JUNE 1969 2s 6d

tape recorder

HEADPHONE MONITORING

THIRTY-ONE CHANNELS AT THE HIGH COURT

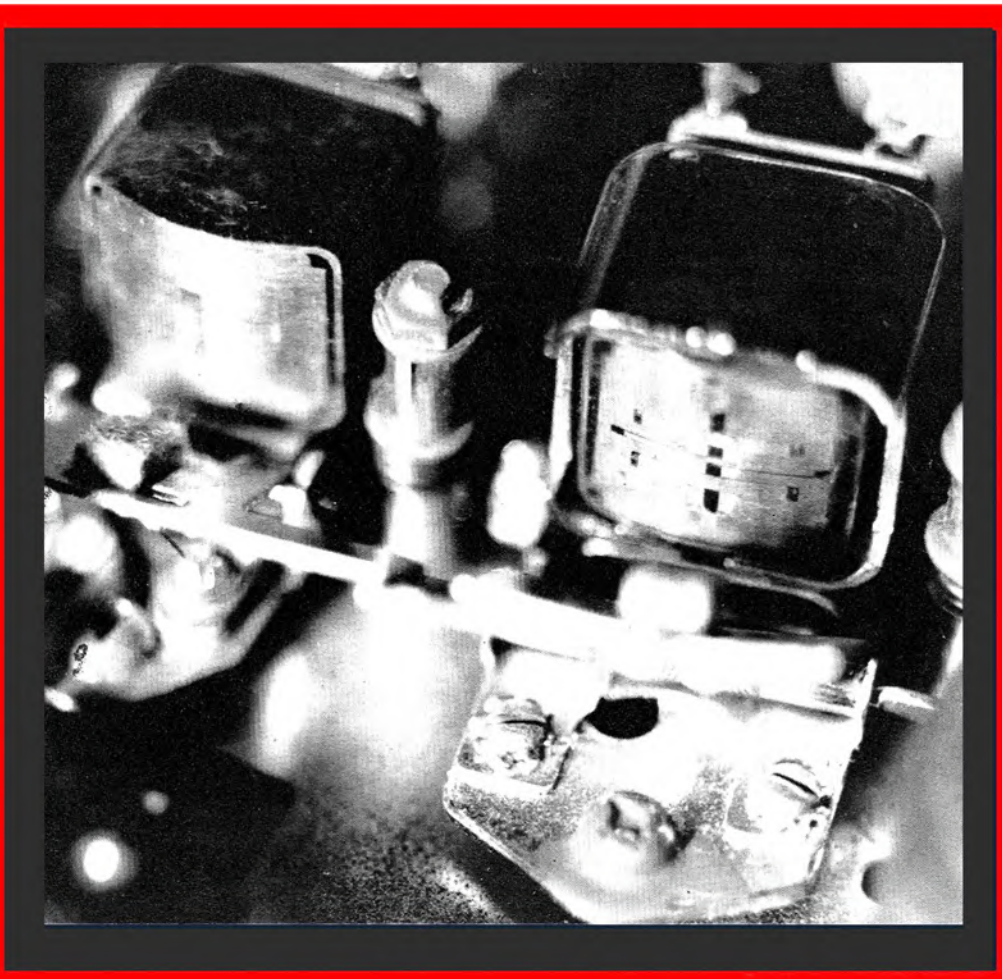
EXTENDING AN AKAI M8

THE OTHER SIDE OF THE COIN

STUDIO MICROPHONES

REVIEWS: NATIONAL RS-790S, EAGLE MP7 AND DJ101

TRUVOX 50 SERVICING



K. J. ENTERPRISES

BRITAIN'S PREMIER MAIL-ORDER AUDIO SPECIALISTS

Immediate despatch on Advertised Lines.

Send Cash with Order.

DISCOUNT BARGAINS ★ VAST STOCKS OF TAPE & EQUIPMENT ★ REFUND GUARANTEE.

BRANDED TAPES
20% OFF!
BASF—EMI—GRUNDIG—PHILIPS
SCOTCH—AGFA

Brand new, Fully Guaranteed and in normal manufacturers pack.

		LIST PRICE	OUR PRICE
STANDARD PLAY			
5″	600′ }	22/2	18/-
5¾″	900′ } Except Agfa	29/5	24/-
7″	1200′ }	36/7	29/6
LONG PLAY			
3″	210′ Not Scotch	9/3	7/6
3″	300′ Scotch only	9/7	7/9
4″	450′	14/9	12/-
4½″	600′ BASF, Agfa only	22/-	18/-
*5″	900′	29/2	23/6
*5¾″	1200′	36/5	29/6
*7″	1800′	51/7	41/6
8¼″	2400′ BASF, Scotch	74/-	58/9
10″	3280′ Agfa only	85/9	68/9
10″	3600′ BASF only	96/6	77/6
10½″	4200′ Agfa, BASF only	113/6	89/3
SCOTCH DYNARANGE (L/P)			
5″	900′	32/8	26/3
5¾″	1200′	41/-	33/-
7″	1800′	58/1	46/6
8¼″	2400′ (Metal Reel)	84/3	67/6

GRUNDIG TAPE AVAILABLE ONLY WHERE MARKED WITH ASTERISK

		LIST PRICE	OUR PRICE
DOUBLE PLAY			
3″	300′ Not Scotch	14/3	11/6
3″	400′ Scotch only	16/7	13/3
4″	600′	26/-	21/-
4½″	900′ Agfa, BASF only	31/-	25/-
5″	1200′	43/2	34/9
*5¾″	1800′	56/11	46/-
*7″	2400′	79/-	63/6
10″	4600′ Agfa only	140/9	112/9
TRIPLE PLAY			
3″	450′ Not Scotch	22/3	18/-
3″	600′ Scotch only	24/10	19/9
4″	900′	40/-	32/3
*4½″	1200′ Agfa, BASF only	50/-	40/3
5″	1800′ Not Scotch	67/2	54/-
5¾″	2400′ } Agfa, BASF	91/4	73/6
7″	3600′ } only	116/6	93/6
COMPACT CASSETTES			
C.60		17/6	14/3
C.90		25/-	20/3
C.120		33/6	27/-

Postage and packing 2/6. Orders over £3 post free.

AMPEX TAPE—SAVE 30%

A special offer of top quality, premium grade, mylar (Polyster) base tape with Full Leader and Stop Foil. Boxed and Fully guaranteed.

TYPE	DESCRIPTION	LIST PRICE	ONE	THREE	SIX
541-12	1150′ on 5¾″ reel Long Play ...	35/-	24/6	71/-	137/-
551-12	1200′ on 5″ reel Double Play ...	42/-	29/6	86/-	166/-
551-16	1650′ on 5¾″ reel Double Play ...	55/-	33/6	97/6	189/-
551-24	2400′ on 7″ reel Double Play ...	77/6	49/6	145/6	285/-

POST AND PACKING 2/6. ORDERS OVER £3 POST FREE.

Compact Cassettes
UP TO HALF PRICE

Compact Cassettes with 60 and 90 minutes playing time. Brand New and packed in normal plastic library box. Available at this exceptional price.

MAXELL MC.60	MAXELL MC.90
1 for 10/6	1 for 14/-
3 for 30/-	3 for 40/6
6 for 55/6	6 for 78/-
12 for 105/-	12 for 150/-

Post and Packing 2/6. Orders over £3 post free:

Must not be confused with cheaper American Overture Cassettes advertised elsewhere with M.C. prefix.

Standard pattern to fit Philips, Stella, Elizabethan Dansette, Sanyo, Ferguson, Bush, HMV, Sony, etc.

ILFORD—
ZONAL TAPE
40% OFF!

SOUND VALUE GUARANTEE

NEW KJ SPECTACULAR

From the Motion Picture and Magnetic Products Division of **ILFORD LTD.** we are proud to present a New Stupendous **BARGAIN OFFER**! Never before have you been offered such a breathtaking opportunity. **ILFORD-ZONAL** premium grade magnetic tape (extensively used by the B.B.C.) at a terrific reduction of 40%! Brand New, Boxed, Fully Guaranteed and complete with leaders, trailers and stop foil. **UNIQUE TO KJ.**

DESCRIPTION	LIST PRICE	ONE	THREE	SIX
900′ on 5″ reel Long Play P.V.C. ...	29/1	17/6	50/6	96/6
1200′ on 5¾″ reel Long Play P.V.C. ...	36/1	22/6	65/-	125/-
1800′ on 7″ reel Long Play P.V.C. ...	51/4	29/6	86/-	165/-
1200′ on 5″ reel Double Play (Polyester)	43/1	27/9	81/-	157/6
1800′ on 5¾″ reel Double Play (Polyester)	56/1	36/-	105/-	204/-
2400′ on 7″ reel Double Play (Polyester)	78/10	49/6	145/6	285/-

Post and Packing 2/6 — Orders over £3 post free

BARGAIN OF THE MONTH
SANYO CASSETTE RECORDER

SAVE £8

LIST PRICE **£30-2-4**

OUR PRICE

21 GNS!

PLUS CARRIAGE 7/6

A really top quality cassette recorder, fully guaranteed and supplied complete with remote control microphone, carrying case, earpiece and pre-recorded compact cassette. Finished in Olive and White case with chrome speaker grill and 3·5 mm jack sockets for microphone and earpiece.

MODEL M26

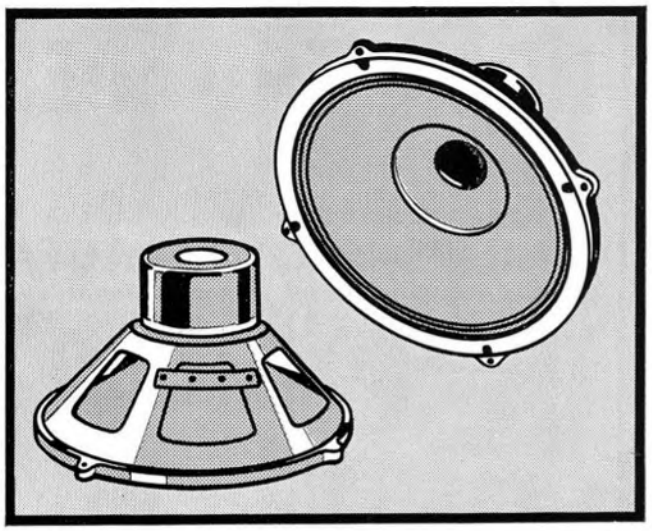
SPECIFICATIONS

Transistors	2SB303 x 1 2SB186 x 3 2SB22 x 2 2SC536 x 1
Diode	1S188 x 1
Thermistors	SD1-09 x 2
Recording System	Double track, AC Bias
Erasing System	DC Erasing
Tape Speed	1⅞″ (4.75 cm)/sec.
Recording Time	Up to 60 min. on one track 120 min. on double tracks
Power Output	Maximum 500mW 250 mW at 10% distortion
Speaker:	2¾″ (7cm) Diagonal P.D.S.
Recording Tape:	300ft. (90 m) Length
Wow & Flutter:	0.5% RMS
Signal to Noise Ratio:	30db.
Freq. Response:	150 c/s—6 Kc/s.
Operating Temp.:	0°C—40°C.
Batteries:	UM-2 x 5 (C-Cell x 5).
Battery Life:	More than 12 hours.
Microphone:	Dynamic Microphone with remote control switch.
Dimensions:	8¾″ (L) x 5″ (W) x 2¼″ (H). 225.5 (L) x 123 (W) x 58 (H).
Net Weight:	3.3lb. (1.5 kg).

K. J. ENTERPRISES (Dept TR6) 17 THE BRIDGE, WEALDSTONE, MIDDLESEX (Opposite Harrow and Wealdstone Station). 01-427 7758. Showroom hours: 9.30a.m. - 5.30p.m. Closed Lunch 12.30 - 1.30p.m. Close 1p.m. Saturday.

FREE Our New 100 page illustrated catalogue sent entirely FREE on request. Britain's most specialised comprehensive range of recording tape, Accessories and Audio equipment. 20,000 reels of tape always in stock with reductions ranging up to 50%

Faithful Reproduction



with the Grampian TC12 loudspeaker

The Grampian TC12 loudspeaker is a high quality twin cone unit at a reasonable price. The loudspeaker is built of high quality materials to a rigid specification and is eminently suitable for good quality sound reproduction. Let us send you full details or better still go and hear one at your local dealers now.

Design for suitable cabinet available.

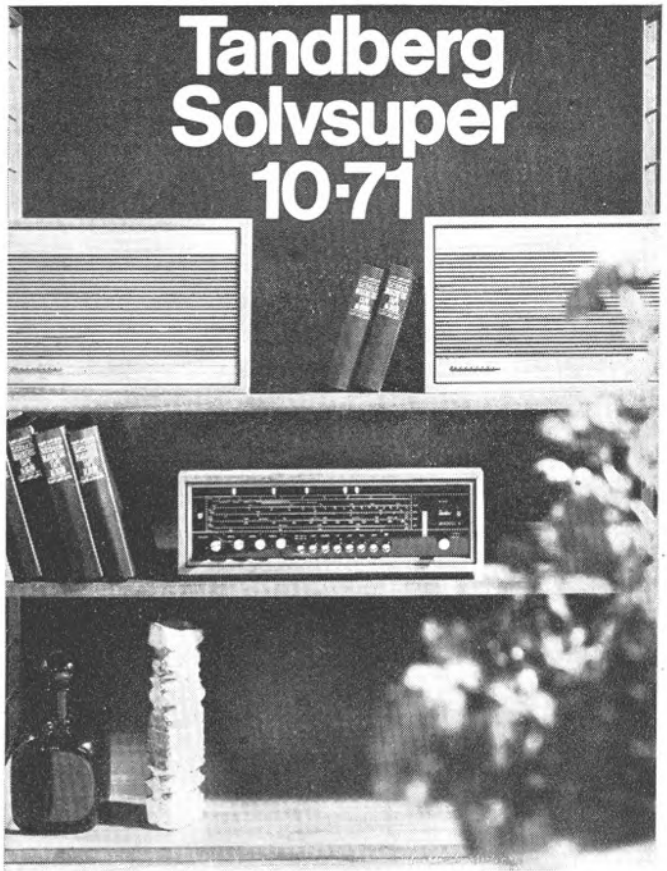
Grampian manufacture high grade microphones, parabolic reflectors, windshields and accessories, also mixers and amplifiers.

Grampian SOUND EQUIPMENT
Integrity that you hear

Send for leaflet giving full details

GRAMPIAN REPRODUCERS LTD
Hanworth Trading Estate, Feltham, Middlesex
Tel: 01-894 9141/3 Cables REAMP, FELTHAM

Tandberg Solvsuper 10-71



The Solvsuper 10-71 is a combined AM/FM tuner and stereo amplifier in a compact, elegant teak case. It combines a remarkable list of facilities with Tandberg's renowned quality of faithful sound. Just look at these features, then compare the price with any other radio of similar quality.

* 5 wave bands (long, medium and two short wave bands plus an FM band). A ferrite aerial serves long and medium waves.
* Automatic frequency control on FM.
* Station markers on dial to facilitate FM tuning.
* Ready for installation of FM multiplex decoder (an optional extra).
* Stereo indicator (glows when receiving stereo broadcasts).
* Output power: 6 watts on each channel RMS.
* Bass and treble controls continuously variable ± 10db.
* Will feed radio signals to a magnetic tape recorder and replay the tape signal simultaneously.
* Equalisation to RIAA specification for magnetic gramophone pickups.
* Price: £76.0.0.

Compare our Performance – then Compare our Price!

Please send me full details of the Tandberg Solvsuper 10-71 ☐
the full range of Tandberg audio products ☐
Please tick appropriate box(es)
NAME .....
ADDRESS .....
.....

Post to:
Elstone Electronics Ltd.,
Dept. TR3 Hereford House,
Vicar Lane, Leeds, 2.

Tandberg

Let's cut the crackle! Telefunken 204 TS.

You don't want a load of waffle about the brilliance of the Telefunken 204TS all-stereo tape recorder.

It speaks for itself!

Whatever you put in, comes out unmolested. No irritating hums, buzzes or crackles find their way onto the track.

But what you want is facts not words.

It complies with the very, very stringent German tape recorder standards.

Separate controls for recording and playback, including sound level meters.

Single selector switch for all operating functions.

Three speeds.

Signal to noise ratio $\geqq$ 50db at 7½ips.

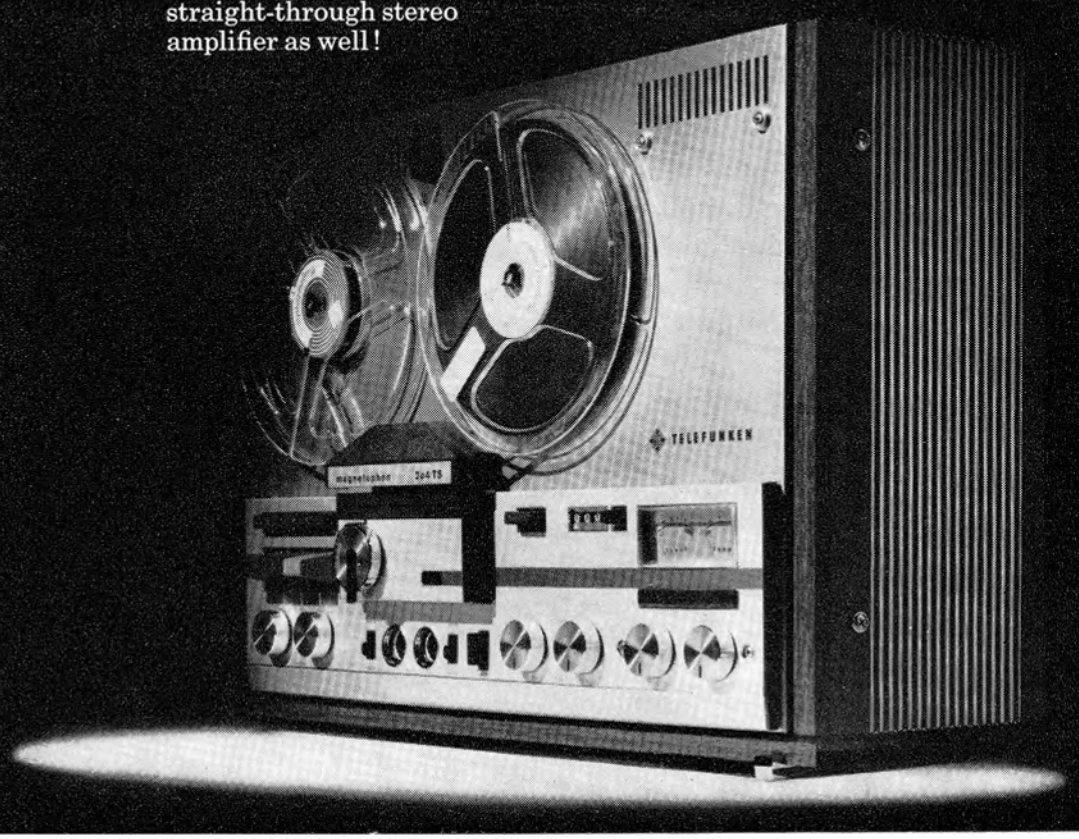
And it can be used as a straight-through stereo amplifier as well!

Another fine example of the Telefunken philosophy: dedication to faithful reproduction.

Get the full story from your dealer or write direct.

AEG/Telefunken
Publicity Dept.
86/88 Upper Richmond Rd
London SW15

TELE FUN KEN



tape recorder

JUNE 1969 VOLUME 11 NUMBER 6

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COVER PICTURE

New tape heads running in. Our photograph shows two of the four heads on the bi-directional ½-track National *RS-790S*, reviewed on page 253.

SUBSCRIPTION RATES

Annual home and overseas subscription rates to *Tape Recorder* and its associated journal *Hi-Fi News* are 30s. and 47s. respectively. U.S.A. $4.80 & $5.60. Six-month subscriptions are 15s. *(Tape Recorder)* and 24s. *(Hi-Fi News)*, from Link House Publications Ltd., Dingwall Avenue, Croydon, CR9 2TA.

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

RICHARD GOLDING concerns his *Closed Circuit* column this month with the subject of 'jargon'. The linguistic gulf between the sound recordist and the man in the street has grown extraordinarily wide during the past forty years. We have borrowed heavily from electronics diction, from music, from the terminology of the mechanical engineer, from acoustics, and even (RMS and all that) from mathematics. Golding's own speciality, video recording, extends still further into the language of optics and television.

To this collection of imported terms, a number of originals can be added, coined in recording (and advertising) studios and on the factory floor. 'Back bias', 'wobble', 'pre-echo' and 'scrape' are peculiar to recording and convey little meaning to the raw amateur ; still less to the uninterested rest of the world. *Tape Recorder's* purpose in life has been to educate and encourage amateur recording enthusiasts along the path to professionalism, educating ourselves in the process. Some enthusiasts stray into the 'hi-fi' rut and curtail their creativeness in favour of chasing the latest transistor amplifier, the latest IC tuner, and the latest 'Dolbyised' discs. These are the folk, generally speaking, who tolerate capstan sleeves and narrow tracks, plastic mics and miniature jacks, and then complain that their tape equipment is not as good as their gramophone.

