April 1975 25p

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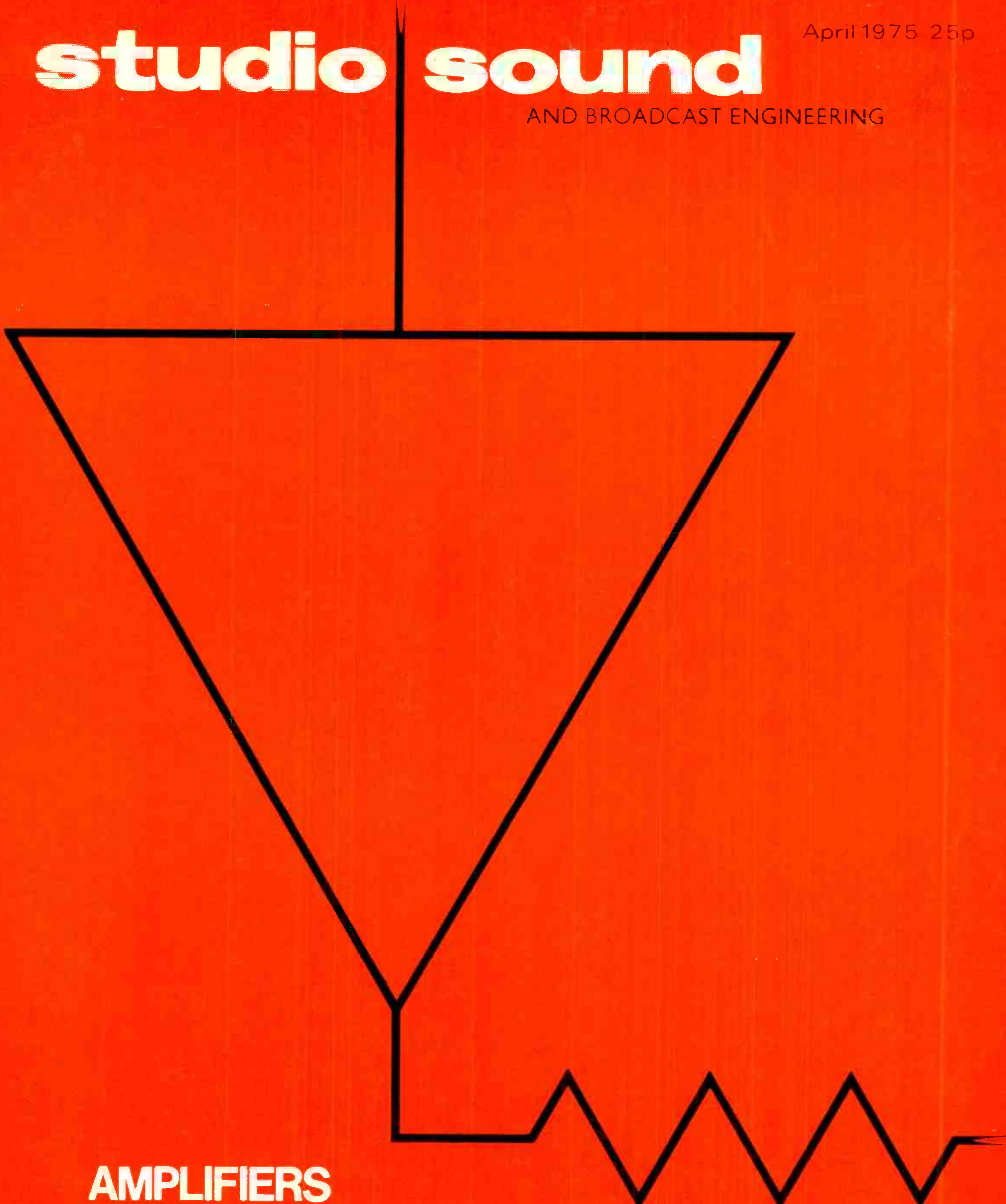
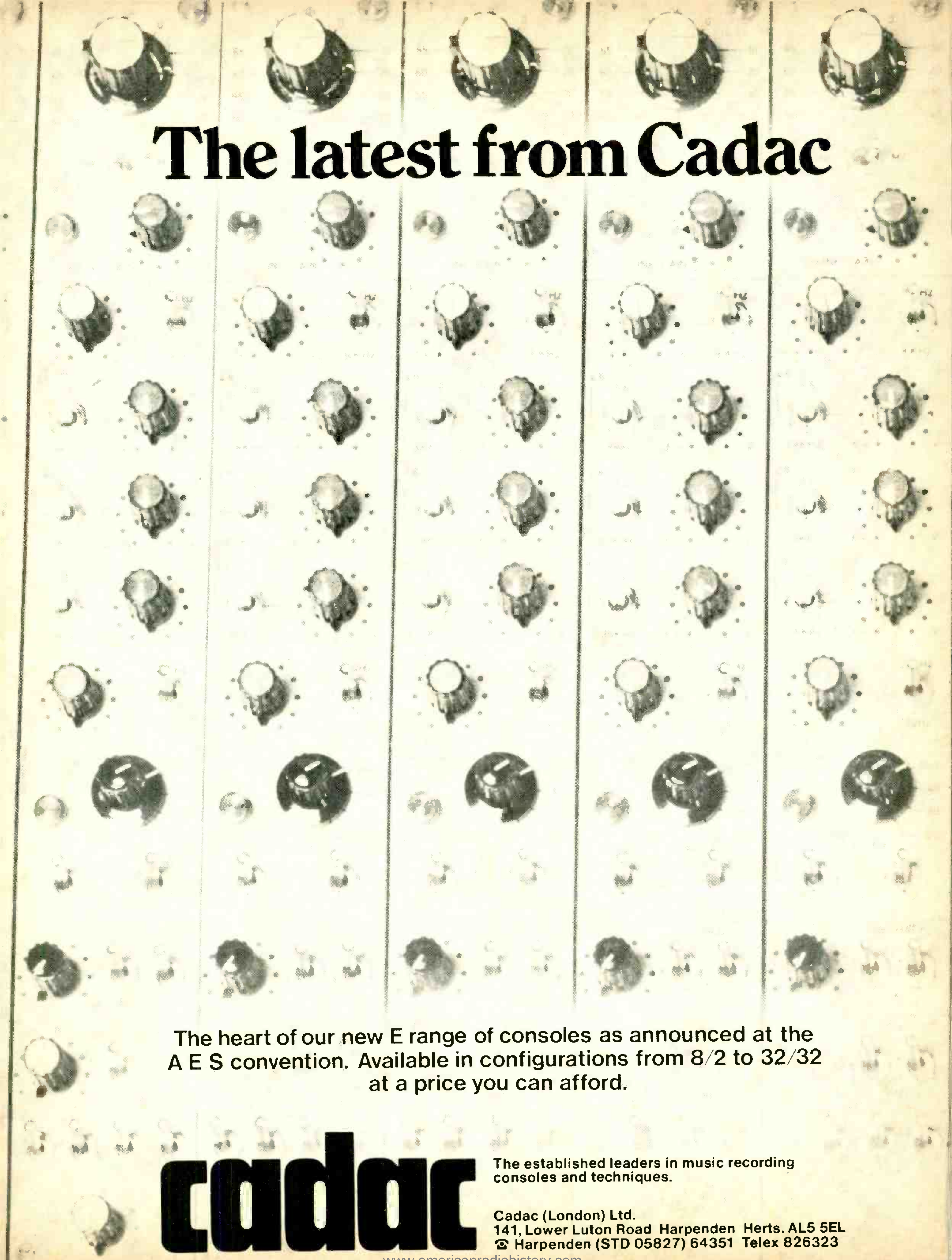


AMPLIFIERS THEORY, PRACTICE AND REVIEWS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APRIL 1975 VOLUME 17 NUMBER 4

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Perhaps the golden age is over after all. When Command was launched four years ago in a blaze of publicity and considerable financial commitment in a claimed up-to-the-latest studio, it was the child of a new, vigorous expansion in the industry. That attitude is still there, although the present overall tendency is towards consolidation rather than such relatively wild optimism. That the entertainment business flourishes comfortably in adverse economic circumstances is a truism that bears repetition; the failure of Command had nothing to do with climate.

Command is now stone dead. It wasn't merely a product of its time, for other large complexes opened around then are still thriving in varying degrees of comfort. Throughout its life, the whole London studio grapevine knew that something was wrong, and 'Command stories' kept a big fund of gossip well supplied. Other agonies continue to come from elsewhere, but with nothing like the frequency that Command used to inspire.

It is a ghoulish and rather sordid exercise to peel apart the layers of a concern that is dead and gone. But the complex interreactions of circumstance and personality, as far as was known informally or John Dwyer was able to find out, often strike a sympathetic note. Command may be gone, but its mistakes had the same beginnings as can be seen in some places now. It simply had the misfortune to acquire more than most.

The boundary between muck-raking and cautionary tale is very slight. There is no reason to turn over stones if the things found are of no future use to others. However amusing it might be to propagate miserable stories of the studio, that cannot be the function of an article. This effort to piece together the difficult story of financial precariousness, technical doubt and basic personal incompatibility is given in the hope that it might avoid some other mishap. There are no easy conclusions, even looking from the outside and with hindsight. But the studio had the unfortunate distinction of embodying many problems that exist, in embryonic form, elsewhere, with a concentration that is unusual by anybody's standards.

CORRESPONDENCE AND ARTICLES
All STUDIO SOUND correspondence should be sent to the address printed on this page. Technical queries should be concise and must include a stamped addressed envelope. Matters relating to more than one department should occupy separate sheets of paper or delay will occur in replying.

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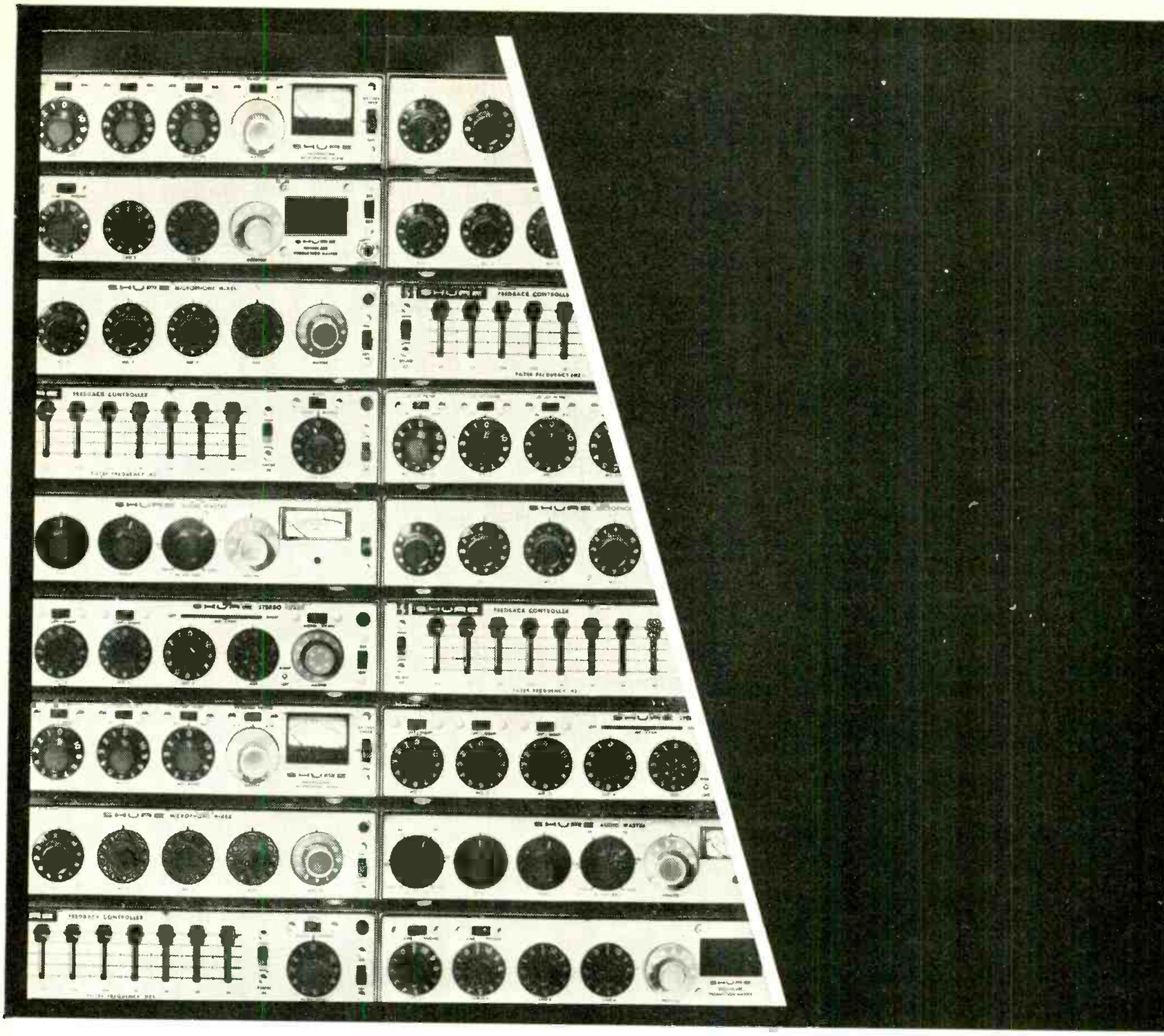

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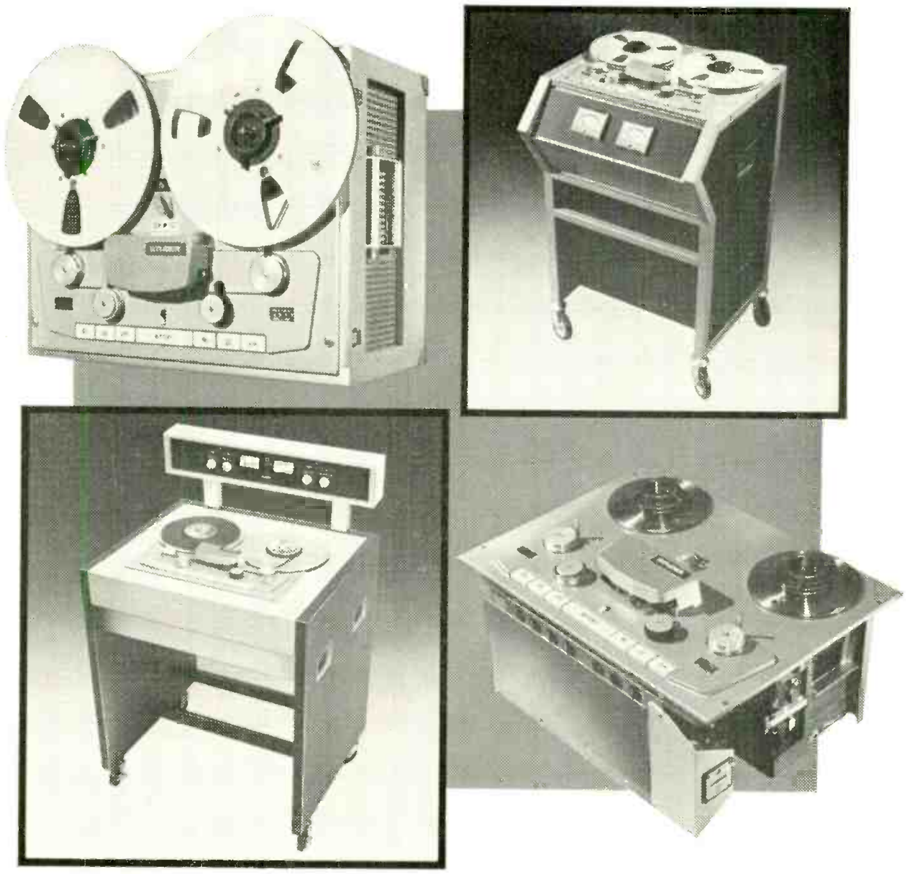

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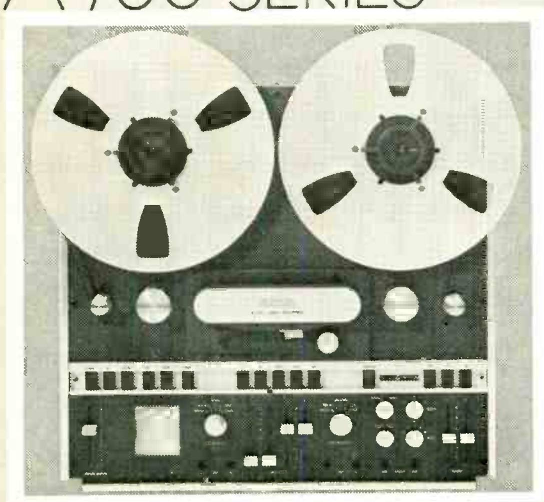

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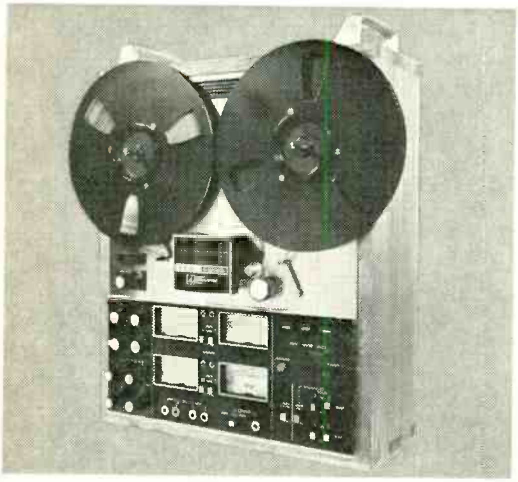

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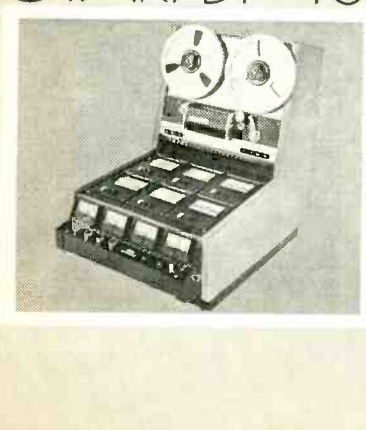

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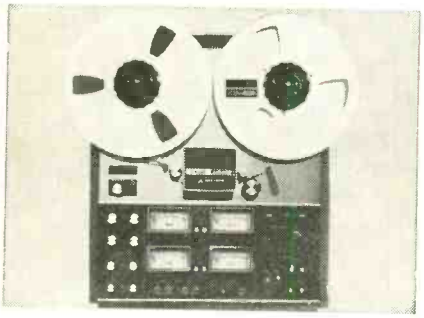

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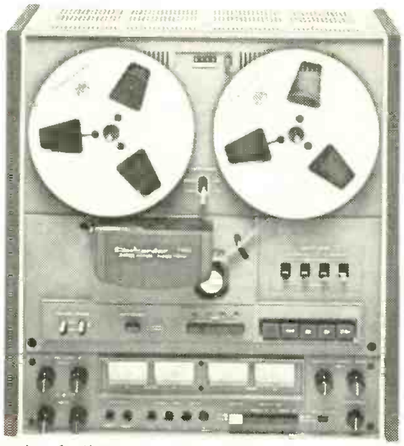

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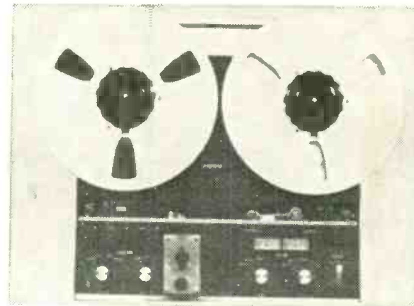

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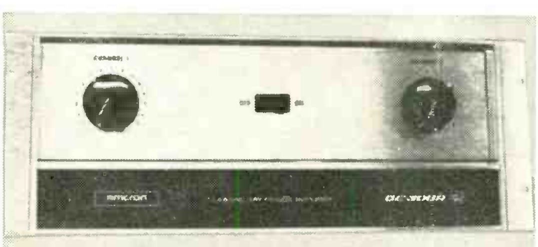

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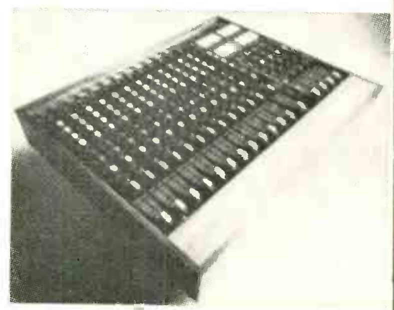

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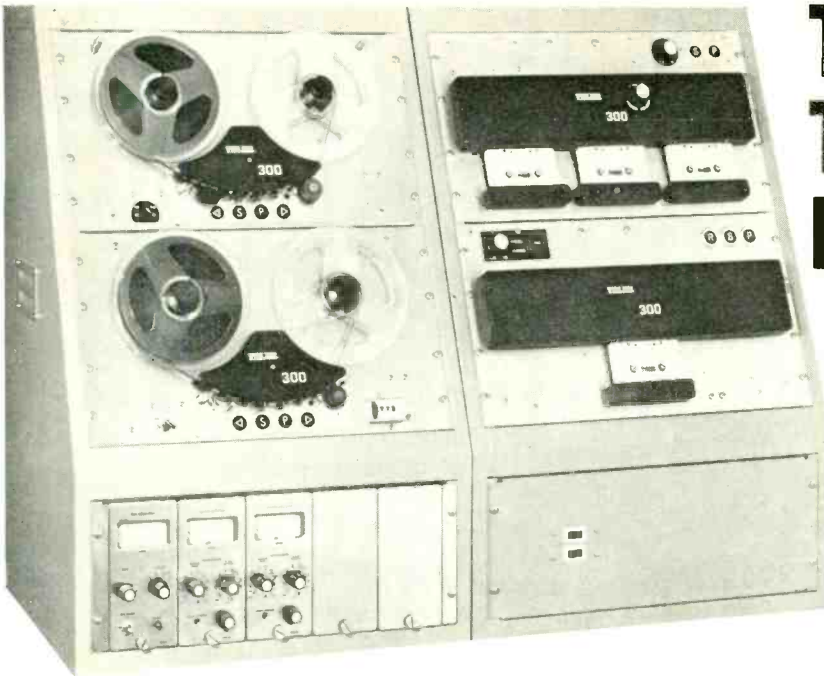

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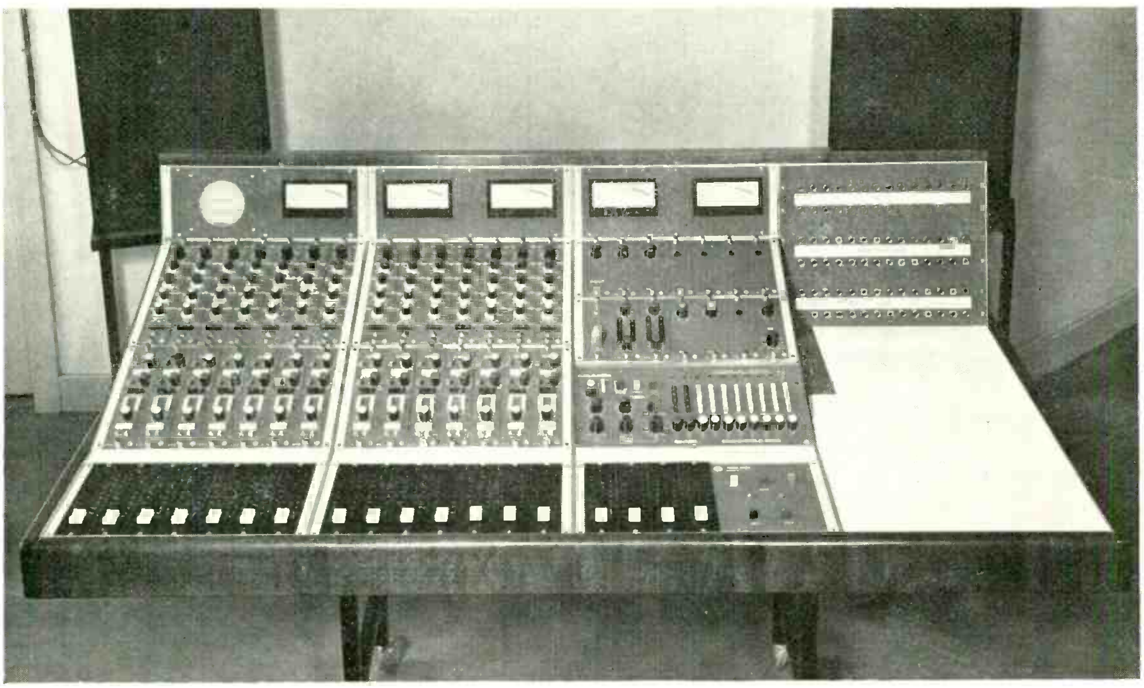

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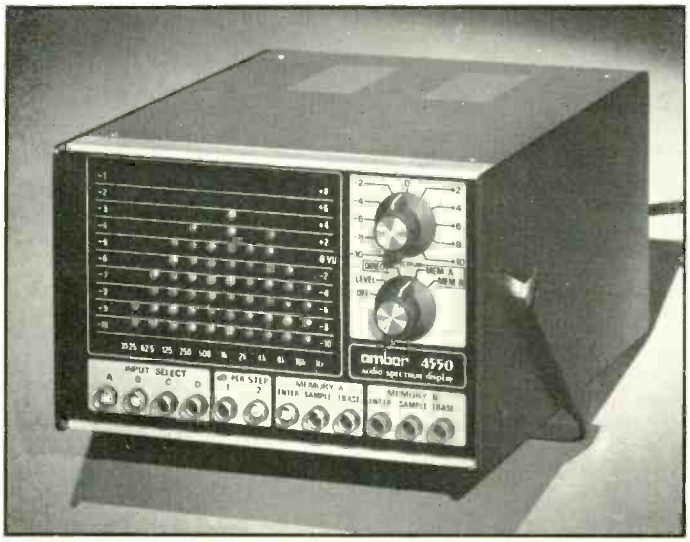
STUDIO SOUND hopes to review the analyser shortly.



Amber 4550 low cost Audio Spectrum Display

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WITH A LITTLE bit of help from a cassette loading machine manufactured by Duplison of Milan, up to 1400 cassettes can be loaded in an eight hour shift by one operator. This is one of the claims made by the UK agents Electronic Brokers Ltd for the £1495 machine.

The loader, designated type *211*, operates by spooling the prerecorded tape from a left hand pancake to the take-up spindle of an assembled cassette which has the leaders poking out the front. The leader and tape are spliced together by an integral semi-automatic splicer. The winding tension is controlled by a servo system in a manner similar to open reel recorders; subsonic signals, prerecorded on the tape, provide an automatic stop on cessation of programme material. Another splice, similar to the first, is made with the remaining leader after which the cassette is rewound using the high speed winding bay provided.

For blank cassettes, the machine uses a tape timer wheel, analogous to those on pro open reel machines, to control the length of tape wound on producing a signal when the correct length of tape has elapsed. During the splicing operations, the tape is held in place by a channel with holes in the bottom connecting to a vacuum pump. Using 12.5 mm splicing tape, the cutters are self sharpening. Electronic Brokers Ltd, 49/53 Pancras Road, London NW1. Phone: 01-837 7781.

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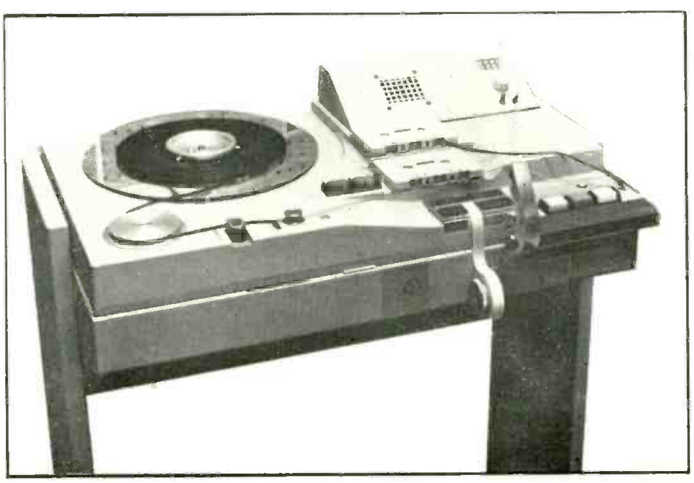
Cassette loader 211—Duplison



Midem '75

AS THE MAN with the beaky nose and the fat cigar observed, 'There aren't any comments about the show. You come here and you talk to people and you do some business. Sometimes business is good, sometimes it's bad. But the show? It just *is*.' And so was the annual music biz establishment parade, with the rows of stalls and the January sunshine on the old folks on the promenade and the stargazing kids hustling on the steps outside ('C'est Clodagh?').

And, predictably, business was good, and the real weather paid no attention to the economic climate. There were the usual figures about increases in floor area, trading activity, etc, which followed the typical inflationary spiral. But, apart from the knowledge that the companies who pay the wages are in good shape, there were other things of interest to recording studios.

The number of hardware companies exhibiting at Midem has shown a steady increase, one by one, until this year when there was a clear equipment sector. For example, Feldon, who have been there consistently for several years had an extensive area of thin regulation carpet and reported contracts for complete outfitting of some Turkish studios, largely with MCI gear.

However, in contrast with the Feldon stand, which had the same outward appearance of everyone else's, those of 3M (France) and Studer had operational 50 mm tape transports as well as other associated paraphernalia. They find fairly apparent the shift in new studio construction away from the traditional one backed by a consortium with £200 000 or so to spend, in the direction of bands and other well-lined artists who want a place of their own to settle into and work without the constant threat of overtime. Yes, one or two were being sold to conventional studios, but the emphasis was changing steadily.

Another possibility which may have crossed people's minds is that they are more readily paid by customers who have the money in the bank already, rather than those operating on conventional contemporary financial lines. Certainly, their stands were constantly overrun with execs, producers and others who were interested in rather more than the basic exhibition.

From another angle, the *CD-4* disc system put on a bold sales front, nominally by JME Associates in conjunction with JVC and National. John Eargle pointed out the reason for the use of the best *CD-4* demodulation equipment available: the visitors did not need to know what was available commercially but rather what was possible and therefore could be expected to appear in domestic form. Among equipment used was the new 'professional' demodulator, the *CD4-1000* and *JBL 4341* loudspeakers. The latter were certainly honest, for the brightness showed up any roughness and the level was not low. Obviously, the sound was rough in comparison with a 12.5 mm tape, but it began to be comparable with that from a conventional stereo playback. In particular, crosstalk was reasonably smooth, and what was there was high frequencies only. A cut from a new phase-locked loop encoder was played successfully; for reference purposes a Sheffield direct-cut stereo disc was available. This roadshow was due to appear at AES London in March.

