STUDIO SOUND & tape recorder

MARCH 1970 2s 6d (12½p)

MASSIVE MIXER SURVEY

MAKING EFFECTS EFFECTIVE

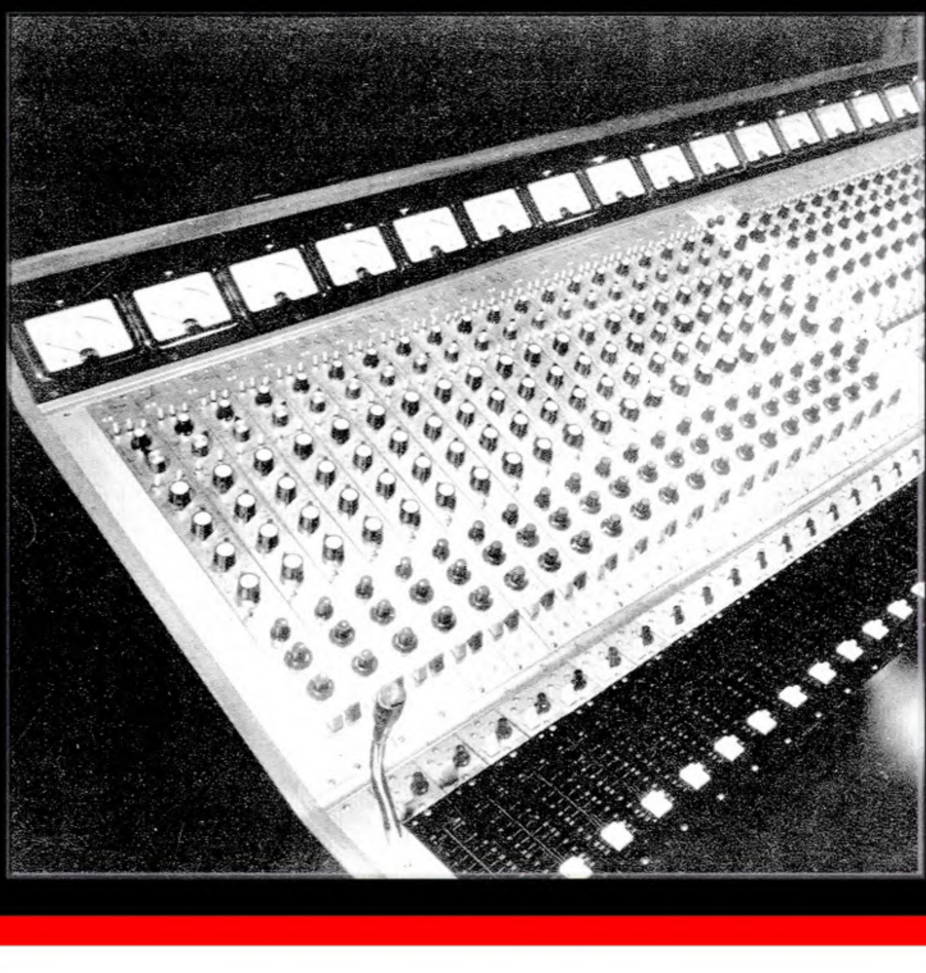
FOUR CHANNEL STEREO FOR LUDWIG'S BIRTHDAY

AROUND THE STUDIOS: STAR SOUND

SERVICING THE SONY TC800

TELEFUNKEN M28C RECORDER REVIEWED

PRERECORDED BALLET



SONY

Model TC-630—the complete stereo sound control centre. Echo and sound-on-sound recording at the flick of a switch. Multiple inputs for stereo tuner, microphone, auxiliary speakers and optional turntable. Further refinements include three heads, three speeds, dual VU meters, retractable pinch roller, noise suppressor, and scrape filter.

Compact and superbly built, the TC-630 has a built-in stereo amplifier delivering a full 15 watts per channel rated output. Two lid-integrated speakers open up a world of stereo sound... **What more can we add?**

Model TC-630, recommended retail price £199:15:0

Specification

Recording system 4-track stereo/mono recording and playback.
Power requirements AC 100, 110, 117, 125, 220 or 240V, 50/60 Hz.
Power consumption 40 watts.
Tape speed 7½ ips (19 cm/s), 3¾ ips (9·5 cm/s) 1⅞ ips (4·8 cm/s).
Reel capacity 7 in. (18 cm) or smaller.
Frequency response 30 Hz–22 kHz at 7½ ips; 30 Hz–13 kHz at 3¾ ips; 30 Hz–10kHz at 1⅞ips.
Bias frequency 160k Hz.
Wow and flutter 0·09% ot 7½ ips; 0·12% at 3¾ ips; 0·16% at 1⅞ ips.
Power output 15 watts per channel.
Signal-to-noise ratio 50 dB.
Harmonic distortion 1·2% at rated output (overall); 0.5% at rated output (amplifier).
Level indication Two VU meters.
Inputs Microphone: sensitivity –72 dB (0·2 mV), impedance 250 ohms.
Tuner: sensitivity –22 dB (0·06V), impedance 100k ohms.
Auxiliary: sensitivity –22 dB (0·06V), impedance 560k ohms,
Phono input (MM or MC cartridge): sensitivity –53 dB (2 mV), impedance 14k ohms.
Outputs Line: output level 0 dB (0·775V), impedance 100k ohms.
Headphone: output level –28 dB (30 mV), impedance 8 ohms.
External speaker: impedance 8 ohms.
Lid speaker: impedance 8 ohms.
Rec/PB connector Input. sensitivity –40 dB (7·75 mV), impedance 10k ohms.
Output: output level 0 dB (0·775V) impedance 100k ohms.
Dimensions 17⅞ in. (w) x 20 in. (h) x 11⅜ in. (d).
Weight 46 lb. 3 oz.
Supplied accessories Microphone (F-45) (x2), Sony pre-recorded 5 in. tape, Sony empty reel (R-7A), connection cord (RK-74), head cleaning ribbon, reel cap (x2).
Optional accessories Speaker system (SS-3000), telephone pick-up (TP-4), stereo headset (DR-5A) (8 onms), microphone mixer (MX-6S).

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RESEARCH MAKES THE DIFFERENCE Sony (UK) Ltd Ascot Road, Bedfont, Feltham, Middlesex

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79/6 + 2/6 P/P

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LP 35	900′ on 5″ reel LP	25/6	16/6
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	1800′ on 7″ reel LP	47/6	29/6
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	1800′ on 5¾″ reel DP	52/6	32/6
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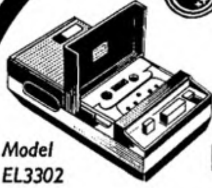
List Price £28.7.0



Model EL3302

21 gns.

P & P 7/6

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PRICE £29.19.6

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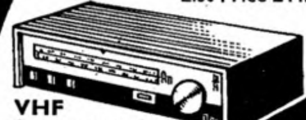

VHF

Stereo reception with AFC & MPX Decoder. Cabinet finished in teak. Dimensions 14″ x 6½″ x 3½″.

SAVE £23

Philips GH 944 AM-FM Stereo tuner with AFC, MPX Decoder, moving coil meter and silent FM tuning. Receives long, medium and short waves as well as stereo VHF. Cabinet finished in teak. Dimensions 15″ x 8¾″ x 5¼″.

PRICE £49.18.0

List Price £72.18.4

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Studio Sound
& tape recorder

MARCH 1970 VOLUME 12 NUMBER 3

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COVER PICTURE

Well mixed without being all mixed up—this could be the slogan for our mixer survey starting on page 96. Sixteen channels are certainly well mixed with the greatest care and control, in the desk by *Sound Techniques Ltd.* featured on our cover. This mixer, made specially for use by *Trident Studios*, comprises banks of twenty and sixteen 'input', 'studio' and 'output' units, together with a master monitor unit; all based on the modular parts detailed under *Sound Techniques* in our survey.

SUBSCRIPTION RATES

Annual subscription rates to *Studio Sound* and its associated journal *Hi-Fi News* are 30s. ($4.30 or equivalent, overseas) and 44s. ($5.60) respectively. Six-month home subscriptions are 15s. *(Studio Sound)* and 22s. *(Hi-Fi News)*, from Link House Publications Ltd., Dingwall Avenue, Croydon CR9 2TA

Studio Sound is published on the 14th of the preceding month unless that date falls on a Sunday, when it appears on the Saturday.

JUDGING BY the number of mixers included in our survey in this issue—incidentally the most comprehensive catalogue yet published in a magazine—laymen might be forgiven for believing that we are in the food business. Indeed, in this multi-miking, multi-tracking age, there are analogies with the culinary art: recording producers doff the chef's hat, so to speak, and exercise a comparable selective skill over the blending of ingredients.

The cook dictates quantities and forms for flesh, fruit, flour, fats and fish, salads, spices and sauces, and judges the final effect with a skilled tongue. Similarly, the man at the mixing console will raise or lower the signal levels from a dozen or more microphones covering various soloists or instrumental groups, allocate positions on the stereo sound-stage, and mix in some reverberation, all with due regard for overall blending within an aural ambience which (he hopes !) sounds convincing. Like the cook, he makes a final judgement with his sensory organs.

But here the similarity ends, for unless the chef is following some standard recipe to produce a dish indistinguishable from its fellows—like tins of baked beans or packaged pies—he is truly a creative artist, seeking that refinement of taste beloved of the epicure, with no standard of reference beyond his own tongue and the reaction of his gourmet patrons.

The sound balancer, however, is a producer and arranger of other people's work. His art is reproductive as much as creative, and while much pop music and some *avant-garde* experiments never have an objective acoustic existence, most conventional music has been heard (or is hearable) coming from acoustic instruments and unamplified voices in real halls with real reverberation. This is why, despite many microphones and a great deal of fiddling (mixing !), nearly all major recordings of serious music still attempt to present the sound picture in a more-or-less coherent and recognisable fashion, as if set in some sort of hall or studio—albeit an idealized hall, with a combination of clarity and reverberation seldom to be found in real life.

While there is always room for experiment, especially with electronic music, we approve of the philosophy underlying this approach, a philosophy which continues to dominate music recording in Europe—despite many changes since the early days of simple Blumlein stereophony.

If Europe's recording 'chefs' tend to produce a more musical blend than their transatlantic competitors, it is in London that we find the heart of this great industry, with the main British companies undoubtedly leading the whole world in recorded musical sound quality. No wonder that so many mixers are available in the U.K. for listing in our survey, and no wonder also that one of the world's major non-British recording companies is seriously considering—so it is rumoured—moving its headquarters to London, now virtually centre of the musical world quite apart from the recording business.

But we lag behind the Americans in 4-channel stereo, latest contender for serious studio attention. Not only have they taken some important initial steps (see Alec Nisbett's article on page 110), but we hear that CBS will be (1) moving into the Royal Albert Hall in February to (2) record the Verdi *Requiem* in the Quadraphonic mode. Two firsts—but at least they have to come to London for the hall and the LSO. The related public concert is on February 22nd.

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BBC T.V.–moonshot: Where there can be no re-take you'll find Ferrograph.

During the Apollo 11 moon landing, the BBC used Ferrograph Series 7 Tape Recorders to monitor the NASA commentary. The recorders were in use continuously 24 hours a day. There could be no break, there could be no re-take. The BBC now has over 40 Ferrograph Series 7 recorders in use throughout the country.

Every Ferrograph Series 7 recorder is made in Britain and combines quality, reliability and a unique range of facilities. Available in mono or stereo, with or without amplifiers, all solid state, three-speed, with two inputs per channel and independent mixing. Retail prices from £175 including P.T.

Follow the professionals; choose the recorder you know will serve you best at home or in your work: Ferrograph—it makes sound sense. See your nearest stockist or send the coupon for details and address of nearest Ferrograph specialist or ring 01-589 4485.

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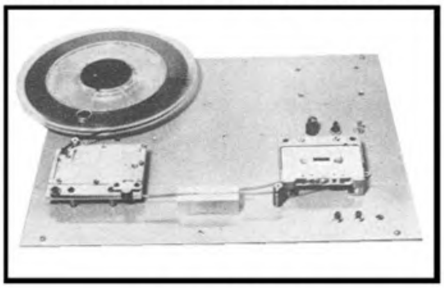
studio diary

Can you help your Father with his 'Studio Sound'?

EDITING CASSETTES

AMATEURS who wish to edit, shorten or lengthen cassettes are now offered the Bin cassette editor, which includes compact version of their well-known standard splicing block. For professional purposes (?) a motorised editor with separate replay head and built in editing block has been produced. Featuring automatic take-up and with facilities for adding tape from a spare reel the editor is the IMEC model MN 1001 illustrated below, not imported into this country at present.



STUDIO SOUND

READERS who are perhaps puzzled at the new words that have crept into our title are reminded that the magazine's name is now *Studio Sound and Tape Recorder*. It is intended eventually to change this title to *Studio Sound* alone, for reasons which were outlined in last December's editorial. Meanwhile the present title will be employed, but with the emphasis changing to *Studio Sound* after next month's issue.

AKG CHANGES

MICROPHONES and headsets made by AKG Vienna will now be imported by AKG Equipment Ltd., a subsidiary of AKG Vienna, which will also be associated with marketing companies in Eire, South Africa, Australia and New Zealand with effect from the 1st April.

Despite the change of trading title, the company's present staff will be retained, but the telephone number is revised. All enquiries should therefore be addressed to AKG Equipment Ltd., Eardly House, 182-184 Campden Hill Road, London W.8 (01-229-3695) in future.

BFOC CHANGE

DETAILS OF BRITISH Ferrograph Owners' Club membership, hitherto supplied by G. E. West of Oldham, will in future be available from K. G. Farran, 26 Belgrave Road, Cadishead, Manchester.

ON THE MOVE

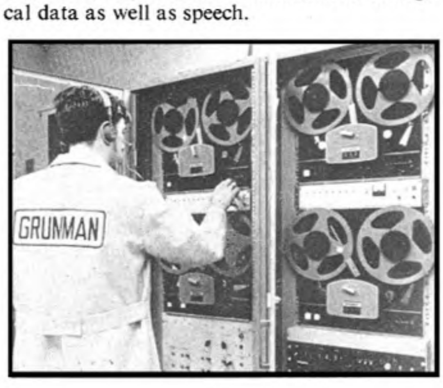
F. W. O. Bauch Ltd. are moving to new premises, situated in Borehamwood. Importers of a wide range of professional and studio equipment, including Studer tape machines and ancillary equipment and Neumann microphones and disc cutting equipment, they are now at 49 Theobald Street, Borehamwood, Hertfordshire. Phone number is 01-953-0091.

Also in new premises are Shriro (U.K.) Ltd., importers of a range of equipment including Pioneer headphones and tape recorders. Their new address is Lynwood House, 24-32 Kilburn High Road, London N.W.6, telephone number 01-624-9102.

Finally, not exactly moving, Teleton Electro have opened a London showroom, and introduced a portable cassette recorder to boot. The showroom is at 16 Savile Row, London W.1 and telephone number is 01-437-6796.

APOLLO ON TAPE

GETTING a man to the moon depended on the efforts of a great number of people, directly and indirectly and tape played a part in many ways apart from providing cassetted trivia (see last month's cover). The LEM, the bit that finally landed on the moon, was developed by the Grumman Aircraft Corporation for NASA and multi-track, multi-deck Dictophone DP 248 recorders were used during 'dummy runs' to record all the commands and functional behaviour so that the module's reactions could be checked in detail by engineers at a later time. Many thousands metres of tape were employed during the testing procedure which was duplicated by other sub-contractors some of whom employed devices specially designed by the Dictaphone Corporation or its subsidiaries. A 7-track Dictaphone machine, using 200m of 6.25mm tape went to the moon in Apollos 11 and 12 and was used to record chemical and biological data as well as speech.



AUDIO ANNUAL 1970

THE FIFTH Audio Annual was published on January 23, comprising reprints of selected reviews from *Tape Recorder* and *Hi-Fi News* plus six original feature articles. David Kirk, who was highly amused by the reality of the first multitrack pop studio he visited, contributes a detailed guided tour under the title 'Multipop' (it had to be called something). Donald Aldous describes the mechanics of manufacturing gramophone records while Frank Jones asks the question, and endeavours to answer it, 'Are Equipment Reviews Honest?'. Gordon Edge considers 'Noise—Its Form and Origins', Michael Gerzon produces some theories about record wear (discs), and Rex Baldock contributes 'Air Modulation'. Price is 7s. 6d. from bookstalls or post-free from Link House Publications Ltd., Dingwall Avenue, Croydon CR9 2TA.

ARR RENAMED

THE MONTHLY JOURNAL *Audio Record Review* changed its title with effect from the January issue and becomes *Record Review*. This move is designed to emphasise the magazine's prime role — criticism of commercial recordings. Audio topics will continue to be covered by Donald Aldous, though on a smaller scale. Price is 3s. 6d. and publication date is the first of each month.

TANDBERG DONATED TO RoSPA

A TANDBERG TAPE recorder was recently donated to the Royal Society for the Prevention of Accidents as a contribution to the society's Home Safety courses. The machine was presented by John Farnell of Farnell-Tandberg Ltd to Ken Shaw, first home safety organiser to embark on the course.

TAPE RECORDERS—AUGUST 1969

AT 13 972 MACHINES, production of tape recorders was 11% lower during August than in the same month last year.

Although the total value of British manufactured machines delivered in the month was 26% lower than in August 1968, the value of exports was 39% higher. Total deliveries of foreign machines were at the same level as a year before but re-exports, although less than half as many by number, were 12% higher in total value.

Stocks of British machines at the end of the month were 27% higher than at the end of August 1968 and 7% higher than at the end of July 1969. Stocks of factored machines were 5% lower than a year previously and 15% lower than at the end of the previous month.

Ministry of Technology statistics.

NEXT MONTH

Despite this month's concern with ready-made mixers, we haven't forgotten the hard-pressed home constructor, for whom Gerald Chevin has devised *A Budget Mixer* to be described next month. Bob Auger will begin a series on Sound Balancing and 'Dropout' will drop out after delivering his final *Column Speaker* piece—a lambasting for those recordists who don't use their machines.

THE following survey is believed to be the most comprehensive so far published in a magazine on the subject of sound mixers and related equipment. It encompasses manufacturers of studio desks, high-quality and medium quality portable units, down to the simpler less expensive units designed for PA and domestic applications. Only the cheapest end of the market has been omitted, comprising mainly passive units.

Sound Mixers Surveyed

AB AUDIO ELECTRONIC EQUIPMENT, 49/90a FORDHOOK AVENUE, EALING COMMON, LONDON W.5.
(Tel. 01-992-4163)
Model: AB102 (portable).
Inputs: 10 channels, 60 dB gain swing in 10 dB steps. 200 or 600 ohm balanced microphones; 100 K unbalanced line bridging.
Equalisers: ±18 dB at 40 Hz, 3 kHz and 18 kHz.
Faders: Ruwido horizontal sliders.
Outputs: 2 groups, 0 dBm unbalanced. +13 dBm maximum.
Distortion: 0.3%.
Signal-to-noise ratio: 60 dB.
Level Indicators: Two VU meters.
Connectors: GPO jack.
Features: Line-up oscillator, FX Limiter and Equaliser, Talkback, Metered Echo and Foldback groups, Stereo monitor output, stereo headphone monitor amplifier, miniature patchboard.
Power supply: 22 to 28 V. Mains supply included.
Price: £500 (modular construction, other versions to order).

ALICE ELECTRONICS, 1A BEXLEY STREET, WINDSOR, BERKSHIRE.
(Tel: Loddonvale 5932; Windsor 61308)
No basic models. Each project given separate study and costing. Production facilities for the manufacture of three consoles simultaneously in two workshops. All consoles finally tested under session conditions in our own studio. Range of compressors, equalisers, echo units and monitor loudspeakers also produced.
Typical system: Mixer comprising 20 channels, 8 groups, 4 echo sends, 2 foldback systems, VU meters with buffer amplifiers, 4 echo returns, push button route selection, separate stereo monitor mixer with echo system, digital group selection readout, comprehensive jackfields, illuminated mode/colour change controls, etched anodised panel work, natural teak cabinet. 14 to 20 weeks delivery.
Price: approximately £8,500.

'ASTRONIC' (ASSOCIATED ELECTRONIC ENGINEERS LTD.), DALSTON GARDENS, STANMORE, MIDDLESEX HA7 1BL.
(Tel: 01-204-2125)
No basic models. Custom assembly from **Series 1700** modules including:
A1702 Microphone preamplifier. **Price:** £9 1s. (basic).
A1703/R Radio input preamplifier. **Price:** £11 0s. (units also to accept 'Gram' and 'Tape').
A1712 Master gain and Mixing amplifier. **Price:** £6 4s. 8d.
A1735 Monitor loudspeaker (for 1 W, 100 V line). **Price:** £5 7s. 4d.
A1747 Monitor LS and amplifier (120 mW). **Price:** £9 13s. 4d.
A1734 VU meter. **Price:** £5.
A1740 DC supply. **Price:** £6 3s.
Full catalogue: Available from manufacturer.

AUDIX SOUND SYSTEMS, STANSTED, ESSEX. (Tel: Stansted 3132/3437).
MXT-6 Series silicon transistor modules including: **MU/30, MU/200** balanced and **MU/1** unbalanced microphone preamps, **GU/1** Gram, **TU/1** Tape and **RU/1** Radio preamps, and **TS/1** oscillator (400 Hz to 2 kHz).
Power amplifier, control consoles, rack equipments and installations as needed.

CADAC (LONDON) LTD., STANSTED, ESSEX. (Tel: Stansted 3132/3437).
Studio control desks, all installations to customer's specification. Delivery around 6 months, depending on size.

CARSTON ELECTRONICS LTD., 71 OAKLEY ROAD, CHINNOR, OXFORDSHIRE.
(Tel: Kingston Blount 8561).
Model: PM3 (portable.)
Inputs: 4-channel, 50/200 ohms balanced to suit Nagra. Speech filter.
Output: Two groups, 0 dBm.
Frequency response: 30 Hz to 30 kHz—3 dB.
Signal-to-noise ratio: 120 dB.
Distortion: 0.1%.
Price: £43.

CHEESEMAN ELECTRONICS, SHEWELL ROAD, COLCHESTER, ESSEX.
(Tel. Colchester 5921).
Model: Cheeseman Mono (portable).
Inputs: Four channels, two sensitivities each.
Outputs: 15 mV and 500 mV at 2 K.
Frequency response: 20 Hz to 30 kHz±1 dB.
Signal-to-noise ratio: 70 dB.
Distortion: (0 dB, 1 kHz): 0.1%.
Level Indicator: Single meter.
Connectors: DIN standard 3-pin.
Faders: Rotary.
Power Supply: Mains.
Dimensions: 254 x 127 x 89 mm.
Price: £25 (retail).

