Proceedings of The Institute of Acoustics

SOUND INTENSITY MEASUREMENTS IN STUDIOS

J.J.P. Shelton

Bruel & Kjaer (UK) Ltd, Harrow Weald Lodge,
92 Uxbridge Road, Harrow, Middlesex, HA3 6BZ

INTRODUCTION

Since the introduction of commercially available analysis systems early this decade, sound intensity measurement has become the fastest growing field in acoustics. Of the available methods, the two-microphone technique is now generally accepted as the most accurate and repeatable, although limitations are imposed on frequency range and type of acoustic field.

It has been shown [1] that reverberant conditions can cause large inaccuracies in intensity measurements due to the available phase resolution of the measuring system, so care must be exercised in the majority of situations.

In the field of studio-acoustics, however, the environment can be considered virtually semi-anechoic, or at least non-reactive, and this, coupled with recent advances in microphone technology [2] [3], has meant that sound intensity could be a powerful technique.

There exists, however, a basic paradox. Sound intensity measurement has, until recently, implied the use of complex real time analysers and, as such, has been beyond the pocket of the studio consultant.

The recent introduction of a portable serial octave analysis system could change this and it is the purpose of this paper to show the types of measurement which could be used in studio commission.

An opportunity arose recently in which a control cubicle became available for intensity measurements and these were performed first with an expensive 1/3 octave system and then, after acoustic treatment, using the 1/1 octave analyser. In this way, it can be seen that octave analysis is probably sufficient for most situations and that useful results can be obtained.

THE THIRD OCTAVE MEASUREMENTS

The conditions which prompted the measurement was a series of complaints by control engineers of a subjective problem at low frequencies [less than 80Hz] during monitoring of recordings.

The analysis system used is shown in Fig.1 and, as the interest lay at low frequencies, a large microphone spacing was used giving a frequency range of 31.5Hz to 1.25kHz.

Pink noise was injected into the monitoring system and measurements were performed first with one monitor then with both.

An initial real-time survey was carried out by moving the probe around the area of the engineers' head position and this revealed an anomaly at 160Hz where the direction of acoustic energy flow appeared to change from a positive to negative direction where positive is from front to back of the cubicle. The phenomenon spread to the two adjacent 1/3 octave bands at some locations. Although this is a higher frequency than subjectively estimated, it was felt to warrant further investigation. A typical spectrum is shown in Fig.2.

A grid was laid out in the cubicle [Fig.3] and a series of measurements taken and stored, with the probe held horizontally, hence judging the acoustic energy flow from front to back of the cubicle.

Contours were then interpolated between the measurement points to yield an intensity map over the grid. Fig.4 shows the intensity map for the overall frequency range and clearly shows the two speakers as sources with the intensity reducing with distance, as expected. However, at 160Hz [Fig.5], the calculations clearly show the polarity change which corresponds with the engineers' monitoring position.

To substantiate the results, a vertical grid was taken over the back wall and measurements performed of intensity perpendicular to the wall [Fig.6]. The results at 160Hz show that the modular absorbers appear to be reflecting energy strongly at this frequency and this could go some way towards explaining the subjective effects [Fig.7].

THE OCTAVE MEASUREMENTS

Since the above measurements, considerable acoustic treatment has been performed on the cubicle, including the installation of diffusers on the rear wall.

The measurements were repeated with a serial octave analyser [Fig.8] and the results showed a greatly improved acoustic behaviour [160Hz is shown in Figs. 9 and 10], showing none of the polarity reversal that was apparent before. The rear wall appears to be "absorbing" more effectively even though diffusers and not absorbers are now fitted.

The subjective reaction at low frequencies is now satisfactory although there have been some comments regarding the sound when near to the diffusers, caused by the complex acoustic field at this position.

