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SOUND LEVEL LIMITING
- An Overview of the Means for Effective Control

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INTRODUCTION

There can be little doubt that because of an increasing awareness of the environment in which we live and a new found consciousness towards health and general well being, regulation - whether it be to protect ourselves from our own folly or to moderate the activities of social minorities for the benefit of the population at large - is very much a part of the age we live in. So whether it be seat belts in cars, safety in the design of buildings, safety in the workplace or in leisure activities, excesses in the consumption of alcohol or drug abuse, most activities which are likely to be harmful, or are likely to have an adverse effect on the population at large, are becoming subject to regulation of some sort.

Thus it is with exposure to loud music. Unregulated and in the hands of irresponsible operators all the evidence suggests that hearing damage will ultimately ensue, both to those responsible for its creation and to those who assemble to enjoy the performance. It can also be distressing to those prevented from enjoying the peace and quiet of their own homes. So whilst we may debate the actual levels at which loud music becomes harmful, whilst we may argue the point at which intrusive sound becomes nuisance, whilst we may argue for the freedom of the individual to do as he or she might like, there can be no argument that at some point, some form of regulation becomes socially desirable.

SCOPE

It is not the intention of this paper to make the case for or against the principle of volume regulation per se. Given the premise that volume regulation of some form or other is inevitable this paper will take a practical overview of methods of control that have been found to provide effective solutions in many different situations and circumstances over a 12 year period.

It is principally concerned with indoor venues where activities involving amplified sound - such as discotheques and rock music performances take place as well as such buildings as bingo halls, ice rinks, leisure and community centres, 10-pin bowling lanes, social clubs, and other similar places of entertainment.

WHERE IS VOLUME REGULATION REQUIRED?

There are three basic reasons for volume regulation:-

i) To constrain volume levels to those values which the building structure is able to contain such that the external environment or adjoining buildings are not materially affected.

ii) To comply with the requirements of the Code of Practice for Sound Levels in Discotheques (1).

iii) To constrain volume levels to enable a venue to be staffed within the requirements of the proposed Prevention of Damage to Hearing from Noise at Work Regulations (2).

iv) To prevent damage to equipment by overdriving the expensive and sophisticated amplifier and loudspeaker systems used in modern music making.

Environmental Considerations

This requirement is likely to arise as a result of complaints from neighbours being brought to the attention of the local authority Environmental Health Department who will either have had an informal word with the operator and reached an amicable agreement that volume regulation would be employed, may have issued a Section 58 Notice under the provisions of the 1974 Control of Pollution Act, or else may have convinced the local licensing authorities of the need for volume constraint as a condition of license (3)(6).

Code of Practice Requirements

The instrumentation requirements of the CoP are considered by many to be somewhat over zealous in terms of the problem it seeks to address (4). It has been found that among the few local authority areas where this Code is being implemented, straightforward volume regulation by other means is being accepted as complying with the spirit of its intentions and to provide adequate regulation (6).

Health & Safety at Work Regulation

Although this requirement does not come onto the statute book until 1990 January 01 when EEC Directive 86/188 comes into force, clearly the requirements must be taken into account in the planning of any new facility or the refurbishment of any existing venue (5).

Sound System Protection

Even given a responsible operator protection is considered an essential requirement for any sound system of any quality. Given that the "adrenalin level" for modern music is around the 96dB(A) mark it is invariably the case that because of the combined effects of the excitement of the performance and of TTS the operator is frequently unaware that the volume level has crept up 6 - 10 dB during the course of the evening. Thus, some form of level indication at the DJ console, combined with overall volume regulation, is necessary (6). At least two major installers are currently fitting a regulatory device as an integral part of the sound system architecture and requiring its use as part of the warranty conditions, whilst one national operator is fitting such apparatus as to every new installation as a matter of course.

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METHODS AVAILABLE

Each method of providing for the regulation of volume levels has advantages and drawbacks, each a different underlying philosphy and varying degrees of operational acceptability as follows:-

i) Simple sound level dependent switch used to switch off the AC mains power supply to the amplification system.

ii) Sound level dependent attenuator, used to attenuate the line level of the audio signal before being fed to the power amplifier.

iii) Dynamic range compression, in which the available dynamic range of the amplification system is controlled by compression and/or limiting.

iv) Aural compensation, in which the equalisation curve of the system is varied by volume level in accordance with the Robinson & Dadson Equal Loudness Contours (7).