EDUCO ELEKTRONIK
Distributor: P. A. Jassoy & Associates, 10 Clayfarm Road, New Eltham, London S.E.9. (Tel: 01-850 7176).
Model: Control Master Six-S. (Transportable).
Inputs: 6 channels, 0.775 V (0 dB) at 8 to 10 K. Echo input 0.7 V, 2 M.
Equalisers: ±20 dB at 50 Hz and 20 kHz.
Frequency response: 20 Hz to 75 kHz±1.5 dB.
Signal-to-noise ratio: Better than 90 dB.
Outputs: 0 dBm (0.775 V, 600 ohms) for amp (2), monitor, tape and echo unit. Booster amp can be fitted to raise voltage by 20 dB.
Power supply: 220/240 V (110 V to order), 5 W.
Dimensions: 240 x 460 x 120 mm.
Weight: 4.8 kg.
Features: Channel and O/P slide faders, switched peak voltage meter, mono/stereo mixer control, plug-in preamps matching all standard mikes and PUs.
Connectors: Tuchel.
Price: £242 ex. preamps.

ELCOM (NORTHAMPTON) LTD., ROSS ROAD, WEEDON ROAD INDUSTRIAL ESTATE, NORTHAMPTON NN5 5AD.
(Tel: 0604 51873).
No basic models. Custom assembly from modules including:
***EP51** Bass/treble equaliser **Price:** £26 10s.
***EA151** Presence unit. **Price:** £27 5s.
***EM41** Microphone preamplifier with transformer. **Price:** £31.
***ER141** 30 dB amplifier. **Price:** £15.
***EX111** Star mixing module (12 inputs). **Price:** £17 10s.
CA24/D Star mixing module (24 inputs). **Price:** £40.
ADA240 Line distribution amplifier (10 outputs). **Price:** £89.
JFS60 3 x 20-way audio jack field **Price:** £48 15s.
VP 001S 18 way video patch field (3 x 'U' Links). **Price:** £63 3s. 2d.
'U' Links as extra. **Price:** 16s. 6d.
PPM 24 PPM drive amplifier. **Price:** £88 13s. 6d.
ICA 24 Intercom amplifier. **Price:** £20 3s.
VUA 24 VU amplifier with meter. **Price:** £39 15s.
TO24 Tone oscillator. **Price:** £33 15s.
FO12 Hi-pass, lo-pass filter. **Price:** £26.
FO13 Tele FX filter. **Price:** £29 10s.
FO17 Weighting filter. **Price:** £52 10s.
TBA-24/50 Talkback unit (PC card only). **Price:** £13 15s.
FO14 Variable-frequency notch filter. **Price:** £48
*Replacement service only. Details on request.

EMT
Distributor: F. W. O. Bauch Ltd., 49 Theobald Street, Boreham Wood, Herts. (Tel: 01-953-0091).
Model: Studer 089/002 (transportable console).
Inputs: +81 to + dBm, balanced, floating. 12 channels maximum. Input impedance 5 K (200 ohms microphone source, 600 ohms line source).
Equalisers: ±6 dB at 80 Hz and 8 kHz. 7-position step switches. 6 dB/octave slope. 9 dB maximum presence boost at 1.5, 2.2, 3 and 4.4 kHz continuously variable. 60, 125 and 300 Hz bass filter, 3, 5.5 and 10 kHz treble filter, 12 dB/octave, 4-position step switches.
Outputs: —9 to +16.2 dBm at 2 ohms (1 K minimum load).
Distortion: (30 Hz to 15 kHz): 0.5% max at +15 dBm.
Level Indicator: Peak meter, dB calibrated.
Connectors: Cannon XLR.
Signal-to-noise ratio: 78 dB RMS, 76 dB peak.
Features: Full details on request.
Power supply: Mains or battery.
Dimensions: 700 x 650 mm (desk), 1020 x 700 x 650 mm overall.
Weight: 66 kg.
Price 12/2: £4,392.

Model: EMT 104 (transportable).
Inputs: Four channels, balanced, floating. 94 dB gain (dynamic microphone, with or without bass cut) 73 dB gain (capacitor microphone, with or without bass cut); 22 dB gain (line). 1 K minimum impedance (microphone); 3 K minimum (line).
Outputs: +6 and +15 dBm, balanced, floating, 50 ohms impedance. Two groups.
Frequency response: 30 Hz to 15 kHz ± 1 dB.
Distortion: (100 Hz to 5 kHz): 0.8% max at +6 dBm, 300 ohm load.
Signal-to-noise ratio: 126 dBm RMS.
Level Indicator: PPM (10 mS to 90% FSD; 2 seconds 0 to -30 dB).
Connectors: Cannon XL.
Features: Compressor/limiter.
Monitor loudspeaker.
Line-up oscillator.
Pre-fade listening.
Faders: Rotary.
Power Supply: Mains or battery.
Dimensions: 335 x 246 x 118 mm.
Weight: 9.8 kg.
Price: £489 (basic).
Fader modules: W-VE10, W-VE15 and W66 series. Details on request. 3E-Regietisch modular system: Details on request.

GRAMPIAN REPRODUCERS LTD., HANWORTH TRADING ESTATE, FELTHAM, MIDDLESEX.
(Tel: 01-894 9141).
Studio mixers to special order. Typical facilities include prefade listen, individual channel monitoring, simultaneous rehearse and transmit facilities, PPM, calibrated faders, bass and treble equalisers, and independent talkback. Quotation on request.
Model: 16/6 (transportable).
Inputs: Six channels, sensitivity 200 μV at 600 ohms.
Equalisers: —10 dB at 100 Hz, —12 to +6 dB at 10 kHz.
Output: 600 ohms floating, single group.
Distortion: Less than 1% at 0 dBm.
Signal-to-noise ratio: 65 dB.
Level Indicator: Meter.
Connectors: Screw type GR connector.
Power Supply: Mains (battery to order).
Dimensions: 488 x 181 x 161 mm.
Weight: 5.56 kg.
Price: From £98 10s.

Model: 18/4.
Inputs: Four channels, 500 μV 600 ohms or 100 mV at 100 K for 0 dBm output.
Equalisers: —8 dB (microphone input), ±8 dB (aux input) at 100 Hz, —25 to +8 dB at 10 kHz.
Frequency response: 100 Hz to 10 kHz ±3 dB.
Output: 600 ohms floating.
Distortion: less than 1.5% at 0 dBm.
Signal-to-noise ratio: 60 dB.
Connectors: Standard jack.
Power Supply: PP9 battery.
Dimensions: 289 x 177 x 73 mm.
Weight: 2.04 kg.
Price: £37 (standard model).

GRUNDIG
Distributor: Grundig (Great Britain) Ltd., Newlands Park, London S.E.26. (Tel: 01-778 2211).
Model: 422 (portable).
Inputs: Four channels, 100 μV to 15 mV, 3K (microphone); 100 μV to 10 V, 3 K (radio); 60 mV to 10 V 160 K (tape).
Outputs: Two groups, 2 mV, 39 K for minimum quoted inputs.
Connectors: DIN.
Noise: 1 μV (microphone); 1.5 μV (radio).
Frequency response: 40 Hz to 20 kHz (—2 dB).
Power supply: Two PP3 batteries.
Dimensions: 343 x 185 x 72 mm.
Weight: 1.8 kg.
Features: Slide faders, pan pot, echo with separate reverb unit HUSI).
Price: £39 18s.

Model: 420 Mono version of above, four inputs.
Price: £26 8s.

HELIOS ELECTRONICS LTD., 95 RAILWAY ROAD, TEDDINGTON, MIDDLESEX.
(Tel: 01-977 7841).
Studio control desks, all sizes from 8-channel stereo to 32-channel 16-track; also for tape reduction, film dubbing, mobile vans. No standard models, all units designed to customer's requirements. Typical deliveries 4 to 7 months, according to size.

MILLBANK ELECTRONICS, FOREST ROW, SUSSEX. (Tel. 0342-82 2288).
Model: FAS 10 (portable).
Inputs: Six channels, 100 μV 30 ohms balanced (microphone); 100 mV at 100 K, 1 V at 1 M (auxiliary).
Equalisers: To order.
Output: 0.775 mV at 10 K.
Distortion: 0.2% on 10 K load; 0.6% on 1 K load.
Signal-to-noise ratio: 60 dB.
Tone controls: Bass and treble.
Connectors: 3-pin DIN.
Power Supply: Mains (battery to special order).
Dimensions: 491 x 119 x 160 mm (in case).
Price: £64 12s.

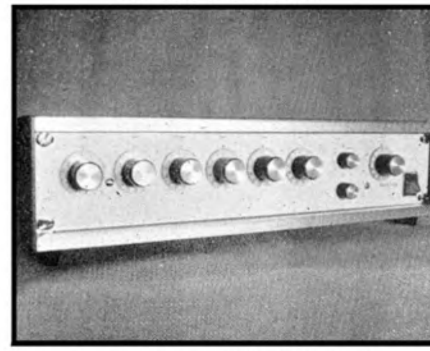
Custom assembly from modules including:

050 RIAA Equalised PU preamplifier.	**Price:** £4.
051 CCIR Equalised tape head preamp.	**Price:** £4.
052 100 K Input preamplifier.	**Price:** £4.
054 30 ohm Microphone transformer and preamplifier.	**Price:** £6.
058 1 kHz tone oscillator.	**Price:** £4.
059 4-frequency oscillator.	**Price:** £6 10s.
056 Preamplifier combiner with tone controls.	**Price:** £5 5s.
063 2 W Power amplifier.	**Price:** £6.
061 Stablilised power supply.	**Price:** £13 10s.

NEUMANN
Distributor: F. W. O. Bauch Ltd., 49 Theobald Street, Boreham Wood, Herts. (Tel 01-953-0091).
No basic models. Range of 40 x 190 mm control modules (silicon transistor) including:
PV76 Microphone preamplifier, 76 dB gain adjustment, 40, 80 and 120 Hz filters. **Price:** £177.
PEV HF, LF and presence equaliser. **Price:** £183 9s.
PVV Preview monitor amplifier. 5 W output for —24 dBm input. **Price:** £129 15s.
PKV Talkback amplifier with limiter. **Price:** £127 2s.
PPG Test oscillator, 60 Hz, 1, 7, 10 and 14 kHz. **Price:** £111 8s.
PTMV Peak level amplifier. **Price:** £155 19s.
Plug-in boards:
PV34 Line amplifier. 34, 40 or 46 dB gain. **Price:** On request.
PTS Isolation amplifier. **Price:** On request. (Twin or triple units to order.)
PLTV Line isolation amplifier, +6, +9 or +15 dBm and (+6 dB) monitor outputs. **Price:** £70 15s.
PR Pan pot (40 x 64 mm panel). **Price:** £65 10s.

PHILIPS
Distributor: Pye TVT Ltd. Weybridge, Surrey. (Tel: Weybridge 45511).
Model: MP4 (portable).
Inputs: Four channels, floating, 250 ohms (for 50 ohm microphone), 109 dB maximum amplification; 1000 ohms (for 200 ohm microphone), 103 dB maximum amplification; 4000 ohms (for 600 ohm line), 32 dB maximum amplification. **Cue:** +6 dB 3 K.
Insertion :—7 dB 2 K.
Faders: Carbon rotary. Alternatives to order.
Outputs: Two groups. +30dBm, +24 dB (150 ohm load), + 18dB (40 ohm load).
Insertion output: —7 dBm. Monitor: +6 dB 200 ohms. **Oscillator:** —2 dBm 1 kHz.


Unimixer 4S by *Soundex*


Portable mixer by *Millbank Electronics*


36-channel TV desk supplied to ATV Birmingham by *Rupert Neve*

Distortion: 0.2%.
Level Indicators: VU meter.
Connectors: Cannon and DIN.
Power supply: Mains or 12 x 1.5 V battery. 10 W consumption.
Dimensions: 140 x 515 x 360 mm.
Weight: 15.7 kg.
Price: £385

RUPERT NEVE & COMPANY LTD., CAMBRIDGE HOUSE, MELBOURN, ROYSTON, HERTFORDSHIRE. (Tel: Melbourn 776).
Consoles and transportable mixing systems assembled to individual order.
Standard broadcast unit: 10 input channels with comprehensive equalisation. Two main output groups. Horizontal slide faders (input channels and output groups). Echo send/return group. Foldback group with studio loudspeaker facility. Cue or prefade listen speaker built into desk. Two-speaker stereo monitor circuits. Talkback desk microphone, used also for DJ announcer. Line-up oscillator. Two output level meters (VU or PPM to order). Cue light and 'Transmit' interlock system.
Typical multitrack music recording unit: 24 input channels, 8 output groups. Four reverbera-
(continued on page 99)

tion groups, two foldback groups. Talkback communication, prefade listen or cue speaker. 12-track reduction monitoring. 4 monitor speaker circuits, 13 meters, integral patch panel. Line-up oscillator, 4 limiter/compressors.

RADON INDUSTRIAL ELECTRONIC CO. LTD., ORME ROAD, WORTHING, SUSSEX.
(Tel: Worthing 34904).
Model: DL6C/M (portable).
Inputs: Six channels, 1 mV at 35 to 100 ohms. (High impedance to order.)
Output: 0.025 mV p-p at 68 ohms, 2.5 V p-p at 6 K, single group.
Power Supply: Mains.
Dimensions: 355 x 175 x 105 mm.
Weight: 3.25 kg.
Price: £49 19s. 8d.

SANSUI
Distributor: Brush Clevite Company Ltd., Thornhill, Southampton, Hampshire SO9 1QX. (Tel. Southampton 45166).
Model: MX-10 (portable, valve).
Inputs: Six channels, three 780 µV at 50 K (microphones); 2 mV, 50 K (tape heads); 5.5 mV, 40 K or 22 mV, 70 K (phono); 780 µV 500 K (auxiliary).
Output: Cathode-follower, 1 V.
Signal-to-noise ratio: 50 dB (microphone input), 47 dB (tape head).
Distortion: 1% (microphone input to 1 V output).
Equalisers: ±16 dB at 50 Hz, + 10—12 dB at 10 kHz.
Frequency response: 30 Hz to 15 kHz ±1.5 dB.
Level indicator: VU.
Power supply: Mains, 40 W.
Dimensions: 503 x 229 x 190 mm.
Weight: 7.5 kg.
Price: £65 (retail).

SENNHEISER
Distributor: Audio Engineering Ltd., 33 Endell Street, London W.C.2.
(Tel: 01-836 0033).
Range of meter and amplifier modules, details on request.
Model: M 101 (portable).
Inputs: 4 channels, 0.1 mV at 1 K. 120 Hz LF filter.
Output: Single group, +6 dBm at 4 ohms.
Frequency response: 40 Hz to 15 kHz ±1.5 dB.
Distortion: 0.5% (+6 dBm, 200 ohm load).
Equalisers: +10 dB to —14 dB at 40 Hz, ±12 dB at 15 kHz.
Power supply: 2 x 9 V.
Weight: 6 kg.
Dimensions: 347 x 233 x 126 mm.
Price: £320 basic.

SHURE ELECTRONICS LTD., 84 BLACKFRIARS ROAD, LONDON S.E.1.
(Tel: 01-928 3424).
M62 Level-Loc. AVC unit. **Price:** £27.
M67-2E. 5-channel mixer/VU. **Price:** £87.
M68FC-2E. 5-channel mixer. **Price:** £45.
M63-2E. 2-channel mixer/equaliser/VU. **Price** £54.
Further details to be announced.

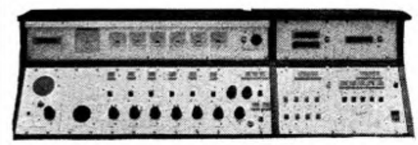
SOUNDEX LTD., 18 BLENHEIM ROAD, LONDON W.4. (Tel: 01-995 1661).
Model: Unimixer 4S.
Inputs: 4 channels, 25 to 60 ohms 30 µV, 150 to 600 ohms 75 µV, switchable.
Output: Two groups, 250 mV into 10 K load. 4 V maximum.
Noise figure: <2.5 dB.
Distortion: 0.25% up to 40 dB above rated input.
Signal-to-noise ratio: 55 dB.
Frequency response: ±2.5 dB, 20 Hz to 20 kHz.
Battery Indicator.
Faders: Rotary, including pan pots.
Connectors: GPO jack and 5-pin DIN.
Power Supply: 18 V 25 mA (2 x PP9).
Dimensions: 305 x 165 x 153 mm.
Weight: 3.75 kg.
Price: £45.

SOUND TECHNIQUES LTD., 46a OLD CHURCH STREET, LONDON S.W.3.
(Tel: 01-352 2354).
No basic models, Systems assembled to individual specification from AS.1 units:
Input Unit: Microphone transformer and amplifier, insert key and fader (first sub-unit). Comprehensive equalisation, echo send, foldback gain and select, pan pot, pre-fade listen, echo and main signal routing (second sub-unit).
Output Unit: Bus amplifier, main gain fader and insert key (first sub-unit). Monitor gain, monitor echo send, foldback gain and select, echo return, monitor speaker select, guide track select, meter switch and re-insertion control (second sub-unit).
Master Monitor Unit: 15 illuminated push-button line-out monitor selectors, line in out/out switching for meters and monitors, master monitor gain, mute switches, etc.
Studio Unit: Twin microphone talkback with four route keys, feeds with individual level controls for studio floor, rostrum and remote booth. Master level control. All signals (floating, 0 dBm) available at GPO jack panel.
Maximum system capacity is 50 inputs and 23 outputs. 22.5° console slope (from flat faders), 67.5° meter slope. See cover photograph.

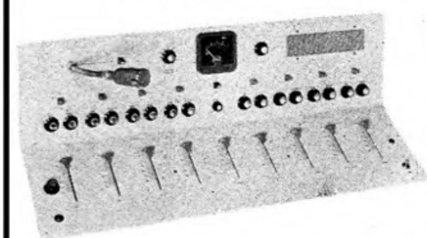
UHER
Distributor: Bosch Ltd., Rhodes Way, Watford, WD2 4LB.
(Tel: 92 44233).
Model: A121 (portable).
Inputs: 5 mono or 2 stereo plus 1 mono. Provision for 200 ohm and 47 K microphone unbalanced, high-impedance pickup, and radio, across eight 5-pin DIN sockets.
Dynamic range: 60 dB.
Output: 30 mV 20 K. (Internal 1 kHz signal generator 200 ohms.)
Distortion: 0.5%
Power Supply: 9 V PP3.
Faders: Five sliders and rotary pan pot. Input presets and muting switches.
Price: £48 14s. 5d.

VORTEXION LTD., 257/263 THE BROADWAY, WIMBLEDON, LONDON S.W.19.
(Tel: 01-524 2814 and 6242).
Range of portable mono and stereo mixers and mixer/amplifiers including:
2 + 2 Stereo. Price: £58 15s.
3 + 3 Stereo. Price: £82.
4 + 4 Stereo. Price: £104.
5 + 5 Stereo. Price: £123.
4-way Mono. Valve unit, 500 mV 20 K output. **Price:** £50.
4-way Mono/600. Valve unit, 1 mW 600 ohm output. **Price:** £55.
6-way Mono. Price: £71.
8-way Mono. Price: £92.
10-way Mono. Price £112.
3-way Mono/PPM. Price: £75.
4-way Mono/PPM. Price: £86.
6-way Mono/PPM. Price: £107.
8-way Mono/PPM. Price: £128.
12-way Mono. Price: £124.
4-way FET 50/70 W Mono mixer/amplifier. **Price:** £75.
2-way FET 20/30 W Mono mixer/amplifier. **Price:** £35.
CP50 Amplifier/3-way mixer (40 W). **Price:** £84 basic. AC mains and 12 V working.
4-way mixer/10 to 15 W amplifier. Price: £62 basic.

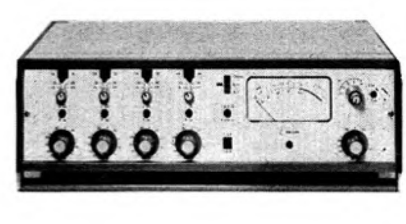
Elcom mixing desk



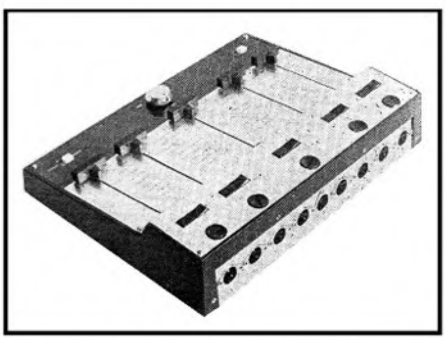
Modular mixer by *Astronic*



Compact desk by *Grampian Reproducers*



Philips MP4 portable mixer



Five-channel *Uher* mixer type A121

Vortexion

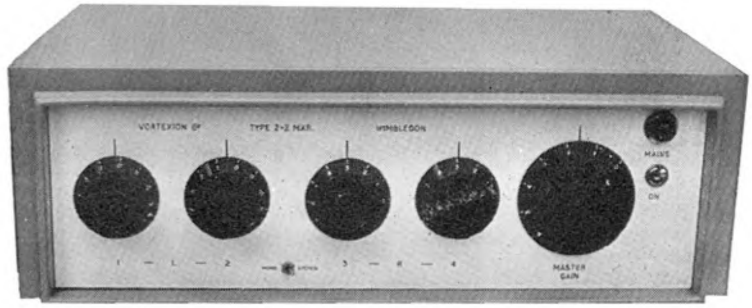
STEREO MIXERS

These electronic Stereo Mixers range from 2+2 to 5+5 input channels, with left and right outputs at 500 millivolts into 20K ohms up to infinity.

Separate control knobs are provided for L & R signals on each stereo channel so that a Mono/Stereo changeover switch provided can give from four to ten channels for monaural operation, in which state the L & R outputs provide identical signals.

A single knob ganged Master Volume control is fitted, plus a pilot indicator.

The units are mains powered and have the same overall dimensions as monaural mixers.



Also available Monaural Electronic Mixers:—

4 Way Monaural Mixers	3 Way Monaural Mixers with P.P.M.
6 Way Monaural Mixers	4 Way Monaural Mixers with P.P.M.
8 Way Monaural Mixers	6 Way Monaural Mixers with P.P.M.
10 Way Monaural Mixers	8 Way Monaural Mixers with P.P.M.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN MIXER USING F.E.T.'s This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 watt amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-60 ohms balanced line microphones, and a high impedance line or gram input followed by bass and treble controls. Since the unit is completely free from the input rectification distortion of ordinary transistors this unit gives that clean high quality that has tended to be lost with most solid state amplifiers. 100 μV on 30/60 ohms mic. input. 100 mV to 100 volts on gram/auxiliary input 100K ohms.

CP50 AMPLIFIER An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms-15 ohms and 100 volt line. Bass and treble controls fitted. Models available with 1 gram and 2 low mic. inputs. 1 gram and 3 low mic. inputs or 4 low mic. inputs.

100 WATT ALL SILICON AMPLIFIER A high quality amplifier with 8 ohms-15 ohms and 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

200 WATT AMPLIFIER Can deliver its full audio power at any frequency in the range of 30 c/s-20 Kc/s±1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watts on continuous sine wave. Input 1 mW 600 ohms. Output 100-120 V or 200-240 V. Additional matching transformers for other impedances are available.

30/50 WATT AMPLIFIER With 4 mixed inputs, and bass and treble tone controls. Can deliver 50 watts of speech and music or over 30 watts on continuous sine wave. Main amplifier has a response of 30 c/s-20 Kc/s±1 dB 0.15% distortion. Outputs 4, 7.5, 15 ohms and 100 volt line. Models are available with two, three or four mixed inputs for low impedance balanced line microphones, pick-up or guitar.