SOURCE LOCATION

Although not a major part of the scope of this paper, it should be mentioned that the directional characteristics of the probe can be used to "track" intensity vectors and, as a result, the analyser should find a large application in source location with respect to acoustic leaks and crosstalk.There are also established techniques for using intensity measurement for in situ measurement of absorption coefficient [4] [5].

CONCLUSIONS

By using sound intensity measurements, anomalies in the acoustic field of the control cubicle were found at 160Hz which could possibly be the cause of adverse subjective reaction. To be sure, it would be necessary to perform similar tests in other studios to compare with subjective results.

The addition of acoustic treatment to the cubicle resulted in a measurable improvement in the acoustics and yielded interesting results with regard to the diffusers on the back wall.

Now that a low-cost acoustic intensity analyser is available, intensity measurements in the studio environment will undoubtedly become an important part of the studio commissioning process.

REFERENCES

[1] S. Gade et al "Sound Power Determination in highly reactive environments using Sound Intensity techniques" Proc. Internoise 83 [1983].

[2] O. Schultz, E. Frederiksen "New types of Pressure Microphones for Sound Intensity measurements" Proc. Nordic Acoustical Meeting 86 [1986].

[3] E. Frederiksen "Phase characteristics of Microphones for Intensity Probes" Proc. 2nd International Congress on Acoustic Intensity, Senlis [1985].

[4] J. Cauberg "Determination in situation of the transmission loss of various components of a building facade with the aid of sound intensity measurements" FASE Proceeding 1984.

[5] T. Nielsen "Intensity measurements in Building Acoustics" Bruel & Kjaer Application Note No. BO 0147-11.

