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Pye Records chose a Cadac Care® equipped console for their new London studios.
Every studio manager has a short list of the most desirable qualities for any given control room; usually his own will possess more of them than the studio across the street/town/world. A consensus of opinion would most probably indicate that 'good acoustics' head that list.

However, further investigation of that particular quality would be a relatively useless exercise; the revelation that control rooms should provide a 'nice tight bass sound with lots of crisp top' isn't exactly earth shattering. In spite of such easy conclusions, one fact, albeit negative, will emerge. There are very few studio people who will attempt to describe acoustics, whether talking about their own studio or generalising, in terms of Hz and dB. If they do, they are more likely to be specologists than recording engineers. Actually, this is very surprising considering the quantity of blurb surrounding other bits which make up a control room.

On the desk, nearly every function is dutifully inscribed in dB or Hz (pair is about the only one that isn't). On compressor limiters, equalisers and monitoring circuits, dB and Hz abound in pro and con fusion. Loudspeaker manufacturers nearly always quote millions of dB's to add to listening pleasure. So how strange it is that real live, two eared people talk about 'tight bass and tinkly treble' rather than -4 dB at 63 Hz (ISO centre 1-octave pink noise) and +6 dB at 12.5 kHz, etc. One can only suppose that God provided almost everybody except the spec writers with a pair of ear drums instead of B & K spectrum analysers, but such are the imperfections of Creation.

Lesser individuals such as recording engineers have to use their ears to monitor the effects of subtle changes in eq; in time, a certain adjustment to the number of dB and Hz as shown on the console will become associated with a particular audible change but the process is never the other way round. From this, the function of desk calibrations may be understood. But what of the learned gentlemen who make their living by quantifying the acoustics of other peoples' studios—the consultants?

In this issue, George Augspurger, a much respected US acoustician tells of his approach in relating objective acoustic measurement to subjective effect. He also describes what can and can't be achieved with monitor equalisation. He would never suggest that his instruments can predict the consultants? It is, in fact, very surprising considering the quantity of blurb surrounding other bits which make up a control room.

More often than not, Mr Augspurger's instruments provide the starting point for subjective discussion.
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Call Tony Shields at the number below - he's got some very interesting literature that you should see.

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Noise measured at 70 dB gain (voltage referenced).
20Hz to 20KHz unweighted R.M.S. 128.5 dB below input across 200 ohm input load.
Measurement according to I.B.A. Code of Practice.
Noise measured peak with precision P.P.M. 70 dB gain referenced to 0 dBm output.
Unweighted 20Hz to 20KHz -52 dBm (Code Limit -48.5 dBm). Weighted CCIR Rec 468 -46 dBm (Code Limit -40dBm).
(The I.B.A. Code of Practice refers to complete signal paths but the test remains valid for a single mixer because noise in a system originates predominantly from the first microphone amplifier stage.)
Frequency response of measured system + 0.5 dB 40Hz to 20KHz at 0 dBm output and 70 dB gain.
Channel overload margin greater than 30 dB.
Sweet sixteen

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STUDIO SOUND, FEBRUARY 1977
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Loudspeaker: 1 W—both switchable Tape/Direct
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BELGIUM, Rodet, P. V.B., Rue de l’église 17, Antwerpen, TF: 03-507 56 05.

CANADA, Philips Audio-Video Systems, 200 Consumers Road, Suite 105, Willowdale, Ontario M2J 4R4, Canada, TF: 494-1453.

DENMARK, S.C. Sound, Brondbyestvæj 84, DK-2650 Hvidovre, TF: 01-471222.

FINLAND, Nores 8, Co., Oy, Fabianinkatu 32, Helsinki 10, TF: 13360.

FRANCE, Roditec, 27, Rue du Progres, F-93107 Montreuil, TF: 283-78-90.

GERMANY, Akustische und Kino-Geräte Gesellschaft m.b.H., Bodenseestraße 226, 80 Munich 60, TF: 089/870011.

ITALY, M. Casale Bauer, Via IV November N 6-8, 00165 Roma, TF: 06/1766648.

NETHERLANDS, Rema Electronics, Van Eeghenstraat 11, Amsterdam, TF: 020-774 00 00.

SWEDEN, Harry Thellmod AB, Hornsgatan 89, S-11721 Stockholm, TF: 08-600745.

SWITZERLAND, Audio Electronic AG, Lohwilerstrasse 24, CH-8213 Sempach, TF: 071-770.

USA, PHILIPS Audio-Video Systems Corp., 91 Mickey Drive, Mahwah, New Jersey 07430, TF: 020-529-5900.
news

Sonifex cart machine

Sonifex has brought out a new cartridge machine accommodating A size cartridges. The machine, QFX-500, is equipped with servo motor drive, an air damped sole-noid for quiet operation and muting in the fast forward (50 cm/s) and stop position. It uses Cannons for the signal interface.

Equipped with primary cue facilities, it incorporates an equalised cue output to enable operation with external secondary and tertiary cue apparatus. Extract from manufacturer's specification:
Cart size: NAB A.

Frequency response: 40 to 15k Hz ±2 dB.
Stereo phase: 45° at 100 Hz and 15k Hz reference 0° at 1 kHz.
Distortion: 2% thd ref +8 dB above standard tape reference (NAB 19 cm/s 300 nW/m @ 6% one sup-
poses—Tec Ed).
Wow and flutter: less than 0.15% rms.
Start/stop time: less than 100 ms.
Dimensions: 76 x 215 x 290 mm.
Sonifex Sound Equipment, 15 College Street, Irlhlingborough, Wellingborough, Northants NN9 6TU.
Phone: 0933-650700.

Midem 77

Midem, the acronym for Marche International du Disque et de l'Edification Musicale, will be held from January 11 to 21, 1977 at the traditional Cannes venue. To pro-
vide space for an additional 105 exhibition booths, the covered car park has been turned into extra display space. The total number of stands will exceed 1000; how-
ever, nobody can state with any degree of certainty whether there will be any facilities for the de rigueur crop of Rolls-Royces that the event attracts.

There will be an international meeting of lawyers at the Hotel Majestic which will take place on the 20 and 21. Subjects for dis-
cussion include the legal problems set by 'videogrammes' whatever they are and 'the part played by jurists in the drafting of contract and sub contract clauses'. Quoting the Marx Bros, it should prove conclusively that 'there ain't no Sanity Clause'.

Harrison—survey omission

Inadvertently, we omitted Harrison from our survey of recording con-

solves (January Studio Sound). Belatedly, here are a few facts about this company's products which should have been included:

For company's desks are built on an input/output channel v, 2% thd ref +8 dB, which is mode selectable from a button group adjacent to the channel fader. The basic capacity is either 40/32 or 32/32, the syntax organisation relies on use of state (e.g. selection of the operational status of the various channels from four options corresponding to the usual mic/macro monitor etc.

The channel panning facilities are extensive with normal odd/even for the routing, each channel incorporates full quad position with quad mix busses for sound mixdown.

Vca faders allow up to nine groups together with a read/write update control when used in automation. The eq facilities are two-band parametric with his-

Now for further details see Multi-Track Review (January 77, p68) and APRS report (August 76, p54).

Harrison Systems, PO Box 3720, Nashville, Tenn. 37202, U.S.A.
Phone: 615 324-1184.
UK: Scenic Sounds Equipment, 14/16 Bryanston Street, London W1H 7AB.
Phone: 01-935 9019.

Tannoy change of address

Tannoy has moved location. Buckinghamshire following the addition of Harman Kardon Ortofon products for distri-

bution by the group throughout the UK. Tannoy Rentals Ltd remain at West Norwood.
The new address is Tannoy Products Ltd, St John's Road, Tannoy Green, High Wycombe, Bucks.
Phone: 049 481-5221.

The new Harris CB-1201

professional transcription turntable—a new broadcast product

Teach in/sell out

At a recent symposium held at the Melodia Studios in Moscow, 3M, Sondor, White, Cadac, dbx, Master-Room et alia demonstrated their European and American technology to more than 200 senior engineers working within the Soviet Broadcasting, Film and Recording Industries.

At the close of the seminar, the State Committee placed orders for 3M 79 machines, dbx noise reduction, Master-Room reverberation units and White Instrument products proving that capitalism isn't dead.

Rotary pot

Penny and Giles potentiometers have introduced a single axis pot with 240° turn. The manufacturer claims a combination of precision and reliability in adverse operating conditions. It offers a self centring mechanism stated to produce a rest position accuracy better than 0.5% between wiper and centre tap.

Units can be supplied in fundamen-
tal resistance values between 250 ohms and 30k ohms; further, they can be fitted with or without additional taps including centre tap. Penny and Giles Ltd, Muleford, Christchurch, Dorset BH23 4AT. Phone: 042 52-71511. Canadia: Aviation Electric Ltd, PO Box 2140, Station 0, Montreal H4L 4XH. Phone: (514) 744 2811.

Modules

An Australian Company, Studio Electronics Pty Ltd, has entered into the encapsulated/pcb module market with a series of devices which claim a very high standard of electrical performance:
1) SEO-1 Operational Amplifier. This offers a quoted 100 kHz power bandwidth delivering +20 dBm into 100 ohms. Distortion stated as less than 0.1% thd. Noise less than 0.7 uV equivalent input 20 to 20k Hz. Price $40.
2) VCA-1 Voltage Controlled

Gain Attenuator. Claims 100 dB dynamic range; tracks within 2 dB between any two units over 60 dB. Distortion quoted as less than 0.01% at +4 dBm. Price $36.50.
3) 150 Peak Programme Meter. LED column scale reads from -30 to +6 dBm. Integration time quoted as 10 ms. Price $140.

4) 377 Headphone Amplifier. Produces 2W at 0.1% thd.

Quality Control Centre 

Studio Electronics Pty Ltd, PO Box 1055, Burwood North 2134, Australia.
once is enough!

Water is pure and clear. Still, if we look at a leaf which is partially submerged in it, the leaf looks distorted. It is surprising how easy it is to introduce distortion, even by the simplest type of operation on the real thing. The bent leaf doesn't really bother us very much, but when distortion in sound results from the use of equipment, this bothers us a lot!

Some OTARI specialists spend most of their day making sure that the equipment that we produce has the lowest possible wow and flutter, and the highest possible S/N ratio. Naturally, these are not the only features which create the top performance of OTARI products, but they reflect the care that results in a totally balanced OTARI product, and better service.

Trust through experience— one encounter with OTARI equipment and from then on, You will trust the OTARI name.
NEWS

Delay price reductions
FWO Bauch has announced price reductions of between 10 and 15% on all Lexicon Digital Delay equipment including vco modules and the new stereo version of the
102 range.
The new prices mean that a basic delay system with 160 ms of delay and two outputs now costs £2890.
FWO Bauch Ltd, 49 Theobald Street, Borehamwood, Herts WD6 4RZ. Phone: 01-953 0091.

Level vdu
Link Electronics has produced a unit for translating audio inputs of up to 32 channels into a single signal enabling colour or monochrome tv monitors to display level information in bar form. Designated type B2, it uses a pin board matrix to control the size of display; when showing less than 32 audio inputs, unused bars can be deleted from the display with remaining bars increased in width to enable greater clarity.
The unit is supplied with identifying buttons for location adjacent to the channel faders which modify the relevant bar in either colour or brightness for quick identification. When a channel is overdriven, a similar display change occurs. Switched ballistics simulate either vu or ppm characteristics.
Link Electronics Ltd, North Way, Andover, Hants SP10 5AJ. Phone: 0264-61345.

New range of mixers
Gelf Electronics Ltd is a relatively new company engaged in the production of studio and allied gear. Among its products are a 16/6 monitor mixer, a studio desk with eight subgroups, full channel eq, P & G faders, XLRs etc; an auto phasing unit, electronic phaser incorporating an internal control oscillator as well as an envelope phaser, and an active crossover. The active crossover offers fixed frequency four section split combined with stereo operation.
Gelf Electronics Ltd, 38 Home Close, Bletchley, Milton Keynes MK3 6EJ. Phone: 0908-77263.

Studer address
The Swiss Studer organisation has changed address to new premises effective since December 15: Studer International AG, Althardstrasse 150, CH-8105 Regensdorf, Switzerland.

Didn't they do well...
ALICE—for a major revamp at Radio Clyde, John Lumsden chose variants of the AM system for the two main on-air studios. The new mixers, which should be working in the new year, will be in addition to existing Alice products situated in the music studio and the ob van. The company has recently sold an £8000 desk to CFRW in Winnipeg—the service of high quality music to the Prairies. NEVE US has also sold a few more. An 8038 24-track has turned Sounds Studio, Hawaii into the only 24-track facility in the 50th State. The chances are Hula music will never be the same again. Neve has also supplied an 8068 compact console to the Manta Sound Company of Toronto and Les Studios Marco of Montreal. These are in addition to the recent installation of the same type of desk at the Four Star Studio Complex at Nashville—not counting the five recent broadcast installations scattered around the US.

Leader available
C. E. Hammond say that they can now supply, off the shelf, the following Leader instruments:
- LDC 821 digital frequency counter, the LAG 120 audio generator
- LMV186A stereo millivoltmeter and the LEM 75 electronic multimeter.
C. E. Hammond & Co Ltd, 109 Oyster Lane, Byfleet, Surrey KT14 7LA. Phone: Byfleet 41131.

Alignment oscillator
Barry Porter, erstwhile design with Trident, has started his own company, Midnight Audio Ltd. One of his first products is an instrument designed to simplify routine lining up of pro tape recorders.
The Alignment Oscillator 19 484 offers:
- Push button selected 10 frequencies
- Oscillator with up to +20 dB output capability. A metering section which claims to give 1% accuracy at any attenuator setting when reading 0 vu.
- Duplicated XLRs for oscillator output and meter input.
- A sum reading (whatever it means) for head azimuth alignment. The unit is mains power and costs £165.
Another Porter-designed Midnight Audio product is an audio meter type 345 for accurate

Low cost Studer
Studer has brought out a master recorder, the A80/1RC, which offers a price reduction of about £800 on the A80/IR stereo machine. Developed from the A81 machines supplied to the German Broadcasting Corporation, the new machines incorporate a new tape transport control, and an electronic tape timer is standard. The manufacturer claims that the price reduction has been achieved through rationalisation of production techniques and testing procedure.
Studer International AG, Althardstrasse 150, CH-8105 Regensdorf, Switzerland.

The new range of Miniflux led meters. Available in several ranges of resolution, they are said to comply with DIN, IEC or BS 497 standards.

Studer low cost A80JRC stereomaster machine.
The New Master-Room 'C' Series

Independently variable series available with two 1-3 second channels, two 2-4 second channels or one 1-3/one 2-4 second channels.

Studio 'B' Series
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Sole UK agents: Scenic Sounds Equipment 27-31 Bryanston Str., London W1H 7AB Phone: 01-933 0141 Telex: 27 939
NEWS

Voltage and frequency measurement. It offers an f5 frequency range from 150 µV to 50V in 12 ranges and reads 0 to 30 dB at centre scale. Also it offers direct power reading to 250W into 8 ohms. The unit incorporates three filters: 1) 20 to 20kHz. 2) CCIR. 3) DIN A weighting. The frequency counter is a six digit unit with gate periods of 0.1, 1 and 10 seconds. The unit costs £395.

Midnight Audio Ltd, PO Box 12, Fleet, Aldershot, Hants GU13 8EF. Phone: 02514-20143.

Bloodsucker

This man, the advertisement manager of Studio Sound, was given the Dracula Award at the recent DEAF dinner for being 'the biggest bloodsucker in the industry'. We, the magazine, feel this an award that he richly deserves; however, we should point out that this has been exacerbated by an unfortunate medical condition (see picture). Our medical correspondent writes: It is not uncommon for ad managers to suffer pecuniary toxemia (Itchy Palm), usually concurrent with symptoms of inflationary paranoia. Classic symptoms include a tendency to make rash statements of a promissory nature, while leaving two little puncture holes in the wallets of those who have been in close contact with the subject. The prognosis isn't very hopeful. Treatment: frequent transfusions from blood donors.

Quantum Audio Desk

Each module on the new QM-128 has solo, mute, two independent echo sends and two independent cue sends, six frequency eq on three knobs and switchable 15 dB padding on the mic amp. Channel faders are of the conductive plastic type.

Monitoring can be selected by pushbutton to bus, line or playback: slate can be put on any of the eight output groups. They also incorporate bus metering facilities.

The desk comes in a beige colour with a textured brown chassis; all control functions are colour coded for ease of identification. Optional extras include a patch bay, phantom powering and an eight input expander. The basic price is $4300 which seems very reasonable.

Quantum Audio Labs Inc, 1905 Riverside Drive, Glendale, Ca 91201, USA. Phone: (213) 841 0970.

