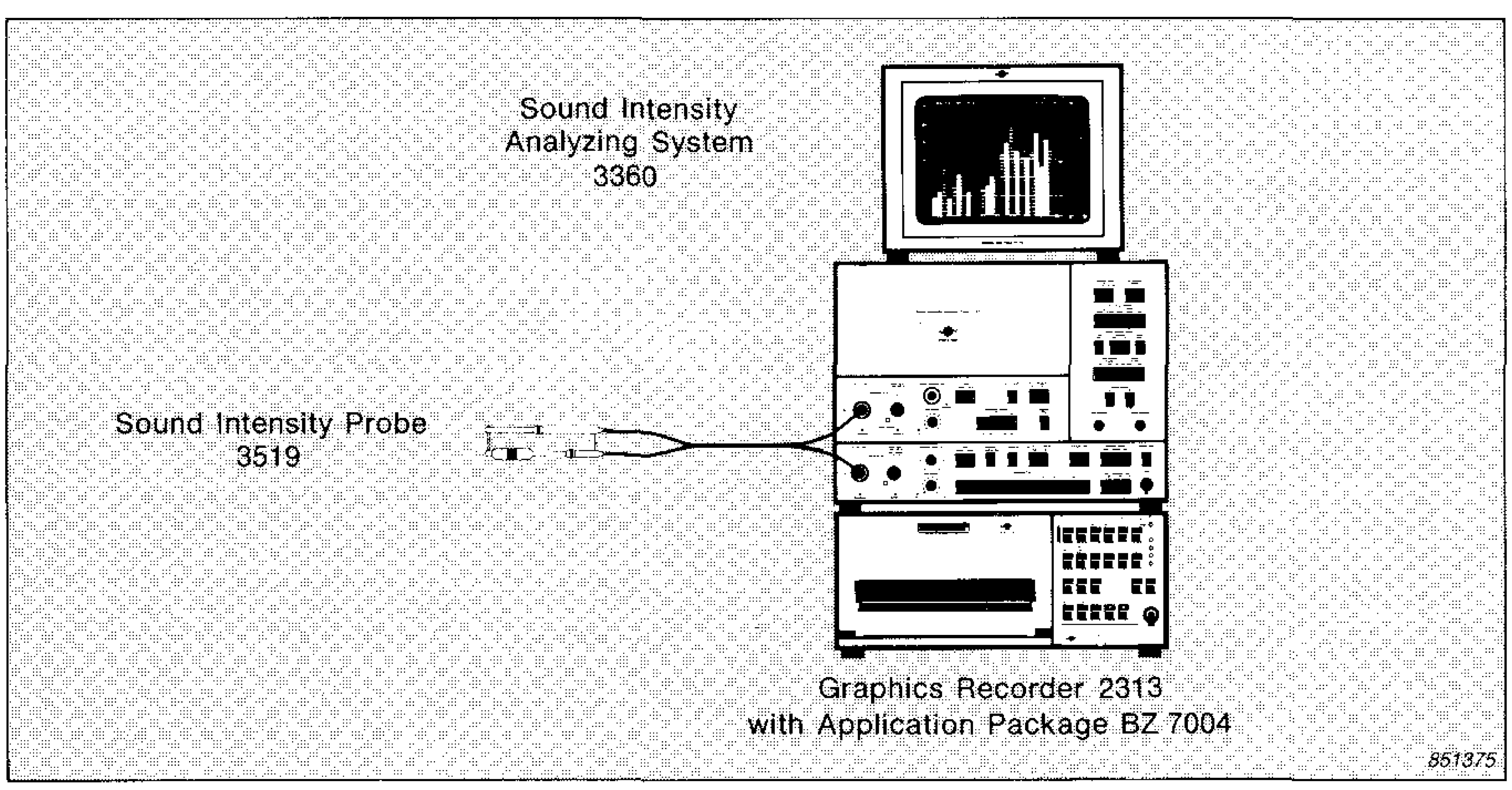

Fig. 4. A system for semi-automatic measurement of sound power based on sound intensity