SOUND INTENSITY MEASUREMENTS IN STUDIOS

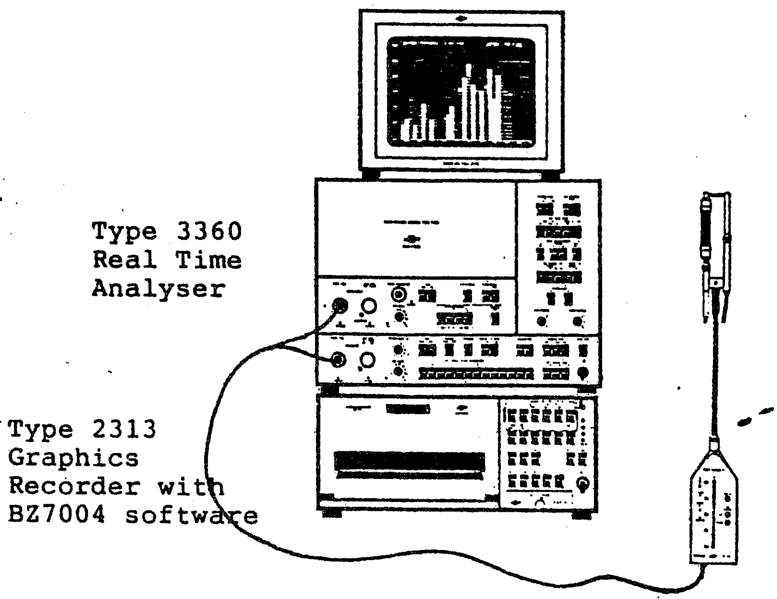

Fig. 1

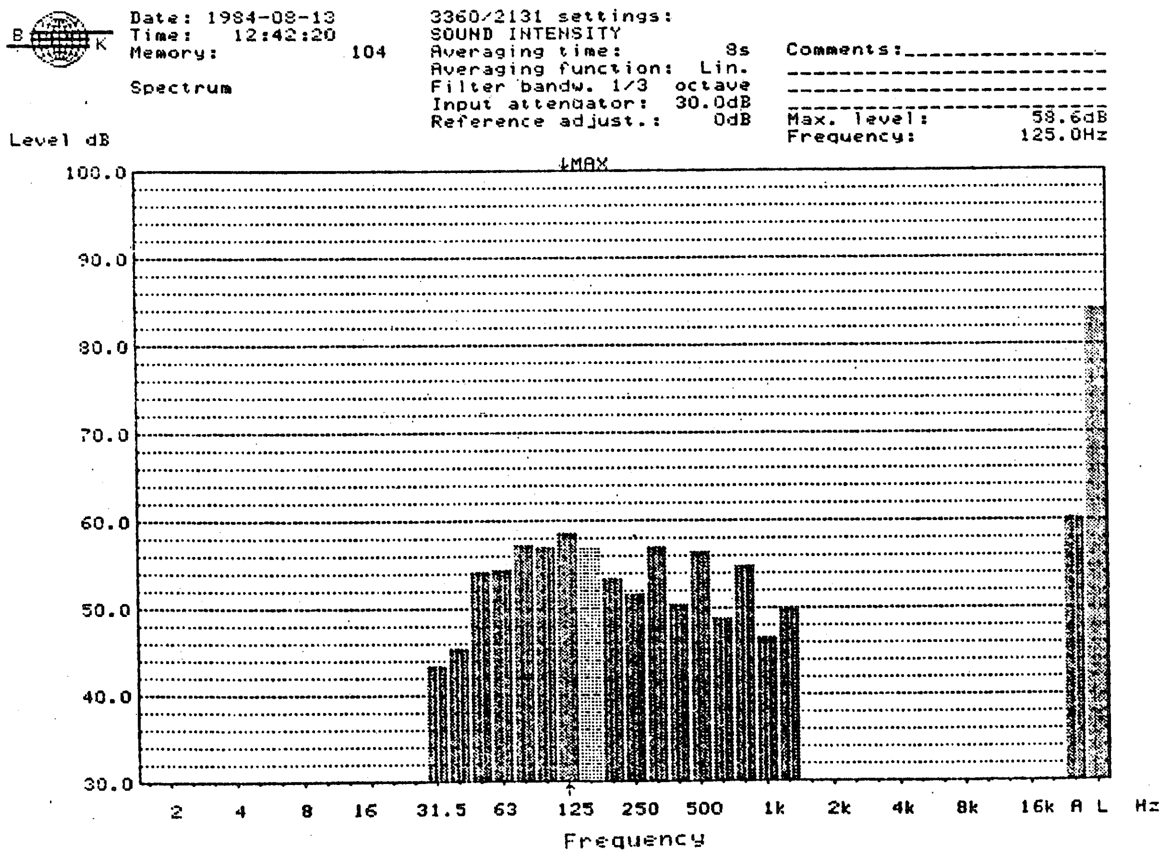

Fig. 2

SOUND INTENSITY MEASUREMENTS IN STUDIOS

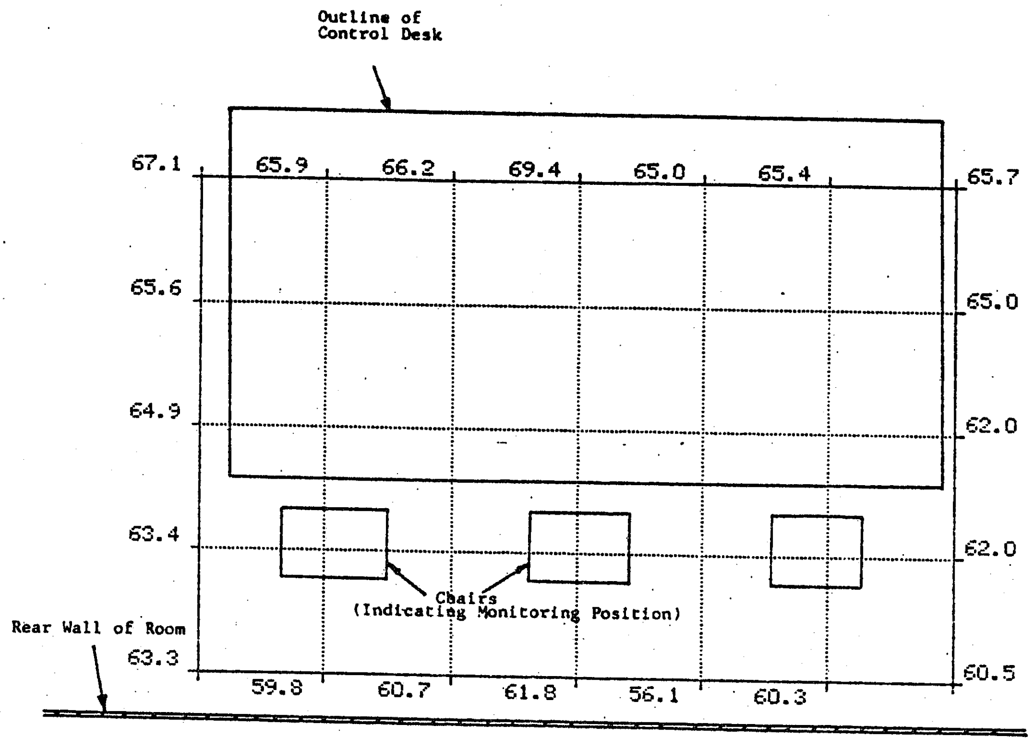

Fig. 3

Date: 1986-10-09
Time: 17:38:17
Last memory
Mic. space: 50mm
Contour plot
A-weight range:
31.5 - 1250.0Hz

3360/2131 settings:
SOUND INTENSITY
Averaging time: 8s
Averaging function: Exp.
Filter bandw. 1/3 octave
Input attenuator: 30.0dB
Reference adjust.: 0dB

** DIFFERENT SETTINGS **

Comments:

Rows,Columns: 5, 7
Interpol.steps: 10
Interpol.type: Log.
Delta level: 1dB
Base line: 50dB