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Amber Electro Design Limited
1064 Golf Road
Montreal, Canada H3E 1H4
Tel: (514) 769-2739

UK Representative
Scenic Sounds Equipment
27-31 Bryanston Street
London W1H 7AB England
Tel: 01-935 0141
Telex: 27 939

Elsewhere
Gotham Export Corporation
741 Washington Street
New York New York 10014
Tel: (212) 741-7411
Telex: 12-9269
Monitor equalisation

GEORGE AUGSPURGER

Third octave analysis can't replace a good pair of ears. However, objective analysis can provide a good starting point for subjective discussion.

Historical perspective

Electrical equalisation of loudspeakers has been practised for more than 40 years. The renowned 1933 stereophonic re-creation of the Philadelphia Orchestra made use of sophisticated equalisation, and the description of the experiment in the Bell Laboratories Record points out that correct equalisation of a given reproducing system is different for every hall. In the United States Dr C P Boner later pioneered the use of equalisation in sound reinforcement systems, both for suppression of acoustic feedback and to achieve natural tonal quality. In the 1940's, Ampex presented a number of "live vs recorded" demonstrations and again the reproducing chain was equalised for natural sound quality.

In 1968, Altec's 'Acousta-Voicing' process was first used to equalise the response of recording studio monitor speakers. Since then, a variety of active and passive equalisers suitable for monitor equalisation has appeared. In US control rooms and mixdown rooms, probably more than 50 per cent make use of some degree of electrical equalisation in their monitor chains.

I became interested in equalisation of sound reproducing systems about 15 years ago. My early experiments were confined to attenuating one or two bands of frequencies in the mid-bass region, where room coloration is most apparent in typical listening rooms. Later, when 3-octave analysis and equalisation gear became generally available, I tried to develop techniques to meet the particular requirements of recording studios.* The following paragraphs represent a personal view on the subject, based on experience in some 80 control and mixdown rooms.

Measurement—objective or subjective?

Early measurements of acoustical response were made using swept sinewaves. However, in any enclosed space, normal modes or eigen tones are so closely spaced, and sound pressure changes so dramatically with the positions of ear (or microphone) and source, that sinewaves tell us a lot more than we would really like to know. Some sort of averaging is needed to correspond with our subjective assessment of tonal balance.

So, marble tones were later used to generate a 'window' of frequencies, usually 10-20 Hz wide. But the technique that has proved to give the best correlation with listening tests is the use of bands of noise, nominally 1-octave wide.

In theory, pink noise can be filtered into 1-octave bands either before it is fed to the loudspeaker or after it is picked up by the measurement microphone. There are practical reasons for choosing one or the other (as will be pointed out shortly) but the results should be the same. Random noise simulates the transient characteristics of typical program material and 1-octave bands on standardised centres

*In co-operation with a Canadian associate, these are in the process of being formalised under the trade name Sonovoice.

A 2 dB uncertainty factor is unacceptable to the recording engineer. The remedy is to give up that fascinating toy, the real-time analyser. By driving the system sequentially with low octave bands of noise, one can compare the relative levels of left and right speakers not only with the test microphone, but also (radical suggestion) by listening. If, as usually happens, there are differences in timbre between the two monitor speakers, final balancing can be done on the basis of subjective response, a single band at a time. This works in spite of the fluctuating nature of the test signal because a rapid A-B switch catches it in mid-strike, so to speak. And, by using the ear as a check against the test microphone, one can allow for subtle differences within a single band that do not show on the plotted response curve.

2) Additional uncertainty is introduced in trying to define the listening location. Even with the averaging effect of a band of frequencies, the measured sound level in any one band can vary dramatically with small changes in microphone position. The usual response curve derived from a single microphone at the centre of the console is analogous to what would be heard by a one-eared recording engineer with his head in a clamp.

One possible remedy is to move the microphone around in the general vicinity of mix centre and try to average the readings obtained. One can sit at the console with a sound level meter in one's lap, for example, and sort of wave it around slowly in a

*Most 1-octave sound analysers used for monitor testing and equalisation are not true 'real time' devices. However, the distinction is not important to this discussion.
circular pattern while noting the variations in level. But this may not be any better than accepting the limitation of a fixed measuring position. For another, waving and watching and mentally recording allows the subconscious to insist on the figure hoped for rather than the one that would be noted by a truly unbiased observer.

A better technique is to make three or more separate sets of measurements at defined positions and then average the results. This takes time, especially when performing equalisation. The three locations can be better averaged automatically and simultaneously by using three calibrated microphones and some kind of multiplying circuit to average (not mix) their outputs.

3) A third area of uncertainty exists because of the directional characteristics of the measuring microphone and of the ear. With a little caution one can be reasonably certain that the microphone is responding in random-incidence fashion over most of the audible frequency range. A 12 mm microphone such as the B & K 4134 has omnidirectional response up to about 5 kHz. In the range from 5 kHz to 15 kHz random-incidence response and grazing-incidence response are within 2 dB of each other (Fig. 1). However, if a strong directional component approaches the mic at an angle of 60° or less a bias of several dB can be introduced.

In comparing curves run with my equipment against those logged by others, I find the largest discrepancies in the frequency range above 5 kHz. In some cases the differences can be traced to ignorance of microphone characteristics. (Point a sound level meter at the loudspeaker and simply plot what it indicates.) In other instances it does not seem that my array of three 4134 microphones. These beautiful little B & K units are truly omnidirectional up to about 20 kHz. That is, they would be omnidirectional if the associated preamplifier did not shadow the microphone at its rear. As always, nothing in life is perfect.

In any case, a non-directional pick-up pattern does not ensure correlation with the directional characteristics of the ear. The difference in perceived loudness between frontally directed and diffuse sound fields is about +3 dB at 1 kHz, -2 dB at 2.5 kHz and more than +4 dB above 8 kHz. In many control rooms the diffuse field predominates at low frequencies, the direct field predominates at high frequencies, and the two are roughly equal through the mid-range. Since different monitor speakers in different environments will produce differing ratios of direct-to-reflected sound, the notion of measuring the response of the system is beset with uncertainties on this basis alone.

Fortunately, from a practical standpoint the important thing is to have a test setup which correlates reasonably well with subjective evaluation and which allows repeatable measurements to be made. One learns quickly that, for engineer A in control room B, measured high frequency response should be shelved 1 dB above 2 kHz and rolled off at about 3 dB per octave above 5 kHz. Whether this curve represents the 'real' response of the system is beside the point.

4) Finally, using 1-octave bands on standard centre frequencies gives ambiguous readings if the peaks and dips in system response, as measured with a swept sinewave source, happen to be about 1-octave apart. This is exactly what happens below 200 Hz or so in small rooms.

Fig. 2 shows the sinewave response of a control room monitor as measured at the centre of the console. An array of three microphones was used, so that space averaging is already included in the plot. Note that the lowest peak and following dip are close to the standard centre frequencies of 31.5 and 40 Hz and, therefore, will also show up on 1-octave analysis.

However, the peak at 56 Hz and the dip at 75 Hz fall in the 'cracks' between standard 1-octave bands. 1-octave analysis will give a misleading picture of the true state of affairs in this region.

There are a number of ways in which the resolving power of our measuring system can be improved in the low frequency range. Sinewave response can be plotted, but this takes a lot of time to do manually or a lot of money for extra equipment to do automatically. One might switch to ½-octave analysis at low frequencies but this increases the difficulty of getting a true level average over a sufficient length of time. Even with ½-octave bands of noise, signal fluctuations at the lower frequencies require several seconds of averaging time and make eyeball estimate difficult.

A continuously swept ½-octave analysis works reasonably well, but again is time-consuming and requires additional expensive test gear. It seems to me that a good compromise between measurement resolution, simplicity and speed is to use sequential sinewave signals at ½-octave centres for measurements in small rooms.

![Fig. 2: Sine Wave Response of Control Room Monitor as Averaged from 3 Microphone Positions Near Console Centre](image)

![Fig. 3: The Curve of Fig. 2 Re-Plotted from ½ Octave Sine Wave Signals Below 200 Hz](image)

Below 200 or 250 Hz. Fig. 3 shows what happens when the response curve of fig. 2 is replotted in the new format.

**Acoustical vs electrical monitor equalisation**

Having measured the response of a monitor loudspeaker with some degree of accuracy, the question arises: to equalise or not to equalise? It would seem that if the loudspeaker is inherently flat and if the listening room is correctly designed, measured response should be uniform and no further adjustments should be required.

But a control room is rarely an ideal listening room. It is too small. As a result, the normal modes of the room produce audible peaks and dips at low frequencies, as we have seen. To make matters worse, the listening location is necessarily near the centre of the room, the worst possible location from the standpoint of low frequency response.

In those cases where a room can be designed from the very beginning with plenty of adjoining space for low frequency absorption, smooth bass response can be realised over a fairly large listening area. In effect, one builds a visually small room inside an acoustically large shell.

More often than not, however, even though we use all the tricks learned from previous experience, and although we spend two or three days experimenting with reflective and absorptive surfaces, the best we can manage is smooth response except for, say, a general hump in the 125 Hz region and excessive roll-off below 50 Hz, as in Fig. 4.

Faced with this common situation it makes sense to introduce very simple electrical equalisation even if the client does not want a fully equalised monitor system. The equalisation required for such trimming has gentle slopes with correspondingly little phase shift. Even the most vehement anti-equalisationist accepts a few dB of boost at 40 Hz and a few dB of attenuation at 125 Hz once he hears the improvement in listening quality.
MONITOR EQUALISATION

If such results can be achieved with only minimal equalisation, and if one believes as I do that the best equalisation is the least equalisation, how is it possible to justify the use of complete 1-octave banks of equalisers, with separate filters for each band from 40 Hz to 16 kHz and 10 dB of boost and cut available at each centre frequency? Easy. The value of complete 1-octave equalisation lies not so much in its ability to compensate for gross problems in monitor response (which is never really satisfactory anyway) as the precision with which more subtle changes can be achieved. With today's complex multitrack mixes it takes only a dB or two in a given band of frequencies to change the balance between tracks. Only with full 1-octave capability is it possible to arrive at and maintain the best response curve for comfortable mixdown in a particular situation.

And only with complete 1-octave equalisation is it possible to achieve near-identical response from all of the monitor speakers in the control room. Even though many filters may be set at 0 during the process of equalisation, they may be needed two or three months later when the monitors have drifted slightly from their original performance characteristics; I don't know why loudspeakers should drift, but the level of stability for a typical monitor system is about that of a grand piano.

Let me emphasise that equalisation will not allow you to make a Tannoy sound like a JBL; it will not fool your ears into believing that large, dead control room A is small, bright control room B. It will not circumvent the basic limitations of the electronics, the loudspeakers and the room.

FIG.4 B & K 4134 HYPOTHETICAL 1/OCTAVE RESPONSE OF A GOOD MONITOR SPEAKER IN A WELL-DESIGNED CONTROL ROOM

![Diagram 1](image1)

Properly done, monitor equalisation will allow you to mix with confidence, knowing that the balance between tracks and the special effects created at the console are accurately portrayed by the control room monitors.

Phase shift and ringing . . . ?

The filters used for sound system equalisation usually consist of single LC sections or their active equivalents. They are simple resonators with maximum phase of ±90°. As used for speaker equalisation, phase shift seldom exceeds 45°. Moreover, such resonators are not only minimum-phase devices but their response combines in minimum-phase fashion. By adjusting individual filters in such a way that the resulting sinewave response curve is smooth and gentle, results are exactly the same as if only a few much broader filters had been used. The mistake made by many technicians is to set all near-identical response filters at -10 dB and the next filter at +8 dB in an effort to get a 'flat' response curve. The resulting curve may look flat but it sounds terrible because of the narrow peaks and notches in the electrical response of the equalisers.

Some people believe that 1-octave bands should never be boosted 'because boost filters ring'. This is nonsense based on a germ of truth.

In most filter sets having boost and cut capability the functions are reciprocal. At extreme settings the bandwidth is much narrower than when only a little boost or cut is inserted. If an isolated filter is set for 8 or 10 dB of boost (again in a misguided effort to make the analyser display look pretty) the band of frequencies near the centre is narrow enough to be heard as a definite tonality. If filters are used only in the cut mode there is a built-in safeguard against this mistake (see fig. 5). To make use of the added flexibility of boost/cut filters without running into trouble, one simply remembers not to boost any single control more than 3 or 4 dB above the settings of its neighbours.

A more insidious problem can be encountered when filters in either the boost or the cut mode are pushed beyond the range in which their skirts combine smoothly. The amount of overlap between filters at various settings is different for different products. Most professional-quality filter set built by a reputable manufacturer will introduce no more noise and distortion than a line amplifier. With all filters set at zero it is a line amp and should perform as such.

And there are people who believe that only active filter circuits should be used for monitor equalisation because 'passive circuits have inductors and inductors ring'. I would have more sympathy for this common belief if such inductors had 1-octave bands with sufficient inductance to develop more than 500 kHz. If such a capacitor is then paralleled with an inductor, two resonance frequencies can be produced. In the case that brought this effect to light, parallel LC filters had been used in a control room to boost the 40-80 kHz region. The studio maintenance engineer called my attention to the fact that when the filters were inserted, high frequency ringing could be observed on squarewaves. The ringing was traced to a peak in the 60 kHz region, and this was found to be caused by a particular batch of Mylar capacitors. The moral is: never trust anything until you have checked it.

Given a choice between an LC resonator and its active equivalent, I would choose the passive circuit simply because it is simpler, quieter and more reliable. The fact is that the top-quality equalisers made by White Instruments, UREI and Altec all use passive LC sections suitably buffered by active amplifier stages.

Finally, there is the stubborn recording engineer who listens for the recording industry has already established the validity of equalisation, and that sounded better with the equalisation switched out. Well, certainly I have heard pianos that sounded better before the inptune started tinkering with them. The fault lies in the practitioner, not in the concept of tuning.

To sum up, it seems to me that monitor equalisation has value for the recording engineer only to the degree that it makes his job easier. Its purpose is to provide a more reliable sonic standard in the mixdown room. In my experience, the acceptance of equalised monitor systems by many of the most critical engineers in the recording industry has already established the validity of equalisation as a powerful tool for the studio.
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Survey: test equipment

Clearly it would be impossible to include full details of all equipment from every manufacturer. The following survey comprises an abbreviated directory of currently available test and calibration hardware on a manufacturer by manufacturer basis.

ADVANCED ELECTRONICS
A E Corporation, 65 Wellesly Avenue, Needham, Mass 02194, USA.
Phone: (617) 449 3142.

Products
FUNCTION GENERATORS
Features: available in either kit or assembled form. 1 Hz to 1 MHz, sine, square or triangle. $124 built.

ALICE
Alice Stancoll Ltd, Alexandra Road, Windsor, Berks.
Phone: Windsor 51056. Telex: 849323.

Products
NOISE MEASURING SETS
Features: ppm with calibrated amplifier and CCIR 468 filter, intended for noise measurement in accordance with the IBA code of practice. £420.

AMBER
Amber Electro Design Ltd, 1064 Chemin du Golf, Montreal, Quebec, Canada H3E 1H4.
Phone: (514) 769 2739.
Export agent: Gotham Export Corporation, 741 Washington Street, New York, 10014, USA.
Phone: (212) 741 7411.
UK agent: Scenic Sounds Equipment, 27/31 Bryanston Street, London W1H 7AB.
Phone: 01-935 0141.

Products
AUDIO TEST SETS
Features: multipurpose instrument (see review p60).
SPECTRUM ANALYSERS

B & K
Bruel & Kjaer A/S, Naerum, Denmark.
Phone: 02 80 05 00, Telex: 37316.
US agent: B & K Instruments Inc, 5111 W 164th St, Cleveland, Ohio 44142.
Phone: (216) 267 4800. Telex: 510421.
UK agents: B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex.
Phone: 01-570 7774. Telex: 934150.

Products
ACOUSTIC STANDING WAVE MEASUREMENT
BEAT FREQUENCY OSCILLATORS
DISTORTION ANALYSERS
FILTERS
FREQUENCY RESPONSE MEASUREMENT
GATING SYSTEMS
IMPULSE RESPONSE TESTING
INSTRUMENTATION AMPLIFIERS
INTERMODULATION DISTURBANCE ANALYSERS
LEVEL RECORDERS
MEASURING MICROPHONES
MICROPHONE CALIBRATION GEAR
NARROW BAND ANALYSERS
NOISE ANALYSERS
NOISE GENERATORS
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PSDOPHOMETERS
REAL TIME ANALYSERS
SINE RANDOM GENERATORS
SOUND SOURCES
SPECTRUM ANALYSERS
VOLTAMETERS

DYMAR
Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts WD2 4LA.
Phone: Watford 37321. Telex: 923035.

Products
AUDIO POWER METERS
AUDIO SIGNAL GENERATORS
COUNTERS
DISTORTION FACTOR METERS
RF GENERATORS
SSB TEST GEAR
WAVE ANALYSERS

FARNELL
Farnell Instruments Ltd, Sandbeck Wetherby, Yorkshire.
Phone: 0937-3541. Telex: 557294.
Overseas agents: in most countries.