The Sound Level Switch

These devices usually rely on a sensing microphone coupled to a variable threshold level detector for their operation, usually providing some form of visual or audible warning before actually operating. A well known example, the Castle Electronic Orange is shown in Fig 1 and whilst this may be suited to a simple problem in a smaller venue there are a number of inherent problems:-

The first is that most modern amplifiers dislike repeated switching transients, usually sustaining considerable damage in consequence.

The second is that the inrush current to a large power amplifier can be 100A or more on initial switch-on, typically reducing to its quiescent current draw over approximately a 0.5 second period. In order to avoid tripping the mains power breaker to the building when several such amplifiers are turned on together these are usually powered up sequentially allowing a few seconds settling time between each turn-on. In an attempt to address this problem some recently introduced amplifiers have an integral "soft start" facility to limit the inrush current to more manageable levels whilst one manufacturer has incorporated an inbuilt start-up sequencer as well. But this sophistication tends to come at the upper end of the price range and cannot yet be considered the norm.

The third problem is that of low frequency energy delivered to the loudspeaker system whenever the control electronics are switched on or off whilst the power amplifiers are active. This can annihilate thousands of pounds worth of loudspeakers in an instant and is again usually overcome by a sequenced start-up procedure - often automated in order to avoid accidents.

A fourth problem is that of fallibility in that any enterprising DJ or band will just run an extension cable to another socket which is not subject to

control by the device. Alternatively chewing gum or some other substance of high elasticity and poor acoustic conductance will be used to modify the microphone sensitivity.

Finally, it will be found that in many areas the Fire Officer will require that a public address provision is available at all times in order to control an evacuation of the building. Clearly, should an alarm sound whilst the sound system is shut down there is no means of public address and for this reason fire authorities do not favour, and in some instances will not accept, this approach.

Among its advantages however are its relatively low cost, ease of installation, it does not normally require specialist setting up, it is simple to operate and because it employs a microphone sensor it is largely self regulating in terms of numbers of audience present. Further, the form of presentation is usually such that it will instill confidence in an EHO because it employs basic instrument technology rather than sophisticated electronics and thus provides a calibratable and quantifiable means of control.

Sound Level Attenuator

These devices are not dissimilar to the basic sound activated switch except that the method of control is by switching an attenuator into the audio signal line thus reducing the drive level to the power amplifiers. Some models, such as the CEL-206 shown in Fig 2 have the option of either or both modes of operation.

This is an altogether preferable means of control as it overcomes all the problems associated with mains power switching. However most are still microphone operated and are therefore open to tampering and, because they need to be connected up as an integral part of the sound system, are only suitable for use in venues where a permanently installed house system is provided.

Dynamics Compression

This is an altogether different approach in which the dynamic characteristics of the incoming audio signal are monitored and the gain structure of the sound system maintained within pre-set parameters, thus effectively regulating the maximum volume levels attainable irrespective of any equipment control settings. Fig 3 shows a typical device and illustrates its operating modes.

Such apparatus can be extremely sophisticated in that RMS and peak values can be independently set and in the case of a bi-amplified sound system, the attack, release, threshold and ratio controls can be optimised for each section of the system. Further, an equaliser can be inserted into the compressor side-chain so that the system becomes frequency selective in its operation.

Among its many advantages is that the sound is actually perceived to be louder than it actually is, thus averting the need for quite so much volume.

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Further, by careful selection of equipment coupled with critical setting up such a system can be virtually inaudible in operation and can actually enhance the perceived sound quality in many situations. Secondly, at no time is the sound system switched off or even attenuated so there is not the embarrassment of the stoney silence or the contravention of the fire regulations associated with the more established control methods.

Its drawbacks are firstly that it can only be used as part of an installed house sound system and secondly, that the hardware is unlikely to be familiar to the Environmental Health or Public Protection Officer, the setting up is a specialised operation and although protective covers can be fitted, the apparatus does not lend itself to any form of calibration such that the EHO can document the settings and stand up at the licensing hearing and categorically state the limit levels imposed.

Aural Compensation

This method is largely psycho-acoustic in that the object - as is partially the case with the dynamics control method - is to remove the need for very high volume levels by increasing the perceived impact of the sound as it is reproduced.