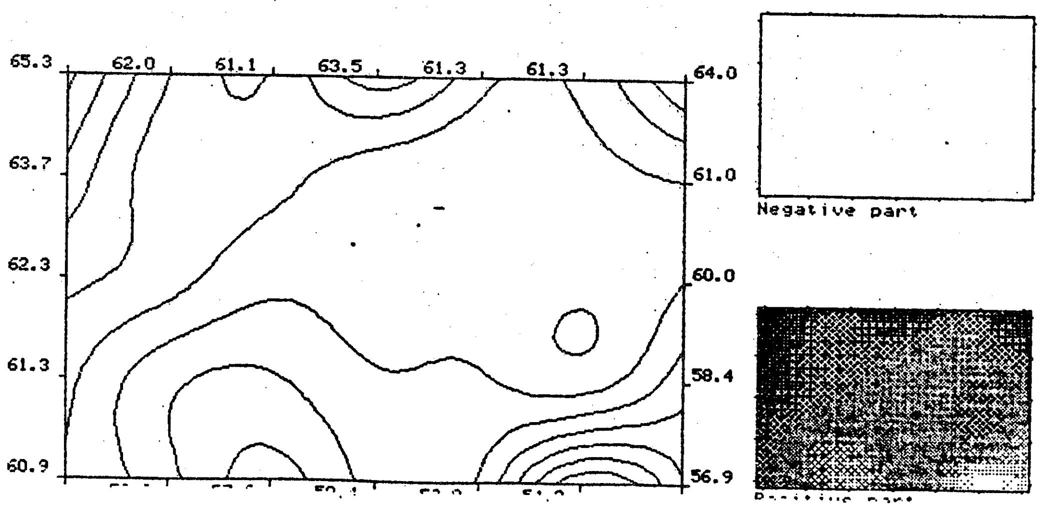

Fig. 4

SOUND INTENSITY MEASUREMENTS IN STUDIOS

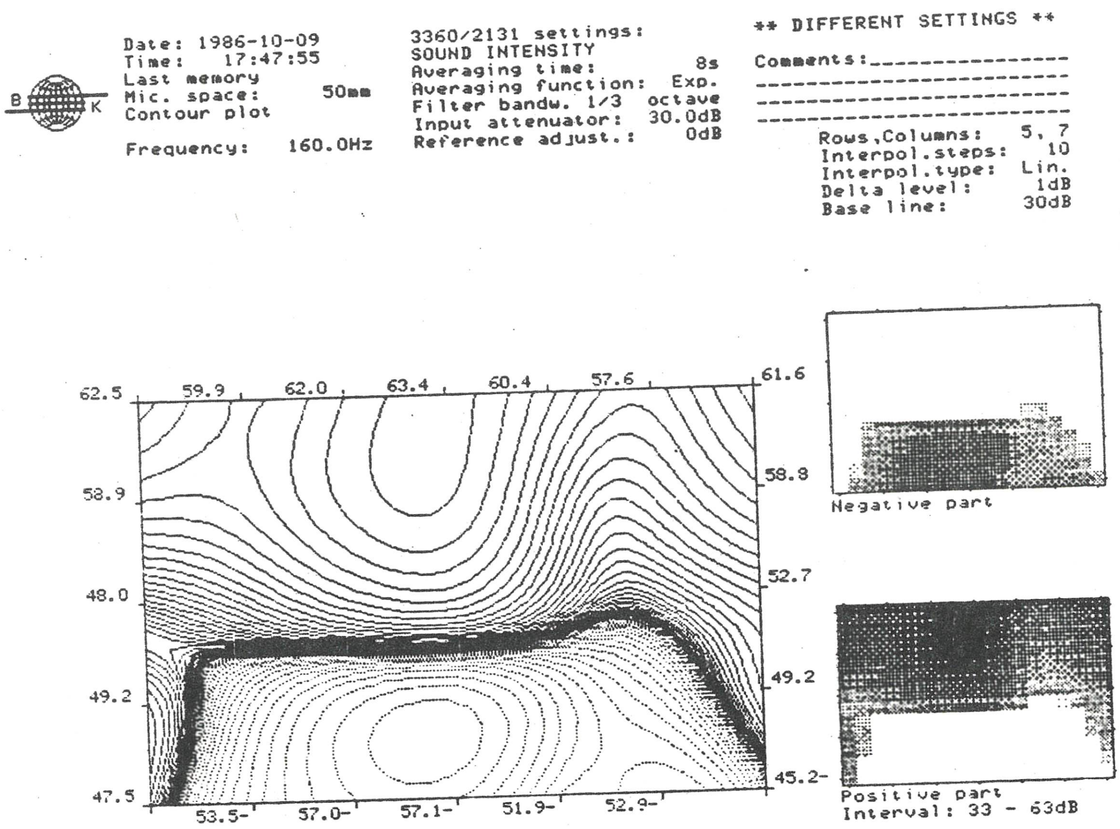