Other enthusiasts, the majority of our readers we hope, progress from simple domestic recorders to more reliable semi-domestics, from piezo-electric to magnetic and capacitor microphones, until they reach the 38 cm/s ½-track stereo stage. At this point they begin to realise the commercial possibilities latent in their equipment and experience. They follow the example of John Shuttleworth, integrating recording with an existing profession, or turn more or less fully to tape recording, in the manner of Terence Long and Alec Tutchings. Alternatively, if caught young, they enter the superficially glamorous rat-race of broadcasting and disc recording.

Like everyone else in audio, we were reared on beginners' books and fairly simple magazines. We could cater better for today's audio tyros by allocating a larger proportion of space to articles for beginners, and by using common English instead of jargon. The man-in-the-street equivalent of 'wobble' is fairly straightforward—fluctuations in tape speed—but how are we to define 'back-bias' in common English, every time we refer to it, without boring experienced enthusiasts to tears ? Either we use jargon or we bury our heads and pretend that the technicalities of tape recording do not exist. Therefore we use jargon, referring beginners to the thirty or so tape recording books currently available to explain the expressions.

Our monthly list of new Musicassette releases, beginning on page 241, has been started to attract readers with cassette recorders in the hope of introducing them to the creative side of audio. The general trend of articles and reviews in the past year has been away from domestic activities. We find studio affairs more illuminating than the reminiscences of all but the most lively amateurs, and feel that amateurs can usually learn more from professionals than from fellow amateurs. In the case of K. R. Wicks' series this also allows professionals to learn from each other, though we will of course continue to accept and publish domestic and amateur material when it offers useful new advice.

Defining a tape recorder (as distinct from a tape recordist) as professional or domestic-cum-amateur was once a matter purely of personal opinion. As domestic recorders improved, the term 'semi-professional' became so meaningless that, for a while, it was religiously excluded from this journal. Purchase tax solved that problem, however, marking a clear border between studio/industrial and domestic recorders. We shall shortly be commencing an extra review column devoted exclusively to studio recorders, contributed by Terence Long, and plan ultimately to expand our reviews to cover helical scan VTRs.

FEATURE ARTICLES

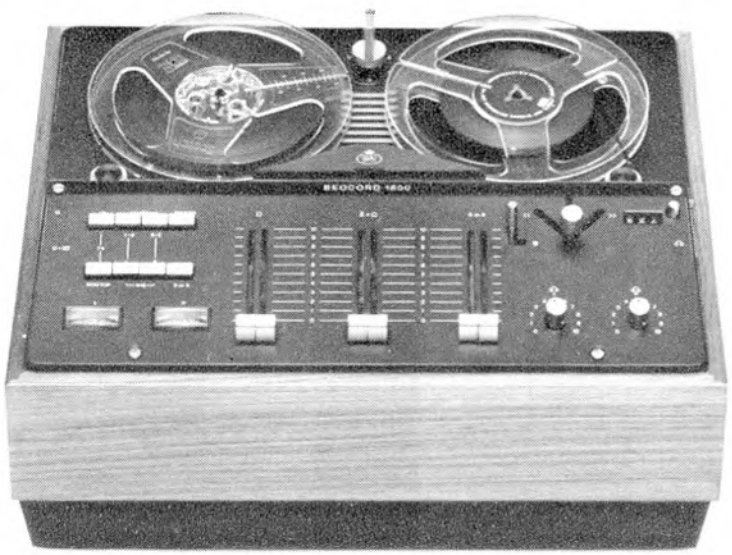
REGULAR ITEMS

EQUIPMENT REVIEWS

A brilliant new stereo tape deck –the Beocord 1800

Made by Bang & Olufsen for those who consider design and quality before price.

Designed especially for use in conjunction with a high fidelity amplifier such as the Beomaster 1400 or Beolab, this new tape deck from B & O has an impressive specification. Available in twin or 4 track and finished in either teak or rosewood. The twin track model has an additional switched 4 track stereo head for the playback of pre-recorded 4 track tapes.



Specification (Exceeding the DIN 45.500 requirements)

FREQUENCY RESPONSE:
$7\frac{1}{2}$" per sec. 20-20.000 Hz
(±2 dB 30-18,000Hz). DIN 45.500.
$3\frac{3}{4}$" per sec. 20-15,000 Hz
(± 2dB 30-13,000 Hz) DIN 45.500.
$1\frac{7}{8}$" per sec. 30-7500 Hz
(± 2dB 40-6000 Hz). DIN 45.500.

EQUALIZATION: DIN 45.513
1966-67 = NAB 1965.

SIGNAL TO NOISE RATIO:
achieved without the use of special low noise tapes
>60 dB for $\frac{1}{2}$ track version
($\frac{1}{4}$ track version >57 dB)
unweighted (DIN 45.405)

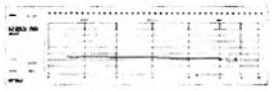
CHANNEL SEPARATION:
Mono: >60 dB at 1000 Hz
Stereo: >55 dB at 1000 Hz

TAPE HEADS: specially developed hyperbolically ground.
Two track machine: 2t erase, 2t record, 2t replay, 4t replay.
Four track machine: 4t erase, 4t record, 4t replay.

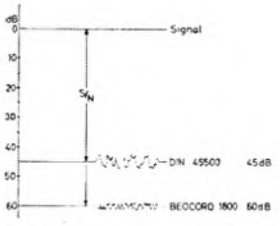
WOW AND FLUTTER: (Measured according to DIN 45.506)
$7\frac{1}{2}$" per/sec RMS Value <0.07%.
$3\frac{3}{4}$" per/sec RMS Value <0.11%
$1\frac{7}{8}$" per/sec RMS Value <0.18%

EXTERNAL CONNECTIONS: Inputs to three Channel stereo mixer for microphone, radio/gramophone and line. Outputs for headphone, line and radio.

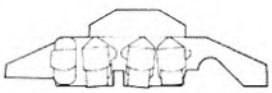
SPECIAL FACILITIES INCLUDE:
Fast acting thyristor controlled auto stop.
Three channel stereo mixer with split controls on each channel (6 inputs)
Separate headphone volume controls
Tape slack absorbers.
Push button selection of: A-B monitoring, sound on sound, echo, synchro play, mono left, mono right, mixed mono & stereo play.



Wide Frequency Response
$7\frac{1}{2}$" sec: 20-20,000 Hz.



Signal to noise ratio
60 dB on twin track version, 57 dB on 4 track. Results obtained without using special 'low noise' tapes.



Tape head bridge
Provides gentle tape handling with minimum wear to tape and tape heads (Tape heads are hyperbolic with a smaller contact face and a higher powered magnetic field for less noise)

See your specially appointed B & O dealer or write today for full details.
Bang & Olufsen U.K. Limited. Eastbrook Road, Gloucester. Telephone: 0452 21591
London Showrooms 70/71 Welbeck Street, London, W.1. Telephone: 01-486 2144

NEW COMPANY TO MANUFACTURE STUDIO RECORDERS

JOHN S. ALCOCK, who until recently was sales manager for Leevers-Rich, has left this company to become sales director of a new British-sponsored concern which has been incorporated for the purpose of developing and manufacturing professional recording equipment. We understand that the emphasis will be on multi-track systems for the music recording industry.

$1,000,000 VTR CONTRACT

A CONTRACT for 500 colour videotape recorders has been placed with Ampex by Orbit Communications. It is believed by Ampex to be the largest single order ever made for television recording equipment. The 500 units will be installed in universities and research laboratories in various countries. Established by an American industrialist, H. Dudley Wright, Orbit produces and circulates colour videotape programmes on scientific subjects. A series of Orbit recordings entitled 'Selected Topics in Bio-Chemistry' was presented recently to the sixth annual congress of European Biomedical Societies in Madrid as a demonstration of the medium.

AGFA-GEVAERT MOVE

DUE TO EXPANSION, the Magnetic Tape and Reprographic Divisions of Agfa-Gevaert have moved to *Brent House, Great West Road, Brentford, Middlesex* (01-560 2131).

EIGHT-CHANNEL LEEVERS-RICH IN ACTION

THE FIRST eight-channel Leevers-Rich recorder has been purchased by Spot Productions and installed in their South Molton Street studio.

A 25 mm tape transport is employed, developed over a four-year period for industrial application and now being aimed at pop music studios. Spot Productions are feeding the recorder from a sixteen-channel microphone mixer, pictured here at the hands of their sound engineer, Derek Mills.

RIVAL AUDIO FAIR AT GROSVENOR HOUSE?

A NINE-DAY exhibition of audio equipment will open on August 15 at Grosvenor House, Park Lane. Although open to the public, entry will be by ticket only. These will be available free from interested retailers and hotels. The organiser, D. G. A. Shallcross, has approached manufacturers, importers, record producers and retailers for support. Exhibitors are being asked to contribute 25s. per square foot of stand space, offered in 150 square foot units. A company has been formed to administrate this and three other exhibitions, including a Festival of Light. Creative Exhibitions Ltd. occupy 70 *New Bond Street, London, W.*1 (01-493 1911).

TEAC CASSETTE RECORDER

A REPORT in our March issue that Teac were developing a 9.5 cm/s cassette recorder was based on misinformation, we understand from Philips. Teac have no plans to depart from the established 4.75 cm/s cassette speed.

APRS EXHIBITION

SOME THIRTY leading manufacturers of professional recording equipment will be represented at the Association of Professional Recording Studios Exhibition on Saturday, May 17. The exhibitors list includes AKG, Ampex, Audio & Design, Audio Developments, Audio Engineering, B & K Laboratories, BASF, F.W.O. Bauch, Bosch (Uher), British Homophone, Carston, Dolby Laboratories, EMI Tape, Feldon Recording, Grampian, Hayden Laboratories (Kudelski), KEF Electronics, Leevers-Rich, Lennard Developments, 3M, Rupert Neve, J. Richardson Electronics, Scopetronics, Shure, and Tape Recorder Developments.

The exhibition is being mounted at the Hotel Russell, Russell Square, London W.C.1, from 10.30 a.m. to 6 p.m. and will coincide with the APRS Annual General Meeting. The general public will not be admitted but invitation tickets are available to readers engaged in any aspect of professional recording from *The Secretary, APRS,* 47 *Wattendon Road, Kenley, Surrey* (01-668 1554).

SCRIPTS FOR TAPE RECORDING

A LIST OF short sketches and full-length plays for tape recording has been prepared by *Samuel French Ltd.*, 26 *Southampton Street, London W.C.*2 (01-836 7513). The list has been prepared to meet a growing demand for easily-licensed scripts and caters for a wide range of tastes and age levels. Copies are freely available on request from Samuel French.

WORLD OF TAPE

DOLBY AND ROBINSON IN SAN FRANCISCO

DR. RAY DOLBY and his Chief Engineer, David Robinson, left for the USA in April to demonstrate the Dolby *A301* Noise Reduction System at the Audio Engineering Society Exhibition in San Francisco. Frank Sinatra, reputedly critical of his recording quality, used an *A301* for the first time a few weeks ago at A & R Studios, San Francisco. Granada TV and the GPO have also joined the list of Dolby patrons. The GPO units are currently being installed on the Glasgow to Belfast music landline.

KODAK TAPE DRIES UP

SOUND RECORDING tape manufactured by Kodak Pathe S.A. in France is no longer available on the UK market.

VIDEOTAPE AT CAMDEN FESTIVAL

VIDEOTAPE RECORDING will be presented as an art form during the Camden Fringe Festival this month. John Hopkins, an ex-freelance photo journalist now studying cybernetics, is organising this aspect of the Festival. He has invited English television companies to view locally produced material and to participate by submitting their own recordings. The Festival has been offered as a public platform for material considered 'too avant garde' for general transmission. The event was initiated after the Fringe Festival Programme went to print but further information is available from *The Public Relations Office, Camden Town Hall, Euston Road, London N.W.1.* Mr. Hopkins can be contacted by telephone at 435 2643.

BATRC JUDGING

RESULTS OF the British Amateur Tape Recording Contest have been delayed, partly because of the change in Audio Fair plans. Prizes were due to be presented at the Hotel Russell in April but this ceremony may now be postponed until the October Audio/Photo Fair at Olympia. The actual results should be announced in June.

NEXT MONTH

SINCE PUBLISHING W. H. Myall's article *Peak Limiters in Theory and Practice*, we have received many requests for a supporting constructional feature. Gerald Chevin describes *A Simple Transistor Limiter/Compressor*, employing a cadmium sulphide cell, in our July issue. K. R. Wicks examines studio mixing systems while David Kirk considers the problems of recording live music on battery portables. Battery tape recorders will also be the subject of a survey.

This is a page of hi-fi news.

Into the world of Hi-Fi, now and again there comes a product that represents terrific value to the enthusiast.

Such a product is the Grundig TK247 de luxe Stereo tape recorder.

Never before have so many professional features been incorporated in a machine at a price the amateur enthusiast can afford.

Permit us to dangle the specifications in front of you.

Four track, full stereo record and playback to Hi-Fi standard.

Independent record/playback controls and tone control.

Facilities for in-put mixing, super-imposition, multiplay and echo effects. Also monitoring via ear-phones, automatic tape-stop, parallel track operation, tape inching, and a tape joining channel.

More?

Right. Plated steel chassis and frame ensure perfect mechanical alignment.

Tape pressure band prevents drop-outs.

Double-action safety clutch. Easily modified for 60Hz mains operation. Amplifier hinges for easy servicing.

Two tape speeds give up to eight hours playing time.

Less than 0.15% wow and flutter.

Twin-edged illuminated VU level meter.

Two $6\frac{3}{4} \times 3\frac{3}{4}$" high-quality elliptical speakers with two-inch tweeters.

It is $17\frac{1}{2} \times 13 \times 7\frac{3}{4}$" and weighs 30 lbs.

Quite a tape recorder for anybody.

Please send me details of the Grundig TK 247 de luxe.

Name .....

Address .....

.....

.....

GRUNDIG

Dept. T.R.1 Grundig (Great Britain) Ltd., Sydenham, S.E.26.

the other side of the coin by Peter Bastin

THE columns of our technical press occasionally contain laudable gripes from amateurs. It is, in my opinion (and, I am sure, in the opinion of the magazine in question) a very good thing that grievances should be aired in this way. If all goes well, a manufacturer, or whoever is shot at, will reply and everybody may well be that bit wiser. It is not, of course, inevitable that a reply is received; some targets don't like replying because a reply might expose a tender spot. It is with all this in mind that I am going to trample heavily through the supply side of our recording field.

First and foremost, let us look at inconsistencies. Let us look at plugs—probably the most inconsistent things in the world. We have standard jack-plugs and non standard jack-plugs, phono-plugs and DIN plugs, miniature plugs and sub-miniature plugs, banana-plugs and plugs of every shape and size. Some machines are fitted throughout for jack-plugs, others (notably Continental machines) are fitted for those appalling creations, DIN plugs. Some machines, notably the Tandberg *11*, use *three* types. What a chaotic state of affairs. To use more than one machine, it is probably necessary to have your studio festooned with lengths of screened cable, appropriately plugged ready for immediate (?) use. Quite apart from the inconvenient multiplicity of plugs, there is the problem of wiring them up and mending them when they break. My soldering technique is as good as that of an orang-utang and the miseries I go through in trying to solder up a DIN plug are only matched by the colour and volume of the accompanying language. You can solder or you can't solder; it's as simple as that and, for the latter category, the only answer is the jack-plug fitted with screws in place of soldering tags. The three or five pins sticking out of the back of a DIN plug are not only difficult to get at but have the disagreeable habit of melting away if you aren't lucky enough to get the solder to stick first time. I know that some wiseacre will be saying that we should all learn to solder, but is that *really* the answer? Isn't it a fact that it is easier and cheaper to produce a plug with soldering-tags than less-permanent cable-connections? The complete answer is to do away with all nasty plugs; and that, for my money, would be everything except jack-plugs.

Then we have the multitudinous microphone mounts. No two separate manufacturers appear to make similar fittings and your stands and booms have to be festooned with clumsy fittings so that the *X* microphone will fit on a stand which was made only for a *Y* microphone. It would seem that this may all be a not-very-clever trick to hog the scene. After all, why, if you have bought an *X* microphone, should you buy an *X* stand? On the other hand, why shouldn't you? Very often the *Y* stands are better than the *X* stands. And talking about stands, why are those manufactured by named firms so darned expensive? A Grampian boom-arm cost me 5 guineas—a length of chromed bar with a central pivot and securing handle which, I am sure, could have been produced and marketed for less than half that price. I can buy a hefty Japanese microphone stand for about £3, yet a British firm would want a fiver for one very little better.

There is a very strange contradiction in marketing. Sometimes, machines and components get the full treatment—groovey packaging and slinky cases. Other times, you get the machine or whatever it is and nothing else. I bought a Tandberg recorder. The base is made beautifully of teak, which has no effect at all upon the machine's performance, yet there is no lid to keep out the dust. No tape was supplied. On the other hand, I bought a cheap Hong Kong radio, which came with a case and all sorts of odd accessories. Grampian *DP4* microphones come in a sensible stout card box, yet another microphone, costing three times as much, will very likely be handed over to you in a brown paper bag. And what about handbooks? Philips' come in a multi-language version, understandable up to the point where they try to explain plug connections. The Tandberg handbook requires reading several times before you can begin to understand it. The Ferrograph handbook is a model of clarity and comes as a hard-backed book with good paper, good type and clear illustrations. Most handbooks are flimsy things, printed on semi-glazed paper with limp covers which get battered to death in no time at all. Some instructions are merely duplicated typewritten sheets—viz: my Grampian reverberation unit. The writers of these handbooks take one of two views—(a) the reader is a twit and his hand must be held all the way through, or (b) the reader is a professional with 30 years experience and knows the lot.

DEPENDS WHAT YOU MEAN BY A DEALER

And what have we to say about dealers? It depends what you mean by a dealer. He can be an audio specialist, a radio retailer or the manager of a fridge-and-washing-machine outfit. My money goes to the audio specialist who should have enough interest in his job not only to sell his equipment but to be conversant with its virtues and drawbacks. He should not be afraid to name bad stuff nor, for that matter, to push the good stuff. London proprietors stock their shops with hard-eyed salesmen who are interested only in ringing up the till and getting to the next customer. I do admit, however, that my views are confined to my experience in the hard glitter of the West-end and that more-human dealers may exist in other parts of the metropolis. One can only speak as one finds. Provincial towns appear to have a complete lack of specialist dealers and, despite what you may read in the advertisement columns of the technical press, most towns of the size of Birmingham, Liverpool and Manchester have few—if any—genuine audio dealers. In my experience, it is the smaller provincial towns who can produce the shops which sell only audio equipment. There must be some reason for this.

Another sore point with me is the small matter of correspondence or, to put it another way, courtesy. How often have you written to manufacturers and received (a) no reply at all, (b) a reply two months later or (c) a belated reply missing all the points in your letter? All are equally infuriating and I have copies of letters to manufacturers on my file which have been there for over a year without even the courtesy of an acknowledgment card. Not all manufacturers blatantly ignore letters or their contents, but it is very surprising the number of major firms who just can't be bothered to answer a letter, either at all or properly. I think that I would prefer to have a letter ignored than the point of my letter missed. After all, if you ask a specific question of great importance, it is the moral obligation of the firm to answer that question to the best of their ability. Public relations has a long way to go, or so it seems to me. The general tone of letters varies; some replies are condescending, some brief and even curt, some chock-full of sickening clichés such as 'always at your service', some patronising and some reasonably written, albeit they have missed the point of your enquiry.

The natural outlets for all recordists, whether they be amateur or professional, are the record companies and the BBC. It is here that all hopes of a reasonable response to tapes or letters are dashed to the ground. The BBC, which is peopled with friendly, well-mannered types, has a very nasty habit of ignoring your masterpieces. At the present moment, I have five tapes lodged in various parts of the BBC. One has been paid for. Two are being thought about (i.e.: when can they be broadcast?), another was received joyfully ('leave it with me, old man; I'll be in touch in a day or two') and another was presumably received and immediately locked up without telling me. The usual drill is the receipt of a telephone call in the middle of the evening or when you are away at work. You are assured that the material is super and that it is just what they want. You are assured that the matter will be gone into most thoroughly and you will be contacted very shortly. Your rosy dreams fade over the weeks to a dull yellow and then you forget all about the wretched tape. And bang goes another brand new 13 cm reel. (As a matter of fact, I now send material to

(continued on page 242)

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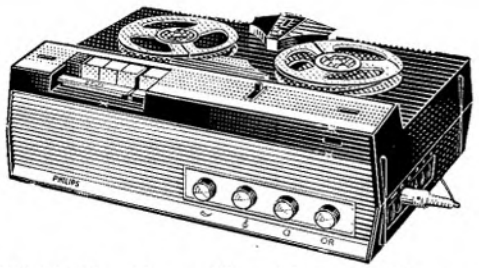

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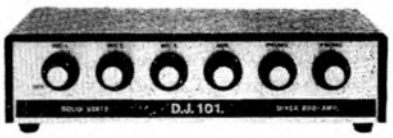

SPECIFICATION:

INPUTS:	
MIC 1	8 MV AT 50 K OHMS.
MIC 2	8 MV AT 50 K OHMS.
MIC 3	8 MV AT 600 OHMS.
AUX 1	50 MV AT 500 K OHMS.
PHONO 1	50 MV AT 500 K OHMS.
PHONO 2	50 MV AT 500 K OHMS.
OUTPUT	250 MV (R.M.S.) AT 100 K OHMS FOR RATED INPUT
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HARMONIC DISTORTION	LESS THAN 0.5% AT 1 VOLT.
SIZE	10⅝" x 2⅝" x 4⅛".
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Extending an Akai M8

F. W. SUTHERLAND DESCRIBES METHODS
OF ADDING SOUND-ON-SOUND AND MULTI-TRACK FACILITIES TO STEREO RECORDERS

THE minor modification described here entails only the installation of two switches, a few lengths of wire, and a resistor. Yet it greatly increases the versatility of the machine by making possible the following:

Playback of any one track through both power amplifiers (if desired), doubling the output power.