Products
ATTENUATORS
AUDIO OSCILLATORS
FUNCTION GENERATORS
MILLIVOLT METERS
MODULATION METERS
OSCILLOSCOPES

Court Acoustics, 50 Dennington Park Road, West Hampstead, London NW6.
Phone: 01-435 0532.

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Features: 29 x 11 matrix of led indicators on standard and ISO centres from 28 to 20kHz. Particularly suited to disc cutting applications.

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Hewlett-Packard Co, 1501 Page Mill Road, Palo Alto, Ca 94304, USA.
Phone: (415) 493 1501. Telex: 348461.
UK agent: Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.
Phone: 0734-784774. Telex: 847178.

Products
DISTORTION ANALYSERS
Features: manual and auto null.
FOURIER ANALYSERS
Features: 80 dB range of amplitude and phase resolution for extrapolation of the transfer function.
FUNCTION GENERATORS
GROUP DELAY MEASUREMENT
NETWORK ANALYSERS
OSCILLATORS
Features: synthesised, phase locked and low distortion types available.
PLINE INVESTIGATION EQUIPMENT
SIGNAL GENERATORS
SPECTRUM ANALYSERS
Features: H-P manufactures real time equipment suitable for use between low Hz and 40 GHz.
SWEEP GENERATORS
WAVE ANALYSERS
Features: portable and rack mounting instruments available for both at and rf.

LEADER
UK agent: C E Hammond & Co Ltd. See Sound Technology.

Products
AUDIO GENERATORS
Features: 10 Hz to 1 MHz. Facilities for external synchronisation.
FREQUENCY COUNTERS
MILLIVOLT METERS
MILLIMETERS

LEVELL
Levell Electronics Ltd, Moxon Street, Barnet, Herts EN5 5SD.
Phone: 01-449 5029.

Products
AC VOLT METERS
INSTRUMENTATION AMPLIFIERS
MULTIMETERS

MARCONI
Marconi Instruments Ltd, Longacres, St Albans, Herts AL4 0JN.
Phone: St Albans 59292. Telex: 23350.

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SWEEP GENERATORS

3M
Mincom Division, 3M Company, 3M Center, Saint Paul, Minnesota 55101, USA.
UK: Mincom Division, 3M United Kingdom Ltd, Whitley Works, Whitley Gardens, Southall, Middx.
Phone: 01-574 5929.

Products
TEST SET
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WOW AND FLUTTER METER
WAVE ANALYSER
Features: low frequency unit specifically designed for flutter analysis.

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35
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* MCI (UK) LTD

Possibly the most misunderstood, and usually the most maladjusted piece of equipment in a recording studio, is the tape recorder. Because it is a combination of sophisticated electronics and mechanics, confusion sometimes exists as to the cause of its ailments when it malfunctions. A mechanical fault can often give electronic like symptoms, and vice versa. Also, a badly slit tape will often appear to indicate that the mechanical alignment of guides and heads is in need of adjustment. Uneven oxide coating of the tape can give bizarre modulation effects. A careful and logical approach is necessary in order to achieve optimum performance from a machine, coupled with an understanding of the basic techniques involved.

It is hoped that the following will impart some of the techniques and provide a greater understanding of the mechanical and electronic adjustments which are made.

Mechanical alignment

Tape heads require four accurate adjustments if the machine is to perform to specification.

Height. To set the track pole-pieces to the correct position on the tape.

Zenith. To set the head face perpendicular to the deck, i.e., parallel to the tape.

Wrap. To set the headgap at 90° to the tape, viewed from above.

Azimuth. To set the headgaps at 90° to the tape, viewed from the front.

Height can normally be set by visually aligning the head for equidistant spacing between the top and bottom shield plates and the edges of the tape. If the shield plates are not visible, transparent leader tape can be used and the track pole-pieces viewed.

For the adjustment of DIN stereo heads, where the track spacing is much closer than multitrack heads, a test tape is available with signal recorded along the centre of the tape, i.e., in the guard-band. The head height is then adjusted for minimum signal from both tracks.

Zenith is an important and often neglected adjustment which gives equal head to tape contact across the width of the tape. This ensures even head wear across the head, and is essential in multitrack machines for good tape tracking, as the tape will tend to slide upwards or downwards across a non-vertical surface. Maladjustment is easily recognisable after the damage has been done, as the wear-pattern across the head will have non-parallel edges. Unfortunately, when it has reached this state, the cure is either relapping the head or replacement. Realignment of an asymmetrically worn head usually results in bad head contact across part of the head stack, and tape mistracking on multitrack machines. The moral of the story is to align it correctly in the first place.

The usual method is to smear a thin coat of ink across the head face, put the machine in the play mode for a few minutes and then observe the wear-pattern, adjusting until a parallel wear-pattern is obtained. Another method involves the use of a set-square to set the angle from the deck to the head face at 90°. On certain machines, this method is not possible, either because of obstruction in front of the heads, or because of deck trim plates which are not necessarily in the correct plane.

The quickest, simplest and most accurate method so far used is an aluminium block, precision ground, about 10 x 4 cm. This is bridged across from a known vertical surface to the next surface along the tape path. By holding the block against the face of the known vertical, usually a fixed guide, and gently pressing the opposite end against the next surface face, extremely small amounts of non-parallelism can be felt as the block will rock to and fro if the two surfaces are not parallel. Proceed through the tape path until all heads, guides, and the capstan, are vertical.

Wrap is another neglected adjustment, which will affect the high frequency response. This is easily checked by playing the 16 kHz band on the test tape, and slightly increasing the back tension by lightly touching the supply spool. If the signal level increases then the wrap adjustment is incorrect. Adjust the head wrap for maximum signal at 16 kHz, and minimum change when touching the supply spool. It should be possible to achieve less than 0.25 dB change. The check should be repeated for the record head, in the sync mode, or if the machine does not have a sync mode, by recording 16 kHz and observing the playback level.

The erase head is much less critical, but can be adjusted for maximum depth of erasure.

Azimuth adjustment is normally achieved by playing the azimuth section of the test tape, combining all tracks at similar levels, and adjusting for maximum output as viewed on a meter. Ensure that the real maximum is found, as there will be lower level peaks on either side of the real maximum. This method gives an average value azimuth adjustment across the whole head stack.
Another method utilises an oscilloscope to display Lissajous patterns from two widely spaced tracks of the test tape, excluding the edge tracks. This is to minimise disturbance of the pattern due to dropouts. This method gives minimum phase error between two tracks, but could be in error between other tracks, due to gap scatter and inaccuracies in the manufacture of the head stack. To check this, use one track as a reference and check all other tracks against it.

A simpler method than the above is to display the two tracks on a dual beam scope and adjust for minimum phase error between the two signals. Ensure that the scope is set to the on a dual beam scope and adjust for minimum phase error against it. To check this, use one track as a reference and check all other tracks

Because of the short wavelength of high frequency signals, it is possible for the signal to appear correctly in phase while in fact being one or more complete cycles displaced. This would mean that signals at other frequencies would be in error. To guard against this, always start at a low frequency and make gentle corrections as the frequency increases, always keeping the two signals in phase. Short term phase jitter up to about ±90° will be observed at the higher frequencies and azimuth should be adjusted to give equal positive and negative displacement. If larger amounts occur, it implies either a damaged test tape or mechanical maladjustment of guides and rollers. The latter would cause the former, of course, and should be corrected before a new tape is used on the machine.

The same method is used to align the record head when a sync mode is available. On machines without sync, record head azimuth is adjusted by recording and simultaneously observing the playback signal. The erase head azimuth is not normally critical, but can be adjusted for maximum depth of erasure.

A point which must be borne in mind, with certain head mounting arrangements, is that some of the mechanical adjustments are interactive to a degree; for instance, head height will usually affect the other parameters, which must then be re-adjusted.

Electrical adjustment—playback

**Playback Level.** The required playback level is set by using the 'Reference Level' of a test tape. Unfortunately, a number of different reference levels are used by different manufacturers, so leading to confusion unless the relationship between the various levels is understood. See 'Reference Levels' by Hugh Ford—STUDIO SOUND (January 1977, p 42).

<table>
<thead>
<tr>
<th>Fluxivity nWb/m</th>
<th>Flux level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>185 nWb/m</td>
<td>-0.7</td>
</tr>
<tr>
<td>200 nWb/m</td>
<td>0</td>
</tr>
<tr>
<td>250 uWb/m</td>
<td>+2</td>
</tr>
<tr>
<td>320 uWb/m</td>
<td>+4</td>
</tr>
</tbody>
</table>

The required playback level is determined in conjunction with the type of recording tape to be used, and also the line level used in the studio. Normally the majority of studios operate at a line level of +4 dBm. The standard vu meter will read 0 vu with a +4 dBm signal applied to it.

So, if it is required to operate at 'elevated level', all that is necessary is to adjust the tape recorder playback level to give 0 vu when playing a 250 nWb/m test tape. If a test tape with a different flux level is available, then the playback level is adjusted to compensate for the difference in flux levels, for example, a 200 nWb/m test tape would read -2 vu if 0 vu were required to indicate 250 nWb/m. The difference between any two flux levels can easily be calculated by the formula:

\[
\text{Difference (dB)} = 20 \log \frac{\text{Flux 1}}{\text{Flux 2}}
\]

**Frequency Response.** The playback response is set by using the frequency response section of the test tape and adjusting the high and low frequency controls of the test tape for flattest responses. Test tapes with NAB equalisation usually have the response section recorded at the same level as the reference level. This allows response adjustments to be made using the tape machine meters. On the other hand, DIN equalisation test tapes usually have the response section recorded at -10 dB or -20 dB relative to the reference level, necessitating the use of an external ac millivoltmeter to indicate levels. When aligning a multitrack machine, this means a considerable amount of time being wasted in plugging the meter from track to track. An NAB machine can usually be aligned solely on its internal meters, allowing all tracks to be seen at the same time.

When adjusting the low frequency responses, allowance has to be made for the effect of 'fringing'. This is due to the test tape being recorded as a full track tape, instead of individual tracks across the tape. Due to the long wavelengths at low frequencies, the head picks up a certain amount of spil from either side of the track width proper. This adds to the overall signal level, i.e. it gives an apparent increase in flux level at low frequencies. If this level is used without due allowance, the low frequency response of the tape machine will end up deficient by the amount of fringing addition when playing a normal recorded track width equivalent to the playback track width. The amount will vary from one head manufacturer to another, and is related to the efficiency of the low frequency shielding built into the head. Certain test tapes have compensation incorporated, and care must be taken in knowing whether or not a compensated tape is being used. If an uncompensated tape is used, the low frequency response should be allowed to show a rise of approximately 3 dB at 50 Hz. A more accurate and consistent method is to leave the low frequency adjustment until the record alignment is performed. Then, by recording at frequencies between 40 Hz and 150 Hz, the flattest overall response may be obtained. It will be noticed that the response will not be flat, but will show a series of bumps and troughs. This is caused by the shape of the head pole pieces and is also influenced by tape speed.

Occasionally, it is necessary to align a machine to one equalisation standard using a test tape of a different standard. This is simple if conversion tables are available. The most common conversions are DIN 38 cm/s to NAB 38 cm/s, and DIN 19 cm/s to NAB 19 cm/s, and vice versa.

**Record alignment**

**Bias.** Bias setting can be performed in a number of ways. The most common method is to record a 1 kHz signal, and while increasing the amount of bias observe the playback level until a further increase in bias causes the playback level to decrease. At this point continue increasing the bias until the playback level has decreased by approximately 1 dB. The amount of overbias will vary from tape to tape, and should ideally be found by measuring the distortion produced by the tape at different bias levels. The point of minimum distortion is usually taken as the correct bias point. If the decrease in the level from peak bias is now noted, this overbias point can be used to bias all other tracks, without the need for the distortion analyser. It is usually more consistent to overbias at 10 kHz, where the amount of level decrease will normally be about 3 dB. This is easier to see, and results in more accurate biasing.

Another method is to bias for minimum modulation noise, by recording a very low frequency such as 3 Hz. The bias is then adjusted for minimum noise. However, on most modern tapes, the minimum distortion point and the maximum modulation noise point are usually very close together, and it becomes a matter of...
Dear Sir, Congratulations on an excellent August issue. It contains many extremely interesting features and the 'inside information' on Abbey Road is certainly deserving of the larger exposure that you have now given it. Perhaps it is not surprising that such an interesting issue should evoke some comments of a more or less serious nature.

The first is not so much a complaint as a serious epidemic, and it is reassuring to learn that Drs. Blair, Peckham, Davies and their professional colleagues have the antidote (literally) at their fingertips. I refer to the current resurgence of the frenetic struggle for more and more level on disc records. For those who may not be aware of the magnitude of the problem I would point out that recorded velocities greater than 50 cm/s at 10 Hz are now by no means uncommon.

Being deeply involved in the design of record playing equipment for domestic use, I would like to suggest that what the cutting fraternity are trying to do is actually self-defeating. The state of the art in low-price record players at the beginning of 1976 was that adequate overall gain and signal-to-noise ratio, together with adequate bass response, could be obtained by using a crystal pickup cartridge and a simple discrete or integrated amplifier. This could give very acceptable results for an outlay of between £40 and £50. (Just to quantify, 'adequate' gain means that the amplifier is driven to maximum by a recorded velocity of 3 cm/s at 4 kHz with the volume control at maximum; 'adequate' S/N is -60 dB ref. max. output CCIR weighted, and 'adequate' bass response is -3 dB at 50 to 70 Hz, with or without peaking.) Early last year the industry began to receive many complaints of pickup jumping and general tracking failure on products which up to then had been perfectly complaint-free. It was fairly soon clear that some labels were particularly testing, notably B&EE. The only practical solution was to abandon the crystal cartridge and use a ceramic, with improved tracking capability but with 3 to 4 dB less output! The gain loss had nullified the increased level on the disc, and the amplifier (believe me) cannot be modified to give more gain without compromising the cost (not recoverable due to the Price Code!), the S/N or the bass response unacceptably. Nett result—sorrow all round. Perhaps the 'friendly rivalry' and jolly japes will be tempered with a little thought along the above lines in future! One wonders whether Mr Blair has 'slipped in a V15/III' on his cheap gramophone (sic).

Yours faithfully, J. M. Woodgate.

Ken Townsend replies:

We sympathise with the problems mentioned by J. M. Woodgate, but an instant remedy is not possible. Record producers naturally insist that their records are cut at the highest level possible to compete with the opposition. If one cutting room will not oblige then they will take their work to one that will. For our own part, we at Abbey Road realise that records have to be played on not only good equipment but also on the very cheapest. We have a standard 'low quality, low price, record player' which is used to check that pop records do not jump, and any which fail the test are re-cut. We therefore earnestly try to satisfy not only the needs of the record producer but also the record-buying public at large.

Mr Woodgate admits in his letter that he is having to keep the price at a minimum in order to compete with other low-priced players, and if all such manufacturers designed to a slightly better standard then the problem would be almost eliminated. We have actually purchased from customers who have complained about 'jumpers' their disc-playing equipment, in order to test the industry minimum standard, not only in London but also in Europe and the United States.

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Yours faithfully, P. G. Adshead, Pennine Sound Studio, Gladstone Street, Oldham, Lancs.
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17 cm disc for testing stereo replay equipment; it gives channel and symmetry information, loudspeaker phasing etc. The flip side is an assortment of everyday noises. This disc is available with announcements in French or English.
1099 008, 1099 010
30 cm versions of 1001 942 and 1001 944 respectively.
1099 011
30 cm disc with 45 rpm playing speed for measuring intermodulation distortion to DIN 45 403 sheet 4, 400 Hz + 4 kHz in the absolute velocity ratio of 4:1.
1099 014
30 cm disc for demonstrating the audibility of bandwidth distortion.
1099 015
30 cm disc for demonstrating the audibility of non-linear distortion.
1099 103
Level measurement at 45 and 33 rpm.
1099 106
Frequency response measurement to DIN 45 547.
1099 108
For testing intermodulation distortion of pickups by use of a gliding pair of tones with 400 Hz difference.
1099 109
Warble tone for loudspeaker tests.
1099 111
Tracking tests.
1099 112
Universal frequency measurement disc containing glide tones and spot frequencies.
1641 001
Hi-fi stereo test disc.

EMI
EMI Records Ltd, Manchester Square, London W1. Phone: 01-486 4488.
TCS 101
A stereo frequency response disc with a recorded equalisation characteristic to British Standard 1929/1960, except that the level of frequency bands above 10 kHz has been dropped by 6 dB. Spot frequencies and reference tones.

TCS 102
A series of glide tones for detecting resonances.

TCS 103
As TCS 101 but in mono only (lateral modulation).

TCS 105
As TCS 104 but with vertical modulation.