Fig. 5

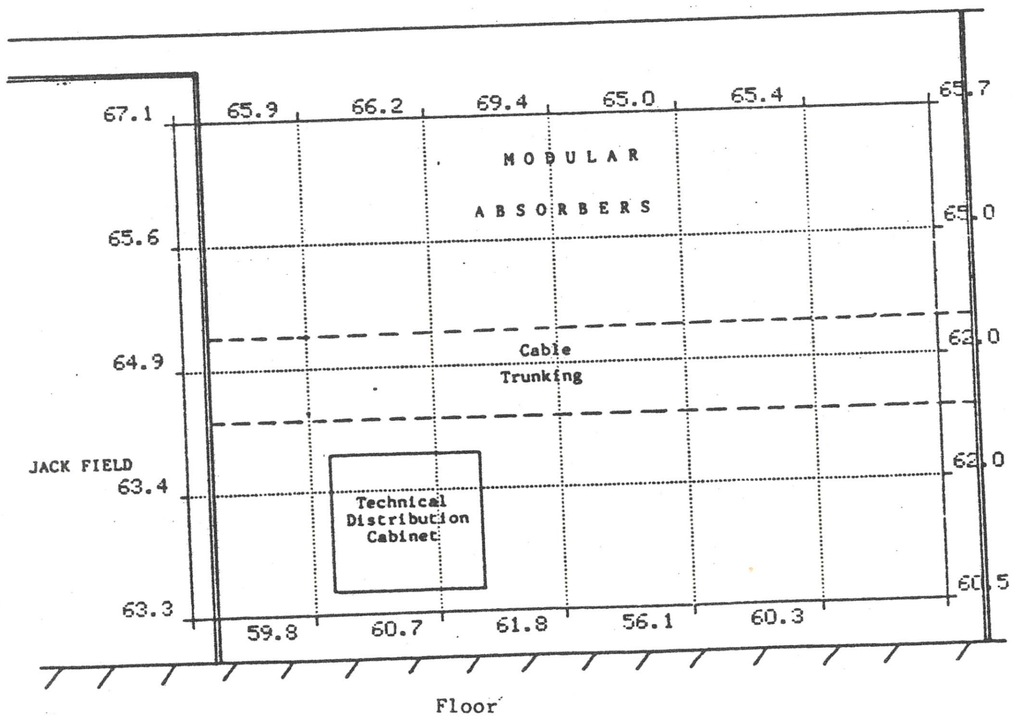

Fig. 6

SOUND INTENSITY MEASUREMENTS IN STUDIOS