Playback of two tracks with controllable mixing, and output of mixed signal through both power amplifiers, making possible sound-with-sound recording and playing, and mono playback of stereo tapes.

Recording with two microphones on any one track, with independently adjustable volume for each microphone.

Better sound-on-sound recording.

Independent playback of one channel while recording on the other.

Complete each stage of the modification, re-assemble the machine and test it before going on to the next, to eliminate possible confusion.

The first stage entails the disconnection and earthing of the conventional sound-on-sound line where it joins the circuitry of the left amplifier. When the back panel has been removed, this line will be seen as a 500 K resistor running from jack 16 to the record/play switch of the left amplifier, where it joins a blue-sleeved, yellow-cored screened lead coming from the microphone input jack to the same point on the switch. (Jack 16 is the one on the right side of the amplifier when seen from the back, and is engaged by a plug on one of the two cables that come from the DIN plug.) Disconnect the resistor (not the screened lead as well) from the record/play switch and reconnect it to the earth (black-leaded) side of the nearby output transformer. It is best to remove the amplifier from the case for this operation.

The modification can be ended here if so desired. The machine will still operate as always, but no internal mixing will take place in the sound-on-sound mode: the right amplifier will replay in the normal fashion while the left records, thereby facilitating acoustical mixing by means of a good quality loudspeaker, or else by way of a good mixer.

The second stage calls for the installation of a toggle switch, the common on/off type (single-pole single-throw), between the volume and tone controls of the left amplifier (see photo). Install the switch so that it will be open (off) in the down position when the amplifier is re-installed.

The wiring of the switch is simple. Remove both amplifiers from the case and solder two leads to the grid pins of the power valves. (Pin 2 of valves *6BQ5/EL84*. When the valve holders are viewed from the underside, the pins are counted clockwise.) On the right amplifier this lead is taken out directly so that it will leave the back of the amplifier when re-installed. On the left amplifier, this lead goes through the switch on the front panel first and thence out the same way.

Re-install the amplifiers. Cut both leads to the right length, strip the ends and connect by soldering, twisting together or using a suitable plug.

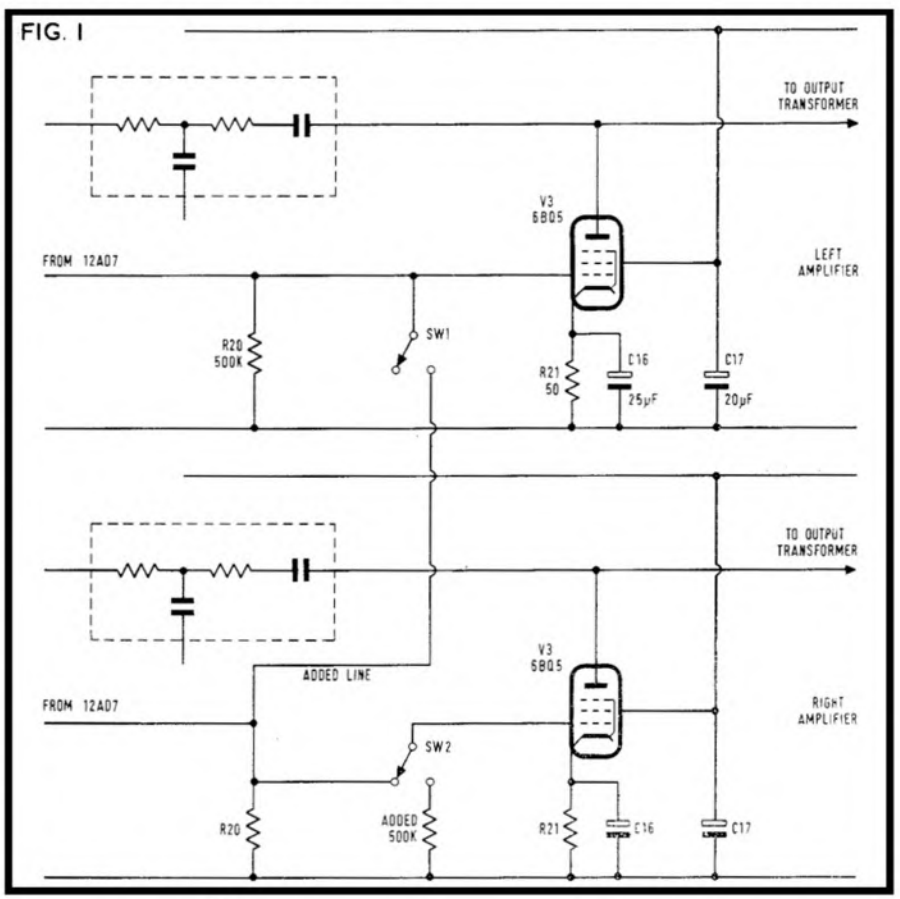
When the switch is in the 'off' (down) position, the machine will operate as always, except in the sound-on-sound mode, as already explained. When the switch is closed, it interconnects the grids of the power amplifiers and these two valves will then always give out the same signal, regardless of the mode in which the machine is operating or the pre-amplifier from which the signal is coming. In the 'play' mode, therefore, both VU-meters will react and both amplifiers will drive a speaker, regardless of whether either or both volume controls are opened. When both are opened, the signals from the two tracks will intermix and the mixed signal will appear at both speaker output jacks. (The preamp output jacks remain unaffected.) Sound-with-sound or mono playback of stereo tapes is therefore possible.

In the 'record' mode, the same reaction takes place, with the signal coming from the microphone or line inputs: either input will operate both power amplifiers and both tracks will have the signal, mixed or otherwise. Care should be taken here that the track selector is set in the stereo position, or else only one track will be recorded properly.

To make a sound-on-sound recording, follow the instructions given in the instruction manual, leaving the switch open (down). When the sound-on-sound button is depressed, the switch is closed. Note that the output which is recorded now appears at both speaker output jacks:

(*continued overleaf*)

FIG. 1



a singer recording the second part of a song will therefore hear the first part through his earphones as well as his own voice singing the second part. You can plug a second headset, which can be of low impedance, into the speaker jack of the right amplifier and hear the same output. Note again that, because the right amplifier is in the play mode, the VU meter will not indicate the same level as that of the left amplifier, which is recording. You need only watch the level on the left amplifier.

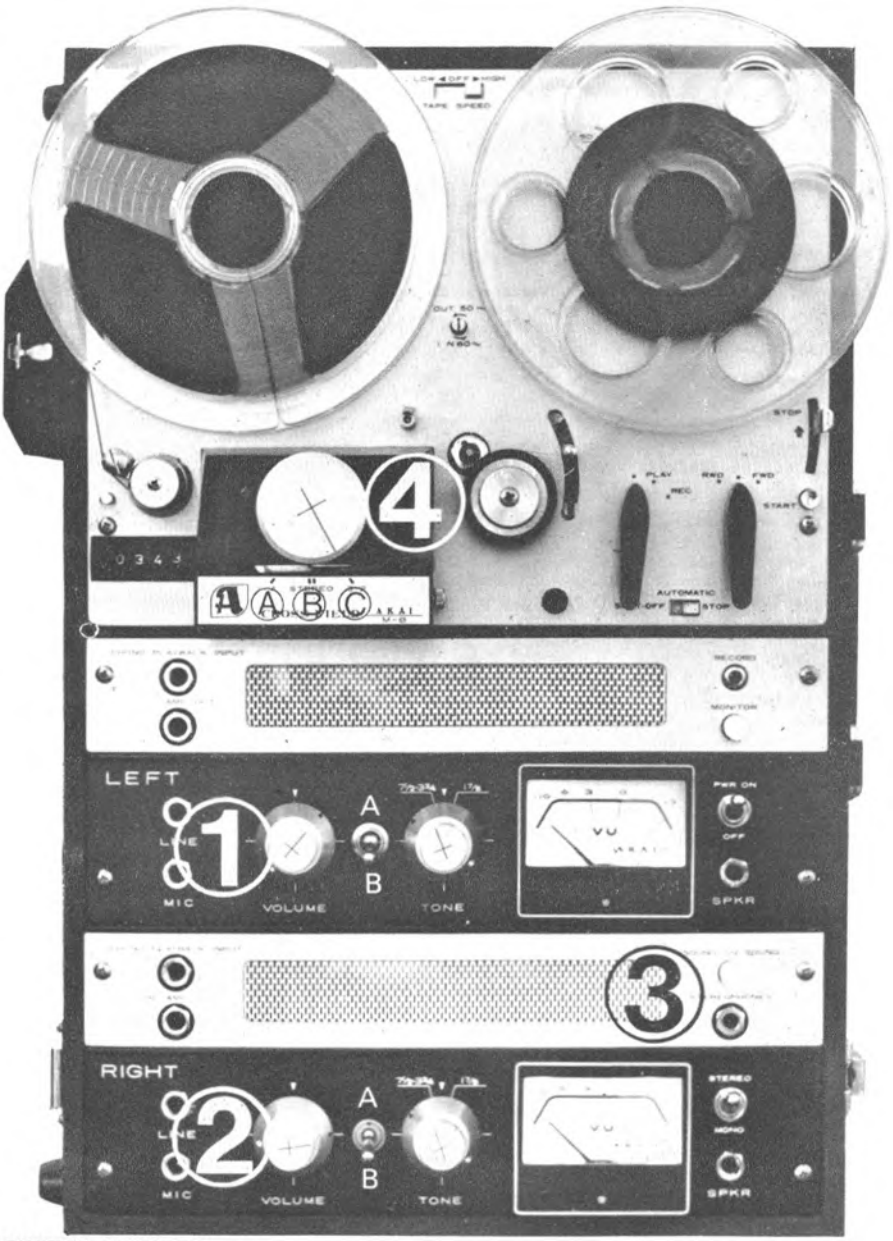
In the paragraph before last I mentioned that the track selector should be set to stereo if the switch is closed during recording. The reason is that, in one of the mono positions, one track will not have bias or erase current and will only superimpose a scratchy noise over any recording already on that track. The other track will make a normal recording and you will find that this is always the one recorded by the left amplifier. It follows, therefore, that if we could stop the right amplifier from feeding a signal to the recording head, we could set the track selector to one of the mono positions and mix two signals on to one track, making an ordinary mono ¼-track recording. This is the third stage, and it entails the installation of another switch (single-pole double-throw) and a resistor. Install this switch between the volume and tone controls of the right amplifier (see photo).

THREE PINS

The switch will have three connection pins. Disconnect *all* wiring from pin 2 of valve *6BQ5/EL84* (that is, the capacitor and resistor and also the wire going to the switch installed in the left amplifier) and reconnect the lot to that connection on the switch which is uppermost when the amplifier is lying on its back. Then run a single lead from the middle connection to pin 2 of the valve. This should now be the only wire connected to this pin. One end of a 500 K or 470 K resistor is now soldered to the remaining pin on the switch. The other end is soldered to an earth connection, such as the little centre tube of the *6BQ5*. Check for potential short circuits and re-install the amplifier. Remember to reconnect the leads of the first switch.

Now, when the machine is in the play mode and both switches are up, the two tracks can still be intermixed, but the output will appear only at the left speaker jack. Similarly, in the record mode, the inputs can be mixed, but only the recording head of the left amplifier will put a signal on the tape. Select only the 'mono' positions on the track selector: in the stereo position both tracks will always be erased.

The modified circuit diagram is shown in **fig. 1** for the benefit of the electronically minded. **Fig. 2** gives a summary of the switch positions and the results obtained from them. Some practice and experiment, however, will soon make you fully conversant with the arrangement, eliminating the need to carry this magazine about with the recorder. Just keep a level head and check both switches, the sound-on-sound button, a nd the track selector before you start recording· And remember to do it every time.



SWITCH	POSITION	
1	B	
2	B	Recorder operates normally, as before modification.
3	B	Switch 3 In (A), Out (B).
4	A, B, C	
1	A	
2	B	Playback: Controllable track mixing.
3	B	Combined output at both speaker jacks.
4	B	Record: Controllable input mixing.
		Combined signal recorded on both tracks.
1	A	
2	A	Playback: Controllable track mixing.
3	B	Combined output at left speaker jack only.
4	A, C	Record: Controllable input mixing.
		Combined signal recording on one track only. (B: playback only)
1	A	
2	B	
3	B	Sound-on-sound recording: See text and instruction manual.
4	A, C	
1	B	
2	B	Left amplifier records independently while right amplifier plays back.
3	A	
4	A, C	

TRUVOX SERIES 50

BY H. W. HELLYER

IT is not necessary to flip back through many copies to find the report of Richard Golding's visit to the Hythe headquarters of the Thermionic Group, under whose wing Truvox are now snugly settled. (*February. 1969, actually*—Ed.)

Tucked away almost as snugly you will there find the throwaway line 'The Truvox Series *50*, introduced soon after the move, (from Neasden to Hythe), was in all essentials a product of the old Truvox company . . .' Later, Mr. G. goes on to describe the *R50* production line and the impressive quality tests that Henry Howitt and his boys give to all the tape recorders—and, by inference, other products—that roll off the lines. The written specification of the *R50* runs to six foolscap pages, Mr. Golding tells us. There are 42 separate test operations, plus stringent soak tests.

This is all very reassuring, and I would like to be able to say that a Truvox *R50* had never landed on my bench—or, even better, that it was the ultimate in tape recorder design, as regards value for money.

It so happens that a manuscript of a review of this model was recently revised because the Truvox company objected to my phrase: 'teething troubles'. (Not a *Tape Recorder* review, I hasten to say.) It was precisely those teething troubles that had given me the opportunity of drafting notes on the machine from practically every one of the earlier fugitives from the production run—and when the review machine arrived with minor faults of a similar nature to those previously noted, I almost threw up my hands in despair.

But, I must stress, these were minor faults; the sort of things that could happen to any mechanism and printed circuit panel during transit, and have since been righted. It would be dishonest to pretend that 'punctures on the way out of the garage' cannot happen. Only this week I have had a cracked preset on a Sony *777* (three hundred pounds worth of deck and preamps in *that* package), causing a pair of transistors to fail, a Quad *303* amplifier with a dry joint (almost unthinkable!), and a Revox which returned from the Eton headquarters minus the remote control blanking plug, without which the thing will not run. We and they are still trying to find it, and there is a three week delivery delay for a new one! So let us not delude ourselves that faults and mistakes cannot happen.

CROSSOVER DISTORTION

The important point is that, when they occur, these faults and omissions cause a flurry of activity at the factory. I remember the feverish telephone calls when the prototype *R50* came to us and we noticed crossover distortion at low level outputs. An immediate modification was made, at our suggestion. We learned later that other changes had been made as the result of similar dealers' objections. This is where Truvox score; they are ready to listen, to investigate, to alter if necessary, and overcome their teething troubles. Certain other makes retain these troubles till their teeth drop out.

None of which carries the subject of servicing very far, so let us take a look at our *Series 50*. For the sake of those who have not been hooked by the extensive advertising (which included that unfortunate reference to Low-Fi), I should say that it is housed in a fashionable teak case with furniture type lid, hinged at the back to unclip, but with no catches to retain it. The machine is thus an uncompromising table model, a fact that we find underlined by the loudspeaker arrangements.

Two units are employed, and these are not a matching pair. They are chosen to give the best acoustic balance, having regard to their being housed in the confined space of the 380 x 343 x 178 mm. cabinet, with the sound bouncing around from component to component. The loudspeakers are 15 ohm units, wired in parallel, and, as our circuit shows, isolated by insertion of an external loudspeaker. An output of 6 W is obtainable from the pair of 180 x 100 mm speakers, or from an 8 ohm speaker at the external socket (or a pair of 15 ohm speakers in parallel). Using a different impedance such as a single 15 ohm, or a 4 ohm which is decidedly *not* recommended, will lose a little of the available power. Having recently spent a few weeks playing around with a brand-new *R54*, taken straight from the production line, I can vouch for the good clean sound that this attractive machine provides.

But enough: this is not a review. What about service facilities? To begin with, dismantling is an easy matter, and leaves no bunches of interconnected gubbins lying around the cabinet. Even the speaker wires are sensibly lengthened enough to permit basic tests to be made without a lot of temporary, dangerous hookups. Four screws beneath the top plate secure the deck.

The head cover is removed by releasing its two retaining screws but work around the sound channel is eased by stripping down a little more. The control knobs can be taken off, remembering that these are screw-retained, not lift-off types, and the speed change lever knob pulled off first. Lay the latter down carefully so that you do not lose the spring clip and, when reinserting, do it with the deck vertical and you may avoid the rigmarole of searching for the errant clip. Then take out the four top screws and remove the top plate, to which the front portion of the head cover is attached. This gives access to practically all the items on the upper deck that we are ever likely to need.

Fig. 2 shows not only the rear connections to the heads, but also the uncluttered sound channel and the top view of the tape guides. Despite the rather dramatic shadows, one of the microswitches about which we shall have something to say can also be seen. Our illustrations are of the later machine. The earlier models, although similar, had a different type of headplate, with the heads mounted in stirrups beneath which were curved spring blades. Adjustment of the azimuth screws allowed both height and tilt alteration in one go and was a nuisance. In the type shown, the erase head is a rigid fixture and the record/play head is only adjustable for tilt, not height. To allow for any minor discrepancies, the centre of the three guides can be adjusted on this model, the *Mark 2*, bringing the tape to the exact height required. The outer guides are fixed, very accurately positioned during manufacture, and can be used as a datum, much as Truvox have done on previous machines, though without the familiar upper guideline of a top plate.

HEAD FACE TILT

In my experience, manufacturers take head mounting and alignment very seriously but do not allow for the fact that subsequent wear can make a very slight adjustment of head face tilt, or even height, helpful to retain the wide frequency response of the machine in its original state. Particularly in less expensive machines, the realignment of heads after a thousand or so hours use can effect a decided improvement. Ideally, a proper test tape ought to be used for this job. Lacking this, the owner will almost certainly have a good tape made on the machine when new, and adjustment of the head while replaying this tape could bring about that subtle improvement that is the difference between muddy sound and crystal clarity.

It should be clear by now that soft and gentle pressure pads are the order of the day, and that pinch pressure, where adjustable, requires also that the roller shall be clean and the spindle and bearing vertical and free from

(continued overleaf)

binding. Pressure roller adjustment of this machine is for a 750 gm inward force, give or take 100 gm or so. A grub screw in the middle of the arm allows variation, and should require a pull of between 600 and 1000 gm to lift off the roller and allow the tape to slip when the machine is in the play position. While doing this test, always make sure the pause latch is clear of the end of the pressure arm. This is a general note that applies in different ways to many machines: quite often, variations in pressure, even wow, can be traced to the simple matter of the pause assembly being inaccurately adjusted.

FREE TO SLIDE

Which brings us indirectly to brakes. The pause brake—our bridge passage, so to speak—presents few problems, being a pad on a slide bar, butting against the left-hand spool carrier. All we need to ensure is that the slide bar is free to slide and that it does not rattle. Both possibilities are taken care of by a smear of grease, as can be seen from **fig. 2.**

But the brakes at each spool carrier are a very different proposition. They are mounted on identically acting pivoted arms, with rod operation from a centre-pivoted bracket, part of which is also the tongue that operates the start switch we passed by lightly a little while ago. The two rods can be seen running laterally across the picture in **fig. 2,** and a portion of the left brake arm. Now the temptation when adjusting brakes of this nature is always to bend the rod. Please do not. The secret with this particular deck is to ensure about 3 mm play between the bent end of the rod and the outer side of the lug when the brakes are applied. And any adjustment should be made by bending the lug, not the rod. When the deck is in a playing position, with brakes 'off', there should then be between 1 and 2 mm clearance to the edge of the drum. The main drag brake is attached to the main arm which carries the rewind idler and is thus 'off' during rewind, and 'on' at other times. A similar clearance to that above should be made by bending the blade slightly. This adjustment can be important to prevent spillage.

Also important for a different reason, but with similar effect, is the adjustment of the micro-switch actuator tongues and arms. There are three of these switches. The main start switch, which is a single-pole type in the live line to the motor, the reversing switch, and the auto-stop switch, which is actuated by the tape feeler and is over to the right of the deck.