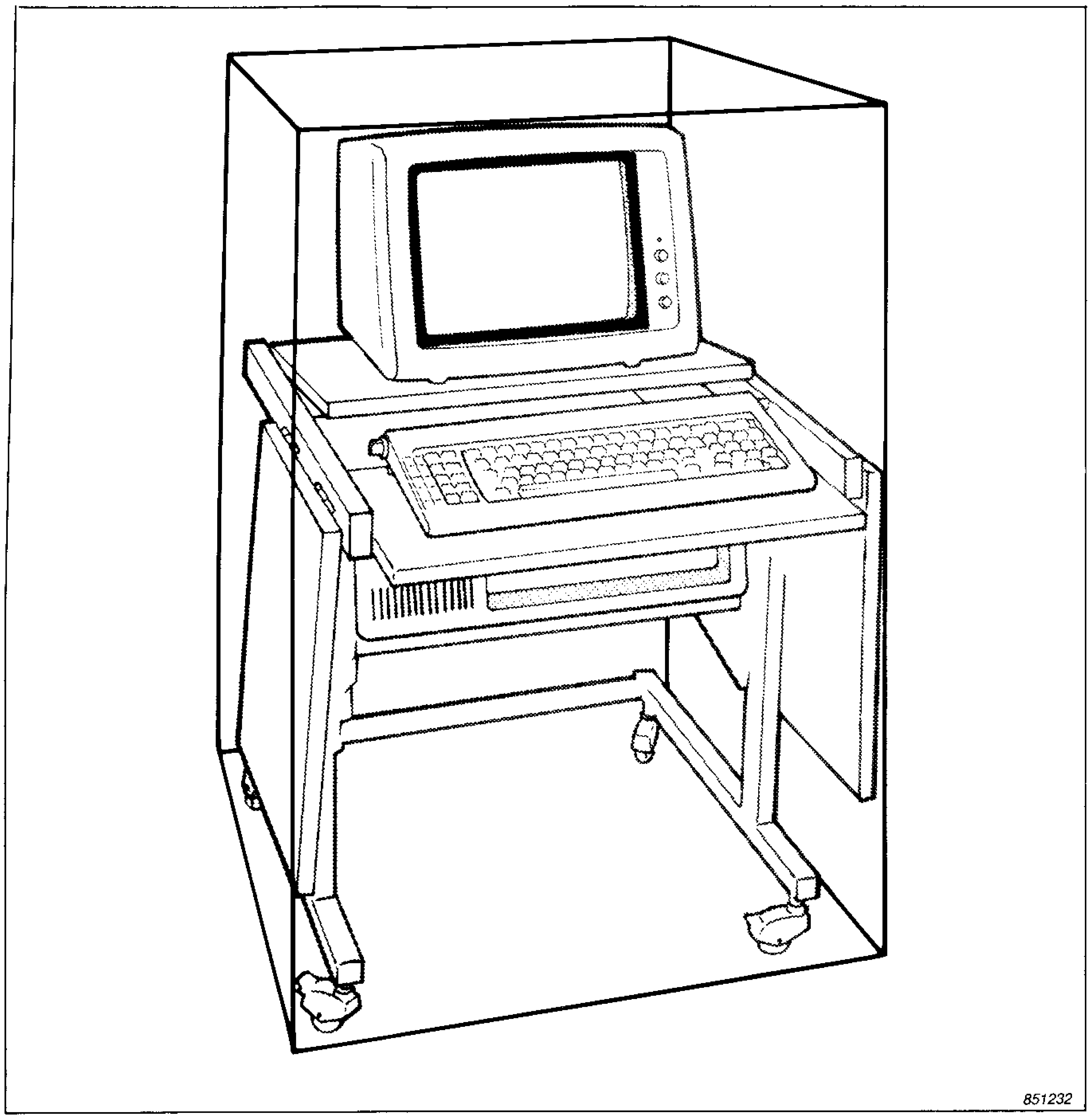

Fig. 5. Measurement surface about a personal computer

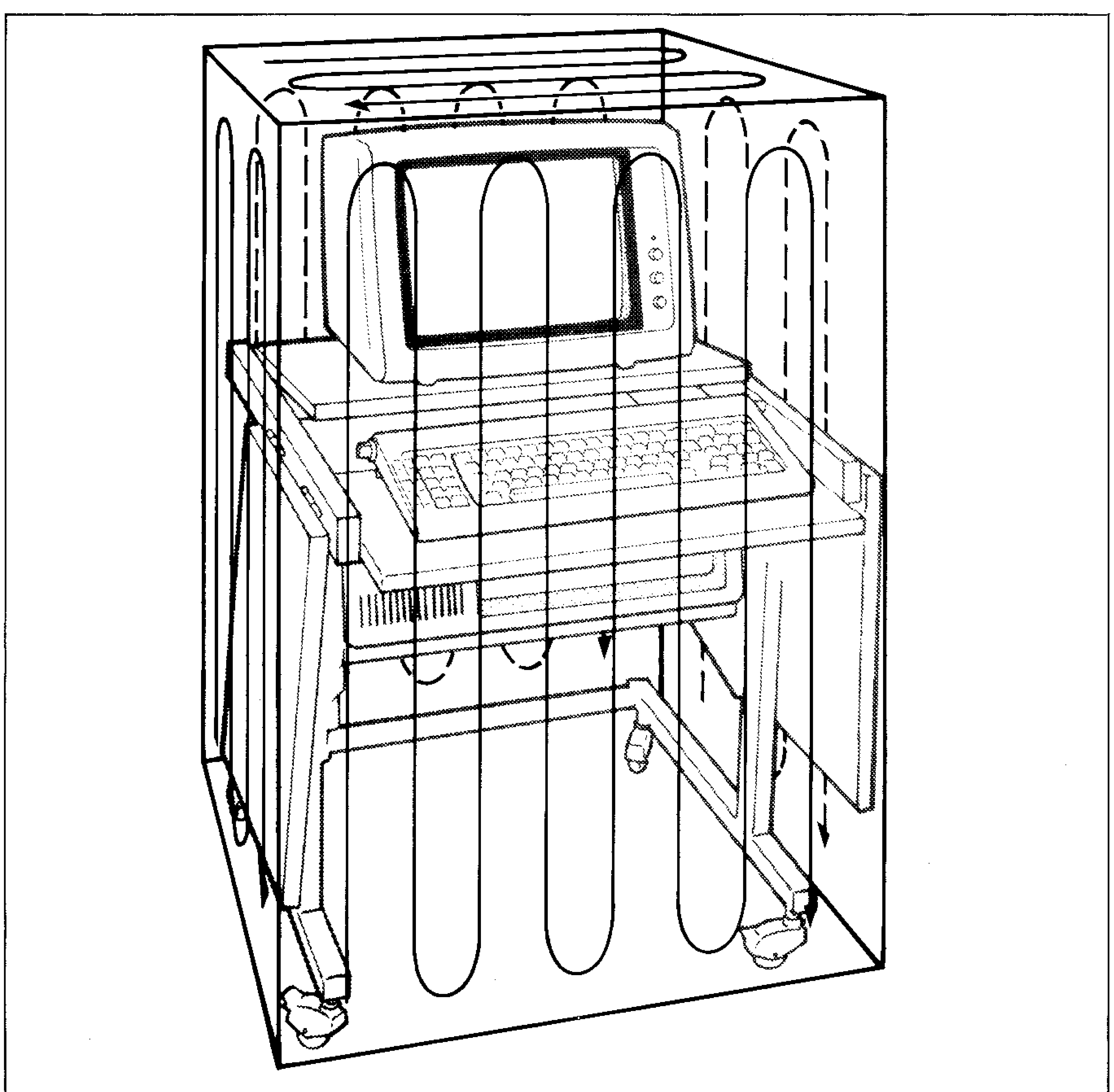

Fig. 6. Measurement of sound power on a personal computer showing the intensity probe's path over the measurement surface

consists of the Sound Intensity Analyzing System Type 3360 and the Graphics Recorder Type 2313. Details of the measurement surface are fed into the 2313, while the sound intensity measurements are made using the 3360. On completion of the measurements, the 2313 delivers hard copy documentation of the results of the tests. Provided the measurement surface remains unchanged, such tests can be repeated over and over again without the need for changes in the settings of the 3360 or 2313.

Figs. 5, 6 and 7 illustrate the process for a personal computer. Fig. 5 shows the measurement surface, which totally encloses the computer and termintes on an acoustically reflecting plane. Fig. 6 shows the path of the sound intensity probe as it was scanned over the measurement surface to integrate the sound intensity flowing through the surface. Fig. 7 shows the final print-out from the 2313 of the measured sound power giving the 1/3 octave, A-weighted, and linear levels. The entire measurement process, including entering the required settings into the 3360 and 2313, took two to three minutes. The process was automatic, apart from the manual scanning of the probe.

As was mentioned earlier, sound power measurements based on sound intensity can tolerate background noise levels up to more than 10 dB higher than the source noise. However, as background noise levels increase, the frequency range of the measurements is reduced. Hence, it is in the user's interest to keep the signal to noise ratio as high as possible. Since the sound intensity method places no restrictions on the measurement surface, one method of doing this is to make the measurements as close to the noise source as is practical. Alternatively, in areas of very high background noise, a room can be maintained close to the production line where the sound intensity measurements can be carried out. Although this might seem to defeat the object of using sound intensity, that is avoiding the need for a special acoustic test facility, it should be remembered that the only requirements for the room will be the accommodation of the test object, and the sufficient attenuation of background noise through the walls. Further, transportation to a dedicated acoustic test facility can often involve much larger problems, such as transportation over distances of up to several hundred kilometres.