The one system which is at present commercially available is the Greystone Inflexor shown in Fig 4 along with its operating curves. It applies the Robinson & Dadson 70dB(A) Equal Loudness Curve until that volume level is exceeded, progressively reducing the amount of LF and HF lift until at above about 100dB(A) a flat response is obtained, thus compensating for the frequency characteristics of the human auditory system over the middle to upper SPL values (8).

Again, the device is inserted into the audio signal chain rather than being connected to a microphone, relying therefore on the relationship between the low level signal and the reproduced SPL for its information. Therefore, whilst freed from the tampering problem, the system can only be incorporated into a permanent installation and does not compensate for the changing acoustics of the environment as the venue fills up. It has however been found extremely effective in encouraging a generally lower order of volume requirement, although, because of the effects of TTS towards the end of the evening a more conventional fall-back provision is usually required where predictable control is required.

FREQUENCY WEIGHTING

Fig 5 shows a typical discotheque SPL vs Frequency analysis and Fig 6 a typical live band situation. Fig 7 shows how such high levels of energy in the 63 - 100Hz 1/3rd octave bands can be accommodated within a relatively moderate A-weighted SPL.

One of the problems experienced with all the microphone operated systems is that they frequently operate on crowd noise - ie applause, singing along with the music or screaming, often with no music playing at all! But when adjusted to a higher threshold level in order to overcome this problem it will be found

that the required level of control over the bass thump is not provided. More recent models however have selectable frequency weightings to enable A, C, linear, or in the case of the Minim 3 shown in Fig 8, a bass emphasis setting to be used (9). Thus, in situations where the predominant bass beat is the problem a device set at, say 110dB linear, will adequately control the low frequencies without being affected by the crowd noise.

Similarly, a dynamics compressor - which being line operated is not subject to crowd noise anyway - can be given a frequency weighting by the insertion of a weighting filter or a graphic or parametric equaliser into its side chain, thus rendering the device frequency selective. This can be an extremely effective means of control where one particular band of frequencies are causing problems - perhaps due to room modes or eigentones, and will avoid the need for unnecessarily harsh system equalisation at lower volume levels.

The choice of the correct weighting is thus critical to the success of any regulatory systems.

LAeq REGULATION

The Disco CoP (1) and the Noise at Work Regulations (2) both require that measurements are made in LAeq units. However, none of the devices being considered are available with an integration facility and the author is not aware of any that are. However this is not considered a material problem as whether microphone or line levels are used as a detector, given a fairly predictable programme source the apparatus can be set up so that regulation is provided which fall within the required LAeq value. All that matters for this application is that effective and appropriate regulation is provided. Most devices are not provided with an SPL readout anyway, the line level devices do not lend themselves to accurate calibration and even the CEL-206 - as the only instrument to be fitted with a meter, is usually set up to read dB linear or will have been de-calibrated to achieve some offset requirement.

SUMMARY OF COMMERCIALLY AVAILABLE PRODUCTS

The following provided some guidance on the more popular dedicated sound level controllers available. General purpose devices such as compressors and equalisers are available from specialist studio equipment distributors and are to numerous to be listed here. One such product is however included because it provides independent RMS and peak adjustments and excellent musicallity.

Castle CS22A Electronic Orange

A basic, low cost, microphone operated, A-weighted switching device with a working range of 65dB(A) to 120dB(A). The maximum AC mains switching load is 15A at 240V AC and the unit comes complete with microphone and orange warning globe. Other working ranges and weightings can be supplied to order.

Aims Minim

Another microphone operated system providing selectable A, C or "bass" weightings as standard, also working on the mains interrupt principle but rated

at 20A. It features a good level of flexibility in setting the operating parameters and comes complete with its microphone and a "traffic light" status monitoring unit. It is somewhat more sohpisticated than the Orange but does require intelligent installation and setting up.

CEL-206

Also microphone operated, this device is available unweighted or with A or C weightings to order or with switching between any two. It may be used either as an AC power switch or as a 20dB line level attenuator, and an impressive "lighthouse" sound level beacon is available as an optional add-on. It has the advantage of security against unauthorised tampering and an SPL meter on the front panel. Probably the best of this type of device, but expensive.

Beam dBa

This too is microphone activated and comprises two units - a control unit which would normally be housed in the amplifier rack, and a seperate monitor unit housed near the sound control desk. The method of control is by sounding a high pitched bleep when the preset level is exceeded and to provide a 20dB attenuation of the line level if the volume is not then reduced. The standard unit is A-weighted but it can be modified to order.