The important adjustment is for the reversing switch to come on just before the start switch because it is normally in its 'reverse' mode, and must change over for play or forward wind. If it is not slightly ahead, or if it fails, you may get broken or stretched tape. Some spillage can occur before the releasing action of the auto-stop switch cuts power to the motor. So these adjustments are all vital. They are, as we have noted, part of the basic mechanical operation, tongues, etc., being bent-up parts of main levers. Again, bending is the solution.

As important, and here we must suggest another modification, is suppression of the start switch. This is the one across which the spark occurs when recording, and this is the one that causes the 'plonk' to be put on the tape. Quite heavily, too, as much because of its proximity to the rear of the head wiring as to its disturbance to the electrical power circuit. Remedy, in this case, is to fit a series 0.1μF and 100 ohm resistor across the contacts, making sure your capacitor is rated at 500 V AC or more, and also small enough to sit nicely alongside the switch.

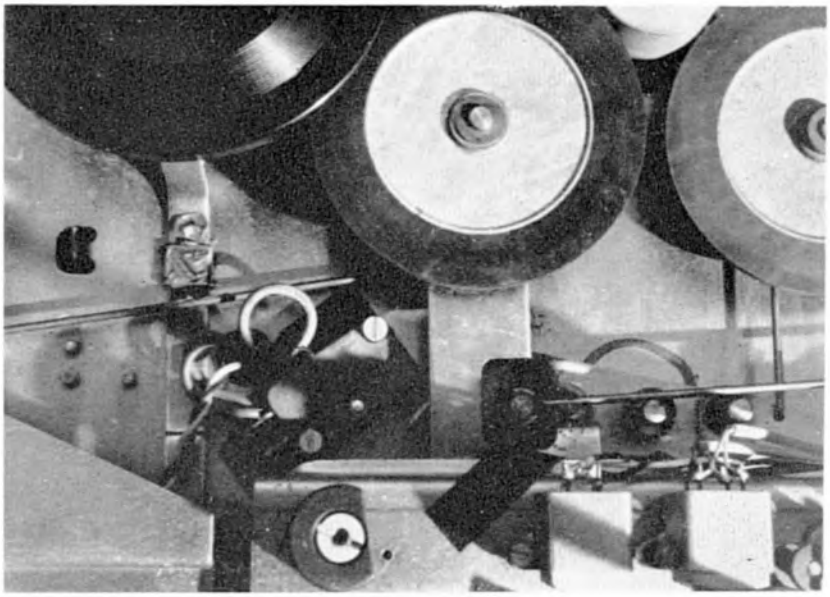
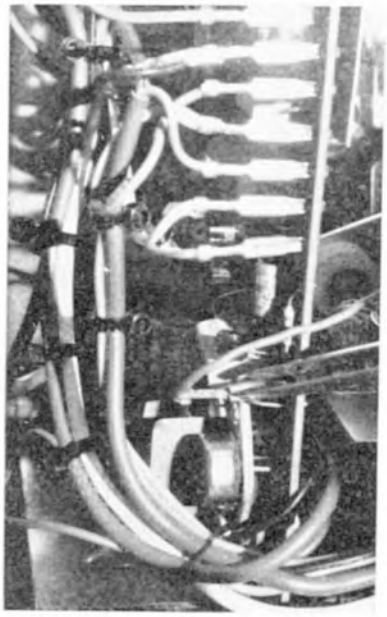


FIG. 2 View of mechanism with top deck plate removed.

FIG. 3 Printed circuit board clips.



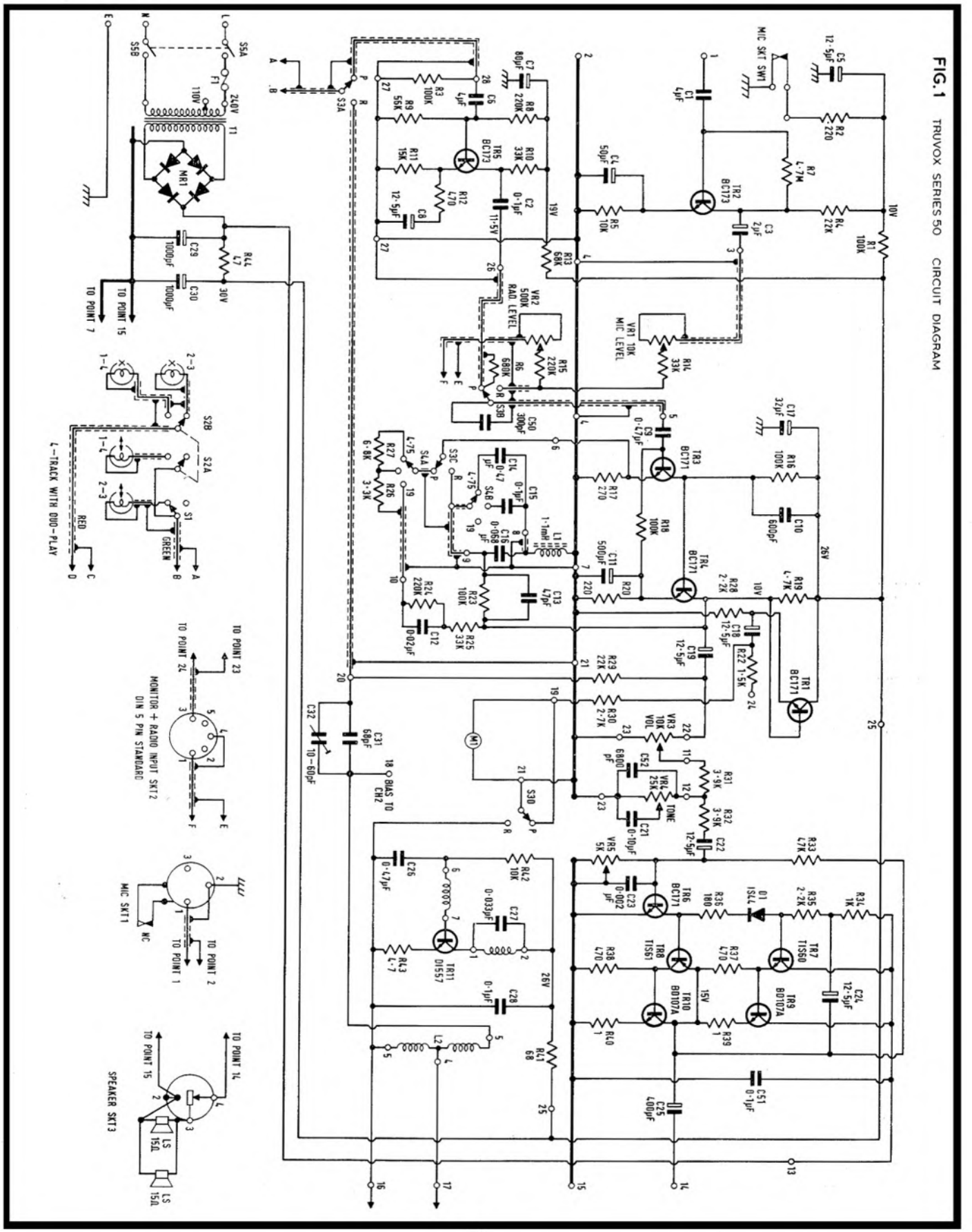
We are getting all electrical but, before crossing the floor to the electronics section, mention must be made of the pinion brake hidden away below the deck and used to halt the motor. This is necessary because of the flywheel action of the motor armature and reversing operation for rewind, so the pinion comes on and off again when the stop key latch operates. A rod linkage is again used but this time we have some adjustment, by a push-on clip which determines how much rod shall be allowed to protrude through the lug. There should be 1 to 2 mm clearance from the spindle after the brake has operated. It is a point that a firm pressure on the key (all these keys need a firm action) helps to ensure good pinion brake action.

Of similar (cork) material to the pinion and spool brakes is a small brake on a pivoted bracket actuated by the start mechanism, whose job is to retard the flywheel. When start is selected, the drive idler engages the motor pinion and flywheel just before this brake comes off. This allows the torque to build up and probably ensures a more definite run-up. As to its effect on idler life, only time will tell.

STRAIGHTFORWARD CIRCUIT

The electronics have not occupied us much and a glance at the **fig. 1** circuit will show why. The circuit is quite plain and straightforward and the layout is all on one board with push-on tag connections for the most part, harness wiring and a record switch operated by a fork and cam assembly on the underside of the deck. The printed circuit board clips into place with simple spring clips. Too simple for, on the machine I carried off, the board had worked itself loose and was supported by the wiring with a poor connection as indicated in **fig. 3,** which may or may not have been the result. But perhaps it was my own rough treatment of the machine that was to blame, for I confess it is not a problem I have met on others of the *50* range. I have not yet had occasion to service any of

(continued on page 261)



SOUND WORKSHOP

ASSEMBLING MUSIC ON TAPE

BY F. C. JUDD

'SOUND Workshop' would not be complete without reference to multi-track music, the more creative techniques of which have already been dealt with pretty thoroughly by Peter Bastin and other writers. Readers new to multi-tracking may welcome a little extra information on the technical rather than the creative aspects, not only of multi-track music but of electronic music as well. For example, what can be done to solve the quality deterioration problem in multi-tracking? What constitutes an ideal system? Just how good and how flexible are those tape recorders with track-to-track facilities when it comes to really serious work? Electronic music also creates special problems. It calls for numerous specialised items of equipment which cannot easily be purchased ready-made and must therefore be constructed. I hope to deal with a number of these in later months.

Successful multi-track music making depends on one's own ability as a musician, or the ability of a musician to play for the recording, the quality and flexibility of the recording equipment, and expertise of the recordist.

IDEAL SYSTEM

There are of course professional multi-channel recorders having up to 16 separate channels and which employ wide tape so that each track can be recorded separately and in synchronism with the others. This is the ideal system but, as these machines cost a small fortune, we must leave them to the professional studios who can afford to buy them. With domestic tape recorders, synchronisation of the tracks is accomplished by mixing the part or parts already recorded on one track with the signals for the next part, both of which are then recorded together on another and unused track. This means a two-channel recorder or two separate recorders.

Not all twin-channel recorders are suitable for true multi-tracking. Some will play Track A while recording Track B, though some will not even do this (*see page 235*—**Ed.**). It is usually possible to monitor an existing recording (Track A) via headphones whilst recording on the remaining (B) track as shown in **fig. 1.** Thus two recordings can be synchronised but there it ends. This facility is limited; adequate for making cine film and slide show sound tracks.

Next there are those tape recorders which allow tracks to be recorded separately but require an external mixer to transfer an existing track on to new track, together with a third part (**fig. 2**). Such recorders may have a combined record/play head or two spaced heads. Provided that the signal levels from the replay head preamplifiers and the direct music source are both fairly high, the external mixing facility might well consist of a simple passive system. Such an arrangement is not exactly ideal, however, and a mixer with an amplifier to offset the inherent attenuation of a passive network is a better arrangement.

We are left now with recorders that have fairly flexible built-in facilities for track-to-track. The recent Uher *Stereo Royal*, for example, has built-in switching and mixing for instant track-to-track work but such recorders are expensive and one could in fact buy two good mono half-track machines for almost the same price. My reason for saying this, and I speak from experience, is that despite the flexibility of such recorders, really serious multi-track music work can be accomplished far more easily and successfully with two good mono recorders, or better still, two stereo recorders. The method of working from one recorder to another is by far the superior, to my mind, and lends itself to much more accurate balancing, mixing and monitoring. For my own multi-track music work, over quite a

(*continued overleaf*)

FIG. 1 SOUND ON SOUND

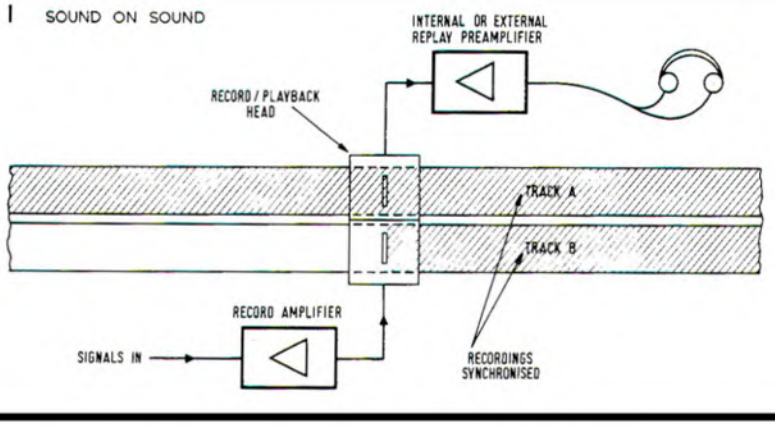
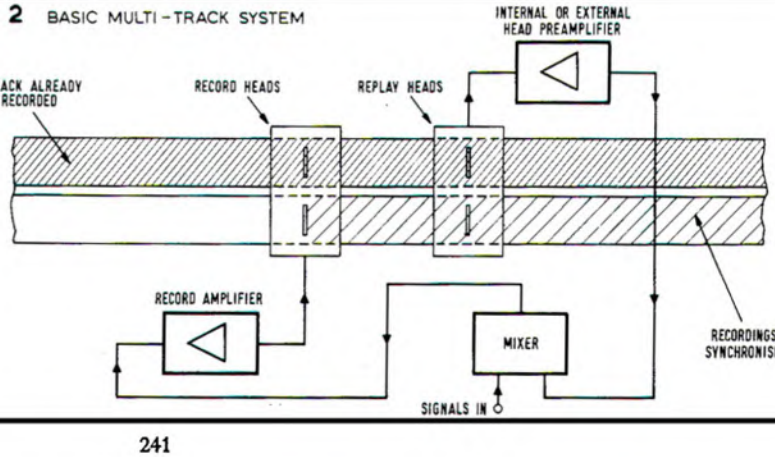


FIG. 2 BASIC MULTI-TRACK SYSTEM



number of years, I have always used the recorder-to-recorder system. Professional multi-track music makers like Wout Steenhuis also prefer to use two tape recorders, especially the double-track to double-track method with two half-track stereo Revox machines. Briefly the technique is as follows: the first recording is made on Track A of Recorder 1. This is transferred to Track A of Recorder 2 while the next part of the music is recorded on Track B. These two recordings are then replayed via a mixer, so that both tracks are balanced as required, and fed as a mono signal to Track A of Recorder 1. The next part of the music is recorded on Track B of that machine and so the transfer and balance of successive recordings is continued until the work is finished. The final recording, which is split on two tracks, is then copied to make a master mono recording. Since the final recording ends up split on to two tracks, it is possible to produce a faked stereo copy by carefully intermixing the tracks.

MONITORING IS ESSENTIAL

Monitoring of the recorded tracks, and those being recorded, is absolutely essential and is best done via an external amplifier and speaker (headphones, if a microphone is used) coupled to the mixer. The actual balancing of one recording against another, and with the direct music signals, is far more accurate when done aurally. After all a multi-track music recording is really the equivalent of a small orchestra and balancing should be much the same as if a number of musicians were playing simultaneously. The acid test of multi-track music recording is finally to play it with the sound going 'life size' and see if it really sounds like several musicians performing. Having completed a backing track, I usually play this at 'life size' volume via a 50 W (RMS) amplifier and speaker system and play the final part (electronic organ or electric guitar) with it, also at an appropriate sound level. In fact an entire recording is usually monitored this way from start to finish. If this worries the Noise Abatement Society, I should mention that Wout Steenhuis monitors everything at 100 W! There is no more searching test for hum, noise or distortion.

I am often asked how many tracks I use, but the question should really read: how many tracks can be added by this system before noise, hum and distortion become noticeable? Electronic musical instruments are often very good hum sources. Electric guitar pick-ups are very sensitive to magnetic fields and will pick up hum from mains transformers in nearby amplifiers and tape recorders. Electronic organs rarely have exemplary HT smoothing and the signal take-off for recording may also be the source of 50 Hz ripple. Accurate matching of the music signal source to the mixer or tape recorder is also vital and the ultimate is a large signal into a high-level input. Low-level signals mean that more gain is required to get them up to full recording level and any very small amount of hum in the signal will consequently be amplified as well.

Noise produced by successive copying is more likely to determine the number of tracks that can be added. The very slightest of noise from the recorder, the tape, or even the music signal source (especially electronic organs) will soon build up to an obnoxious level. One enthusiast once wrote to me saying he intended to make up to 12 recordings for his particular multi-track music, using an ordinary domestic stereo recorder. The noise build up would have been tremendous and even six track transfers would have been too many. Unless the tape recorders have an exceptionally low level of noise and the source signal-to-noise ratio is comparable, four or five transfer recordings would be about the limit if one is to end up with a noise level of not less than —40dB.

Distortion, curiously enough, is not such a problem unless it is due to overloading or over-recording. Distortion arising from track-to-track dubbing is mainly frequency response loss coupled with noise modulation. Loss in frequency response can be compensated for to some extent by boosting the treble a little on the final recording. Treble boost at each recording to compensate for tape head and amplifier losses more often than not only brings up the noise and is best avoided.

Incidentally a lot of the foregoing applies equally to straightforward tape copying where impedance matching between tape recorders and other items of equipment is also very important. Signal level requirements too must be matched. If the input sensitivity of an amplifier or tape recorder is 200 mV, then it should be supplied with a signal around that level. Too small a signal means turning up the gain control at the risk of bringing up hum and noise. Too much signal can result in overloading, despite the fact that the gain control has been turned down.

Next month I will deal with some of the techniques concerned with electronic music and include circuits for various items of related equipment. Meantime, suggestions as to other possible constructional features and subjects for this column are always welcome.

new releases on cassette

PHILIPS
Concert in Manhattan Leroy Anderson CPP1070.
Merci Mauriat Paul Mauriat and his Orchestra CPP1073.

MERCURY
Cabal The John Dummer Blues Band CMP7019.

VANGUARD
Together Country Joe and The Fish CVP14000.

PYE
Come Dance With Me Cyril Stapleton Choir and Orchestra CYP192.

CBS
Eydie Gorme's Greatest Hits 40-63260.
Yesterday I Heard the Rain Tony Bennett 40-63351.
Miles in the Sky Miles Davis 40-63352.

LIBERTY
Our Winter Love Felix Slatkin C0603.
Swingin' New Big Band The Buddy Rich Big Band C0752.

the BBC on old stock and tell them that it is a copy of the original.) I think that we are all well aware of the pressures that exist in broadcasting and realise that our small efforts are only a very small drop in the vast ocean of broadcast entertainment. Yet it seems to me that things could be handled a little differently. How can we amateurs really believe that the BBC is interested in us (if, in fact, they are) when our efforts are treated in so lukewarm a fashion?

The divergence in tape prices is rapidly approaching the rather sickening supermarket situation. 'Special offers' in current tape magazines and catalogues announce discounts ranging from 10% to 40% on branded tapes. You can buy Ilford Zonal at 40% off, BASF at 20% off, and so on. For the life of me, I can't see the sense in it all. If a 13 cm reel of LP PVC is sold by, say, a radio shop for 29s. 1d., how is it that another firm can sell the same thing for 17s. 6d.? I know that the answer is 'bulk buying' but it seems a poor sort of situation to me that identical reels of tape can be wildly different prices in different parts of the country. If the discount firms can chop prices, why can't others? And while on the subject of tape, can't some control be put upon the purveyors of cut-up used computer tape? Tape is advertised at ridiculously low prices and it must be a fact that the stock is either used stuff or computer slice-ups.

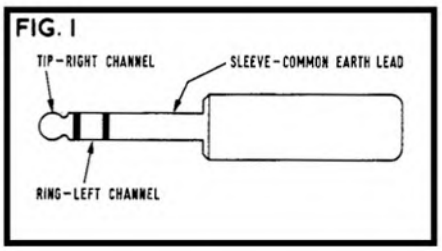
MOUNTING COST

Lastly, of course, there is the mounting cost of everything. Bits and pieces for tape-recording have always been pricey and recent tax and petrol increases have given manufacturers an excuse to put prices up. Any married recordist will have heard from his wife at great length how food items have soared in price: 3d. increase in a week and that sort of thing. After all, if a microphone bracket cost, say, 15s. before the recent tax increases, what justification is there in putting the thing up to, say, 17s. 6d.? Without going into the accountancy complex of manufacturing, it seems unreasonable to me that we should be burdened with increases in the order of 10% to 15%. Jack plugs—of which I use a considerable number—always cost an excessive amount of money. That is, until the Japanese got into the act. Now I can buy a Japanese jack-plug at a fraction of the cost of a Ferrograph jack-plug. And it works just as well. How, in the name of heaven, can a firm umpteen thousand miles away manufacture, pack, ship and pay tax on components and still sell at prices well below home-made stuff? No doubt someone has a carefully worked-out answer which, not being economists or accountants, we have to accept.

It is sometimes difficult to reconcile oneself to living in a country whose economy seems to be based upon excessive, unpredictable and wholly mystifying taxation and, whereas one accepts this deplorable situation, it seems to me that the burden of living in England today could be considerably lightened by a little more attention to old-time courtesy from manufacturers and retailers. This applies to almost everything and rather especially to audio.

