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IMPROVED RELIABILITY OF ACOUSTICALLY OPERATED SECURITY SYSTEMS BY THE APPLICATION OF DIGITAL SIGNAL PROCESSING

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INTRODUCTION

This paper suggests a technique for the use of a simple acoustic transducer (ie a microphone) as a replacement for the more usual type of vibration sensor fitted in many buildings as the "front end" of electronic security systems.

In many security system applications, "Breaking and Entering" through window frames is detected by means of a vibration sensor commonly known as a "Trembler".

These devices represent a cost effective solution, but their reliability against false triggering often leaves much to be desired. The reasons for this being due not only to the basic design of the sensor, but also to the often simple electronic processing of signals received from such sensors.

This method suggests a technique for significant improvement by the use of a more reliable sensor from which signals can be processed in three dimensions, thus allowing far greater differentiation between a genuine "Break-in" and, for example, a gust of wind or an accidental thump.

BACKGROUND.

For many years now there has been a need to detect vibration at particular points in buildings in order to trigger disturbances to a central electronic monitoring unit. The method used being to fix a "trembler" device to prone points (for example, window frames) which would then transmit a signal to the central unit if a disturbance is affected.

The "trembler" consists of a small ball bearing which rests on a conducting bed of contacts, the principle being to produce an electrical discontinuity for a short period of time according to the type of disturbance.

Although this system works fairly well and is also extremely cheap, it does suffer from several disadvantages:-

i) Signals are only produced by fairly high amplitude, low frequency disturbances. Any disturbance which contains high frequency information would be lost in the response of the sensor.

ii) The mass of the ball bearing itself places severe constraints on the ranges of signals that can be generated.

iii) Being a mechanical device, the theoretical reliability as an electrical transducer leaves much to be desired, particularly at the low-cost end of the market where such luxuries as gold plating are completely out of the question.

iv) The electronic processing of the trembler generated signals carried out is at worst limited to a simple flip-flop and at the best, a simple delay circuit, or sometimes a simple pulse-counting integrator.

-AN ALTERNATIVE APPROACH

The technique describes here is based upon the use of a simple acoustic transducer (ie a microphone) which replaces the trembler type of transducer. Being an audio frequency device, disturbances within a wide frequency range are received.

A block diagram of the proposed system is shown in Fig 1. The principle of operation being to sample the signal received and by analogue to digital conversion [1][2], to store many samples in a digital memory. This means that information will be available in the microcomputer memory on frequency components and their amplitudes as a function of time as shown in Fig 2.

Using a microprocessor system with associated hardware and suitable software, this three dimensional concept of any disturbance should allow decisions with regard to the viability of a signal as being valid or not to be made with far greater reliability provided that there is sufficient difference in the representation of signals in this form between valid and non valid signals. This is discussed further in the Results section.

INPUT FILTER

This is required in any sampled system to prevent aliasing by the presence of signals that do not meet the niquist sampling criteria. From measurements taken to date, a maximum baseband signal of around 10kHz would seem to be quite adequate and therefore a sampling rate of around 30kHz would make the input filter realisable and cost effective.

ANALOGUE TO DIGITAL CONVERTER

The maximum dynamic range of the system need only be quite small. Again from the results taken, a dynamic range of around 40dB seems quite acceptable and in fact by correct set-up will ensure that signals below a defined threshold will never be coded [3].

With a dynamic range of 6dB/bit, 7 bits would be satisfactory but as 8 bit converters are readily available at low cost, this seems a reasonable choice.

SIGNAL STORE

The size of the store is defined by the sampling rate, word size and maximum sample duration required for processing. The first two parameters have already been defined as 30kHz and 8 bits/word.

However, from the results taken at present, the maximum disturbance duration has been found to be around 250 mS and therefore with the approach suggested, a store size of about 7.5 KB would be necessary.

This is achievable at low cost. An 8 KB RAM costing less than £5.00 at todays prices.

MICROCOMPUTER HARDWARE

A single 8 bit microprocessor should prove adequate for this application such as the 6502, 6800 or even an 8035 single chip microcomputer with 16 I/O lines.

A single chip microcomputer such as the 8048 or 8049 would represent an excellent choice for a high volume application, but 2 KB max of program memory is difficult to predict as being adequate at this early stage.