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, London, S.W.19

Telephone: 01-542 2814 & 01-542 6242/3/4 **Telegrams: "Vortexion London S.W.19"**

RECORDING STUDIO TECHNIQUES

DURING 1931 AEG in Germany commenced the development of the first tape recorder to have a specification reasonably similar to the quality of recording on discs in the same period.

In conjunction with BASF, using the first 50 km of tape produced at Ludwigshafen in 1934 (an iron oxide coated collulose acetate variety) they carried out research into the use of the tape recorder for recording music as well as speech. It may surprise readers to learn that the first classical music recording on magnetic tape of a comparable quality to contemporary discs was made by BASF at Ludwigshafen with the London Philharmonic Orchestra conducted by Beecham in 1936, at about the time that the Magnetophon tape recorder was shown at the Berlin World Fair. Surprisingly little interest was shown in the equipment except by Hitler who immediately put the development on the 'secret list'. No more was heard until the war years when British Intelligence became confused by Hitler's apparently rapid movements from one end of Germany to the other, as he was heard to make radio broadcasts of high quality from all parts of the country. After some investigation it was found that the Magnetophon had been developed and also that, in about 1941, RF AC biasing had been introduced to replace the DC bias which had been applied before then. The early Magnetophons gave a response usable from 50 Hz to 10 kHz.

After the war, when tape recording equipment was captured by Britain and her allies, explosive development took place. By 1948 many different makes of tape recorder were available, including the well known EMI *BTR1*.

The earliest tapes made on the Magnetophon before the war were at 1 m/s (meter per second) and during the war this speed was reduced to 77 cm/s. Later this speed was amended to 76 cm/s to bring it closer into line with inches while giving easily divisible speeds for subsequent semi-professional and amateur use.

As the *BTR1* was a typical example of the tape recorders in use before 1950, a brief specification should be of interest. The signal-to-noise ratio was approximately 50 dB. The recording characteristic was arbitrary, and the engineer actually tweaked the record and play back equalisers to give as flat a response as possible and with much adjustment, and with luck, a response to 12kHz was obtained. Acetate backed tape was still in general use, and the wow and flutter on machines then available measured approximately 0.15% RMS, a figure which was easy to obtain because of the very high tape speed. In the early 1950's the EMI *BTR2* was developed, with recording speeds of 38 and 19 cm/s. With improvements of recording tape, such as EMI *Type 77*, an overall S/N ratio of 60 dB was obtained. The full width of the tape was used for mono recording, and most of the noise measured when a weighting network was applied was caused by tape hiss. The gap in the recording heads was of the order of 25 μ since at that time techniques had not advanced sufficiently for the manufacture of narrower gap heads of sufficient reliability for professional use. Not withstanding this, even at 38 cm/s, a flat response extending to 18 kHz was easily obtainable, although at 19 cm/s the average professional machine only extended to 10 kHz. 38 cm/s is still used today for professional tape recordings because of the greater reliability of that speed with respect to lack of dropouts, constancy of frequency response and freedom from tape hiss, in addition to editing being easier at higher speed.

The first professional stereo tape recorders widely used in this country were imported from Ampex in the States, and allowed a greatly improved response at 19 cm/s, extending to 14 kHz. With the wide use of imported low noise and high output tapes, such as Agfa *FR4* in 1958, it was found that many professional tape recorders had insufficient drive available from the recording amplifier to the record head, in addition to insufficient bias available to bias these tapes. Many studios, including my own, had to carry out extensive modifications to the equipment to make full use of these tapes. A signal-to-noise ratio of 60 dB was attainable on each of the two tape tracks, which at that time was considered satisfactory.

Almost all professional equipment is designed for balanced line working with the inputs having an impedance of 10 K allowing several machines to bridge the same line, and the outputs having a source impedance of considerably lower than 600 ohms. In the studio, once the record and playback levels have been set up, together with the equalisation and bias, the tape recorders are not further adjusted, all the adjustments of level being made in the mixing desk. For this reason, very few professional tape recorders have other than preset gain controls. Each studio normally has its own preferred line level and, with valve equipment, a peak line level of +8 dBm (just under 2 V) into 600 ohms was used, although with transistorised equipment many studios use 0 dBm as their peak level. Studios use a number of different test tapes for alignment and details of these will be given in a later article. The replay gains are set up such that peak recording level on the tape leaves the tap recorder at the peak line level in use and therefore the peak levels into the recorder equal the levels out. In general practice most studios check the professional equipment daily and the heads are cleaned even more frequently as it is no good removing oxide from the heads *after* it has caused poor recordings and dropouts. It is also usual to leave master tapes end-out ; engineers wishing to play them are then obliged to respool to the beginning which gives a significant decrease in print-through. Twin-flange NAB spools of 27 cm diameter with a large centre hole and containing 720 m (2400 ft) of tape are in almost universal use in studios, and the same applies to 12.5 and 25 mm tape now used for multi-track machines.

With the ever increasing rates for musicians recording in studios, it has been becoming more and more important to make recordings quickly and without faults either in the tape or in the balance. It is for this reason that machines are now in use having up to 16 tracks, allowing not only each mike but even the outputs of reverberation devices and other special effects to have their own tracks. With such machines it is also possible to use the recording head as a playback monitor, at the same time as recording on other channels, allowing the dropping in of extra tracks in synchronisation with previously recorded ones. This facility avoids the use of dubbing from one machine to another when it is required to add, for instance, a vocal track to the previously recorded orchestral one. Pop groups, such as the Beatles and the Rolling Stones make very full use of such facilities, and the recording time can be cut down to perhaps a quarter of the time that would otherwise have been required. The cost of such a machine made by Ampex or Sculley in the USA can be anything up to £12 000 or more, but I am pleased to see that a number of smaller firms in this country are expanding in the multitrack market. Professional readers may well be interested in the activities, for instance, of Richardson Electronics in North-East London, who quote a price of approximately £4 000 for an 8-track machine they are in the course of developing, having modular electronics with very good specifications.

Although professional 2-track stereo tape recorders usually cost in excess of £1 000, I am also pleased to see a number of British firms making machines of almost full professional calibre at prices far lower than before. One such machine, at under £300, having four speeds including 38 cm/s, is made by Tape Recorder Developments Ltd., also in North East London, including line in and out facilities, and incorporating a PPM which is far more useful than the usual VU meters found on American machines. It is hoped to review the TRD shortly.

As I have said before, speed and accuracy in the recording studio are essential, together with consistency, allowing tapes made at different sessions to be edited together. Up to a few years ago studios used to bias their recorders using a 1 kHz tone and increasing the bias above peak output of the tone so that this output drops. It was found, however, that relatively small differences in the output of the tone with changes of bias resulted in

(*continued on page 103*)

BY ANGUS McKENZIE (Roundabout Records)

PART 3

PROFESSIONAL TAPE RECORDERS

INCREDIBLE OFFER FROM R.E.W.

SAVE £68

on the incomparable

AMPEX 1100

Stereophonic Tape Recorder

Here is value beyond compare. A unique tape recorder with features unknown outside the professional field, offered by R.E.W. at only 138 gns—a saving of £68 on the list price of £213! The Ampex 1100 gives you the supreme advantages of automatic threading and electronic reversing. To load, simply place a reel of tape on the recorder, drop the end of the tape in the 'magic slot' and you're ready to play. Then sit back and enjoy a complete 4-track stereo tape without reel switching—the recorder reverses automatically at either or both ends of the tape. And there are many more impressive features. 3-speed operation, VU meters to constantly monitor the record level input with unerring accuracy, and precise dual capstan drive to reduce wow and flutter to a point where it is inaudible. The Ampex 1100 also incorporates silicon solid state electronics and special deep-gap heads which give a quality that never varies—year in, year out. Complete with stereo amplifier giving 6 watts R.M.S. output per channel, the Ampex 1100 can be used with any pair of good quality speakers. It all adds up to one of the finest tape recorders ever—at an incredibly low price from R.E.W.!

List Price: £213
R.E.W. Price
138 GNS
£48.18.0 DOWN and 12 monthly payments of £8 (INTEREST FREE)

2 GREAT CASSETTE PORTABLES-DOWN IN PRICE AT R.E.W!

PHILIPS EL3302

List Price £28.7.0
R.E.W. Price **22 GNS.**

Record or playback, anywhere, instantly. Just snap in a Compact Cassette or Musicassette. Powered by five 1.5 volt batteries — mains unit available. Lockable record control. External speaker take off. Supplied with carrying case, C60 cassette, library rack, etc.

SANYO M48M

List Price £23.2.0
R.E.W. Price **18 GNS.**

A compact, light, cassette tape recorder which operates on four U11 batteries. Features include automatic record level and remote control. Comes complete with microphone and carrying handle. A/C adapter available as optional extra.

INTEREST FREE TERMS

Available on all our equipment. You pay no extra for our generous H.P. facilities —just the prices quoted whether you pay cash or not. One-third deposit required and balance over 12 months.

Come along to either of our showrooms and see and hear the full range of PHILIPS, SONY, AKAI, REVOX, FERROGRAPH, B & O, amongst others. If you can't call, send off the coupon or phone for details.

R.E.W. AUDIO VISUAL Co

HEADQUARTERS SHOWROOMS AND MAIL ORDER: DEPT. TRM9
266-8 UPPER TOOTING RD., LONDON, S.W.17. Tel.: 01-672 4471/2 and 9175.
WEST END SHOWROOMS:
146 CHARING CROSS ROAD, LONDON, W.C.2.
Telephone: 01-836 3365 (*opposite Astoria Cinema*).

Name ....
Address ....
.... TR

AKG D202

The popular D202 used on radio, T.V., sound recording studios, schools and by many amateur sound recordists, incorporating two dynamic moving coil systems in a single housing, one for high and one for low frequencies, giving smooth frequency response similar to a condenser microphone.
Electric Bass attenuation
0 to —20 Db Hz Frequency range 20/18,000 Hz.

Retail Price £32.

For more information on this and other AKG Microphones please contact AKG Equipment Ltd., Eardley House, 182/4 Campden Hill Road, London, W.8.

larger differences in output at higher frequencies and, because of improvements in tape, it is now possible to bias tapes at slightly lower values than were in use some years ago. For many years I have myself biased machines using a tone of 10 kHz, allowing the output to drop between 2 and 5 dB depending upon the tape used, and the recording speed. It must be appreciated that biasing professional machines can be a long and tedious process, especially when they are multi-track, and also one can never be sure that a particular drop at 10 kHz is best for any particular batch of tape.

Biasing at 3 Hz

A very recent development in biasing has just been made, of considerable interest: Many years ago the correct bias point did not necessarily coincide with the biasing points for minimum modulation noise, maximum available outputs, minimum distortion and minimum tape noise. With present day tapes having low noise and high output, designated for example by BASF as *LH*, it has been found that the setting for minimum modulation noise measured with a small DC current through the recording head in the presence of RF bias, coincides closely with the best biasing possible. Such a procedure is extremely difficult in the studio because it needs the introduction of very small DC currents through the recording head which subsequently has to be very effectively demagnetised. A frequency of 3 Hz (*Not a printer's error!* —**Ed.**) applied to the recording head however, allows the correct bias point to be established by listening to the output of the replay amplifier at high level, provided the 3 Hz tone is pure, having negligible even harmonic distortion. It should not be necessary to demagnetise the heads since the 3 Hz tone, if pure, is effectively a varying DC voltage being applied backwards and forwards. After the test the 3 Hz tone should be taken down gradually to prevent magnetisation. It will be noted that, at a low bias setting, the sound of the playback will appear to hush six times per second, representing six pulses of DC. As the bias is increased, the wide band pulses will audibly be reduced to a minimum and, as the bias is further increased, they reappear gradually but with less high frequencies present. On increasing the bias still further, they will appear to drop right off. The correct bias point is represented by the first minimum just before the pulses reappear with top cut. A word of warning must be made here in case the recording amplifier is driven too hard at such a low frequency, causing even harmonic distortion. It may be necessary to connect an oscillator to the record amplifier side of the bias trap experimentally and to remove the output of the record amplifier which may well otherwise be a load on the oscillator, and whose negative feedback circuit could attempt to battle with such an unusual signal.

I have recently tried this technique with BASF *LR56*, *LGR30* and *LP35LH* tapes, EMI *Afonic* and an old reel of Agfa *FR4*, and I have found that the bias level giving the minimum hush pulses has in all cases given very accurate results. This technique is particularly recommended for multitrack machines. The same 3 Hz signal can also be used for adjusting the symmetry of the oscillator which in the past was best adjusted by using a symmetry tape consisting of an ordinary tape having the oxide removed every 3 mm or so in zebra style, and adjusting for minimum buzz. Using this latest method, however, normal tape can be used and the oscillator should be adjusted so that the negative and positive going pulses of noise are judged to be of equal amplitude. Again it is important to check that the recording head is completely demagnetised and that the 3 Hz signal is completely clear of even harmonics which would themselves cause unequal amplitude in the two directions.

Finally I would like to mention briefly the specification of the latest Ampex *MM1000* 8 and 16-track recorders, recording on 25 and 50 mm wide tape respectively. Spools of up to 35.6 cm diameter are usable, although normally 27 cm NABs are used. The wow and flutter are considerably better than their specification of 0.08% RMS and the speed constancy is to the incredible accuracy of 0.1%, the highest accuracy I have yet heard of in audio equipment. Using high output low noise tape, a signal-to-noise ratio of 66 dB should be attainable with a response appreciably better than their specification of ± 2 dB, 30 Hz to 18 kHz. All preset controls are easily reached on the front of the amplifiers. The 16-track version costs £12 500—quite a tidy sum! I can remember paying £2 500 approximately seven years ago for the 4-track valve predecessor. 15 years ago, tape recorders did not reach full recording speed for several seconds; the new Ampex machines, and indeed most others produced today, reach this speed in half a second.

From the above it will be seen that, to set up a major recording studio, an expenditure of six figures is now necessary. I cannot help wondering what is to come in the future and what role will be played by chromium dioxide tapes.

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effective effects

By Gerald Chevin

TREMOLO and vibrato, in addition to being particularly effective effects (hence the title of this column), are two of the most misused expressions in the recording business, second only to *monaural* ('one-eared') and *echo* (a distinct repetition, see also *echolalia*—exit reader to find his dictionary).

Tremolo is defined as amplitude modulation of a sound source and may be obtained in a variety of ways. Most electronic tremolo units may be set between 3 and 30 Hz, the most common circuit using an oscillator with a sinewave output which feeds a suitable part of the amplifying chain. Unfortunately an oscillator operating at these low frequencies will tend to 'thump' and this is undesirable, particularly in high level monitoring conditions.

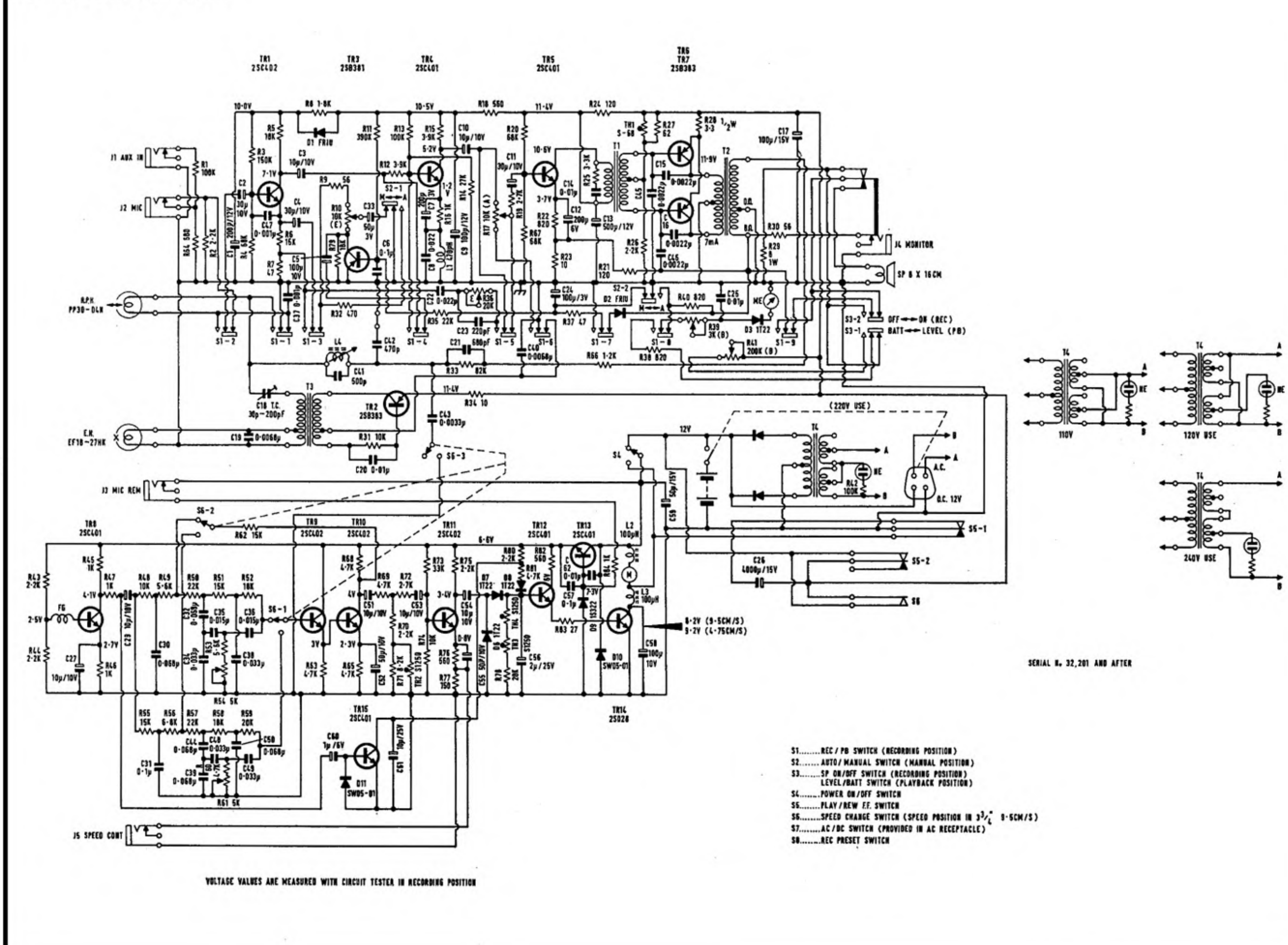
An alternative method is to connect the output of the oscillator to a DC amplifier and small LES lamp optically linked to a light dependent resistor (LDR) in such a manner that the gain of the amplifier depends on the resistance of the LDR, minimum gain with maximum bulb luminance and vice versa. The oscillator component in this instance is seen but not heard. A suitable circuit may be derived from the transistor limiter described in the July/August issues.

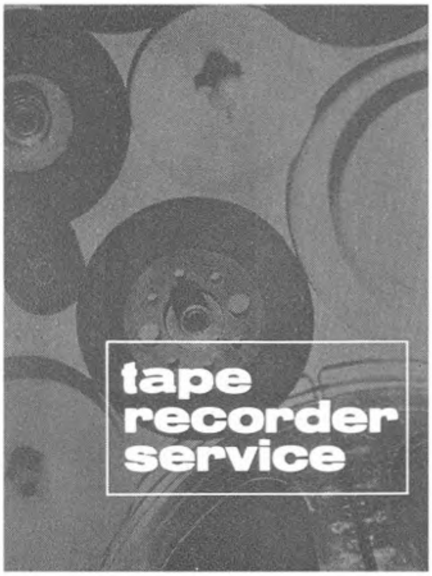
Tremolo is normally associated with electric guitars, as are 'fuzz' and 'wah-wah', though I have experimented with it on vocal tracks, drum tracks, and even echo return.

The so-called 'tremolo' arm of an electric guitar is really a vibrato arm and changes the pitch of the signal source, frequency modulation. Vibrato is difficult to produce electronically but may be achieved with the aid of a suitable recorder. The method I employ is to introduce excessive regular wow (inherent in some machines!) by increasing the capstan diameter over about half its circumference; in other words, build up a layer of splicing tape about a quarter the original capstan diameter. I used such a unit for an American 'pen that writes under water' TV jingle. The whole of the vocal track was fed to the unit running at 76 cm/s, producing the desired 'bubbly' effect. Pitchless percussion instruments also sound enhanced.

Finally, a quick anecdote. One is constantly striving for originality in pop records and, whilst taping The Move pop group, I suggested we record the electric guitar in the street. So our precious AKG *C28* capacitor was placed in the middle of Great Portland Street at 8.30 p.m. one Thursday evening, the amplifier sitting on the pavement and an extra long headphone lead running out from the studio. Traffic noise really added an extra dimension to the tape, but there were difficulties: after ten minutes solid playing and 4s 6d the richer, Roy Wood the guitarist was firmly told by a neighbour, who obviously had no creative feeling, to 'stop the infernal row!'.

FIG. 1 SONY TC800 CIRCUIT DIAGRAM





SONY TC800

BY H. W. HELLYER

(PLUS A MAJOR DIGRESSION ON TRANSISTOR TESTING)

LAST week brought an irate telephone call. 'When are you getting away from Sony? Aren't there other machines on the market?'

Well, yes, there are. Quite a few, in fact, But, having got on the Sony kick a few months ago, your correspondent has found it increase ingly difficult to get off again, as this enterprising and extremely efficient Japanese company markets so many worthwhile domestics that the whole of 1970 would be needed to cover the range in these articles, at the present rate of progress. True, there have been one or two failures. Mention the *135* to any self-respecting Sony man and he will shrivel up with shame. The noise level on the *210* is not as good as one would like, and the latest types of clutch mechanism on the take-up side of the *TC252* and others needs a rethink. But, in general, Sony produce well-engineered models and back them up with superlative service. Our subject this month is an excellent case in point.

The Sony *TC800* is a 4.75 and 9.5 cm/s, half-track battery portable, reel-to-reel, taking 13 cm reels, with automatic and manual recording level control, variable speed function, an exceptionally wide frequency response for such a small machine, the usual Sony facilities of remote control and mains/battery operation, and as neat and practical a styling as one could find. Latest versions also operate at the more Christian tape speed of 19 cm/s. Looking at the circuit of the motor control, and the switching arrangements, one is led to the conclusion that this is a conversion many *TC800* owners could perform for themselves.

But first—as the comperes of radio programmes annoyingly persist in saying—we must honour our obligations. Last month I promised a short run-down on transistor testing with the minimum of instruments. Here goes . . .

My own experience, even with a well-equipped workshop, leads me to believe that the principal difficulty is choosing and fitting a substitute. This may only be wanted for a brief test, to prove a point or confirm a diagnosis. Running down the road every time a gain-comparison has to be made is not everybody's idea of well-spent time, so we resort to the spares box, that heaving compendium of the strange and nostalgic that lurks in the shadowy corner of every den. And then, perhaps with no circuit or other reference, we have to identify the strange device we suspect as being faulty. Commonsense and knowledge of general circuitry help us partly along the way. But a few quick tests will sometimes save a bit of head-scratching; and, anyway, help us maintain our familiarity with semiconductor devices.

Leaving aside all the esoteric devices, spider-legged ICs, unijunctions, varactors and other deceptive additions to the component shelves, we shall be faced with two-, three- or four-terminal objects. Appearance and size will give some clue to power rating, but not always. So, using no more than a simple meter capable of reading ohms, how do we go about identification?