HEADPHONE MONITORING

By Anthony Eden



IN order to make high quality live tape recordings, some method of monitoring the incoming signal is essential. There are two basic methods, the first using either an internal or external amplifier and loudspeaker fed with either the pre- or post-recorded signal. The second method is through headphones, usually driven from the monitoring amplifier of the tape recorder. Loudspeakers have the advantage since the signal can be heard critically under more or less the same conditions as the recording will subsequently be played. However, loudspeaker monitoring demands complete acoustic isolation from the live sound source. Any attempt to monitor the signal on a loudspeaker within range of the microphone will either result in acoustic feedback, or demand such low level listening as to make any reasonable assessment of the incoming signal impossible. Headphones consequently play an important role for monitoring the incoming signal. This review sets out to assess the relative merits of seven sets of headphones from a monitoring point of view. The more important requirements for this type of use were considered to be :

Reasonably effective exclusion of external noise.

Comfort over periods of an hour or more.

Wide frequency range.

The ability to stand high input levels without apparent distortion.

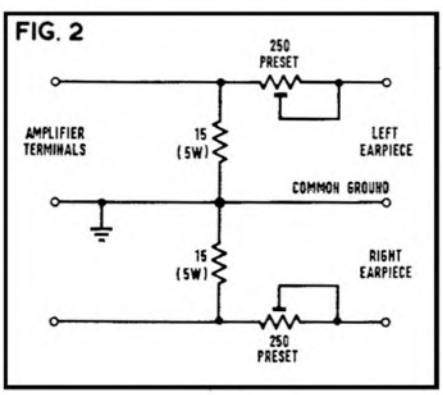
Rugged construction.

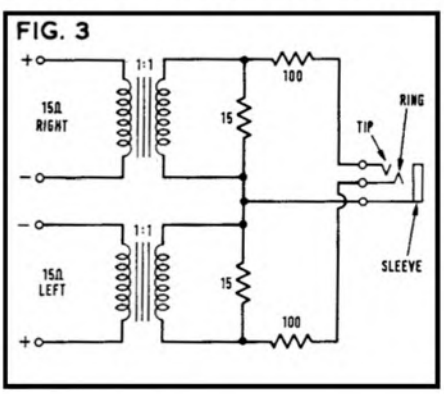
All the headphone leads were terminated in standard three connection GPO jack-plugs. It is normal convention for the tip of the plug to be the right hand channel, the ring to be the left hand channel and the sleeve to be common to both channels. (See **fig. 1**) Four out of the seven headphones did not indicate the left or right earpiece, which could prove most inconvenient when making stereo recordings on location. The fitting of stereo jack sockets is by no means common to all stereo tape recorders and it may well be easier to reterminate the headphone leads with the appropriate plugs. The nominal impedance per earpiece is 8 ohms for all the headphones and for monaural monitoring it is necessary to common the left and right hand earpieces. Generally, it is not possible to connect the headphones directly to the loudspeaker output of an amplifier. The reason for this is that, due to the intimate contact of the headphones with the ears, the amplifier and tape noise becomes very disturbing. Hence, a terminating network is strongly recommended and the type shown in **fig. 2** is suitable. For monaural listening only one matching network will be required.

If the amplifier output impedance is not 15 ohms, the shunt resistor is merely altered to the correct matching value. In many cases, if one pair of headphones only is to be used, the 250 ohm preset pots can be replaced by fixed value (say 100 ohm) resistors (the exact value depends on the sensitivity of the headphones). The series resistor is used to reduce the sensitivity of the headphones, such that the volume setting of the amplifier has to be advanced more than would otherwise be the case, and hence the signal masks the amplifier noise to a greater extent.

Certain stereo transistorised amplifiers (for example the Dinsdale) do not use a common ground connection and, if headphone listening is required, the earpiece leads must be used separately (with no common connection between the channels). Alternatively some method must be adopted to isolate the amplifier connections from the headphones. Since almost all headphones use the three-pin stereo jack type of connection with a common ground as the sleeve connection, it may be easier to isolate the amplifier connections. Academically the best method is to use two 1:1 isolating transformers (such as the Radiospares), one in each output lead. The complete circuit of an isolating network, for stereo-amplifiers having no common earth loudspeaker terminals, is shown in **fig. 3.**

The problem of loudspeaker terminals with no common earth connection arises in amplifiers where a 'reverse stereo' switch is provided. Virtually all tape recorder amplifiers use a grounded earth speaker output terminal, and so the necessity of isolating the speaker terminals should not arise. It should be pointed out that sockets on amplifiers and tape recorders marked 'phones' do not need any form of matching network described above, as the attenuator resistors are already included at the socket. However, sockets marked 'extension loudspeaker' will require a matching and attenuating network of the type described.





THE SOUND STUDIO

PART THREE STUDIO MICROPHONES

BY K. R. WICKS

MICROPHONES may be divided into two basic groups, *constant amplitude* and *constant velocity*. The means by which the signal voltage is generated determines the category into which a given microphone falls.

The output voltage of a crystal microphone is proportional to the deflection of the crystal so that, in order to obtain a flat response over the AF range for a given acoustic level, the displacement *amplitude* must be constant at all frequencies. The crystal microphone is, therefore, an example of the constant amplitude type. Another example is the capacitor microphone, where the output voltage is proportional to the changes in capacitance caused by sound waves striking the diaphragm. Since the capacitance variations are proportional to the amplitude of the diaphragm vibrations, it follows that the displacement *amplitude* must be constant at all frequencies.

FIG. 1 POLAR DIAGRAM FOR PRESSURE-OPERATED MICROPHONE

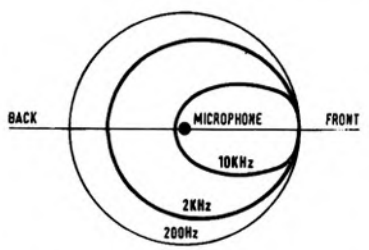
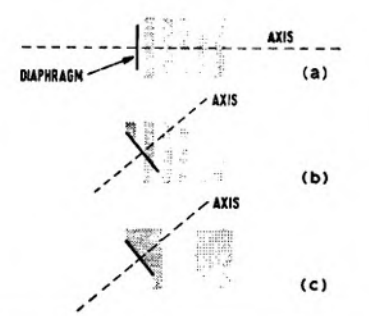


FIG. 2 SOUND WAVES, REPRESENTED HERE BY AREAS OF COMPRESSION AND RARIFACTION, TRAVEL FROM RIGHT TO LEFT. CANCELLATION OCCURS AT THE DIAPHRAGM IN CASE (b)



The velocity of a vibrating body is given by $U=2\pi fx$, where f is frequency, and x is the displacement amplitude, so that the velocity must be proportional to frequency for the amplitude to be constant.

Constant velocity microphones are those in which the output voltage is proportional to the *velocity* at which the moving element vibrates. In ribbon and moving coil microphones, the output voltage is proportional to the rate at which magnetic flux is cut by the conductors, so the velocity of the movement must be constant at all frequencies in the working range in order to obtain a flat response for a given acoustic level.

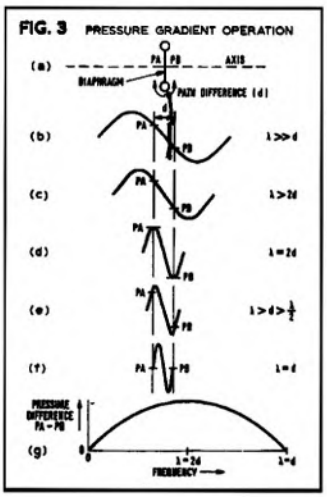
Considering the formula given above for the velocity of a moving body, it can be seen that, if at any given acoustic level the velocity is to be independent of frequency, it follows that the displacement must be inversely proportional to frequency.

So far, we have seen that microphones operate on either the constant amplitude or the constant velocity principle. For practical purposes, however, it is more convenient to divide them into two other basic groups, namely *pressure operated* and *pressure-gradient operated*. The latter group is often called *velocity operated*, but there is a danger of confusion with constant velocity operation with which there is, in fact, no connection.

In pressure-operated microphones, the displacement of the diaphragm is proportional to the instantaneous pressure of the sound wave. Only one side of the diaphragm is exposed to the sound source, the other side being enclosed in a rigid casing, and the force on the diaphragm is equal to the acoustic pressure multiplied by the area, and is independent of frequency.

The pressure-operated microphone is said to be omnidirectional, although it can be seen from the polar diagram (**fig. 1**) that this is strictly true only at LF, where the size of the microphone itself is small compared with the wavelength of the sound, and does not appreciably distort the wavefront. The sound will then envelope the microphone and produce the same pressure at the diaphragm, regardless of the angle of incidence. At higher frequencies the microphone will distort the wavefront, setting up a complex diffraction pattern caused by the scattering of a secondary wave from the surface of the microphone. When the wave length is small compared with the diameter of the diaphragm, incident sound waves striking the diaphragm will be reflected causing a standing wave pattern to be set up, and assuming total reflection to take place, the effect

FIG. 3 PRESSURE GRADIENT OPERATION



Above: Neumann *KM74* capacitor microphone

known as *pressure doubling*[1] will occur. This will tend to increase the output at HF, and a small diaphragm is desirable to prevent mid-frequency pressure doubling.

When reflection occurs at one side of an obstacle, a 'sound shadow' is produced on the other side and, in this region, the effective acoustic pressure is reduced. Thus, when HF sounds originating at the rear of the microphone are reflected by the case, the result is that the pressure variations at the diaphragm are relatively small. The shape and size of the microphone casing will therefore affect the shape of the polar diagram for high frequency sounds.

Another occurrence which has an influence on the polar diagram at HF is the effect of phase difference across the diaphragm. In **fig. 2a**, the sound is normal to the microphone so that the whole diaphragm is subjected to the same acoustic pressure at any instant. If, however, the source is off-axis as in **fig. 2b**, areas of compression and rarefaction exist across the diaphragm simultaneously and cancellation occurs, causing the effective acoustic pressure to be reduced. At low frequencies, the whole diaphragm responds to each compression and rarefaction (**fig. 2c**), so cancellationdoes not occur.

The fact that pressure-operated microphones are omnidirectional at LF but directional at HF may be used to alter the sound quality of a speaker or a musical instrument. By placing

Above right :
Sennheiser
MD ZII omni-directional
moving-coil.

the source off the axis of such a microphone, the HF may be reduced whilst retaining the same LF content as would be obtained if the source were positioned directly in front of the microphone.

Pressure-gradient microphones are those in which both sides of the diaphragm are exposed to the sound wave. **Fig. 3a** shows such a microphone. A wave travelling along the axis will cause pressure variations on each side of the diaphragm but these variations will be out of phase by an amount determined by *d*, the extra distance around the microphone which the sound has to travel in order to reach the far side of the diaphragm. This distance is known as the *path difference*, and the resultant pressure (P) on the diaphragm at any instant is equal to the *difference in pressure* ($P_A - P_B$) on the two sides of the diaphragm. From **figs. 3b** and **3c** it can be seen that, as long as *d* is small as compared with the wavelength λ, P increases with frequency and at any instant depends on the *gradient* of the pressure curve, hence the term *pressure gradient*. Working on this basis, it would appear that, if frequency is increased so that $d = \frac{\lambda}{2}$ (**fig. 3d**), then a pressure maximum on one side of the diaphragm coincides with a minimum on the other side, so that the resultant pressure difference is large. A further increase in frequency would cause the pressure difference to fall (**fig. 3e**) and when $d = \lambda$ (**fig. 3f**), the resultant pressure would be zero. The variation of pressure difference with frequency is shown in **fig. 3g**, but the effects of reflection at HF have not been taken into account. As the frequency is increased, a sound shadow forms on the far side of the diaphragm, so that pressure operation gradually takes over from pressure-gradient operation, and the HF output is prevented from falling to zero. By careful design, the resultant pressure (and thus the *force* on the diaphragm) can be made to vary in direct proportion to frequency, and the output voltage can be made independent of frequency throughout the working range of the microphone by the use of a form of *control*. The type of control used will depend on whether the microphone is electrostatic or electrodynamic, and will be dealt with when considering specific types of microphones.

So far, we have considered only waves which are travelling along the axis of the microphone. Waves originating at right angles to the axis will cause in-phase pressures either side of the diaphragm, as the distance from the source to each side of the diaphragm is the same (i.e. the effective path difference is zero), resulting in zero output from the microphone. The variation in effective path length from a maximum on the axis to a minimum at the sides results in a bi-directional ('figure of eight') polar-diagram as shown in **fig. 4**. It should be noted that the fall-off in sensitivity at the sides is virtually independent of frequency.

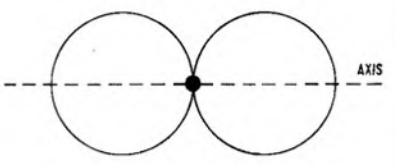
The bi-directional property of pressure-gradient microphones may be used to reduce the pick up of extraneous noise, by arranging for the source of unwanted sound to lie on a line at right angles to the axis of the microphone.

Besides discriminating against unwanted sounds, the bi-directional microphone will reduce the effects of room reverberation[2] as the proportion of indirect to direct sound will be less than when an omnidirectional microphone is used.

Moving-coil microphones fall into the constant-velocity and the pressure operated categories. The velocity of the diaphragm and coil is given by $U = \frac{F}{Z}$ where F is the applied force, and Z the mechanical impedance. For a pressure operated microphone the force has been shown to be independent of frequency, so that for a given acoustic level, the velocity is inversely proportional to the mechanical impedance of the system, and for the velocity to be constant, the impedance must be kept constant. This impedance is at a minimum at the resonant frequency of the movement, being analogous to the electrical impedance of a series circuit consisting of inductance, capacitance and resistance. The resonant frequency falls within the audio range, causing a peak in the velocity/frequency curve of the movement, and *resistance control*, sometimes known as *friction control*, is used to dampen this resonance mechanically in order to obtain a relatively flat characteristic. This form of control can be applied by the introduction of layers of silk inside the microphone, so that for the diaphragm to move, it has to force air through the silk. Additional damped resonances may be deliberately introduced inside the microphone at frequencies above and below the natural resonant frequency of the movement in order to obtain a flat velocity/frequency characteristic over most of the AF range. Early moving-coil microphones resembled miniature moving-coil loudspeakers, having conical diaphragms, but nowadays most moving-coil microphones are constructed as shown in **fig. 5**. Generally speaking, the smaller the microphone the better the frequency response, because the effect of

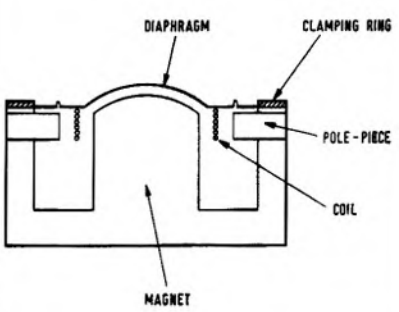
(continued overleaf)

FIG. 4 POLAR DIAGRAM FOR PRESSURE GRADIENT OPERATED MICROPHONE



THE POLAR DIAGRAM IS VIRTUALLY THE SAME FOR ALL FREQUENCIES IN THE WORKING RANGE

FIG. 5 SIMPLIFIED CROSS SECTION OF A MOVING COIL MICROPHONE



phase shift across the diaphragm and diffraction are less marked, but the smaller the microphone the lower the output level, so the size of the microphone is chosen to obtain a compromise between response and output level.

Ribbon microphones are constant velocity devices, and the usual type encountered is pressure-gradient operated, the basic construction being illustrated in **fig. 6.** When dealing with pressure-gradient operation in general, it was shown that the resultant force on the diaphragm is proportional to frequency, so that some form of mechanical *control* is necessary to ensure that the ribbon velocity is independent of frequency. This is achieved in practice by what is known as *mass control*, the ribbon being constructed to have a resonant frequency well below the audio range, usually in the order of 3 Hz. This ensures that over the working range of frequencies, the effect of the *mass* of the ribbon on its movement is large compared with the effects of mechanical resistance and compliance (stiffness), and results in the mechanical independence being proportional to frequency. The velocity of the ribbon is given by $U=\frac{F}{Z}$ but since the force and mechanical impedance are *both* proportional to frequency, the result is that the velocity is independent of frequency, i.e., constant velocity operation. Since the ribbon impedance is very low, a step-up transformer is built into the microphone case and is used to couple the microphone to line, and prevent the signal losses which would otherwise occur.

The simple electrostatic or capacitor microphone is pressure operated, and of the constant amplitude type. The diaphragm and backplate form a capacitor, and sound waves striking the diaphragm cause it to vibrate, producing corresponding variations in capacitance. The microphone is connected to a polarising supply as shown in **fig. 7,** and the charge Q may be taken as being constant. Since the voltage (V) across a capacitance (C) is given by $V=\frac{Q}{C}$, and Q is constant, it follows that *variations* in C will produce a proportional *variation* in V. It should be noted that although $V\alpha\frac{I}{C}$, this does not imply that the voltage variations are inversely proportional to the variations in capacitance, but rather that they are 180° out of phase (namely at an instant when capacitance is increasing, voltage is decreasing, but the actual amounts by which the quantities vary are in direct proportion. This note applies also to the relationship $C\alpha\frac{I}{D}$ where D is the distance between the plates).

As this is a constant amplitude microphone, the displacement amplitude of the diaphragm must be independent of frequency, which infers that the velocity must be proportional to frequency. This is ensured by *compliance control* (otherwise known as stiffness control). This involves making the diaphragm tension relatively large so that its natural resonant frequency occurs above the working range of the microphone. When compliance is the controlling factor, the mechanical impedance becomes inversely proportional to frequency $\left(f\alpha\frac{I}{Z}\right)$. Now the velocity is given by $U=\frac{F}{Z}$ and since, for a pressure-operated microphone, the force F is independent of frequency, then $U\alpha\frac{I}{Z}$ and thus $U\alpha f$, which is the condition for constant amplitude operation.

The bi-directional electrostatic microphone is similar to the electrostatic microphone described above, but both sides of the diaphragm receive sound waves. This is achieved by providing holes in the fixed plate, and the microphone is pressure-gradient operated. The design of the diaphragm is such that its mass and tension are small but the mechanical damping is very large so that the system is resistance controlled and the mechanical impedance is independent of frequency.

Then, from the formula $U=\frac{F}{Z}$, since F is proportional to frequency (pressure-gradient operation), and Z is constant, it follows that the velocity U is proportional to frequency, and the constant amplitude requirements are fulfilled.

The most important microphone not yet mentioned is the *unidirectional* or *cardioid* type. It has been seen that an omnidirectional response is obtained by pressure operation, and a bi-directional response by pressure gradient operation. If pressure and pressure-gradient elements of similar sensitivities are series connected and mounted next to each other, an omnidirectional response is obtained. The two polar diagrams combine but the output voltage of the pressure-gradient element is phase reversed when the source is behind the microphone, whereas, for the pressure operated element, the phase of the output voltage is the same regardless of whether the source is in front or behind. This means that, for sounds on one side of the microphone, the two voltages add, whilst for sounds on the other side, the two voltages subtract so that the unidirectional response shown in **fig. 8** is obtained. Such microphones usually consist of a combination of ribbon and moving-coil elements, although many different combinations have been used.

Another way of obtaining a unidirectional response is by introducing an acoustic phase shifting network between the back of the diaphragm and the outside of the case of a moving-coil microphone. The phase shift is such that, for sound coming from behind the microphone, the pressure variations on each side of the diaphragm are zero, so that no sound is picked up from the back. The response is therefore unidirectional.

A variation on the normal electrostatic microphone is the twin-diaphragm type which has one central fixed electrode, with a diaphragm on either side. An acoustic phase-shifting network is incorporated between the plates so that sound at one side of the microphone, having caused the diaphragm on that side to vibrate, passes through and also around the microphone, and produces equal pressures on each side of the other diaphragm. As a result, the second diaphragm will not respond to the sound. A unidirectional response is obtained by connecting only one diaphragm to the polarising supply. If both diaphragms are similarly polarised, two back-to-back in-phase cardioid responses are obtained, the resultant being an omnidirectional polar diagram. If the diaphragms have opposite polarity, however, the two cardioid response patterns are out of phase, and they combine to give a bi-directional polar diagram. Versatile microphones such as this are very useful in general purpose studios where microphone requirements vary.

The basic operating principles of most types of studio microphone have now been dealt with but other aspects of microphones, such as electrical impedances and microphone placing, will be discussed in later articles.