DIGITAL TO ANALOGUE CONVERTER

There are now many 8 bit D-A converters available. At the word size and sampling rate estimated in this application, a low cost solution should represent no problem.

OUTPUT INTERFACE TO ALARM

By suitable software design, this needs to be only minimal in its nature. A simple voltage or current level converter being the only requirement likely to be necessary.

SOFTWARE STRATEGY

A good philosophy with any microprocessor approach is to do as much processing as possible in software. Software costs nothing to implement at manufacturing level if memory capacity is available and even if it is not, the falling price in memory devices still makes this approach attractive.

The main software requirements are:-

i) Carry out frequency domain analysis.

ii) Look for patterns or develop algorithms to determine valid or non valid disturbances.

iii) Carry out time domain analysis. For example:- Has this disturbance occured within pre-defined time limits?

Having carried out the appropriate signal processing, the same microcomputer system may also be used to carry out the tasks normally required in a modern security system, for example, loop continuity, exit time-out and door entry monitoring. This may also therefore have further cost saving advantages.

MEASUREMENTS AND RESULTS

The measurements were taken using an small electret condenser microphone and an Eventide Spectral Surface Plotter and are shown in Figs 2,3,4,5,6,7 and 8.

It can be clearly seen from this 3D representation that there are significant differences between the types of disturbances used and it seems therefore that there is a sound case for developing this concept into a practical product.

CONCLUSIONS

REFERENCES

[1] B.P Lathi, "Modern Digital Communication Systems" Holt, Rinehart & Winston, 184-187, (1983)

[2] B.A Blesser, "Digitization of Audio" J.A.E.S, Vol 26, Vol. 26, no.10, 739-771, (1978).

[3] "Limitations of Audio CODEC's, P A Conway, Proc.I.O.A. Vol7 Pt3 (1985) p121-128.

IMPROVED RELIABILITY OF ACOUSTIC SECURITY DEVICES

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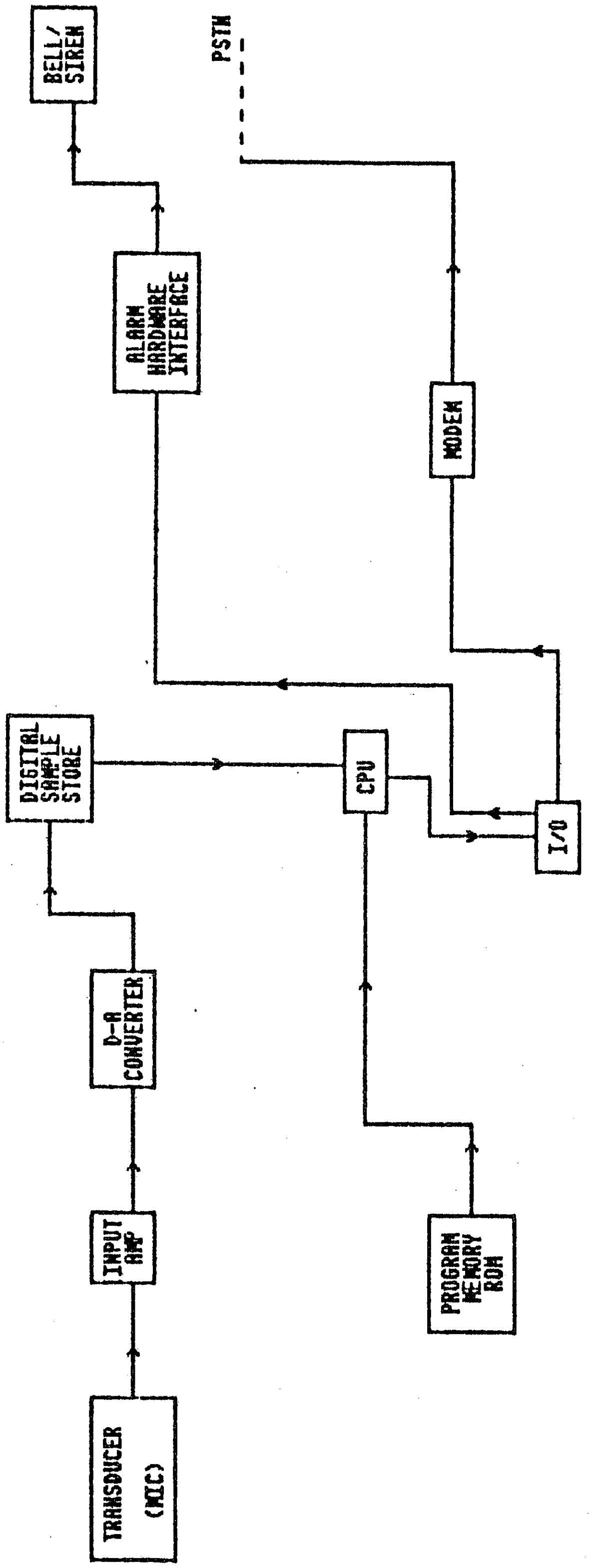