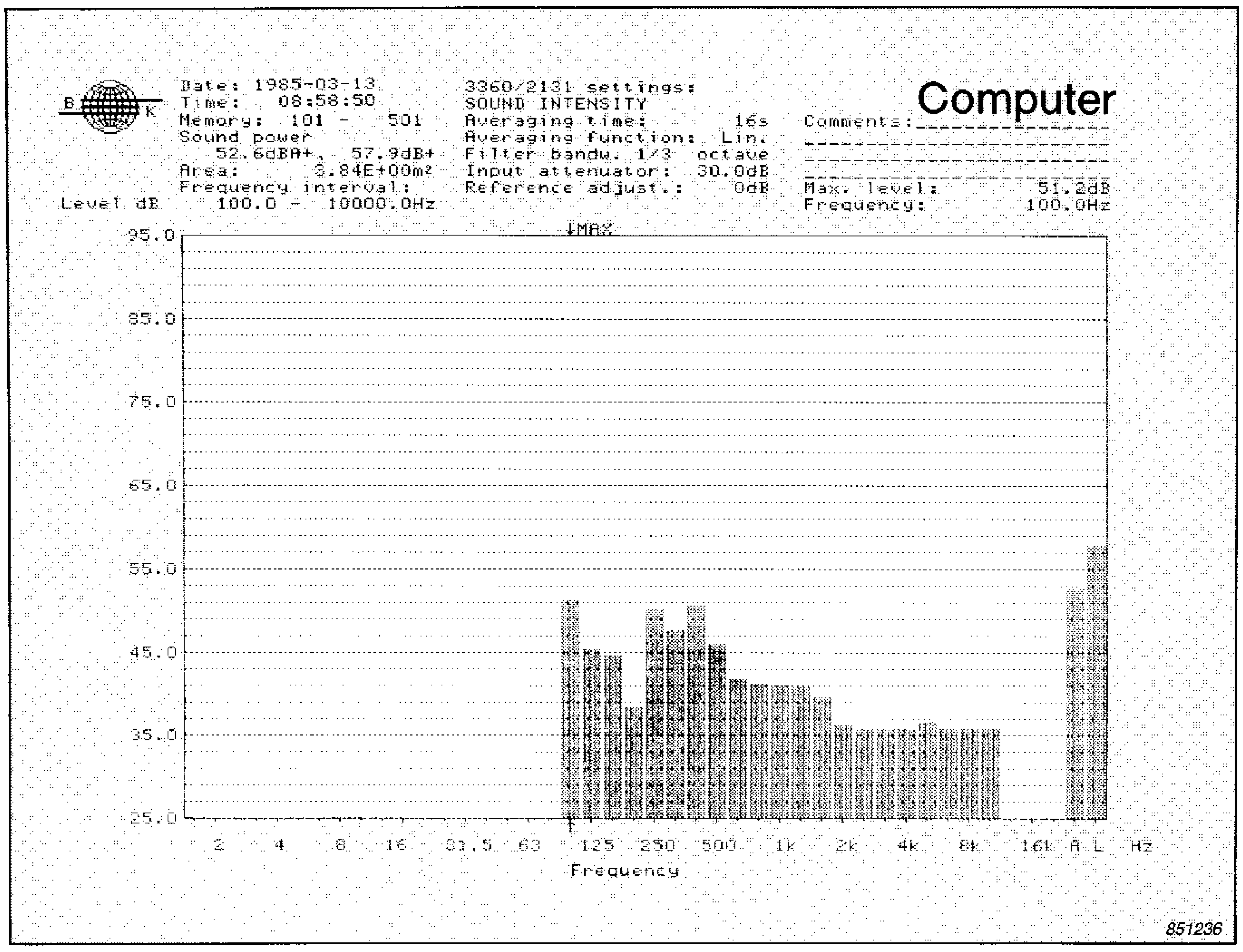

Fig. 7. 1/3 octave plot of the sound power of the personal computer, obtained from the 2313

Conclusion

This application note has described some of the methods available for production testing of noise from business machines. Although it has not been possible to be specific, the methods described are based on those being successfully used by a number of companies producing business machines throughout the world today. The proliferation of standards limiting noise emissions from business machines is making such production testing necessary, and although at first sight it might seem a little daunting, the methods are available for it to be carried out.

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