FIG. 6 SIMPLIFIED CROSS SECTION OF A RIBBON MICROPHONE

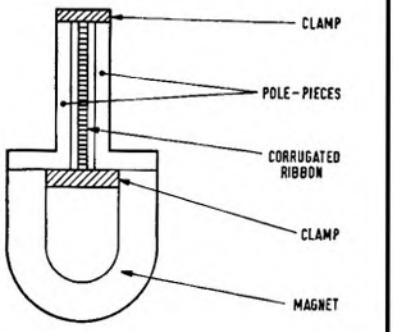


FIG. 7 CONNECTIONS TO AN ELECTROSTATIC MICROPHONE

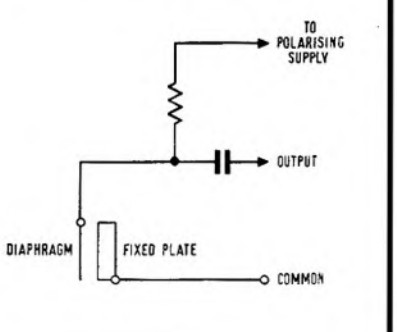
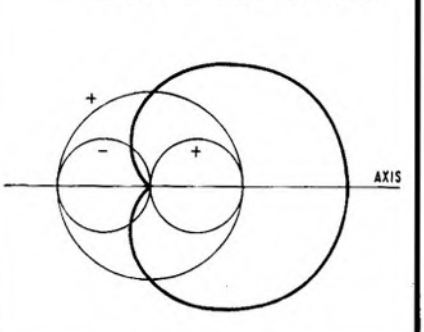


FIG. 8 UNIDIRECTIONAL RESPONSE, OBTAINED BY COMBINING OMNIDIRECTIONAL AND BIDIRECTIONAL RESPONSES TAKING INTO ACCOUNT THEIR RELATIVE PHASES AS INDICATED BY THE POSITIVE AND NEGATIVE SIGNS.



THIRTY-ONE CHANNELS AT THE HIGH COURT

BRIAN W. HAINES DESCRIBES THE HIGH COURT SOUND RECORDING INSTALLATION

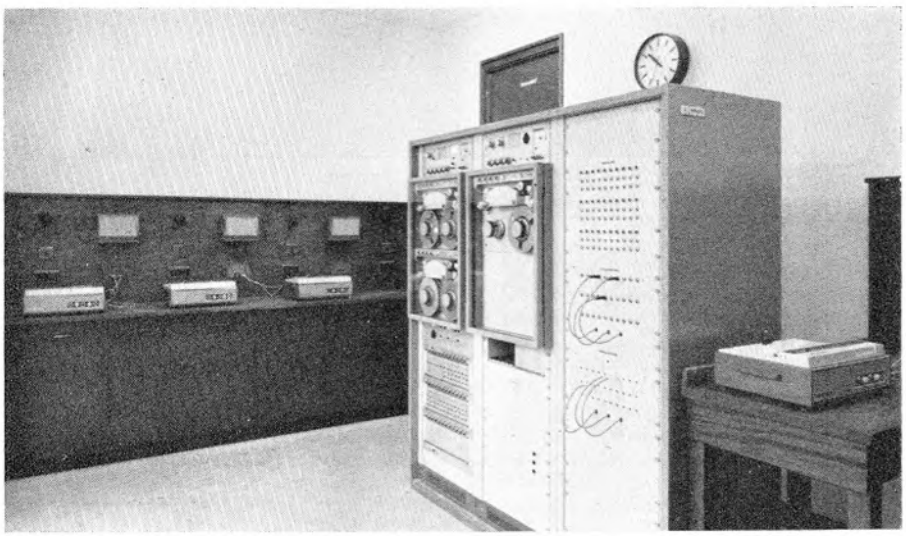
THE mechanical recording system in London's High Court of Justice is the most advanced in the world. Almost daily, representatives from the legal departments of other countries arrive to view the installation. They come because until recently it was considered practically impossible to devise a comprehensive system capable of performing the specialized requirements of court reporting.

The basic problem was to find a system which would consistently produce recordings from which accurate and adequate transcripts could be made as and when required. This was tackled through a series of experiments from as far back as 1949, when the results were far from encouraging, to 1965 when the present system was evolved.

The High Court is a Court of Record, which means its proceedings are recorded for all time and do not have to be proved when they are produced. In earlier times the proceedings were taken down in longhand, as indeed they still are when all else fails. Then the shorthand writers appeared and are still prominent to-day. They are specially trained to reproduce an accurate record shorn of unnecessary verbiage and tedious repetition. For instance, a question put to a witness may have been in the following form :

'Now, let me see, you are um, Mr Brown. No, sorry I mean Smith. Are you Smith ?'. This can safely be recorded as 'Are you Smith ?'. Such editing is desirable and other instances can be envisaged. As the reporter is in the court, he can distinguish between the accidental slip and the deliberate error, he can clarify inaudible passages and verify information; thus the chances of editorial mistakes are minimal. It was contended that to remove the reporter from the court room would increase the margin of error.

During the course of a trial a Court frequently wishes to be reminded of what has transpired earlier. The reporter can flip his book back and read out the relevant passage straight away. He usually has a vivid recollection of the trial and can turn to any place in his notes with ease. It was this particular aspect of a mechanised system that puzzled experimenters for a long time. Unless an easy economical solution could be found for the location and identification of material, the whole concept of mechanised court reporting would fall to the ground.



Philips installation at the High Court of Justice showing 31-channel unit and modified domestic recorders.

Perhaps the greatest disadvantage of the court short-hand writer is his expensive training. The effect of a mechanised system would be nullified if he had to be replaced by an equally expensive sound engineer. The system must be capable of running under the minimum of supervision with untrained staff, a guarantee against failure, and complete security. These are exacting requirements and they have been met with unqualified success.

Basically the High Court installation consists of two master recording consoles linked to individual tape recorders in each court room. There are five microphones in each court, four of which are live. The microphones are set up before the Judge, the witness box, and both counsel. The fifth is for the foreman of the jury and is only switched on when required. Very careful calculation was required to site the microphones where the best level of speech with a minimum of reflection and feedback could be obtained. It was found that counsel's microphones gave the best response suspended from the ceiling at exactly two metres above floor level. This avoided asides spoken by counsel and solicitors, the rustling of papers and other extraneous noises being recorded. In earlier experiments, occasional embarrassing comments were picked up which could well sway an appellate Court if they listened to the recording. This was undesirable as no-one would be able to say whether the comment had been made in jest or in earnest.

Each microphone is fed through its own preamplifier, then through a mixer to a modified Philips domestic stereo tape recorder which is in the court room, and to one of two multi-channel tape recorders in separate recording rooms. The multi-channel machines, specially designed and built by Philips, record the proceedings of all the courts at the same time on adjacent tracks of 25 mm recording tape. There are 31 tracks on each machine. Thirty of the tracks are utilised for speech and one track records the GPO telephone time signal. This is fed back to the stereo machine in court where it is recorded upon the second track. By this method, the difficulty of identifying particular passages is overcome.

At the start of the Court day, an official called the Associate switches on the Court tape recorder. He then 'logs' the main events of the day on a standard form beginning with the time he switches on. The more detail he can note down the better, for instance '11 a.m. witness faints. 11.15 a.m. counsel resumes cross examination of Jones.' When anyone subsequently wishes to find a particular passage he refers to the log, runs the tape through to the appropriate time as indicated by the GPO signal, then switches to the speech track. If the associate forgets to switch on the court recorder, a recording is still taken on the main equipment, and a duplicate recording can be prepared when the mistake is discovered. In the event of a failure on the master tape, the main unit is self monitoring and automatically switches to stand-by units.

An interesting variation between the court

(continued overleaf)

tape and the master tape occurs when the court requests a playback of earlier proceedings. The master tape will continue to record the playback in the court, giving a more accurate record of what took place. The court tape will only contain direct evidence as it will have ceased to record during playback.

With such a large number of tracks on one tape, initial trials revealed an element of cross-talk which would render the recording useless. This occurred when voices were raised above the normal speaking level as in emotional outbursts. This risk was eliminated by reducing the tape speed to 2.375 cm/s, limiting the frequency response to 300 Hz-3 kHz±3 dB with respect to 1 kHz.

The same tape speed is used on the in-court tape recorder as on the master tape. DP tape is used to accommodate a full day's hearing on one spool. The master tape runs for 8 hours, 15 minutes, the whole tape being used. At the end of a reel, an adjustable over-lapping mechanism ensures nothing is lost on a change-over.

The Court tape is kept for 60 days unless it is needed for reference, after which it is reused. If it is needed for any purpose such as study by the solicitor with a view to an appeal, it is sent with the log book to an audio typist for transcription. This typist does not have to be so highly trained as a court reporter, and experience has shown that an intelligent typist quickly understands the work and can produce an adequate record. If a demand is made for the tape after 60 days, a new copy is made from the master. The master tapes themselves are stored in the archives. They are examined regularly to check that no deterioration has taken place and respooled every two to four years to prevent print-through. So far, the first tape made on January 11th, 1965 has suffered no loss of quality but continues to be kept under observation. It is envisaged that these tapes will be kept for a period of 10 years.

An early criticism of taped records was the ease with which they can be erased either intentionally or by accident. Experience shows that accidental erasure can be avoided by built in safeguards, such as duplicate recording, pre-adjusted machines, and proper storage facilities. Intentional erasure, or attempts at alteration, can be prevented by strict security precautions together with the precautions against accidental erasure. It is conceded that it might be possible for a determined person to obtain the in-court recording somehow and alter that, but the technical equipment required to alter the master tape would be beyond the resources of the majority of people. The system does suffer from some minor disadvantages. The in-court recording is used to produce a transcript. This means a transcript cannot be produced until the end of the day when the tape is changed. Again if the court wishes to hear the previous day's recording, they must wait while the tape is brought to the court and fitted to the machine. Some inevitable delay must occur if an engineer is not available or the demands upon his time are heavy. The advantages however outweigh what are only occasional trifling inconveniences.

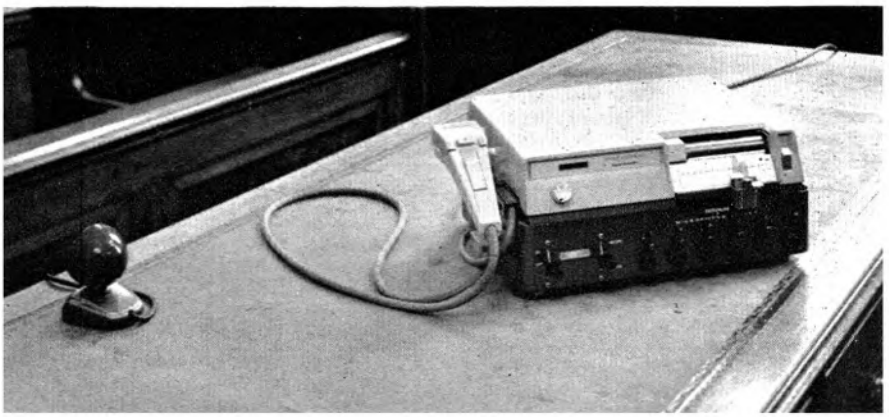
It would be desirable to extend mechanical recording to all courts. This was recognised by the Committee on the Mechanical Recording of Court Proceedings. But such systems must be financially justifiable in relation to the work and location of the Court. The situation and number of Court rooms in the High Court makes it an economic proposition to install sophisticated equipment. The lower Courts, which in many cases consist of only one or two court rooms and perhaps sit only two or three times a week, would still find it cheaper to employ the court reporter when they are obliged to keep a record. Quite a lot of Courts use buildings owned by local authorities who are understandably reluctant to lay out large sums on equipment in which they have little direct interest. Other Courts sit in buildings so antiquated as to render the technical problems financially insuperable. At the other end of the scale the Magistrates Courts have come up with a good compromise solution suited to their particular needs.

The Magistrates Courts, unlike the superior Courts of Record, are not required to keep minutes of evidence except in domestic and certain industrial cases. They do have to produce notes of evidence when there is an appeal and, as there is a time limit of 14 days, these can be destroyed after that time. Where a person has been accused of an indictable offence, the prosecution must first adduce its evidence before examining magistrates in 'committal proceedings'. The evidence of the witness is written down verbatim, read back and signed by the witness in the presence of the accused and the Magistrate: this is a 'deposition'. The Magistrates Court also find it convenient to have evidence in a contested case recorded, especially traffic accident cases where civil proceedings may follow, as it helps the public generally.

In the London area, the Receiver of Metropolitan Police supplies the Magistrates Courts with either a standard Philips *EL3581* tape recorder or with a normal secretarial Dictaphone. This would be a *Time Master TA650* and *Transcriber TB6J*, or the *Travelmaster PBR*. There is a strong bias towards the Dictaphone, indeed the Receiver advocates its use.

As a rule no direct recording of witnesses is taken. It has been tried and found to be possible if the need arises. The Court recording is made by the Clerk of the Court or his assistant with the machine on the table in front of him. He holds the microphone to his mouth and dictates the notes of evidence he requires. When an immediate transcription is required (for instance with depositions where he will repeat the evidence of the witness word for word) the recording is taken straight to another room where it is typed out at once. It is for this reason the Dictaphone is preferred.

The Dictaphone cuts a microgroove recording on a plastic belt. The recording is visible and permanent so there is no fear of losing it. A full belt runs for about 15 to 20 minutes. In long deposition proceedings the Clerk records for about five minutes, takes the belt off and sends it for typing, continuing with a fresh belt. This ensures a constant flow of typewritten evidence ready to be signed at the end of the committal. The unused portions of the belt are gradually used up during the day. It is noteworthy that this method was used in both the Bloom and Kray cases.



A strong bias exists in favour of Dictaphone microgroove belt recorders.

Where the tape recorder is used, much the same method is followed, making use of smaller reels of tape. It is in that instance more economic as the tape can be used time and again. However the Dictaphone scores heavily when the notes are not required for immediate transcription. In the Juvenile Courts for instance, where files are kept on all offenders, the belt can be slipped into the file along with other papers. In other cases, so long as the belt is given an identification by writing upon it, filing is simply a matter of putting it in a drawer. No special precautions except a lock, are needed. The tape suffers badly in comparison in this respect unless a full high court system is adopted.

For the work of a Magistrates Court, the dictabelt is economic and practical. The dictating machines are foolproof, they have automatic volume control, speedy play back and a simple visual indexing system for the location of material. The ordinary domestic tape recorder cannot really compete with a machine designed to do a specific job. For wholesale recordings quite obviously a tape recorder designed for the job is the better solution because of the technical advances in that field.

In the out-lying Courts, the Clerks are pretty well their own masters. They are responsible for the day to day running of the

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metrication

THE IMPACT OF METRICATION ON THE FILM, SOUND AND TELEVISION INDUSTRIES

PART TWO

BY P. M. CLIFFORD*

Text of a lecture delivered to the British Kinematograph, Sound and Television Society, January 1969, published by kind permission of the Editor of *British Kinematography, Sound and Television.*

THE electrical system can be tied in to the mechanical system of length, mass and time in a number of ways. That which has been chosen is to define the Ampere (the unit of current) as 'the constant current which, if maintained in two straight parallel conductors of infinite length, of negligible cross section, and placed at a distance of one metre apart in a vacuum, will produce a force between them of 2×10^7 newtons for metre length'. Infinitely long very thin conductors in a vacuum would be difficult to arrange, and the force produced would also be very small, so in practice the wires are arranged as short solenoids in an arrangement similar to the Kelvin Ampere Balance of our schooldays.

The newton (abbreviation N) is the SI unit of force (corresponding to the c.g.s. dyne). It is that force which will produce an acceleration of 1 metre per second per second on a mass of 1 kilogramme. This is an example of where the SI is a coherent system: the units are one metre, one second and one kilogramme.

This definition of the Ampere produces a unit of exactly the size we are all used to: the volt, the ohm, the henry and the farad also remain exactly the same.

Where the SI really comes into its own is in the relationship between the various systems. If one ampere passes through one ohm, then one volt is developed and one watt of work is done. Similarly, if the point of application of a force of one newton moves through one metre in the direction of the force, then also one watt of work is done.

All work is measured in watts, there is no messing around with the thermal properties of arbitrary liquids like water to produce the calory. All heat and work is in watts.

If one watt of work is done for one second, then one joule of energy is expended. At present in England, if you heat your house by electricity, your energy consumption is measured in watt-hours or kilowatt-hours. This is more or less reasonable, as the joule is too small a unit for use in house heating. The kilowatt-hour is 3.6 megajoules, so a megajoule is about the right size for measuring domestic electric power consumption.

However, if you heat your house by gas, your energy input will be measured in therms. A therm is the amount of heat required to raise 1,000 pounds of water through 100°F. One therm=about 105.5 megajoules. If you heat it by oil, it will be rated in British Thermal Units and, if in summer you cool your house, the refrigerator will probably be rated in tons. A British Thermal Unit is the amount of heat required to raise one pound of water through 1°F. One BTU=1.055 kilojoules i.e., it is one hundred thousand times smaller than a therm. The ton of refrigeration is the amount of heat required to melt one short (American) ton (2,000 lb.) of ice at 0°C to water at 0°C in 24 hours. It is thus a unit of power, not one of energy. One ton=1.85 kW. These are all units of energy, and it is crazy not to use the same unit for them all. It would be like buying carrots by one unit of weight and turnips by another on the grounds that this is the tradition in the industry.

Another feature of the SI is that it restricts the prefix multipliers and divisions to successive factors of 1,000. Ideally one should not use the hecto, deka, deci and centi prefixes. Ten cm should be expressed as 100 mm. But there are exceptions: because of its wide use, the decibel (dB) is accepted. **Fig. 5** gives a full list of the SI prefixes.

I think I have said enough to show that the metric system, and in particular the SI form of it, is much more logical than the Imperial system. The unit names do not change at each magnitude step, and the multipliers are always the same.

Additionally, the distinction between force and mass which has been known for generations, and given effect to by the c.g.s. unit of force, the dyne, is made really forcefully, and pressures, for example, are in units of newton per square metre, the newton being the unit of force. There should thus no longer be the problems which we used to have at school when one multiplied or divided by 32.2 or 981, apparently at random, in order to make the answer come out right.

Unfortunately, the SI cannot be universally applied, as long established practice in some areas is too much to overcome. For example, the unit of angle in the SI is the radian, but the degree, minute and second of arc are so firmly and universally established that they continue to be permitted, and I expect that trigonometrical tables will continue as at present for all time.

In addition, the multiples of the time unit, the second, continue to be the minute, the hour and the day, with multipliers of 60, 60 and 24. Luckily, the sub-multiples of the second-milliseconds, microseconds, nanoseconds and now picoseconds—always have been SI units.

The adoption of the SI has necessitated the introduction or re-introduction of some new units which were not previously used in the c.g.s. system.

These are: The newton, the unit of force, being that force which is required to give an acceleration of 1 metre per second per second to a mass of 1 kilogramme.

The unit of frequency, the cycle per second, has been called the hertz. This is not essential but is, I find, very useful, as one can now refer to, for example, a short direction signal as containing 43 cycles of 48 kilohertz. The earlier practice of using 'cycles per second' was usually made nonsense by our lazy habit of omitting the 'per second' and saying '48 kilocycles', which is a pure number, not a time-rate.

In magnetism, the weber takes the place of the c.g.s. maxwell, and the tesla takes the place of the c.g.s. gauss.

There is no named SI unit of magnetising force to correspond to the c.g.s. oersted. The unit is just referred to by its dimensions, ampere-turns per metre. I think this is a pity, as it is an important concept, and a mere statement of its dimensions does not to me convey the concept of full strength. There is hope that we may get a name for this unit, as I know I have support in high places.

The illumination units are all new and reflect the abandonment of the various old standard candles as units of luminous intensity.

We start with the candela, the unit of brightness, defined (in effect) as the brightness of 1 sq. cm of platinum at its temperature of solidification. This equals 60 candelas. This odd (and non-coherent) definition is done to make the candela about the same as the old international candle.

From the candela comes the lumen, the unit of luminous flux. The definition involves the steradian which is the unit of solid (three dimensional) angular measure. The steradian is comparable with the two-dimensional radian measure of plane angle.

From the lumen comes the lux, which is 1 lumen per square metre. It is the same sort of

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**Standards Laboratory, Hawker Siddeley Dynamics Ltd.*

unit as the foot-candle and the lumen per square foot.

Fig. 6 summarises the new SI units and their relation to the c.g.s. units.

It must be admitted that not all the SI units are of a convenient size. For example, graph paper graduated in inches and $\frac{1}{10}$ inches is very convenient, but 10 mm and 1 mm graph paper has too small an interval to be plotted and read easily. Even 20 mm and 2 mm is a bit on the small side.

However, most of the objections to going over to the metric system are due basically to laziness and are based on 'why should I learn a new set of units and multipliers? I'm quite happy using our present ones'. Learning the names and the mathematics is, of course, only a part of the change that must be made. We must learn to *think* metric and, instead of looking at a door and estimating that it is 3 feet 6 inches wide, estimate that it is 1.1 metres wide.

This process of re-education will take some time and a good deal of effort but I think it will be well worth while for our children and grandchildren, even if not for us. In any case, the die has been cast and we may as well go willingly as protestingly. The scientists among us will see almost no change in their work, as science always has been metric. There will be a small change from c.g.s. to m.k.s. units, but this is a simplification and rationalisation.

To some extent, metrication can be accomplished merely by applying conversion factors, but this is only a stop-gap measure. For example, in our larder, 1 lb. pots of jam are also marked as 454 gms. This is all right while they are sold basically as 1 lb. pots of jam but, when we finally 'go metric', it would be silly to continue to sell 454 gm pots of jam: presumably a slightly larger pot containing 500 grammes will then be produced.