Two-lead devices, diodes, have cathodes with a red spot, band or arrow, or may be otherwise indicated. As is generally the case in emergency, the marking will have been rubbed off, putting us back to square one. We connect our ohmeter to the unknown device and look for a deflection. Current flow will indicate that the positive of the meter battery is applied to the anode of the diode. First snag: some meters, when switched to 'Ohms', have the positive polarity on the terminal that was previously used as the common negative voltage or current terminal. To prove this, it will be necessary to use the meter once for a test on a known diode, thenceforth marking the meter, or remembering its characteristics.

An alternative method recommended by some is to make up a foolproof testmeter with a single 1.5 V torch battery cell in series with an amp-meter. Polarity is then unmistakeable, the 'pip' of the cell being positive. Using such a low voltage also ensures safety.

First check then, a reading one way round, and little or no reading the other way round. No reading either way would indicate an open circuited diode. The amount of current flow in the reverse direction (i.e., with cathode connected to the positive polarity) will depend on the device, the applied voltage, and the limiting resistance of the meter. A very small reverse current (typically 50 μA or less) will be found with silicon diodes, and hence little or no reading in one direction, with a full-scale deflection, or practical short-circuit reading in the other direction.

Choice of a substitute, once we have determined polarity, depends on the circuit function. Small-signal germanium point-contact diodes are of little use except as RF detectors, being limited to a forward current of a few mA (typically 1 to 6 mA), and the improved junction types, which may look little bigger, or much different, can handle up to about 30 mA and voltages up to 28 or so. Silicon rectifiers, again deceptively small, may take 100 mA at 150 V or 1 A and upwards at full mains voltage (peak inverse voltage ratings of 400 V may be reached), but are not necessarily, for that reason, better in place of low-voltage types. Try to keep within the general type if you are able.

From the two-terminal device, let's jump quickly to the four-terminal transistor, just to get rid of that extra wire end before it gets in the way. It is generally the connection to an internal shield, and may, or may not, be connected to the outer 'can' of the transistor. And it has not always been the case that the base configuration is common, any more than it is common practice for the collector to be nearest a spot or stripe marking, or a pip on the side of the can. This is often so, but not always and, unless the type of transistor is known, should never be taken for granted. We are assuming here that the device is unidentifiable.

To identify the fourth lead: pair the leads. This gives six pairs of leads from four total. Apply the ohmeter in each direction to each pair of leads. You will discover that one lead, and only one, gives no reading whatsoever when paired with any other one, in either polarity. This is the screen—the odd lead out.

We now have a three-terminal device and want to identify base, collector and emitter, and then determine whether it is *p-n-p* or *n-p-n*. Before going on, it is as well to point out that the transistor, for the purpose of these very rough tests, can be regarded as a pair of diodes. So there will be one condition where our attempts to get a reading with an ohmeter, either polarity, should be doomed to failure, and this is when we try to 'measure' across emitter and collector. So if we 'pair' emitter and base, or collector and base, we shall expect to get a healthy meter deflection in one or other polarity, little or no deflection when polarity is then reversed, but when we 'pair' emitter and collector, whatever the polarity, the meter reading will be nil or insignificant. Ergo, the odd lead out is the base.

SHORTED ELECTRODES

This assumes a good transistor. A faulty component will give erroneous results, of course. No good transistor should give strong deflections of the meter in *both* directions with *any* pairing. This would indicate that the device had short-circuited electrodes. Conversely, if no readings, or very low readings, were obtained for all our three pairings, either polarity, we could assume the base to be open-circuited. Not an uncommon fault, I should add. And if only one pairing gives a good reading between base and another electrode, then we can assume that either collector or emitter is open-circuited.

After this, having determined base electrode, we apply the positive terminal of our test meter to it and touch negative to either of the others, and a full-scale reading in this setting with a low or zero reading with the polarity reversed tells us this is an *n-p-n* device.

To check which of the two remaining electrodes is the emitter, we need a test circuit with some means of achieving base drive and

(continued on page 107)

reading collector current. We are still not greatly concerned with parameters, so can be satisfied with a rough test. With an open-circuited base and the transistor connected in the correct polarity, we can expect a small reading of collector leakage current I_{CO}. This will vary from 30 to 40 μA with a cheap germanium device down to virtually nil with some silicon transistors. (Not that low I_{CO} is necessarily the ultimate criterion—other factors are involved.) If the base and emitter are short-circuited, the collector leakage current will always decrease or disappear. This new reading is termed I_{COE}. We can very often determine whether the transistor is a silicon or germanium, and whether a high-gain or general-purpose type, simply by observing the I_{CO} and I_{COE} differences. But only after we have got it into a test circuit 'right-way-round'.

So our next step is to apply voltage between the two unknown electrodes, metering the series current, then apply a voltage to the base. We can use between 6 and 9 V for the main voltage and keep our 1.5 V cell as the base supply. If we have determined that our transistor is *n-p-n*, then we can make the negatives of the two batteries common, apply the unknown terminals, note readings if any, touch base to 1.5 V positive and note increase in reading when the transistor is in its correct mode.

One or two points need watching. The low base-to-emitter threshold voltage of some silicon devices demands base drive from a high source voltage via a large resistor, and there will be no I_{CO} or I_{COE} readings. If you get no I_{CO} reading, take care not to make the base test until you have tried the transistor both ways round.

This same factor should be mentioned with regard to updating 'front-end' circuits to obtain better noise figures. In this respect, the 'siliconise' advice is sound, except that one cannot just change components willy-nilly and still expect to get good results. Why not browse back through a few 'front-end' circuits and use *these* as the basis for a modification? That's what I did.

Looking at the circuit of the Sony *TC800*, with which we began, some of these factors begin to show. The input stage is a *2SC402* silicon *n-p-n* transistor, feeding into a *2SC401*, followed by a similar driver stage. Not by any means an over-ambitious amplifier, but capable of 60 dB gain with a very respectable signal-to-noise performance. Testing the amplifier follows much the same procedure we have already outlined. Electrode voltages are perhaps the best guide to operation, with signal tracing methods a useful second line of attack, aided by the published 'rate of progress—dB charts'.

Getting at the printed circuit boards (main amplifier and servo control boards) is not difficult. After removal of the top plate, revealing all the mechanical parts and some of the switching, the chassis can be slipped from its enveloping case by taking off knobs and handle, removing five screws with painted heads, slackening the socket board so that it can be pressed inwards for withdrawal and unsoldering battery and loudspeaker leads. The last should be undone at the tag strip on the top deck, not at the speaker. I've had a couple of bad joints at cone connections through heat running up the flexible wires. It is easier to tip the whole caboosh upside down and take the cabinet from the works. When doing so, watch out for loose screws, washers and bits of wire—the motor casing is magnetic. One of the problems is the VU meter, which flops away from its cut-out and can be damaged. Stick it down with Scotch tape, or hold it with an elastic band. When reassembling, watch that the meter is sitting squarely in its cutout—it is all too easy to clamp down the top plate on its bevelled edge. Watch those volume control tags, too. They are too easily swivelled on their open rivet fixing, and the result is noisy and intermittent operation. A judicious touch with a soldering iron to affirm those rivets is now routine procedure when we do a *TC800*.

As a matter of interest, because of this simplified circuit, one facility is lost to the *TC800*. This is control of monitoring during record. If you do not cut out the speaker with the muting switch, then the Playback volume control will have no effect. Further to this, the recording gain control tags, and the wiring that goes past them, must be replaced correctly when reassembling. I would advocate making a test recording before final assembly, checking the routing of the neon lamp leads. Do this on mains and battery supply, noting that the neon lamp leads can induce hum into the recording circuits and must be dressed carefully away from recording gain control and the auto-manual switch.

Another little joker that gives us hum troubles sometimes is the microinductor in the emitter circuit of the second stage. This 470 μH encapsulated coil looks for all the world like a little green capacitor, and is sited by the jack sockets, near the end of the record play switch. It should be bent toward the jack to avoid magnetic coupling with the trap coil. Symptoms

of the fault are an indicated noise level with no input, during record. Avoid touching the trap coil, on the other side of the board, and do not attempt to eradicate noise by its adjustment unless you are absolutely certain all other avenues of approach have been tried. Its function is, of course, to prevent pick-up of the bias frequency in the amplifier circuits, and not only its value but also its position and adjustment are precise. If you must adjust, switch to record and manual, turn gain control down, measure with VVM between red lead of trap coil and chassis, turn the coil adjustment fully clockwise then back off for minimum reading. An ordinary meter is no good for this job, and an oscilloscope difficult to interpret—you can't beat the plain VTVM.

Thus far I have not said much about the servo control of this machine—its principal feature. In the first place, it should seldom need attention and, when it does, by far the quickest repair procedure is to change the whole servo panel. If you do this, take great care to make a colour code drawing of the connections around the board. There are quite a few, and Sony have released two or three subtle variations which can cause the mechanic to come unstuck unless he is prepared to trace the layout from the circuit, especially at the leads to the remote jack and the white leads to the motor.

It is not intended to go into great detail of the servo operation—this quite separate subject of control and regulation is being treated generally in the near future, so I am informed. Visualise the *2SD28* power transistor as being in series with the motor, whose positive voltage is set by the main supply, but whose negative end may be anything between 7.5 and a little over 9 V. On fast winding, the full available voltage is applied.

The first fault is fast running, when the *2SD28* takes the negative end down to chassis. Before delving too deeply for faults, try the actual wiring of this transistor, especially where it passes through the chassis. Watch for a short-circuit on the collector tag. Next, check with an oscilloscope for pulses from the motor. These are mechanically derived and can hardly fail, but there have been reported breaks in wiring. Trace the pulse through to the switch point at the end of the speed-change network and, after this point, revert to the VTVM and check voltages, which will be more revealing.

Note that measurement of the 3 V reading at the base of Tr9 will cause the motor to speed up when the probe is applied. It can be a good quick check that this part of the circuit is operating. Sometimes, operation is erratic, especially after speed switching. The motor runs fairly, then speeds up. Try fitting a 0.1 μF capacitor across the collector load of this stage (i.e., across R68).

Fine control of speed is available with screwdriver control through a space in the works but, be warned, use an insulated screwdriver. Similarly, avoid inadvertently shorting the remote jack socket to chassis—very easily done while working on the dismantled machine. This socket carries the positive supply.

If all voltages appear to be in order and the tendency of the motor is to run slowly during record and play, but correctly on Fast Wind, then the stage to suspect is Tr11, the check-pulse amplifier. This is the stage with the emitter control for external speed variation and, even when all seems well, fitting another *2SC402* can improve speed regulation. If there is speed fluctuation when this external control is used, a bit of extra smoothing, a couple of μF typically, on the front end of the servo circuit, can help things along a lot.

As for the differences from the three-speed model: these are really quite small, and can be detailed when more space is available. But the voltage readings to note are the new figures at the collector of Tr14—5 V, 7.75 V and 8.7 V for 19, 9.5 and 4.75 cm/s respectively. The part number of the three-speed board, for those who want to do it the easy way, is *X 34254-51.*

Around the studios 2

Star Sound Studios

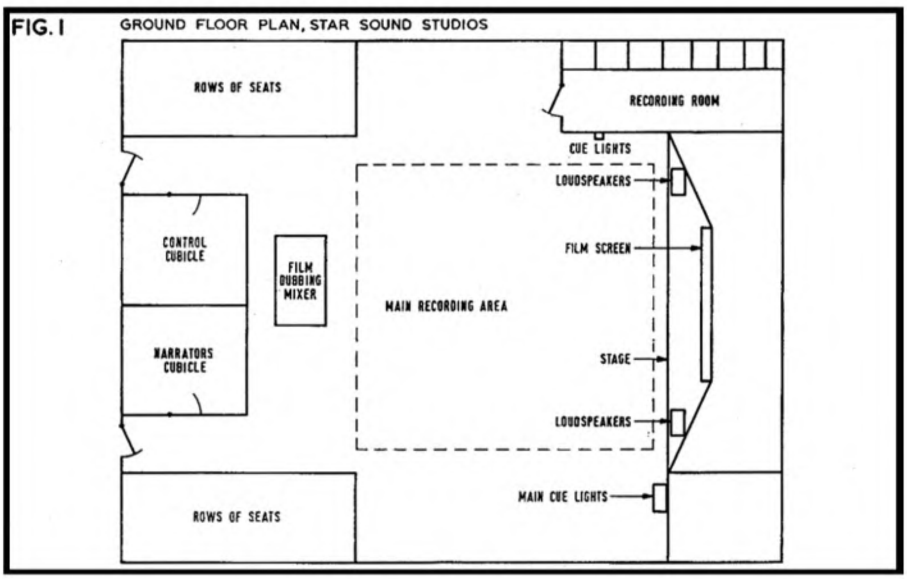
By Keith Wicks

STAR Sound Studios have been in operation longer than most other recording companies in London, and their technical director, Derek Faraday, has several decades of experience behind him. Originally with the BBC at Savoy Hill, he later formed his own recording company with which he has worked for many broadcasting organisations throughout the world.

On entering the studios, the first thing that catches the eye is a wall plaque which states, 'In this studio in June 1949, Star Sound Studios recorded the first full length radio programme to be recorded on magnetic tape in Great Britain'. Nearby, a door to the control room is marked 'SSS and BBC control cubicle'. My curiosity having been aroused, I asked Mr Faraday what the connection was between this studio and the BBC, and found that Star Sound have over the years recorded a large amount of material for the Corporation. With so much broadcasting experience, it is not surprising to find that most of the work of the studio is for radio and TV. I was shown a weekly programme sheet for Radio Luxembourg on which the material which had been recorded by Star Sound was marked. For that week, the studio had recorded no less than 26 of the programmes, six of them going out on one day, including such gems as 'Take Your Pick' and 'Double Your Money'. As for TV, material recorded by Star Sound has been broadcast by ITV on every day since the transmissions began.

Derek Faraday's broadcasting background shows up very clearly in the technical design of the studio, which is arranged much along traditional BBC lines, with a recording room separate from the control cubicle. Post Office type jackfields are provided to give access to the various pieces of equipment, so that the system is quite versatile. The studio is a small theatre with seating accommodation for 130 people in the balcony, and about 150 people downstairs. **Fig. 1** is a ground floor plan, and it can be seen that the control and narration cubicles are both situated at the back of the studio, whilst the recording room is in one corner next to the stage. The studio is fully equipped for film dubbing and has a control desk for this purpose **(fig. 2)** on the studio floor, just in front of the main control cubicle. It is a standard RCA film console.

The mixer in the control cubicle can handle 18 inputs, and is made up from a number of different units. The desk is illustrated in **fig.**



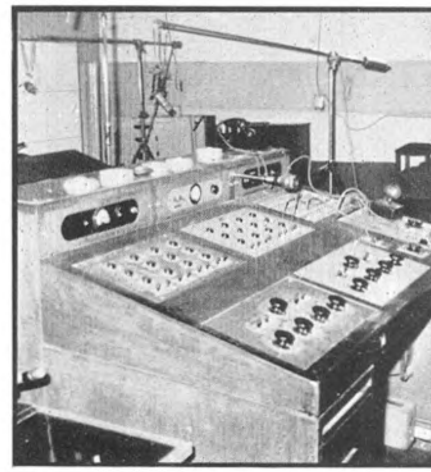
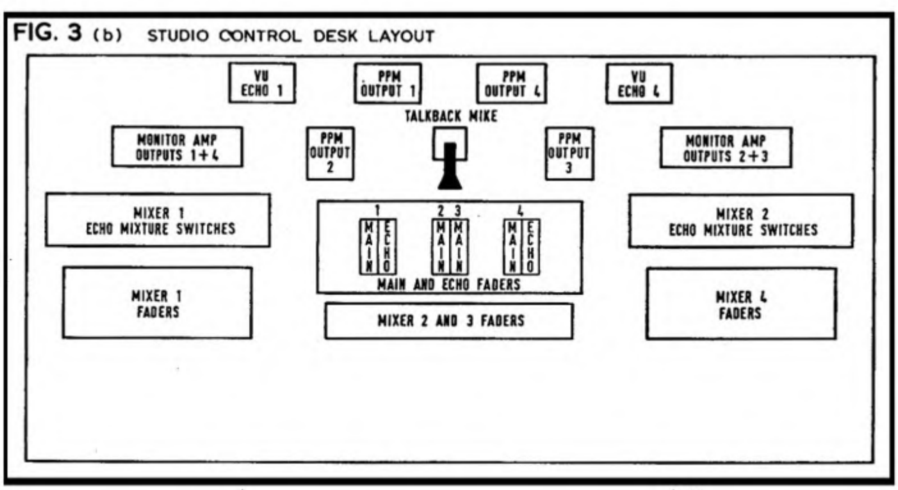
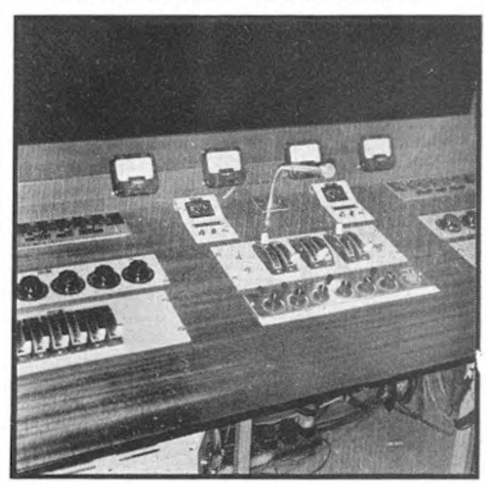


Fig. 2 (above): Film dubbing control desk.

Fig. 3(a) (below): Studio control desk.

Fig. 4 (right): Ampex twin-track recorders.





3a, and the plan (fig. 3b) is for identification of the various parts. Inputs are connected to equalisers (response selection amplifiers) which are situated beneath the control desk, and cannot be seen in the diagram. In the normal mode of operation, four separate groups may be mixed and fed to a 4-track recorder. Groups 1 and 4 each have six inputs, with associated echo mixture switches, whilst groups 2 and 3 are available from a 2-channel Ampex mixer unit, which has six inputs, each of which may be switched to either or both outputs. No echo facilities are provided in these two groups.

In the centre of the desk are the main faders for each group, and also the echo return faders for groups 1 and 2. Besides an echo room, spring and plate reverberation are available, and 'echo send' VU-meters are used to ensure that these devices are not overloaded. For monitoring the four group outputs, PPM's are used; two have the conventional black scale with white markings, whilst the other two are larger with black markings on a white background, and very similar in appearance to the echo VU-meters mounted next to them. Slightly confusing at first, since one would expect the row of four meters to be associated with the four outputs of the desk—but this is not so. The flexibility of the system is such that by appropriate plugging on the jackfield, various mixing arrangements can be obtained; for instance, all channels may be fed to one output if desired. Monitoring is provided by a pair of stereo power amplifiers feeding four Tannoy loudspeaker units which are mounted in the back wall of the cubicle. The room is approximately three metres square and what with the control desk, table, two chairs and an ashtray, is rather cramped; an onlooker such as myself becomes afraid to make even the slightest noise during a session as it would be fairly distracting for the engineer at such close quarters.

The recording room is long and narrow with the various pieces of equipment arranged along one wall. There are three Ampex 2-track recorders (fig. 4), then an EMI *TR 90*, which is a full track machine (see fig. 5). Next to this is a bay containing a jackfield where the various pieces of apparatus are interconnected, and then a 4-track Scully recorder which uses 12.5 mm tape. The final tape machine is a *TR90* mod, used for editing, while in the corner there is an MSS disc cutter which operates at 33⅓ or 45 RPM. Monitoring speakers are mounted on the wall at this end of the room.

I visited Star Sound on two occasions, the first to see one of several plays being produced in English for the overseas service of German Radio.

For this, a relatively short reverberation time was required, and several expanded Polystyrene panels were used to separate the balcony area acoustically from the main part of the studio. These panels measured about 2400 x 1200 x 80 mm, and were suspended above the studio to give the desired effect (fig. 6).

The recording was a straightforward affair, with a narrator in the separate cubicle and the action going on in the main part of the studio, screens being used to obtain different acoustics for some scenes.

My second visit was to hear a number of musical items being recorded under the direction of Cary Blyton (Faber Music Limited) for an American Television Company. For increased studio reverberation, the acoustic panels along the front of the balcony, and most of those suspended above the studio, were removed. Fig. 7 shows the studio set up ready for the session, which involved ten musicians.

(*continued on page 113*)

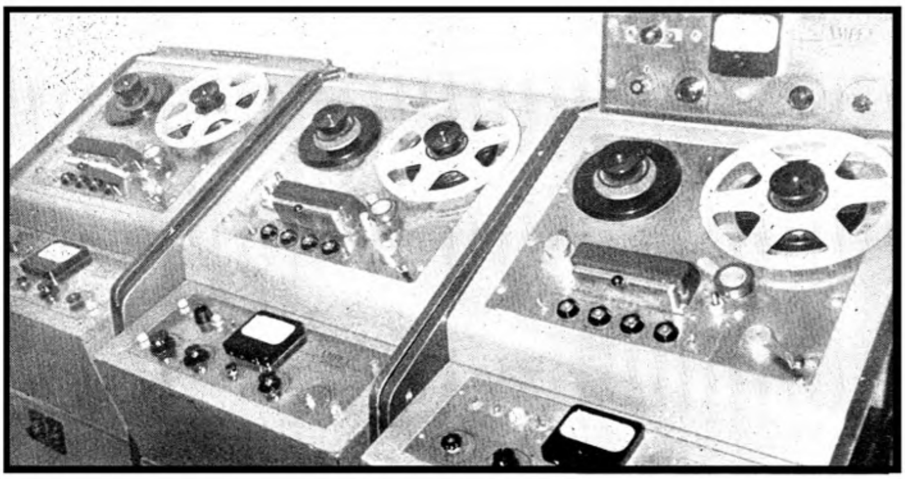
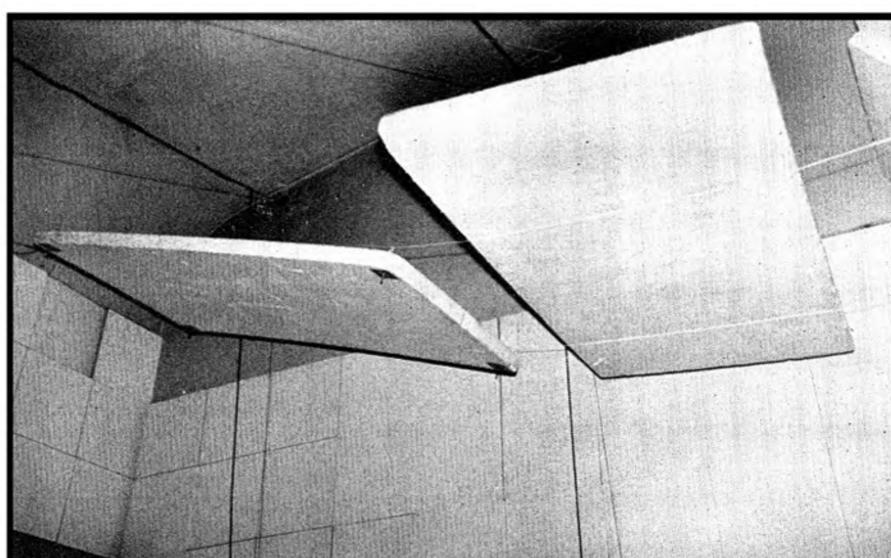


Fig. 5 (below): EMI and Scully recorders.
Fig. 6 (right): Suspended acoustic panels.
Fig. 7 (top right): Set-up for music recording.