TS 201 and TS 202

RLPS 22
Wow and flutter.

HI-FI NEWS
Link House Publications, Link House, Dingwall Avenue, Croydon CR9 2TA.
Phone: 01-686 2599.

QUADRAFILE
A two record set featuring the four major quadrophonic systems on successive sides; the same positional tones and musical material is recorded in SQ, CD-4 and UD-4 for comparison purposes.

HI-FI SOUND
Haymarket Publishing Group, Gillow House, Winski Street, London W1. Phone: 01-439 4301.
HFS 75
This test record is intended for both aural and quantitative testing of turntables and cartridges.

JVC
JVC Cutting Center Inc, RCA Bldg, Suite 300
6363 Sunset Boulevard, Hollywood, California 90028, USA.
UK: JVC (UK) Ltd, Eldonwall Trading Estate
Staples Corner, 8-9 Priestly Way, London NW2 8DH.
Phone: 01-450 0251.
TRS 1001
Mono disc for checking frequency response mechanical resonances, etc.
TRS 1002
Stereo disc for checking frequency response, wow and flutter, etc.
TRS 1003
Stereo frequency response record for testing high frequency response of CD-4 pickup cartridges.
TRS 1004
A record cut for undertaking quick checks of frequency response, crosstalk, and phase of CD-4 cartridges. Primarily intended for checks at production.
TRS 1005
Record for high frequency response and cross checks on CD-4 cartridges using level record such as the B & K 2305/2307.
TRS 1300
High frequency response and crosstalk.

SHURE
Shure Bros Inc, 222 Hartrey Avenue, Evanston, Ill 60204, USA.
UK: Shure Electronics Ltd, Eccleston Road II
stone ME15 6AU. Phone: 0622-59881.

TTR 110
‘An Audio Obstacle Course’. All sorts of which highlight deficiencies in cartridges.

TTR 102
Tests low frequency resonance and intermodulation distortion.

TTR 103
Disc intended for disc tracking tests—for use with external analysis equipment.

TTR 109
Level and crosstalk record for use with et analysers.
PART TWO: Test Tapes

AGFA
Agfa-Gevaert AG, Vertrieb Magnetband, D-569 Leverkusen, West Germany.
Phone: (201) 288 4100.
UK: Agfa-Gevaert Ltd, 27 Great West Road, Brentford, Middlesex TW8 9AX.
Phone: 01-560 2131.

The company manufactures a range of recording test tapes in a variety of widths and speeds to the DIN/IEC format only. No further information received.

AMPEX
Ampex Corporation, Audio-Video Systems Division, 601 Broadway, Redwood City, Ca 94063, USA.

The company manufactures a range of test tapes in all size formats between 6.25 and 50 mm; these are available both in full and separate tracking. Speed standards are 76, 38, 19 and 9.5 cm/s (the last speed is available only in 6.25 mm size).

Equalisation standards are to either DIN or IEC (76 cm/s uses 17.5 μs AES).

Tapes are available in three groups: reproduce alignment tapes, flutter test tapes and level set tapes.

The first group offers operating level tones at 11 spot frequencies at operating level (38 and 76 cm/s respectively). The lower speed tapes use -10 dB tones at spot frequencies at operating level (38 and 76 cm/s use –10 dB, 17.5 μs AES).

A speed check of stroboscopic markings on tape is available both in full and separate tracking.

The company manufactures a range of test tapes in all size formats to the DIN/IEC format only. No further information received.

EMI
EMI Sound and Vision Ltd, 254 Blyth Road, Hayes, Middlesex UB3 1HW.
Phone: 01-573 3888.

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- Less time is needed for reproducer test and adjustment because of the more comprehensive and convenient MRL formats.
- Your specific reproducing system parameters and signal chain characteristics are readily measured with specialised MRL test tapes and companion reference products.

Manufactured by Magnetic Reference Laboratory Inc., 229 Polaris Avenue, Suite 4, Mountain View, California, 94043, USA.

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This tape offers the same tests as the SRT 17/18 but at a tape speed of 9.5 cm/s. Some tests have been modified to accommodate this speed.

The SRT 18 test tape is available in cartridge format designated SRT 18C. All the above are 6.25 mm wide.

Standard equalisation tapes
Standard MRL test tapes have a reference fluxivity of 250 nWb/m which is appropriate to tapes such as the generation prior to the 3M 206 etc. The company also manufactures a range of test tapes corresponding to a maximum flux of 250 nWb/m for the so called 'high output' tapes.

Product line includes tapes which incorporate rapid sweep (for technical reasons, these are restricted to frequencies above 500 Hz; checks below this require standard tones at spot frequencies). These are also a range of tapes with the usual spot frequencies throughout the audio spectrum. Tape width 6.25, 12.5, 25 and 50 mm. Normal eq standard; NAB 50 + 3180 us. Tape speed 19, 38 and 76 cm/s. IEC equalisation test tapes are available in the above tape width sizes referenced to a fluxivity of 320 nWb/m.

MRL also produces a range of azimuth correction tapes using an alternate tone difference measurement process for correct adjustment.

MRL MAGNETIC REFERENCE LABORATORY
F.W.O. Bauch Limited
49 Theobald Street, Boreham Wood
Herts. WD6 4RZ Tel: 01-953 0092 Telex: 27502
**Well respected Konk**

It used to be the done thing for an emergent Rock Star to lavish his newfound riches on a limousine for himself, a country seat for his much-loved parents, and maybe, a couple of record shops. Well times change as, thankfully, does the music industry—and the current superstar status symbol seems to be the possession of one's own studio. Among the first groups to recognise the inherent economic sense of this were the Kinks, whose career had successfully spanned studio. Among the first groups to change, as, to try and find the cause.

To get from the reception area to the studio you go through a veritable labyrinth of narrow corridors and light, airy practice rooms, and the feeling is of something between an old fashioned music academy and rambling country house. Go through the heavy double doors and into the studio proper, and it's another story. The new Konk, you see, was not just a simple refurbishing job on the existing building. Instead, a separate self-contained shell has been built up inside the structure of the old warehouse, and resting on an extremely solid poured concrete foundation.

The control room is impressively large— it will seat up to 19 people with ease—fully air-conditioned and subtly lit from overhead light tracks. Its layout and equipment reflect the ideas and experience of one man, Roger Wake; Studio Manager, Recording Engineer and general factotum at Konk. When he came to Konk, he inherited the old 16 track setup, so the change to 24 gave him the chance to set things up exactly as he wanted them. After nearly 10 years in the business, including a long spell at Phonogram and a period as an independent radio commercial producer, he had a fairly good idea of what he was after and, generally speaking, feels that he's got it with the new studio.

You can't have things 100 percent perfect though, and in Roger's case this meant that he had to forgo the pleasures of a custom-built Neve desk, because he'd have had a wait of over a year for delivery. This would have gone way over the schedule for converting to 24 track, so he settled for a standard frame, which has been considerably re-worked, but only took six months to build and install. The modifications are, says Roger, designed to make the board more ergonomic in use, and they include a centralised monitoring panel which was taken from another frame, and sliding faders instead of the standard stub rotaries. Also, the standard Neve limiters have been replaced by Audio & Design units.

A Sony cassette recorder is permanently mounted on the board. This can be used to take instant run-offs of finished masters or individual takes. There are 24 input channels—although the board is wired for 32 and the others might be hooked up soon—and 24 out. The channel amplifiers are Neve's most sophisticated, with 20 presence frequencies. EMT stereo plates, and four separate echo sends, each with individual level controls, are used. Likewise, there are four separate foldbacks, each of which can be independently balanced.

One of Roger's hangups from his Phonogram days was the relatively low playback level of the resident Tannoy monitors: "I remember a couple of Status Quo sessions where the group were playing very loud and we just couldn't get enough sheer volume on play back through the Tannoys to reproduce the original levels accurately. I've obviously got a lot of respect for them, and I like using them—but they're really just not big enough for modern rock recording." To make sure that Konk doesn't have similar problems, a huge JBL 4450 looms at each corner of the room. Even the squawk boxes on the board are a lot bigger than normal; they're made by Audio Shack in the States and despite their diminutive 14 cm diameter, they can handle no less than 25W rms apiece. They're driven off a compact 2 x 20W Sonamp mounted in the board, and the system at full blast should be capable of giving even the dealer a sizeable headache.

Behind and to the right of the desk, the recording equipment is grouped. There are four machines and tucked forlornly away in the corner is the smallest and oldest a 2 track Ampex of somewhat uncertain vintage. It's there if it's needed, but future users should be warned that Roger doesn't like operating it one bit. Two Studer A80s come next, one 2 track, and the other 4 track. Both are hooked up to Dolby 3615. The 24 track machine is an Ampex MM1100 which has nothing but praise from Roger, especially the tape transport system. In fact the 1100 was something of an offer that Konk couldn't refuse. It previously belonged to IES, a hire outfit, and it had only been used three times—so an asking price of £13,000 complete with an M24 Dolby system had to be a bargain, and went a long way towards keeping capital expenditure down to an £80,000 target.

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WORK

The work was handled by Peter Savory and Associates, an architectural practice which is gaining a considerable reputation in the recording industry. The studio environment itself is relatively long and narrow, but at Roger was surprised to find, it gives extremely clear separation. At the opposite end to the present control room is the site of the old one. This is currently being converted to a general purpose recording area, which will be used for overdubs, brass ensemble work, vocals and as an open drum trap — which should give the kind of fairly live sound which many groups are using currently. Also, at the time we were there, the old screens which were rather suspect were being gradually replaced with purpose-built Sonaplan units which have far superior acoustical properties, according to Roger. While intended primarily as a rock studio, Konk is capable of accommodating up to 25 musicians with ease, and it’s fully ventilated and heated so that there’s a comfortable working environment. Instruments in situ include a Fender Rhodes, Yamaha piano, Hammond organ and Leslie—and there’s generally some of the Kinks’ own gear lying around if it’s needed. If something else is required, Konk has an extremely good working relationship with Julians the W1 hire outfit. ‘We needed a Studio Fender Rhodes for one session, ordered it up and had it delivered within the hour.’ Equipment can be loaded and unloaded without tears and strained backs because there’s a fully enclosed Transit-sized loading bay, which allows vans to be backed up virtually into the studio.

Technical wizardry aside, one of Konk’s nicest features has to be the bar and games room which adjoins the studio. Most of the group were there waiting for the board to be repaired, and a heated darts game was in progress. It certainly beats sitting in the corridor with a lukewarm can of lager clutched in a sweaty hand between takes. The bar stocks a comprehensive range of alcoholic beverages, and while CAMRA wouldn’t exactly be over the moon about the bitter, Roger pulled us a very passable pint with the sort of style that only comes with practice. Decor is authentic pub kitsch, circa Kilburn, right down to the ducks on the wall, buttoned velvet upholstery and Formica-clad bar. In a separate alcove, there’s a full-size snooker table for the athletically inclined. Apparently competition is fierce, and there was hot debate as to who was the current champion among the Kinks. All the place needs for complete authenticity is a blousy barmaid, a hint of sawdust on the parquet floor and a couple of drunken Irishmen in flat caps sleeping it off.

While the new studio opened officially on July 23 1976, but pressure of work was such that sessions were booked even before that date. Dick Emery was one of the first people to record there, when he cut his Christmas disc in July. Other notables who’ve been in since include goldene oldie Bert Weedon (very professional—we mixed 11 tracks in a single working day), Mud, who did the overdubs for their next single at Konk, and Cafe Society, a new group produced by John Miller and rated very highly by Roger Wake. When the Kinks are in doing album sessions, they generally work for three days per week, but they’re usually prepared to work their sessions in around other clients, to make Konk a paying proposition.

At present Roger is the only full-time member of staff, but the chances are that he’ll be getting a junior in soon; ‘now it takes about 35 to 40 minutes to set up for each take, so it would be nice to have a skivvy to take some of the work off my shoulders and generally help out around the studio.’ He was fairly certain that at £34 per hour, Konk probably offers one of the cheapest 24 track rates, in the London area. This is another benefit of the Horsey location, because the low overheads can be passed on to the customer. 16 track is £32 per hour, 2 and 4 track is £30 and, while the studio is available on a 24 hour basis, there’s a £5 per hour overtime surcharge after six in the evening.

When we left, the desk was finally brought into commission (after two hours of probing, much sage nodding of heads and dark mutters about over-efficient relays, the bother was traced to a single leaky capacitor!) and recording was just about to begin—which seemed like a good cue for an exit from the overworked look on Roger’s face. The impression we had was of a friendly, well-equipped studio that doesn’t maybe have the gloss of some of its West End counterparts—but seemed like a far nicer environment to work (and play) in. We certainly can’t have been alone in this sentiment; at the time of writing the studio was healthily booked up for quite some time ahead, which can’t be bad.

Dave Hamill

Invisible Sound

There are two very surprising things about A Chorus Line which opened some months ago at the Theatre Royal, Drury Lane. One is the fact that it actually lived up to all its advance publicity. Dedicated to ‘anyone who has ever danced in a chorus or marched in step... anywhere’, the show is a fascinating chart of the agonising course of an audition for a Broadway show, with a couple of dozen hopeful dancers giving their best, telling their life-story to the director and finally being whittled down to a final troupe. At the time of writing, a stream of hopeful English dancers is playing exactly the same role, and while the studio is available on a day basis, there’s a £5 per hour overtime surcharge after six in the evening.

The second surprise is in the sound. I saw the show almost by chance and loved it, but found myself thinking throughout the performance about how on earth the voices of the cast could be coming over the house pa so loud and clear, cutting through the amplifiers (pit band hidden under a gauze roof to the pit) without ever the sight of a mic or a hint of feedback. At first I was sure that they must all be wearing hidden radio mics; but soon it was physically apparent that they weren’t. Then I wondered briefly about mixing, but that, too, was clearly a non-starter. Mics hidden on stage? The stage set is a bare rehearsal room, and there just isn’t anywhere to hide a mic. So after the show, all I could do was check to find out who was organising the sound and phone them the next day.

The show, as everyone by now knows, was already playing simultaneously in several US and Canadian cities before another performing cast came over to England, particularly for such rare occasions. The American import team that arrived was fully rehearsed and ready to go and was accompanied by an army of technicians and advisers, only a very few of whom turned out to be freeloaders. Autograph, the production sound engineers, were promised a full sound system, and were naturally somewhat surprised to find that the ‘full sound system’ was missing all cables and connectors. And as they subsequently found out, no single shop in London can supply 700m of cable off the shelf. Around £1000 was spent in Wardour Street in a single day on connectors alone.

Also, the imported communication system, for providing a link between the pit orchestra, off-stage chorus, lighting director and sound engineers, was of highly dubious reliability. Obviously, the Americans can already realise this, because everything was duplicated, thereby doubling the cable requirements. It’s now been replaced by a single, more reliable system. Even so, at least multiple multi-cores must snake out over the theatre roof, to provide all the necessary links.

There was no sound cue-sheet available, quite simply because there are too many sound cues to write down, and no one could possibly look at the stage while reading a sheet and working the microphones.

So it was taught by word of mouth and learnt by heart to understand why the cue-sheet is so complicated; you have only to look at the heavily amplified vocal sound...
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WORK

from the cast on stage, without radio mics or mining used anywhere in the whole show.

Along the front of the stage, at ground level, there are mounted five Sennheiser 802 hypercardioid mics, and slung over the stage, some 8m up, there are five Sennheiser 816 rifle mics in one line of two and another of three. In this way directional mics cover the whole area of the stage. The mics are all wired through separate faders on the mixing console which, following the old adage that the only place you can judge audience sound balance is from a seat in the audience, takes up £30-worth of stalls seats every night. The mixed mic outputs are routed in mono via Altec power amps to a bank of eight Altec 9846A speakers, six of which, weighing close on a ton, are hung in a cluster over the front of the proscenium. As the actors move about the stage, they are at any one time always in the line of fire of at least one of the ten directional mics. Every stage movement is rigidly pre-planned, and provided the sound operator (Jonathan Deans, late of Covent Garden) knows his job (which he clearly does) it is possible to track each piece of dialogue or song at constant level. But of course the difficulties in practice are immense. Frequently there are several people talking or singing at the same time, unused mics must be killed to keep the tracked sound uncluttered with background noise, and even the slightest movement of an actor's head or down can mean a difference of several dB either way between mic channels. But, as anyone who pays a visit to A Chorus Line can find out for themselves, the system can and does work. Although this hypercardioid mic technique has been tried before, for instance during the West Side Story revival, it has never so far been really successful. This is because the sound level generated in this manner has never really been able to crowd out a stage band.