Other familiar names showed a change of accent. Virgin Records, looking discreetly alternative, simply concentrated on the licensing side. Last year, they had come complete with the Manor mobile which they placed outside, but the resulting responses were not encouraging and so it was left behind next time round.

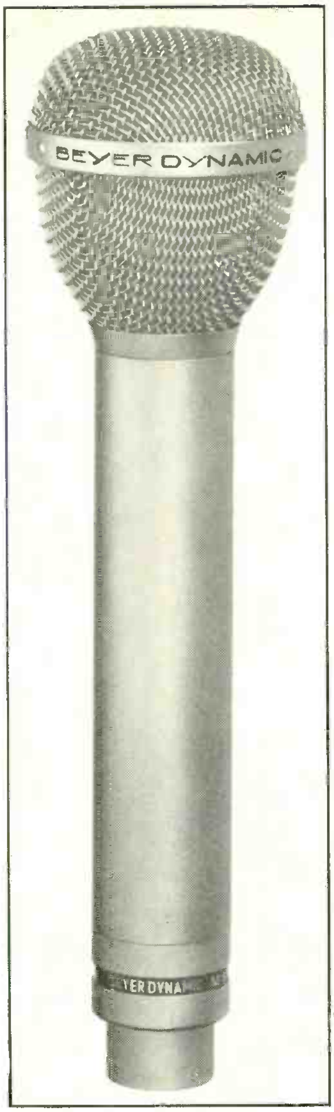
And so it petered out on Friday afternoon. Apart from eating and/or peering at the Mediterranean, the only remaining attraction seemed to be a lady dressed in feathers and things being thoughtfully interviewed by a smart young man outside the centre. Something to do with radio, said the monsieur.

Beyer mic

IT'S BEEN AROUND for a bit of time but perhaps deserves closer attention. The Beyer *M88* series dynamic mics claim to offer a high standard of performance, an effective hypercardioid polar pattern and resistance to handling noise. The external appearance has been modified for use in front of cameras; the model now carries a matt finish. Beyer's spec includes a 30 Hz-20 kHz±2.5 dB response, a 120° side lobe attenuation of 23 dB and an EIA sensitivity rating of -144 dB/m. A hum buck coil is fitted. The cased *M88N* (Cannon) costs £78.88 from Beyer Dynamic (GB) Ltd, 1 Clair Road, Haywards Heath, Sussex RH16 3DP. Phone: 0444-51003.

Hi-Fi 75

DESCRIBED AS A 'dramatic expansion' over last year's show (it goes on for six days as opposed to five) High Fidelity 75 venue is the Skyline Hotel, Heathrow from April 8 to 13. The first three days, trade and press only, are from 09.00 to 19.00, the next two (public) 10.00 to 20.00 and the final day (public) 11.00 to 18.00.



Beyer M88N

Small mixer

A SMALL TRANSPORTABLE mixer from Studio 99 Video is intended to provide on site facilities for up to eight sound inputs. Designated the *R8MP*, the unit offers two output groups selected on a channel basis by A-B toggle switches. A single or twin needle ppm indicates the output level. Foldback output (which may be used as an echo send) is controlled by a front panel rotary pot. The mixer, vertical control panel rack mounting, connects with the outside world by Cannon *XLRs*. Studio 99 Video Ltd, 73/81 Fairfax Rd, London NW6. Phone: 01-328 3282.

Cadac mini consoles

PRELIMINARY DETAILS of a new range of small mixing consoles have been announced by Cadac. Aimed particularly at small studios, individual musicians and composers, the desks offer many of the facilities associated with the larger relations from which the range has been derived. The range will be known as the 'E type consoles' of which further details will be published at a later date. Cadac (London) Ltd, 141 Lower Luton Road, Harpenden, Herts AL5 5EL. Phone: 05827-64351.

B&K level meter

THE HANDOUT calls it 'inexpensive' at £154. Perhaps it is something to do with the ailing exchange rate against the kröner. However, the *2213* meter is claimed to meet international specifications IEC R 123 and ANSI S1.4-1971 2 and features simplicity of operation to enable use by unskilled people.

B & K 2213 meter

Operating in up to 90% relative humidity, the portable meter with integral 12.5 mm omni mic offers a dynamic range from 45 to 130 dB (A) measured in eight 10 dB steps. The meter is calibrated -5 to +10 dB relative to the selected range. The instrument has a built-in calibration generator capacitance coupled directly to the diaphragm. B&K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex. Phone: 01-570 7774.

Racal-Zonal salesman

RACAL-ZONAL ANNOUNCE the promotion of the erstwhile UK sales manager to European status. The man, Jim Robson, hopes for £1 000 000 of trade with east and west Europe this year. Racal-Zonal Ltd, Holmethorpe Avenue, Holmethorpe Estate, Redhill, Surrey RH1 2NX.

California split feed

ROBERT ALTMAN's 'Celebration of gambling', *California Split*, will interest audio engineers, even if poker, craps and roulette leave them cold. The film, launched in this country at the Curzon Cinema, Mayfair, uses sound techniques which, although not novel, are new to films of this type.

Multitrack tape recorders pulse-synchronised to film cameras are frequently used to film pop music events. The multi-track tape is mixed down, after the film has been edited, into however many tracks are available on the final release format. Now Altman, in conjunction with Lion's Gate 8-track Sound Services, has recorded all the location sequences for *California Split* by spot-miking the gamblers with as many as 11 mikes at a time and using 8-track equipment. Such a technique leaves the mix-down options on individual voices open until after the editing stage. The result is one of the cleanest, most intelligible dialogue tracks ever, a welcome change from the unintelligible jumble of spoken words which is often foisted on audiences under the label 'realistic'. However realistic such recordings may be, they do nothing whatsoever to help an audience understand any plot the film may have.

The Curzon Cinema uses standard Cinemeccanica projectors with solid state amplification. It is not Dolbyised and the *California Split* sound track is not issued in Dolby encoded form. The marked absence of noise but bright sounding track suggests that either some other noise reduction process has been used in the production of the film as most conventional optical tracks and sound systems consistently produce low-par results.

AES lectures

ALL THE MEETINGS are on Tuesdays at The Institution of Electrical Engineers, Savoy Place, London WC2 starting at 19.15. Tea available from 18.45.

April 15. Speech Perception and Synthesis by D. B. Fry.

May 13. Measurement of Loudspeaker Dynamic Performance by Roger Driscoll.

June 10. What's Happening in Quadraphony? by Keith Barker.

Radio Forth

THE TENTH INDEPENDENT local radio station started broadcasting to a

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potential audience of 930 000 living on the east coast of Scotland. This figure represents the vhf service area; the medium wave transmissions on 194m could reach even more. The share allocations in the new station are held by a wide cross section of local interests in keeping with the IBA charter.

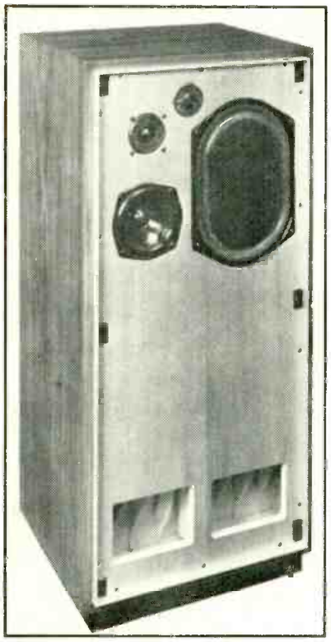
Portable stereo mixer

BASED ON AN eight input main frame expandable in four input blocks, the stereo output mixer from the Canadian firm of Richmond Sound Design Ltd claims to offer full pro facilities and specification. The channel spec includes five position trim, pre eq foldback level, three centre eq, echo send, pan pot, sealed fader and pfl. All connectors are *XLR*. On the output side, there is illuminated vu and headphone monitoring and line amplifiers.

The eight input version measures about 60 x 38 x 10 cm and costs $1600 (Cdn). This represents about £675 in the UK at current exchange rates. Richmond Sound Design Ltd, PO Box 65507, Vancouver, BC, Canada. Phone: (604) 736 7207.

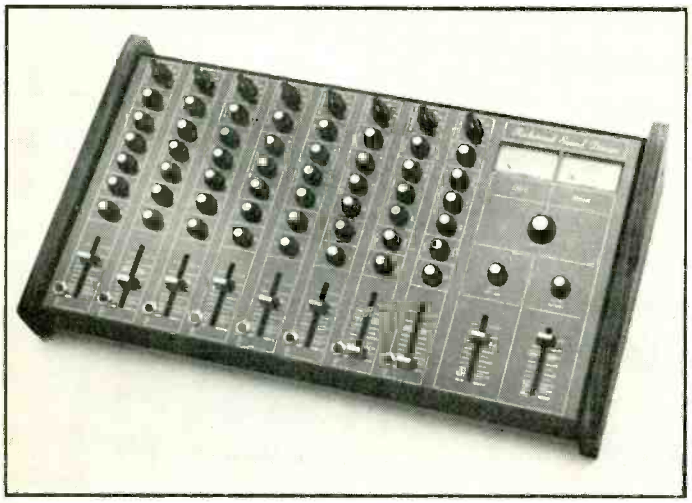
IMF loudspeakers

IMF ELECTRONICS LTD has recently introduced a new model into their range. Designated the *TLS 80*, it fills the space between the *TLS 50* and the 'professional' transmission line units. From the graphs and traces supplied in the publicity handout, the new speakers appear to offer a flat frequency response from 40 Hz to 20 kHz ±2 dB and impressive results in tone burst tests. The polar diagram looks good over a 120° angle. IMF states that the drive power requirements are between 40 to 80 watts. IMF Ltd, Westbourne St, High Wycombe, Bucks. Phone: High Wycombe (0494) 35166.



Left: *IMF TLS80*

Below: *Richmond Sound Design's portable stereo mixer*



Wait for it—'peak performance from Pye transmitters' (ours) or 'Pye transmitters take to the air' (theirs). Either way, the photo depicts 10 kW tv transmitters being installed up on a Swiss mountain above Lugano in the winter.

Bedlam

THE NATIONAL ASSOCIATION of Hospital Broadcasting Organisations will hold their agm at Whittington Hospital, London from April 12 to 13. 'Delegates from some 112 services around the country will be attending the conference style meeting to discuss such problems as the recent increased landline charges.' Interested? Phone Steve Coote 0705 64488 ext 57.

The magazine has been asked for help in an appeal for gear 'surplus to requirements'; this includes old mixer units or, indeed, any equipment that individuals or organisations feel inclined to donate to this worthy cause. Stan Langer on 061-205 2214 would very much like to hear from them.

Papst agency

PERHAPS BETTER KNOWN as suppliers of electronic components, Celdis has obtained the sole UK franchise for Papst motors. These motors find their way into many of the tape transports used in recording studios. Celdis claim to hold the basic range of units in stock; details available from the company at 37/39 Loverock Road, Reading, Berks RG3 1ED. Phone: Reading 582211.

H/H Electronic

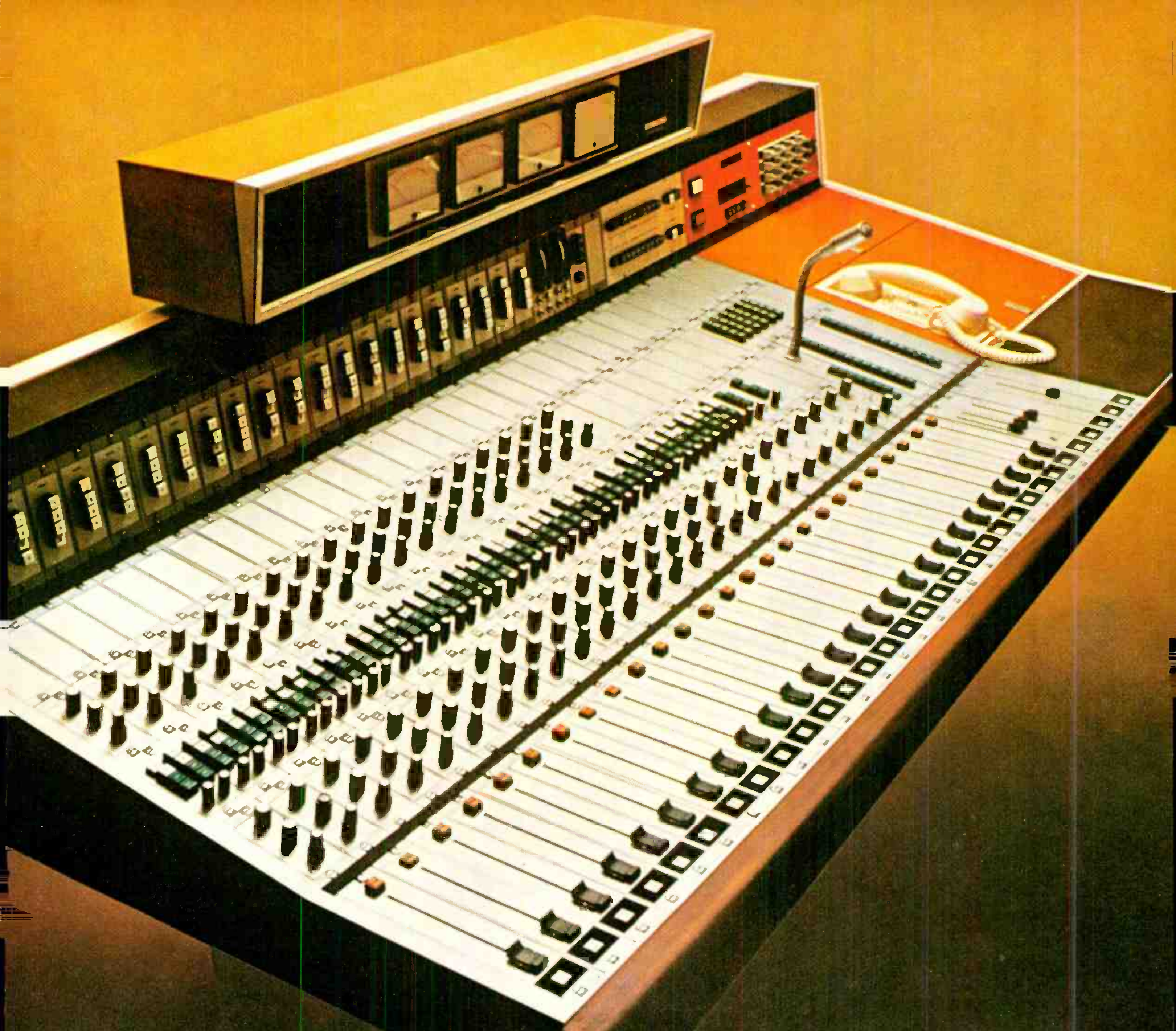
MALCOLM GREEN, founder partner of the company, has sold out to pursue activities described by H/H as 'other interests'—believed to be a career in journalism in partnership with the erstwhile ad manager of *Beat Instrumental*, Rick Desmond.

In spite of the supremo's departure, H/H report business as usual.

Fidelipac move

FIDELIPAC, A DIVISION of TelePro Industries Inc, have moved shop to another address with rather more room for expansion: 109 Gaither Drive, Mt Laurel, New Jersey 08057. The new phone no. is (609) 235 3511.

Fidelipac claim to be the largest manufacturer of broadcast tape cartridges in the world. They also manufacture ancillary hardware for erasing, storing and cleaning these devices.



The modular mixer

Take a good look at this mixer. Under that eye-catching console is a system that reflects the technical expertise gained from years of experience in the studio sound business.

Here, at last, is a mixer tailor-made to your requirements, but costing no more than a standard production model.

It's the Schlumberger UPS 4000, giving you real state-of-the-art technology at your fingertips. Fully modular, with plug-in units made of die-cast aluminium alloy to ensure highest accuracies, it's the system that has everything – integrated circuits, field-effect transistors, printed circuit cabling.

And modularity means you get the facilities you need now . . . with the flexibility you could need later.

Just specify your system requirements, and leave the rest to us. We custom-build the mixer *you* want. At a price you can afford. With filters, reverberation, foldback and much, much more.

Find our about this new concept in studio mixers. Contact Schlumberger, now.

Schlumberger

Schlumberger Instruments and Systems, 296, Avenue Napoleon Bonaparte,

About a decade ago, the thermionic valve operated audio amplifier, which had reigned unchallenged and unchallengeable in this field for nearly half a century, began to be replaced in practical usage by various arrangements based on 'solid-state' components, originally based on semiconductor action in germanium, and later, as technical improvements were evolved, using silicon as the base material. Since even now there is a body of opinion, as much represented in the recording studio field as elsewhere, that the earlier valve amplifiers were better, it seems prudent in looking at the present to cast a backward glance at the earlier technology to see how this compared in actuality, and what were its relative strengths and weaknesses in relation to the best that can be done at present.

The straight wire with gain?

JOHN LINSLEY HOOD*

IT IS SAID that sailing ships reached their highest state of efficiency and technical development at the time at which they were replaced by steam. By analogy, the same could be said of the valve audio amplifier, in that by the late 1950s the normal circuit design for a high quality instrument had reached the form shown typically in **fig. 1**, using output beam-tetrodes in class-A push-pull, in the split-load or 'ultra-linear' connection, which gave a higher output power for a given output valve plate dissipation, at a virtually identical harmonic content, than the earlier (Williamson) triode connected configuration.

With a single pair of output valves, operated from a 450V ht line, typical performance figures for this type of circuit would be:

Output power: 25-30W.
Small signal frequency response: 3 Hz-200 kHz.
Phase linearity (small signal): ±45° from 3 Hz-150 kHz.
Signal/noise ratio: Referred to maximum output. Band-width 20 Hz-20 kHz —80 dB.
Harmonic distortion: 0.1% maximum rated output, at 1 kHz decreasing as output power is reduced.
Im distortion: 70 Hz/5 kHz 4:1, max output —3 dB. Less than 0.25%.

However, as is often the case no matter how full the specification, it is always the things which are not specified which one needs to know, and which can make the difference between excellence and mediocrity. In the case of the valve amplifier, the unspecified things included a relatively favourable harmonic content of the distortion components—mainly third, with little content of harmonics higher than the fifth, especially at higher frequencies, and a graceful overload characteristic, in which the onset of clipping was gradual and allowed short-term power outputs of 20-30% beyond the nominal rating without dramatic worsening of the harmonic content. In addition, higher powers could be obtained when needed without substantial revision of the circuit design by incorporating additional output valves in parallel, with the only limitation being imposed by the physical size of the output transformer and the power demand from the dc power supply. Moreover, this type of design was very nearly short-circuit proof, had a good intrinsic overload protection characteristic, was relatively unaffected by load reactance, and the harmonic distortion, such as it was, was of an audibly acceptable kind.

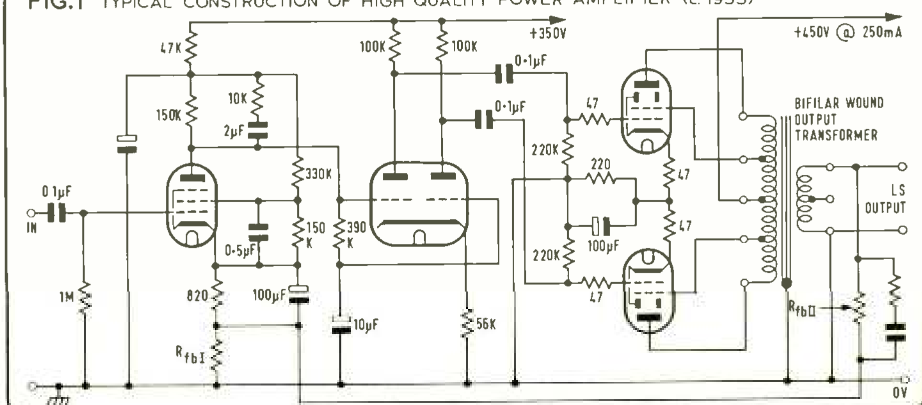
What then were the snags?

The output transformer was a large and costly item, and the quality of this almost completely dictated the performance which could be obtained from the amplifier. This, therefore, entailed careful construction, to provide good matching between primary halves, a large incremental inductance and a very low order of leakage reactance. The heat generated was considerable, and the total harmonic distortion, mainly generated within the transformer, worsened fairly rapidly with increasing frequency due to the limitations of the feedback network, particularly at higher output powers, and the step-function performance—the sort of thing which is assessed nowadays in amplifier reviews with a 10 kHz square-wave and a reactive load (simulated notionally by a 2 μF capacitor in parallel with some specified resistive load)—was very poor by presently-accepted standards. Also, if anyone should then have been interested in the phenomenon, the transient intermodulation distortion, as defined by Otala,[1] was poor. Finally, if the amplifier were operated, even at moderate output levels, into an open-circuit load, either the output valves or the output transformer might flash-over because of the very high primary voltages which could be generated, even though, in principle, this should not happen.

Nevertheless, within the limitations imposed by its power-to-weight ratio, cost and heat output, the valve power amplifier did, and does, a good job.

By comparison, the early transformerless transistor - operated 'quasi - complementary' power amplifiers, derived from the ingenious original design proposed by Lin,[2] and shown in **figs. 2a** and **2b**, were relatively low quality systems, of which the fundamental shortcomings were only slowly realised, and even more tardily remedied. Of these shortcomings, the most important was the necessary adoption of class-B or class-AB, working in the interests of limiting the thermal dissipation of the power devices. The implication, not realised at the time, was that the harmonic distortion at full power was not necessarily or even probably the same as the distortion at lesser powers; also that the distortion level at 1 kHz

FIG.1 TYPICAL CONSTRUCTION OF HIGH QUALITY POWER AMPLIFIER (c. 1955)



*Research and Development Division, British Cellophane Ltd.

was unlikely to be the same as that at 10 kHz, or that the performance with a resistive load, on the bench, was unrepresentative of that which might be expected from a more reactive load when the equipment was in use.

Since the bulk of the 'medium-fi' audio amplifiers imported into this country from the Orient have adhered to the Lin design with few, if any, refinements, it is hardly surprising that the sound quality associated with many domestic installations is unattractive. If this is the yardstick by which transistor-operated design is judged, then there can be little dispute that valves 'sounded better'. However, in informed technical appraisal it is important to compare like with like, and it is probable that only in the last six or seven years have designs emerged which could compete with valves on an equal footing, and these have only emerged in commercial hardware within the last two or three years, and again mainly in the higher price bracket, having inevitably a lesser distribution.

It is fair to say, however, that one form of transistor-operated amplifier (that employing transformer drive with transformerless output, of the style adopted in the UK by Rogers and Radford) was capable, given good transformer design, of a very satisfactory performance even with early transistor types. This was subject only to the inevitable limitations imposed by the transformer and the cost and quality considerations it implied. This style of design has not attracted a large following in the design field because of the inherent difficulty of getting reproducibly good performance from low cost transformers, and because of the greater technical challenge offered by the solution of the problems of the transformerless systems.

The faults of this early style of design and its immediate successors, which are now fairly widely realised, stemmed from the unsatisfactory matching of the push-pull halves in the output stage, the presence of 'crossover' distortion (which is an inevitable feature, to some extent, in class-B or class-AB operation) and the use of excessive amounts of negative feedback (limited only by the steady state resistive load stability considerations) to try to alleviate the intrinsic non-linearity of the system.

Improved transistor-operated power amplifier designs

Although the steady state harmonic distortion characteristics of amplifier systems can be improved by the use of negative feedback, limitations in the use of this are imposed by the need to maintain close-loop stability, even if the requirement of good transient performance is not considered and the fact that the utility of this diminishes as the open-loop phase shift enters the second quadrant, as shown experimentally by the author.[3] This is because the classical formulae omit the possibility that the application of negative feedback may reduce the magnitude of the fundamental to a greater extent than that of the unwanted harmonic. To a large extent, therefore, the performance of a feedback amplifier, when feedback has been applied, is determined by the characteristics of the design without the benefit of this. Thus, such things which can be done to improve open-loop performance will show benefits in the final result obtained after feedback has been incorporated. In the case of transistor amplifiers, the open-loop characteristics are largely determined by the form of the output stage, and residually influenced by the performance of the preceding low power voltage amplifier stage.

The most obvious requirement for improvement in the open-loop linearity of the quasi-complementary transistor amplifier was the removal of the asymmetry of the output devices, which, in turn, required the production of fully complementary power transistors. When these became available, fully symmetrical designs employing these, of the type shown in **fig. 4**, were evolved by Locanthi[4] and Bailey.[5] The major advantage of this type of output transistor configuration is that it allows a much closer match in the transfer, at the crossover point, of the two output halves than is obtainable by other simple systems. However, it has snags. These are that the proper operation of the output stage demands a correctly-chosen forward bias (like any other class-B push-pull system), but this depends on the temperature-dependent characteristics of the output transistor base-emitter junctions. It will be found,

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FIG 2a BASIC STRUCTURE OF TRANSFORMERLESS AMPLIFIER SYSTEM PROPOSED BY H.C. LIN. (1956)

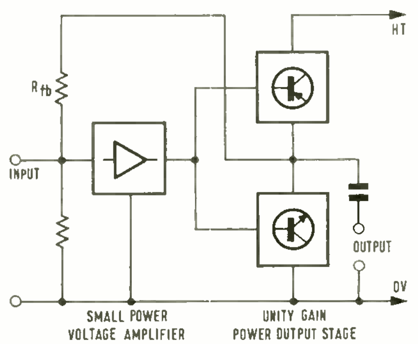


FIG. 2b CIRCUIT OF AMPLIFIER USING 'QUASI-COMPLEMENTARY' OUTPUT STAGE.

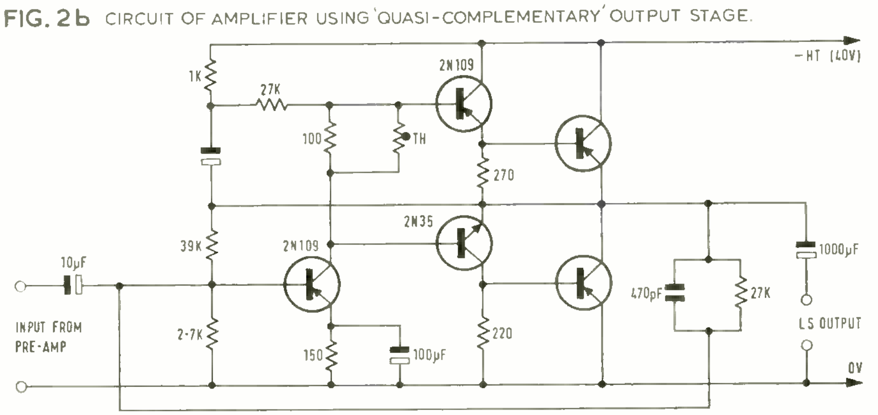


FIG. 3 ORIGIN OF DISTORTION, DUE TO DISSIMILARITY OF OPPOSED HALVES, OF 'QUASI-COMPLEMENTARY' OUTPUT STAGE.

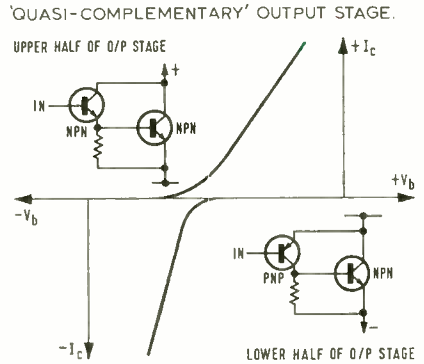
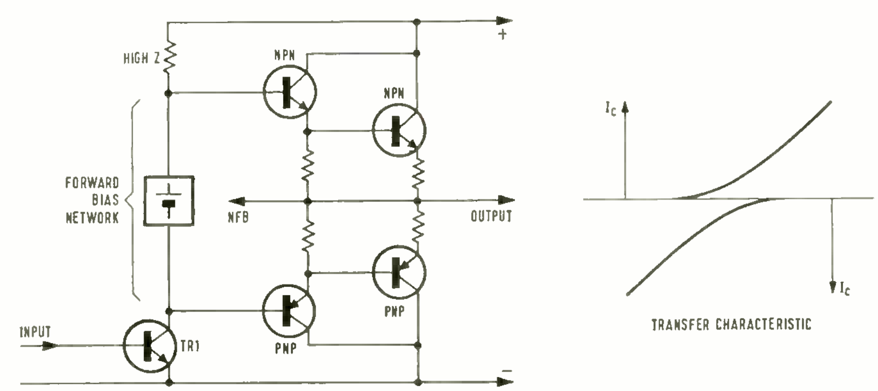


FIG. 4 FULLY SYMMETRICAL TRANSISTOR OUTPUT STAGE



therefore, that if the quiescent current is set at some optimum value for minimum harmonic distortion, with the output transistors at normal idling temperature, and the amplifier is then driven hard for a minute or two, the quiescent current will alter to some less favourable value. If some temperature-sensitive device is mounted on the output heat-sink to compensate for this effect, the result will be complicated by the temperature lag between output transistor base-emitter junction and sensing device. An additional but minor disadvantage of this configuration is that the available output swing delivered to the load is lessened by the presence of two forward biased base-emitter junctions in each output stage half. Additional imperfections are that the output stages, even when employing apparently mirror-image types of device, are not truly symmetrical at high powers and at operating frequencies approaching F /10, as shown by the author,[6] and that even when a notionally good match has been obtained at lower powers and frequencies the crossover transfer is still discontinuous[7] (Blomley).

Designs using an alternative output configuration, of the type shown in **fig. 5**, which minimises the first two of these problems, have been described by Teeling,[8] Ruehs,[9] the author,[10] and Hardcastle and Lane.[11] Until the advent of monolithic complementary (pnp and npn) power Darlington output transistors at economical prices (which have tended to encourage the use of output stages of the form shown in fig. 4 but with a substantially worse thermal stability than that obtainable using separate driver transistors) this latter form would represent the majority of the better power amplifiers having output powers of 30-75W into eight or four ohm loads designed in the USA. Numerous examples of this system can be found in the application notes of the semiconductor manufacturers.

In all of these systems, it is important that the output stage should not present a significant load upon the driver transistor (*Tr1* in figs. 4 and 5) which means that in general it is easier to obtain good steady state harmonic distortion characteristics if a 'triple' is used as the output 'half'. However, this leads to rather greater difficulties in obtaining the high degree of loop stability needed for satisfactory transient performance.