Formula Sound CX4 Guardian

This new device is a line operated unit using sophisticated VCA and micro-processor control instead of passive attenuators and which incorporates an emergency voice-over facility. As a volume regulator the device is activated when the signal levels in the left and right stereo channels combine to exceed the pre-set threshold, and if the warning system is disregarded then the volume levels are reduced to a pre-set lower level. Reset can be manual or automatic. In an emergency however, upon receipt of a signal from the fire alarm panel all audio programme channels are attenuated and a single microphone is routed direct to the power amplifiers to provide the necessary public address facility, regardless of what else may be going on at the time.

The Symetrix 501 Compressor/Limitor

This comprises seperate RMS and peak detectors controlling the gain structure of a single VCA channel. The RMS section has fully variable attack, release, ratio and threshold controls whilst the peak limiter is pre-set at infinity ratio with variable threshold and gain controls. An optional "auto" setting is also provided. The device works on the "soft Knee" principle (see Fig 3) and when properly set up is inaudible in operation until very high levels of compression, or hard peak limiting such that the crest factor is reduced to 1:1, is called for. Side chain insertion is provided for external frequency weighting as required.

Greystone Inflexor

This device also works at line level and functions only as a level dependent automatic equaliser to compensate for the non-linearity of the hearing senses.

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It has no actual volume regulatory function, relying on the psychology of the auditory system to achieve a lower operating sound pressure level. For ultimate control the use of another device is recommended as a back-stop provision.

SUMMARY

It has been shown that there are several methods available to achieve control ranging from basic sound operated switches used to interrupt the AC mains supply, thru sound operated attenuators, to some fairly sophisticated electronic processors capable of inaudible operation coupled with no less effective control.

A number of commercially available devices have been identified in all three categories and their respective features summarised in an attemt to introduce some of the less obvious alternatives to those not specialising in this field, as well as identifying the strengths and weaknesses of some of the better known products. It is felt that such an overview would be incomplete without the specific commercial references given and it is here stated that the author has no commercial interest in the manufacture or marketing of any of the devices mentioned and that The Sound Practice do not act as selling agents for any of the manufacturers concerned.

Clearly, certain devices will find application in certain fields - for example the Electronic Orange will lend itself to the local public house or youth club whilst a pair of Symetrix 501s, used one on bass and one on mid/high, with equalised side chain on the bass channel, and with possibly a CEL-206 as a back-stop provision, will provide sophisticated inaudible control in a select nightclub or at a major rock concert - but at a price!

Volume regulation, if sensibly and sensitively applied with due regard for the artistic endeavour of the performers as well as for the regulatory requirements and well being of all concerned, and if used in conjunction with adequate training, need not be a problem.

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[7] Robinson D W and Dadson R S "A Re-determination of the Equal Loudness Relations for Pure Tones" Brit J Appl Phys, Vol 7 May 1956, pp 166-181.

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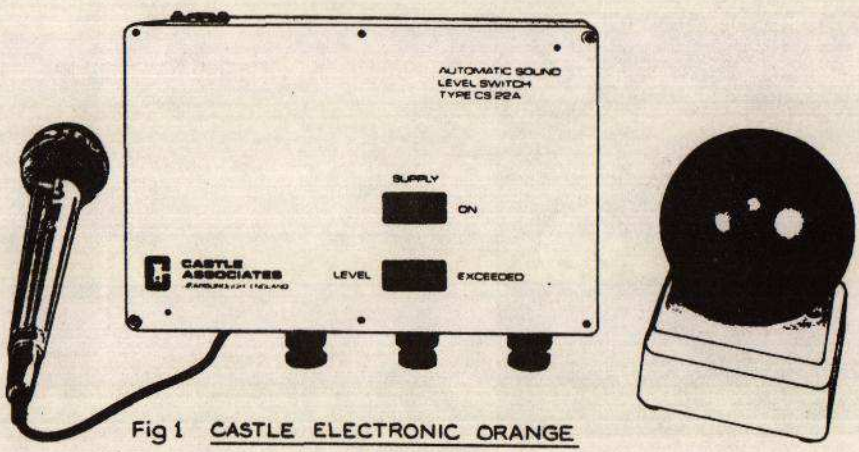