TOTAL SYSTEM CONCEPT

Fig. 1

IMPROVED RELIABILITY OF ACOUSTIC SECURITY DEVICES

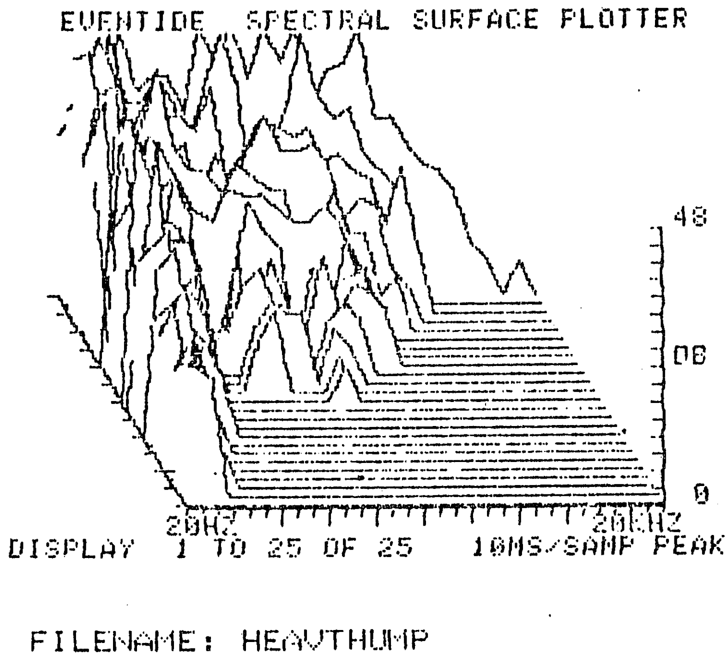

Fig.2

IMPROVED RELIABILITY OF ACOUSTIC SECURITY DEVICES