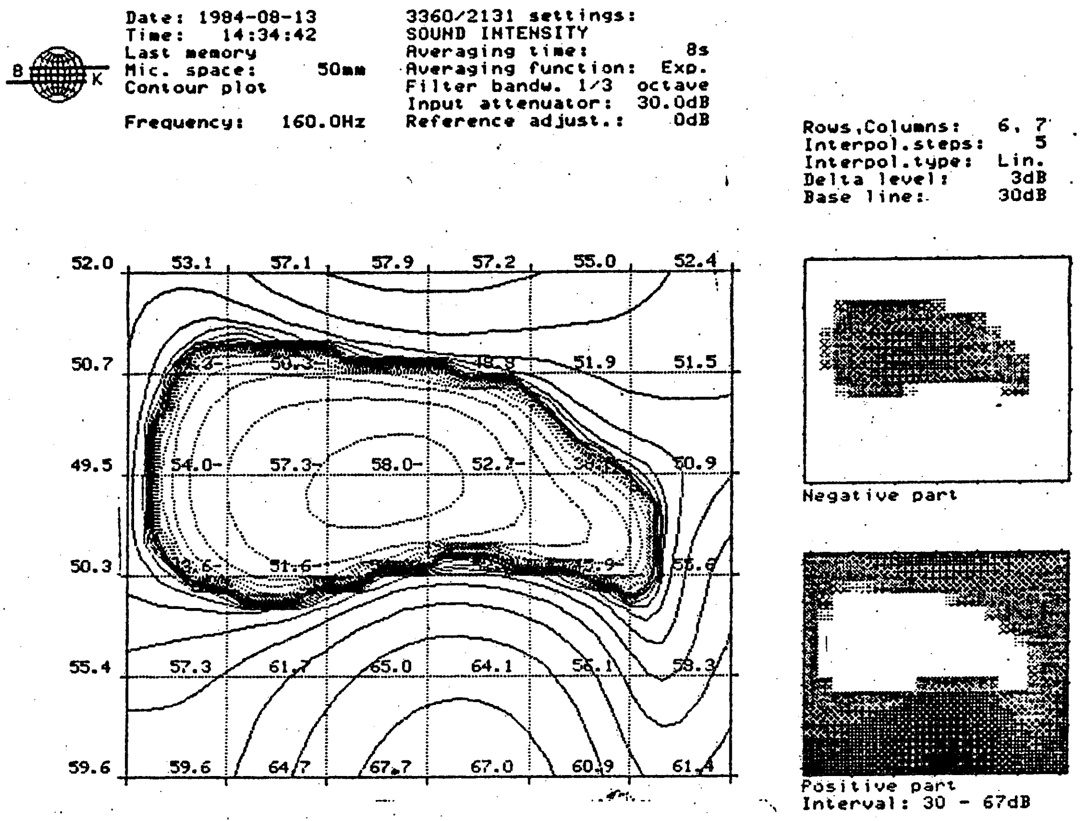

Fig. 7

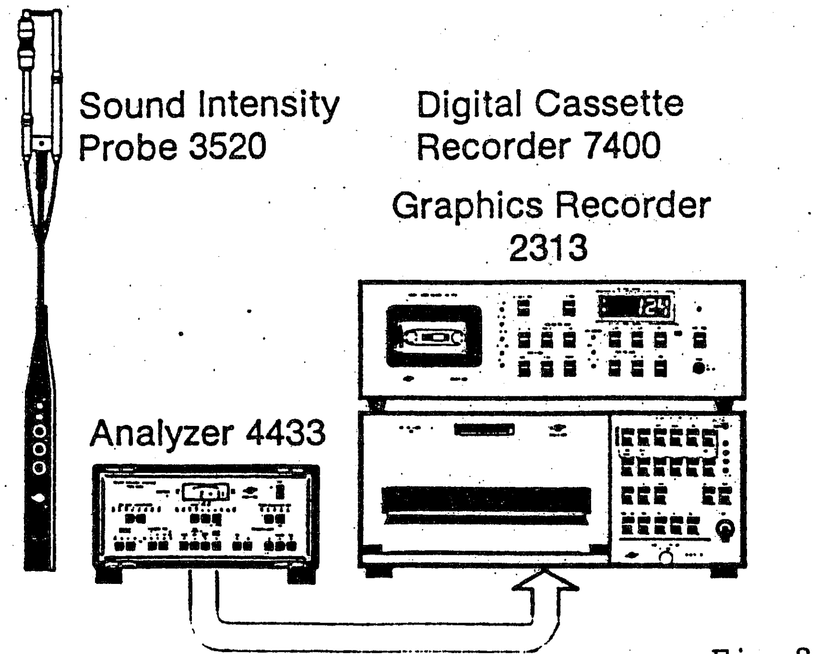

Fig.8

SOUND INTENSITY