FIG.5 ALTERNATIVE FORM OF FULLY SYMMETRICAL TRANSISTOR OUTPUT STAGE

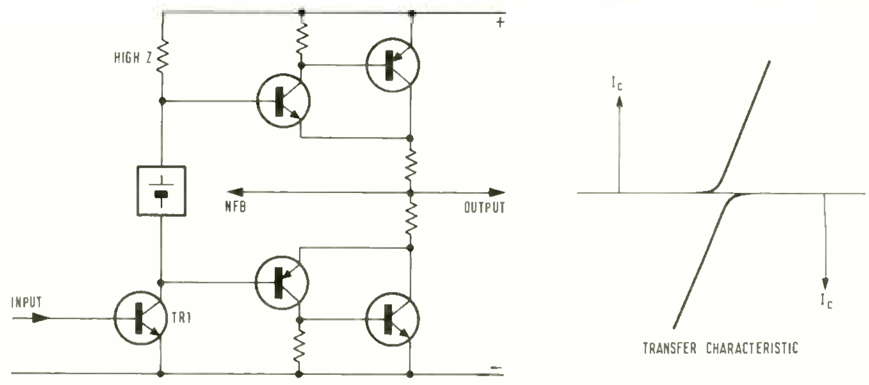


FIG. 6 THE 'QUAD' OUTPUT TRIPLE ARRANGEMENT

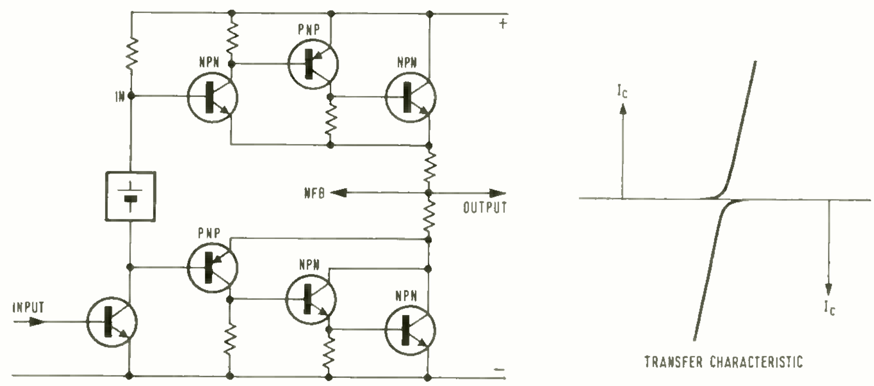
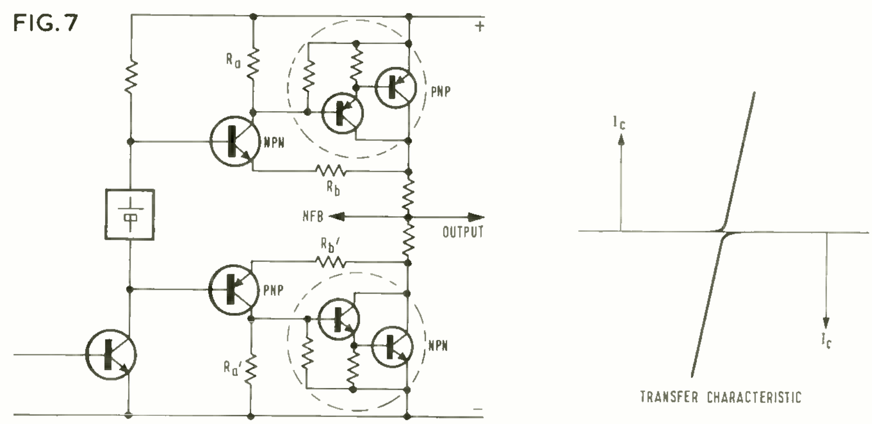


FIG.7



Further improvements

If, then, this is the representative state of the bulk of the good quality audio power amplifiers, of medium power, how does this compare with the state attained by valve-operated designs, at their highest stage of evolution in the late 1950s, and what further steps in transistor design are necessary or have already been taken to provide improvements in performance or higher output powers?

Taking first the question of comparative performance, it can be said at once that the general transient behaviour of the transistor circuit is considerably superior to that of even the good valve amplifiers of the '50s, and this definitely shows. Although most circuit designers would admit to shortcomings in pa transient behaviour, this reflects mainly a greater understanding of the problems involved, particularly with the highly reactive loads offered by current multiple-driver ls units in the contemporary 'monitor' class. Further improvements need to be made if the designs currently offered are to yield a good transient fidelity at output levels approaching their rated power maxima. On the subject of steady state harmonic distortion or overload behaviour, the situation is not nearly so satisfactory. Although most of the better contemporary designs offer harmonic distortion figures of the order of 0.05% or better at maximum and lesser powers, the structure of the harmonic distortion tends to be richer in higher order 'odd' harmonics which are by their nature alien to the ear and are therefore noticed and found unattractive.

Also, these relatively low thd figures are conditional upon the amplifier in question having been set up correctly in the first place and upon the design being of a form which allows this adjustment to be preserved through the changes in operating characteristics imposed by ageing and ambient temperature. This is nowhere so automatically a product of careful design as in the case of their valve forerunners. Additionally, there is an insidious type of fault

FIG. 8 'SECONDARY BREAKDOWN' CHARACTERISTICS OF TYPICAL SILICON POWER TRANSISTORS

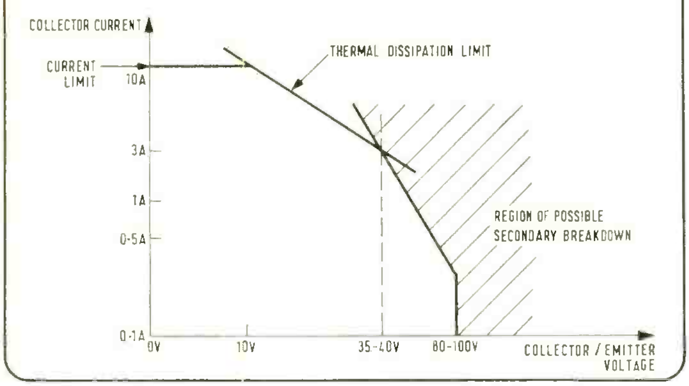
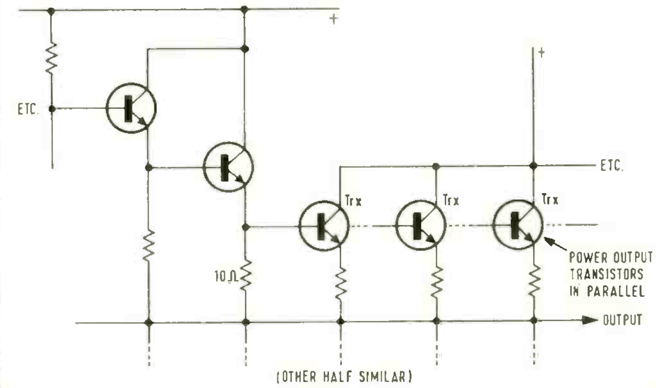
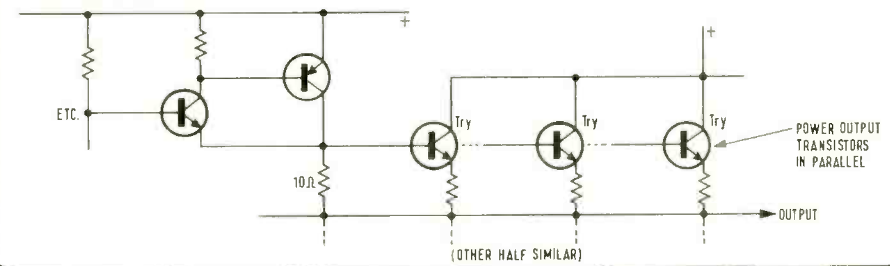


FIG 9a



which can arise in the case of the 'solid-state' design, that of transient instability on reactive (ie real life) loads due to the designers having been tempted into the use of excessive amounts of negative feedback in the pursuit of impressively low thd figures, without being sufficiently cautious about the subsequent effects.

FIG. 9b HIGH POWER OUTPUT STAGES USING PARALLELLED POWER TRANSISTORS



For the necessary stability of the quiescent current in the output stages of the amplifier—essential for preservation of the desired cross-over continuity—it is desirable that the base-emitter junctions of the output transistors should not be included in the forward bias determining system. The forms shown in fig. 5, the celebrated 'Quad' triple of **fig. 6**, and the arrangement shown in **fig. 7** using power Darlington transistors are much to be preferred. In particular, the latter form has a very high degree of symmetry, even up to high operating frequencies, due to the nature of the construction of the power devices, and allows the design of power amplifier circuits having distortion figures in the region 0.003-0.006% at 1 kHz. (A circuit of the type evolved by the author's laboratories using this configuration, for high output powers, is shown on p.28.)

The other remaining problems, those of somewhat greater frailty of the semiconductor systems under overload and the need for mproved transient performance, require either better devices or a better understanding of the problems involved. Taking the first of these, the present disadvantage of the transistor, *vis-a-vis* the thermionic valve is, in part, due to the relatively diminutive size of the power transistor 'chip' (about 0.1g) and its consequently trivial thermal capacity, to which is added the further problem of secondary breakdown of the junction. This type of failure occurs, typically, in modern silicon power transistors when currents in the range 100 mA-3A are drawn from the device at voltages in excess of 35 or 40, the nature of this voltage/current relationship being shown in **fig. 8**. If this region is transgressed in the operation of the device for any significant length of time, the semiconductor material begins to heat up in such a manner that the forward base-emitter junction potential begins to decrease. Since the effect of this heating is inevitably non-uniform, if only because of microscopic variations in the thermal conductivity or degree of doping of the emitter, some regions of the emitter will heat more than others, with a consequent further decrease in their junction potential and a further increase in the current flow. This situation is obviously an unstable one and can lead to rapid destruction of the semiconductor device if the current flow persists, or the rate of generation of heat exceeds the rate of possible lateral diffusion of it. One of the big advantages offered by the use of power fets, of the type developed by Yamaha (see the article by Michael Thorne in *Hi-Fi News*)[12] is that this type of self-destruction mechanism doesn't occur, and the device characteristics are more akin to those of the thermionic valve in this respect apart, of course, from the still small size of the active component.

Two alternatives are therefore available to the designer of semiconductor circuitry for high powers—to use relatively low collector voltages, so that the secondary breakdown regions are avoided, or to develop very rapid action protection circuitry. The first of these involves the restriction of the use of the circuit to low load impedances, if the Lin type transformerless construction is adopted, or the use of transformer output systems. These latter designs are, in general, the mainstay of present high-power amplifier units (250W or greater), but it is difficult to obtain harmonic distortion figures much below 0.5% with this configuration because of the limited amount of nfb which is practicable. If sufficiently effective protection circuits are employed, so that the transistors can be used safely in proximity to the secondary-breakdown region, the transformerless form can be used with low distortion, and with output powers up to 500W into four ohm loads. Two notable examples of power amplifiers in this power bracket are those developed in the USA by Crown (Amcron) and Phase-Linear. The type of output transistor configuration used in these is shown in **fig. 9a** and **9b**, and is subject to patents covering its employment. In these output stages, the transistors *Trx* and *Try* are normally non-conducting. but come into conduction when the transistors *Tra* and *Trb* pass sufficient current through their emitter circuit resistors. An apparent snag with this arrangement, even though it does, conveniently, allow the use of output transistors in parallel, is that it produces an even more complex crossover transition, with the consequent need for large amounts of negative feedback to minimise the ensuing distortion. Presumably for this reason the preceding voltage amplifier stages in both the Crown and Phase-Linear designs are highly complex, with great care taken to ensure the linearity of phase within the effective pass band of the system. It was mentioned earlier that the use of negative feedback becomes less useful as a means of reducing distortion when the open loop phase angle enters the second quadrant, and from this certain guide-lines can be laid down for the design of low distortion feedback amplifiers.[13] In general these require the use of transistors which have adequate hf response, and the use of as few signal amplifying stages within the overall nfb loop as practicable. If more gain is required, this should be obtained by separate, and separately linearised, voltage amplifiers, with their own loop feedback.

Transient distortion

Over the past few years, the importance of good transient behaviour, particularly when used with reactive loads which may well exaggerate incipient tendencies to malfunction, has been much more widely realised, mainly

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due to the work of Otala[11,15,16] who has shown the conditions in which transient intermodulation may occur. At least one commercially available design has been offered in which this parameter has been optimised in the manner suggested by Otala. However, there is some body of opinion that this is not the whole story, particularly since, even with sensitive test methods and amplifiers of a type which are likely in principle to suffer from tid, this phenomenon only tends to show up at power levels close to the output maximum of the design. It is, in any case, an awkward parameter to define. In the form suggested by Otala, in which the input stage of a feedback amplifier will overload and produce gross, short-term intermodulation effects when the rate-of-change of the input signal exceeds the possible rate-of-change of the voltage (dV/dT) or current feedback, the propensity of the design to suffer from this defect can be predicted by knowledge of the output slew-rate. If the possible output slewing rate divided by the feedback ratio is greater than the input signal slewing rate, then this form of distortion will be made less likely, or eliminated altogether; this is true regardless of the internal form of hf compensation employed within the amplifier.

In view of the need to define the transient performance of an audio amplifier in a manner which is as simple to comprehend and as unambiguous as the defined thd or im distortion for the steady state condition, the author has suggested the adoption of the concept of 'settling time,[17] as the parameter to optimise, partly because this is now in widespread use as a means of defining the performance of operational amplifiers, and partly because it seems evident that when an amplifier has 'settled' following a transient disturbance, the known steady-state parameters will apply. From this argument, it would follow that the shorter the settling time of the amplifier (defined as the time which it takes the output signal voltage to arrive within, and stay within, some small, specified, error band on either side of the true steady-state value, following the application at the input of a transient disturbance—usually a step-function in voltage) the more faithfully will the amplifier reproduce signals containing transient-type level changes. It is interesting in this context that the types of circuit design and hf stabilisation which lead to short settling times also provide good tid performance, and good reactive load stability. Unfortunately, the converse is not always true. However, as mentioned earlier, these are the parameters which concern the designers of high quality solid-state circuitry, in which a very much higher standard has already been reached than was practicable with the valve designs of the late '50s. What would be possible in the light of present knowledge, with the use of hybrid valve-transistor designs using transistors for the small-signal stages for which they are ideally suited, and power output valves coupled to high quality toroidal output transformers to minimise hf phase-shift, is an interesting field for speculation, but it seems unlikely to attract commercial interest.

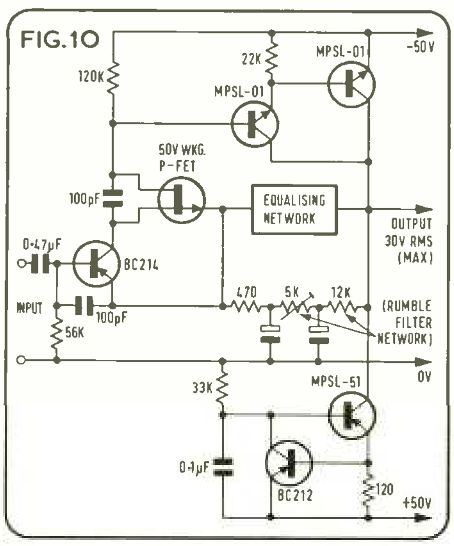

FIG.10

Preamplifiers

If anywhere, this is the field where the transistor and, in the near future, the monolithic integrated circuit, has really come into its own, with the elimination of heater-circuit wiring, the facility of the use of npn and pnp devices (for right-way-round and upside-down usage), junction and mos field-effect transistors for very high input impedance applications and the minimisation of circuit stray capacitances by virtue of the small physical dimensions of the elements in use. Also, because of the absence of heater circuit and cathode-heater capacitance complications, much greater freedom is available to the designer in the choice of signal and feedback injection paths. As ever, the requirements remain for good signal-to-noise ratios, low hum and radio-breakthrough pick-up, good linearity and good overload margins to cope with inadvertent maladjustment of the gain controls. Only in this latter context has the thermionic valve a significant advantage over the solid-state device and this advantage, stemming from the limited voltage capability of the low-noise small-signal transistor, is being eroded by design improvements. A circuit arrangement giving a very low input noise level, a low distortion factor, and an output of up to 30V rms, is shown in **fig. 11.**

For very low noise levels, the impedance of the input circuit is of primary importance, in order to minimise the thermal noise originating at this point. At the moment, discrete transistors offer a significantly better performance than the best of the available integrated circuits, and pnp bipolar transistors are better than npn devices because of their lower surface recombination noise. With good small-signal transistors, device input noise values over the 10 Hz-20 kHz bandwidth of the order of 0.15 µV have been claimed, but under circumstances where the input circuit itself would introduce some 0.5 µV of wide band noise.

With practical devices, and low input-impedance arrangements, a figure of the order of 0.25 µV, referred to the input would appear to be the lower practical limit. Such circuits must use series feedback configurations, of the type shown in **fig. 10,** in order to take advantage of the low input impedance offered by, say, a microphone transformer. This leads to the penalty, as shown previously, that the distortion with feedback will be higher than with a shunt feedback arrangement.[18,19] This arises because of 'common mode' failure in the feedback path, but can be substantially reduced, as in fig. 10, with a single input transistor, if the input device is operated in 'cascode' to minimise the extent to which the feedback voltage applied at the emitter is able to modulate the emitter-collector voltage. Also, as shown earlier,[20] the distortion in the bipolar transistor is an input characteristic function, and decreases as the input device gain is increased. This is obtained in practice by keeping the emitter circuit impedance low, and the collector circuit impedance as high as practicable.

At the typical 0 dB level at which much signal handling and mixing is done, there seems now to be little reason why devices of the type of the third-generation monolithic operational amplifier integrated circuit should not be used, since these are reliable, have good thd and settling-time characteristics into fairly high impedance loads and have excellent supply-line, signal and ripple rejection, which simplifies the task of isolating signal channels.

A practical high-power, high quality amplifier

The design of good quality, transformerless systems of the general structure shown in fig. 2a requires the use of output transistors of 'complementary' structure unless one of the several possible circuit artifices[21,22,23] is used to provide an operational equivalent using only npn power transistors. Of the complementary power transistor types available at an economical cost, the choice at high working voltages is restricted to power Darlington devices, constructed using an epitaxially grown base region. This indicates the use of the output configuration shown in fig. 7 which can, if operated with suitable component values, give a very high intrinsic linearity coupled with excellent transient behaviour and negligible load on the preceding class-A driver stage.

This allows the use of a low-power high voltage driver transistor, operating under conditions of very high voltage gain into a two-transistor constant-current-generator load. Since the forward bias for the output transistor 'triple' is defined by the characteristics of the input transistors in the 'triple', and these remain at ambient temperature, it is possible to use the characteristics of the constant current generator circuit to provide the necessary compensation for the influence of ambient temperature on the quiescent current. Since the transistors determining this remain cold, even under high power drive, the power output of the amplifier does not influence the quiescent current setting. This is a necessary requirement for ensuring low distortion. Moreover, since the stages which determine the I_q setting handle only small powers, their parameters will remain constant with time; again, this is a desirable feature.

In order to minimise the effect of common mode distortion at the input, while preserving the facility of a direct coupled structure, the customary input 'long-tailed pair' has been replaced by a single transistor, in which the offset which would otherwise arise due to its base-emitter voltage and the emitter circuit

28 ▶

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current flow through the feedback resistor, is removed by an additional constant current source employed to inject a sufficient quantity of current into the emitter of the input transistor to offset this voltage. Again, since the input transistor remains at ambient temperature, the constant current source can be arranged to track this thermally, and remove errors in dc offset due to ambient temperature changes.

The input preamplification is provided by a monolithic operational amplifier integrated circuit, which minimises the gain requirement of the power amplifier circuit. Very fast-acting output transistor protection is provided by *Tr11,12,13,14* and *Tr21,22,23,24* of which *Tr13,14* and *Tr23,24* are connected to act as small signal thyristors.

Prototype amplifiers built to the design shown in fig. 11 have given measured performances as below:

Power output: 270W, continuous power, into 4 ohms. (500W + in bridge connection into 8 ohms).
Frequency response: dc —40 kHz (—3 dB point).
Harmonic distortion: Less than 0.01% at maximum and lesser powers, 10 Hz-3 kHz. No crossover products detectable at max output —3 dB.
Settling time: <5 μs.
Output impedance: (1 kHz) 0.02 ohms.
No instability or alteration of square-wave response on reactive loads up to 2μF+4 ohms. Unaffected by o/c operation, system closes down and draws negligible power from power supply if s/c or improperly low impedance load is connected across outputs.
S/N ratio: —90 dB ref max output.

Acknowledgements

The author wishes to thank the Group Technical Director, British Cellophane Ltd, for permission to publish details of the power amplifier circuit described above, of which the input stage configuration, and the method of operation of the power transistors, are the subject of Patent applications.

Although the circuit, as described, was intended for a high quality industrial application, for which high linearity, direct coupling from input to load, and minimal phase-shift within the operating region were desired, the characteristics of this amplifier would appear to be ideally suited to use in high quality audio and studio applications, should the circuit shown be of interest to companies operating in this field.

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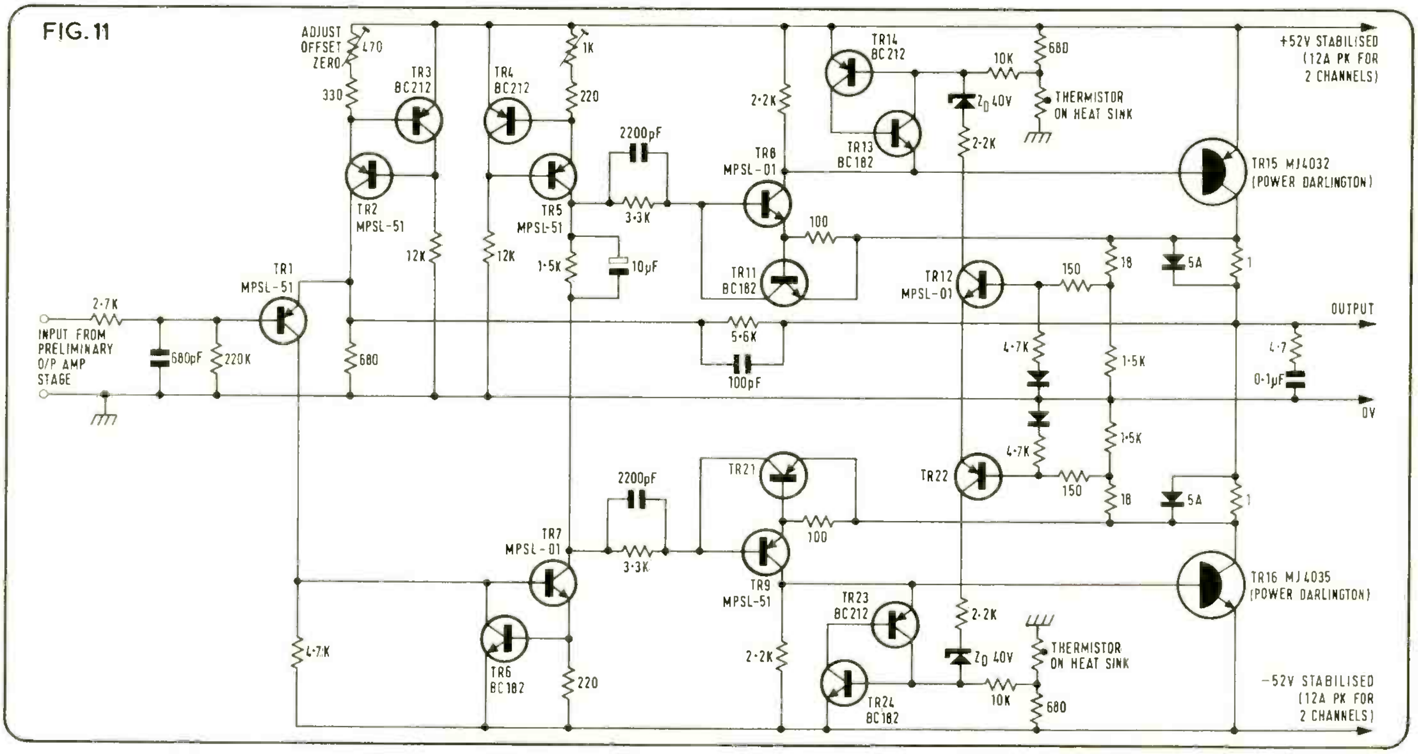
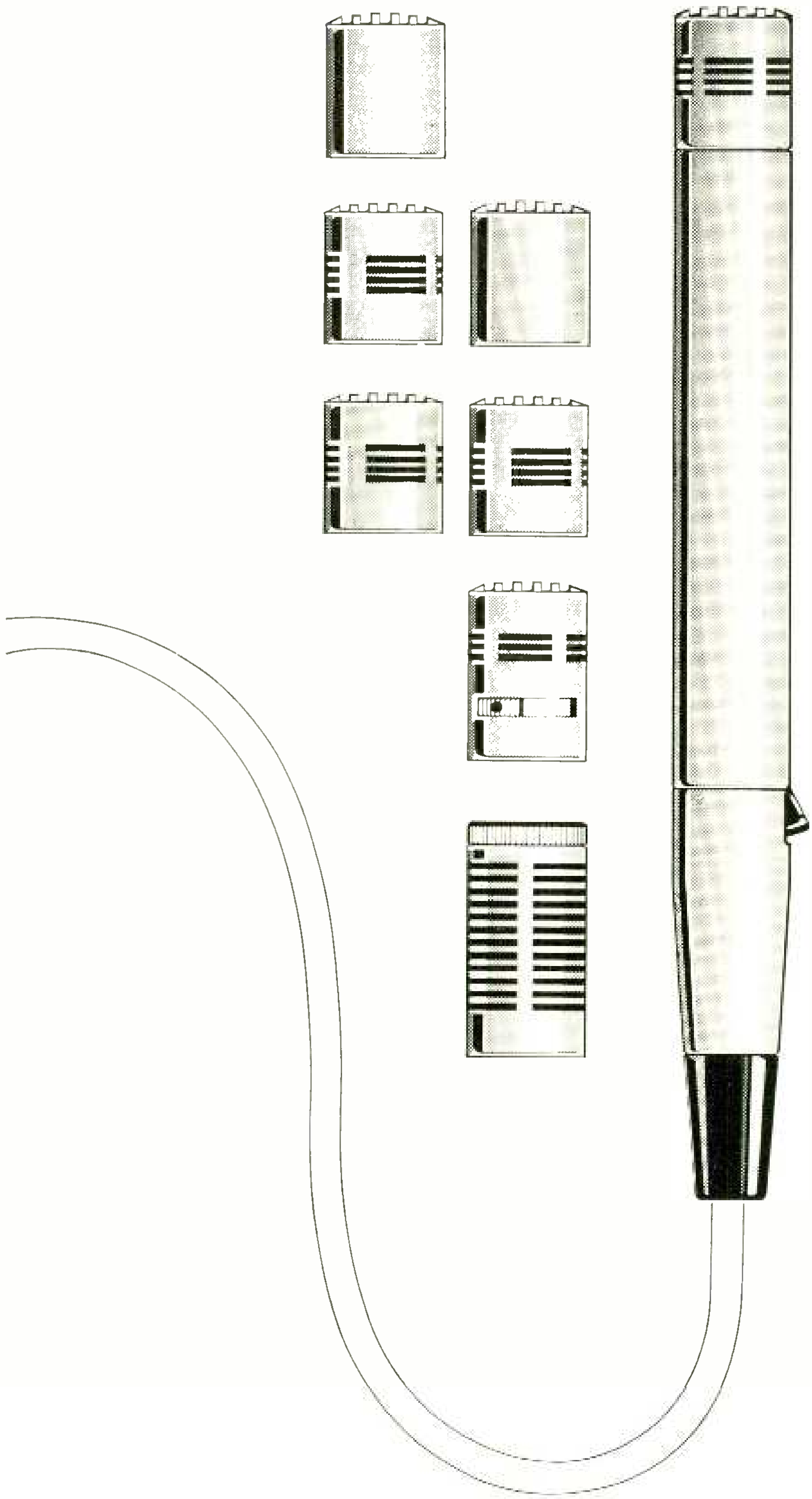
FIG. 11



AGONY COLUMN

■The md for the session was one of the new breed who has no formal musical skill but is a bottomless source of new ideas. A very successful operator, he isn't quite universally loved. One of his less likeable characteristics is flaunting his new Lamborghini. 'Hullo, there', he said subtly, on the session in question. 'I've just driven here in my new Lambo'. Most of the musicians continued talking among themselves but one couldn't let the remark go. 'Oh, you've got a new Lambo, have you', he said with apparently genuine interest, 'I've often thought about getting one of those. My younger brother has a Vespa, and he reckons to get nearly 100 miles a gallon from it'.



LETTERS

Dear Sir, We have read the review measurements and noted Mr Ford's comments regarding the power output and alignment of the vu meters (See p.62—*Ed.*).

The review's measurement of power output will be seen to be directly proportional to our specification. The difference error occurs since our measurements were made with the amplifier connected to our standard incoming mains supply, which is approximately 248V. Future production models will have a small increment in the transformer's secondaries' voltages, so that the specification is met with a 240V supply. This difference error expressed in dB rather than watts is 0.7 dB, which in fact exceeds the ±1 dB power response quoted for most power amplifiers. We were pleased to note that very low distortion measurements were obtained at 10 Hz/75W; since this would have been less than 0.5 dB below the 1 kHz clip-point, still lower distortion measurements will be obtained after the headroom is increased by 0.7 dB.

The vu meter card is provided with a preset enabling the customer to align the vus to his own requirements. Future production models will be aligned to the NAB recommendations where 0 vu is equivalent to 10 dB below peak output.

Yours faithfully, Mike Turner, Turner Electronic Industries, 175 Uxbridge Road, London W7 3TH.

Dear Sir, We have received from International Press Cutting Bureau a copy of an editorial which appeared in your magazine (to which we are an advertising contributor) entitled 'Radio Idi' (January, p37). The offending part, 'General Idi Amin VC (self awarded)', we find to be totally irresponsible and facetious and can do this company great harm and jeopardise future export orders.

We request that you print a retraction of the '(self awarded)' portion in the next issue of your magazine indicating that the comment was entirely editorial and originated from your Mr James and had nothing to do with this company.

In your response to this letter please also make it perfectly clear that this was an editorial comment for which you are totally responsible and does not originate in any way from this company.

We look forward to your reply and to seeing a retraction in your next editorial in STUDIO SOUND.