Although Autograph readily acknowledge that putting the hardware together was relatively easy (as far as anything in the theatre is ever easy), one could write a short book on the fine practical details and problems. The desk used is a Trident Flexmix, about which everyone seems to have much praise, and which certainly seems to have lived up to its name. Initial delivery, from order, took two hours, and the mods to tailor it to A Chorus Line took another hour. A problem over providing the necessary 48V phantom supply for the Sennheiser mics was fixed next day, and the desk layout currently stands at 35 channels in, to seven sub-groups out. When the show is over, it will remain the property of Michael White, the presenter, who to his credit seems to have spared nothing to get the show on the road without problems. The desk can then be converted into two or three separate smaller desks for future shows. The Altec speakers over the proscenium can be panned or tilted and are fed by the Altec power amps via an Altec 27-band room equaliser. This takes some fairly hefty chunks out of the sound spectrum, eg above 3 kHz, both for eq purposes and to kill the possibility of feedback altogether. A similar mix fed to the Altecs over the proscenium is fed to a stack of eight Altec and Electrovoice speakers ranged round the circle and gallery rear, but with a 25 ms delay. Although all the stage sound is mixed as mono, the 23 musicians in the pit are fairly close-miked and mixed into stereo at the desk, for reproduction along with the mono stage sound. In this way there is a stereo spread of the music with voices centre front. Mics used in the pit: two Neumann 822's on the six woodwind, and two Electrovoice RE29's on the six brass. But as the pit musicians start putting deeps in, as will inevitably happen as the run progresses, internal section balance is bound to deteriorate. Doubtless there will then have to be more mics, closer to the players, so that a sectional balance can be created at the desk. So far the band mics take up 15 inputs on the desk. A Musidisc安全事故系列可用的cctv unit is used for special effects only, never sweetening; the pa is otherwise totally dry. The total power of the pa is 5.2 kW, the volume of the theatre being nearly 2 million cubic feet!

In the covered pit, musical director Ray Cook conducts with the help of foldback from the stage and a closed circuit tv monitor, showing a view from the stalls. Similar foldback, via Sennheiser HD414 phones, and a cctv monitor is available in the offstage chorus booth, where an average of seven or eight singers are picked up (in stereo) and mixed into the band and on-stage sound for chorus numbers.

So far A Chorus Line has been a success story in the tradition of hit shows like My Fair Lady and Camelot that preceded it at Drury Lane. The first main hurdle to the future will be substitution of the American cast with a British cast. No one can yet say how successful this will be. But so far seats are almost unobtainable, and people are happy to buy (often from scalpers) even those few behind the sound mixing desk that the box office will sell only with the disclaimer that they have 'restricted view'. But the sound engineers are still having to learn to live with nightly taps on the shoulder. One night it was a little old lady. 'Can you hurry up and finish fiddling with those knobs and move out of the way before the show starts?' she asked. The next night a precise German tourist begged Jonathan Deans 'to be so kind and move down in his seat by 1 1/2 inches'. Just how he arrived at this figure, rather than a round inch or even two, is still puzzling the Drury Lane engineers.

Ron Geesin Revisited

Several years ago I intruded on the decidedly un-ordinary world of Ron Geesin, who was then working out of a studio at his home in Ladbroke Grove. As I found out when I came to write up this article, Geesin is, in many respects, a journalist's Waterloo; you just can't sum him up pithily in an introductory paragraph. He's a musician, playing more or less every keyboard and stringed instrument in his own highly individual, unclassifiable style; an electronics amateur; a creative recording professional with several short and feature film soundtracks to his credit; a record company with three lp's; a publisher with one book; and a performer of live events even less easily classifiable than his unclassifiable musical styles.

Shortly after the Ron Geesin Unlimited article that I finally put together, Geesin moved house to Heathfield, Sussex (home of a wild farm-style house that was then too smelly and gloomy for the locals to touch with a barge pole and is now everybody's dream escape from city life). But the sound engineers found him still impossible to sum up, still bubbling with creative ideas, and still (somewhat surprisingly, bearing in mind his unclassifiable world of commerce) managing to make a happy living out of putting some of those ideas into practice. The enthusiasts seem more ordered; he has for instance been making some KPM discs. But the sleeve notes are vintage Geesin. 'I present some tunes, untunes, anti-tunes, delightful and un delightful sounds, for all sorts of purposes, and state that: the pieces herein displayed may be combined with themselves (as much out of sync as possible) to achieve thicker, diffuse atmosphere, and playing things at different speeds would not be wrong.'

Geesin claims one, I introduce you to a world of electronic sounds, shapes and rhythms created to enhance and aggravate moving and unmoving pictures to startling effect', says the other. There is no point in being outgoing with ideas if there is nothing into which to put the 'outgivings', he says in person, while explaining the need to save some ideas for the future.

The present is financed both by past royalties on recordings like the Pink Floyd's Atom Heart Mother, in which he had an arranging hand, present book and record sales and the music for a regular succession of commercial films, such as the excellent BP series on the history of motoring. The old Revox G36s have been replaced by A77s. The new machines are now being subjected to the same abuses as the old, a necessary part of the musical
a question of ECONOMICS?

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ANM2 Audio Noisometer. True r.m.s. reading £200.00

Four instruments are now available for the measurement of audio frequency signals including noise. They are derived from a basic battery operated voltmeter design having 16 measurement ranges from 10V for full scale meter deflection to 300 V f.s.d. The Voltmeter has a high input impedance and low inherent noise. It is fitted with a high grade meter having a 5" mirror scale of excellent linearity, calibrated in volts and dBV.

The audio Voltmeter (HSV1) becomes an Audio Noisometer (ANM1) by the inclusion of frequency contouring networks having characteristics recommended by international organisations concerned with specifications and measurement standards, as being suitable for the quantitative measurement of the subjective effect of noise in audio systems. The HSV1 and ANM1 instruments respond to the average or mean value of the waveform being measured and are calibrated in r.m.s. values on a sine wave.

In the HSV2 and ANM2 instruments an r.m.s. to d.c. converter module is incorporated which provides a true r.m.s. reading on waveforms with a crest factor in excess of 10. These instruments are also provided with an additional output socket giving 1.00 V d.c. output corresponding to 1.00 V at nominal full scale meter deflection to operate a chart recorder or d.c. digital voltmeter.

All the instruments are fitted with a socket to enable an external network of any weighting characteristic to be introduced in the measuring circuit. This extends the use of the instruments to vibration and acoustical measurement as well as to the measurement of gramophone turntable rumble, f.m. receiver noise, etc.

Brief Specification:
Frequency response as Voltmeter:
4 Hz to 500 kHz +0.5 dB at frequency limits.
Input impedance: 1M ohm shunted by 30 pF.
Attenuator accuracy: 0.25%.
Meter scale linearity: 1% typically better than 0.5%.
Wavenorm error in true rms instruments: 1% for crest factor 10.
Noisemeter included weighting characteristics: Wide band (flat response as Voltmeter), DIN 'Audio Band', IEC/DIN Curves 'A', 'CCIR'.

Size: 112 x 72 x 81 deep overall.

Please write or phone for descriptive leaflet giving details of the design and full performance characteristics of the above instruments, together with a reprint copy of Dolby Laboratories Inc. Engineering Field Bulletin No. 19/2—Noise Measurement on Consumer Equipment—

Radford Laboratory Instruments Ltd
ASHTON VALE ROAD, BRISTOL BS3 2HZ, AVON
Tel. 0272 662301

47
formula for instant overdubbing; this is essential to Geesin's musical and recording technique. It's damnably clever, horribly difficult to put into operation, and is even now only occasionally copied — for instance by Queen in fairly primitive fashion on their Night At The Opera lp. When listening to the final results, it's only too easy to forget that the only multitrack recorder in sight is a Teac 4-track. Everything is done in stereo, often mono subsequently tricked up one way or another to produce a stereo effect, and stored in 'slabs' on the Teac or several Revoxes running in sync for short periods. In its simplest form, the system relies on running a reel of tape from the take-off spool of one machine through the heads of that machine (set in the 'record' mode) and from there, not on the recorder's take-up spool but through the heads (set in the 'playback' mode) of another. Revox alongside it, using that machine's take-up spool. In this way the same tape runs first through the record head of one machine and then, with a delay determined by the spacing between the two machines, through the playback head of the other machine. Geesin feeds a sound signal, for instance by direct injection from an electric guitar, through a mixer onto the tape running through the first batch of heads. In this way the injected sound is recorded onto the tape and after the substantial delay inevitably imposed by the spacing of the two machines, the recorded sound is played back by the heads of the second machine. Audible reproduction is either over loudspeaker monitors or headphones and at the same time the mixer feeds the reproduced signal back to the first set of heads, to re-record it on the tape. Thus a single note will in this way be recorded on the tape as a repeated succession of exactly similar single notes, spaced by the fixed delay governed by the separation of the heads of the two machines.

Because the delay is considerable, the repeat may be of a musical phrase and the mixer enables Geesin to add another, different phrase to it and another, and another and so on. Thus in practice a single bass line can be laid down by the player, he explains, and the first set of heads, heard as it passes through the second set of heads and fed back to the first set of heads again, along with a matching melody line. It sounds easy enough but it's not. The main difficulty is in matching rhythm to delay so that each new phrase is in sync with those already being recycled. Geesin has now mastered the technique to such an extent so that within a matter of minutes, a musical (and I emphasise the word musical to distinguish from garbled musique concrète) orchestration can be built up in the time it takes for a reel of tape to run through the machine. Indeed, if one had to pick on a single reason why Geesin succeeds where others fail in the same field, it would be his ability at one and the same time to handle electronics, compose melodic tunes and maintain rigid tempo.

Electronics, along with all his other do-it-yourself activities, such as photography, metal and woodwork were learned the hard way. 'No one taught me; I'm doing it by doing it', he says. Geesin's ability to write catchy tunes is doubtless a gift, but a cultured gift, nevertheless. Plenty of those blessed with the ability to write melodies gradually decide it is beneath their dignity to do so. And the need for a good sense of rhythm? Well try for yourself the almost impossible task (which Geesin's delay technique requires) of tapping in time with single beats spaced all of eight or nine seconds apart!

The basic delay system is obviously under continual modification. When I arrived, Geesin had just finished making an extension to the disc as it rotates so that the pins strike the transducer in a continuous rhythm, dictated by the spacing of the pins. If several transducers and several rows of pins are used on each disc, they produce variations of sound, each in different rhythms but all within the same basic metre, as dictated by the number of divisions on the disc. Even in its primitive prototype form, the gadget was able to produce instant jungle drums, and create time and tempi that would make even the most modern jazz drummer wince at their imposibility.

All this isn't meant to replace musicians. It's simply another part of Geesin's scheme to make himself ever more musically independent. This is highly necessary if you work from the depths of Sussex, where you are likely to be snowed up in the depths of winter, with a dead-line for a film soundtrack tape.

Also on do-it-yourself self-sufficiency basis, Geesin appears to be growing enough vegetables to weather a siege, publishing and distributing his own books and records, coping with mundane miseries like VAT, and even finding time to write two-page rude letters to the French RCA Black-and-White record label. Geesin's keener than average rhythmic ear detected that, in re-issuing cleaned-up versions of old jazz recordings, the company had erased clicks and pops by physically removing segments of tape. Geesin's answer, gleaned from his friend J R T Davies ('upholder of quality in re-issue programmes') has obviously never been heard of in France. 'What you do', he says, 'is simply scratch off a little of the oxide at the point on the tape where the click appears. That way you bloop out the noise without affecting the rhythm.' The partly puzzled, and partly offended producer recently rang him from France. It remains to be seen whether future Black-and-White re-issues are rhythmically sound.

Summing up and rounding off a Geesin piece is as difficult as writing an introduction. I can't do better than quote a couple of unrelated comments verbatim, because together they do the trick. 'A man's got to use all his energy...the secret of creativity is to use all your energy' and 'What I want to do is innovate—no go on Opportunity Knocks and talk about it—just innovate, be challenged and continue.'

Adrian Hope

Musicians' humour tends to be the same the world over. The cruise liner docked for a day at a tiny port in Alaska and the multi-national band resident on board explored the one-horse town. Main street sported a bar, bank, barber and general store. Everywhere you looked there was a snow-capped mountains. 'What could you do in a place like this?' said one musician, as they killed time before sailing. 'Open a bassoon repair shop?' said the other, without a moment's thought.

The radio play recording was going well, but the headdress scene wasn't quite to the producer's liking; he felt that cutting a cabbage in half sounded like cutting a cabbage in half. At the direction of the studio effects manager, a pig's head was duly brought in and, with some difficulty, they hacked it in half; first with an effects sword and when that didn't work, a fireman's axe.

A mutilated pig's head is not the easiest of things to dispose of, even given the ingenuity of this production team. It was therefore probably pure coincidence that brawn appeared on the canteen menu the next day.

48 STUDIO SOUND, FEBRUARY 1977
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Specification:
- Frequency range: 10Hz-100kHz (4 bands)
- Output voltage: 10 volts r.m.s. max.
- Output source resistance: 100 ohms unbalanced
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- Output attenuation accuracy: 1%
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Send for leaflets for further details:

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Tel. 0272 662301
Radford low distortion oscillator

Hugh Ford

MANUFACTURER'S SPECIFICATION
Frequency range: 10 Hz - 100 kHz (four bands).
Output voltage: ±10 V rms maximum
Output waveform: sine and square.
Output attenuation: 0-20 dB potentiometer.
Output source resistance: 151 ohm constant.
Output monitoring: 102 mm mirror scale meter engraved: 0-1, 0-3.2 and 0 dBV to -15 dBV (1V = 0 dBV).
Calibration accuracy: 1% fsd.
Overall size: 430 x 178 x 230 mm.
Price: £300 Standard version.

Sinewave rise and fall time: 50 ns.
Squarewave rise and fall time: 50 ns.
Output monitoring: 102 mm mirror scale meter: engraved: 0-1, 0-3.2 and 0 dBV to -15 dBV (1V = 0 dBV).
Calibration accuracy: 1% fsd.
Overall size: 430 x 178 x 230 mm.
Weight: 7.8 kg net.
Price: £300 Standard version.
Manufacturer: Radford Instruments Ltd, Bristol, England.

MUCH modern audio equipment has harmonic distortion specified in the third decimal place and one really does wonder how the manufacturer manages to make the measurements with any confidence, for to my knowledge there are only two makes of oscillator commercially available which have any hope of giving meaningful measurements.

The first on the scene was the Radford which has been about for many years and naturally used valves, but Arthur Radford has of course now caught up with things in the form of the new Series 3 Low Distortion Oscillator, which is of course a completely 'solid-state' instrument. Two versions of the instrument are available: the standard version has an unbalanced 150 ohm output and the B version offers a 600 ohm balanced floating output, in addition to the possibility of a 300 ohm floating output or a 150 or 300 ohm unbalanced output. As is to be expected the distortion performance of the balanced output is restricted by the addition of a drive amplifier and transformer, but as will be seen the performance is remarkably good.

The presentation of the instrument is a black crackle case with an alloy front panel with clear legends in black. There is a 11.5 cm diameter frequency tuning dial which covers one decade and operates in conjunction with a four-position range switch, thus covering the total range 10 Hz to 100 kHz.

Signal output level is controlled by an 11-position 10 dB step attenuator covering 0.1 mV to 10 V maximum outputs which are incremented by a potentiometer which has in excess of 20 dB range. The actual open circuit output level is indicated by a meter scaled in volts and dBV and which is equipped with an anti-parallax mirror. Three outputs are available, a fixed level unbalanced output at a BNC socket, the attenuated unbalanced 150 ohm or 300 ohm output at a second BNC socket and the balanced output. This comprises a floating 600 ohm centre tapped output at spring-type terminals and an extra terminal which is connected to earth.

The remaining front panel facilities comprise a green incandescent power indicator lamp and four pushbutton switches. The top one of these is the power on/off switch below which there is a sine/squarewave output switch and a non-locking 'oscillator off' switch which is a very useful feature. The fourth switch controls the output routing to nominally '150 ohms unbalanced' or '600 ohms floating'. However, it does not isolate the unused output and this can create problems.

At the rear of the instrument there is the fixed mains lead (I prefer IEC connectors) and the voltage selector. In addition, there is the 20 mm power fuse the value of which is a closely guarded secret! The technical instructions provided give component values, circuits and servicing information but nothing about the mains fuse.

The standard of components and printed boards used in the construction is excellent, and should board replacement ever be needed, this is a very simple matter as all connections are by slide-on tags. However, the instrument suffers from my bete noir, the knobs fall off the rotary switches because the shafts do not have flats and single screw fixing is used. Another small grumble is that there is no tilting foot arrangement which can make the meter awkward to read.

Distortion

The prime quality of the Radford Low Distortion Oscillator is that, while to my knowledge there may be one equal, there is certainly no better commercial oscillator so far as distortion is concerned in the audio frequency band.