MEASUREMENTS IN STUDIOS

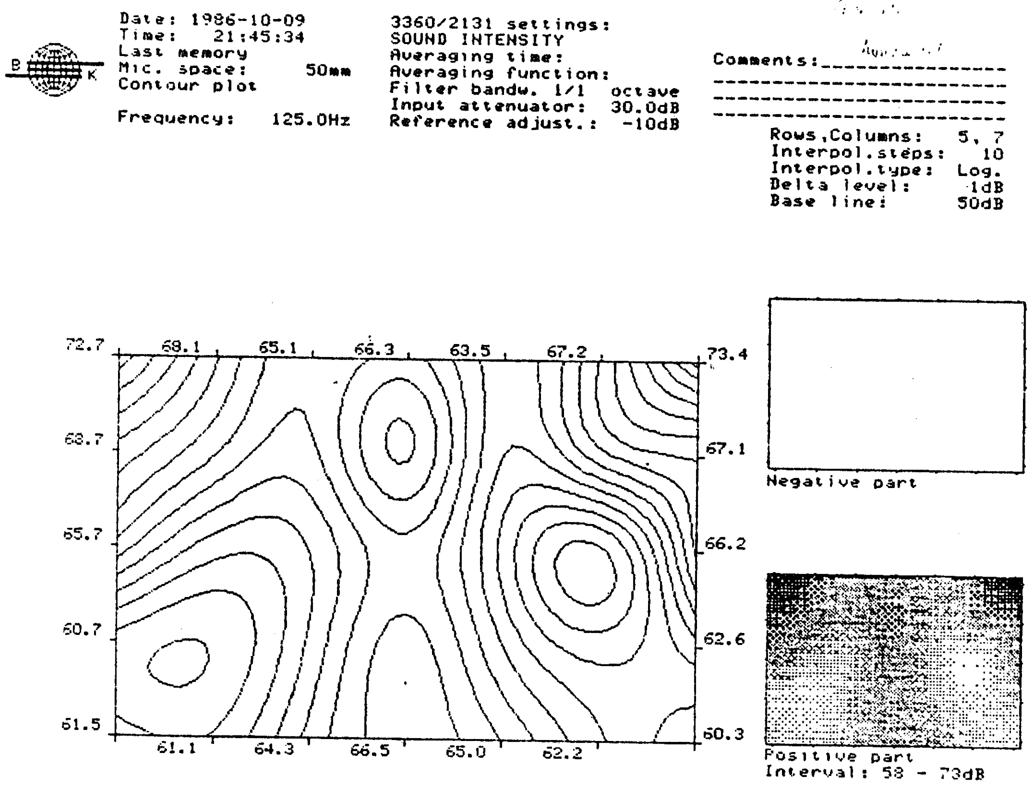

Fig. 9

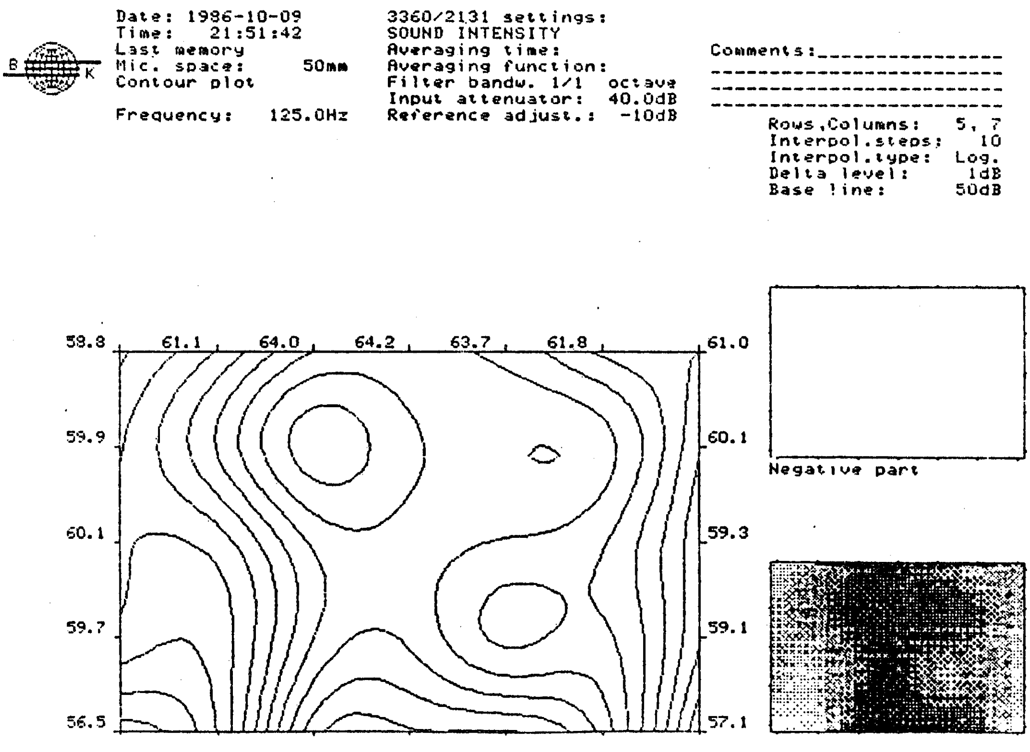

Fig. 10