Happy Birthday Ludwig!

By Alec Nisbett*

The rights and wrongs of Four-Channel Stereo

LIKE Edward Tatnall Canby (*Hi-Fi News*, December '69) I was looking the other way when four-channel stereo suddenly arrived on the American scene complete with equipment, tapes and price-tags. For him it all happened when he suddenly found himself being carried at high speed to various points in New York and New England to hear versions of the new sound medium.

For me the situation was a bit less comfortable: I was sitting on the wrong side of the Atlantic happily (until that moment) correcting the proofs of a book on, amongst other things, stereo microphone techniques. Naturally enough, I had all my notes on what I thought four-channel work *ought* to sound like and how I thought it ought to be done—but here it was, already reportedly pouring out in all directions. First reports were decidedly thin on the sort of detail I needed to see whether they were doing it right (i.e., with great minds thinking alike and all that) or wrong (i.e., in some fantastic way I hadn't thought of). Accordingly I rapidly let out a series of loud howls, and within days the missing details began to arrive on my doorstep.

The immediate answer appeared to be that two systems had got off the ground almost simultaneously and that one (by the above definition) was splendidly, delightfully right, while the other was marginally even wronger than ETC's first report suggested—unless somebody at his demonstration, finding the truth unbelievable, had helpfully swapped a couple of the loudspeakers left to right.

At this point, a quick word about what four-channel stereo is supposed to do. Its primary role is to make up deficiencies in listening room acoustics. With two-channel stereo all the direct sound comes from the arc between the A and B loudspeakers; but unfortunately nearly all the reverberation does too, only a very little (in duration) being derived as reflections from the listening room walls. It's not a question of acoustic treatment being too heavy and mopping it all up: the path lengths are just far too short. So the main purpose of the rear speakers is to simulate the long path-length reverberation that is so characteristic of musical sound.

There is also a second purpose: to allow *for special purposes* direct sound (or in some cases reverberant indirect sound for which there is no related direct sound) to come from directions other than in the main A to B arc. The North, South, East and West brass bands in the Berlioz *Requiem* can *only* be reproduced satisfactorily in this way. Less obviously, however, the system could be used for off-stage choruses (as in *Sicilian Vespers*); for strangely close-yet-distant choral effects in *Daphnis and Chloe*, or to actually let the boys and girls in the *Planets* tip-toe quietly out of the Albert Hall to be last heard singing backwards from somewhere north of the Round Pond. In addition to what can be done with existing works there are opportunities for modern composers and arrangers to use the rear speakers in new ways, but please—please always—with discretion. Most of the time we want those rear speakers to be for purpose one, above, with a clearly defined sound stage along the front wall. (Purpose three, exemplified by the express train through the living room *in a straight line*, and ping-pong from the point of view of the net, we can dispense with after one rapidly sneaked demonstration.)

One thing I ought to get clear is that I agree quite happily with the American loudspeaker layout: it seems to me to be a perfectly satisfactory and logical answer to the need for a

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FIG. 1

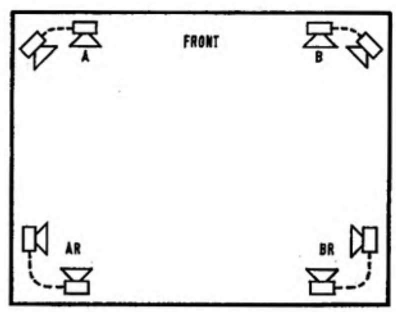


Fig. 1. Four-speaker layout. The arrangement should be symmetrical about a front-to-rear axis, but the rear speakers, AR and BR, need not be opposite the corresponding front speakers, A and B.

FIG. 2

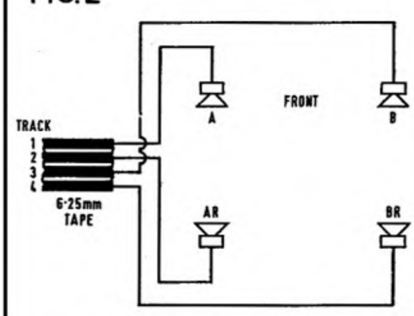


Fig. 2. The Vanguard track configuration for 6.25 mm tape.

Happy Birthday Ludwig!

By Alec Nisbett

FIG. 3

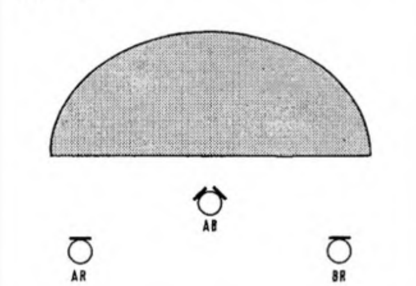


Fig. 3. Stereo microphone layout for either 2-channel or 4-channel stereo. In BBC usage AB might be a C12 or a pair of C24's and AR and BR individual C24s. This is one of a range of four microphone (or four-element) layouts which can readily be adapted to the four-channel system.

reverberation field you can walk around in. My first response to Granville Cooper's proposed tetrahedral system was a vision of the top speaker in its ideal position, suspended from the chandelier, at which point it would be pretendedly regarded as invisible by the wife and her best girl-friend who already regards the man about the house as a bit nutty . . . but the Editorial (January *Tape Recorder*) destroys this fantasy by politely and firmly pointing out that in a practical GC system the top speaker would be above the lower rear speaker, on the back wall. Even so, I feel that the lower centre speaker is likely to be too critical in its position in most small rooms, and too restrictive of movement, whereas the fifth speaker alternative that is suggested is unnecessarily fussy.

I am not being totally facetious when I suggest that if God had meant us to take an interest in the vertical separation of sounds We would have an ear on the top of our heads. Lacking such a rainwater collector, I don't see much need to feed directional information in this sense, even though it is present in the concert hall: the horizontal component is enough. Anyway, I am going to cut short this argument by saying that if you don't like the horizontal box format it's just too bad, because that's how it's going to be—there's no turning back, unless you want another big battle over standards, which would be exhausting, expensive and, I suspect, unwinnable. So everybody please agree with me.

The actual layout is flexible. A and B speakers should be in their normal positions on the front wall, 2.5 to 3.5 m apart; the rear speakers can be spaced (for convenience of room layout) symmetrically with each other, but not necessarily with the front ones. A layout in which the front speakers are as close as they might reasonably be for a two-speaker system, and the rear speakers widely separated (perhaps even on the side walls) would probably be perfectly adequate.

Starting from scratch, four somewhat less powerful speakers could be used than those required for a comparable two-channel system: after all, the total power is limited by the size and absorption of the room and the ears of the audience. But in any case a matched foursome is not necessary: in adding to an existing system, smaller speakers will be adequate for the rear. Except for the Berlioz *Requiem* the difference should not be noticed, and even there it would be only marginal.

The next crucial standard is the tape track configuration. Vanguard have led with a very sensible system in which tracks 1 and 2 (of 6.25 mm open reel tapes) are front and rear left; and 3 and 4 are front and rear right. Such tapes are therefore compatible with ½-track and ¼-track two-channel stereo players, the former scanning the total left and right signals, and the latter the correct frontal information (but omitting the additional rear reverberation). A full-track mono replay head will also derive an adequate signal. Note that (vertically) *in-line* stacked heads are used for the commercial tapes. The speed initially adopted to give an acceptable signal-to-noise ratio is 19 cm/s which comes a bit expensive (over £4 for a work of single LP length) but cheaper, lower speed recordings are promised in due course—and eventually cassettes as well (here compatibility requires that tracks 1 and 2 carry the frontal information; again Vanguard promise that this will be the case).

Obviously this would never get off the ground without plenty of support from recorder manufacturers—and plenty is there, certainly enough to keep the competition healthy: Teak, Wollensak, Telex and Crown are already in the market place with suitable decks, and Northronics and Michigan Magnetics are busy converting existing decks. (An additional two-channel power amplifier is, of course, also required.)

The easiest way of balancing the four speakers is simply to match the lot to a common

(continued on page 113)

Fig. 4. The Boston experiment: the arrangement of two multiplex receivers (R1 and R2) to generate 4-channel stereo. There have been complaints from those who can't (or don't want to) rustle up the second system.

Fig. 5. The layout of four omnidirectional mikes in the Boston Symphony Hall. Dimensions: width of Hall 55 feet. Separation of front mikes: 15 feet, 7 feet from stage; rear mikes, 22 feet apart, 14 feet from stage. Height, 20 feet above floor of auditorium (16 feet above stage). Recordings are made on 12.5 mm tape using an Ampex 440-4. These positions, and the microphone types selected, were chosen after a series of comparison tests, the object being, said WGBH, to make the total output sound as much like the hall as possible. They add: 'the state of the art of microphone placement is still rather empirical, but this would seem to be the basic pattern appropriate for any hall'.

FIG. 4

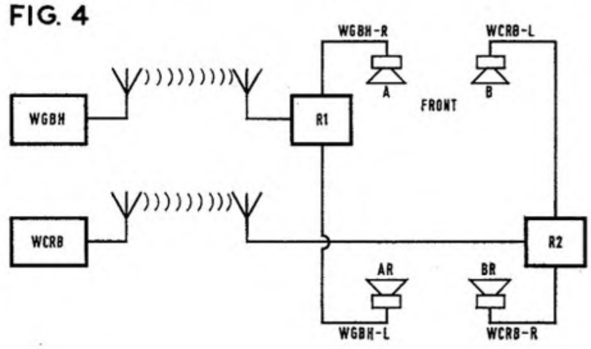
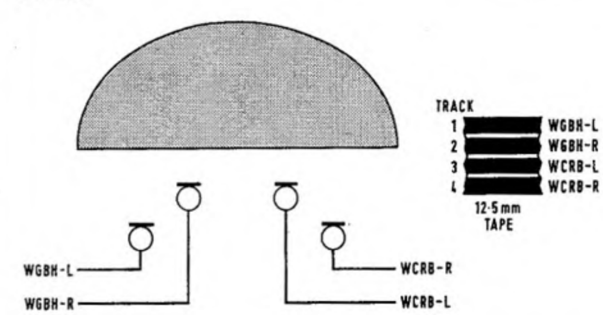


FIG. 5



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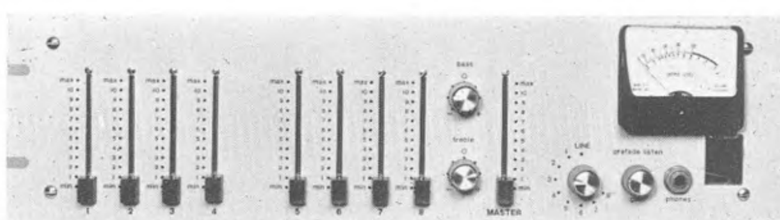

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The microphone balance adopted for all conventional works is straightforward and again sensible. The frontal information is derived in the normal way: for my money that would nearly always be with a co-incident cardioid pair at or near its normal two-channel stereo position and angled at about 120° . . . though presumably the spaced pair (with a split hole-in-the-middle filler) could be adopted by those who aren't worried about phase-distortion. In either case A and B rear signals are derived from separate mikes facing outwards and backwards and set back in to the studio. Obviously, if these pick up any direct sound or close first-reflection sound it must be from the near side, when the effect will be pleasant enough, slightly pulling out and pinning down the corners of an orchestra.

Now, as it happens, this (with the central co-incident pair) is the basic balance used for most of the best orchestral work in the BBC's Maida Vale Studio One; so, together with a number of variations all of which use four basic mikes (plus any necessary spotting mikes), this should provide a first class range of balances that are readily adapted to either two or four channels.

Vanguard have trade-marked their recordings *Quadrasonic Sound* and *Surround Stereo* and led off with that Berlioz, a couple of Mahlers, some Joan Baez, Buffy Sainte-Marie, Jean Jacques Perrey ('The Amazing Electronic Sound of'), Highlights of Handel's *Jephtha*, and a slice of Country Joe and the Fish. Apart from a reservation or two on Symphonies costing £8 plus, the best of luck to them

That's the good news. Now for the . . . well, to say the least, the very *odd* news from Boston.

In the race to get going before a couple of New York stations (WNYC and WXCR) which scheduled their debut in October 1969, the improbable team consisting of the commercial WGBH and the Educational WCRB hit the air, as everybody now knows, on September 27 last. What is less well known is what on earth made them choose to put one side of the hall on the A and B channels of one station, with the rest on the other. As there must be remarkably few home participants in this experiment (two stereo receivers as well as the four speakers are required) the bulk of the audience hears some very strange half-concerts indeed.

To provide any semblance of compatibility, all four mikes have to contain direct sound, so the first purpose of four-channel stereo is lost without trace from the start. Even so, 'We have been suffering the slings and arrows of a few single system buffs' who are displeased with the arrangement of mikes. 'Let me say that we are working to solve this problem,' says WGBH's Production Manager, adding obscurely that 'It is, in part, political'. Even with that solved, nothing will presumably change the fact that the Boston Symphony Hall has four omnidirectional mikes right up at the front ('Cardioid mikes create some very strange effects') and therefore are bound to produce a perspective as though heard from the second desk of violas—though, it must be admitted, with a rather better balance than these two gentlemen normally hear.

One small side benefit of the curious division of forces is that those without any stereo at all can get the older type of two-station, two-channel experimental stereo by using two mono receivers. Another is that, if you write to the commercial channel from your home in a Boston suburb for information about where to put your loudspeakers, they'll send you as a bonus a crimson Dayglo car-sticker joyfully shouting HAPPY BIRTHDAY LUDWIG . . . but as neither this nor the system itself appears to have much to do with what I envisage four-channel stereo to be all about, my theory is that this one is not here to stay.

One of the New York Stations, WNYC (after its initial co-operative venture), has concentrated on being first on the air with a single station four-channel experimental system. That proposed is due to William Halstead and has additional multiplexed signals based on subcarriers at 72 and 92 kHz for channels 3 and 4. But even an experimental system has to be agreed by the FCC, the licensing authority—and this is not the only four-in-one radio proposal on the table. Long hearings, battles over the engineering principles that could be 'like 1960 history repeating itself' have been forecast by some.

In this country we'll just have to let them get on with that one: I don't see a hope in a hundred of there being any four-channel stereo broadcasts here for years to come. I haven't asked my friends in BBC radio; it's enough to remember the sad case of the definitive stereo control desk that was shown around (internally) about a year ago and which then suddenly disappeared without trace as it was discovered that there was no money to pay for it. Frankly, I don't think there are enough people listening to two-channel stereo yet for it to be worth anyone's trouble even using the breath to ask for the next stage up. Let's see how it goes on tape first—and even with tape I'd like to see prices a bit lower all round before I'd predict a healthily growing market.

Three microphones were connected to Mixer One to cover the three woodwind players, two microphones being used for the percussion as this was provided by several instruments spread over a relatively large area (**fig. 8**). These microphones were connected to two inputs of the central mixing panel, switched to channel 2, and another input to this unit was switched to channel 3 and used to control the single microphone covering the two brass players. Four microphones were connected to Mixer Four to cover violin, piano, bass and cello respectively.

The four main controls thus covered woodwind, percussion, brass, and strings, and these outputs were fed to the Scully 4-track recorder. **Fig. 9** shows Derek Faraday at the mixer controls during this session. When the edited four track tape is eventually reduced to single track for TV, any further adjustments of the balance between the four sections will then be made if considered desirable at that stage.

During my visit to the studio, I was surprised to find so little attention paid to the business of sound insulation. During the recording of the play, I was sitting at the side of the studio, and could sometimes hear extraneous noise, although at the microphones the situation would not, of course, be quite so bad. Derek Faraday agreed with these comments but pointed out that the studio is about to be re-equipped and reconstructed, when insulation difficulties will be overcome.

The fact that the studio has been used for so many years by customers from all over the world is proof enough of the skill of the engineers at Star Sound Studios, and their ability to produce high quality material.

Fig. 8 (left): Microphones covering various percussion instruments.
Fig. 9 (right): Derek Faraday at the mixer controls.

INSIDE DOLBY

PART TWO
The Dolby production line

BY KEITH WICKS

THE first of these articles dealt with the basic principles of the Dolby *A301* System, which reduces the noise level produced in sound transmission or recording chains by at least 10 dB. In a tape recording system, the material is processed by the unit and recorded in this state, deprocessing taking place on playback. Low level signals are boosted during processing, and the complementary attenuation of these signals during playback causes the noises introduced by the tape system (hiss, rumble, cross talk, print through, modulation noise, hum, etc.) to be attenuated as well.

Before examining the *A301* in detail, the basic requirements of a noise reduction system must be considered.

The first essential is the obvious one, namely the processing and deprocessing operations should not cause any perceptible change in the signal as far as frequency response, transient response and dynamics are concerned. Distortion and noise introduced by a system must be kept to a minimum and signal processing should not create adverse effects if the system is used on the same material a number of times: for instance, when multitrack material is successively recorded, reduced to two-channel, then recopied. The specification must, therefore, be extremely good in all respects for the system to be of value in studios.

The next requirement is that the processed signal should be of a form suitable for transmission through a channel of normal bandwidth; the overload characteristics of the channel should not be noticeably modified, such as by compressor output overshoots. The system should be independent of the phase-frequency response of the channel, and errors in gain and frequency response should not cause any perceptible changes in the output signal.

Finally the system must be sufficiently stable to allow repeatable results with different units, and the noise reduction obtained should occur throughout the whole AF range, without giving rise to audible signal-modulated noise effects.

The compression and expansion curves used by the *A301* are shown in **figs. 1a** and **1b.** The compression curve is formed by adding a signal known as the *differential component* (**fig. 1c**) to the input signal, whilst the expansion curve is formed by subtracting the differential component from the processed signal. The way in which this is done is shown in **fig. 2,** the operators G_1 and G_2 consisting of complex signal multipliers producing a differential signal dependent on the amplitudes, frequencies, and dynamic properties of the signal fed into them. It can be shown mathematically that when $G_1 = G_2$ the input is identical to the output, so in practice one network is used in each processor, and the differential signal obtained is switched so that it adds to or subtracts from the main signal, depending whether the device is to be in the record or playback mode.

A main feature of the Dolby system is that it treats the signal in four independent frequency bands, the gain in each band varying according to the amplitude of the signals in that band. In a band containing high level signals, the *A301* does not alter the signal,

(*continued on page 116*)