Reference to fig. 1 shows that the third harmonic distortion at the unbalanced output is over 100 dB down on the fundamental (0.001 % distortion) over the frequency band 20 Hz to 15 kHz and that the second harmonic is not far short of this fantastic performance. The testgear required to measure individual harmonics at these low levels (with a 20 dB noise floor) unfortunately did not function outside the band 20 Hz to 20 kHz, so fig. 1 includes spot checks on the total harmonic distortion and noise at 10 Hz, 20 kHz and 50 kHz but in these instances the margin in hand with the testgear affects the results, all of which relate to ±20 dBV output (10 V rms).

Perhaps even more remarkable is the performance of the floating balanced output when driving a 600 ohm load with 5 V rms which is the maximum output into a matching load. This performance is shown in fig. 2.
which shows the expected distortion introduced by the balancing transformer, but a total harmonic distortion of less than 0.002% from 60 Hz to 7 kHz is an achievement which deserves applause.

Noise in the output was also respectable at -107 dB over the band 20 Hz to 20 kHz with mains hum being greater than -120 dB. Investigations into the square wave performance showed that there was no overshoot or tilt or ringing at the unbalanced output which had a rise and fall time of 55 ns irrespective of the oscillator frequency.

The 'maximum output' connector has a slower rise and fall time at 100 ns and it was while investigating this output that a fault was found to occur. At frequencies below 80 Hz there was a tendency for the edge of the square wave to become unstable for a period of around 60 µs as is shown in fig. 3. This fault was not apparent in a second sample of the oscillator which was a modified version submitted as a result of this and other faults which were found.

**Frequency response and calibration**
The flatness of the oscillator at maximum output was generally reasonable with a boost and 100 kHz was actually 92.4 kHz with a genuine 100 kHz being available off the end of the scale.

![FIG. 1 RADFORD LDO AT UNBALANCED OUTPUT](image-url)

![FIG. 2 RADFORD LDO TOTAL HARMONIC DISTORTION & NOISE](image-url)

![FIG. 3](image-url)

![FIG. 4 ATTENUATOR OUTPUT FREQUENCY RESPONSE - SEE TEXT](image-url)
RADFORD LOW DISTORTION OSCILLATOR

Attenuator and outputs

The attenuator accuracy for each 10 dB step at 1 kHz is shown in fig. 6 in terms of incremental accuracy and individual step accuracy. The step accuracy can be seen to be very good with errors only in the order of 0.04 dB, but this is unfortunately cumulative and added up to a 0.4 dB error from maximum to minimum setting. This is a shame because the accuracy of the meter at full-scale deflection at maximum output was really excellent and within the width of the narrow pointer and also as good as it could be at 30%, full-scale deflection.

It is possible to hold a long debate about the meter scaling: clearly we want the excellent output-I regard this as confusing as we all now know that people do not read instruction books!

The output impedance of the 600 ohm balanced output was found to be 606 ohms on the 0 dBV range and below, rising to 611 ohms on the +10 dBV range and to 644 ohms on the +20 dBV range. Operation of the variable attenuator did not have any effect upon these impedances, but it is felt that the manufacturer could make the change of output impedance clearer in his literature. As is to be anticipated, the use of half the balanced output as a 300 ohms floating output has similar output impedance characteristics.

While the attenuator output has constant impedance of either 300 ohms or 150 ohms nominal, the output is clearly identified '150 ohms source' when in fact it has a 300 ohms source impedance unless a link is inserted to joint the 'outer' connections of the floating output-1 regard this as confusing as we all know that people do not read instruction books!

The output balance was found to be better than Radford's specification, being 65 dB at 10 kHz, 84.5 dB at 1 kHz and 106 dB at 100 Hz as measured with 300 ohms between the centre tap and each outer of the output with the unbalance being measured across 600 ohms between the centre tape and earth.

The internal meter claims to be average reading calibrated in terms of rms, and I have no grumble about this so far as sinewaves are concerned, but with squarewaves the meter is intended to indicate the rms value but was found to indicate 1 part in 10^4.

A further peculiarity was that the meter appeared to suffer from leakage at high frequencies, in that on all output voltage ranges at 100 kHz with sinewaves the meter spuriously showed that there was a warm-up drift as is shown in fig. 7 which demonstrates an initial drift of six parts in 10^6 per hour which is rather sensitive to vibration, such that lightly tapping the instrument's case produced a 10% increase in the reading calibrated in terms of rms, and I have no grumble about this so far as sinewaves are concerned, but with squarewaves the meter is intended to indicate the rms value but was found to indicate 1 part in 10^4.

Other matters

Investigations into the frequency stability showed that there was a warm-up drift as is shown in fig. 7 which demonstrates an initial drift of six parts in 10^6 per hour which is roughy twice that shown in the manufacturer's literature. After warm-up, the drift pattern broke up with drift varying between two parts in 10^4 and 14 parts in 10^5 over five-minute periods.

These orders of stability make distortion measurements useless. A tuned notch filter rather tiring, as it is impossible to retain the optimum balance without continuous knob twiddling with these orders of frequency drift. Furthermore, the oscillator frequency was rather sensitive to vibration, such that lightly tapping the instrument's case produced an undesirable frequency shift.

Summary

In terms of distortion performance this is a most excellent oscillator at a reasonable price, but it is let down by a large number of shortcomings in other directions. Giving credit where credit is due, Radford quickly submitted a second modified version of the oscillator which had added screening in the area of the attenuator and meter amplifier. This sample did not suffer from attenuator leakage or meter leakage and the low frequency squarewave problem did not exist.

It is understood from Radford that these faults are peculiar to the balanced output version of the low distortion oscillator, and that all future production will be modified.
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ANNOUNCE THE HARMONIZER

PITCH CHANGER
The HARMONIZER employs digital circuitry and Random Access Memories to actually transpose input signals by up to a full octave up or down. Unlike the so-called "frequency shifter" which creates dissonances, the Harmonizer preserves all harmonic ratios and thus musical values. Any musical interval can be achieved by the continuously variable control, and an optional monophonic or polyphonic keyboard allows real-time "playing" of the Harmonizer, so that the musician can harmonize with himself.

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The HARMONIZER is a low-cost, very versatile digital delay line. The delay is variable in 7.5 ms steps up to 112.5 ms, a second output is optionally available that varies up to 62.5 ms.

ANTI-FEEDBACK
Feedback caused by energy build-up due to room resonance is decreased by shifting successive repetitions of the same signal away from the original frequency.

SPECIAL EFFECTS
It can be used to speed up and slow down tapes without affecting pitch. It can create some of the wildest effects on record.

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POWEND

PITCH CHANGER

DIGITAL DELAY

ANTI-FEEDBACK

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audio laboratory instruments
for the professional

LD03.B Low Distortion Oscillator,
balanced output
A LD03 but fitted with an output amplifier and screened balanced transformer providing a 600 ohm floating/balanced output, and 150 ohms unbalanced output.

DMS3 Distortion Measuring Set (illustrated)
Measures total harmonic distortion down to 0.001% speedily and accurately.

HSV1 High Sensitivity Voltmeter
As HSV1 but true r.m.s. reading.

ANM1 Audio Noisemeter
An active filter to CCIR weighting characteristic for use with external voltmeter.

ANM2 Audio Noisemeter
As ANM1 but true r.m.s. reading.

ANFI Audio Noisecfilter
An active filter to CCIR weighting characteristic for use with external voltmeter.

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ZD22 Stereo Pre-amplifier Control Unit
A stereo pre-amplifier of virtually zero distortion. Inputs for disc, tuner and two tape machines, providing comprehensive recording and reproducing facilities. Sensitivities: Disc 1mV, and Auxiliaries 50mV, for IV output. Exceptional signal/noise ratio. Output at eip level 18V r.m.s.

ZD100 Power Amplifier
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HD250 Stereo Integrated Amplifier
Uses ZD22 pre-amplifier with a power amplifier having a power output in excess of 50W per channel into 4 ohms. Distortion less than 0.02% at rated power, typically less than 0.01%. True complementary symmetry output. Headphone output. Inputs: Disc tuner, and two tape machines.

ZD11, ZD100, HD250 are available from stock.
Available soon: ZD50 (110 w.p.c./4 ohms, 70 w.p.c./8 ohms) and ZD200 (250 w.p.c./4 ohms, 150 w.p.c./8 ohms).

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The Radford Distortion Measuring Set is of course intended as a companion to the Low Distortion Oscillator, and as such has a similar form of mechanical and electrical construction. As with the oscillator, the printed boards and components are to the highest standards and the overall presentation is good.

An interesting point about the distortion measuring set is that it operates from two 9-volt PP9-type batteries drawing less than 7 mA from each battery. Such a low current means that the batteries should have an extremely long life, but when the time does come to change the batteries it is a fairly long-winded operation involving the removal of four slotted screws and seven Phillips screws!

The advantages of battery operation are the loss of mains hum problems, and more important, the fact that there are no longer any ground loop problems when measuring distortion of power amplifiers—that is provided that the oscilloscope monitor output is used with caution.

Battery condition is checked by depressing a front panel switch which activates the front panel meter if the instrument is switched on, thus battery condition is—as is only sensible—checked on load. The meter has a green sector for the battery check, and three scales 0-1, 0-3.2 and a decibel scale from 0 to -15 dB. These scales cannot, as would be useful, be used as voltage scales because there is no voltage calibration; therefore a separate voltmeter is essential for normal work. Input level is controlled by a 3-position range switch with nominal level capability from 50 mV to 50V in conjunction with a concentric potentiometer for setting the 100% level on the meter in association with a 'set fsd/read distortion' pushbutton.

Distortion in the form of total harmonic distortion is read from the meter by using the 9-position 'distortion range' switch which covers full-scale deflections from 100% distortion down to 0.01% distortion in 10 dB steps. Nulling of the fundamental is done by a twin T-network with feedback, the tuned frequency being selected in four ranges by a rotary switch and the fine frequency being tuned on a large diameter dial which covers one decade, the total instrument range being the four decades from 5 Hz to 50 kHz. The ultimate balancing of the network is done with three sets of dual concentric controls which have coarse, medium and fine action—the latter being none too fine when measuring very low total harmonic distortion.

The only remaining operator control is a pushbutton switch which inserts a 500 Hz high-pass filter for reducing the effects of hum and noise when measuring the total harmonic distortion of signals above around 1 kHz.

The input and also the distortion residual output are by means of single-ended BNC connectors at the front panel, which is black anodised with very clear legends. However, as the two lowest distortion ranges of 0.01% and 0.03% fsd do not operate with the input level switch on its most sensitive range of 0.05-0.5V, I would have liked to have seen this indicated on the front panel, as the likes of myself just pick up an instrument of this type and drive it without reading the instruction book.

**Performance**

Probably the most serious error in many distortion meters is due to the rejection notch being too broad and thus lowering the level of second and higher harmonics which we wish to measure. Fig. 1 shows the overall frequency response of the Radford instrument when it is tuned to reject 5 Hz. It should be noted that the second harmonic at 10 Hz and higher harmonic frequencies are within ±0.2 dB, which is a very good performance. At the high frequency end, the -1 dB point is at about 120 kHz and as will be seen this is a cause for complaint.

Reference to fig. 2 shows the curves for the notch filter at 10 Hz, 100 Hz, 1 kHz and 10 kHz, it being seen that at all but 10 kHz the attenuation of the harmonics is less than the specified 0.5 dB by a very good margin. However, at 10 kHz we have a curve which attenuates the second harmonic by 1.2 dB and the 3rd, 4th, 5th and 6th harmonics by 1 dB. While this performance is not bad by many standards it is not to specification, and similar results were obtained at 20 kHz and 40 kHz notch frequencies.

<table>
<thead>
<tr>
<th>FREQUENCY IN Hz</th>
<th>RESPONSE (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>-0.5</td>
</tr>
<tr>
<td>100</td>
<td>-0.2</td>
</tr>
<tr>
<td>1 kHz</td>
<td>-0.2</td>
</tr>
<tr>
<td>10 kHz</td>
<td>-1.2</td>
</tr>
</tbody>
</table>

![Fig. 1 Radford Distortion Set Overall Frequency Response Measuring Distortion at 5 Hz](image)
There are very few limits to what we can do with our Series 2 mixer. Usually we can modify it to suit almost any studio, and any customer's requirement.

We can make it bigger, build in patch bays, LED VU/PPM metering, sweepable equalisation, remote switching, or anything else you ask for.

And even without modifications, the Series 2 is a highly versatile mixer with impeccable specifications. (Each model is made individually and by hand to make sure that the specifications stay that way.)

The Series 2 comes in six standard versions: 12/4, 12/8, 16/4, 16/8, 24/4, 24/8.

In every model, each group output has dual track switching so, for example, an 8-output console can be hooked up to a 16 track recorder without any repatching. And there are direct line outputs from each input channel, either pre- or post-fade, so that you can use a recorder with as many tracks as the mixer has inputs.

Used together, these two features let you make multitrack recordings with simultaneous stereo reduction.

And what's more, all this versatility won't cost you the earth.
The performance of the 500 Hz high-pass filter is shown in fig. 3, which demonstrates that it acts at the correct frequency and its effect is minimal above 1 kHz.

The accuracy of the dial indication of tuned fundamental frequency was generally within ± 2% such that the dial can be used as a rough frequency meter. More important, the accuracy of the distortion range attenuator was within ± 0.08 dB cumulative error over its entire range with a worst case incremental error of 0.2 dB - a very satisfactory performance, as shown in fig. 4.

Efforts to measure the maximum fundamental rejection were hampered by the instability of the instrument when used on the most sensitive range of 0.01% total harmonic distortion full scale. However a 16 dB margin below 0.01% was achieved at all frequencies, this being equivalent to a residual of only 0.0015% total harmonic distortion with inputs above 0.5V. The actual indicated residual noise without any input was 0.0018% equivalent distortion without the high-pass filter in circuit or 0.0012% with the filter in circuit.

In practice when using the companion Radford Low Distortion Oscillator or my laboratory oscillator, the residual distortion was found to be less than 0.002% below 20 kHz and to be limited by the Radford oscillator at higher frequencies. Measuring such low levels was tiresome, particularly at high frequencies where the balance of the distortion meter was not only very critical, but drifted. Also, the instrument was microphonic such that even abrupt operation of the distortion range switch completely upset the balance. However this is not an unusual complaint with this type of instrument - you just have to be gentle and not thump the bench in frustration, or you start again!

On the input end, the required input level for use on the most sensitive distortion ranges was 0.517V at 1 kHz with the ability to handle 50V which is adequate for most power amplifier applications. On the most sensitive input ranges where the 0.01% and 0.03% distortion ranges are not available for use, the input sensitivity was found to be 50.6 mV which is close to specification.

The input impedance was adequately high at between 55k ohms and 65k ohms in parallel with less than 20 pF at any input sensitivity setting. The distortion output offered 1V rms for full-scale meter deflection from a source impedance of 2k ohms.

While some manufacturers use an average or peak programme meter the companion instrument is that it acts at the correct frequency and its effect is minimal above 1 kHz.

The PEAK DEVIATION METER for monitoring mono or stereo FM stations either off air or at the transmitter. This is a rack mounting unit, calibrated in kHz, percent and decibels, including a 75 kHz deviation standard and a high impedance probe head for use with a monitor receiver. A 20 dB increased sensitivity switch allows checking of pilot and signalling tone levels.

Observation here shows that many UK and continental AM stations overdeviate at some times and this explains some of the 'sibilant splashing' complaints familiar to Hi Fi retailers. Monitoring the true peak multiplex deviation with a very fast attack time meter gives much more insight into modulation levels and implies over-deviation than standard programme meters displaying the decoded and de-emphasised stereo signals. A chart recorder addition allows continuous records of modulation levels to be made and can show up jumps in level between different programmes.

The FORGE, LUCKS GREEN, CRANLEIGH, SURREY GU6 7BG STD 0486 5997

STUDIO SOUND, FEBRUARY 1977
The DBX 117 and 119 are units that can be added to any system to re-expand the dynamic range that has been lost during the recording process when used with disc, cassette, open reel and FM. They can also be used to compress signals for various purposes including recording constant level background music.

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The DBX II models 122 and 124 give improvements in noise reduction of up to 30 dB across the whole frequency range when used with tape or cassette (compared with 10 dB for Dolby B). They also enable a far wider dynamic range to be recorded. DBX encoded records are now also becoming available possessing a complete absence of surface noise when decoded with these units. Send for full literature

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Amber 4400 multipurpose audio test set
Hugh Ford

MANUFACTURER'S SPECIFICATION
Function Generator Section
Outputs: sine, triangle, square, pulse, asymmetrically clipped sine, asymmetrically clipped triangle.
Frequency range: 10 Hz to 150 kHz.
Output amplitude stability (20 Hz to 20 kHz): ±0.5 dB.
Sinewave distortion: 20 Hz to 20 kHz worst case 0.1%, typically less than 0.02% thd.
Triangle linearity: better than 1%.
Square and pulse rise/fall time: main output 2 µs, pulse output 100 ns.
Sweep Generator Section
Sweep: log sweep of sinewave 20 Hz to 20 kHz or 100 Hz to 100 kHz.
Sweep speed: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 seconds.
Amplitude stability (20 Hz to 20 kHz): ±0.25 dB.
Noise Generator Section
Characteristics: pseudo random noise.
Amplitude accuracy over spectrum: ±0.5 dB.
Comb Generator Section
Frequencies generated: 31.25, 62.5, 125, 250, 500, 1000, 4000Hz.
Frequency accuracy: better than ±0.01%.
Amplitude uniformity: better than ±0.2 dB.
Distortion of each frequency: less than 1% thd.
Output Characteristics
Source impedance: 50 ohm.
Load impedance: 600 ohm nominal, 50 ohm minimum.
Maximum levels: ±33 dBm, 600 ohm load.
Attenuator: 11 positions, 10 dB per step—70 to +30 dBm.
Level control: 20 dB range.
Configuration: single ended or balanced.
Gating: time or period mode; in time mode, range is approximately 16 ms to 16s. In period mode, range is 1 to 1024 periods. Switching may be zero crossing.