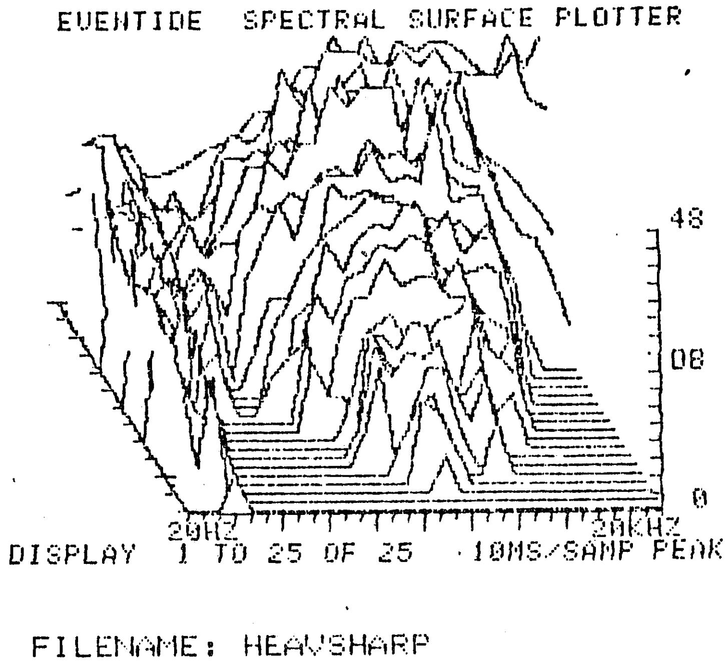

Fig. 3

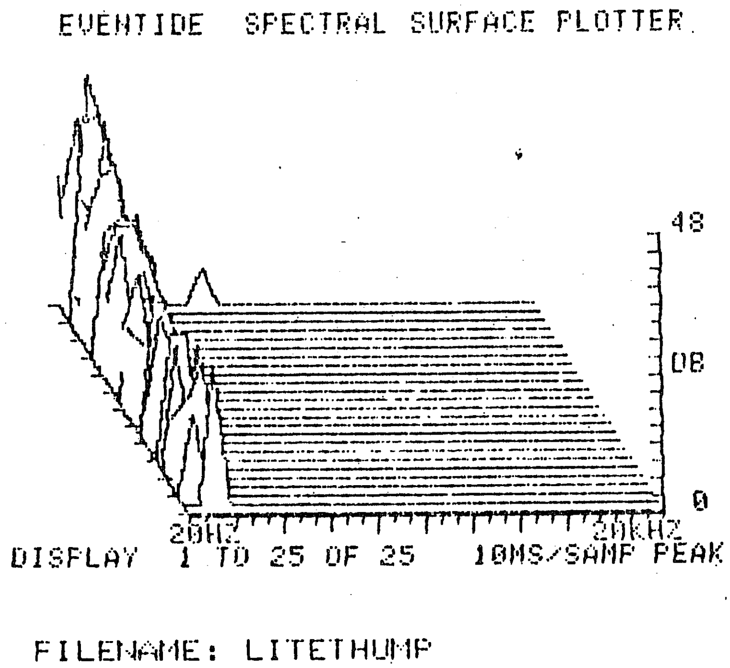

Fig. 4

IMPROVED RELIABILITY OF ACOUSTIC SECURITY DEVICES

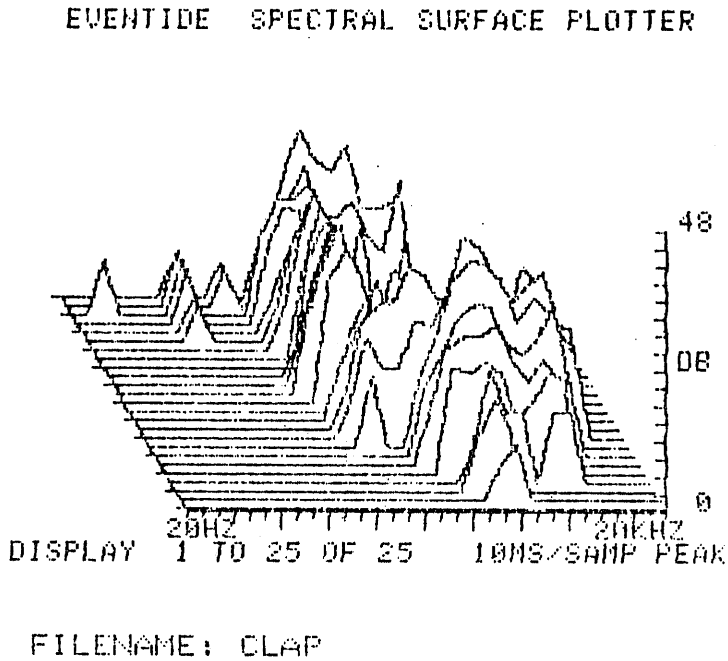

Fig. 5