FIG. 1 TRANSFER CHARACTERISTIC CURVES

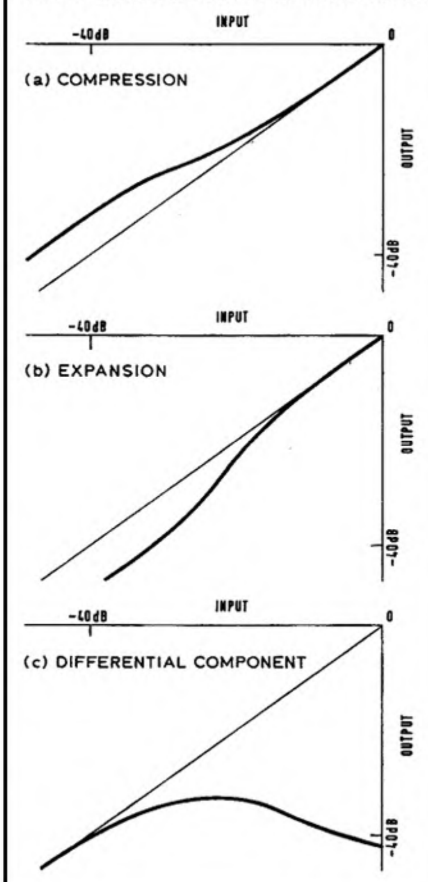


FIG. 2 BASIC ARRANGEMENT OF THE NOISE-REDUCTION SYSTEM

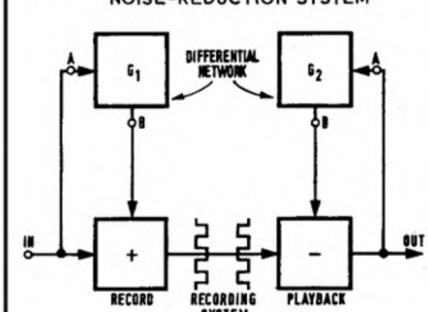


FIG. 3 DIFFERENTIAL NETWORK

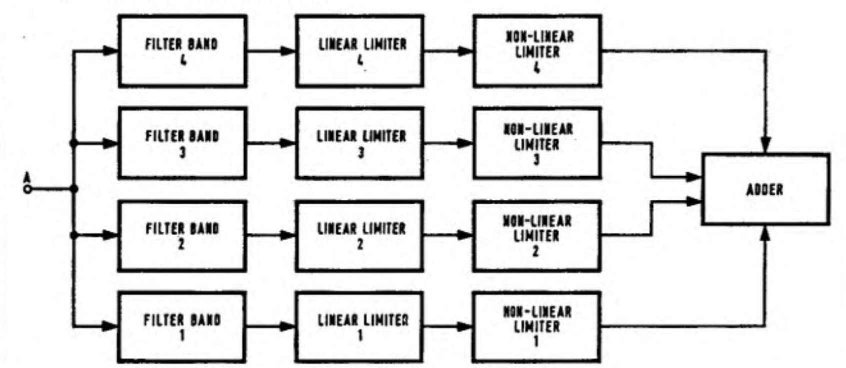
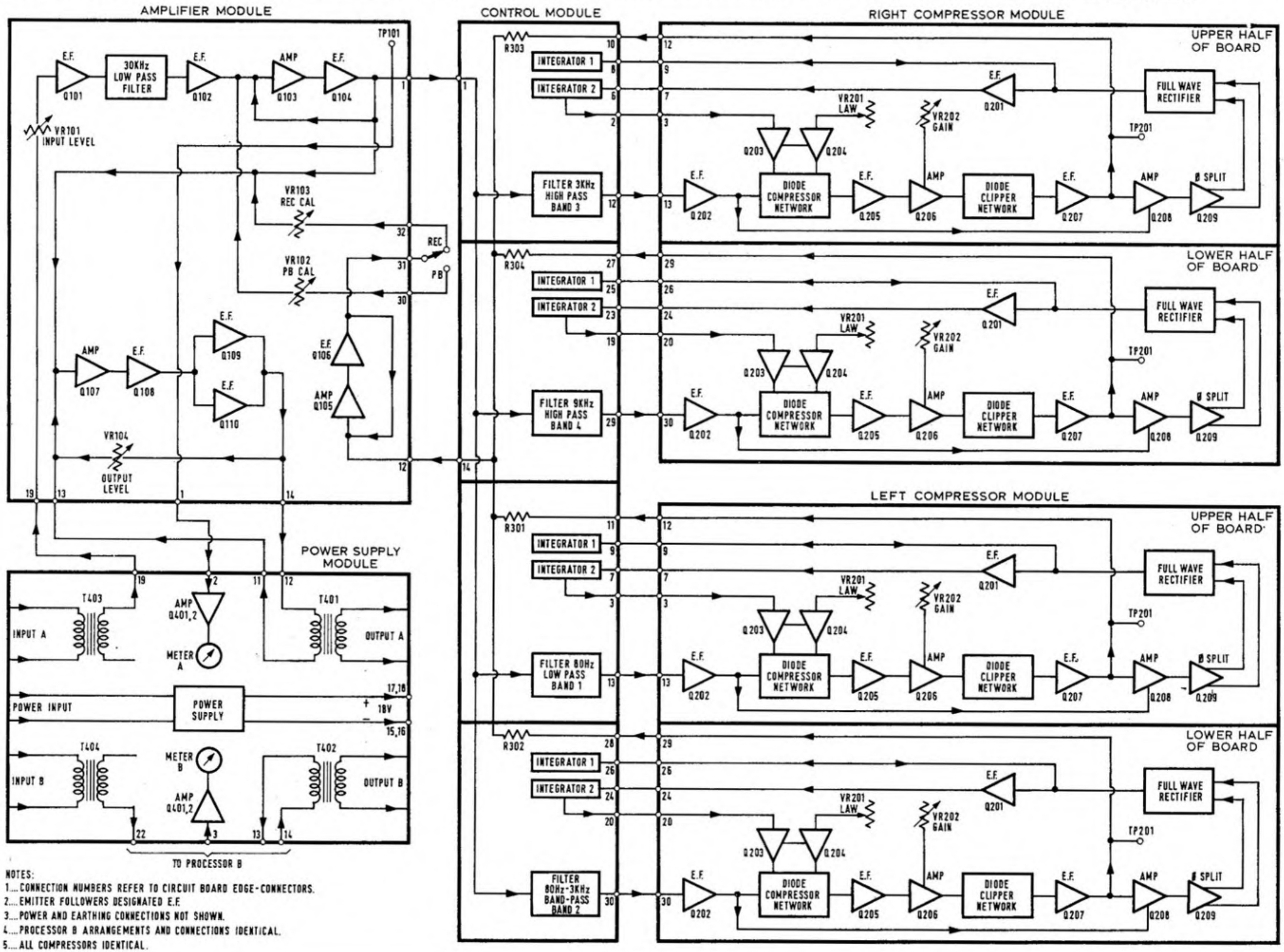
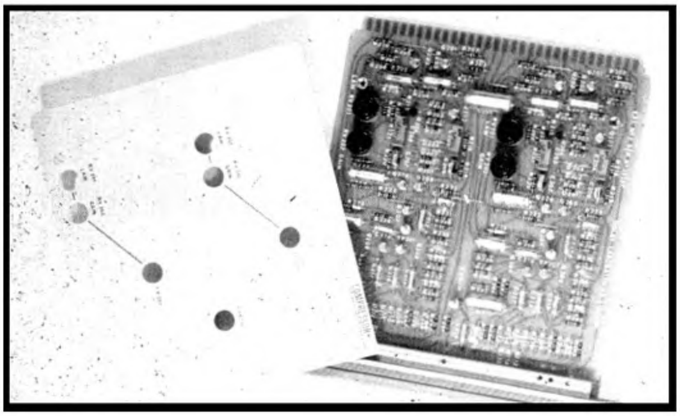
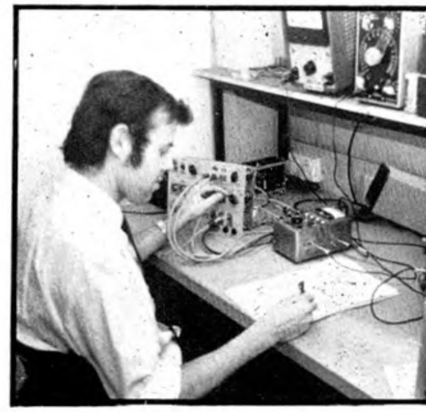


FIG. 4 A301 BLOCK DIAGRAM THE SYSTEM COMPRISES TWO IDENTICAL PROCESSORS, EACH OF WHICH MAY BE USED EITHER FOR RECORDING OR PLAYBACK. PROCESSOR A (AMPLIFIER, CONTROL, AND TWO COMPRESSOR MODULES) IS ILLUSTRATED.



NOTES:
1.... CONNECTION NUMBERS REFER TO CIRCUIT BOARD EDGE-CONNECTORS.
2.... EMITTER FOLLOWERS DESIGNATED E.F.
3.... POWER AND EARTHING CONNECTIONS NOT SHOWN.
4.... PROCESSOR B ARRANGEMENTS AND CONNECTIONS IDENTICAL.
5.... ALL COMPRESSORS IDENTICAL.





5 (top left): Component layout of the Compressor Module.

6 (top right): Dolby production line.

7 (mid left): Wiring up a printed circuit board.

8 and 9 (middle and mid right): Alignment and testing of various units.

10 (bottom left): David Robinson working on an adaptation of the A301 for domestic applications.

11 (mid bottom): KLH Model 41 fitted with a Dolby system.

and relies on the masking effect of the ear by which any noise introduced *in that particular frequency band* is effectively covered by the relatively loud signal. By using the four-band system, noise modulation effects ('swishing' and 'breathing') associated with conventional compandors, and caused by the sudden altering of all the background noise components, are eliminated.

The differential network is shown in block schematic form in **fig. 3,** the way in which the network is connected during record and replay being indicated in **fig. 2** by A and B.

The signal is first split into the four independent frequency bands, so that the content of each band can be dealt with separately. The division of the bands is as follows :

FREQUENCY DIVISION

Band 1	80 Hz Low pass
Band 2	80 Hz to 3 kHz Band pass
Band 3	3 kHz High pass
Band 4	9 kHz High pass

The differential signal obtained from the network must be such that (in the recording mode) it will boost the signal in all bands containing low level sounds only, but it must not add any appreciable signal in bands containing high level sounds. The output from each filter is passed to a linear limiter (compressor), then to a non-linear limiter (clipper), and finally to an adder where the four separate signals are combined to form the differential signal. The effect of the compressor is to cause increased attenuation at high levels, so that the differential output is low *in relation to the main signal* at high input levels. The critical shape of the differential curve shown in **fig. 1c** is obtained by suitably combining the compressed signals with direct signals fed from the filter outputs. This is not shown in **fig. 3** but can be seen on the logic diagram of the *A301* (**fig. 4**).

As soon as a compressor is introduced into a circuit, troubles arise because of the time taken for the device to act (i.e. the attack time), and overshoots occur which will either occupy part of the dynamic range of the channel, or else be clipped by the channel, causing unwanted side effects. The most common method of combating these overshoots involves using a very short attack time, but the rapidly changing gain results in modulation distortion which will not necessarily be counteracted by complementary treatment during playback.

However, in the Dolby system, a clipper is connected immediately after each low-level limiter, as shown in the diagram, and the differential overshoot is limited so that, when added to the main signal (which is much larger in amplitude), the overall overshoot is negligible. For a suddenly applied signal of peak amplitude, the quoted overshoot is 2 dB, and the resultant distortion does not last for more than 1 mS, and so is masked by signal transients, and also by the loudness-growth characteristics of the ear. In practice, with normal programme material, conditions are such that the clipper rarely needs to function.

The attack time varies automatically, depending on the dynamic characteristics of the signals in each band. For small signal amplitude transitions, the attack time is of the order of 100 mS, which is long enough to avoid the modulation effects previously mentioned. Another advantage obtained by the use of a long attack time is that the noise reduction properties of the system are improved. The long attack time means that short transients of moderate amplitude are not compressed, so the amplitude of the differential component relative to the main signal is maintained and the noise reduction is prevented from deteriorating. For large changes in amplitude, the attack time of the device is reduced in order to minimise the duration of the overshoots, the minimum attack time being about 1 mS. Under these conditions, the distortion produced by modulation and clipping is marked by the high level signal transients. The desired variable attack time is obtained by rectifying the output signal of each band and feeding it to a non linear integration circuit, producing a smoothed control signal which is used to alter the biasing of the compressor diodes.

Like the attack time, the decay or recovery time of the system is important as far as noise reduction is concerned. When a high amplitude signal ceases, the ear is relatively insensitive for a short period because of the residual masking phenomenon, and so it is desirable that the recovery time of the system is such that its action is restored before this subjective effect wears off, which is about 100 mS after cessation of the signal.

The recovery time is therefore always less than 100 mS, and is made to vary in a similar way to the attack time, being relatively long for small transitions in level, but short for large abrupt changes. The LF distortion associated with short recovery times in compressors is kept within reasonable limits as the system operates at low levels, whilst the recovery time is short enough to avoid perceptible noise modulation effects following the abrupt cessation of a signal. The LF distortion is greatest at an input level of about —20 dB where a peak in the differential component is partially compressed but, even here, the total harmonic distortion produced at 30 Hz is held below 1%.

The overall effect of the differential network is to provide (in the record mode) a boost of 10 dB at low levels, up to about 5 kHz. Above this frequency the boost rises to 15 dB at 15 kHz, then levels out. The amount of boost obtainable is a compromise between several design factors, in particular the need to minimise the unit's sensitivity to gain errors in the audio channel, and it was found that in general 10 dB was the optimum figure, although it could be pushed to 15 dB at the HF end without much trouble.

It has been shown that the unit operates on the principle that any band containing relatively high level signals is unaltered and, in practice, with average orchestral music, this means that band 2 is 'blocked' most of the time, bands 1 and 3 fairly often, and band 4 rarely. However, the band-splitting filters do not have sharply defined boundaries, so that a useful amount of noise reduction can occur in a band in which compression is taking place, by the action of the adjacent band(s). The overall noise reduction action occurs most of the time as a result of pre-emphasis and subsequent de-emphasis in bands 1, 3 and 4, as band 2 is usually blocked, but under these conditions, band 1 will provide appreciable noise reduction up to about 120 Hz, and band 3 will do the same down to about 1.8 kHz. Thus, real and apparent noise reduction are combined, as noises occurring near the edge of one band are less easily masked by the signals in that band, but tend to be reduced by adjacent band action.

The *A301* contains two separate signal processors, constructed on printed circuit modules which plug into a standard rack mounting unit containing a power supply module (see **fig. 5**). Each processor consists of four modules: an amplifier module, a control module, and two compressor modules (each containing two separate compressors). By arranging for all the circuits which differ in the four bands to be contained in the control module, the number of different modules is kept down to three (excluding power module), and the problem of spares is simplified as all compressors are then interchangeable.

Fig. 4 shows a simplified diagram of one processor and the various interconnections between the modules. The signal to be processed is applied to the bridging transformer T403, from which it is fed to a level setting potentiometer RV101. After this, the signal is filtered to remove any unwanted HF components present (such as tape bias), and then fed via Tr104 to the filters in the control module. The same signal is fed also to a level setting meter on the front panel, and to the output amplifier feeding T401. After band splitting, the separate signals are fed to the compressor modules and, via the emitter followers Tr202, to the compressor and clipper circuits. The output of Tr207 is combined in Tr208 with a signal taken prior to the compressor in order to obtain the desired shape for the differential characteristic. The output of Tr208 is fed to a phase splitter and rectifier in order to obtain the control signal which, after smoothing by the integrators 1 and 2 in the control module, is fed back into the compressor modules for application to the compressor networks. This signal controls the diode currents and thus the compression characteristics. The outputs of the four bands are taken from the emitter followers Tr207 and combined by a resistive network R301 to R304 in the control module. The differential signal thus obtained is fed to the amplifier module and amplified by the feedback amplifier (Tr105 to Tr106), the output of which is taken to the record/playback switch. In the *record* position, the differential signal is combined additively with the main signal between Tr104 and Tr107, whereas in the *playback* position, the differential signal is combined with the main signal between Tr102 and Tr103. At this point, the phase of the main signal is such that the differential signal causes partial cancellation. This negative feedback action restores the dynamic range of the sound to its original value by depressing the level of quiet sounds, and at the same time reduces all the unwanted low level noise introduced by the audio channel.

When I visited the Dolby Laboratories in Clapham Road, London S.W.9, first the *A301* system was demonstrated to me and then I was shown the various stages in the production of the unit. As I said last month, the demonstration was most impressive, and the same goes for the production line (**fig. 6**), where it is obvious that every care is taken to produce an extremely reliable product.

So that each unit conforms to the rather stringent specifications, it is necessary for batches of some critical components to be measured accurately in order to select the ones nearest to the particular value required. The wiring of the various circuit boards

(continued on page 123)

abridged specification of the A301

OVERALL (RECORD-PLAYBACK) FREQUENCY RESPONSE	Better than ±1 dB, 20 Hz to 20 kHz.
OVERALL TOTAL HARMONIC DISTORTION (+8 dBm)	Less than 0.1% at 1 kHz; less than 0.2% from 40 Hz to 20 kHz.
NOISE REDUCTION	10 dB from 20 Hz to 5 kHz, rising to 15 dB at 15 kHz.
OVERALL NOISE LEVEL	Better than 80 dB (unweighted) below +8 dBm.
CROSSTALK	Better than 80 dB, processor to processor, 20Hz to 20 kHz.
MATCHING BETWEEN UNITS	Better than 1 dB at any level and frequency.

the synthesis of musical instrument tone

Part Six
By Robert M. Youngson

THE 'attack' parameter is of basic importance. No matter how accurate your waveform, if the attack is wrong your synthesis will fail to carry conviction. Fortunately, attack is a simple characteristic which may be defined as the rate at which the opening section of the tone builds up to the full sustained level. It may be measured in terms of the length of time between the instant that sound is first discernible and the instant it is fully developed. Attack times vary from two or three to about 100 mS and, although in general attack time is fairly characteristic of a given species of instrument, it is important to appreciate that it can vary a good deal in the same instrument with changes in pitch and in dynamics. It is not therefore sufficient to build in a fixed attack time: it is necessary to ensure that the time decreases with rise in loudness and in pitch in a manner characteristic of the instrument concerned.

As already mentioned, the attack rate of a voltage-stable oscillator like an emitter-coupled Hartley is readily adjusted by varying the time constant of an RC network between the power supply and the oscillator, as in **fig. 40.** Fixed control of this kind can be fitted to each oscillator and the capacitance value for each selected so that, with a single value of resistance, the time-constant varies appropriately with pitch. Since we are dealing with monophonic instruments, it is not difficult to arrange for the supply current to pass through a resistor which is common to all oscillators. Now if this resistor is made variable, the attack time of any note can be adjusted by a single control and this ganged to the main loudness control (**fig. 69**). In addition, an over-riding separate control can be fitted, so that an unusual degree of attack is possible, for the simulation of special modes of playing.

If the circuit arrangements are such that control of attack, at master oscillator level, is not feasible, we have no alternative but to find a method which can be applied either at the output of the sawtooth generator or after the tone filters. Such a method is available in the form of semi-conductor gates. These important components will be dealt with below. Note, however, that the use of such signal control circuits implies that the signal is already present (i.e., the generators must either be running continuously or must be switched on shortly before the gate circuit operates). Now it is obviously convenient if the only switching we have to trouble about is the gate switching, so we must consider whether continuously running generators produce any problems or disadvantages. Since all generators are tuned to different frequencies we need not worry about phase-locking but care must be taken to avoid stray fields and inadequately screened conductors connected to high-impedance circuits as this will degrade the signal-to-noise ratio, which must be kept very high. Three or four chromatic octaves of generators simultaneously leaking signal into the main output channel can produce an impressive, if unwanted, background. So keep the input impedances low at the points of main amplification and use closed-field inductors as already advised.

If continuously-running generators are used, it is essential that the gating circuits, when off, should cut the signal to negligible levels. Even minor leakage from each may add up to an unacceptable level of background noise.

Semiconductor gates can be arranged in a variety of ways and some of these are considerably better, for our purposes, than others. The most immediately obvious approach is to pass the signal through an ordinary common emitter amplifier, as in **fig. (70a).** The transistor is held off by the large negative voltage V_B— until the switch S is opened, whereupon the positive bias through R_B+ turns on the device and allows the signal to pass. The rate of turn-on varies with the value of the capacitor C from which the negative charge leaks away to ground. This arrangement is not satisfactory with germanium transistors because of their relatively high leakage, but works reasonably well with silicon devices. A *p-n-p* version employing an emitter-follower is shown in **fig. 70(b).** This gate can be improved by biasing the emitter through a diode rather than biasing the base. A practical circuit is shown in **fig. 70(c).**

Another arrangement is the shunt gate shown in **fig. 71.** This requires that the signal should be either wholly negative-going or wholly

(*continued on page 121*)

FIG. 69 VARIABLE ATTACK CIRCUIT ALTERING THE VALUE OF A TIME-CONSTANT NETWORK COMMON TO ALL OSCILLATORS

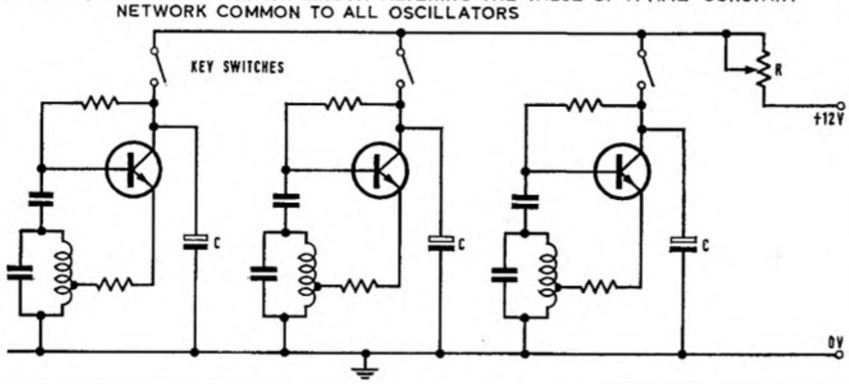
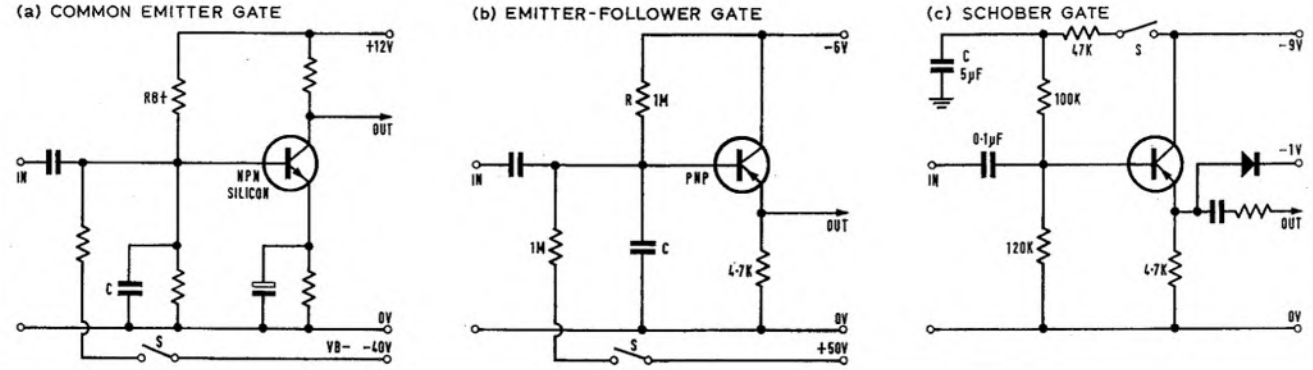


FIG. 70
(a) COMMON EMITTER GATE
(b) EMITTER-FOLLOWER GATE
(c) SCHOBER GATE



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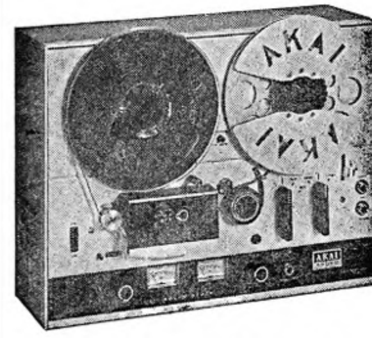

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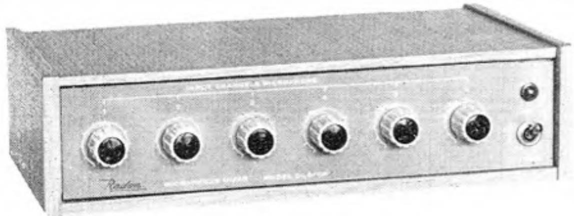

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Output	@6K ohms position 2.5v. max. @68 ohms position 0.025v. max.
Gain	x2 and greater than 5
Input Impedances	35 to 100 ohms (or Hi-K if required)
Hum and Noise	Better than 40dB down
Power Supply	220 to 240 volts 50c/s or 110 to 120 volts 50-60c/s Please state voltage required.
Size	Inches: 13 x 7 x 3½ Centimetres: 32.5 wide, 17.5 deep, 10.5 high
Weight	6lb. 8oz. 3¼ kilos.

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positive-going with reference to ground, but this can easily be arranged by clamping.

With the key switch S open, the transistor is held fully on by the positive bias through the 10 K resistor. In this state it offers a very low impedance to the signal, which it effectively short-circuits to ground. When S is closed, the transistor base becomes negatively biased and it cuts off, allowing the signal to pass on. The potential divider at the output ensures that any leakage signal, when the gate is off, is reduced to insignificant level. The two 47 K resistors also isolate the gating transistor. Again, a rate-of-turn-on network can be inserted between the keying switch and ground. The circuit shown is suitable for a signal which remains on the positive side of ground. (When the emitter goes more positive the base is made relatively more negative.) A negative signal will require a *p-n-p* transistor. The gating transistor could, of course, be used in the more conventional orientation with the emitter connected to ground. The advantage of using it as shown, is that the on resistance is lower and the off resistance higher than if used the 'right' way up.

A third gating method is to feed the signal into the emitter of a transistor and take it out at the collector, controlling the flow by changing the base bias. **Fig. 72** shows how this is done. Adjustable slope of both turn-on and decay rates is possible with this circuit. R1 and R2 can be made variable.

Unless you have access to fairly elaborate equipment, you will have to rely on careful listening and empirical trials to determine the appropriate attack rates. The same applies to the next set of characteristics.

FIG. 71 SHUNT GATE

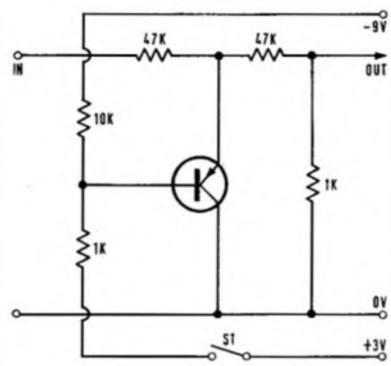
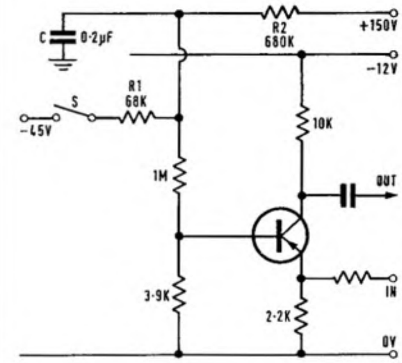


FIG. 72 SERIES GATE



Starting transients and noise

Many musical tones start smoothly and build up evenly so all that is necessary, in managing the opening phase, is to arrange the proper attack time and provide the *noise component*. With others, however, the starting transients are so characteristic of the instrument concerned that failure to simulate these will seriously detract from verisimilitude.