Fig 1 CASTLE ELECTRONIC ORANGE

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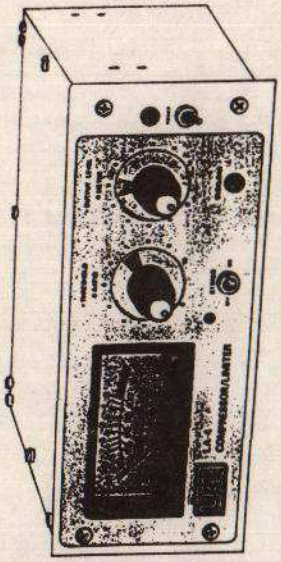


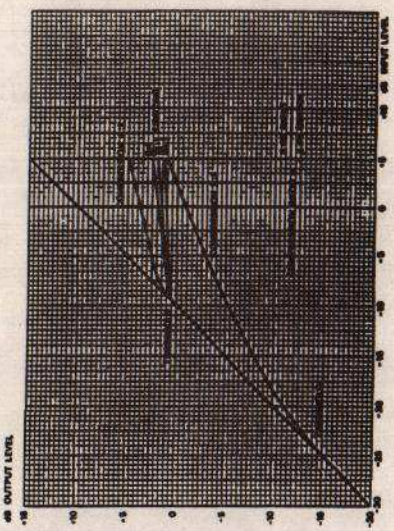
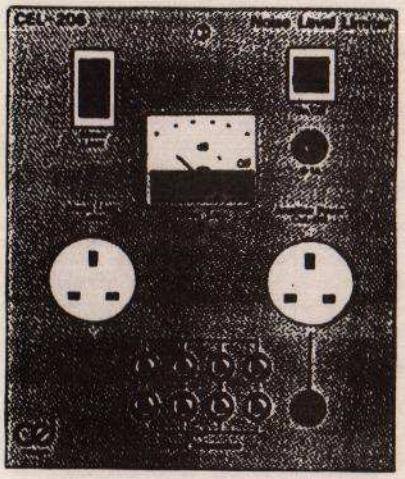
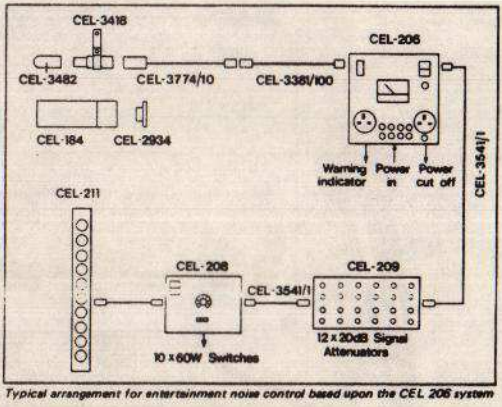


Fig 3 UREI LA-4 COMPRESSOR/LIMITER





Typical arrangement for entertainment noise control based upon the CEL 206 system

Fig 2 CEL-206 NOISE LEVEL LIMITER

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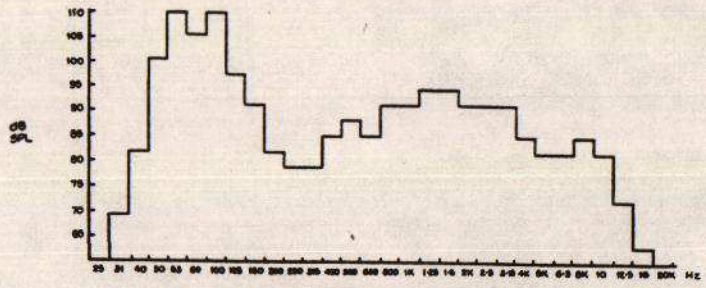

Fig 5 Typical 1/3rd Octave Spectrum Analysis of Discotegue Dance Music measured at 96dB(A) on the Dance Floor. 1987 February

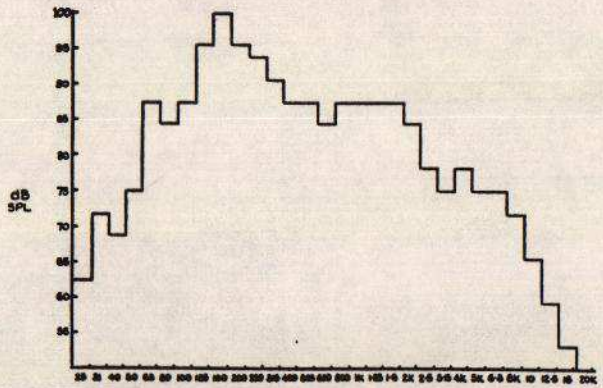

Fig 6 Typical 1/3rd. Octave Spectrum Analysis of Rock Concert Performance measured at 96dB(A) Theatre Circle Front. 1986 June