Yours faithfully, G. Angelou, Sales Director, Computer Equipment Co Ltd, Shaftesbury Street, High Wycombe HP11 2NA, Bucks.

Certainly, the comment was editorial in origin. Whatever might be practice elsewhere, STUDIO SOUND *editorial is completely independent. If a concern wishes to advertise, they do so only on the basis that people will read their advertisements. Mr James neither wrote nor prompted the note, since he is an acting advertisement representative.*

Since General Amin has used the initials VC after his name to imply Victoria Cross and has not been awarded this through the usual channels, the facetious 'self-awarded' comment cannot really be retracted. Sources: The Times *and* Punch.

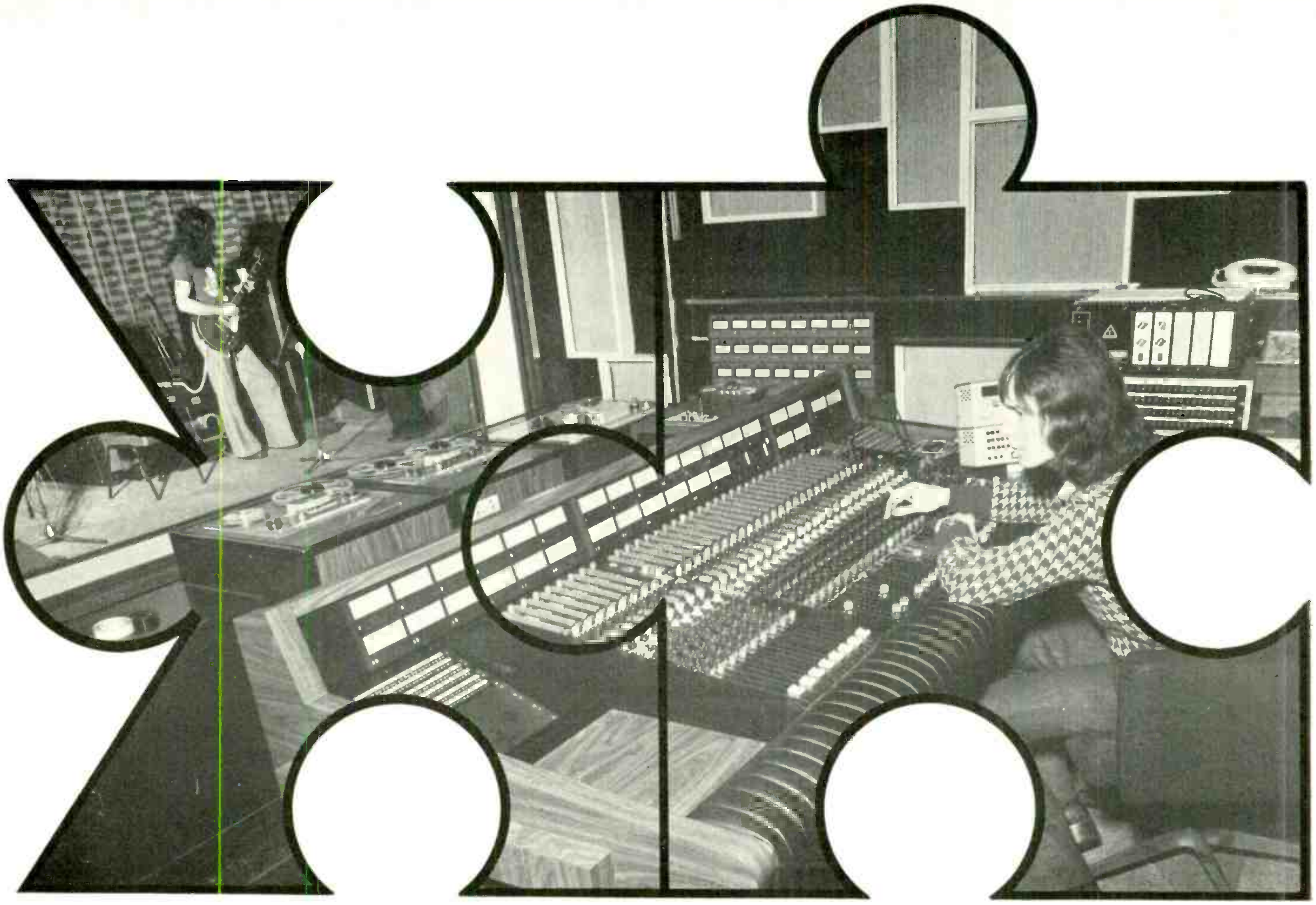
There are many large obstacles around to upset such an order. If such lightweight trivia cause trouble, it's lost anyway with or without STUDIO SOUND'S *help.*—**Ed.**

Dear Sir, May I venture a rejoinder to Mr Sandy Brown's letter published in the January '75 issue? He is absolutely right of course. *Caveat emptor* and all that. But the 'Silly Question' was not merely rhetorical but it has, in the light of subsequent events, now become only academic.

Perhaps it should be borne in mind that the majority of record producers wouldn't recognise a standing wave if they fell over it, and some think *eigenton* is 20 cwt in German. Now, it is claimed that the producer should confine his interest strictly to the musical performance leaving the technicalities entirely to the engineer. Personally I do not agree with this view but I respect its validity. We all have our individual ways of working. However, it does mean that many producers have to, and do, rely completely on the studio and engineer. It may take a little time for such a producer to discover that a studio, and its staff, is not as competent as a lavish display of expensive equipment and costly rates would suggest.

Recently there has been written into the Statute Book some comprehensive legislation aimed at increased consumer protection. It says, broadly speaking, that goods and services must be what they pretend to be, or else! Maybe there are still some studios which should benefit from the advice of Mr Sandy Brown and his associates, even, dare I say, his competitors.

Yours faithfully, Dennis Comper, Treelands, Debden, Saffron Walden, Essex.



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PATENTS

THE FOLLOWING list of Complete Specifications Accepted is quoted from the weekly *Official Journal* (Patents). Copies of specifications may be purchased (25p) from The Patent Office, Orpington, Kent BR5 3RD.

January 2

1384160 Opsonar Organ Corporation.
Low distortion optical organ.
1384186 Hama Hamaphot KG Hanke & Thomas.
Adhesive splicing element and method of splicing.
1384233 British Broadcasting Corporation.
Quality of electrical speech signals.
1384418 Sony Corporation.
Capacitor microphones.
1384478 Hama Hamaphot KG Hanke & Thomas
Apparatus for use in splicing together the ends of two strips.
1384493 Soc D'Etudes Technicques Et D'entreprises Generales.
Information retrieval apparatus.
1384502 Western Electric Co Inc.
Apparatus for adjusting equalisers of signal transmission systems.
1384558 Eaton Corporation.
Communications system for mobile vehicles.
1384604 Mohawk Data Sciences Corporation.
Reel control for a tape transport system.
1384610 Sony Corporation.
Apparatus for reproducing quadraphonic sound.
1384654 Libbey-Owens-Ford Co.
Windshield antennas and method of producing the same.
1384656/7 Newell Industries Inc.
Pliable tape record and reel therefor.
134716/7/8 Matsushita Electric Industrial Co Ltd and Sekisui Kagaku Kogyo KK.
Loudspeaker diaphragm.
1384761 United Recording Electronics Industries.
Audio frequency apparatus.
1384763 Licentia Patent-Verwaltungs GmbH.
Arrangement for scanning signals along at least one track.
1384783 Nippon Gakki Seizo KK.
Orchestral effect producing system for an electronic musical instrument.

January 8

1384819 Grundig EMV.
Magnetic tape sound recording apparatus.
1384827 Eastman Kodak Co.
Tape cassettes.
1384888 Clarke & Smith Industries Ltd.
Tape machine.
1384927 Siemens AG.
Amplitude adjustment circuits for transmitters.
1384944 Matsushita Electric Industrial Co Ltd.
Variable transfer signal apparatus.
1384968 Hazeltine Research Inc.
Apparatus for resolving phase ambiguities in regenerated carrier signals.
1384971 Nippon Telegraph & Telephone Public Corporation and Nippon Electric Co Ltd.
Signal switching arrangement.
1385161 Standard Telephones & Cables Ltd.
Electro-acoustic transducers.
1385188 Powerdrive Drum Co Ltd.
Instruments of percussion.

January 15

1385493 Defence, Secretary of State For.
Speech communication system.
1385518 Elektroakustik, AG Fur.
Hearing aids.
1385607 Nippon Gakki Seizo KK.
Musical instruments.
1385613 Matsushita Electric Industrial Co Ltd.
Cartridge locking and ejecting mechanisms for cartridge players.
1385651 CBS Inc.
Matrices and decoders for quadraphonic sound systems.
1385660 Philips Electronic & Associated Industries Ltd.
Resistance-to-frequency converter.
1385765 Electronic Music Studios (London) Ltd.
Data input devices.

January 22

1385850 Philips Electronic & Associated Industries Ltd.
Receiver for a selective paging system.
1385896 Racal Communications Ltd.
Manually operable control arrangements for controlling electrical signals such as the outputs of frequency synthesisers.
1385905 EMI Ltd.
Aerial arrangements.
1385916 Tektronix Inc.
Phase control system for signal modifying circuits.
1385942 Standard Telephones & Cables Ltd.
Loudspeaker assemblies.
1385945 International Computers Ltd.
Methods of manufacturing magnetic transducing heads and parts thereof.
1385946 International Computers Ltd.
Methods of manufacturing magnetic transducing heads.
1385953 Nippon Victor KK.
Signal modulating and demodulating system.
1385959 Bosch GmbH, Robert.
Processes for the production of a writing head for a device for recording information on a record carrier.
1386144 Pioneer Electronic Corporation.
Magnetic head and method of manufacturing same.
1386148/9 Storage Technology Corporation.
Drive unit for magnetic tape.
1386220 Pope, B. C.
Audible frequency indicating device.
1386256 Krone GmbH PCM.
Coder with compression characteristic.
1386265 Matsushita Electric Industrial Co Ltd.
Beat indicator for an automatic rhythm instrument.
1386273 Kudelski, S.
Device for mounting a magnetic head of a magnetic tape recorder.
1386320 Compagnie Industrielle Des Telecommunications Cit Alcatel.
Device for producing a polychromatic display.
1386331 Motorola Inc.
Multitrack tape recorder and/or reproducer apparatus.
1386358 Philips Electronic & Associated Industries Ltd.
Magnet system for an electro-acoustic electrodynamic transducer.
1386388 Matsushita Electric Industrial Co Ltd.
Colour video tape recorder.
1386466 International Business Machines Corporation.
Equaliser for a transmission channel.

January 29

1386570 Thomson-Brandt.
Electromagnetic wave collectors for portable and mobile receivers.
1386571 Acoustic Fiber Sound Systems Inc.
Loudspeaker enclosures.
1386604 British Broadcasting Corporation.
Automatic colour correcting system.
1386668 Nippon Electric Co Ltd.
Variable equaliser.
1386671 Cunard Steam-Ship Co Ltd.
Reception techniques for intelligibility of an audio frequency signal.
1386724 Perforag Ltd and Elteba AG.
Appliance for punching, cutting and splicing information carrying materials.
1386745 Zellweger Ltd.
Active filter.
1386777 Thomson-CSF.
Antennae with linear aperture.
1386884 Matsushita Electric Industrial Co Ltd.
Character display system.
1386889 Siemens-Albis AG.
PCM time-division-multiplex telecommunication network system.
1386923 Anstalt Europaische Handelsgesellschaft.
Transmitting apparatus for generating, converting and transmitting signals and receiving apparatus for use therewith.
1386979 Siemens AG.
Multiplex telecommunications systems.
1387001 Sumitomo Electric Industries Ltd.
Leaky coaxial cables.
1387026 Nippon Victor KK.
Compressing and/or expanding circuit.
1387074 Western Electric Co Inc.
Loudspeaking telephone sets.
1387168 Siemens AG.
TDM telecommunications systems.
1387207 Telecommunications Radioelectriques Et Telephoniques.
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1387321 Gagnon, R. T.
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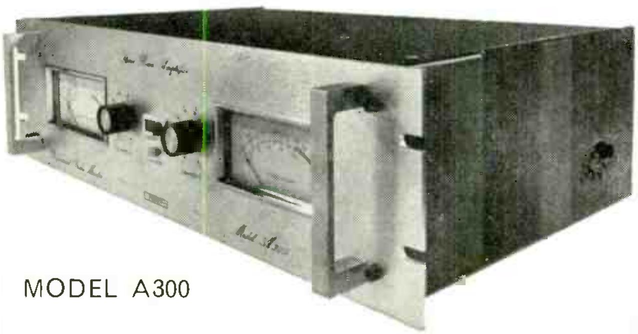

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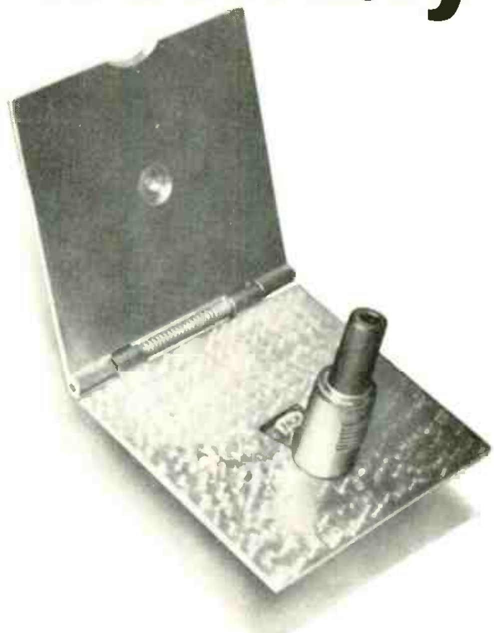

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P300
No of channels: Two.
Power output: 150W rms, both channels driven, 200W rms into 4Ω.
Nominal output impedance: 8Ω.
Damping factor: 20.
Power bandwidth: 20 Hz to 20 kHz ±0.2 dB at rated power.
Protection: Unspecified.
Input impedance: 100 kΩ.
Gain: 1V for rated power output.
Hum and noise: 100 dB below rated output.
Distortion: Less than 0.1% thd and im (any level and mixture between 20 Hz and 20 kHz) at rated output.
Other features: Produces 'subtle nuances of inner musical fabric which stir and warm the soul with emotion'. Twin vu meters, power limiter control. dV/dT 15V/μs.
Connectors: 'Plenty of input/output terminals.'
Power requirements: 100 to 240V ac. 500W.
Dimensions (whd): 445 x 152 x 355 mm.
Weight: 25 kg.
Price: £450.

P250
No of channels: Two.
Power output: 100W rms, both channels driven.
Nominal output impedance: 8Ω.
Damping factor: 20 adjustable.
Power bandwidth: 20 Hz to 20 kHz ±0.2 dB at rated power.
Protection: Short circuit cutout.
Input impedance: 100 kΩ.
Gain: 1V for rated power output.
Hum and noise: 94 dB below rated output.
Distortion: Less than 0.1% thd and im (any level and mixture between 20 Hz and 20 kHz) at rated output.
Other features: Vu meters. dV/dT 15V/μs.
Connectors: 'Plenty of input/output terminals.'
Power requirements: 100V to 240V ac.
Dimensions (whd): 445 x 152 x 335 mm.
Weight: 19.5 kg.
Price: £325.

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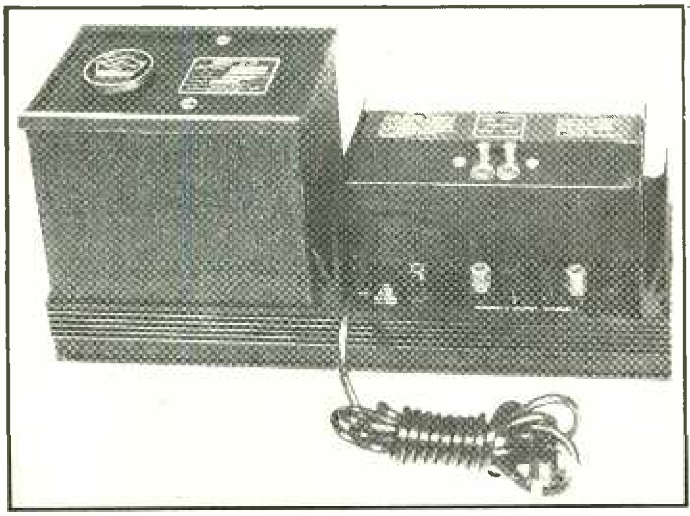
UK agents: Macinnes Laboratories Ltd, Macinnes House, Carlton Park Industrial Estate, Saxmundham, Suffolk IP17 2NL. Phone: 0728 2262/2615.

D60
No of channels: Two.
Power output: 30W rms both channels driven, 64W rms into 4Ω, one channel.
Nominal output impedance: 8Ω.
Damping factor: 200.
Power bandwidth: 5 Hz to 30 kHz ±1 dB.
Protection: Not specified.
Input impedance: 25 kΩ.
Gain: 0 dBm nominal for rated output.
Hum and noise: 106 dB below rated output.
Distortion: Below 0.05% thd to rated output. Im (SMPTE) better than 0.05% at all levels.
Other features: dV/dT 6V/μs.
Dimensions (whd): 48 x 4 x 20 cm.
Price: £155.

D150
No of channels: Two.
Power output: 75W rms, both channels driven, 100W rms into 8Ω one channel.
Nominal output impedance: 8Ω.
Damping factor: 200.
Power bandwidth: 5 Hz to 20 kHz ±1 dB at rated output.
Protection: Not specified.
Input impedance: 25 kΩ.
Gain: 1.19V for rated output.
Hum and noise: 110 dB below rated output.
Distortion: Below 0.05% to rated output. Im (SMPTE) better than 0.05% to rated output.
Other features: dV/dT 6V/μs.
Price: £260.

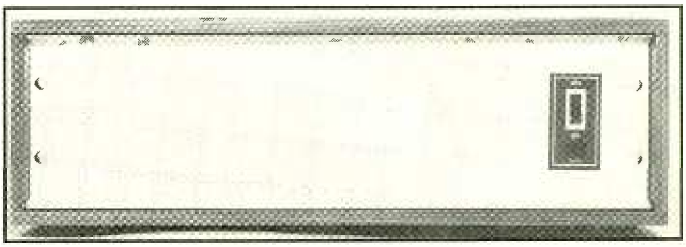
DC300A
No of channels: Two.
Power output: 150W rms both channels driven.
100W rms/1Ω, 500W rms/2.5Ω, 200W rms/8Ω } one channel only.
Nominal output impedance: 8Ω.
Damping factor: 200.
Power bandwidth: Dc to 20 kHz ±1 dB.
Protection: Full output protection.
Input impedance: 10 kΩ.
Gain: 1.75V for rated output.
Hum and noise: 110 dB below rated output.
Distortion: Im and harmonic below 0.05% to rated output.
Other features: dV/dT 8V/μs.
Power requirements: 120 to 260V ac.
Dimensions (whd): 48 x 17 x 24 cm.
Price: £420.

M600
No of channels: One.
Power output: 600W rms nominal, 1350W rms into 4Ω.
Nominal output impedance: 8Ω.
Damping factor: 400.
Power bandwidth: Dc to 20 kHz ±1 dB at rated power.
Protection: Output s/c not specified. Line over-voltage and thermal protection provided
Input impedance: 25 kΩ.
Gain: 20 dB.
Hum and noise: 120 dB below rated output.
Distortion: Better than 0.05% thd and Im (SMPTE) to rated power level.



Left: *Amcron D150*

Below: *Audix PA18*



Other features: Level meter. dV/dT 16V/μs.
Power requirements: 120, 220, 240V ac.
Dimensions (whd): 48 x 22 x 41 cm.
Weight: 41.7 kg.
Price: £830.

AUDIX

Audix Ltd, Stansted, Essex CM24 8HS. Phone: 0279-813132.
No of channels: one.

PA 18/25/80

Power output: 18/25/80W rms.
Nominal output impedance: 8Ω or 100V line.
Power bandwidth: —3 dB at 30 Hz and 16 kHz on 100V line ref rated power.
Protection: Short and open circuit.
Input impedance: 5 kΩ.
Gain: 200 mV for rated output.
Hum and noise: -90/70/70 dB below rated output.
Distortion: 0.8% thd at rated output.
Connectors: Cannons optional.
Power requirements: 110 to 240V ac.
Weight: 4.1/5.9/8.2 kg.

PA 120/200

No of channels: One.
Power output: 120/200W rms.
Nominal output impedance: 100V line.
Power bandwidth: —3 dB at 30 Hz and 16 kHz ref rated power.
Protection: Short and open circuit, thermal protection.
Input impedance: 5 kΩ.
Gain: 200 mV for rated output.
Hum and noise: -90 dB below rated output.
Distortion: 0.4% thd at rated output, conditions not specified.
Connectors: Cannons optional.
Power requirements: 110 to 240V ac.
Weight: 13.5/14 kg.

BOSE

Bose Corporation, The Mountain, Framingham, Mass 01701, USA.
UK agents: Bose (UK) Ltd, Sittingbourne Industrial Park, Crown Quay Lane, Sittingbourne, Kent. Phone: 0795-75341.

1801

As a policy, Bose do not publish detailed specifications of the *1801;* however they claim that any residual distortion etc is totally inaudible and therefore pointless to quote. The only hard specification is an output of 250W/channel into 8Ω, both channels driven corresponding to 400W into 4Ω.

The amplifier is available in rack mounting form with calibrated led peak level indicators in a plain trim *(1800).*

CTH

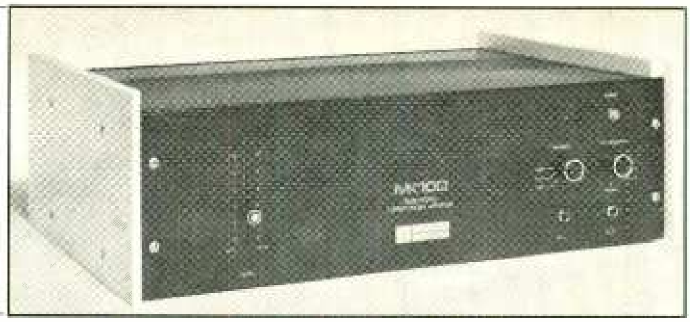
CTH Electronics, Industrial Estate, Somersham Road, St Ives, Huntingdon PE17 4LE. Phone: 0480 64388.

GA30

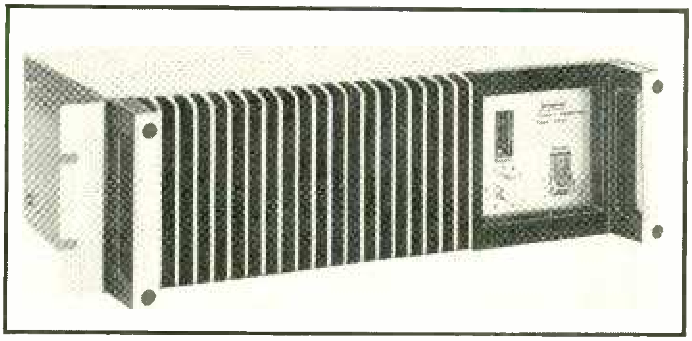
Mains only. 25W rms.
Post Office type *B* jack.
4 ohm output.
Free standing unit.
Price: £62.

MA 30/8

Mains 120/240V. 45W rms.
Battery 12V. 35W rms.
Post Office type *B* jack



Right: *Goodmans Galactron MK 100 professional stereo power amplifier*



Left: *Grampian power amplifier type 7441*

100V output.
100V peak reading output meter.
Rack mounted.
Price: £132.

MA 51/8

Mains 120/240V. 70W rms.
Battery 12V. 55W rms.
Post Office type *B* jack.
100V output.
100V peak reading output meter.
Price: £170.

MA 100/8

Mains 120/240V. 130W rms.
Battery 12V. 100W rms.
Post Office type *B* jack.
100V output centre tapped.
100V peak reading meter.
Rack mounted.
Price: £200.

MA 250/8

Mains 120/240V. 300W rms.
Battery 24V. 250W rms.
XLR type inputs.
100V output.
100V peak reading meter.
Rack mounted.
Price: £430.

GALACTRON

Galactron Spa, Italy.
UK agents: Goodman Loudspeakers Ltd, Downley Road, Havant, Hampshire PO9 2NL. Phone: 070 12 6344.

MK 100

No of channels: Two.
Power output: 100W rms, one channel driven.
Nominal output impedance: 8Ω.
Damping factor: Adjustable to 100.
Power bandwidth: 16 Hz to 70 kHz —3 dB.
Protection: Not specified.
Input impedance: 20 kΩ.
Gain: 0 dBm for rated output.
Hum and noise: 95 dB below rated output.
Distortion: less than 0.1% thd 20 Hz to 20 kHz, less than 0.2% im (60 Hz and 5 kHz, 4:1) at rated output.
Other features: 4 μs risetime.
Connectors: Cannons optional.
Power requirements: 240V ac 280W.
Dimensions (whd): 46.2 x 14.5 x 31 cm.
Weight: 16 kg.
Price: £241.67.

GRAMPIAN

Grampian Reproducers Ltd, Hanworth Trading Estate, Hampton Road West, Feltham, Middlesex TW13 6EJ. Phone: 01-894 9141.

743/744

No of channels: One.
Power output: 50/100W rms.
Nominal output impedance: 8/4Ω.
Damping factor: 30.
Power bandwidth: 50 Hz to 15 kHz ±3 dB at rated power.
Protection: Most eventualities.
Input impedance: 10 kΩ.
Gain: 26 dB (voltage).
Hum and noise: —70 dB, no reference given.
Distortion: less than 0.5% thd at rated output. Less than 0.2% thd at 10 dB below this level.
Other features: Meets four hour full rms IEC test.
Connectors: Screw block.
Dimensions (whd): 483 x 133 x 320 mm.
Weight: 18 kg.

HARMAN/KARDON

Harman/Kardon Inc, 55 Ames Court, Plainview, NY 11803, USA. 36 ▶

UK agents: Highgate Acoustics, 38 Jamestown Road, London NW1 7EJ. Phone: 01-267 4937/8.

Citation Twelve
No of channels: Two.
Power output. 60W rms both channels driven.
Nominal output impedance: 8Ω.
Damping factor: 40.
Power bandwidth: 5 Hz to 35 kHz ± ?dB
Protection: Not specified.
Input impedance: 30 kΩ.
Gain: 1.5V for rated output.
Hum and noise: -100 dB ref rated output.
Distortion: Better than 0.2% thd over full power bandwidth.
Other features: 2 µs rise time, cabinet options.
Connectors: Phono input, banana out.
Dimensions (whd): 31.7 x 14 x 31.1 cm.
Weight: 13.6 kg.

H/H
H/H Electronic, Industrial Site, Cambridge Road, Milton, Cambridge CB4 4AZ. Phone: 0223 65945/6/7.

TPA 25D
No of channels: One.
Power output: 30W rms.
Nominal output impedance: 15Ω.
Damping factor: 200.
Power bandwidth: 20 Hz to 20 kHz ±0.1 dB.
Protection: Short and open circuit protection.
Input impedance: 15 kΩ.
Gain: 0 dBm for rated power into 15Ω.
Hum and noise: —100 dB below full output. Unweighted.
Distortion: 0.01% thd at 25W into 15Ω at 1 kHz. Less than 0.1% thd throughout power band.
Other features: dV/dT 10V/µs. Ambient temperature 50°C max.
Power requirements: 115 and 240V ac, 80W max.
Dimensions (whd): 247 x 89 x 155 mm.
Price: £46.

TPA 50D
No of channels: One.
Power output: 60W rms/15Ω. 80W rms/7.5Ω.
Nominal output impedance: 15Ω.
Damping factor: 200.
Power bandwidth: 20 Hz to 20 kHz.
Protection: Short and open circuit.
Input impedance: 15 kΩ.
Gain: 0 dBm for rated output.
Hum and noise: —100 dB below full output. Unweighted.
Distortion: 0.01% thd at 50W into 15Ω at 1 kHz. Less than 0.1% thd throughout power band.
Other features: dV/dT 10V/µs. Ambient temperature 50°C max.
Power requirements: 115 and 240V ac. 140W max.
Dimensions (whd): 483 x 89 x 305 mm.
Weight: 9 kg.
Price: £70.

TPA 100D
No of channels: One.
Power output: 100W rms/15Ω. 180W rms/7.5Ω.
Nominal output impedance: 15Ω.
Damping factor: 200.
Power bandwidth: —0.5 dB at 5 Hz and 20 kHz.
Protection: Short and open circuit.
Input impedance: 10 kΩ.
Gain: 0 dBm for rated output.
Hum and noise: —100 dB below rated output. Unweighted.
Distortion: 0.05% thd at 100W into 15Ω at 1 kHz. Less than 0.2% thd over power band.
Other features: Operating temperature range —25 to +50°C.
Dimensions (whd): 483 x 89 x 305 mm.
Price: £98.

MARANTZ
Marantz Co Inc, PO Box 99, Sun Valley, California 91352, USA.
UK agents: Pyser Ltd, Electronics Division, Fircroft Way, Edenbridge, Kent. Phone: 073-271 4111.

250
No of channels: Two.
Power output: 125W rms, both channels driven.
Nominal output impedance: 8Ω.
Damping factor: 100.
Protection: Unspecified.
Input impedance: 100 kΩ.
Gain: 1.75V for rated output.
Distortion: 0.1% thd and im (any level and mixture between 20 Hz to 20 kHz) to rated power output.
Other features: Vu meters.
Price: £330.

500
No of channels: Two.
Power output: 250W rms, both channels driven.
Nominal output impedance: 8Ω.
Damping factor: 400.
Power bandwidth: 20 Hz to 20 kHz
Protection: Unspecified.
Input impedance: 100 kΩ.
Gain: 1.75V for rated output.
Distortion: 0.05% thd and im (any level and mixture between 20 Hz to 20 kHz) to rated power output.
Other features: Vu meters.
Price: £775.

MIDAS
Midas Amplification, 87 North Grove, Tottenham, London N15 5QS. Phone: 01-800 6341.

PRO POWER AMPLIFIER
No of channels: main frame accommodates up to four channels.
Power output: 200 or 250W rms per module, minimum impedance 6Ω.
Nominal output impedance: 8Ω.
Power bandwidth: Not specified.
Protection: Short circuit, mismatch and open circuit.
Input impedance: } 0 dBm nominal for rated
Gain: } output.
Hum and noise: Not specified.
Distortion: Better than 0.1% thd at rated power output.
Connectors: Cannon *XLR*.