Similarly, in engineering, a great many dimensions are 'nominal'. In designing the control panel of some electronic apparatus, for example, one tends to lay out one's components at round inch, half inch and quarter inch intervals. All of these could be metricated by multiplying the dimensions by 25.4 to express them in millimetres. But in a metric design, where at present one makes a dimension one inch, one should make its metric equivalent not 25.4 mm but 25 mm exactly. Another change which the designers must make is to no longer carry out the repeated halving which we do (half, quarter, eighth, sixteenth, etc.), but stick to decimal sub-divisions of the unit. This is much less difficult than might be feared, and many of us are already doing it, in inches, where decimal dimensions are compulsory. I must admit, with regret, that far too many of my own drawing dimensions are '6.625 inches' and suchlike. I am sure if I had thought properly, I could have made that '6.60 inches'.

A great deal of engineering design is based on 'stock' materials—one inch by eighth mild steel bar, one sixteenth thick perspex sheet, etc. In many cases, the nearest standard metric equivalent can be used with no change. Or if a metric design is done before metric stock is available, an old Imperial stock size can often be used.

The changeover in the engineering industry involves not only new metric designs, but ensuring that the stock materials that these will require will be available, both from the manufacturer, and in the works stores.

In the limit, the store could hold an infinite number of sizes even of mild steel bar, all dimensioned in millimetres. This is obviously uneconomical, and a 'preferred series' of sizes will have to be available. There must be universal agreement about what these sizes are to be, so that the raw material manufacturers can make for stock for universal sale, rather than having to make specials for every customer. This work of agreeing on 'preferred sizes' is being carried out by the British Standards Institution, and the majority of the important standards are now issued.

The change to the metric system will also enable us to get rid of some of our excellent but arbitrarily dimensioned stocks—things like sheet and wire being measured in Standard Wire Gauge.

The Standard Wire Gauge is one of several similar systems, all slightly different. It does represent a form of 'preferred sizes', but the actual dimensions of each gauge are awkward in diameter and cross sectional area, whether expressed in inches or millimetres. Except for very commonly-used sizes, we all have to use wire tables, which is a waste of time, as the dimensions are not easily memorable.

Even with this preferred number system of wire diameters available, the electric cable industry went along mostly on its own when standardising on the conductor sizes used in electric cables, **fig. 7.** Out of the nine wire sizes used, only four are S.W.G. standard sizes, and one of those is a rarely used odd number size.

To a large extent, introducing metric designs into a factory or into an industry is a case of 'After you, Claude'. There is no point in doing a metric design until it can be made, so the purchasing department must be able to buy metric stock material. However, the raw material manufacturer is not going to make metric stock for which he has almost no sale.

What will undoubtedly happen is a series of engineering compromises and concessions. Where 3 mm sheet is specified on the drawing but is not available, a concession will, where it is appropriate, permit the use of $\frac{1}{8}$ inch sheet, although the exact equivalent of $\frac{1}{8}$ inch is 3.175 mm. In certain cases, the next larger available size may have to be used and, where essential, the excess material removed as a machining operation. Obviously this is wastefu and costly.

Even when metric designs and practice are thoroughly established, instances will still occur where it is necessary to produce an old Imperially dimensioned design, either as a replacement or as an extension to an old system. In many cases it will not be worthwhile to modify the design owing to the cost involved, and an imperial design will have to be made from metric materials, using the nearest equivalents available and a set of concessions.

In the workshop, new metric rulers, micrometers, height gauges, dial gauges, etc., will have to be provided. This sounds drastic and expensive, but is not really so bad since tools are always having to be replaced as they wear out and it is likely that, in many cases, all that will be necessary will be to buy metric replacements for Imperial tools as the Imperial tools need replacing.

'Imperial' lathes can, with the aid of a 127 tooth gearwheel, produce perfectly accurate metric screw threads, but the thimbles on the tool holders will need their scales replacing. Even this will not be very satisfactory, as there is not a convenient integral number of metric divisions corresponding to one turn of the motion screws.

(continued on page 259)

FIG. 5 S.I. PREFIXES

	Multiplier		*Prefix*	*Abbreviation*
MULTIPLIERS	Million-Million	$\times 10^{12}$	tera	T
	Thousand-Million	$\times 10^{9}$	giga	G
	Million	$\times 10^{6}$	mega	M
	Thousand	$\times 10^{3}$	kilo	k
	Unity	$\times 10^{0}$		
DIVISORS	Thousand	$\times 10^{-3}$	milli	m
	Million	$\times 10^{-6}$	micro	μ
	Thousand-Million	$\times 10^{-9}$	nano	n
	Million-Million	$\times 10^{-12}$	pico	p
	Thousand-Million-Million	$\times 10^{-15}$	femto	f
	Million-Million-Million	$\times 10^{-18}$	atto	a

FIG. 6 NEW S.I. UNITS

NAME	QUANTITY	c.g.s. EQUIVALENT
MECHANICAL		
newton (N)	Force	$=10^5$ dyne
TIME		
hertz (Hz)	Frequency	Not named = 1 cycle/second
MAGNETISM		
weber (Wb)	Magnetic flux	$=10^8$ maxwell
tesla (T)	Magnetic flux density	$=10^4$ gauss
(not named) ampere—turn/metre	Magnetic field strength	$=10^3 / 4\pi$ oersted
ILLUMINATION	No c.g.s. Units	
candela (cd)	Luminous intensity (brightness)	Platinum at temperature of solidification = 60 candela/sq.cm
lumen (lm)	Luminous flux	The flux emitted within unit solid angle of 1 steradian by a point souree having a uniform intensity of 1 cd
lux (lx)	Illumination	1 lumen per square metre

FIG. 7 COPPER CABLE CONDUCTORS

CABLE CONDUCTOR *diam.—in.*	S.W.G. *Number*	S.W.G. *diam.—in.*
0.0076	36	0.0076
0.012	31	0.0116
	32	0.0124
0.029	22	0.028
	23	0.032
0.036	20	0.036
0.044	19	0.040
	18	0.048
0.052	18	0.048
	17	0.056
0.064	16	0.064
0.072	15	0.072
0.083	14	0.080
	13	0.092

CLOSED CIRCUIT

A SHORT GLOSSARY OF JARGON

BY RICHARD GOLDING

IN response to requests from several readers, I feel I should begin a glossary of CCTV terms that most of us tend to take for granted. Let us begin with the camera itself. The heart is the pick-up tube of which there are three types in use at the moment. These are the *image orthicon*, the *vidicon*, and the *plumbicon*.

Image Orthicon. This is the most widely used tube in broadcast TV. It is extremely complicated, very expensive, has a comparatively short life, and is not easy to operate. In appearance, it resembles a huge flashlight. At one end is a flat photosensitive glass surface, the photo cathode, on which the camera lens focuses a light image of the scene to be televised. This visible image causes an identical image formed of electrons to be created instantly on the target. The target is made of very thin glass and its temperature is held constant by a heater and a cooling fan controlled by thermostats. By a process called *secondary emission* the electrons forming this image knock more electrons off the target and these are collected by a mesh between the target and the photo cathode, leaving a positive charge image on the target. The number of electrons at each point of this *invisible* image corresponds to the intensity of the light at that point in the original scene.

This invisible electronic pattern is read by scanning the charged image with a stream of electrons fired from an electron gun at the other end of the tube. Scan coils form this stream into a beam which scans the image from side to side and top to bottom at an extremely fast rate. Only the electrons needed to restore the target potential, at the points where the invisible image has changed the target potential, actually land. The remaining electrons return towards the gun on the same path as the scanning beam and are deflected by the persuader electrode on to the material around the gun. The electrons are then amplified millions of times and fed to the transmitter. This amplification is achieved by a complicated method of electron multiplication which allows very high gain from a very low level of beam modulation.

With the image orthicon tube, the camera must be allowed to warm up until the target is the correct temperature. If the target is too cold, the picture can stick or burn on the tube (the cameraman may frame a new shot but the previous image will be superimposed over the new one) and, if the target is too hot, the picture definition may deteriorate. While warming up, or when leaving the camera unattended for some time, a cap may be placed between the lens and the tube to reduce the risk of sticking. An image orthicon camera can cost thousands of pounds and needs highly trained operators.

Vidicon. In comparison, the Vidicon tube is uncomplicated both in construction and in operation. The best tubes cost from £100 to £150, have a guaranteed life of 500 hours and, with correct use, may last for 2,000 hours. Vidicon tubes can be purchased for £25 or even less. They give poorer results in terms of contrast and shading but their use may be acceptable in many CCTV applications. The vidicon needs much more light, however, if the picture quality is to approach anywhere near that of the image orthicon. In low light conditions, pictures tend to lag. That is, bright images take some time to disappear on panning away and moving objects tend to train off.

The vidicon tube has focusing and scan coils which control the electrons from the gun and form the beam to scan the target. The target is made of a material which changes its resistance in proportion to the light falling on it. A thin, transparent layer of tin oxide is deposited on the front surface of the target and this is biased, the rear surface discharging to the tin oxide layer in the areas of low resistance. The beam restores the rear surface of the target to its original potential, causing a small pulse of current to flow directly to the head amplifier, proportional to the resistance of the point scanned.

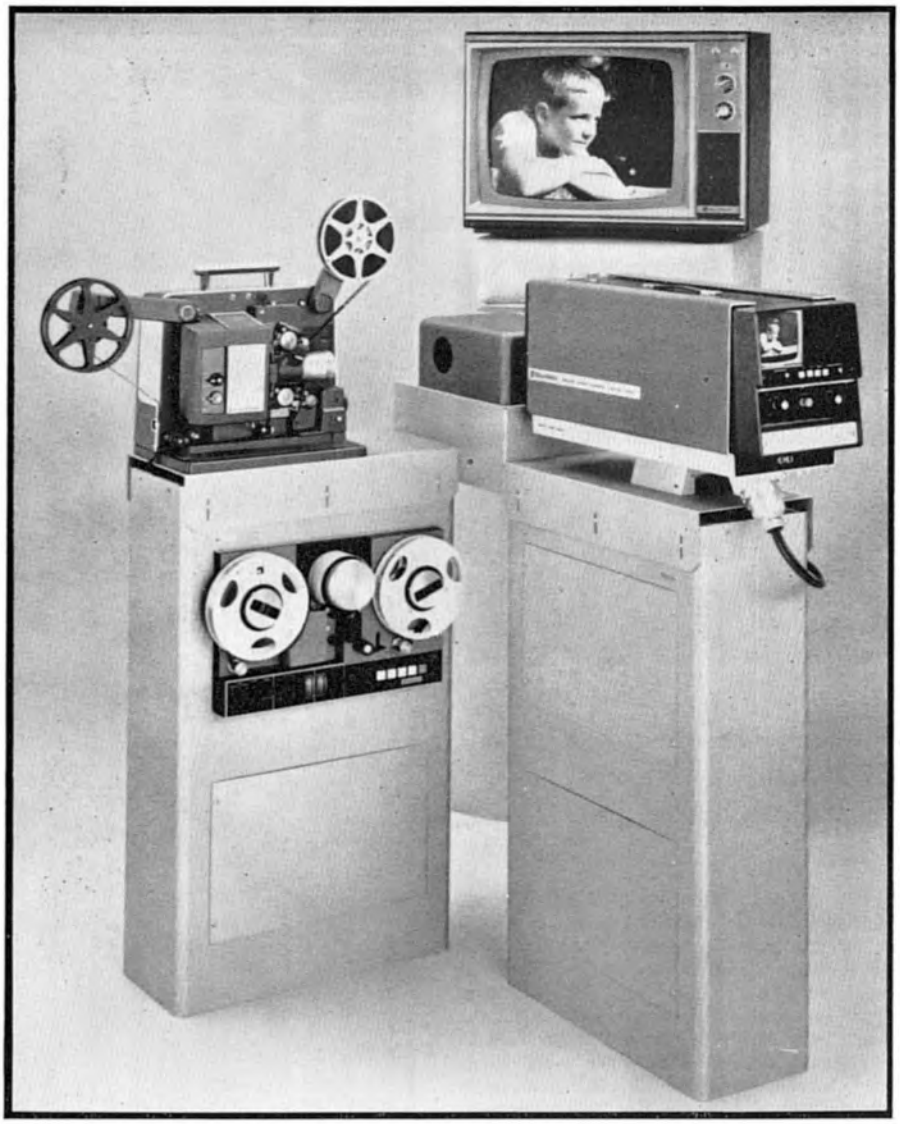
Plumbicon. The Plumbicon tube was devel-

(continued overleaf)

oped by Philips but is now being produced by other manufacturers. As the name suggests, the photoconductive material is lead oxide but the principle is the same as that used in the Vidicon tube. The defects of the Vidicon are not apparent in the Plumbicon, however, which undoubtedly is the camera tube of the future. The Ampex *BC-100* is a hand-held colour camera weighing 10 kg. It uses two Plumbicon tubes and its warm-up time is less than five minutes. It is mounted on a shoulder harness designed to give the operator full flexibility in the field and all the associated electronics are carried in a compact fibreglass back-pack weighing 7 kg. Sharp, brilliant colour is obtained at light levels as low as 150 foot candles. The camera has built-in provision for quickly changing colour temperature and neutral density filters, making it easier to maintain consistent colour indoors and out under rapidly changing conditions.

ECONOMY MODEL

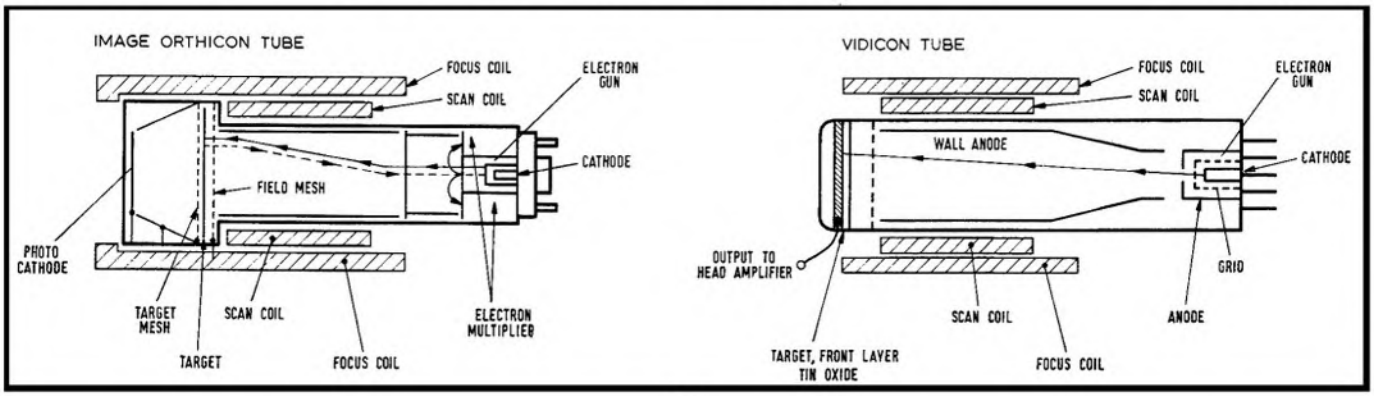
It is possible now to find a series of cameras that can be upgraded from Vidicon to Plumbicon. The Ampex *CC-326* Studio Camera Series starts with an economy model random interlace camera. The top of the series is a broadcast compatible Plumbicon camera complete with all the features needed for incorporation in the most elaborate multi-camera studio. Any single model in the series can be upgraded to a higher model. A low budget user starting out with a random interlace camera is assured that his camera can be made fully compatible with his ultimate studio requirements. The camera frame and mechanical operating features are identical in all models, and upgrading is accomplished by the addition and substitution of printed circuit boards and hardware, with minor changes in wiring.



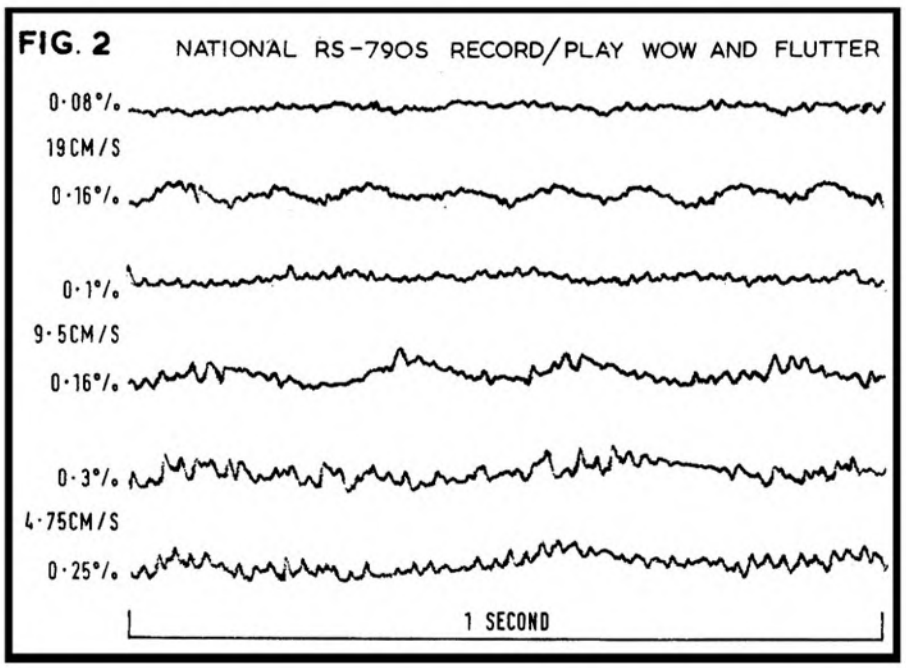
Interlacing or *Interlaced Scanning* refers to the method by which the scanning is made in alternate sets of lines. Special circuitry is incorporated in all modern cameras and receivers to achieve this. It results in a very much improved picture as the line structure becomes smoothed out and much less noticeable. The first set of lines (1, 3, 5, 7, 9, etc.) is scanned in a total of 1/50th of a second, and then the alternate set (2, 4, 6, 8, etc.) is interlaced to complete the picture in another 1/50th of a second, giving a total of 1/25th of a second for the whole picture. Each set of lines constitutes a *field*, and two fields, which make up the whole picture, comprise a *frame*.

Telecine (from *tele*vision and *cine*ma) indicates the studio facilities of televising motion picture sequences and still pictures to a live TV broadcast. Integrated sequences recorded on film make it possible to televise scenes that could not be set up in the studio. Mood scenes, historical backgrounds for period plays, running captions superimposed over stock shots, parallel action shots, and sequences showing time-lapses are but a few of the effects that can greatly enrich television but which are difficult to create by any other method than telecine. There are two types in general use: *vidicon telecine*, which is simply a vidicon camera focused on the picture from a

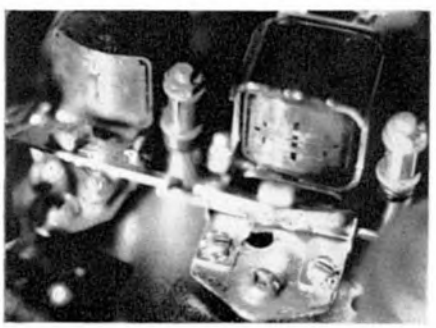
(*continued on page 261*)



NATIONAL RS-790S BI-DIRECTIONAL



Right-hand erase and record/play heads employed during left-to-right tape drive.



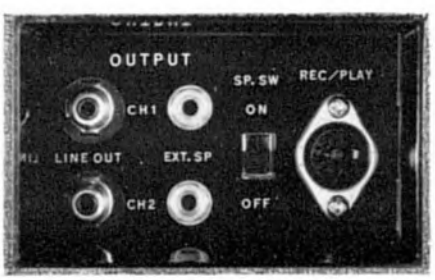
MANUFACTURER'S SPECIFICATION (19 cm/s). Quarter-track transistor stereo recorder with bi-directional recording and playback, power amplifiers and side-facing monitor speakers. **Wow and flutter:** 0.09% RMS. **Frequency range:** 30 Hz - 20 kHz. **Signal-to-noise ratio:** 52 dB. **Spool Capacity** 18 cm. **Tape speeds:** 19, 9.5 and 4.75 cm/s. **Modulation Indicators:** Meters. **Microphone input:** Miniature jack, 20 K. **Line input:** Phono, 20 K; DIN, 13.5 K. **Line output:** Phono and DIN, 10 K. **Speaker output:** Miniature jack, 10 W 'music power', at 8 ohms. **Stereo headphone output:** GPO Jack, 15 mW at 8 ohms. **Tape heads:** Two erase and two record/play. **Internal speakers:** 178 x 127 mm. **Dimensions:** 432 x 419 x 216 mm. **Price:** £187 2s. 5d.
Manufacturer: Matsushita Electric Trading Co. Ltd., P.O. Box 288, Central Osaka, Japan. **Distributor: United Africa Co. Ltd., United Africa House, Blackfriars Road, London S.E.1.**

THE two-capstan reversible drive system was described in some detail by Vivian Capel in the January issue this year. It relies on the slight stretch of the drive belt to alter the drive ratios, due to change of thickness of the belt, so that the pulling capstan is always driven very slightly faster than the feed capstan, whichever way the tape is moving. The 'closed loop' system should give effective insulation of the tape movement over the heads from reel effects. This was confirmed by touching either reel during play of a steady tone, with very little audible effect. The pen recordings of **fig. 2** show an 8 Hz capstan wow at 19 cm/s, 4 Hz at 9.5 cm/s and 2 Hz at 4.75 cm/s. Flutter was low at the two higher speeds and comparable to the wow at 4.75 cm/s. The pen traces show the best and the worst record-play wobble when the capstan wows are either cancelling or adding together in phase. On a low-wobble test tape, steady readings of 0.1% and 0.12% were obtained at the two higher speeds.