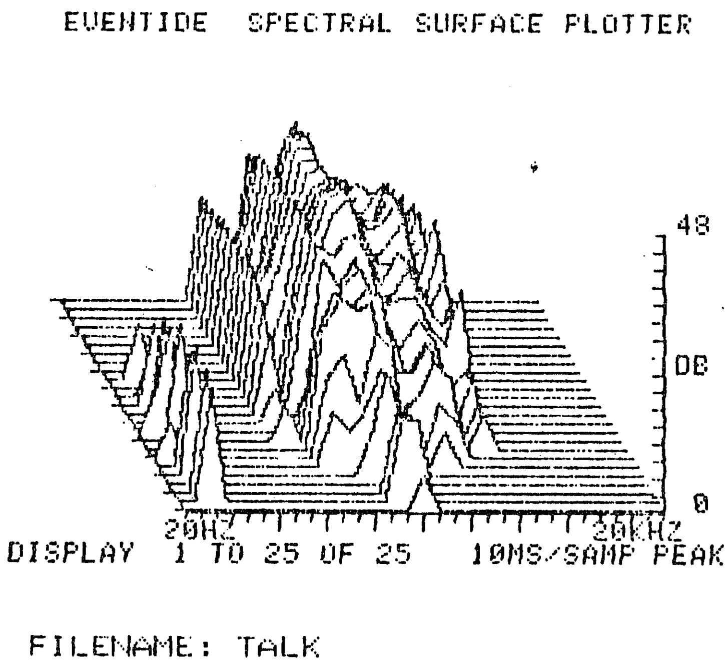

Fig. 6

IMPROVED RELIABILITY OF ACOUSTIC SECURITY DEVICES

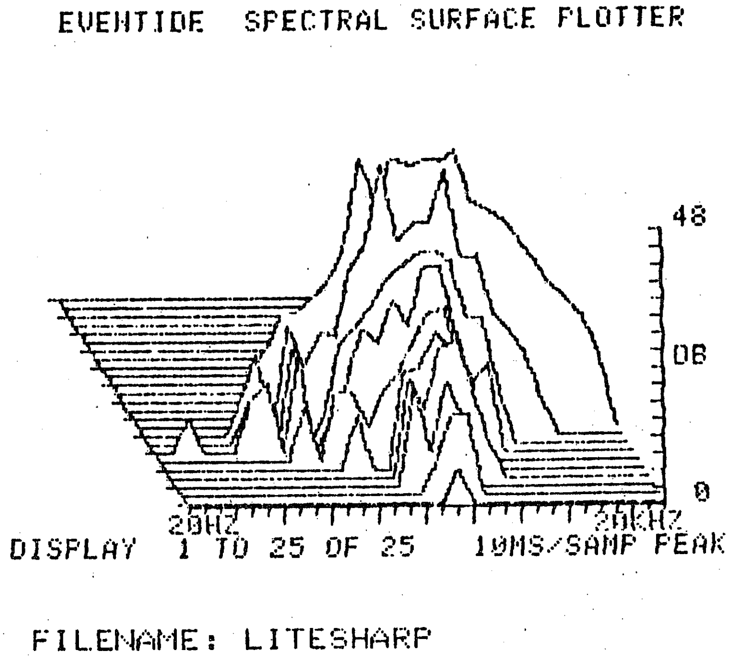

Fig. 7

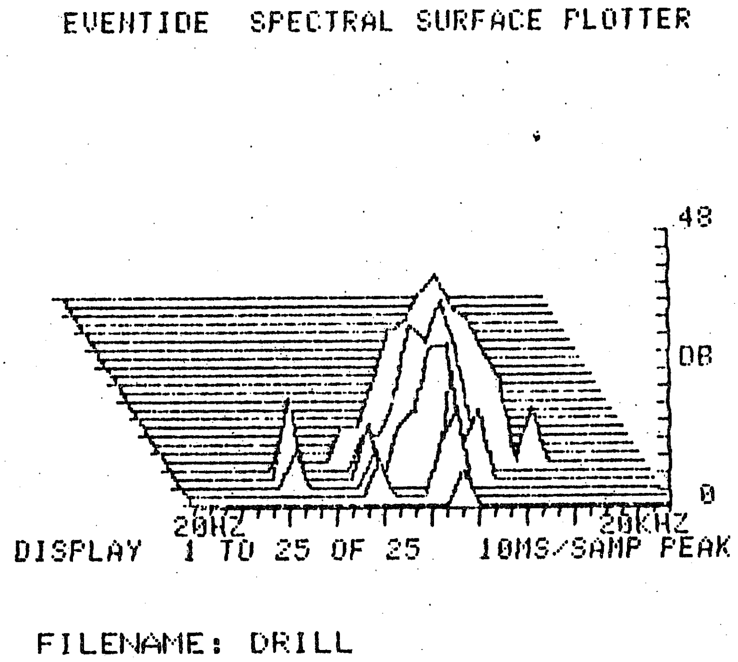

Fig. 8