MILLBANK
Millbank Electronics Group Ltd, Uckfield, Sussex TN22 1PS. Phone: 0825-4166.

MEX 30/50/100 1C
No of channels: One.
Power output: 30/50/100W rms nominal. 46/70/110W rms at 1% thd at 1 kHz.
Nominal output impedance: 8Ω.
Protection: Short circuit.
Input impedance: 600Ω.
Gain: 0 dBm.
Hum and noise: —80 dB.
Distortion: Typically 0.1% thd. Conditions unspecified.
Connectors: Cannon.
Power requirements: 240V ac.
Dimensions (whd): 48.2 x 8.8 x 37.5 cm.

MUSTANG
Mustang Communications, Nelson Street, Scarborough, Yorkshire YO12 7SZ. Phone: 0723 73298.

SS50/SS100
No of channels: One.
Power output: 50/100W rms.
Nominal output impedance: 15Ω.
Power bandwidth: —0.5 dB at 10 Hz and 20 kHz.

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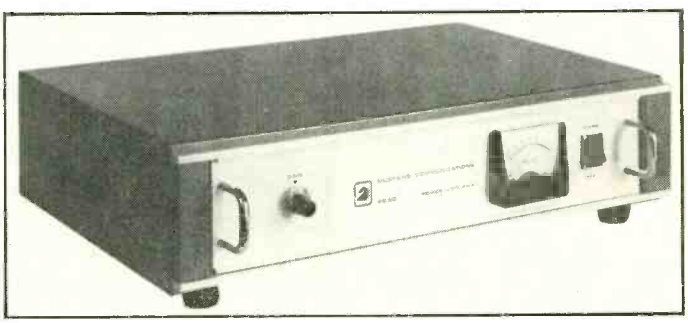
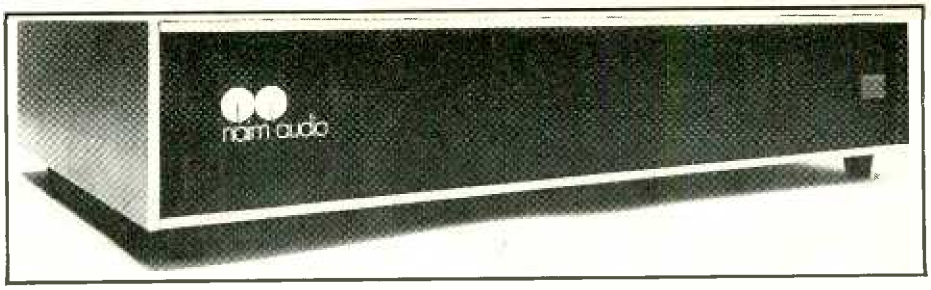


Left: *Harmon Kardon Citation Twelve*

Above: *Mustang SS50 power amplifier*

Protection: Unclear.
Input impedance: 10 kΩ nominal.
Gain: 31/34 dB.
Hum and noise: 90/94 dB below rated power output.
Distortion: Less than 0.5% thd over power bandwidth.
Other features: Level meter.
Connectors: 6.25 mm jack, hardwired output.
Power requirements: 115 to 240 ac.
Dimensions (whd): 483 x 89 x 337 mm.
Price: £83.20 and £110.08.



Naim Audio type NAP 160 power amplifier

NAIM
Naim Audio Ltd, 15 Churchfields Road, Salisbury, Wiltshire SP2 7NH. Phone: 0722-3746.

NAP 160 and 400
No of channels: Two.
Power output: 80W/4Ω, 50W/8Ω and 200W/4Ω. All ratings rms, both channels driven.
Damping factor: 40.
Power bandwidth: —3 dB (voltage) at 5 Hz and 40 kHz.
Protection: Short circuit and thermal.
Gain: 1.4V for rated output.
Hum and noise: —90 dB below 20V output.
Distortion: less than 0.02% thd at 35W and 100W over the specified power band.
Other features: Amplifiers guaranteed for life.
Connectors: Preh lock DIN (160) and *XLR*'s (400).
Power requirements: 120 and 240V ac.
Price: £140 and about £400. The NAP400 will be available towards the end of April.

NEVE
Rupert Neve & Co Ltd, Cambridge House, Melbourn, Royston, Herts SG8 6AU. Phone: 0763 60776.

15W2P
No of channels: Two.
Power output: 15W rms, test condition unspecified.
Nominal output impedance: 8Ω.
Power bandwidth: 20 Hz to 20 kHz at rated output ±? dB.
Protection: Not specified.
Input impedance: 10 kΩ.
Gain: —8 to +6 dBm for rated output.
Hum and noise: 90 dB below rated output.
Distortion: Less than 0.1% thd over power bandwidth.
Other features: Modular system, intended for installation as part of console.
Power requirements: 24V dc at 3A; or 240V ac.
Dimensions (whd): For 48 cm standard rack.
Price: On application.

PHASE LINEAR
Phase Linear Corporation, PO Box 549, Edmonds, Washington 98020, USA.
UK agents: Exposure Hi-Fi, 19 Richardson Road, Hove, Sussex BN3 5RB. Phone: 0273 777912.

400B
No of channels: Two.
Power output: 200W rms both channels driven.
Nominal output impedance: 8Ω.
Damping factor: 1000 at 20 Hz.
Power bandwidth: 5 Hz to 20 kHz ±? dB.
Protection: 'Electronic energy limiter' and fuses.
Input impedance: 10 kΩ.
Gain: 1.75V for rated output.
Hum and noise: 100 dB below rated output.
Distortion: Less than 0.25% thd and im distortion (method of measurement and powerband unspecified).
Other features: Rise time 1.7 μs or better. Fitted with vu meters.
Dimensions (whd): 48 x 19 x 25 cm.
Weight: 15 kg.
Price: £435.

700B
No of channels: Two.
Power output: 350W rms both channels driven.
Nominal output impedance: 8Ω.
Damping factor: 1000 at 20 Hz.
Power bandwidth: 10 Hz to 25 kHz at rated power.
Protection: 'Electronic energy limiters' and fuses.
Input impedance: 10 kΩ.
Gain: 1.6V for rated power output.
Hum and noise: 100 dB below 350W.
Distortion: Less than 0.2% thd and im at unspecified test and power conditions.
Other features: 1.6 μs rise time, 10° phase lag at 20 kHz. Fitted with vu meters.
Price: £574.

PHILIPS
Pye Business Communications Ltd, Cromwell Road, Cambridge BB1 3HE. Phone: 0223-45191.

LLB 1102/3/4
No of channels: One.
Power output: 50/100/200W rms. 15V line direct, or 50/70/100V with line transformer.
Nominal output impedance: 4/2/1 Ω.
Protection: Claimed in respect of switching, misloading, connection errors, oscillating and short circuit.
Gain: 200 mV for rated output.
Hum and noise: 85 dB below rated output.
Distortion: 0.2% thd at 1 kHz rated output.
Other features: Vu meter.

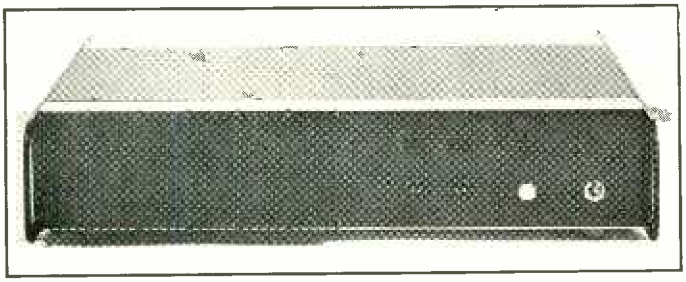
QUAD
Acoustical Manufacturing Co Ltd, Huntingdon PE18 7DB. Phone: 0480-52561.

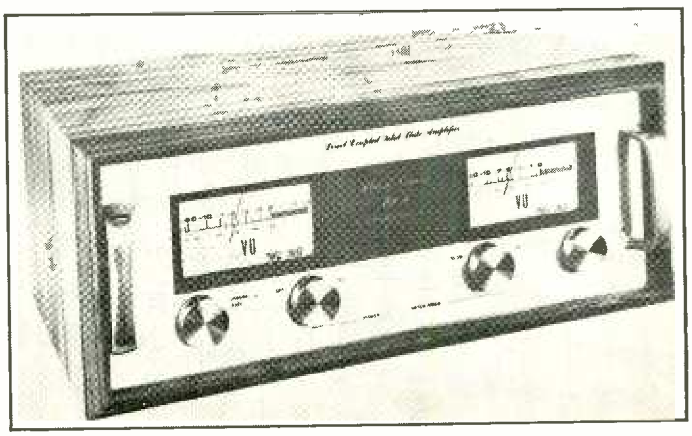
50E
No of channels: One.
Power output: 50W into optimised impedance loads.
Nominal output impedance: Anything between 4 to 200Ω.
Damping factor: About 10 at 1 kHz.
Power bandwidth: —1 dB at 30 Hz and 20 kHz ref rated output.

40 ▶

Right: *Phase Linear type 700B power amplifier*

Below: *Neve type 15W2P amplifier*



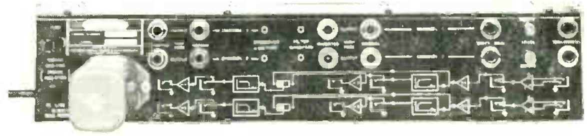


NEW

VFX-2

DUAL CHANNEL CROSSOVER/FILTER

The Amcron VFX-2 provides continuously variable filters which can be used to perform either crossover or band pass functions. The dual channel unit employs two filters per channel, each continuously variable from 20 Hz to 20k Hz. Filter rolloff is at a fixed 18dB/octave.



Our London stockists for all AMCRON equipment are REW (Audio Visual) Ltd., 146 Charing Cross Road, London WC2. Tel. 01-240 3883, and also at 10-12 High Street, Colliers Wood, London SW19. Tel. 01-540 9684.

or Direct to sole agents:

MACINNES LABORATORIES LTD. MACINNES HOUSE, CARLTON PARK INDUSTRIAL ESTATE, SAXMUNDHAM, SUFFOLK IP17 2NL
TEL: (0728) 2262 2615

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In these days of rising prices and galloping inflation it becomes more important than ever to carefully equate the cost of a professional recorder to its performance and reliability. That's where we can help you, follow the example of many commercial radio stations and recording studios. Buy British, Buy Bias for years of hard usage at prices that won't cause a coronary.

BIAS ELECTRONICS LTD. 01-540 8808
572 KINGSTON ROAD, LONDON SW20 8DR

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NOT SO!

At least not in the case of our new MM series public address mixers and amplifiers. Their beauty extends far beyond the front panel, through the glass epoxy circuit boards, round the laced cable-forms, past the mumetal screens and into the remote corners of the plated chassis.

And what performance!

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Mixers, mixer amplifiers and slaves, power amplifiers, lighting controls, transformers, and cabinets.

MUSTANG COMMUNICATIONS

Nelson Street, Scarborough, North Yorkshire, England. YO12 7SZ. Telephone: 0723-63298

■ SURVEY: AMPLIFIERS

Protection: 'Virtually proof against misuse'.
Input impedance: 600Ω balanced.
Gain: 0.5V for rated output.
Hum and noise: better than 80 dB below rated output.
Distortion: 40 Hz < 0.35% ; 1 kHz < 0.1% ; 10 kHz < 1% } to rated output.
Other features: Many taps on output auto transformer.
Power requirements: 110 to 240V ac, 150W.
Dimensions (whd): 120 x 159 x 324 mm.
Weight: 11.3 kg.
Price: On application.

303
No of channels: Two.
Power output: 45W rms, both channels driven.
Nominal output impedance: 8Ω.
Power bandwidth: About 1 dB down at 20 Hz and 20 kHz at 45W.
Protection: Not very clear.
Input impedance: 22 kΩ.
Gain: 0.5V for rated output.
Hum and noise: 100 dB below rated output.
Distortion: 70 Hz < 0.03% ; 700 Hz < 0.03% ; 10 kHz < 0.1% } thd at rated output.
Connectors: Bulgin input, banana output.
Power requirements: 100 to 250V ac, 200W.
Dimensions (whd): 120 x 159 x 324 mm.
Weight: 8.2 kg.
Price: On application.

RAC
Rugby Automation Consultants, 19 Freemantle Road, Rugby, Warwickshire CV22 7HZ. Phone: 0788-810877.

RACAMP 50 and RACAMP 100
No of channels: One.
Power output: 50/100W rms.
Nominal output impedance: 8/4Ω.
Power bandwidth: 10 Hz to 20 kHz ±1 dB.
Protection: Not very clear; some protection of unknown nature provided.
Input impedance: 90 kΩ.
Gain: 420 mV for rated output.
Hum and noise: 76 dB below *50 mW*.
Distortion: 0.025% thd at 1 kHz, 0.15% at 12.5 kHz, power level unspecified. Im less than 0.25% (unstated level and mixture).
Power requirements: 240V ac.
Dimensions (whd): 135 x 133 x 254 mm.
Price: £31.95 and £36.58.

Quad 50E amplifier

RADFORD
Radford Electronics Ltd, Bristol BS3 2HZ. Phone: 0272-662301.

ZD100/200 pro
No of channels: Two.
Power output: 60/100W rms. 100/200W rms into 3 to 4Ω load.
Nominal output impedance: 8Ω.
Gain: 0 dBm for rated output nominal.
Connectors: Cannon *XLR*.
Price: £175/£275.

REVOX
Willi Studer, CH-8105 Regensdorf-Zurich, Switzerland.
UK agents: C E Hammond & Co Ltd, Lamb House, Church Street, Chiswick, London W4 2PB. Phone: 01-995 4551.

A722
No of channels: Two.
Power output: 60W rms, conditions unspecified.
Nominal output impedance: 4Ω.
Power bandwidth: By DIN 45500, 10 Hz to 50 kHz.
Protection: Not very clear; Revox claim full speaker protection.
Input impedance: 20 kΩ.
Gain: 0.75V for rated output.
Hum and noise: 90 dB below rated output.
Distortion: Less than 0.1% thd at rated output at 1 kHz. Less than 0.2% thd over power bandwidth.
Power requirements: 110 to 250V ac.
Price: £197.

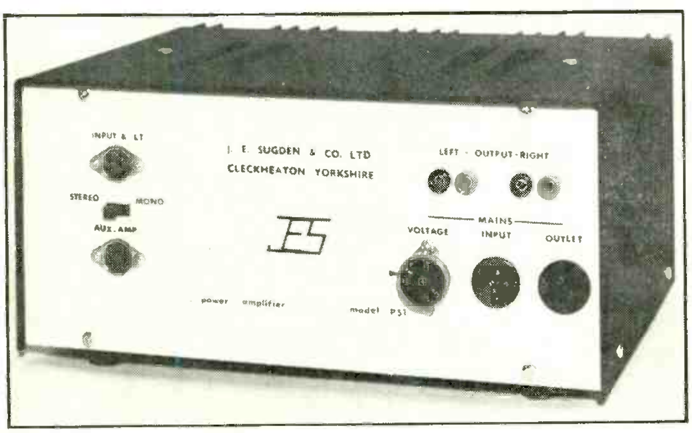
SUGDEN
J E Sugden & Co Ltd, Carr Street, Cleckheaton, Yorkshire BD19 5LA. Phone: 097 62-2501.

P51
No of channels: Two.
Power output: 45W rms channel. Both driven.
Nominal output impedance: 8Ω.
Damping factor: Better than 30.
Power bandwidth: —3 dB at 12 Hz and 35 kHz.
Protection: Current limiting on output pair. Fused.
Input impedance: 300 kΩ.
Gain: (Voltage) 32.
Hum and noise: 90 dB with 4.7 kΩ source.
Distortion: 0.05% thd just before clipping.
Other features: 7 μs rise time.
Connectors: DIN input, banana output and Bulgin mains.
Power requirements: 110 and 240V, 200W.
Dimensions (whd): 29 x 14 x 25 cm.
Wright: 9 kg.
Price: £92.

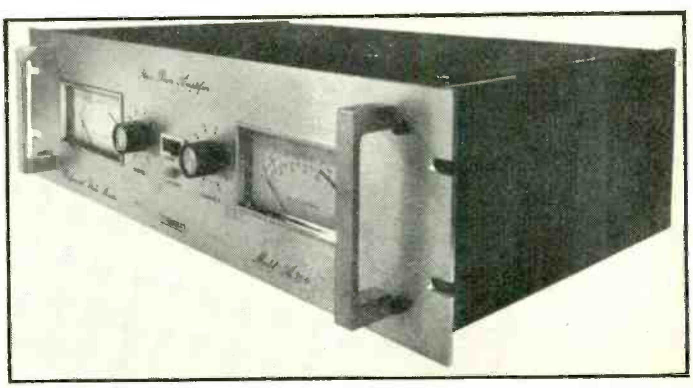
TURNER
Turner Electronic Industries Ltd, 175 Uxbridge Road, London W7 3TH. Phone: 01-567 8472.

A500/A300
No of channels: Two.
Power output: 250/150W rms into 4Ω, both channels driven. 180/100W rms into 8Ω, both channels driven.
Nominal output impedance: 4 to 16Ω.
Damping factor: Better than 300 where it counts.
Power bandwidth: ±0.1 dB, 8Ω at 75W over 20 Hz to 20 kHz.
Protection: 'Complete automatic' including thermal protection.
Input impedance: 10 kΩ
Gain: +4 dBm for 75W into 8Ω.
Hum and noise: 110 dB below rated output.
Distortion: Less than 0.01% thd at rated output into any impedance above 4Ω.
Other features: twin vu meters.
Connectors: Cannon *XLRs*.
Power requirements: 110 to 240V ac.
Dimensions (whd): 483 x 133 x 302 mm.
Weight: 14.1 kg.
Price: £380 and £262.50.

B300/B200
THESE AMPLIFIERS EMPLOY the same signal electronics as the A500/A300, the main difference being in the available power out (150/100W into 4 ohms) due to the incorporation of an unstabilised power supply. Prices are £210 and £160.



Left: *Sugden P51 amplifier.* **Below:** *Turner A300 amplifier*



After four years of troubled business, Command Studios finally ceased operations late in 1974. The background to both the setting up and the subsequent activity is not easy to trace and describe clearly, but may prove a cautionary tale.

Command Studios RIP

JOHN DWYER

COMMAND WAS TO have been one of the largest studio complexes in central London. When the company was formed, money was easy to come by, especially for projects in the booming entertainment business, and it is difficult to avoid the conclusion that much of the sorry tale was the result of baffling financial incontinence.

The story ended with 1974 when its equipment was sold piecemeal last December. It is possible that Simpson's, the outfitters next door in 203 Piccadilly, will expand into Command's premises and that Joe Lyons will give them a new lease for the combination of the old Command place and their own.

Until the last moment Command staff were working on the basis that they could sell the large Studio One to Simpson's and carry on the business in the two studios downstairs. Simpson's have already presented Lyons with plans for alterations to the building which I understand have been rejected but, although no comment is forthcoming from Lyons, it seems likely that they and Simpson's will come to an agreement of some kind.

By the end of the sixties Jacques Levy was no longer associated with Levy studios in Bond Street, which had been bought by CBS, and he wanted to start another studio. Denis Comper had outgrown his studio in Putney and felt he wanted to be involved in something bigger. He and Levy got together and decided to embark on a joint project more ambitious than either could manage separately, and for which Comper said he would try to find a quarter of a million.

John Mosely was brought in at this stage, partly because of his reputation as an engineer. One man I spoke to recalled his first meeting with Mosely, who had come in with a classical recording he had produced: 'I was introduced to this bloke who was dressed like a stockbroker —pin-striped suit, the bowler hat and all that business. He had with him a transfer that had been made from a 7½ and it was brilliant, it really was. It sounded a lot better than a lot of recordings I'd heard at 15.' But in any case Mosely had a number of rich friends, one of whom was Michael Gampell, a solicitor in the firm of Ashurst, Morris and Crisp and Partners and a renowned tax expert.

By now Command had also been introduced to Wm Brandt's Sons, a merchant bank. Brandt's said they would supply half the money if Command, as we shall call the group from now on, could find the other half. This was where Gampell came in. He was acting for Timothy Miller, who had a beneficial interest in the Duncan Trust and who was married to Margaret Miller, *née* Pitman, a member of the family controlling the Pitman trust and daughter of a former director of the Bank of England. Gampell was also a director of Ashmor Nominees, an associate company of Ashurst Morris through which the firm of solicitors could invest. Gampell's other interests were recounted in *Diary* in the July 1973 issue of Studio Sound.

In the end, although advised against investing in Command, Wm Brandt's Sons supplied a good deal more than half, but part of the loan was guaranteed by Mr Miller. Neither he nor Brandt's was willing to say how much of the loan Miller had guaranteed—reliable sources say half—but in any case I understand a writ has been issued, and the laws of contempt of court forbid any further comment.

Having established that the money was available, the group set about looking for premises. After some searching they were offered the old Movietone news studios in Wardour Street which seemed suitable although some alterations would have been necessary.

For reasons that are not altogether clear they did not buy the place. Next they looked at an art gallery in Piccadilly across the road from the Royal Academy. The plan was to turn it into another Abbey Road Number One but Command realised that the scheme was impracticable. Then, further down Piccadilly, someone saw a sign saying 'Recording Studio for Sale'. At the time it seemed an incredible stroke of good fortune.

In the thirties, 201 Piccadilly had been a Lyons restaurant where the trendy set of those times used to collect at tea dances. Then the BBC took the place over and, as the Stagedoor Canteen, during the war years, it was used to broadcast troop shows such as *Itma* and the Ben Lyon series. Glenn Miller is said to have made his last broadcast from there. In the fifties it became known as Piccadilly One and the BBC used it for shows from the *Dales* to *Saturday Club*. Then the BBC started to close its outside studios and by the time they came to sell Piccadilly One the studio was obsolescent in any case.

For Command the place seemed ideal. The standard of engineering was described to me as 'immaculate'. 'It was so easy when we went in there; all we had to do was follow the standards that had already been set.' On the ground floor was the large Studio One, 7.3m high with a floor area of 223 m^2 (2400 sq ft). On the floor below were two studios. Studio Two had an area of 102 m^2 and Studio Three an area of 84 m^2. Between them was a vocal booth which could be used for either studio and which had an area of 13 m^2. The two studios were connected by a short corridor next to the booth along which were two double and two single doors. 'The isolation was superb,' said someone involved in the project. 'You could put a rock group in one studio and a string quartet in the other.' The upper studio, Number One, was a fully equipped theatre with lighting, dimmer panels, tip-up seats and so on. The control room had been built on the balcony and was reached from the studio by a spiral staircase.

Having found the premises they needed, Command was formed as a limited company in April 1970. Brandt's supplied a loan of £200 000 at three per cent above bank rate. The various other parties supplied another £50 000 by subscribing to the 10 000 shares that were issued at a premium of £4, so that each share cost £5. According to records at Companies House, Brandt's took 2998 shares, Ashmor Nominees 3000, Gampell and Miller 400 each, Levy and Comper 1100 each and Mosely 1000. Later another 3000 shares were issued and a bank overdraft was secured with Barclay's which had preference over the loan from Brandt's. Later records show that Miller had increased his shareholding to 2000 and that the Duncan Trust, with which he was associated, had a further 1500.

The newly-formed company had the lease, which ran for 21 years from Christmas Day 1955, assigned to them by the BBC. The rent was £12 000 a year, plus the cost of various insurances on adjacent properties, and rates were £10 850. The premises cost Command £40 880.

Mosely stresses that he had been out of the recording business for ten years and so had said that, if Levy and Comper would tell him what they wanted, he would do it for them. He was not interested, for various reasons, in becoming an employee of Command, and wanted to continue to devote much of his time to his other interests. Thus Comper specified the layouts and ergonomics of the equipment and Mosely set about the detailed design.

One explanation offered to me for Command's subsequent troubles was that they spent too much on externals and not enough on essentials. Another confirmed this view: 'All the gear was bought on the cheap and the place was made to look good'. All the same, accounts for the 18 months to September 30, 1972, three months before the receiver was appointed, show that they spent £129 000 on equipment, and that another £33 000 was paid in fees for the design of that equipment. Comper is emphatic that he received none of these fees, and recalls that they went to an American company called Kitt Associates. Other sources confirm this. 'One thing that has always disturbed me is the fact that, as a director, I only found this out at a much later date and then only by accident.' He also says that subsequent efforts to trace Kitt Associates proved fruitless. John Mosely confirmed that the fee went to Kitt Associates and said that it was a way of writing-off profits. I asked him if he could make a little clearer exactly what the transaction involved, to which he said he could, but that he would prefer not to. He said it was not true that he did the design and that someone else got paid for it, but neither was it true that he was paid for the designs. He knew the name Kitt Associates, 'but it doesn't concern what you're writing about'. Miller, and API, were also reluctant for any attention to be drawn to Kitt Associates.

The receiver issued a document at one stage in Command's career showing that the maintenance, disc-cutting and classical balance engineer got £2000 a year, two of the balance engineers got £1800 a year, another got £1300 a year, a disc-cutting engineer was paid £1500, a maintenance engineer £1400, two trainee balance engineers £15 and £12 a week respectively. The Chairman of Command received £5750.

Another £34 000 was spent on improving the premises. It is possible to say, with the wisdom of hindsight, that had Command confined their activities to the two lower studios, or even had they opened them first, the story might have been different. Instead they built and re-equipped the studios in numerical order, biggest first.

During the summer of 1970 Mosely built the disc-cutting facility and the copy channel; he was once a senior executive at Scully. Studio One took longer to finish than they had thought it would but, with that working, they were able to open for business on November 2, 1970. Many of their difficulties with the equipment, it seems, began with the desks. The first desk, for Studio One, had arrived during the summer and, because of the difficulty of getting it into the control room, two wires on the jack bay broke and had to be repaired when the desk was in place. But there were such extensive faults apart from this that the desk had almost to be rewired. John Mosely remembers that the second desk arrived in January and was working satisfactorily within a week, and that there were even fewer problems with the third desk, which arrived in March or April. However, an engineer who used the desk contests this, saying that the desks were never right at all: 'It wasn't a proper multitrack desk. The desks worked, in a technical sense, but not properly. For example, in Studio Three I once said there was a difference in tone between line in and line out—I could hear it, but I was ignored. Then a year later they discovered that I was right.'

Again, John Mosely recalls and Denis Comper agrees that the initial design of the desk was set out by Comper to be realised by Mosely and built by API. Mosely decided where to buy the equipment. I asked him if it were true that he had visited API in the States before the desks were delivered: 'Yes. There were a great many things wrong with the desk and I accept that it was my responsibility.' He added that API had experienced production difficulties.

It appears that these were rectified shortly after; in any case most studios, Mosely said, had similar problems when any equipment first arrived. Each module at Command, with the possible exception of the compressor limiters, worked well to a high specification, but the faults seem to have been the result of less than perfect assembly. The problems he experienced at Command did not prevent him from going to API again to order a desk for Studio Ferber in Paris; according to a reliable source not working at Ferber, the Ferber API desk was plugged in 'and literally worked straight away'. It has a great many more facilities on it than the Command desk and it has been admitted that the Command desk was too simply designed for multitrack rock work. One Command engineer has said: 'I remember doing a session where I had to use all four outputs, the echo send and the foldback as well'.

The first session at Command was an album by Peter Knight of the music from *Catch My Soul*, for Polydor. John Mosely engineered. Although some of the takes were eventually used the session was beset with difficulties. One of the most crucial was that the power supplies, which were mounted in the desk, were overheating both themselves and the rest of the electronics. The microphone channels and foldback were affected and, in the end, the power supplies cut out in the middle of a take. According to the minutes of a board meeting held later that month Command feared that that session could make them liable for as much as £1000.

By the time the power supplies were put in a separate rack with a cooling fan, disagreements among the directors were beginning to surface. Jacques Levy, who had been managing director, 'resigned' from the board in February 1971 for reasons which he still declines to disclose: 'Let's just say we didn't see eye to eye'. Whatever the mechanism, it was around then that John Mosely began to take a more active interest in the studios. As has already been said, at first he was brought into Command as a consultant to help set up the studio and then to be called in whenever the others decided he was needed.

How the balance shifted is indicated by an advertisement placed on the inside front cover of Studio Sound in June 1971. The ad was taken by Dolby Laboratories, who had innocently captioned a photo showing Mosely at the console in Control Room One with the description of its location as 'John Mosely's Command Studios'. Whatever effects this may be said to have had on Command's prestige it cannot have promoted an atmosphere of comradely feeling within the studio.

The staff were getting restive. 'In the beginning,' said one, 'we were all very keen. It was a very good team . . . but in the end everyone got demoralised.' The more people you talk to about Command the more consistent the reasons for this process of demoralisation appear to become. It is impossible to relate what happened at Command without examining the interaction between the personalities of the staff there and of John Mosely.

The more thoughtful of his former associates realised what he was trying to do and would have been a great deal more in sympathy with his efforts had he been more approachable. 'A lot of us respected him for his knowledge,' said one, 'he is a clever bloke. His ideas were right, but there are ways of getting people to do things.' Another said: 'He was to Command what Edward Heath is to the Conservative Party. His principles were right. He simply wanted the very best for the studio, but he had to do it his way . . . He wouldn't listen to anyone else.'

Mosely was courageous enough to admit this. 'I was brought up in the school of hard knocks,' he said. 'I started at Westminster Recordings in the early fifties and, in those days, you had to be competent both musically and technically.' He remembered that he had to line up equipment to within 0.6 dB from 50 cycles to 15 kHz. 'There were no excuses, you just did it, you worked at it day and night until you got it right.' At Command he had not been prepared to make any compromise and he now realised, he said, 'that it was not the studio for it . . . You have to have certain standards . . . I admit I am very intolerant of people who have lower standards than myself.' 'He wasn't afraid to work as hard as the best of them,' said another of his colleagues. 'He'd muck in and work as long hours as anybody else.' However, one source of irritation was that much of his efforts appeared to the engineers to be devoted to projects of his own in free time.

It has been said that John Mosely was only interested in doing classical work and was contemptuous of rock musicians: 'That's not true. I like working with rock musicians. I'll work with any musician, whether he's a rock musician or anything else, as long as he has a professional attitude to what he's doing—I'm working now with a musician for whom I have nothing but the highest respect, Pete Townshend. As far as the customers at Command were concerned, half the people we got were OK, but the other half . . . it is true that we didn't enjoy the best clientele. They'd leave coffee cups on the equipment, and it would be covered in ashes. They just exhibited a complete lack of respect for the medium, that's the only way I can put it.'