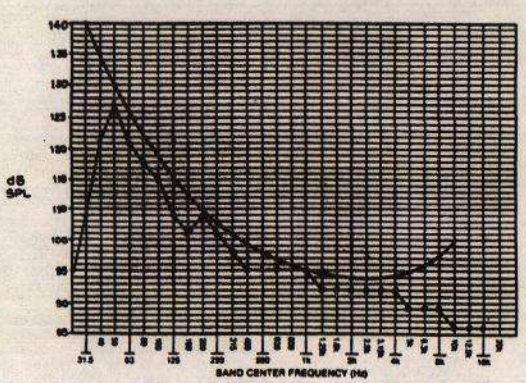

Fig 7 Typical Discotegue Noise Spectra vs 'A' Weighting Curve

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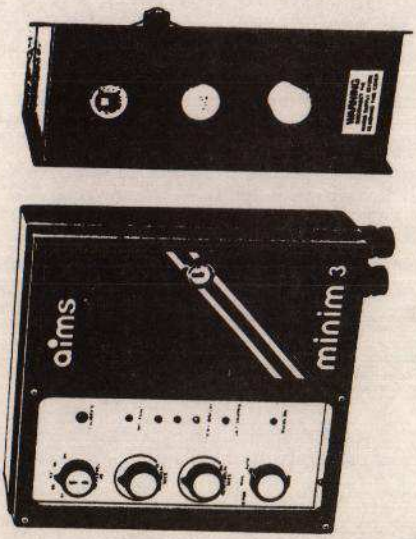


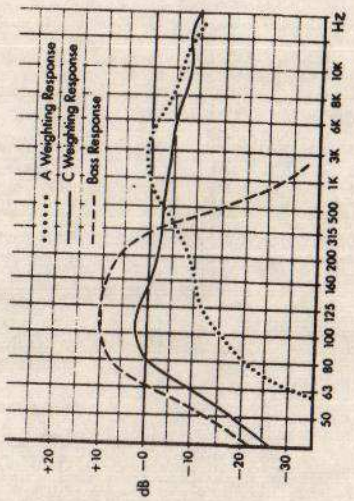
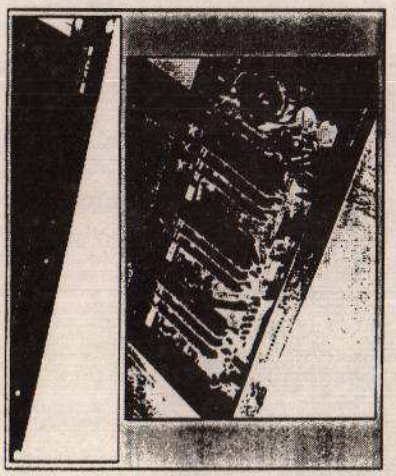


Fig 8 AIMS MINIM 3 NOISE CONTROLLER



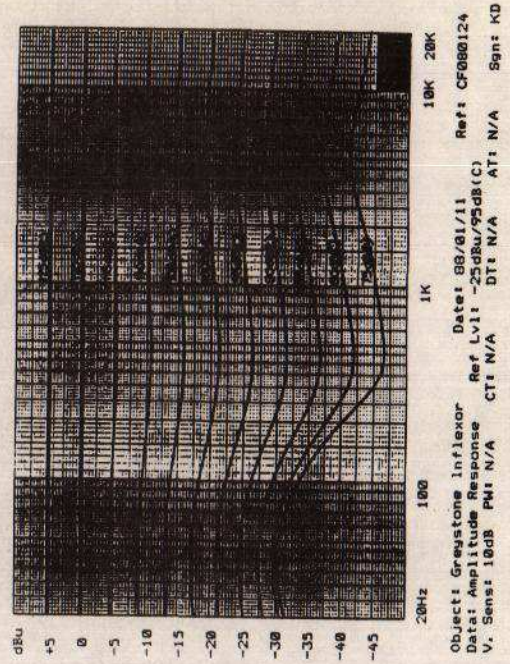


Fig 4 GREYSTONE INFLEXOR