A consideration of the origin of these small but important components of natural instrument tone quality will assist in understanding their nature. For the most part they are HF noises associated with the means by which the musical tones are produced and will therefore be present throughout the duration of the sound. Most will, however, also occur as the initial sounds, actually prior to the appearance of the definitively pitched tone. In stringed instruments, played with a bow, they include the slight scraping noise caused by the friction of the bowhair on the string before the forced vibration develops fully. Once the full tone is produced the scrape becomes much less noticeable, partly because it is largely submerged in the much louder pure tone and partly because the scrape action is replaced by a cyclical 'stick and spring back' mechanism (the string displacement is of sawtooth form) in which the elastic 'spring-back' is very rapid. When a bowed string instrument is played with a mute in place, the scrape component is considerably more prominent and becomes an indispensable ingredient in the tone quality. This is one of the several reasons why effective synthesis of violin tone is much more difficult than that of almost any other instrument.

In reed instruments such as oboe, clarinet, bassoon and saxophone, the opening transients and noise arise partly from reed noise (a momentary buzz before the tone builds up) and partly from wind currents escaping around the mouthpiece in the case of the clarinet and saxophone. Flute noise is mainly wind but this is often prominent and a fairly strong wind component should be supplied, especially during the characteristically long attack period.

Since starting transients and other noises are enharmonic it is unnecessary to consider their phase relationship to the rest of the tone, but only their timing in relation to the onset of the sound and the duration of the attack time. They may, therefore, conveniently be generated independently of the main tone and their timing determined by the switching arrangements. The duration of the transients can be set when designing the transient generators. The sustained noise simply persists for as long as the note switch is held down.

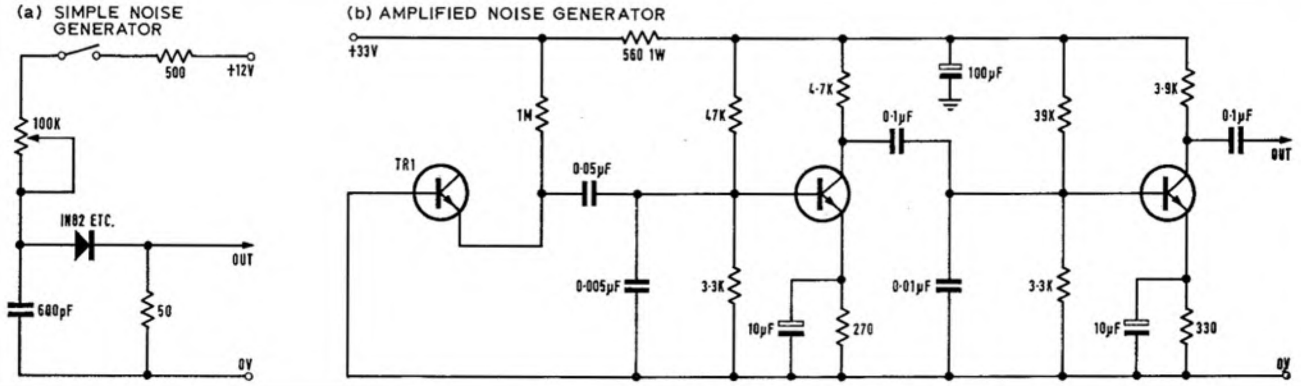
Noise is sound of indefinite frequency and can occupy all or any part of the audible spectrum. Its duration and relative amplitude is usually characteristic. 'White noise,' so called because of the analogy with light, contains sinewaves of all audible frequencies. Such noise currents are present, at low amplitude, in any current-carrying conductor, but some conductors are noisier than others, depending on the material. A good source of noise is a semiconductor junction and if you connect a current-passing diode (such as the emitter-base junction of an early germanium transistor) to the input of a high gain amplifier you have a white-noise generator. A good way is to reverse-bias a diode into breakdown and limit the current with a resistor, as shown in **fig. 73** (Wurlitzer). Diodes vary considerably in the quantity of noise they produce and some selection may be necessary.

White noise can be filtered and the desired

(*continued on page 123*)

FIG. 73

(a) SIMPLE NOISE GENERATOR (b) AMPLIFIED NOISE GENERATOR



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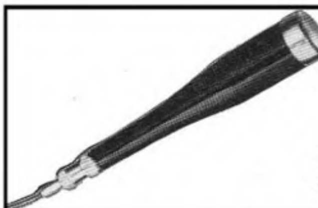

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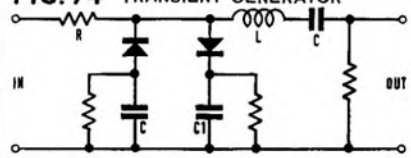
frequency bands selected for the particular purpose required. The adjustment of filters must be done empirically, applying first principles, after careful listening to the model.

Even the most careful analysis by objective methods is no substitute for prolonged, concentrated and repetitive *listening* to the sounds of musical instruments. Examples of solo instrument sound covering the whole range not only of pitch and dynamics but also of musical content, must be listened to, over and over again, until one is thoroughly familiar with every nuance of quality. Unless one trains one's ear to hear every facet of the sound, effective synthesis is impossible, for component factors will inevitably be omitted. The same concentrated attention is necessary for success in performance.

One form of starting transient found in the tones of some wind instruments consists of the appearance of high partials just prior to the onset of the fundamental. This phenomenon is not difficult to simulate and an interesting germinal circuit, designed for the purpose, is shown in **fig. 74**. A near-sinewave input is required. During the first few cycles of each new note, the capacitors C and C1 charge through the diodes, the positive-going phase through one and the negative-going phase through the other. Thus, for a period depending on the time constants RC and RC1, the filter passes a clipped waveform containing harmonics including those desired. The capacitors cannot discharge through the diodes but only, and very slowly, through the high value resistors shunting them, after the note ceases. The tuned filter LC is selected to resonate at the frequency of the harmonics to be accentuated. Thus, at the onset of the tone, the required higher partials are accentuated, the fundamental and lower partials being delayed until the capacitors are sufficiently charged to prevent further current flow through the diodes.

There are, of course, many ways in which such differential delay circuits can be arranged and you should now be capable of working these out. The combination of semiconductor gates, time-constant circuits and frequency-sensitive networks provides almost unlimited possibilities of control.

FIG. 74 TRANSIENT GENERATOR



The regularity of pitch and dynamics, which is a feature of electronic tone production, seems at first to be advantageous but turns out on longer acquaintance as a considerable drawback in our attempt to achieve good tonal synthesis. Ironically, the high standards of smoothness and uniformity in all modalities, painfully sought after by musicians, is achieved only too easily and too well by electronics. The result is a degree of perfection which defeats its own object.

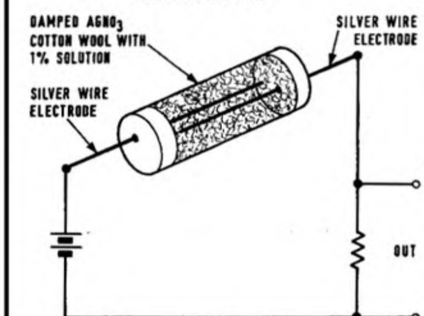
This uniformity applies to almost every parameter which we have considered: pitch is too constant both in sustained notes, and on repetition of the same note; vibrato, as commonly produced, has a degree of regularity, initially delightful but soon found to be mechanical; the dynamic level of sustained notes, nominally of equal volume, is constant to an inhuman degree; and the timbre of any note at a given dynamic level is reproduced time and time again so unvaryingly as to sound 'too good to be true'.

The origins of natural non-regularity in musical sounds are largely physiological and arise from the fact that motor activity results from the summation of a large but constantly varying number of muscle fibre contractions. As a result, although any motor function (bowing, striking, blowing, fingering, embouchure forming, etc.) can be regularised by practice, perfect uniformity is never achieved. We unconsciously note the resulting multiple uncertainty as a feature of musical tone evoked by a human player and, when the uncertainty is absent, we are liable to become suspicious or bored.

The level of output from most oscillators varies sensitively with changes in the supply voltage and, in those circuits in which no subsequent limiting action occurs, the supply voltage can be modulated with another randomly varying voltage so as to cause small changes in dynamics. These changes should be limited to a narrow dynamic range and should vary randomly, in amplitude, within this range. Further, the rate of change must also be confined to the narrow range between zero and about 20 fluctuations per second and should also occur in an entirely random manner. Random current generators are attracting some attention these days, and many suggestions have been put forward, ranging from devices whose output varies with changes in background and cosmic radiation to those responding to the modulation levels of several broadcast transmissions simultaneously received. Various electrochemical devices have been proposed, one interesting example being a sealed cell in which the flow of a small current causes electrodeposition of fine silver whiskers from a solution of AgCl (see **fig. 75**). As these whiskers form, break and return to solution the electrical resistance of the cell changes in a random manner.

To be continued

FIG. 75 RANDOM PULSE GENERATOR. SILVER DEPOSITION CELLS OF THIS KIND CAN BE PARALLED TO INCREASE THE NUMBER OF PULSES IN UNIT TIME



INSIDE DOLBY

(**fig. 7**) is carried out in the cleanest workshop conditions I have come across. All wiring is inspected for dry joints and loose solder, of course, and after alignment and testing of the various units (**figs. 8** and **9**), the whole *A301* unit undergoes a testing procedure, and all the results obtained are recorded and filed.

In **fig. 10** the chief engineer, David Robinson, can be seen working with some B & K test apparatus.

The net result of all this work is that each week twenty units are produced conforming to the specification, part of which is reproduced in **Table 1** to give an idea of the close tolerances involved. Although the device will reduce the noise level caused by any audio channel, the main advantage is in tape recording where the use of an ever increasing number of tracks, and the tendency to copy and recopy material, should prevent the *A301* from becoming redundant, low noise tapes, or not.

Finally, an apology. In last month's article I mentioned that a single-band Dolby System is used by KLH in a domestic recorder (Model *41* is shown in **fig. 11**). As I was under the impression that a wide-band device was being used, I suggested that the noise reduction obtained might not be a fair trade for the usual problem of single-band compansion. It has since been pointed out to me by Ray Dolby that the system used in these machines operates only above 2 kHz, since the main problem with non-professional equipment is the elimination of tape hiss, particularly at slow speeds, LF noise being relatively unimportant. Because it operates over only part of the audio range, the simplified system, like the *A301*, should not give rise to any noticeable modulation effects.

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equipment reviews

TELEFUNKEN M28 C

FIG. 1 TELEFUNKEN M28C RECORD–PLAY WOW AND FLUTTER

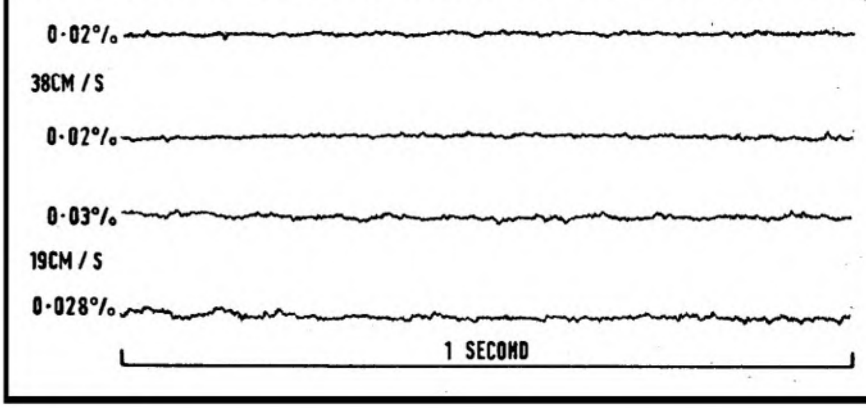


FIG. 2 TELEFUNKEN M28C PLAY–ONLY FREQUENCY RESPONSE (TEST TAPES TO LINE OUT)

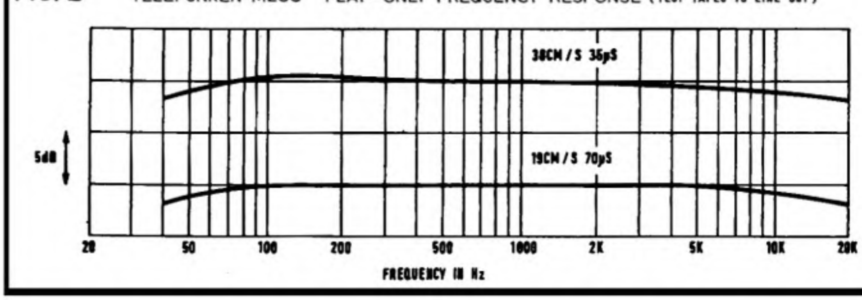
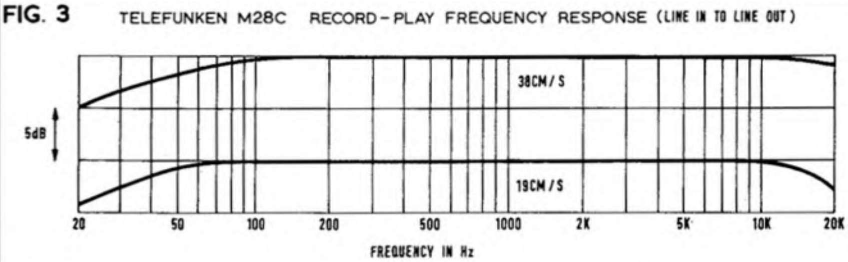


FIG. 3 TELEFUNKEN M28C RECORD–PLAY FREQUENCY RESPONSE (LINE IN TO LINE OUT)



MANUFACTURER'S SPECIFICATION (38 cm/s). Professional 6.25 mm two-channel recorder with fixed-level balanced line inputs and outputs. **Tape speed deviation:** 0.7%. **Wow and flutter:** ±0.08% (DIN 45 515 weighted). **Tape tension:** 80 gm. **Starting time:** 200 mS. **Rewind time:** Three minutes for 1 km LP tape. **Equalisation:** 35 μS and 70 μS DIN 45 513. **Frequency response:** 40 to 100 Hz ±1.5 dB, 100 Hz to 16 kHz ±1 dB. **RMS signal to noise ratio:** 58 dB. **Erase and bias:** 85 kHz. **Line input:** 1.55 V 5K bridging, balanced. **Line output:** 1.55 V 600 ohms, balanced. **Weight:** 17 kg. **Dimensions:** 160 x 409 x 458 mm. **Price:** £495. **Distributor:** **AEG (Great Britain) Ltd., Lonsdale Chambers, 27 Chancery Lane, London W.C.2.**

UNLIKE many of the recorders recently reviewed, the Magnetophon *28C* contains no microphone amplifiers, power amplifiers, VU meters, mixers, track switching, or even A-B switching. It is basically a robust tape transport mechanism built to professional standards and designed to have a long and reliable working life.

The glass-hard ferrite erase, record and play heads, for example, are extremely wear resistant and normally need not be replaced during the lifetime of the recorder. The heads are ground to extreme accuracy and are mounted directly on a heavy brass plate with all gaps vertical to within one minute of arc, so that no azimuth or height adjusting screws are provided.

Tapered guide pins direct the tape path so that the lower edge of the tape always touches the lower path boundary. The upper path boundaries are dispensed with, except the leading one which takes care of deformed or badly wound reels.

Tape tension is maintained to close limits at all parts of a reel by the servo action of tape feelers which tension the supply and take-up reels during the wind, rewind and play cycles.

All circuit (equalisation) switching is done electronically by biasing transistors, or switching diodes, at a relatively slow rate so that no transient switching clicks are passed to the heads.

The switched-pole motor is fitted with a slightly crowned pulley which drives the large diameter flywheel via an accurately ground flat rubber belt.

The fluttergram pen recordings of **fig. 1** show that total cumulative wow and flutter remains constant at 0.02% RMS at 38 cm/s and within limits of 0.028% to 0.03% at the lower speed of 19 cm/s. A pen deflection of 1 cm represents a speed change of 2% peak-to-peak, so it will be seen that peak speed fluctuations are well within the specification limits.

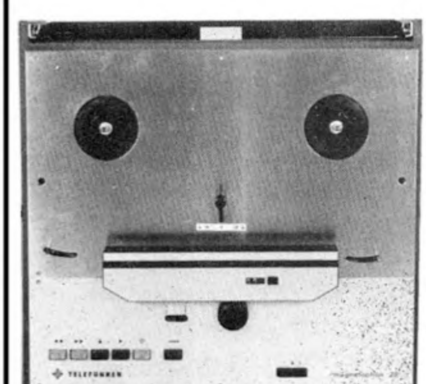
Reference level tape (32 mM/mm at 1 kHz) gave exactly the specified line output of 1.55 V RMS.

System noise with no tape passing the heads gave an unweighted reading of −57 dB and weighting to the IEC 'A' curve gave a reading of −75 dB which is about the lowest system noise we have ever measured. Because of the very low system noise, it is possible to measure tape noise to a high degree of accuracy. Carefully bulk-erased tape gave a reading of −68 dB and machine-erased tape noise was −65 dB.

Distortion from the DIN reference level 1 kHz recording was 0.7% which is very slightly lower than previous measurement on this tape, but could be due to slight cancellation between the playback amplifier distortion and that on the tape. On the other hand it could be due to the very low system noise giving a more accurate measure of the actual tape distortion.

A recording test on the unused portion of the DIN test tape (type *PES 40*, batch number *A 341 D*) gave 0.7% distortion at reference level, and 2% distortion was obtained at 4 dB above 32 mM/mm reference level. It was

(continued overleaf)

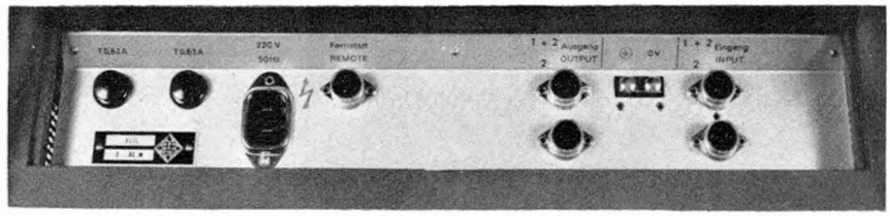


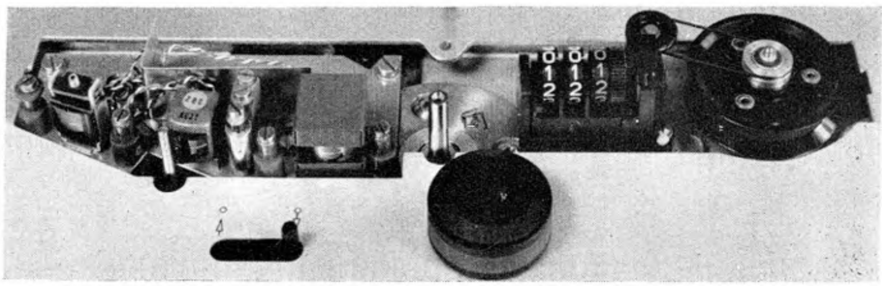
interesting to find that this level and distortion were obtained with bias set for maximum output of the 1 kHz tone and that overbiasing, to drop the 1 kHz signal by 1 dB and then resetting the level by 1 dB, gave no further improvement in distortion. This may be a function of the very low losses in the ferrite record head.

The same tests were performed on Agfa *PE36* LP tape and, due to the increased sensitivity, 2% distortion was obtained at a level 5 dB above reference with a further improvement in erase and bias noise to 66 dB below reference level. This gives a total dynamic range from 2% distortion level to recorded noise of 71 dB weighted to the ear's response at low listening levels (IEC 'A' Curve).

The record-play responses of **fig. 3** were taken at 20 dB below reference level with bias set for maximum 1 kHz output at each speed, and with the high frequency pre emphasis adjusted for the flattest response up to 10 kHz. It will be seen that the responses comfortably meet the specification.

Almost identical responses with very slightly higher distortion and noise were obtained with my domestic standard reference *LGS 35* BASF tape, which has characteristics close to those of DIN domestic reference tape *LGS 26*, batch no. 110 211.





COMMENT

The objective review tests given above show that the Magnetophon *28C* easily meets the manufacturer's specification in all respects.

Not so easy to measure is the feeling of satisfaction and confidence one experiences in the use and handling of this machine. There is never any doubt about mishandling or stretching even the thinnest of tapes, and the feather touch controls are a joy to handle. The internal lighting of each button is useful when operating the machine at a distance by remote control or under poor lighting conditions.

All the level, bias and equalisation presets are conveniently grouped on the left-hand side of the chassis and the slight staggering of the controls, combined with the knurling of the shafts, makes it possible to adjust each control with the forefinger and thumb and not to have to search around for a suitable screwdriver when one wants to make a small adjustment.

The 10 dB difference between system noise and the lowest obtainable tape noise will take care of tape improvements for some time to come, and I have every confidence in recommending this unit to any studio requiring a high quality transportable stereo mastering or copying machine. **A. Tutchings**

hypercardioid capacitor microphone

Part 3 Postscript

by Trevor Attewell

The following text was inadvertently omitted from last month's article—but our Deputy Editor was on the verge of getting married, so we beg readers' forgiveness! It should be read in conjunction with the February illustrations, and strictly it follows the last complete paragraph on page 76: '... to keep the microphones high enough'. **Ed.**

IF capacitor microphones have a snag, it is that their frequency response is flat almost down to zero frequency, so that they respond to wind noise, heard as a background rumble which can easily overload amplifier input stages. The use of a wind shield, or windgag as it is often called, materially reduces the nuisance. The ideal type is probably that in which a layer of porous material close to the microphone is backed up by a second layer placed further out, but this type, if used with a Blumlein pair, makes it necessary to separate the capsules further than one would like.

Instead, it has been found that a simple, close-fitting shield of Declon foam copes with all normal conditions indoors. A suitable grade is porosity 20, thickness ¼" to 3/16", which has a negligible acoustic attenuation. The material is easily cut with scissors or razor blade, and can be rejoined with Dunlop **708** or Evostik adhesives. Failing even this, it had better be wives (or girl-friends) to the rescue, since tests also show that about three layers of 20 denier nylon stocking are suitable.

Armed now with the microphones and their attachments, where should they be placed with respect to the sound source, and what should be the angle between them? These two questions are interdependent, and must be considered together. It is sometimes suggested that a source of any width can be made to appear of any other width at will, simply by altering the microphone angle. Unfortunately, both theory and practice show that it isn't as simple as this!

Let us define the problem by reference to **fig. 7.** This shows the three important angles, M being the microphone 'Blumlein angle', S the angle subtended at the microphones by the source, and I the angle to be subtended at the listener by the image of that source when reproduced by a normal stereo loudspeaker system. We now assume that the image of any point in the source will be reproduced at an angular position depending only on the relative amplitudes of the sound from that point reproduced by the two loudspeakers. In other words, referring to **fig. 8,** the vector position of the image is the resultant (P) of the two vectors (L and R) directed towards the speakers from the listener, the lengths of L and R being proportional to the acoustic output from the respective speakers.