Many of his differences with the engineers centred around their tolerance of these condi-

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tions. 'In the better studios every night someone comes round and clears up.' At Command, he said, he had to do it himself, and cables were left lying around unwound. 'The trouble with the Command people was they regarded it as a job . . . the people were all wrong. I would never do it again without knowing the people. They were wished on me.' He also said they were clockwatchers. One reply to all this was: 'Isn't every studio the same? I personally was very keen. I'd start at 9 am, which meant arriving well before that, eight or eight-thirty, to set up. I never had a tape op—I had some help later on, but never enough—and then I might go on till four or five in the morning; this went on for a long, long time. You weren't finished even then, of course, because you had to break it down after the sessions, and then be ready to come in at eight again.'

Working as an engineer cannot have been easy at Command for other reasons. It is odd to find, when you talk to people who used to work there, so many of them talking about 'the management' and 'the workers', particularly in a business as relaxed as the recording industry is supposed to be. Part of the considerable friction that existed between Mosely and Comper can be explained by the fact that Comper seems to have interceded for the staff with the rest of the management team of which he was supposed to be a member. Most of the engineers say they had a hard time convincing others that they did not expect to be interrupted, watched over or lectured in the middle of sessions. Two of them mentioned individuals, accompanied or otherwise, sweeping in in opera cloaks while the light was on. 'It took a long time to convince them that you had enough to worry about on a session without someone barging in in the middle of it.' It was even said that Miller, whose function it was to collect money, had even sometimes asked for payment in the middle of sessions. 'There were a lot of unnecessary pressures on the engineers. You were well tensioned up as it was, then you had, for instance, to stop a session if you wanted to make tea. There was too much pressure on the workers . . . If they'd listened to the workers it would have been different.'

The result of this friction, which surfaced regularly—on one occasion between Comper and Mosely in a shouting match in front of the staff, and on another when the engineer was bawled out in front of a client—was that the atmosphere deteriorated.

One evening early in April 1971 the staff had a meeting at which they compiled a massive list of disagreements and recommendations. They objected to their being accused of theft, among other things, and said 'staff expect to be treated with respect as adults and engineers. They feel they come to work in a business and not something which should be treated as a hobby.' The number of clients, large at first, began to decline. Miller comes in for some criticism: 'I may have been difficult,' said Mosely, 'but Miller was impossible. He wouldn't even be polite . . . to rock musicians.'

Technical difficulties, too, persisted. In Studio Two the design of the desks was such that if too many facilities were used at once, on the monitors, for example, the circuits supplying them would overload. The false ceiling in the studios was some feet below the original ceiling and bass was absorbed by the ceiling and the cavity between the two. 'The top end didn't stop reverberating,' said an engineer. 'It sounded as if you were mixing in a cellar.' Another engineer once thought he was getting a good sound out of Studio Two and then took the tape over to another studio, and was humiliated by the result when played back in more correct conditions. A third, Denis Comper, who didn't do more than a couple of sessions at Command, told me what it was like on one of them, a speech session for Paul Myers: 'I found myself in the wretched position—you don't know how wretched until you've been in it—of doing a session knowing that I couldn't hear what was going on. I knew the noise from the Piccadilly line was going on to the tape and I couldn't hear it.'

I asked one engineer how, if all these things were true, the BBC had managed: 'Well they weren't doing multitrack rock sessions. They're working at low level with no need for separation and no absorption.' Another reasoned that the BBC had been using the studio for a totally different purpose, and had worked in mono. Why were these conditions allowed to persist? John Mosely: 'The acoustics were not ideal but I didn't object. Yes, the BBC had used it and we refurbished what the BBC had put in. After all, in the old days of classical recording you couldn't pick and choose the acoustics in which the recording was made—you had to make them in the conditions which you were given.' He thought the acoustics were an excuse, and didn't go along with their being responsible for Command's downfall. 'For example I have just made a recording in a studio in the States. The first recording I made there had too much bass and too much top. Next time I went in I allowed for that and changed things accordingly and it's been all right since.'

A contributing factor was that, as often happens in show business, the people who used the studio were reluctant to make any adverse comments at the time. They would merely make appreciative noises about the studio and not come again. However good or bad the studio was technically, the tension among members of the staff cannot have helped business. John Mosely does not think this was a contributing factor.

'We didn't have the right engineers. None of them had a commanding reputation—they had a following, but none that would keep us in business.' Against that must be placed the fact that so many of the engineers who were then at Command have done so well since. 'There were bad vibes all round,' said one of them, and insisted that they lost business because of it.

Eventually it was decided that the only way to make a go of the studio was to form their own production company. So Eddie Kennedy, a business associate of Denis Comper's who had a publishing company and some artists, was brought in. Apparently Command gave Kennedy a percentage on whatever business he could bring into the studio and allowed him to give away some free time if necessary to encourage custom, a facility which some

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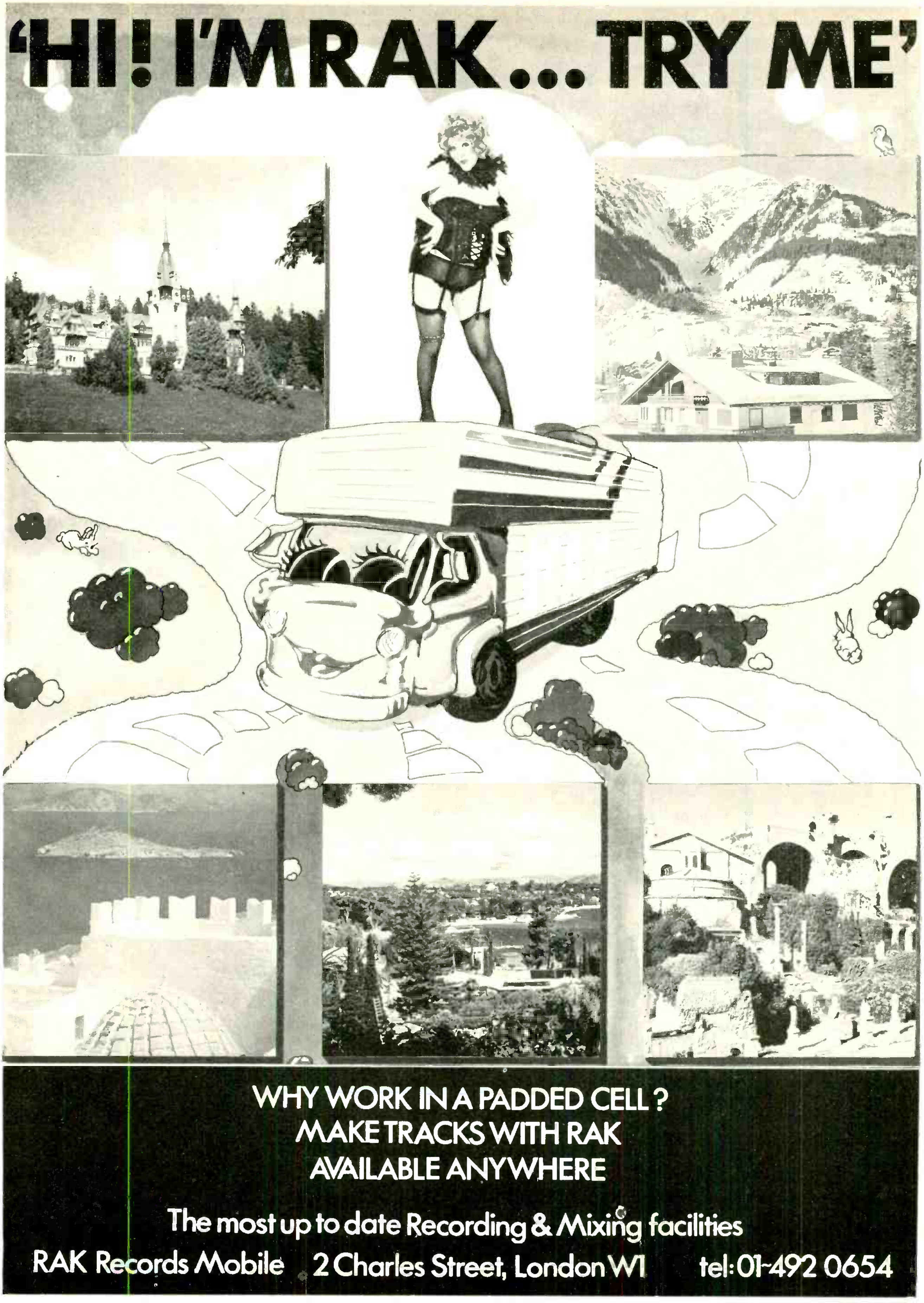
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avaricious band managers were only too eager to take advantage of.

In July 1971 Command got the overdraft from Barclay's bank. The necessity for this was not, apparently, to build and open the Rock Box, which was launched the following November, but to cover running costs. 'People were not paying their bills,' Mosely recalls. The money to build the Rock Box had been allowed for in the original estimate of the amount of money needed for the whole complex. Mosely had seen the Rock Box in the States and had thought it a good way of attracting business. Here again there were problems: the row of 'soundproof' booths had a common floor. The drum booth was considered ridiculously small.

The first director's report and accounts covered the period from April 1970 to September 1971. The turnover of £116 499 represented only the amount invoiced to customers. There was a trading loss of over £77 000 and a loss of £84 000 could be set off against future taxable profits.

Mosely was made managing director in September 1971. 'I then brought in Mrs Wannel, who had worked with me at Pye. He admitted her appointment wasn't popular. 'Miller didn't want her, I know that, but if you ask anybody in this business who has an opinion worth asking she was both liked and respected by all of them, and I wouldn't hesitate to give her the highest recommendation.'

'Hermi Wannel was a nice woman,' was one opinion, 'but the trouble with Command was the management was always older people; there were never any young people running it'. Not long afterwards Comper, who had brought Eddie Kennedy into Command, was told that he was responsible to Kennedy; shortly after this he was admitted to hospital suffering from a total nervous collapse.

While Comper was away, Brandt's (who already had someone on the board, Peter Nutting, whose job it was to keep an eye on their investment) sent in John King to shake the company up in the hope that Brandt's might get some of their money back. Changes, King judged, were necessary, and this time it was Mosely and Comper who were under the shadow.

By this time John Mosely had appeared to alter his way of running the studio: 'He had started to bend six months before the end but by then it was too late,' said one of the staff. Another said: 'He did realise the mistakes he'd made. There was remorse there, there's no doubt about that.' Mosely clearly recalls the moment when he knew the thing had gone wrong: 'I admit now that the redecoration was wrong—it was wrong to do it in the same way as the BBC had done it—the consoles were wrong for the job they had to do, the atmosphere was wrong and the people were wrong. I went to Midem in January 1972 and it was there that I got the message. I realised we had gone about it totally the wrong way. When I came back I wrote a memo, which I still have . . . in which I detailed everything wrong with the studio. I made a list of things which would have to be put right before the studio had a hope of success. They turned me down.' In February he gathered the staff together and said goodbye.

He started another studio in Paris not long after: 'I did to the letter what I said they ought to have done and, I'm not telling you the figures, but the business we did last year was astronomic. In Paris their standards are so much higher, the people are so much more dedicated—it's like a kind of club.' He has also formed closer links with Sansui and has involved himself in film work. About Command he said: 'I don't know if you've discovered this but few things work out in life the way you'd like them to'.

Comper's job at Command was to sell studio time, a function in which, it is not too surprising to relate considering the quality of what he had to sell, he was less than successful. 'A great guy,' said one engineer, 'but I think some of the friction should have been kept under wraps'. Another said he thought he would have done very well at production as he had been doing at Polydor: 'It may be that promotion and publicity didn't suit him. He didn't do very well at it.'

When King suggested that Comper resign Comper offered to run the company for six months and said he would do so if it hadn't turned round by then. This offer, too, was refused, so he sold his share and he left on March 31, 1972, a month after Mosely. Both ceased to be directors on May 31, 1972. Kennedy left a few months later, having had a row with what was left of the Command hierarchy.

Around this time technical changes were made. The Altec speakers were replaced by Lockwoods and the cutting room acoustics were altered. Negotiations were even conducted with Robert Masters with a view to his buying the studio, but in the end he said that the figures weren't right. Brandt's appointed a receiver manager on December 27, 1972.

After that any number of people approached Command and were approached by them to buy the place. Interested parties at one time or another: Chrysalis, MPS (German record company taken over shortly before by BASF) Monty Babson, Philips, Advision, Mecca and a number of individual buyers. Some have said that the receiver manager should have been more aggressive in putting the company right and in trying to sell it. One stumbling block that most of those connected with the studio have mentioned is the shortness of the lease, which expires on Christmas Day next year. J. Lyons and Co, who own the property, would not say why they would not renew the lease. Apart from the shortness of the lease, however, it is also true that Command had little goodwill to offer. Any studio that started up in the place would have had to change the name and address—there is an entrance in Jermyn Street. Hermi Wannel has mentioned another difficulty in the rent and rates: 'The rates have just gone up by 35 per cent,' she said, 'and they're going up again in May'.

One group, who were trying to buy Command right up to the last minute, thought that if the studio could be put right and shown to be a thriving concern Lyons might be persuaded to extend the lease. They had enough business, they thought, to fill 40 per cent of the available studio time, calculated for an 18-hour day. At that rate they would have been making a small profit, they estimated, and could find more business to fill the rest of the available time once the studio was seen to be successful.

These anonymous purchasers even hoped that, if the lease were not renewed, they could move over a weekend at the end of two years. In the end they concluded that the project would have needed a six-month starting-up period, a six-month running down period, and another six months to start up somewhere else. They were also not convinced that they had all the information they needed to take the risk.

The final act in the Command saga has a more disturbing aspect. Jack Davis, the chief engineer, and the rest of the staff had begun to put matters right as soon as the receiver went in. All the studio control rooms were acoustically tested by Eddie Veale early in January 1973. Then they retreated the walls and as much of the ceilings as they were able, repainted and carpentered where necessary, and lowered the monitors to points nearer the floor. 'They did far more than the jobs they were paid for,' said Davis.

They had abandoned Studio One as hopeless ('the white elephant,' someone called it) and concentrated on correcting faults in the two studios downstairs. They finished Control Room Two in May last year and it was retested the following month. It had measurably improved, and any reservations a visiting engineer expressed about the sound could be put down to personal taste. On July 8 they began work on Studio Three and finished in October. This time there was a severe bass absorption at 80 Hz because, as in Studio Two, the staff had not had the resources to treat the ceilings properly and the cavity above Control Room Three had a more marked effect.

After all this work they found that two lots of one hundred hours' studio time had been sold at £10 an hour, well below the price previously agreed at a staff meeting. Nevertheless, right up to the last minute they believed that the studio was making a profit. They were told that the studio had been through a bad patch but that that was all over. Then, on October 31, they were given a month's notice. They had just learned that it would have cost only £400 to put Studio Three right.

The news that Command was to be liquidated was a shock. 'It cut the ground from under our feet,' someone said. 'It was a complete bolt from the blue. I couldn't believe it. You keep thinking right up to the time you start cutting cables, you think a fairy godmother is going to come along to give it a new lease of life.' But another said: 'Superficially we were one big happy family . . . but underneath I don't think any of us reckoned it was going to be saved'.

In the end losses for tax purposes amounted to nearly £150 000. In the six months to June 30, 1974, gross sales were £26 792 and the net loss for the period was £43 552. Malcolm Jackson was asked to dispose of the equipment and fittings and to try to realise as much for these as he could. He produced an inventory that totalled about £85 500. The viewing days were held at the beginning of December. Jackson said much of the stuff had already been sold by then, though some items were still on sale in January. He told me then that he would soon be dealing with two other studios—he wouldn't give the names—in the same way.

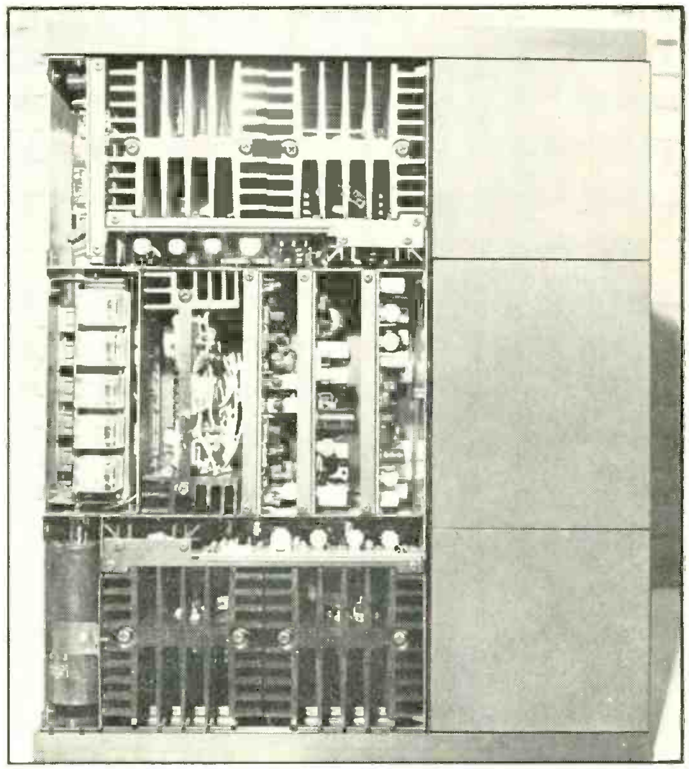
AGONY COLUMN

The session was just strings and solo Spanish guitar and the producer in the box was having difficulties sorting out a reasonable balance. They tried it several times but kept losing the guitar among the strings. 'We're having problems in here,' boomed the producer's voice over the talkback, 'we aren't getting enough guitar—let's try it once through without strings'.

'OK, you're the boss', came the guitarist's voice back through his mic, 'but it'll take ten minutes to unstring it, and then all you'll get is a sort of scratching sound'.

YAMAHA FET POWER AMPLIFIER

Hugh Ford



MANUFACTURERS' SPECIFICATION

Continuous rms power output, both channels driven at 20 Hz to 20 kHz: 8 ohms 150+150W, 4 ohms 150+150W; at 1 kHz: 8 ohms 160+160W, 4 ohms 160+160W.
Dynamic power (ihf, 8 ohms): 360W.
Total harmonic distortion: 8 ohms, 100W at 1 kHz 0.02%, at 20 kHz 0.06%; 8 ohms 1W at 1 kHz 0.02%, at 20 kHz 0.03%.
Intermodulation distortion (70 Hz:7 kHz=4:1 SMPTE method) 8 ohms 100W: 0.04%.
Frequency response, 8 ohms 1W: 5 Hz to 100 kHz +0, −1 dB.
Power bandwidth (ihf distortion 0.5% const): 5 Hz to 50 kHz.
Damping factor (1 kHz 8 ohms): 80.
Input sensitivity: 0.775V for 100W.
Load impedance: 4 to 16 ohms.
Price: £600 approx.
Manufacturer: Nippon Gakki Co Ltd, 10-1 Nakazawa-Cho, PO Box 1, Hamamatsu, Japan.
UK agents: Natural Sound Systems Ltd, Strathcona Road, Wembley, Middlesex.

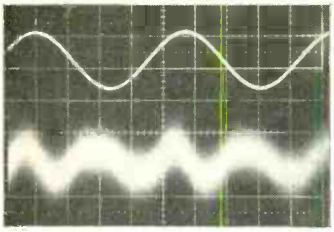
DURING LAST YEAR, the Yamaha prototype fet power amplifier received much publicity, and in fact I had the opportunity to do some work on number 001 which showed some very good characteristics. Now, after a short time, I have the pleasure to undertake the first UK review of the production amplifier, and a 240V version at that.

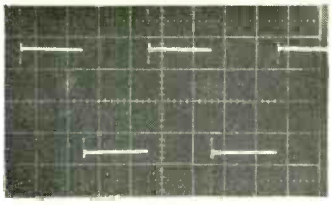
What is so special about the fet power amplifier? One of the very important features of this amplifier is that where manufacturers of high power amplifiers use a multitude of paralleled output transistors, the Yamaha uses single high power field effect devices—the outcome being that the virtually impossible task of matching multiple output transistors for minimum crossover distortion is eliminated. Naturally, the Yamaha power fet has to be a pretty substantial device to replace the usual collection of output transistors, and it may interest readers to contemplate the performance specification of the prototype fet. It could handle a gate-to-drain voltage of 200 to 300V; dissipate 300 watts; accept a drain current 10A, the voltage amplification factor being typically five with an internal drain resistance of typically five ohms and a transconductance of 1000 millimhos. Further advantages of the use of such a device are that fets offer a very good frequency response without the problems of majority carrier storage (hole storage) which is a common cause of crossover distortion and also that they have improved temperature stability such that they are not prone to thermal runaway.

The amplifier uses the fets in class AB configuration with compensation for the small differences between fets, the drivers also being smaller power field effect devices. While the high power supplies are not stabilised, independent power supplies are used for the two amplifier channels and overload and short protection is built in, as well as a loudspeaker protection which is said to disconnect the speakers if more than ±2V dc appears at the amplifier output. While the input sockets are ac coupled, all subsequent stages are dc coupled and use multiple pairs of transistors to minimise drift. So much for circuitry; not surprisingly, the manufacturers' specification is not particularly descriptive, as this amplifier is so new.

Physically, the amplifier is about 460 mm wide, 415 mm deep and 150 mm high excluding large protective feet below the amplifier; while I do not know if the unit is intended for mounting in standard racks I would be surprised if provision has not been made for rack mounting. However, the enormous weight of the unit of around 45 kg would imply that a rear support would be essential. The complete amplifier is finished in black crackle paint, with the exception of an alloy strip which houses the controls at the front of the unit. The strip is, in fact, a plug-in control panel which as standard houses the two level controls, the power on/off switch and three led indicators one of which signifies that power is switched on; the remaining two are overload indicators which are illuminated in the cases of electrical overload and over-temperature.

The rear of the amplifier provides five pairs of loudspeaker outputs which are switched by internal relays, the operation of





◀ FIG. 1 ▲ FIG. 2

which is controlled by wires which are fed to the front panel plug-in—only the main speaker output is functional as standard. These sets of speaker terminals are intended for accepting bared wires, or terminal pins, and unfortunately do not accept banana plugs or even thick wires.

Two pairs of phono input connectors are provided, one of which is a direct input and the second pair an input via the the front panel level controls—the required pair is selected by a rear panel slide switch. A second slide switch is used to select a rumble filter in the input stages. The remaining rear panel functions are a fixed two-core mains input lead, two mains fuses, an auxiliary (flat pin) mains output and a four pin control amplifier socket which provides for remote power switching. All functions on both the front and rear panels are clearly identified, but the intended function of the multiple outputs is not clear. It is assumed that optional front panel plug-in units will be available to actuate the extra output either by means of extra front panel controls or from a plug-in remote unit.

Mechanically, the standard of construction is to full professional standards, with the output fets being mounted on massive cast heatsinks and the driver printed boards and ancillary functions all being plug-in sub-units which are properly secured in place. The printed boards are made of glass fibre and are partially identified with component references; very sensibly, the pre-set controls and test points are all located in readily accessible positions and are properly identified. In general the overall standard of construction is to a very high quality and to the standards expected of the best professional equipment.

Power output and distortion

Initial attention was directed to the maximum power output available into either four or eight ohms at output clipping point. As is my normal practice, an accurately stabilised mains supply was used, the output being loaded with precision high power wirewound resistors to ±0.5% tolerance and the output voltages being measured by means of an accurate digital voltmeter.

Under these conditions the available output power was found to be as follows:—

	Single channel		Both channels	
	Channel 1	Channel 2	Channel 1	Channel 2
8 ohms 1 kHz	199W	224W	196W	220W
4 ohms 1 kHz	193W	235W	194W	232W

While there is a difference in the output capability between the two channels, these figures suggest that the output power capability is far in excess of the specification, and also clearly show the benefits of separate power supplies for each channel. Total harmonic distortion was measured at 100W and 150W outputs into loads of both four and eight ohms, using the Sound Technology distortion analyser which has an inherent distortion in the worst case in the order of 0.002% and the amazing capability of self-nulling within a few seconds.

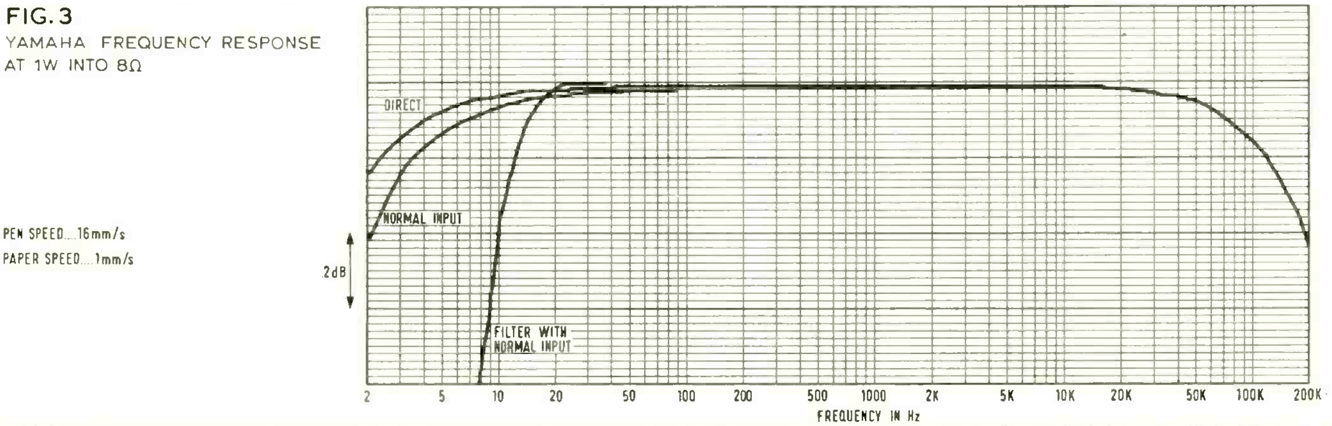
The following table of distortion against frequency shows that the Yamaha amplifier really has exceptionally low distortion at high frequencies, the complete absence of crossover distortion being demonstrated by **fig. 1**, which portrays the 10 kHz fundamental together with the distortion products at 1W into eight ohms, totalling 0.007%.

Load	Power	Channel	Total harmonic distortion (%)				
ohms	watts		10 Hz	100 Hz	1 kHz	10 kHz	20 kHz
8	150	1	0.01	0.01	0.01	0.07	0.074
8	100	1	0.006	0.006	0.005	0.02	0.05
8	100	2	0.006	0.006	0.0047	0.018	0.042
8	1	1	Limited by hum		0.0082	0.007	0.015
4	150	1	0.011	0.011	0.046	0.044	0.094
4	150	2	0.008	0.008	0.031	0.029	0.065
4	100	1	0.007	0.007	0.0048	0.039	0.068

Particular note should be taken of the high frequency distortion performance at the output level of 1W into eight ohms, as this standard of performance is quite exceptional, while there are several amplifiers which have better mid frequency performance; but I doubt if the difference between 0.005% and 0.002% at 1 kHz is audible. Both the harmonic distortion performance and the intermodulation distortion performance as measured by the SMPTE method with 50 Hz and 7 kHz tones in the amplitude ratio 4:1 are far better than the manufacturer's specification.

Equivalent peak sinewave output into 8 ohms	Intermodulation distortion to SMPTE method	
	Channel 1	Channel 2
150W	0.021%	0.024%
15W	0.020%	0.015%
1.5W	0.013%	0.010%
150 mW	0.011%	0.010%

FIG. 3
YAMAHA FREQUENCY RESPONSE AT 1W INTO 8Ω



Square wave testing into resistive loads gave an excellent performance, but the application of eight ohms in parallel with 2 μF produced a rather excessive overshoot as is to be seen from **fig. 2**, which portrays an amplified 1 kHz squarewave. The measured amplifier rise time when loaded into eight ohms was measured at 2μs, with an associated slewing rate of 22 V/μs, both of which indicate the good performance of the fet output transistors.

Frequency response and noise

Nominally there is only one amplifier control which should affect the overall frequency response, and this is the rumble filter; it was, however, found that the choice of direct or normal input also had a small effect at low frequencies. **Fig. 3** shows the overall response using the two alternative inputs, and also the effect of the rumble filter which offers rapid attenuation below 10 Hz thus providing not only rumble rejection but also protection of loudspeakers from infrasonic frequencies which are so good at removing cones. Certainly the overall response of +0/−1 dB from 15 Hz to 80 kHz with the rumble filter switched in is more than adequate for audio work.

The manufacturer's specification does not mention the noise performance, or really suggests any rated output. It was felt that an output of 150W into eight ohms was a fair benchmark for measuring the noise performance, and the following table shows output noise related to this output power with the input shorted and with the front panel level control at its extreme positions.

Condition	150W into 8 ohms to rms noise: Maximum gain, Channel 1	Maximum gain, Channel 2	Minimum gain, Channel 1	Minimum gain, Channel 2
20 Hz to 20 kHz unweighted	—109 dB	—109 dB	—112 dB	—112 dB
'A' weighted true rms	—112 dB(A)	—112.5 dB(A)	—115 dB(A)	—116 dB(A)
50 Hz hum	below —121 dB			
hum harmonics	below —130 dB			

Having regard to the input sensitivity of 0.775V rms for 150W sinewave output into eight ohms, the noise performance is certainly beyond reproach.

Inputs and outputs

The sensitivity of the direct inputs, and of the normal input at maximum gain is essentially identical at 0 dBm for 150 watts output into eight ohms. However, the input attenuators provide for a maximum attenuation of 17.5 dB allowing an input of +17.5 dBm for 150 watts output—it is not felt that this provides adequate range for many applications. Measurement of the input impedance of both the direct and normal inputs showed that not only were the inputs virtually identical but also that the impedance was to all practical purposes unaffected by the gain control setting—the maximum variation of input impedance being 96 900 ohms to 99 100 ohms at 1592 Hz.