I BELIEVE the Amber 4400 multipurpose audio test set to be a unique instrument, as it contains within one medium sized cabinet the functions of at least six conventional instruments. To start with, there is a sinewave oscillator covering 10 Hz to 150 kHz; this oscillator can be swept between 20 Hz and 20 kHz or 100 Hz and 100 kHz with a logarithmic sweep which has 11 switch selected speeds between 1 and 1024 seconds.

In addition to the sinewave output, there are function generator outputs of squarewave or triangle. It also incorporates a variable mark/space ratio pulse output and the unusual facility of producing an asymmetrically clipped sine or triangle output—very useful for amplifier overload investigations and such.

Clearly some of these functions are unusual; Amber has, unlike so many oscillator manufacturers, thought about the output requirements for testing modern audio equipment and has provided a balanced/unbalanced output capable of driving up to +33 dBm—the common ±20 dBm or so is just not enough these days.

Furthermore, the output can be wound down to −80 dBm for use with high sensitivity inputs.

Unusual again—I'm going to keep on using that word—there is a facility for superimposing dc on the output at a variable level which will catch those nasty designs that have dc coupled inputs.

There's much more to come, such as the tone burst facility. This provides tone bursts of either a switched number of cycles between 1 and 1024, or of a switched duration between 16 ms and 16s. By means of a 2-position switch, the bursts may be arranged to start and stop at a zero crossing, or be random in amplitude at the start/stop.

If the above isn't enough, further mention must be made of the sinewave sweeping facilities. This is intended for use in conjunction with an external oscilloscope; the latter displays the serialised contents of a set of internal digital stores overcoming the short persistence of an oscilloscope tube at long sweep times (more about this later). Sweeping may be continuous at the selected speed between 1 and 1024s, or may be single shot at the set speed. It may sweep up or sweep down and can be manually incremented up or down.

An automatic variable speed function called 'base line sense' is included. This switched option increases the sweep speed when the signal being examined is below the cursor on the oscilloscope and reduces the sweep speed when the signal amplitude is of interest, thus saving much time when sharp filters are being examined.

So far I have not mentioned how the output level is monitored. The instrument contains a single decimal display which comprises 5½ digits of 7-segment display. This display can be switched to function either as a frequency display when it has a fixed range in integral cycles per second, or it can be switched to function as an autoranging voltmeter when it reads in dBm in 0.1 dBm steps between +30 dBm and −120 dBm and as a true rms reading instrument, and with 'fast' and 'slow' averaging times.

In the frequency mode the display can show oscillator frequency, input signal frequency or the tuned frequency of internal filters. In the dBm meter mode the display can read oscillator output, signal input and a number of other functions.

To revert to the remaining oscillator...
Stones' Rolling Studio

A complete recording studio in a van? For Mick Jagger, it is almost a necessity. Mick and the Stones can be inspired to produce their next hit anytime, but when they're on tour or on vacation, the best recording studios aren't always around the corner. The Stones rely on their Shure-equipped mobile studio for the unmatched recording perfection they insist upon, for these moments of midnight inspiration. Whether in a recording session or on stage, the Stones' SM7, SM58, SM82, SM53 and SM56 microphones are their assurance of consistent quality and natural sound.

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functions, in addition to those already mentioned, there is a fast rise/fall time output at fixed level for rise-time testing. In addition to the variable frequency sinewave function a 10-frequency comb generator provides crystal controlled frequencies on the standard ISO octave centre frequencies between 31.25 Hz and 16 kHz with the ability to use any combination of these frequencies; and finally there is a digitally derived pink noise output for the audio spectrum.

And now to the receiving section. I have already mentioned the ability to measure input voltage and frequency with the digital display, but a number of other functions are available via the high impedance balanced input. To start with, there are four pushbuttons which select the metering function which may be wideband (100 kHz), rolled off at 20 kHz or weighted in addition to the fast/slow averaging time. The ‘weighted’ function is controlled by an internally pluggable network which can be selected to perform the normal A, B or C weighting systems or other filter functions.

In addition to the selected functions there are variable frequency and variable Q filters which may be switched to bandpass, band reject, high-pass or low-pass with the ability to determine the tuned frequency from the frequency display. To assist with nulling, there is a simple analogue meter with an associated variable gain control, and also a filter output socket for feeding further instrumentation.

As an alternative to manual tuning, the bandpass and band reject filters may be automatically swept in frequency in the aforementioned 11 steps between 1 and 1024 kHz for sweeps, between either 20 Hz and 20 kHz or 100 Hz and 10 kHz. If any other functions are available. As if this wasn’t enough, the final swept facility is a phase plot which is referenced to a separate phase reference input.

All swept functions which, like the oscillator, may be manually or automatically swept continuously or incrementally up or down, depend upon an oscilloscope for the display. Many swept measurement instruments require the use of a display oscilloscope, however, the monitor oscilloscope is located with the chassis.

The main case is of fairly solid construction and is fitted with a carrying handle/tilting foot. The foot was unreliable, with the result that the instrument descended on to the bench with a resounding crash from time to time! At the rear of the instrument, there is a very neat IEC mains connector cum fuseholder (imperial size) and mains voltage selector. In addition there are two multi-pole connectors for use with ancillary test gear which is said to be under way from Amber.

Oscillator performance

Dealing first with the variable frequency sinewave function, the flatness of the manual variable or the swept modes is shown in fig. 1, from which it is apparent that the performance is considerably better than specification over the audio band, but that above 30 kHz there is an undesirable droop in the output to the extent of -3 dB at 100 kHz.

Sinewave distortion was likewise far better than specification with the actual harmonic products being at an extremely low level, but as is usual with function generator type sine-wave synthesizers, there being a fair amount of “rubbish” in the output which reflects in the measurement of total apparent harmonic distortion.

The accuracy of the indicated frequency was within ±1 display digit, ±1 Hz, which is the best accuracy that can be obtained with the adequate size of display in use.

The output attenuator accuracy was within ±0.2 dB up to 100 kHz and even better at 1 kHz; but some care is required when interpreting the actual output voltage. The arrangement is such that output level metering and output monitoring to the oscilloscope is located between attenuator sections, such that the true output is neither being metered (as is common with oscillators) or observed on the monitor oscilloscope. The result is that the effects of loading do not become apparent, and, even worse, the oscillator is capable of driving its output stage into clipping at -32.5 dBm (-33.5 dBm unloaded?). A further complication of the output metering is that the level calibration is nominally arranged to indicate the output level when loaded into 600 ohms, thus giving a 0.7 dB under reading when the nominal 50 ohm source impedance output is unloaded. Personally I would have preferred the metering to have been correct when unloaded, for just how often is one working into 600 ohms?

The pink noise output level was found to be -20 dBms relative to the sinewave output which gives somewhat less than adequate allowance for the worst factor of the noise, and the frequency spectrum in the audio range was adequately accurate as shown in fig. 2.

The remaining output waveforms had the same peak voltage as the sinewave output when the waveform was changed, with true rms metering. In the case of both the square and the triangle outputs, the symmetry was, perhaps, not as good as might be expected, this being tied to the measured 1:1.17 mark/space ratio of the square output. Squarewave rise and fall times at the main output depended slightly on frequency but remained about 3 µs with a low frequency tilt of 4% at 20 Hz which could do with improvement. At the separate ‘pulse’ output 4.2V peak-to-peak was available...
with a measured rise time of 300 ns and fall time of 500 ns, both are in excess of specification, but are anyhow quite fast enough for audio work.

Regarding the comb generator, the frequency of any selected frequency was within five parts in $10^5$ with amplitude variations between individual frequencies being less than $\pm 0.2 \text{ dB}$; total harmonic distortion consistently around the $1\%$ mark with the third harmonic predominant. Individual comb frequency outputs were set $10 \text{ dB}$ below the normal sine output, such that when all frequencies were selected, the output was virtually the same rms output as the sinewave output. However, someone forgot the matter of crest factors! Select more than six simultaneous frequencies and some-thing clips at any output level.

The remaining facility which can come under the hearing of the oscillator is the tone burst facility which can burst any selected waveform including pink noise. While the latter cannot be bursted for a selected number of cycles (which would be meaningless anyway) it can, like the other waveforms, be started and stopped at zero crossings if desired. No trouble was found with bursting the fixed numbers of cycles, but a logical error has crept in the burst time mode such that the time calibrations should be divided by two—this for some reason did not apply to sweep time which uses the same switch.

**Digital voltmeter frequency meter performance**

To take the simplest part first, the frequency meter was found to be accurate to within four parts in $10^5 \pm 1 \text{ digit}$, a creditable performance. The required input voltage for correct frequency indication was a worst case of $2.5 \text{ mV}$ at $200 \text{ kHz}$ falling to less than $1 \text{ mV}$ within the audio frequency band for a sinewave input.

The voltmeter section, which reads in dBm, works on a combination of autoranging over a $60 \text{ dB}$ range and manual ranging in three overlapping $30 \text{ dB}$ steps. The autoranging sections of the overall range were within $\pm 0.1 \text{ dB}$ at $1 \text{ kHz}$, but errors were about $0.3 \text{ dB}$ for the manual step $0$ to $-60 \text{ dBm}$ and $0.5 \text{ dB}$ for the $-30$ to $-90 \text{ dBm}$ range. Below $-90 \text{ dBm}$ the meter was too affected by noise to be useful in the wideband mode.

As is shown in fig. 3 the frequency response was flat up to $10 \text{ kHz}$ on all ranges and useful up to $20 \text{ kHz}$, above which the accuracy depended upon the range selected and became unreliable.

While the provisional instruction book gives an indication of the useful range of the voltmeter section, I suggest that the manufacturer should give clearer information in the publicity material.

In addition to the unweighted mode, two weighted frequency responses are available, a $20 \text{ kHz}$ low-pass weighting and one of the standard weighting networks which were not in fact fitted to the review instrument. The very useful response of the $20 \text{ kHz}$ low-pass filter is shown in fig. 4, which demonstrates a good characteristic for rejecting such things as tape recorder bias.

**Selective measurements**

Four filter functions are provided to cope with high-pass, low-pass, bandpass and band reject; the latter two functions being capable of being automatically swept in frequency. All four functions are tunable from $20 \text{ Hz}$ to $100 \text{ kHz}$ and are also affected by the variable Q control, the effect of this on a fixed frequency bandpass function being shown in fig. 5. It is to be seen that unfortunately the maximum Q setting reduces the overall gain by $9 \text{ dB}$, which is, to say the least, an irritating feature. However, at the maximum Q setting the second harmonic is attenuated by a good $30 \text{ dB}$ thus providing a quite useful wave analyser function, particularly in the swept frequency mode.

A similar situation exists in the band reject function and the effect of the Q control on the high-pass function is shown in fig. 6, the low-pass characteristic being a mirror image of this plot.

An unusual feature of the selective section is that the tuned frequency can be read from the frequency meter, and this in conjunction with the bandpass mode is a very useful facility.

**Storage and display**

All that is required in the way of a display is an oscilloscope with a sweep time of $2 \text{ ms}$ which can be externally triggered, and a vertical sensitivity which can display a $4.5 \text{ V}$ peak-to-peak signal: the output from the Amber simply being two connectors, one for the trigger and the other the signal.

In fact the only function of the Amber which cannot be used without a display is the phase measurement section, this providing plots of

---

**FIG. 3 AMBER 4400 METER**

Response error of voltmeter section for nominal readings of +10,-30 and -60 dB:

- For $+10 \text{ dB}$ error was $+6.4 \text{ dB}$ at $50 \text{ kHz}$ and $-12 \text{ dB}$ at $100 \text{ kHz}$
- For $-10 \text{ dB}$ error was $+6.4 \text{ dB}$ at $50 \text{ kHz}$
- For $-30 \text{ dB}$
- For $-60 \text{ dB}$

---

**FIG. 2 AMBER 4400 CONSTANT BANDWIDTH ANALYSIS OF PINK NOISE OUTPUT**

**FIG. 4 AMBER 4400 20kHz FILTER AT 0dBm**
power dissipation in the power output stage with resulting heat generation, increased output loads.

The total of four available stores means that reference information can be permanently stored (provided the power remains on) and direct comparisons made as a result of the capability of displaying any two stores simultaneously, there being a display offset facility for overlaying the two displays.

As is shown in fig. 7, the comb generator provides frequency markers as desired and one of the other beauties of the display is the ability to select full-scale deflection between 10 dB and 60 dB in 10 dB increments, over the input range -30 dBm to -120 dBm. However, it was found that the accuracy of measurement was rather poor on the more sensitive settings to the extent of 1.2 dB error over full scale.

Summary

The Amber multipurpose audio test set is a versatile piece of audio test gear that I have met, and at a very low price tag for the facilities included.

As a result of the complexity of the instrument, I have been unable to describe many features and applications in the space of this review, and I recommend readers to ask the manufacturer for more information if they are interested in this type of instrument.

With reference to this review we are pleased to have received from Amber the following comments which are generally in agreement with the technical findings of the review. There is however a divergence of opinion about some of the operational aspects and it is up to the reader to form his own opinion.

1. Capability of clipping in power amplifier output.
   The output amplifier clips at just over -13 dBm. This is the specified maximum output and can be read on the instrument's meter. An indication, other than the digital readout, was not felt necessary as very few tests will involve such high levels and good measurement practice will avoid output clipping.

2. dBm level meter requiring a 600 ohm termination on power amplifier output.
   In fact the meter can be very easily recalibrated to read correctly into bridging loads if these are more often encountered.

There are several ways this circuit could have been designed. The best would have provided a complex isolation and gain switched preamp across the actual output terminals and measure the actual output signal. This would have added what we felt was unnecessary cost. Another approach would have used a lower impedance output attenuator to minimise the effect of output loads. This would have caused large power dissipation in the power output stage with resulting heat generation, increased distortions etc. The approach we used, that of monitoring the input to the power amplifier and making the

1. Oscillator output 3 dB down at 100 kHz.
   In general the instrument is designed for 20 Hz to 20 kHz range and is provided to give an approximate 'look' at performance above 20 kHz.

2. dBm level meter requiring a 600 ohm termination on power amplifier output.

In fact, the meter can be very easily recalibrated to read correctly into bridging loads if these are more often encountered.

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3. Oscillator output 3 dB down at 100 kHz.

In general the instrument is designed for 20 Hz to 20 kHz range and is provided to give an approximate 'look' at performance above 20 kHz.

The design of a particular circuit always involves trading performance specifications, cost, features, etc. We felt, for example, that high output capability was more important than response beyond 50 kHz, so the power amplifier was optimised for power output over a 50 kHz bandwidth in place of a lower output capability over a larger bandwidth.

4. Front panel visibility and cosmetics.

The initial panels we received from our supplier had excessive attenuation of the led light transmission. These panels have since been improved and steps have been taken to provide better alignment of the led's with the front panel.

5. Carrying handle not sturdy.

We feel the locking knobs provided satisfactorily hold the handle and the instrument in a convenient operating position. Again, for added cost a locking mechanism similar to that supplied on oscilloscopes could be provided but the tooling costs for such a feature are formidable.

6. Gate on times one half front panel designations.

We have red faces over this one. A simple logic error which for some obscure reason went undetected until this time. Corrective action has been taken to modify all units, including those already delivered (change is a simple one).

7. Comb generator clips when more than six frequencies are selected simultaneously.

This was carefully checked on a number of production units and not found to be the case. I can only assume that the unit received had a defect—amplitude calibration controls set too high or incorrect and excessive gain in the summing amplifier.

8. Square wave duty cycle not exactly 50%.

Steps are being taken to correct this. The pulse wave can, of course, be set to exactly 50%.