No account will be taken of perspective, i.e. the apparent distance of the source from the observer. This is not affected by the ratio of the loudspeaker outputs, but only by their combined magnitude, as shown by the length of the vector P, and we are only concerned with angles for the moment. We can now deduce the relative amplitudes needed from the two loudspeakers to give an image at any desired angle, taking the usual equilateral triangle arrangement of speakers and listener. The results are listed in **Table 1,** from which it will be seen that, for example, an image will appear to move out by 5° from the left speaker when the output from the right speaker is 20 dB lower than that from the left. Many observers find it difficult to detect less than a 7° angle, corresponding to a 16 dB ratio, while, with systems giving a poorer definition or in unfavourable rooms, even a ± 10 dB ratio gives a reasonable image spread. As we shall see, this is rather fortunate!

If we now consider a Blumlein pair of microphones, each having a cardioid characteristic, their respective outputs will vary according to the source position in relation to their respective polar diagrams, as in **fig. 9.** The amplitudes of the signals eventually fed into the reproducing loudspeakers will (or should) be proportional to the respective microphone outputs, so fixing the resulting image position. We next calculate the relative outputs for a series of source angles (S in **fig. 7**) f r each of a series of microphone angles M. For ease of calculation, a true cardioid pattern has been assumed, but the differences between the results and those which would be obtained for the actual slightly hypercardioid case are not significant in terms of the approximations already implied.

The results of these calculations are displayed diagrammatically in **fig. 10,** in which M is plotted horizontally, and S vertically, while each curve represents the angular spread (I) of the resulting image and is labelled with that angle, and also with the maximum speaker output ratio required to give that angular spread.

These curves can now be used to obtain an insight into the degree of angular compression or expansion which may be possible in any particular case. For example, if the microphone and source angles are both 140°, the intersection of the corresponding ordinate and abscissa lies between the 40° and 50° curves, i.e., the image width will be nearly 50° and will cover the full listening field, at least, for all practical purposes. On the other hand, if the source angle were only (say) 80°, then the curves show that the image cannot, theoretically, be spread over the whole field even if the microphone angle is increased to 180°. It is also clear that we always have the possibility of making a source appear narrower, simply by reducing M, until, in the limit, we end up with a double-mono arrangement.

However, if M is less than S, perspective error will arise. Looking at **fig. 9,** and imagining the point source to move to the left and beyond the left axis, it can be seen that, although the *ratio* of the two outputs (OA/OB) will continue to rise towards infinity at OB=O, the actual amplitudes of *both* outputs fall off beyond the left axis. The images of extreme points will therefore appear further away from the listener than they should be, and there is an error in perspective. As a warning of this effect, the curves above the line defined by M=S in **fig. 10** have been drawn dashed.

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BALLET PRERECORDED

Derek Lyons reports from Townsville, Queensland

THE sixty professional members of the Australian Ballet carry their symphony orchestra with them in a box when they tour beyond the confines of those major cities which can boast their own resident orchestras. But let it not be thought that there is anything amateurish or inferior in this £34 000 box of tricks, organized and partially built by ex Australian Broadcasting Commission man Howard See.

'Economically', said Howard, when I met him while the Australian Ballet were here for two days before touring New Guinea, 'It just isn't on to bring one's own 52-piece orchestra along on tours like this. My brief, when I joined the Australian Ballet was to provide tape-recorded sound of the best possible quality; something different.

'Previously I had worked with the Australian Elizabethan Theatre Trust's marionette theatre, with which, of course, the Australian Ballet is also connected. This involved complex dubbing work as the script had to be translated into seven different Asian dialects while we were touring there. The problems with the ballet, though, were entirely different and the sound requirements were more elaborate. At the outset I tried to get a master recording that would simulate the sound of a pit orchestra, rather than a symphony orchestra. I wanted the sound to fill the auditorium, and emanate from both sides of it as would happen if a pit orchestra was really playing. That called for four-channel stereo. It also called for a powerful reserve of amplification. And "reserve" is the operative word. It is not the power that you push out that matters—it's the power you have available if necessary to fill the largest auditorium with clean transients.'

Howard uses four Sony stereo amplifiers, 50 W RMS per channel, providing 400 W power to the 450 mm Celestion woofer speakers housed in 500 litre enclosures. These speakers are reinforced by units containing eight twin-cone 200 mm speakers, covering the frequencies upwards of 250 Hz. 'When we gave performances in Manila and Seoul recently, a resident orchestra and our own tape system were employed. This was because there was insufficient time to rehearse their orchestras in, for example the ballets *Display* and *Pineapple Poll*. So, the orchestra played for Act 2 of *Swan Lake* and our tape system took over after the interval. I am sure many of the audience were unaware that the live orchestra was no longer playing when that happened!'

What happens if a valve blows at the last moment? They have thought of that too; the equipment is all duplicated.

The original recordings were mastered for the Australian Ballet by a 52-piece orchestra formed specifically to provide music for the nation's ballet and opera companies under the auspices of the Elizabethan Theatre Trust, a body not unlike the English National Theatre. Many dancers, about half the company in fact, had stated a preference for dancing to tape-recorded music. They knew the tapes so intimately now that the length of each pause, and so forth, was second nature to them. To my ears, having heard a performance, the sound is as lifelike as an orchestra in the pit. I spoke to members of the audience and unanimously they said that they initially missed the feeling of having an orchestra in front of them but after the first few minutes they had forgotten its absence. In smaller halls the Ballet uses less elaborate equipment fed by a Tandberg *Series 12*. I have heard this set-up, too, and it is still a splendid substitute for an orchestra. The Queensland Arts Council's Opera Company organizes similar shows to a tape-recorded accompaniment, on a smaller scale. Its four principal professional singers and two understudies have mastered the art of singing to a machine that allows no concession for variations in tempo. Like the dancers of the State ballet, these young professional artists agreed that singing to a piano accompaniment on tape was not so difficult as it might seem. They became so accustomed to the tape that they knew and were able to anticipate its timing.

The Opera Group uses a mini-bus to tour schools throughout the length and breadth of Queensland. They carry their lighting equipment, props, stage materials and tape-recorder (an Akai) in the bus, and in about 10 minutes flat can turn a drab classroom into a live theatre.

Classified ads continued from page 130

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FOR SALE—PRIVATE

Akai Stereo Tape Recorder, model 1710, 2 Akai SS30 Speakers and accessories all as new. £75 o.n.o. T. Graham, 17 Marigold Close, Farnham, Hants.

Professional 35mm Sync Sound Camera suitable multi-track recording. SAE particulars. K. Ross, 58 St. Johns Rd., Manchester M16 9QP.

Two Loudspeaker Cabinets 2½ cubic feet, sapele finish, white formica backs, £8 10s. each. Cabinet 3½ cu. ft. afrormosia £8 10s. KEF B139 bass units £7 10s. each. Clestion HF1300 Treble £3. Richard Allan Minette Module £6. 5" bass, treble and crossover £6 set. Spare crossover £1. Barrs, 305 Denby Dale Road, Wakefield, Yorks.

Transformers. Audio for use with Electrostatic Speakers. 20v input for 2000v. output 100 Hz to 20 kHz approx. Excellent quality. £3 each. Mains Transformers for transistor power amplifiers £1 each. New with various tappings 5v to 60v. Barrs, 305 Denby Dale Road, Wakefield, Yorks.

Planet U1 tape deck. Unused 3 heads for transistors. Stereo ¼-track. In partially finished teak case, £26 10s. excellent. Miniflux low distortion Oscillator for above £3 10s. Philips Cassette Recorder, several cassettes, £15 bargain. Loewe Opta Battery Recorder, tapes, £15 excellent. Barrs, 305 Denby Dale Road, Wakefield, Yorks.

Philips N4307 4-track 3¾ current model at £48 10s. Hardly used. Pristine in makers box with microphone. £35. Delivered reasonable distance. Monro, 46 Davenham Road, Formby, Liverpool. Tel.: 051-36 72738 (evenings).

Vortexion WVA/5 tape recorder. Additional monitoring head and head-lift transformer fitted. Mint condition. £50 o.n.o. Phone 01-398 4519 evenings.

Ferrograph 722w. + perspex cover, eight months old, £155. Sennheiser MD421 microphone £20. No offers. 8 Hampshire Drive, Maidstone, Kent.

Reslo Studio Ribbon microphones 30/50 ohms, matched pair, and custom-built coincident holder, with 25ft. cable £35. Two Reslo transformers LMT/L-M £5. Raw, 33 Beech Lane, Earley, Reading.

Sennheiser MDSIN stereo microphones, Dynamic, Cardioid, 200 ohms. Stand mounting brackets for discharging or cross stereo. Can be used individually, £16. Box No. 568 (Northumberland).

FOR SALE—TRADE

Major London Studio has quantity of professional audio and film equipment, mics., mixers, tape and film, recorders, speakers, film lights, etc. for sale prior to complete re-building. Lists SAE to Box No. 567 (London).

W.H.M. 8 Transistor Audio Compressor/Limiter in modular form. Full frequency range. P.P.M. attack. Low distortion. 35 Villiers Road, Watford, WD1 4AL.

60% OFF EMI and Zonatape 5" L.P. Polyester tapes (boxed with leaders). These tapes have been partially used by the professional recording industry, electronically cleaned, and are 100% perfect. Satisfaction or refund. 10/- each, post 9d per tape. 5 tapes 50/- post free. 10 tapes 95/- post free. Avon Enterprises (Dept. TRA), Fladbury, Pershore, Worcs.

Pre-recorded American Stereo Tapes. 7½ ips. Cheap as records. Bernsteins, Mahler, Maazels, Sibelius, Karajan, Beethoven Symphonies. £15 per set of 5 tapes incl. PT and duty (any duty or purchase tax charged by the postman will be refunded—see instruction slip in tape box). £3 cheaper than records. P.O. 5/- for complete catalogue. Postereo Tapes, 9 Darley Street, Harold's Cross, Dublin 6, Eire.

If quality matters consult first our 75-page illustrated Hi-fi catalogue with technical specifications (6/6). Members enjoy unbiased advisory service, preferential terms. Membership 7s. 6d. Our associates also manufacture records from your own tapes, or record the Master at our studios (Steinway Grand). Bulk terms for choirs, fund-raising. Please specify requirements. Audio Supply Association, 18 Blenheim Road, London W.4.

Substantial Discounts on top quality microphones and recording equipment. Reslo, A.K.G., Grampian, etc. All accessories and P.A. equipment. Harrower West, Microphone Specialists, 6 Wolfe Road, Falkirk, Scotland. Tel. Falkirk 22239.

Lancashire. Tandberg, Ferrograph Tape Recorders, etc. Plus over 10,000 high fidelity systems. After-sales service. Holdings Photo-Audio Centre, 39-41 Mincing Lane, Blackburn BBA 2AF. Tel. 59595/6.

TAPE EXCHANGES

A must for every Tapetalker worth his salt: "Tips for Tapespondents—International Message Making." Price 2s. 10d. Worldwide Tapetalk, 36 The Gardens, Harrow, HA1 4HE. Every aspect of the hobby covered!

STUDIO FACILITIES

Studio Sound Recording Studios. Recording and disc transcription service. Latest high-level cutting techniques. Mono and stereo records. Exceptional quality obtained from amateur recordings. Members A.P.R.S., 31-36 Hermitage Road, Hitchin, Herts. Telephone Hitchin 4537.

Your tapes to disc. 7in. 45—25/-, 10in. L.P.—55/-, 12in. L.P.—65/-. 4-day postal service. Masters and Vinylite pressings. Top professional quality. S.A.E. photo leaflet: Deroy Studios, High Bank, Hawk Street, Carnforth, Lancs.

Your own tapes transferred on to discs. Send for details: R. J. Foley Tape to Disc Service, 112 Beach Road, Scratby, Great Yarmouth, Norfolk.

Graham Clark Records. Tape to disc pressings. 23 The Grove, Walton-on-Thames, Surrey. Tel. Walton 25627.

J & B Recordings. Tape to disc—latest high level disc cutting, all speeds. Mastering pressings, studio, mobile. 14 Willows Avenue, Morden, Surrey. MITcham 9952.

County Recording Service. Send your tape for transfer to disc to the people who care about quality. Full time disc recording engineers, using modern cutting techniques. Telephone: Bracknell 4935. London Road, Binfield, Bracknell, Berkshire.

Pressing Specialists, stereo or mono discs manufactured from your own tapes. Mobile recording service. North Surrey Recording Co., 59 Hillfield Avenue, Morden, Surrey.

SITUATIONS VACANT

Tape Recorder Engineer required, experienced most makes. Telesonic, 92 Tottenham Court Road, London, W.1. 01-387-7467.

Young man interested in tape recorders wanted to assist in running hire service. Magnegraph, 1 Hanway Place, London, W.1.

We offer

RADIO AND TAPE RECORDER ENGINEERS

the opportunity of working in an up-to-date radio and tape recorder service department on Bluespot radios and Uher recording equipment.

The applicant should be familiar with the latest transistorised circuitry as well as being able to carry out mechanical work on such equipment.

We offer a good salary, non-contributory pension scheme, subsidised canteen facilities and some local transport.

If you are interested, please write giving brief details about your qualifications and experience to:

The Personnel Manager, BOSCH LIMITED, Rhodes Way, Radlett Road, Watford, Herts.

Classifieds contd. on page 129

GUARANTEED QUALITY AND SATISFACTION

4-TRACK STEREO

	Cash Price			Deposit			12 Monthly Payments		
	£	s.	d.	£	s.	d.	£	s.	d.
Philips N4404 ...	80	0	0	26	13	4	4	8	11
Ferguson 3232 ...	93	5	0	33	5	0	5	1	10
Sanyo MR929 ...	97	4	9	33	4	9	5	6	10
Sony TC 252 ...	99	15	0	33	5	0	5	10	10
Philips N4407 ...	103	15	4	35	15	10	5	13	4
Akai 1710L ...	109	0	0	36	6	8	6	1	2
Sanyo MR939 ...	112	0	2	38	13	6	6	2	3
Grundig TK247 ...	112	10	0	37	10	0	6	5	0
Sony TC 230 ...	121	11	9	40	11	9	6	15	0
Philips N4408 ...	136	3	10	46	19	5	7	8	9
Telefunken 204TS	124	19	0	41	19	0	6	13	4
Sanyo MR990 ...	131	18	1	44	18	0	7	2	4
Philips N4408 ...	136	3	10	46	19	5	7	8	9
Tandberg 1241X ...	149	0	0	49	0	0	8	6	8
Beocord 2000K ...	159	12	0	53	4	0	8	17	4
Beocord 2000T ...	165	18	0	57	18	0	9	0	0
Ferrograph 722/4	204	16	9	68	16	9	11	6	8
Akai 1800SD ...	199	0	0	65	6	8	11	1	2
Philips Pro 12 ...	239	0	7	79	13	7	13	5	7
Revox 1122/24 ...	236	5	0	78	15	0	13	2	6

4-TRACK MONAURAL

	£	s.	d.	£	s.	d.	£	s.	d.
Fidelity Braemar	34	4	8	11	12	8	1	17	4
Fidelity Studio ...	46	0	10	15	17	10	2	10	2
Grundig TK149 ...	55	18	10	18	18	10	3	1	8
Philips 4307 ...	48	11	11	16	15	3	2	13	1
Ferguson 3228 ...	48	16	0	16	16	8	2	13	4
Telefunken 201 ...	51	9	0	17	3	0	2	17	2
Ferguson 3238 ...	59	12	0	20	12	0	3	5	0
Philips 4308 ...	60	0	10	20	14	2	3	5	7
Ferguson 3216 ...	66	2	0	22	16	0	3	12	2
Tandberg 1541 ...	82	0	0	28	0	0	4	10	0

STEREO TAPE UNITS

	Cash Price			Deposit			12 Monthly Payments		
	£	s.	d.	£	s.	d.	£	s.	d.
Sanyo MR801 ...	72	9	0	24	3	0	4	0	6
Sony TC252 ...	72	15	0	24	9	0	4	0	6
Sony TC355 ...	100	2	6	34	2	6	5	10	0
Tandberg 1641 X...	89	10	0	30	0	0	4	19	2
Akai 4000D ...	89	18	8	30	18	8	4	18	4
Tandberg 62/64 X	157	0	0	52	6	8	8	14	6
Ferrograph 702/4	194	15	8	64	15	8	10	16	8

MAINS TWIN TRACK

	£	s.	d.	£	s.	d.	£	s.	d.
Fidelity Braemar	31	0	0	10	14	0	1	13	10
Ferguson 3224 ...	33	14	0	11	12	8	1	16	10
Grundig TK120 ...	39	5	0	13	5	0	2	3	4
Tandberg 1521 ...	77	0	0	27	0	0	4	3	4
Beocord 1100 ...	82	19	0	27	13	0	4	12	2
Ferrograph 713 ...	174	13	6	58	13	6	9	13	4

BATTERY OPERATED

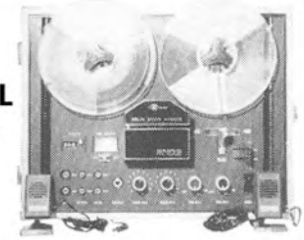
	£	s.	d.	£	s.	d.	£	s.	d.
Philips RR290 ...	31	10	0	10	10	0	1	15	0
Grundig C200 ...	37	17	6	12	7	6	2	0	10
Philips RR482 ...	54	12	0	18	4	0	3	0	8
Telefunken 300 TS	57	15	0	19	5	0	3	4	2
Telefunken 302 TS	68	5	0	22	15	0	3	15	10
Uher 4000L ...	133	13	2	44	13	1	7	8	4
Uher 4200/4400 ...	162	10	7	54	10	7	9	0	0

INTEREST FREE H.P. TERMS.

OPEN SATURDAY 6 p.m.
FRIDAY 6.30 p.m.

IF UNABLE TO CALL, WRITE FOR BROCHURES. PART EXCHANGES. ALSO 18 AND 24 MONTHLY TERMS.

SPECIAL OFFER



SANYO MR-910 **STEREO** (illustrated)

★ 4 Track. ★ 2 Speeds, 7½ and 3¾ i.p.s.
★ 7" Reels ★ 2 x 4" Permanent Dynamic speakers
★ Sound-on-Sound with optional adapter.
★ Sound-With-Sound.
★ Supplied complete with 2 Microphones, 7" tape, Audio leads, Makers 12 months guarantee and Full instructions.

List price £84.15.0. **Our price 62 Gns.**
INITIAL DEPOSIT £21.14.0. 12 Monthly payments of £3.12.4.

SANYO MR-990 STEREO:

★ 4 Track ★ 3 Speeds ★ Sound-on-Sound
★ Sound-With-Sound.
★ 2 Detachable Speaker Boxes.
★ Output 2 x 10 watts Music Power.
★ Natural Wood Cabinet.
★ Supplied complete with 2 Dynamic Microphones, 7" Demonstration Tape, leads, etc., Makers 12 months guarantee and instructions.
★ Automatic Shut-Off. List price £132.5.0.

Our price 110 Gns.

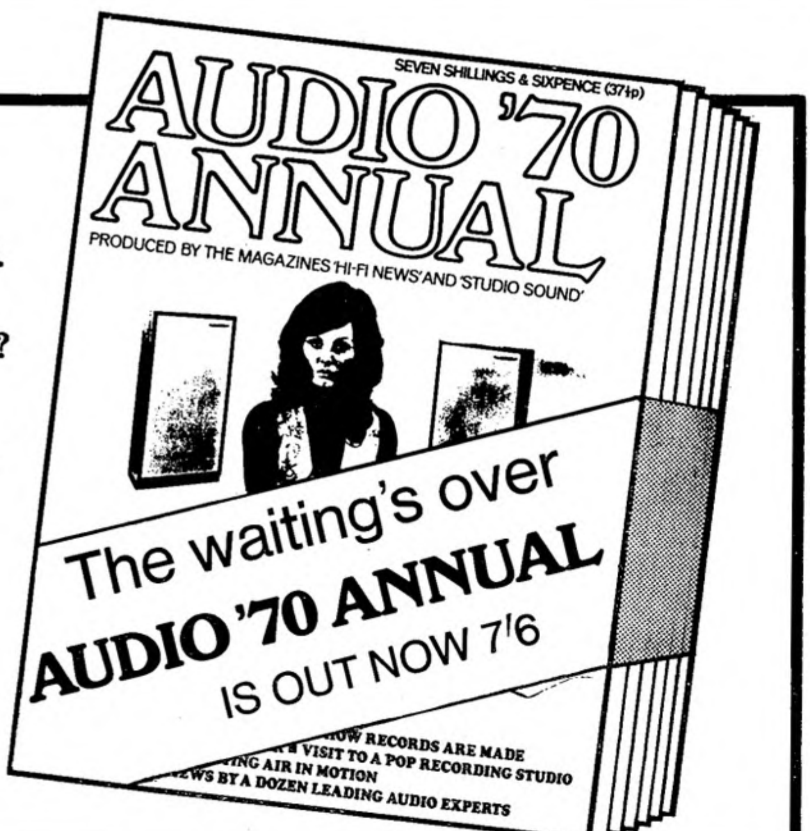
THE RECORDER CO

this is the name

(DEPT. R) 186-188 WEST END LANE, WEST HAMPSTEAD, LONDON, NW6
Telephone: 01-794 4977

Audio Annual 1970 is packed with features of interest for all hi-fi and tape recording devotees. Contents include:

- Are equipment reviews honest?
- How records are made
- A new theory of record wear
- Visit to a pop recording studio
- Noise, noise, noise
- Setting air in motion
- Articles and reviews by a dozen leading audio experts



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It's truly a "Magnificent World" —the world of AKAI. The AKAI sound immediately shows why, for true quality has a sound its own.

"The Magnificent World" is yours if you get acquainted with AKAI.

CROSS-FIELD HEAD

SW-125

Model M-10

THREE MOTORS AUTO. REVERSE TAPE RECORDER—M-10

*CROSS-FIELD HEAD *3 motors *Sensing tape continuous reverse (Auto. reverse) *Manual reverse *3 speeds, 3 heads *3 speed capstan drive motor *Automatic stop/shut off *Automatic pinch wheel release *Automatic lever release *4 track stereo/monaural recording and playback *40W music power solid state amplifier with two integrated circuits *Fine vinyl leather or wooden cabinet *Matching speaker: SW-125 (3 way, 30 watt input).

Model X-330

10½″ REEL MULTI-PURPOSE STEREO TAPE RECORDER—X-330

*Program minder (Automatic continuous reverse) *Sensing tape continuous reverse *Manual reverse *CROSS-FIELD HEAD *3-speed motor for capstan drive *Magnetic brake *Enabling to use 10½″ reel *4-track stereo/monaural recording and playback *3 speeds, 4 heads *40W all silicon transistorized amplifier *24 hours continuous Hi-Fi stereo playback capacity at 1⅞ ips (7,200 feet tape) *12 hours continuous Hi-Fi stereo recording capacity (total 24 hours) at 1⅞ ips (7,200 feet tape) *Matching speaker: SW-150 (3 way, 40 watt input).

Model X-360

PROFESSIONAL STEREO TAPE RECORDER—X-360

*4 heads, 3 motors *4 track stereo/monaural recording and playback *4 tape speeds (1⅞, 3¾, 7½ and 15 ips) *3 speeds main motor *CROSS-FIELD HEAD *50 watt solid state amplifier *Automatic volume control (Comput-O-matic) *Automatic continuous reverse (Reverse-O-matic) *Automatic dust minder *Magnetic brake for motors *Matching speaker: SW-160 (4 way, 60 watt input).

Prove it by the sound!
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AKAI®

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