Fig. 4 shows the relation between output impedance and frequency, the impedance being constant at 0.085 ohms below

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FIG. 4 YAMAHA OUTPUT IMPEDANCE

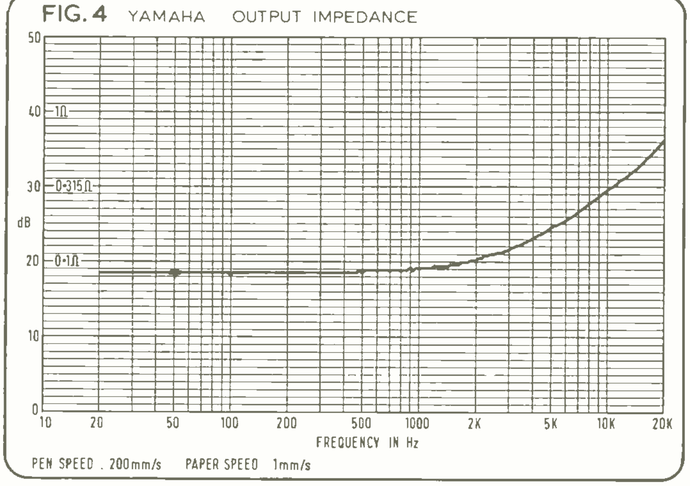


FIG. 5 YAMAHA CROSSTALK AT 150W INTO 8Ω

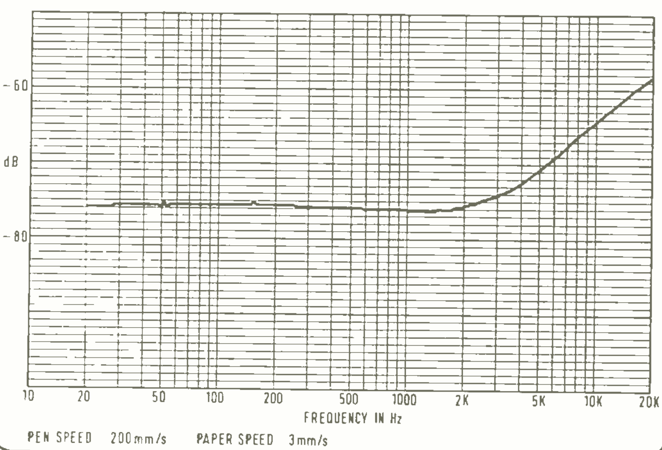
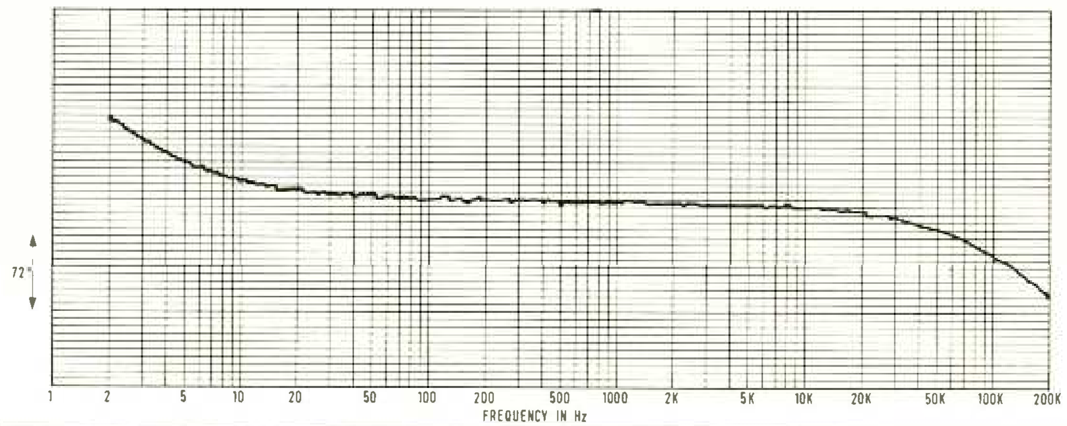


FIG. 6
YAMAHA
PHASE SHIFT
AT 1W INTO 8Ω



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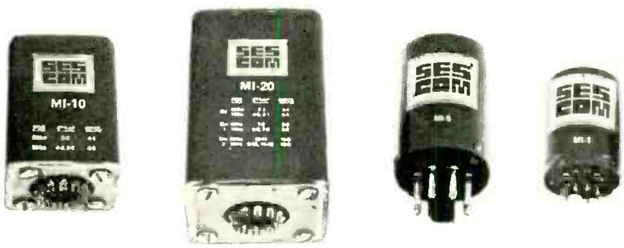

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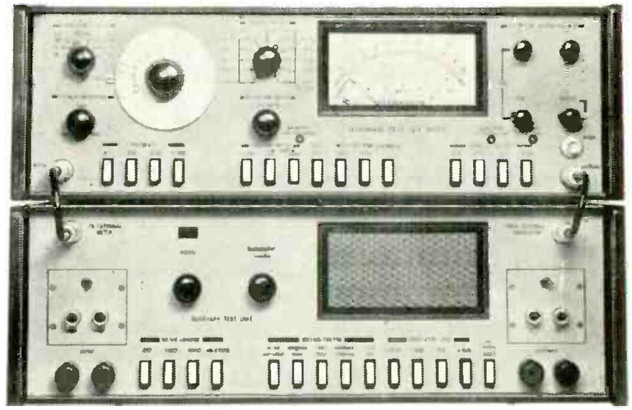

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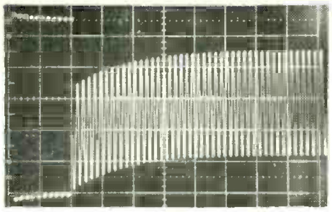


Fig. 7 Showing dc offset (see text)

500 Hz and increasing to 0.63 ohms at 20 kHz. While the relatively high impedance at low frequencies gives a damping factor of 94, this is unlikely to be of significance for audio purposes where the loudspeaker lead impedance is usually the controlling factor.

Other matters

Crosstalk between the two channels is shown in **Fig. 5** with one channel driven at 150W into eight ohms and the other channel with its input terminated into 600 ohms; certainly a crosstalk of −76 dB below 2 kHz is more than is required in practical operation!

A further matter which gives no cause for complaint is the overall phase shift as is shown from 2 Hz to 200 kHz using the normal input. From **fig. 6** it is to be observed that any phase shift is negligible in the audio frequency spectrum, and that nothing alarming happens outside the audio spectrum.

In the context of protection, the amplifier tripped its power supplies in the event of severe overload, and by severe I mean long term operation well beyond output clipping. Restoration of power is automatic. But I am a little worried about the presence of dc in the output when the amplifier has been driven into relatively heavy clipping without tripping. This situation is shown in **fig. 7** which depicts a 100 ms toneburst of 100 Hz driving the amplifier into heavy distortion, the burst being followed by a normal sinewave signal of lower amplitude. It is to be seen that a 20V dc offset occurs after the toneburst, and takes about 150 ms to restore the correct dc level.

The actual operation of the overload protection circuit was quite painless, and it was found that continuous operation at any level below clipping point was possible into either four or eight ohms without operation of the thermal trips at normal room temperature of 21°C.

Summary

The Yamaha amplifier certainly does all that the manufacturer claims, and there is no doubt that the high frequency crossover distortion problem which is typical of many power amplifiers has been eliminated.

In all other respects the Yamaha amplifier is competitive with the very best amplifiers that I have had the opportunity to evaluate, but the squarewave overshoot into capacitive loads could be improved and I am suspicious of the possibilities of loudspeaker damage by dc shifts which occur after substantial driving into overload.

AMCRON M600 AMPLIFIER—

Hugh Ford

MANUFACTURERS' SPECIFICATION

Rms power response: +1, −0 dB dc—20 kHz at 600W into 8 ohms; +1, —0 dB dc—15 kHz at 1 kW into 4 ohms.
Rms power at clip point (<0.01% THD at 1 kHz): Typically 750W into 8 ohms, 1350W into 4 ohms.
Rms burst power (ihf): Typically 840W into 8 ohms, 1600W into 4 ohms.
Dc output: Typically 20A max. (supply fuse limited) at 100V or 2 kVA.
Frequency response: ±0.1 dB dc to 20 kHz at 1W into 8 ohms; ±1 dB dc to 100 kHz at 1W into 8 ohms; ±1 dB 10 Hz to 100 kHz at 1W in ac coupled input mode of standard input plug in.
Phase response: +0, —15° dc to 20 kHz at 1W into 8 ohms.
Slew rate: 16 V/μs.
Im distortion (60—7 kHz 4:1): <0.05% from 0.01W to 600W (peak equivalent to a single sinewave, rms) into 8 ohms; <0.01% at 600W into 8 ohms or 1200W into 4 ohms.
Harmonic distortion (true rms measure): <0.05% from dc—20 kHz at 600W into 8 ohms.
Output impedance: 5.5 milliohms in series with 2.5 microhenry which are together shunted by 2.7 ohms in parallel with 1 microfarad.
Damping factor (8 ohms): Greater than 400 from dc to 1 kHz at 1A rms. Typically 1500 dc to 100 Hz.
Load impedance: Primarily used at 4 ohms or greater; maximum continuous sinusoidal output power at 2.5 ohms, lower impedance only affecting maximum power; will drive a completely reactive audio load with no adverse effects.
Input gain: 20±1% (26 dB) at standard input with gain control fully clockwise; unity±1% at interlock connector input.
Standard input sensitivity: 3.46V rms ±1% for 600W rms into 8 ohms.
Input impedance: 25K ±30% with standard input; 44.76K ±.5% at interlock connector input.
Hum and noise (20 Hz to 20 kHz): 120 dB below 600W into 8 ohms. Typically 128 dB unweighted.
Dc drift at output: Typically <100 muV/°C with all inputs grounded.
Heat sinking: Forced air with high efficiency coolers (8) which can dissipate 1900W with 25°C intake air at 1 atmosphere (dissipation derates to zero at 75°C). A two speed fan with an intake filter (washable) mounted on the left side of the amplifier forces air through the coolers and out both top and bottom of the amplifier.
Turn-on: May be switch selected for instantaneous or 4-5s of delay after applying power. No dangerous transients.
Low frequency load protection: May be switch-selected to produce shut down of the high power supply for dc outputs >6V at low frequency outputs >600W at 10 Hz and 8 ohms.
Output transistor protection: Short, mismatch, and open-circuit proof; electronic protection operates without flyback pulses, thumps or shutdown.
General protection: High line voltage or over temperature results in shutdown of the high power supplies, each of which are fused. Controlled slewing rate voltage amplifiers protect the amplifier against rf burnouts. Input overload protection is furnished by a resistor at the input of the amplifier to limit current.
High power supply: 2 x 1 kW transformers with computer grade capacitors storing 100 joules are powered through a 50A relay.
Low power supply: ±15V dc supplies are provided by a current limited shortproof regulator which has automatic thermal shutdown. Supplies are accessible at the input plugin and interlock connector. Shutdown of these supplies results in shutdown of the high power supplies.
Power requirements: 50-60 Hz ac with adjustable taps for 120, 220 and 240V ±10% operation. Draws 80W or less on idle, 1 kW at 600W output into 8 ohms.
Displays: A lighted 102 mm vu meter is driven by a full wave peak catch and hold amplifier having a step response time of <10 μs to a 'O' vu reading. The reading is held for approximately 0.6s, which is adequate time for the meter to respond fully. A two threshold level comparator drives two level indicating lamps. The red overlevel lamp may be switch selected and indicate at 0, 3, 6, 10, 15 or 20 dB below full output. The green operating range lamp may then be switch selected to indicate the range extending to 0, 3, 6, 10, 15 or 20 dB below the red threshold. An amber neon indicator indicates the standby mode (high power supply deactivated). A red neon indicator indicates power on. A green mechanical indicator in the Power switch indicates switch engaged.
Controls: On the meter display are two knobs for adjusting the indicator lamp thresholds. Push-push power switch. On the standard input plugin are an ac-dc input coupling switch and a gain control potentiometer. The lf protection and delay switches are located on the rear panel.
Interlock: Up to eight units may be commonly interlocked such that if any one is requesting the standby mode all units will be in standby. The standby mode may be initiated by opening an external common to ground contact of 10V 3 mA rating; ie an open collector high voltage ttl output or optoisolator output. The ±15V supplies are available through the interlock connector for supplying interlock peripherals.
Input plugins: The standard plugin contains an ac-dc input coupling

capacitor and switch, a gain control potentiometer, and an universal pc layout which may be adapted for input peripherals such as: differential inputs, filters, oscillators etc. Regulated ±15V supplies are provided with the maximum total available current of the supplies limited to 25 mA. The delay mode of amplifier operation may be programmed from the plugin.
Connectors: Standard input, 6.35 mm phone jack; special input, 3 terminal barrier strip routes to the input plugin; output, colour coded binding posts on standard 19 mm centres; ac line, three wire 20A, 120V male connector with 1.5m minimum cable; interlock, 11 pin 'octal' socket.
Construction: Aluminium chassis with 6.3 mm thick front panel reinforced with steel to retain the power transformers, 3.2 mm aluminium side panels. Heavy duty handles on front to ease transport. Plugin circuit boards.
Dimensions: 483 mm standard rack mount (WE hole spacing), 222 mm height, 419 mm behind mounting surface; handles extend 51 mm in front of mounting surface. Centre of gravity is nearly centred, 127 mm behind the mounting surface.
Weight: 41.7 kg net.
Finish: Bright anodised brushed aluminium front panel with black anodised lower extrusion and black anodised aluminium chassis and covers.
Price: £850.
Manufacturers: Crown International, 1718 West Mishawaka Road, JA3-4919, Elkhart, Indiana, USA.
UK agents: Macinnes Laboratories Ltd, Carlton Park Industrial Estate, Saxmundham, Suffolk.

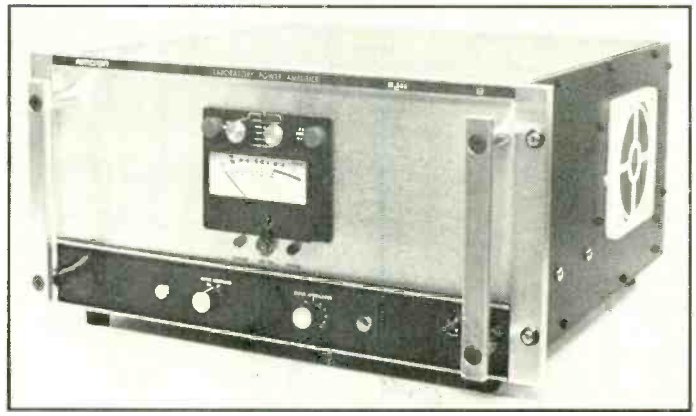
THE AMCRON TYPE *M-600* is a new addition to the well accepted Amcron (also known as Crown) range of high quality power amplifiers which includes the type *DC-300* which is the best amplifier that I have had the pleasure to review.

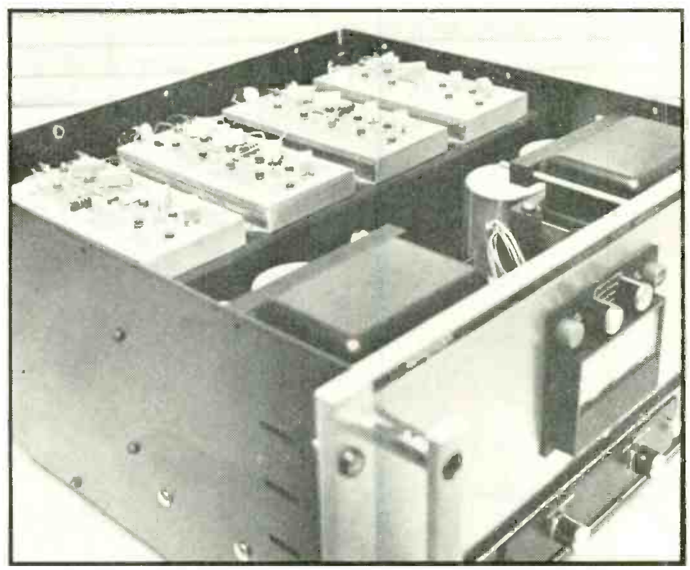
As its type number implies, the *M-600* is a single channel (mono) amplifier which is rated at 600W into eight ohms sinewave power, or some 840W burst power into eight ohms or an astronomical 1.6 kW burst power into four ohms; the sinewave rating into four ohms is 1350W! Clearly, an amplifier with this sort of available drive requires sophisticated protection circuitry, and Amcron have gone to great lengths to provide protection against the common hazards such as shorting the output in addition to providing some more unusual protection circuitry—I was however rather amused to read in the instruction book that the amplifier output leads should be kept away from 'areas likely to be struck by lightning'.

The mechanical construction of the amplifier is rather unusual, and is obviously the result of serious thought about the problems of dissipating a considerable amount of heat as well as providing what is really a compact unit, having regard to the power handling capability. The 32 output transistors, which are arranged electronically into four sets of eight transistors, are mounted in groups of four transistors with each group occupying a finned heatsink which has a corrugated arrangment rather like a car radiator. The eight 'radiator' assemblies are mounted on a tunnel into which cooling air is blown, such that cold air is blown through the fins on the heatsinks. The cooling air is passed through a washable filter before reaching the two speed fan which in normal operation runs at its low speed, but when delivering a great deal of power a thermostat on the heatsinks puts the fan into high speed operation. In normal operation the fan is very quiet, but its noise at high speed might be excessive for some amplifier locations.

All the remaining amplifier and protection circuits are mounted on two plug-in fibreglass printed boards at the rear of the amplifier; unfortunately the component references are not printed on the boards, but this may be because this review amplifier is an early production model. The two large mains transformers are mounted on the front panel of the amplifier, offering the great advantage that the centre of gravity of the amplifier is near the front; this means that there is no excessive strain on rack mounts, which would be the case if the heavy transformers had been mounted to the rear of the amplifier.

The lower recessed part of the rear of the amplifier houses the two fuses, an eleven-pin interlock socket, slide switches for actuating the optional turn-on delay and low frequency protection, and the inputs and outputs. The output connectors are in the form of terminal/sockets on the standard 19 mm spacing which accepts many kinds of adaptors as well as banana plugs. On the input side there is a single pole 6.35 mm jack socket as the primary input, together with an inverting input which is fed to the interlock connector. In addition, there is a three terminal barrier strip connector which feeds to contacts on the input plugin module, which will be described shortly.





The remaining facility associated with the rear of the amplifier is a massive fixed mains lead, which is proportioned to carry the 20A mains current when the amplifier is set for 110V operation. Unfortunately this lead is fitted with one of those horrible flat-pin type American plugs which have the flats at 90° so you can't use shaver adaptors and like! Furthermore, the dimensions of the mains lead are such that it is too large to fit any civilised sort of mains plug. I only wish that equipment manufacturers would not fit fixed mains leads, but fit mains sockets to their equipment so that the mains lead can be unplugged. Anyhow, having had my moan about this, Amcron must be congratulated on the clear identification of all the amplifier sockets, fuses and controls and also on the wealth of information contained in the albeit

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provisional instruction book that was supplied.

Turning now to the front panel facilities, the two heavy duty carrying handles protect the level meter and the various controls from accidental damage when the amplifier is placed face down. The lower part of the front panel has at its centre the input plugin which takes the form of a detachable panel to which is attached a plugin printed circuit board. In the amplifier's standard form, the input plugin houses a gain potentiometer and an ac/dc coupling switch which inserts a 1µF capacitor in series with the jack input. However, the idea of the plugin is that users can construct their own input circuitry for balanced inputs, tone controls, filters, oscillators etc. The panel of the plugin has consequently been laid out for up to five controls, and the printed board is in the form of a universal strip board measuring approximately 10 cm × 7 cm. Power to the strip board is provided by the amplifier power supplies at ±15V up to 25 mA and the connector is ready wired to the amplifier's standard input (jack socket), the barrier strip on the rear panel, the amplifier input and finally to the interlock circuitry. This leaves twelve spare contacts for other purposes.

Working upwards from the input plugin, one comes to the power control switch and two status indicator lamps, one of which shows that power is applied and the amplifier is switched on, and the second of which is illuminated when the amplifier interlock is completed and the main power supplies to the drivers are activated.

Finally there is the level indicating system which is far superior to that normally found in amplifiers. At first sight the level indicator appears to be a vu meter, but in fact the meter has an extremely fast rise time which in association with a hold circuit gives an indication of true peak—the 0 vu indication corresponds to an output power of 600W into eight ohms. In addition to the meter there are red and green indicator lamps, each of which is worked in conjunction with six position rotary switch which is calibrated in the following steps: 0, -3, -6, -10, -15 and -20 dB.

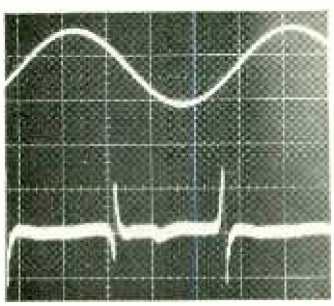
In operation, one sets the switch associated with the red light to the required peak power output. The red lamp illuminates when this peak power is momentarily exceeded—again using a peak hold function. The switch associated with the green lamp is then set for the normal operating region, when the green lamp will be illuminated when things are normal, and the lamps change to red if the desired peak power is exceeded.

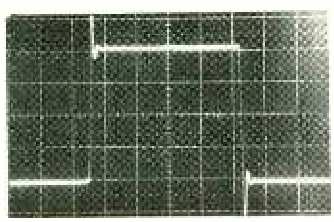
This completes a short description of the basic functions of the amplifier, leaving only the comment that the entire unit is built to a very high standard of construction in both electrical and mechanical aspects.

Power output and distortion

Considerable care was taken when making measurements at high power levels, for the potency of this amplifier is such that even the impedance of normal mains voltage supplies can introduce substantial errors in measurements of output power and distortion. In practice the amplifier was fed from a voltage stabiliser which held the mains supply to 240V ±0.5% throughout the measurements and the amplifier was loaded with four 300W forced air cooled ±0.5% tolerence resistors with a peak power capability of 6 kW for 5 seconds, the output voltage being recorded with a digital voltmeter accurate to ±0.25% worst case. Total harmonic distortion was determined with the Sound Technology type *1700A* oscillator/analyser which has a residual distortion of only 0.0015% at 1 kHz (the decimal point *is* in the right place) and intermodulation distortion with the Amcron *IMA* which has a residual distortion of 0.002%—so far as I am aware this is the very best equipment commercially available, and even then the test gear was taxed to its limit by the Amcron *M-600*.

Waveform clipping at 1 kHz was found to occur at some 1.35 kW continuous sinewave into four ohms, or at 758W into eight ohms with a capability of delivering 826W on short tone bursts. The following tables show the extraordinarily low distortion introduced by the amplifier into four and eight ohm loads at various power outputs:—





◀ FIG. 1

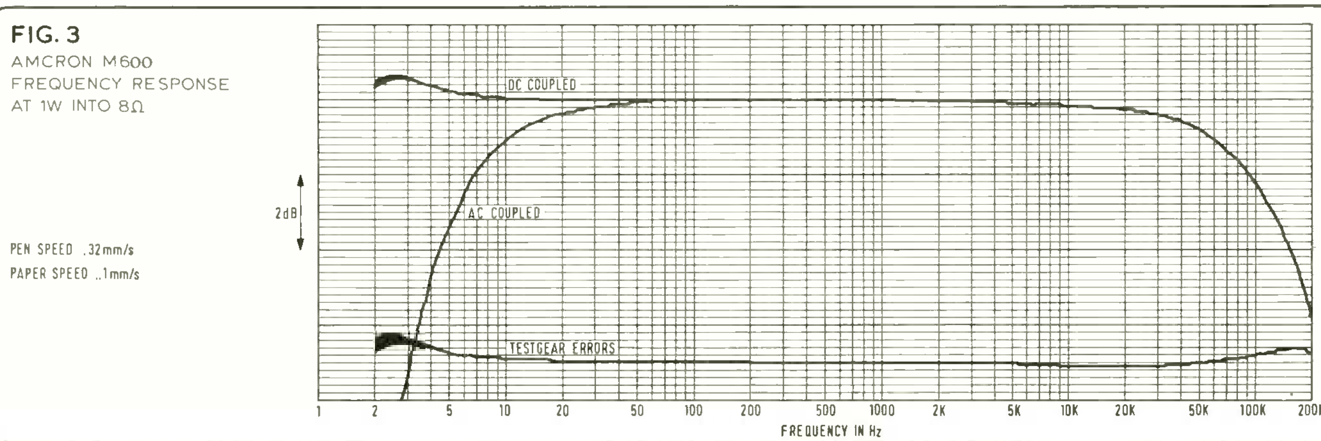
▲ FIG. 2

Distortion into 4 ohm load

Output power	10 Hz	100 Hz	1 kHz	10 kHz	20 kHz
1.2 kW	0.0024%	0.0024%	0.0015%	0.017%	Fuse failed
120W	0.0022%	0.0015%	0.002%	0.012%	0.013%
12W	0.0025%	0.0016%	0.0035%	0.025%	0.046%
1.2W***	0.002%	0.002%	0.005%	0.042%	0.083%

56 ▶

FIG. 3
AMCRON M600
FREQUENCY RESPONSE
AT 1W INTO 8Ω



AMCRON M600

Distortion into 8 ohm load

Output power	10 Hz	100 Hz	1 kHz	10 kHz	20 kHz
600W	0.0035%	0.0015%	0.0015%	0.017%	0.027%
60W	0.0023%	0.0014%	0.002%	0.011%	0.024%
6W	0.0025%	0.0016%	0.0026%	0.015%	0.044%
600 mW	0.0046%***	Results unreliable due to noise			

***Results influenced by noise.

The measurement of intermodulation distortion to the SMPTE method with 50 Hz and 7 kHz tones in the amplitude ratio 4:1 gave equally impressive figures, in that at power output levels (equivalent peak sinewave) between 600W and 600 mW the intermodulation distortion was less than 0.003% as measured with a meter with a residual distortion of 0.002%. At lower power levels into eight ohms there was a slight apparent rise in intermodulation distortion to 0.01% at 60 mW.

This rise in intermodulation products is probably explained by the residual distortion found when measuring harmonic distortion. As is shown in **fig. 1,** the residual consists almost entirely of crossover products.

While doing the distortion measurements it was observed that the current drawn from the mains supply increased rapidly at high frequencies, and further investigation showed that something peculiar happens to the amplifier at ultrasonic frequencies, even when the output is open circuit. This is illustrated by the following table which shows the relation between the input VA and the output when feeding 600W into eight ohms at 1 kHz and holding the input voltage constant at other frequencies and also with the output open circuit, see below.

Continued application of the 50 kHz signal into an open circuit load produced thermal instability, with the mains input current rapidly rising to 10A. While these findings are probably insignificant when the amplifier is used for audio purposes, I find them rather worrying. In fact the application of my normal tortures at audio frequencies showed that the amplifier was quite happy to deliver its full 600W into eight ohms continuously at any frequency between dc and 20 kHz, with the cooling fan occasionally switching to its high speed when the ambient temperature was 20°C.

The application of a 2 μF capacitor across the eight ohm load did not upset the amplifier, and the squarewave test at 1W into this impedance did not provoke instability but perhaps did give rather excessive ringing as is shown in **fig. 2.** The measured slew rate was 20 V/μs with an associated rise time of 4.4 μs.

Frequency	Input VA at 240V	
	8 ohm load	No load
100 Hz	890 VA	98 VA
1 kHz	890 VA	101 VA
10 kHz	940 VA	158 VA
20 kHz	1270 VA	223 VA
30 kHz	2400 VA	300 VA
50 kHz	Over 10A fuse rating	1080 VA

FIG. 4
AMCRON M600
OUTPUT IMPEDANCE

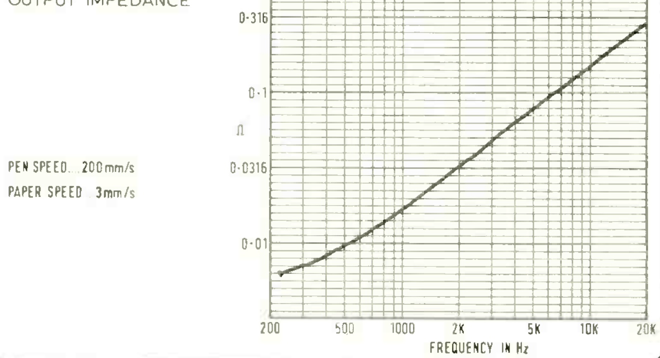
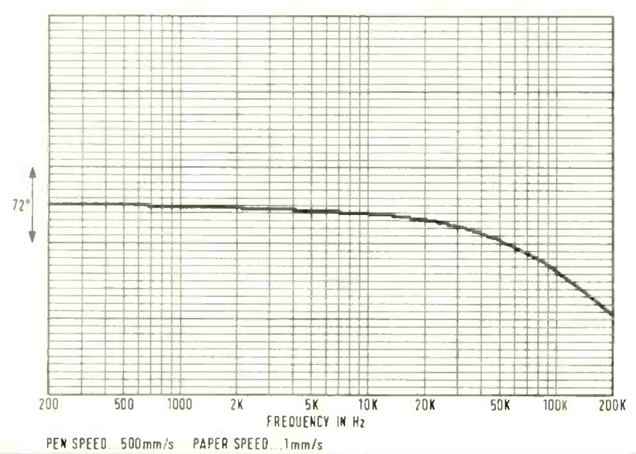


FIG. 5 AMCRON M600 PHASE SHIFT AT 10W INTO 8Ω



Frequency response and noise

The only amplifier control which affects the overall response is the ac/dc coupling switch on the input plugin. The overall response at 1W output into eight ohms is shown in **fig. 3,** with both ac and dc coupling, it was observed that the −3 dB point in the ac mode is at 5 Hz and that the response at the high frequency end extends to 60 kHz before the −1 dB point is reached.

The measurement of amplifier noise with respect to an output of 600W into eight ohms gave an unweighted noise of −127.3 dB when measuring over the band 20 Hz to 20 kHz, or 130.8 dB when taking the 'A' weighted performance—both these figures being really excellent. Likewise the hum output was extremely low, with all mains frequency harmonics being at least −132 dB with respect to 600W into eight ohms.

Inputs and outputs

Two inputs are provided. The normal input is via the jack socket at the rear of the amplifier and has a sensitivity of 3.46V for 600W output into eight ohms and an input impedance which varied between 30 300 ohms and 30 700 ohms according to the setting of the level control.

The second input is associated with the rear panel interlock connector, and is in fact an inverting input with a sensitivity of 69.3V for an output of 600W into eight ohms, ie. it is an unity gain input. In the case of this input the impedance is 44 760 ohms.

On the output end the impedance was found to be constant below 200 Hz and to increase as shown in **fig. 4** above 200 Hz to about 0.3 ohms at 20 kHz, with the effective damping factor into eight ohms being over 500 at 1 kHz.

Metering and indicators

Investigations into the ballistics of the metering system, and also the time constants of the output indicating lamps showed that the response time of the system was extremely fast, such that a single cycle of 10 kHz sinewave was sufficient to give an indication within 0.5 dB accuracy. The meter reading and also the lamp indication of levels was then held for long enough to assimilate the information, with a resulting excellent readability of true short term level.