9. Q control affects centre frequency gain.

This manual should have stated the Q control does not significantly affect passband gain. The intent was to exemplify the difference between two possible techniques for varying the Q. One has constant out of band gain with varying passband gain—the skirts remain fixed in the passband mode while the peak rises or lowers. The second method, the one employed in the 4400, maintains reasonably constant centre frequency gain but varies the out of band gain—the top of the peak is reasonably constant while the skirts move. This latter technique gives a better indication of the filter as Q is increased. Using the former method would necessitate reducing the input level as the Q is increased to avoid overdriving the filter or succeeding stages.
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The TRIDENT FLEXIMIX portable mixing system provides the comprehensive facilities which would normally be found only on an expensive studio console. This gives Fleximix the big desk 'feel' as soon as you operate it. Add this to the unique expandability of the system and you can see why it is in a class of its own. For a little over £2000 you can buy a 10 input—2 output configuration, which could subsequently be expanded to a system with 10 mixed outputs, any number of input channels and 24 track monitoring. Expansion is simply achieved by slotting-in additional channel modules. When available slots are used up another mainframe is added. Modules may be placed in any sequence. No factory rework or rewiring is necessary. Additional mainframes may be either rigidly or flexibly coupled to the original system and flight-cases are available to accommodate any arrangement.

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Contact: Adam Howell.

West Coast:
Studio Maintenance Service,
2444 Wilshire Blvd., Suite 211, Santa Monica,
Ca. 90403.
Tel: (213) 990 5855.
Contact: David Michaels.
Brüel and Kjaer Psophometer

Hugh Ford

MANUFACTURER'S SPECIFICATION

Input: connector; in accordance with DIN 41 628. Construction: symmetrical in accordance with CCITT Recommendation P53. Impedance: 600 ohm ±2% or greater than 10k ohm (both symmetrical). Amplifiers: voltage range: 100 µV to 30V fsd in 10 dB steps. dB range: -80 dB to +30 dB fsd relative to 775 mV. Output: 3.16V rms corresponding to fsd (BNC). Overload Impedance: less than 5 ohms short-circuit protected. Gain range: +90 dB to -20 dB. Attenuator: 12 pushbutton combinations, with overload indication of illogical settings. Earphone output: 3.16V rms corresponding to fsd, 600 ohms.

Overload margins: pre-filter overload indicated by flashing led. Pre-filter: at least 30 dB. Pre-telephone filter: at least 30 dB. +20 dB per decade below 1500 Hz (approx 60 dB at 50 Hz). Post-filter: at least 20 dB in accordance with CCIR 468-I.

Weighting networks: 1) Unweighted in accordance with DIN 45 405. 2) Telephone in accordance with CCITT P53 and DIN 45 405. 3) Radio 1 in accordance with CCITT P53 and DIN 45 405. 4) Radio 2 in accordance with CCIR 468-I. All filters are solid state active circuits.

Noise: equivalent input noise utilising the rms detector. 1) Unweighted less than 8 µV. 2) Telephone 500 Hz (approx 20 dB). 3) Radio 1 less than 10 µV. 4) Radio 2 less than 14 µV.

Detectors: Q-rms: detector; in accordance with CCITT P53. Q-peak: detector; in accordance with DIN 45 405 and CCIR 468-I. DC output: 3.16V dc corresponding to fsd (BNC). Impedance: 47 ohm short circuit protected. Linearity: linearity of both detectors re fsd, 0 dB to -10 dB ±0.2 dB, +10 dB to -20 dB ±0.5 dB.

Power supply: 100 to 250V ac line 50 Hz to 400 Hz or two 18V to 25V batteries.

Temperature range: 5 to 40°C. Weight: 3.4 kg approx.

Dimensions (hwd): 132.6 x 139.5 x 200 mm. Price (at August 1976): £2100.

Manufacturer: Brüel & Kjaer, DK-2850 Naerum, Denmark.

UK: B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middx.

US: B & K Instruments Inc, 5111 West 164th Street, Cleveland, Ohio 44142.

WHAT on earth is a PSOPHOMETER? You may well ask. Well, it doesn't appear in my dictionary but is pronounced something like pissometer and it's used to measure noise... in communications systems.

Actually, the Bruel & Kjaer 2429 psophometer is a multi-range voltmeter equipped with noise weighting networks and rectifier characteristics fulfilling the requirements for noise measurement to the latest standards in audio equipment in the broadest context. Until fairly recently there have been very few instruments which have been capable of measuring noise to the CCIR weighting characteristic which has been shown to give a far better correlation with the subjective effects of noise than earlier weighting curves. Furthermore, meters which comply with the DIN quasi-peak rectifier characteristic and the DIN standard for ballistic performance have, I believe, been restricted to one manufacturer who has sold the instruments under more than one trade name.

In the interests of international standardisation, Bruel & Kjaer have taken this horrible muddle to task and produced an instrument which is up to date in conception and provides both the necessary weighting curves and the standard rectifier characteristics, but at a price which, in terms of the £ sterling, is astronomical. However, having recently visited Denmark, I have learnt that if you divide the cost of things by two to allow for the Danish cost of living, the prices become realistic. Since there is no alternative instrument yet available, you have to pay the cost if you need to make these measurements of noise.

While there are alternative instruments available with the CCIR 468-I weighting curve, none of these have the quasi-peak reading meter which is demanded by CCIR 468-I and which is identical to the DIN requirement as per DIN 45 405.

The Psophometer also offers a floating input which may either be a fairly high impedance or be terminated into 600 ohms. A rear panel facility for listening to the weighted noise on headphones is included.

The form of construction is the now familiar B & K Cassette modular system with a clearly scaled and illuminated front panel meter complete with anti-parallax mirror. Meter scaling comprises a dB scale ref 0.775V from +2 dB to -20 dB and two voltage scales covering 0 to 10 and 0 to 3. These scales operate in conjunction with two pushbutton attenuators, one is a 60 dB step providing volts or millivolts scaling; the second consists of six interlocked pushbuttons which provide 10 dB steps thus providing full-scale sensitivities between 100 µV and 30V (-80 dB to +30 dB ref 0.775V).

The desired frequency response weighting is selected by four further interlocked pushbuttons which allow an unweighted function or any of three weightings which are 1) Telephone weighting to CCITT P53, 2) radio 1 weighting to DIN 45 405 and CCITT P53, and 3) radio 2 weighting to the recent CCIR proposal 468-I. From the audio equipment user's point of view, the latter is the most valuable curve. For the cost of this instrument, it is unfortunate that the common 'A' weighting has not been included. Furthermore, as will be seen the unweighted condition does not follow the recommendations of CCIR 468-I for unweighted measurements, but complies with the requirements of DIN 45 405 unweighted standards which, so far as I am aware, are little used.

I have discussed the problems of other weighting networks and alternative 'unweighted' frequency responses with Bruel & Kjaer, and I am informed that the instrument will be available with a number of alternatives which will be achieved by changing the internal printed circuit boards to alternative types.

Overload of the pre-weighted or post-weighted signal electronics is indicated by a red led on the front panel. This unusual feature is a valuable asset since it is easy to obtain false noise measurements in most meters which run into peak clipping; these may not give significant meter deflections if high crest factors are involved.

Input to the meter is via three sockets which accept standard 4 mm banana plugs or a special three-pin plug to DIN 41 628 which is probably almost unknown outside Germany! One input pin is signal ground within the electronics, while the remaining two pins are the floating input selectable to 600 ohms or high impedance by means of a front panel slide.
The complete system consists of the MAIN CONSOLE, the KEYBOARD CONTROLLER, and five optional blocks for a total of 47 modules.

**MAIN CONSOLE:**
The MAIN CONSOLE contains all the basic modules necessary in a professional system for the synthesizing of sound and can be used alone with the KEYBOARD CONTROLLER as a complete synthesizer in itself. Modules included are: VCO (3), VCF (2), VCA (2), LFO (2), S/H, ADSR (2 x 1), OUTPUT MODULE (which includes PANNING controls, REVERBERATION, and a PHASE SHIFTER), and others.

**KEYBOARD CONTROLLER:**
The 61 key (5 octave) two voice KEYBOARD CONTROLLER has PORTAMENTO and PITCH BEND controls.

**OPTIONS:**
Optional blocks can be chosen and arranged according to the particular needs of each studio. All of the modules in the optional blocks are interchangeable, thus the numbers and types of modules can also be changed to suit the studio. The main modules of the optional blocks are: BLOCK 3 <SEQUENCER> 3 channel, 12 step sequencer; BLOCK 4 <VCO bank> VCO (6), ADSR (2 x 1); BLOCK 5 <VCF/VCA bank> VCF (2), VCA (3), ADSR (2 x 2); BLOCK 6 <Interface/Mixer> frequency-to-voltage converter interface, 9 channel audio mixer, fixed filter bank, VCA; BLOCK 7 <Phase Shifter/Audio Delay> 2 channel phase shifter, 2 channel audio delay.

**MAIN FEATURES:**
All modules are made from high quality parts to ensure high reliability and durability with circuit designs which give high stability for ease in recording perfect sounds.

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switch. The final front panel facilities consist of a pair of slide switches, one of which selects the rectifier characteristic to be quasi-peak of quasi-rms and the other of which injects a fixed level 1 kHz tone for meter calibration.

At the rear of the instrument there is the IEC mains connector and a voltage selector/fuse holder which are properly identified and provide for all the common mains voltages. There are next two banana sockets/terminals which may be linked to connect the signal ground to the chassis or may be used otherwise to avoid ground loops. While these are on standard 19 mm spacing, two similar connectors for headphone monitoring are annoyingly on non-standard spacing. Two BNC sockets provide an ac output at 3.16V rms corresponding to full-scale meter deflection and 3.16V dc on a linear scale. Finally there is a 7-pin DIN socket which duplicates these two outputs and also provides for dc powering of the instrument from ±18 to ±25V sources in addition to allowing variation of the meter instrument from ±18 to +25V sources and also provides for dc powering of the DIN socket which duplicates these two outputs on a linear scale.

There are next two banana sockets/terminals for headphone monitoring which may be linked to connect the signal to the chassis or may be used otherwise to avoid ground loops. There are six attenuators for the use of such domestic quality connectors on this class of equipment is absurd.

The internal construction of the instrument is another story with the best quality printed boards, six of which plug into a mother board by means of gold plated pin-type connectors. Only good quality commercial components are used and, as is to be anticipated, the standards within the instrument are first class.

Performance

The frequency response from the input to the ac output (which is identical to the meter indication) is shown in fig. 1 in the unweighted condition. It shows that the high frequency response has been rolled off very rapidly with the -3 dB point at 24.5 kHz and that the low frequency end has been cut. This response meets the DIN unweighted standard which is different from the more important CCIR 468 document.

Close examination of the CCIR and the DIN weighting networks—the broad characteristics of which are shown in fig. 2—showed that the instrument followed precisely the DIN curve with negligible discrepancies. In the case of the CCIR curve the mid to low frequency performance was also precise but in the early review sample a known error existed in the very rapid high frequency roll off. In the unweighted mode the overall response was not particularly flat and in my opinion rather disappointing with the following tolerances with respect to 1 kHz which are within the DIN unweighted tolerances: 30 Hz -0.4 dB, 37 Hz -0.2 dB, 1 kHz 0 dB, 10.3 kHz +0.2 dB, 16.8 kHz +0.4 dB, 20.7 kHz 0 dB.

It was pleasing to note that the frequency response was not affected by the attenuators and that, while the 60 dB attenuator was very accurate, it was again unfortunate that one step in the 10 dB selector introduced an error in excess of 0.2 dB which is excessive for this class of instrument. The attenuator errors in terms of step error and cumulative error are shown in fig. 3, illustrating this criticism. This defect will, I am assured, be corrected in later production.

In contrast the scaling error and readability combined as shown in fig. 4 was minimal and the scale calibrations were well chosen for maximum resolution. The absolute accuracy of the instrument is checked by means of a 1 kHz internal reference oscillator arranged such that half scale should be indicated with respect to 1 kHz which are within the DIN unweighted tolerances: 30 Hz -0.4 dB, 37 Hz -0.2 dB, 1 kHz 0 dB, 10.3 kHz +0.2 dB, 16.8 kHz +0.4 dB, 20.7 kHz 0 dB.

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In 1967 Amcron (Crown International) introduced the world's first 'Super-Amp'. This was the DC300! It rapidly became a must for all the major recording studios and top bands such as Zeppelin, Jethro Tull and the Moody Blues.

The DC300 set new standards of sound reproduction never previously available for bands or studios, let alone the Audiophile (whoever he is). Coupled with the incredibly rugged construction, and small size of this 600 watts amplifier, it is not surprising that the DC300 became a legend in its time.

The designer of this classic is still in charge of the design work at AMCRON despite rumours that he has moved on to at least five other establishments! Indeed, he has since been responsible for the DC300A, the D150A and all the rest of the AMCRON range of superb power amplifiers.

Now in 1977, the DC300A is 'the' amplifier in all the world's recording studios and is still the only choice for bands such as Zeppelin, Jethro Tull and the Moody Blues, plus quite a few others such as Wings, the Stones, the Rollers, Elton John, 10cc, Pink Floyd, Barclay James Harvest, The Real Thing and so on . . .

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Precise checking of the overload points in the instrument were difficult without delving into the circuit, but a fairly general check showed that the input end had at least 40 dB margin for normal conditions and the post filter section in excess of 20 dB—no cause for complaint here.

Similarly the inherent noise was found to be well below the specifications, but care had to be exercised with the ac output from the points of view of headroom and of noise; the same applies to the headphone output which appeared to be in parallel. Firstly, the nominal rms output of 3.16V corresponding to full-scale deflection was accurate, but the margin above this level at the onset of output clipping was 10 dB which meant that the output could clip below full-scale deflection and without indicated overload conditions. Secondly, the minimum dynamic range did not correspond to maximum instrument gain as would normally be anticipated but occurred at relatively high input signal levels. The result was that both the ac output and the headphone output had minimum dynamic range under unexpected attenuator settings which meant that the 20 Hz to 20 kHz noise was only 50 dB below 3.16V rms corresponding to full-scale deflection. In some circumstances, these matters could create a limitation.

Output impedance at the ac output was extremely low and that at the headphone output was 560 ohms, which provided an adequate impedance and level for many types of headphone without interaction with the ac output. Furthermore neither output interacted with the meter indications.

The dc output which also gave 3.16V for full-scale deflection (with a ceiling of 14V) was proportional to meter deflection and was found to be accurate to better than 0.1 dB down to -20 dB meter indication and to have a satisfactory output impedance of 44.7 ohms.

Checking the quasi-peak meter characteristics showed that the effective ballistics complied precisely with the nominal centreline of the CCIR and the DIN standards and the meter calibration was such that switching between quasi-peak and rms detection did not alter the meter deflections, as is correct.

So far as the rms rectifier is concerned, this is a true rms rectifier but the effective meter ballistics are not to the commonly used "fast" international standard. The effective ballistics are in fact designed to meet the requirements of CCITT P53 to the test method suggested by the UK Post Office. This has resulted in an instrument which overshoots by 0.8 dB when a continuous level is suddenly applied, the 0 to -20 dB fall and rise times being 360 ms and 190 ms respectively.

Summary

The B & K 2429 psophometer is an instrument which fills a long-standing gap in noise measurement; however, it will also make a very large gap in your bank balance. So far as its concept is concerned, the instrument is rather restricted to fill this specialised gap in the CCIR noise weighting and quasi-peak standard meter field, in addition to the CCITT telephone weighting problem.

Unfortunately, with the exception of 'home made' instruments there is a distinct lack of suitable instrumentation to meet these established standards. If you tot-up the real costs of 'home made' instruments, the 2429 could be a reasonable investment and it must be remembered that Bruel & Kjaer represent an international standard as a result of the worldwide use of their measuring equipment.

Bearing in mind that the review sample was one of the first production batch of 'demonstration' instruments, one may be able to forgive the shortcomings found in this sample, but in my experience of Bruel & Kjaer, while the detailed matters may be a sample defect, the overall concept of this instrument is restricted to a limited range of specialised measurements and it will take time to change them.
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Note: Advertisement copy must be clearly printed in block capitals or typewritten.

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musicians:
Beach Boys, Elvis Presley, Supertramp, Pink Floyd, Elton John, Chicago, YES.

sound hire:
Clair Brothers U.S.A. Britannia Row U.K. Audio Analysts CANADA

MIDAS
54-56 Stanhope Street, London NW1 3EX. Tel: 01-388-7060
Louis De Polesta, ARC, S.P.R.L Rue Th. Decuyper, 134, 1200 Brussels, Belgium. Tel: 7-71-30-63
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No matter how remote the location, traditional Ward-Beck studio quality is now available from stock in the highly portable M1002 console. The M1002 earned an enviable reputation as the great performer in the 1976 Summer and Winter Olympics. 55 units were employed by ABC and CBC for network coverage of these historic events. The versatile M1203 offers increased input and output capability. A combination of comprehensive monitoring facilities with an integral front panel jack field make it ideal for mobile or studio installations where space is at a premium. Available from stock, the M1002 and M1203 come in a variety of configurations designed to fit even the most modest budget.