However, it was found that the meter calibration was very 58 ▶

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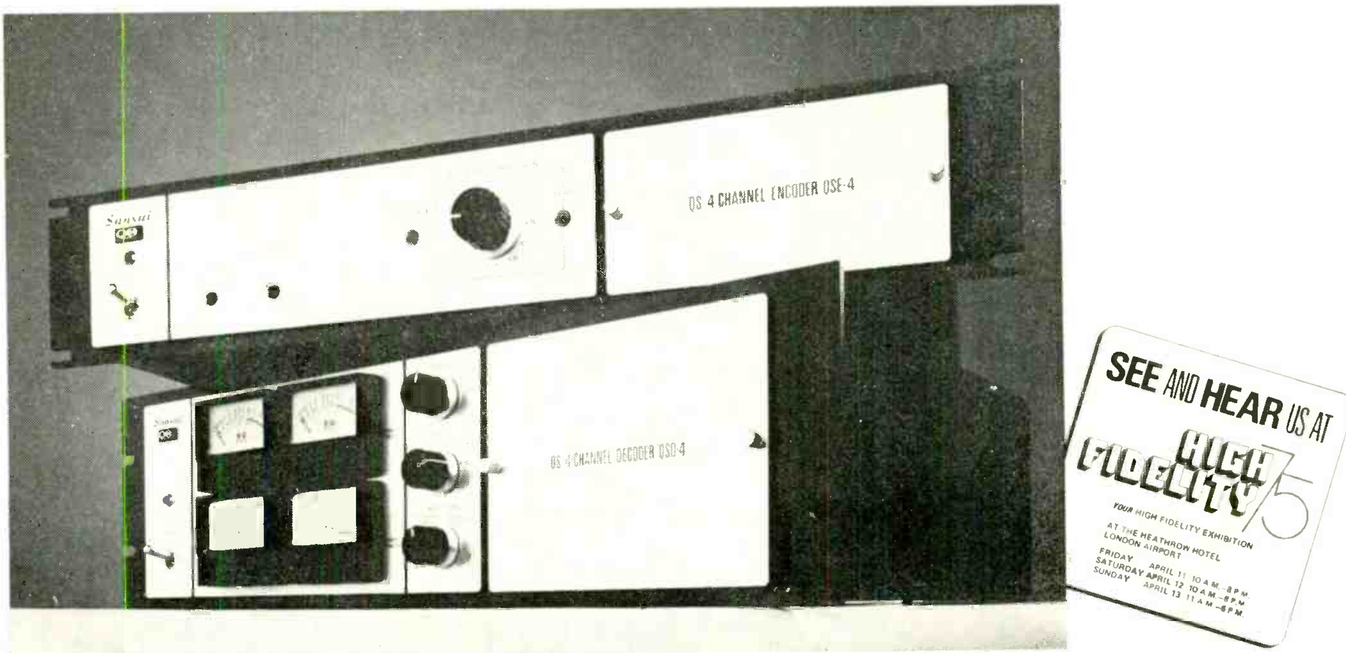

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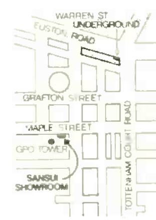

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inaccurate at calibration points other than the zero mark which corresponded to precisely 600W into eight ohms. The −3 dB meter indication was found to correspond to −2.3 dB, the −7 dB indication to −10 dB and the −10 dB indication to −16 dB.

On the other hand, the calibration of the indicator lamp attenuators was more than satisfactory with the zero setting being precisely correct and a worst case error of 0.5 dB occuring with the −20 dB setting.

Other matters

Among the other parameters which were measured was the overall phase shift of the amplifier from 2 Hz to 200 kHz. From dc to 2 kHz the phase shift was less than 1°, from where it increased as is shown in **fig. 5** to 12° at 20 kHz and 104° at 200 kHz thus giving a safe margin on stability.

Checking the low frequency protection facility showed that part of the protection circuitry was inoperative on the first sample amplifier, so another sample was called for and delivered to me within, I think, 24 hours. In fairness to Amcron and their UK agent, I must mention that the first sample had been out on loan before it arrived at my laboratory and might have been damaged by incorrect use of the interlock connector which is not protected against mis-use. Anyhow the second sample behaved as it should, disconnecting the main power supplies if very low frequencies of dc appeared at the output with the lf protection function switched on. This facility is, of course, a great protector of speakers, and is very fast in action; furthermore, the amplifier resets itself when the offending input is removed.

The switch-on delay is another safety factor when the power to the amplifier is applied at the same time as the power to its input devices, as the delay of 4 or 5 seconds before the main amplifier power appears allows switch-on transients in the input devices to stabilise. The main power supplies may also be remotely switched from the interlock connector, thus allowing other safety devices to be added, and also several *M-600* amplifiers to be switched simultaneously in very high power installations.

Dc at the output was found to vary from −20 mV to +70 mV over the full operating temperature range from cold to thermal tripping point, which automatically recovered within a minute at 20°C ambient temperature. Shorting the output, overloading tone bursts and other tests failed to catch out the protection circuits, and switch-on transients were minimal so far as the output was concerned; they did, however, produce a rather alarming mains surge which could do with a little taming.

Summary

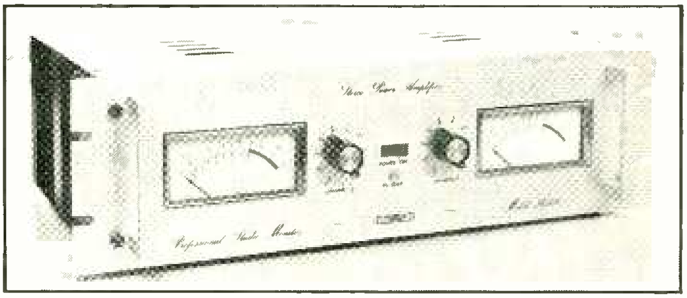
In spite of the length of this review, there remain a number of parameters of the Amcron *M-600* which have not been mentioned. It is, however, a rather outstanding amplifier offering a very high power output potential with outstandingly good performance for its power rating.

Unlike some high power amplifiers which I have tested in in the past, the Amcron rating is a genuine continuous rating at audio frequencies, without the embarrassment of thermal tripping or the alternative: smoke and an expensive I^2R smell.

Considering audio applications, the performance of this amplifier is really excellent so far as power output, distortion, and noise are concerned. It does, however, have a few peculiarities which could cause trouble—the inaccurate meter calibration, the switch-on mains surge, and the increase in mains power when fed with ultrasonic frequencies.

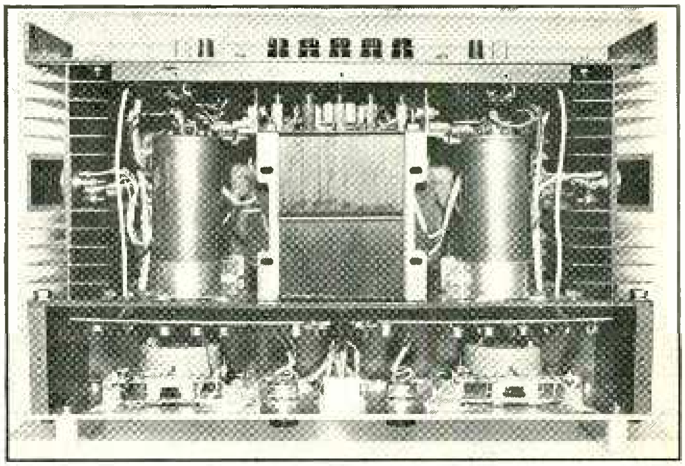
TURNER A300 AMPLIFIER

Hugh Ford



MANUFACTURERS' SPECIFICATION

Power output stereo: 150+150 watts rms into 4 ohms; 100+100 watts rms into 8 ohms; 60+60 watts rms into 15 ohms.
Power output mono: 300 watts rms into 8 ohms; 200 watts rms into 15 ohms.
Power response: ±0.1 dB 20 Hz to 20 kHz at 75W 8 ohms.
Frequency response: ±0.1 dB 20 Hz to 20 kHz at 1W 8 ohms.
Distortion: Less than 0.01% at full rated output into 4, 8 or 15 ohms (typically 0.003% at 75W into 8 ohms).
Hum and noise: 110 dB below rated output 20 Hz to 20 kHz unweighted: circuit noise is —122.5 dB
Crosstalk: 100 dB below rated output 20 Hz to 20 kHz.
Input sensitivity: +4 dBm (1.2V ±2%) for 75W into 8 ohms.
Input impedance: 10k ohms.
Output impedance: 0.01 ohms 20 Hz to 400 Hz 0.02 ohms at 1 kHz.
Damping factor: 1500 20 Hz to 400 Hz 15 ohms, 400 at 1 kHz 8 ohms.
Protection: Complete automatic protection is provided. All stages are inherently current limited to prevent chain destruction. Thermal cutouts protect against insufficient ventilation. HT and mains fuses protect against total amplifier failure and reduce fire hazard.
Power requirements: 110, 120, 220, 230, 240V ±5%. Max input power 600W.
Dimensions: 483 mm x 133.5 mm x 302 mm.
Weight: *A300* standard, 13.2 kg net; with vu's, 14.1 kg net.
Finish: Satin-anodised brushed aluminium front panel with black-anodised chassis.
Price: £262.50 in standard form, or £322.50 with Ernest Turner vu meters.
Manufacturers: Turner Electronic Industries Ltd, 175 Uxbridge Road, London W7.



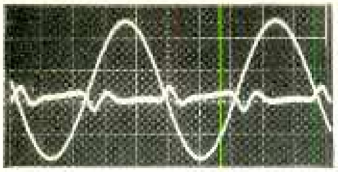


FIG. 1

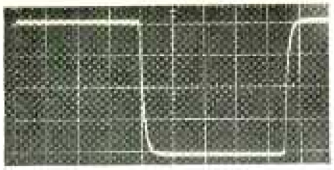


FIG. 2

THE TURNER *A300* amplifier as reviewed included twin vu meters, but was otherwise the amplifier in its basic form. The unit is basically intended for rack mounting in a standard 483 mm rack, but may also be mounted in a wooden case, thus providing a compact portable amplifier. A heavily brushed aluminium front panel with black identifications gives the amplifier a professional appearance, and the overall high standard of mechanical construction suggests that the amplifier will withstand severe conditions of use.

The entire chassis of the amplifier is black anodised, and is bolted to finned heatsinks either side of the amplifier so that the complete chassis dissipates heat generated in the output stages and the power supplies. Thermal cutouts are provided to protect against excessive temperatures, and it was found that these operated when the amplifier was only moderately hot.

A front panel indicator lamp is illuminated in these circumstances, power being automatically restored when the temperature has returned to normal. The other front panel functions are an illuminated mains on/off switch and two separate gain controls which have arbitrary calibration points from 0 to 9. The vu meters which have the standard scaling are also clearly illuminated. The rear panel accommodates the inputs in the form of 6.35 mm jack sockets (with the option of *XLR* connectors, balanced inputs etc being available). The outputs are in the form of terminal/sockets on the standard 19 mm spacing, the mains input socket and five fuses also being rear panel mounted. The latter provide separate protection of the positive and negative supplies for each channel, and also a mains fuse. All the fuses and other facilities are clearly identified, including the power output capability.

With the exception of the output transistors and rectifiers, virutally all the circuitry is mounted on two printed circuit boards (one for each channel) which plug-in behind the front panel. The standard of wiring and general tidiness gives no cause for complaint, and the entire amplifier is to a thoroughly professional standard.

According to the manufacturer, separate power supplies are used for the two channels, and the circuit design is such that constant current sinks are used in all stages in order to prevent chain destruction which is so common in dc coupled amplifiers under fault conditions.

Power output

As is my normal practice, the available power output was measured with the amplifier fed from a stabilised 240V 50 Hz supply, such that the mains voltage was held to within ±0.5% of nominal. The amplifier was loaded with precision resistors and the output monitored with a digital voltmeter which was accurate to within ±0.25%. Under these conditions, the power output at the clipping point of a 1 kHz sinewave was found to be as follows:—

Load (ohms)	Both channels driven rms output power	
	Channel 1	Channel 2
4 ohms	137W	129W
8 ohms	86.5W	83.9W
16 ohms	53.9W	52.9W

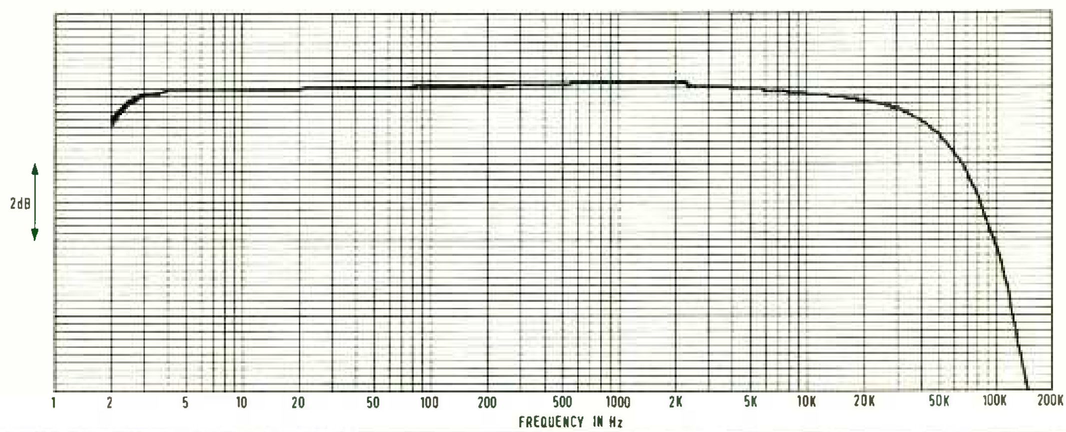
It will be noted that all the above figures are considerably below the figures indicated in the manufacturers' specification, and this is the result of the manufacturers' practice of measuring the amplifier at +5% thd on the nominal mains voltage rating. I do not know of any other manufacturer that does this, and furthermore it is contrary to both the IHF Standard for audio amplifiers and also British Standard 3860:1965 'Methods for Measuring and Expressing the Performance of Audio-frequency Amplifiers'. In short, I do not feel that this is fair practice.

While I have tabled the clipping point as measured with both channels being driven, the effects of driving single channels are negligible—this being the result of using separate power supplies for each channel. As is common with transistorised amplifiers the distortion content of the output is relatively constant until the output power is just below waveform clipping, distortion was therefore measured at 75W into eight ohms which would appear to be a fair rated output:—

	75W into 8Ω total harmonic distortion				
Frequency	10 Hz	100 Hz	1 kHz	10 kHz	20 kHz
Distortion	0.0025%	0.0003%	0.008%	0.009%	0.15%

The above are the average distortion contents of the two channels, there being only small differences between the two channels both of which offer an excellent harmonic distortion performance. As is to be seen from **fig. 1** which shows the distortion of a 10 kHz sinewave at 1W into eight ohms the distortion products are mainly crossover products as opposed to harmonics. Measurements of intermodulation distortion to the SMPTE method with 50 Hz and 7 kHz tone 60 ▶

FIG. 3
TURNER A300
FREQUENCY RESPONSE
AT 1W INTO 8Ω



■ TURNER A300 AMPLIFIER

in the amplitude ratio 4:1 also showed good distortion performance as is to be seen from the following:—

Output power Equivalent peak sinewave into 8 ohms	IM Distortion Channel 1	Channel 2
75W	0.016%	0.016%
7.5W	0.017%	0.015%
750 mW	0.02%	0.015%
75 mW	0.022%	0.015%

The square wave performance was found to be unusually good, the effects of loading the amplifier with eight ohms in parallel with 2 μF when being fed with a 1 kHz squarewave being shown in **fig. 2**, which does not indicate any sign whatsoever of instability. The associated rise time when feeding a resistive load as measured as 3.1 μs with a maximum slew rate of 5 V/μs.

The amplifier was found to be capable of delivering a continuous sinewave at clipping point into eight ohms, and when working into four ohms this appeared to be just on the limit of the thermal capabilities at an ambient temperature of 21°C.

Frequency response and noise

As is to be observed from **fig. 3**, the overall response of the amplifier was within ±0.2 dB from 5 Hz to 20 kHz, the response then falling to −3 dB at about 80 kHz at 1W output into eight ohms. Turning to noise, while this may be related to the manufacturers claimed power output figures it has been seen that these figures do not relate to normal operation of the amplifier. The following noise measurements have therefore been related to an output of 75 rms sinewave into eight ohms.

Condition	Channel 1	Channel 2
20 Hz to 20 kHz true rms	—117 dB	—112 dB
'A' weighted	—120.5 dB	—119 dB

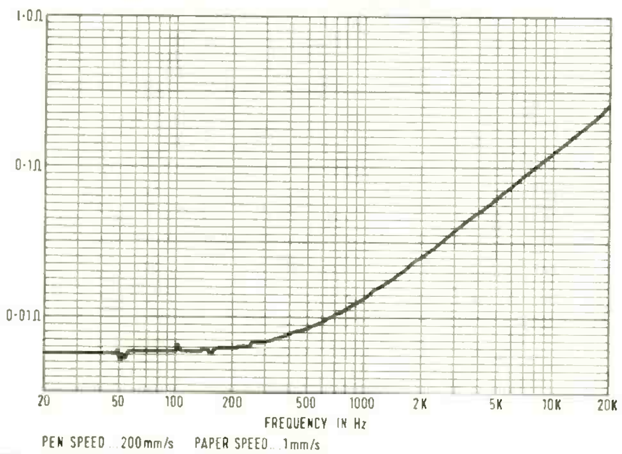
Irrespective of the precise output reference, the above figures are to a very high standard and also demonstrate very low hum levels in the output.

Inputs and outputs

The unbalanced jack socket inputs were found to have a sensitivity of 1.24V for an output at 1 kHz of 75W into eight ohms, there being approximately 0.1 dB difference in sensitivity between the two channels. The input impedance was found to vary over a rather large range, the measured impedance at 1592 Hz being 8530 ohms at maximum gain, increasing to 33 000 ohms when the gain control was at its mid position and further increasing to 52 800 ohms at minimum gain. While the minimum impedance is just high enough not to interfere excessively with 600 ohm lines, it is possible that the impedance variation could cause embarrassment in some circumstances.

On the output end the relation between output impedance and frequency is shown in **fig. 4** from which it is to be seen that the impedance at low frequencies is 6.3 milliohms up to 200 Hz or so, from where it increases at about 6 dB per octave to 0.3 ohms at 20 kHz.

FIG. 4 TURNER A300 OUTPUT IMPEDANCE



Meters

Not only have the meters the correct scaling for a standard vu meter, but also it was found that both the rise time and the fall time were to the ASA requirements, as also was the rectifier response. However, it was found that the setting of the 0 vu indication corresponded to between −1 dB and −1.5 dB below 75 watts into eight ohms, which is far too close to the output clipping point. NAB recommended a minimum margin of 8 dB below 0 vu and output clipping, and if I remember correctly this figure was ascertained in the original Bell specification for the vu meter.

Other matters

The amplifier phase shift was found to be minimal over the audio frequency band, and remained within sensible limits over the pass band of the amplifier as is demonstrated in **fig. 5**

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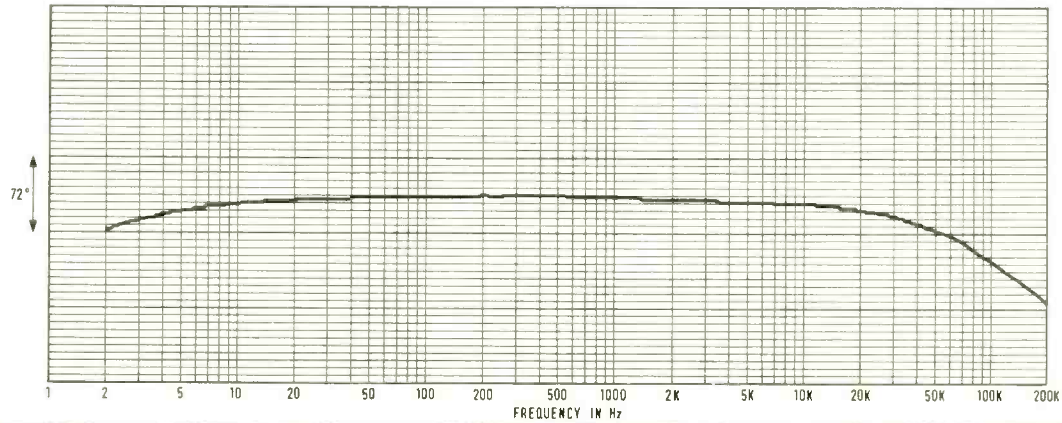
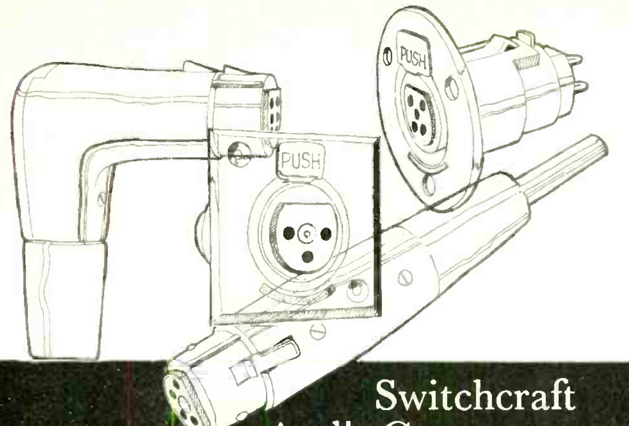
FIG. 5 TURNER A300 PHASE SHIFT





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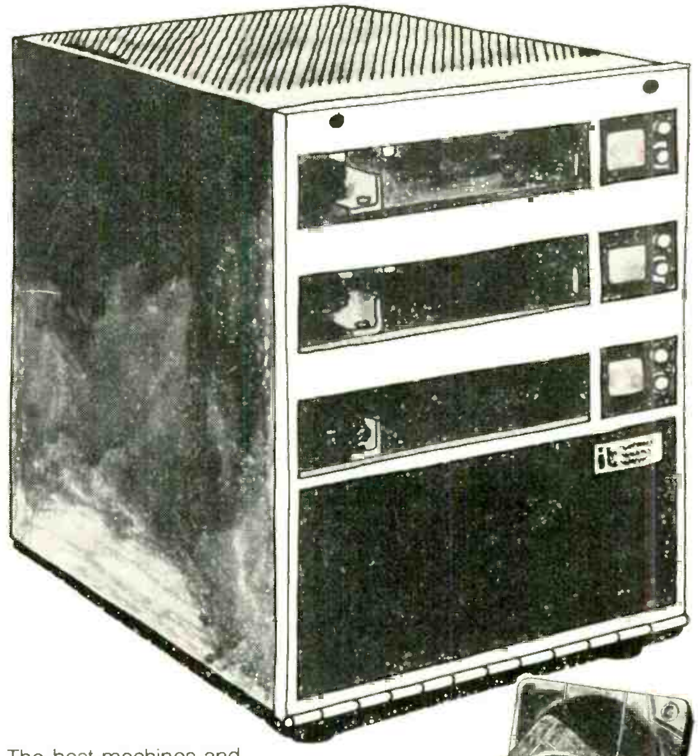

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which portrays the relation between phase shift and frequency.

Quite outstanding was the crosstalk performance which, with one channel delivering 75 watts into eight ohms, was measured at less than 127 dB from 20 Hz to 5 kHz from whence it increased to 110 dB at 20 kHz.

Overload testing demonstrated that the amplifier had virtually instantaneous recovery from overload, and also output shorts did not provoke any troubles; neither was there any evidence on switch-on surges or other untoward dc events!

Summary

The Turner *A300* amplifier offers a very good performance at a reasonable price, but two matters must be put right. Firstly, the setting of the vu meters is about 8 or 10 dB too insensitive and on speech program material the amplifier can be heard to clip when the vu meters are indicating in the −10 vu region.

Once this is corrected I would suggest that Turner put their specification to rights by quoting the power performance at the nominal supply voltage rating—a specification figure of 80 watts per channel into eight ohms is realistic and other performance specifications should be related to the modified output capability.

Perhaps in some ways these grumbles are relatively minor matters, and once they are put aside this is a very good amplifier both in terms of performance and in terms of overall quality of construction. (See Letters, p30—*Ed.*)

AGONY COLUMN

■ As part of the Pye entourage, Cyril Stapleton used to have his own office, complete with hi-fi system. Hi-fi systems being what they are, it went wrong one day, so he phoned the workshop and asked for help. A certain engineer went upstairs at a time nearing 5.30, and to speed things up simply cut through the mains plug, into which was wired both light and sound, an inch from the plug, leaving it disconnected. Exit engineer with amplifier. During the night, the cleaners came, vacuumed, and pulled out their own plug, leaving the switch on. The following dark morning, the occupant wandered in, needed illumination, picked up the plug and pushed it straight into the wall socket. Apparently he was thrown right across the room, and ended up a blithering lump for a few minutes. An irate phone call to maintenance brought up engineer number two, who soon had the patient functioning. 'You're lucky. You survived because you aren't too good a conductor.' Exit engineer two, brought down, but with something to tell the grandchildren. Which he did.

■ Some orchestra leaders are more accommodating over deps than others. London theatre pit leaders are accustomed to the sight of a sea of new faces every night, once a production has run for a few weeks. The story goes that a trombonist in one of London's concert orchestras was recently desperate for a dep to take his place. Everybody, it seemed, was already working somewhere else. Finally, with all possibilities exhausted and time running out, he persuaded his local butcher to don evening dress and go along with an old trombone that the musician had spare. 'There'll be no problem,' he told the butcher, 'you'll be one of so many that no one will ever know you aren't playing'.

That night, the first piece of music on the programme was from *Tannhäuser*, with a solo passage for the trombones. The conductor duly brought them in with a flourish and was rewarded by the sound of silence and the sight of two butchers, a postman, someone's uncle and a friend of a friend, each evening-dressed and clumsily miming the part while trying to avoid the conductor's eye.

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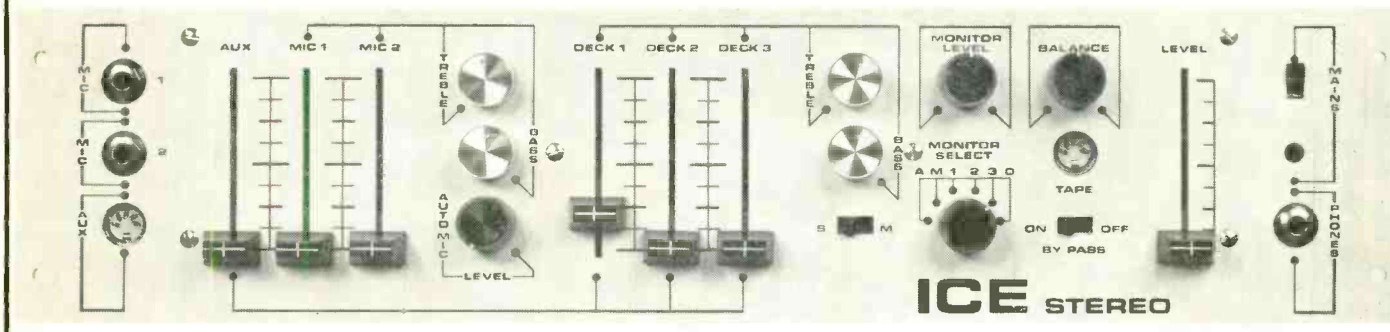

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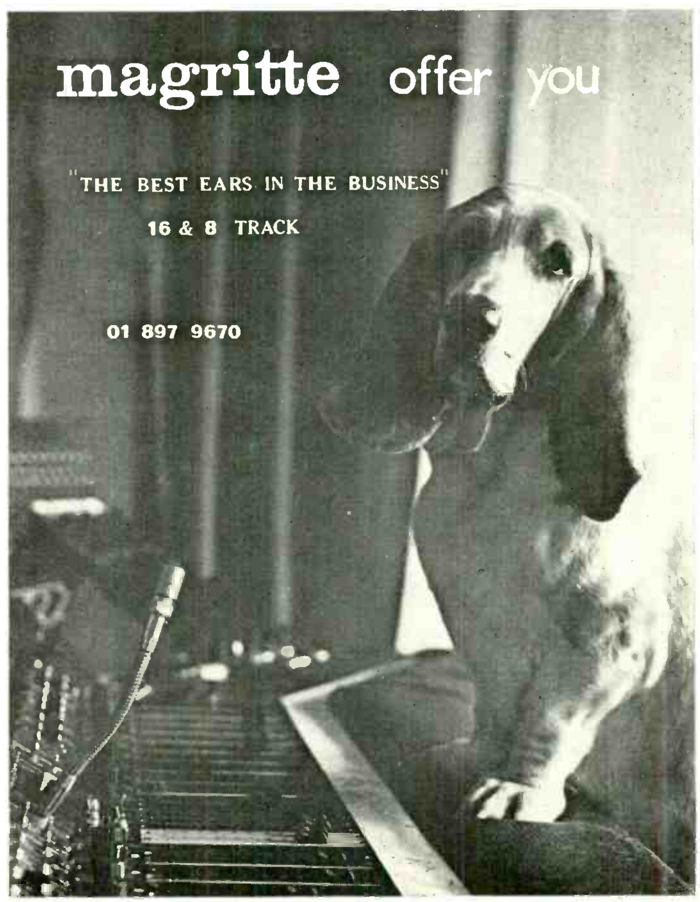

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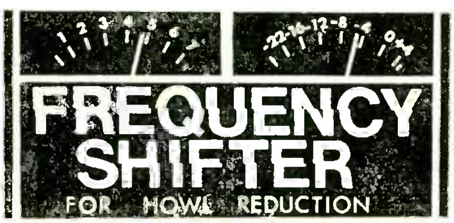

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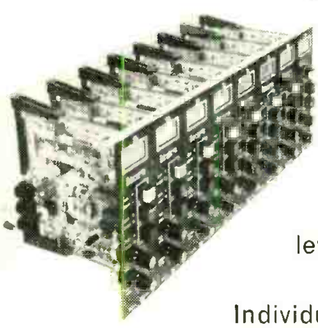

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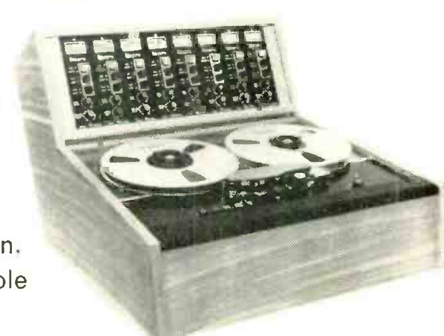

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