The play-only responses of **fig. 3** from NAB test tapes indicate excellent playback equalisation and, together with the play-only wow and flutter figures given above, confirm that the quality from good prerecorded tapes is limited only by the power amplifiers and internal speakers. A glance ahead to **fig. 5** shows that the response of the internal speaker-cabinet combination is somewhat limited, and that the tone controls are effectively only top cut. Nevertheless, close-up stereo quality was quite pleasing, with a lack of 'body', but with good stereo placement.

A pair of National *RP-8058* stereo speakers were sent along with the *RS-790S* recorder. The axial response is shown in **fig. 7** and is seen to be smooth from 100 Hz to beyond 10 kHz with a slightly falling response at high frequencies. The changeover dip at 1.5 kHz is due to phase differences between the two speaker units under my rather close-up testing

(continued overleaf)



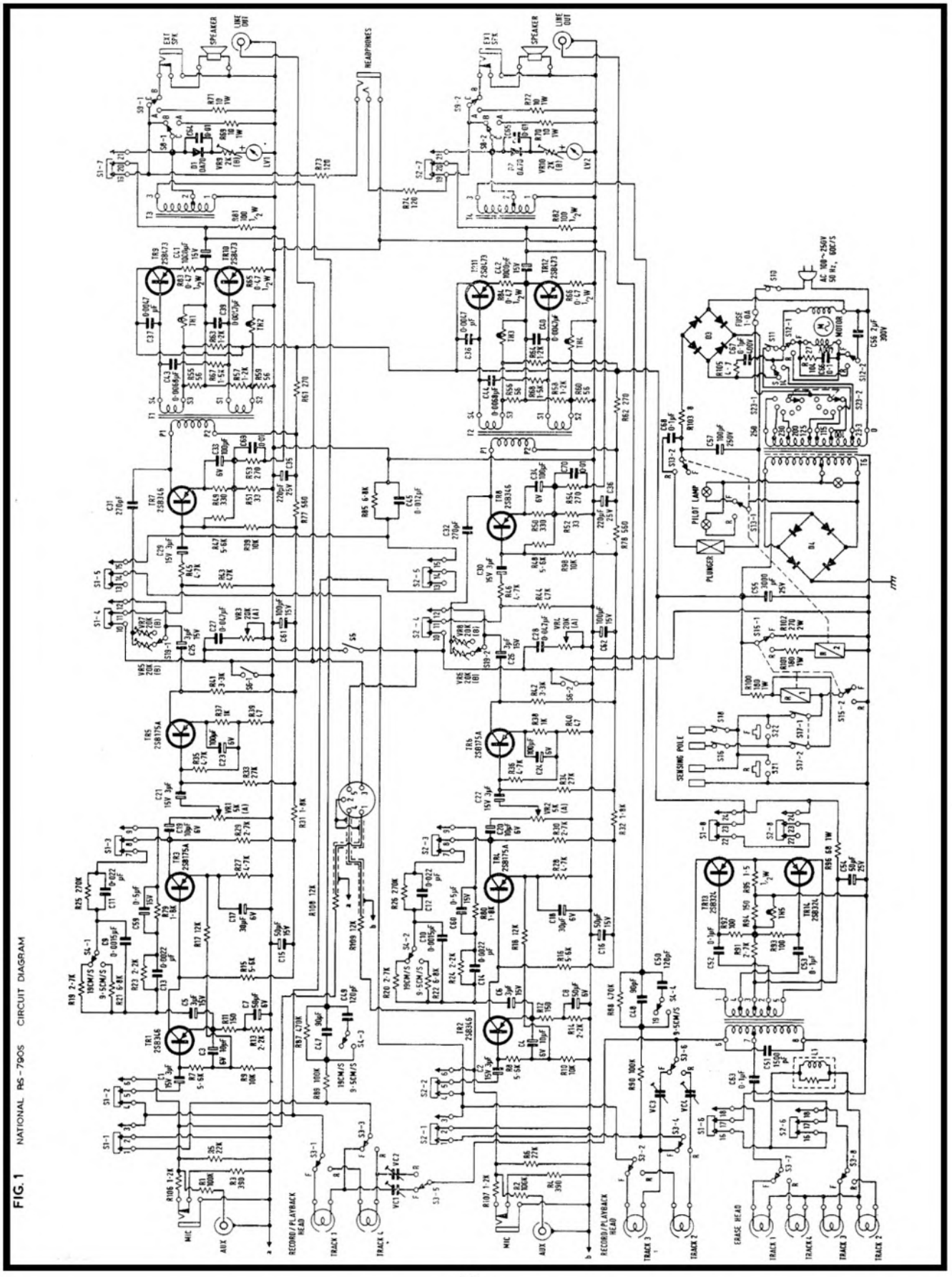


FIG. 1 NATIONAL RS-790S CIRCUIT DIAGRAM

conditions. Subjectively, the response sounded smooth over this range at normal listening distance and, when plugged into the *RS-790S*, gave very pleasing stereo listening.

As with an earlier National machine, I am not very impressed with the overall record-play responses, **fig. 4.** Reference to the circuit diagram, **fig. 1**, shows that once again an effort has been made to obtain all recording pre-emphasis outside the amplifier circuits by shunting part of the head feed resistor with a switched capacitor for 19 and 9.5 cm/s.

Playback equalisation also is only switched for the two higher speeds, and the end result is that the record-play 4.75 cm/s response falls at roughly 3 dB per octave from 120 Hz to 2.5 kHz where it finally expires altogether! Unweighted system noise, with no tape passing the heads, was 50 dB below peak recording level (32 mM/mm). Bulk erased tape noise was 48 dB below peak, and tape erased and biased on the machine was 45 dB below peak.

VU meters were rather lively and undamped but sensitivity was set so that peak recording level was obtained with the meter at full scale on constant tone with tape distortion (1 kHz) 2.5% at 19 cm/s. The full dynamic range of the tape was used with the meter peaks kicking to half scale on most programme material.

The tape position counter clocked up 13 digits for 10 turns of the right-hand take-up reel and wind or rewind time for a 600 metre LP tape on a medium hub 8 cm reel was five minutes.

The microphone response is shown by **fig. 6.** As these units are non-directional pressure types, they must be used widely spaced for stereo recording.

The mechanism is quite robust though the loose sleeves on each capstan, held only by a circlip, produced audible wow. After a few weeks use, a ball bearing fell from the base of one of the capstans, causing the flywheel to foul against another part of the deck.

A. Tutchings.

One of the two capstan pinches. Metal foil autostop/reverse pillars are visible in the foreground.

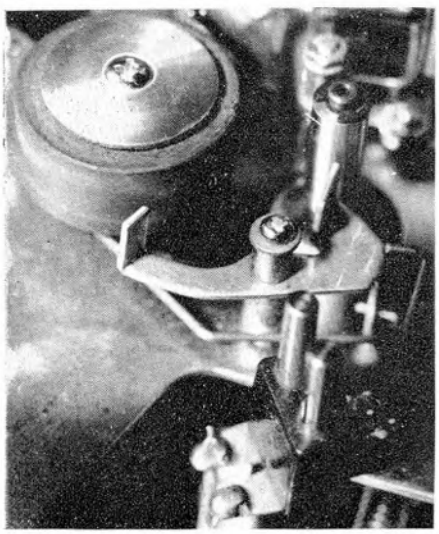


FIG. 3 NATIONAL RS-790S PLAY-ONLY RESPONSE (TEST TAPE TO LINE OUT)

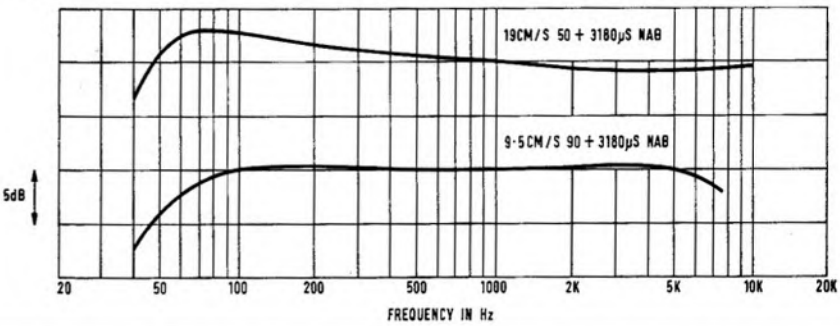


FIG. 4 NATIONAL RS-790S RECORD-PLAY RESPONSE (LINE IN TO LINE OUT)

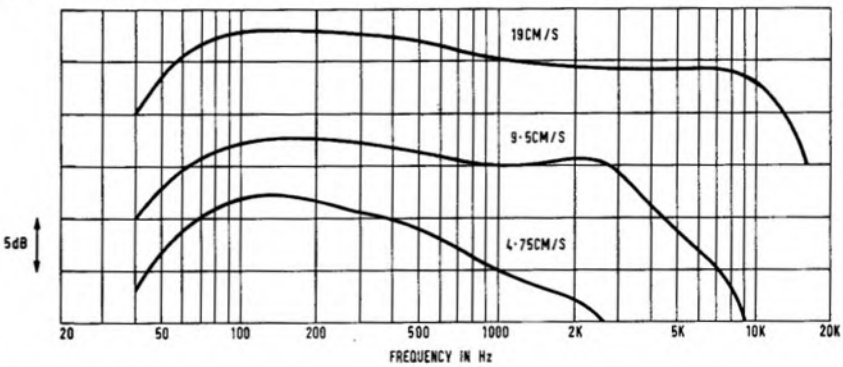


FIG. 5 NATIONAL RS-790S ACOUSTIC RESPONSE (WHITE NOISE TAPE)

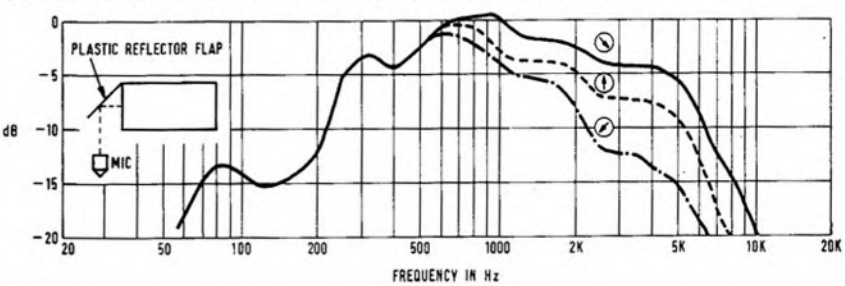


FIG. 6 NATIONAL RS-790S MICROPHONE (1K IMPEDANCE)

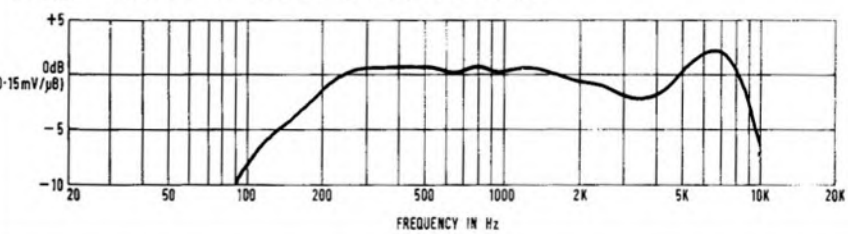
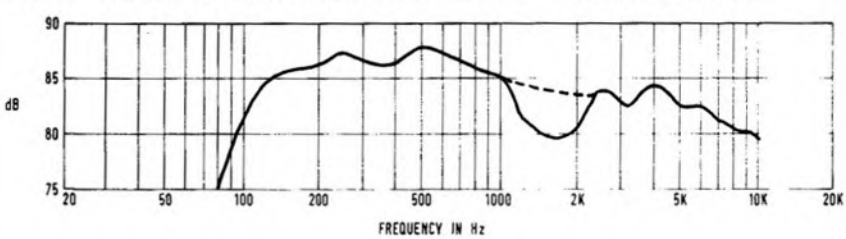


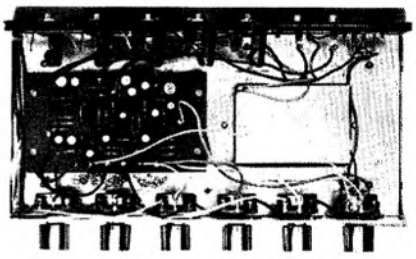
FIG. 7 NATIONAL RP-8058 STEREO SPEAKER SYSTEM FREQUENCY RESPONSE



MANUFACTURER'S SPECIFICATION. Six channel transistor mixer. **Inputs:** Channels 1, 2 and 3 (*microphone*) 3 mV at 50 K. Channels 4 and 5 (microphone) 3 mV at 600 ohms. Channel 6 (*magnetic pickup*) 4 mV at 50 K (RIAA equalised) or (*ceramic pickup*) 100 mV at 1 M. **Output:** 250 mV at 100 K. **Frequency response:** 50 Hz - 12 kHz ± 3dB (Channels 1 - 5). **Signal-to-noise ratio:** 55 dB. **Controls:** Independent level controls for each input. On/off switch. **Power source:** Six 1.5V Ever Ready *U7* or equivalent. Input for external 12 V DC supply. **Sockets:** Standard jack microphone inputs and phono pickup inputs. Two phono output sockets. **Dimensions:** 248 x 127 x 76 mm. **Price:** £12 12s.

Distributor: B. Adler & Sons (Radio) Ltd., Coptic Street, London W.C.1.

EAGLE MP7 MIXING UNIT



THIS is a nicely styled, self-powered six-channel mixer for three high impedance microphones, two low-level 600 ohm inputs, and an equalised phono input for either magnetic or ceramic pick ups.

It will be seen from the circuit diagram of fig. 1 that resistive mixers are used for the three high impedance microphone inputs and again for the two low level 600 ohm line inputs. Each group is fed through separate preamplifiers which feed the output stage. This delivers a mean output of 0.25 V with peaks up to 1 V RMS. Phono equalisation is by frequency-dependent feedback over a two-stage amplifier with mixing taking place at the output of the preamplifier.

Fig. 2 shows my measurement figures taken at full gain with all controls fully clockwise. Frequency response of the microphone and line channels were level within a fraction of a dB from 100 Hz to 10 kHz and response was 3 dB down at 60 Hz and 20 kHz. Magnetic phono equalisation was within ±4 dB of the RIAA curve and the ceramic input gave enough bass lift to give a level overall response from a ceramic cartridge of kpF loaded with 500 K. The ceramic input impedance is in fact 500 K.

FIG. 1 EAGLE MP 7 CIRCUIT DIAGRAM

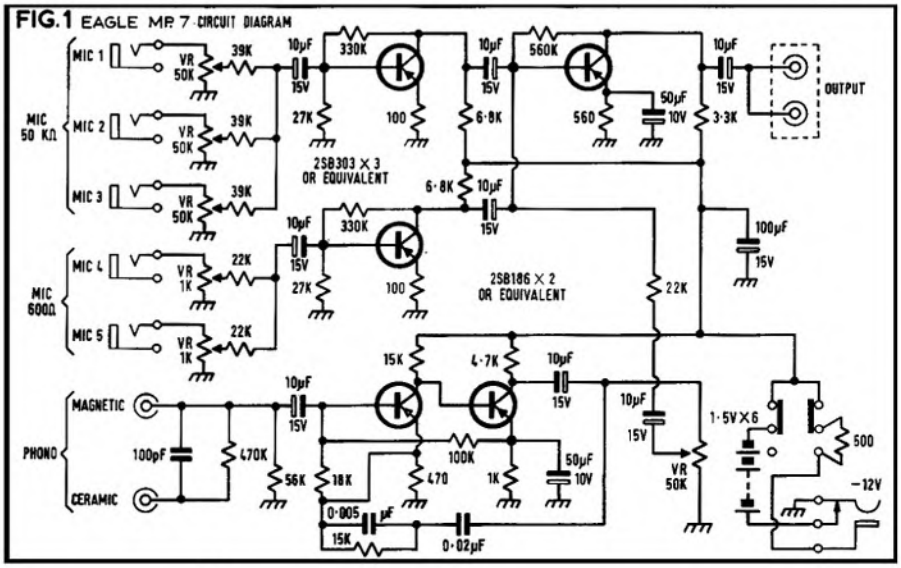
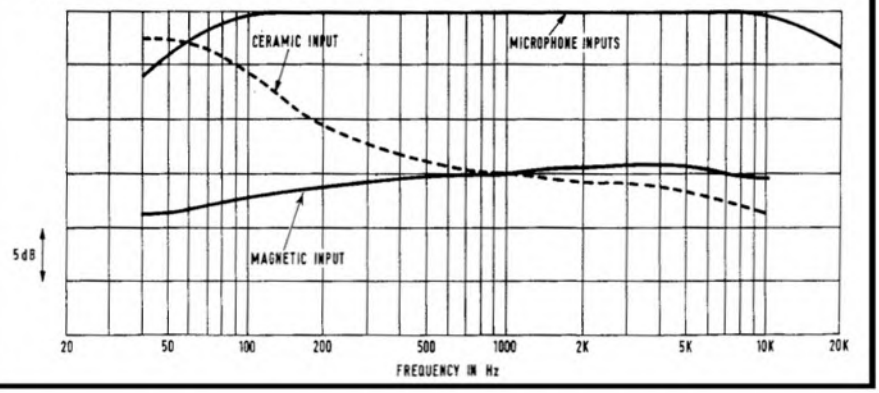


FIG. 2 EAGLE MP 7 FREQUENCY RESPONSE



and not 1M as stated in the manufacturer's specification.

An overload test showed total harmonic distortion of 1.5% at 1 V open circuit output, and 0.5% at the specified mean level output of 0.25 V. The output impedance is less than 3 K so that moderate lengths of screened cable or resistive loads down to 10 K will make little difference to the frequency response or distortion level. The specified load of 100 K is unnecessarily high.

CONSTANT ON ALL SETTINGS

Transistor noise remained an almost constant 1.2 mV at all settings of the mixer controls so that, for the input levels specified, the signal-to-noise ratio is 46 dB. If we take the peak output at the normal 12 dB above mean level (1 V), the peak signal-to-noise ratio is 58 dB. The manufacturer's circuit states that three *2SB303* and two *2SB186* transistors, or equivalent, are incorporated. Our sample contained two *BC109* transistors in place of the *2SB186* pair. A standard *MP.7* mixer was therefore obtained and found to be substantially noisier.

We now have to consider the input levels and see how they relate to average microphone and cartridge outputs. A good quality moving-coil microphone, properly matched to an impedance of 50 K, will generate an open circuit voltage of 2 to 3 mV for an applied sound pressure of one μB, which is close to the level of a normal speaking voice at a distance of about 30 cm from the microphone. However, loading the output of such a microphone with 50 K will drop the output by about 6 dB, giving a practical signal-to-noise ratio on normal speech of a little better than 50 dB. This is perfectly satisfactory in normal domestic surroundings, as ambient acoustic noise will mask the internal noise of the mixer.

Ribbon microphones generally have a lower output, pick up less random room noise, and are generally used at a greater distance from the sound source. I would estimate that mixer noise will be audible under such conditions.

Inputs 4 and 5 are marked 'microphone 600 ohms' but such a microphone only gives an output of 0.15 to 0.25 mV. The mixer output with such a small input signal would be in the order of 16 to 25 mV, with the noise still at 1.2 mV. The signal-to-noise ratio would be only 20-30 dB, even allowing for 12 dB peaks. The only microphones capable of giving 3 mV at 600 ohms would be professional models with built-in preamplifiers. This is why I preferred to call them line inputs in my opening paragraph.

As the mixing control for phono is *after* the equaliser preamplifier, I tested for preamp overload at the phono input sockets. Distortion was just evident at 30 mV input for magnetic cartridge and .5 V for the ceramic input. The ceramic input seems to be fairly safe, but a high output magnetic pickup on a fully modulated record could easily exceed the 30 mV limit. I would therefore suggest that an input attenuator be fitted, if the phono mixer knob is anywhere below the half way setting on average discs, to avoid the possibility of preamplifier overload prior to mixing.

With a little care in the choice of input and output levels, the *MP.4* mixer provides facilities for blending the sound outputs from a number of sources to build up a composite sound picture when this cannot be obtained by skilful placement of a single microphone.

A. Tutchings

DJ101 MIXING UNIT

MANUFACTURER'S SPECIFICATION. Six-channel transistor mixer. **Inputs:** Standard Jack, 8 mV microphone at 50 K (channels 1 and 2), 8 mV microphone at 600 ohms (channel 3), 50 mV line at 500 K (channels 4, 5 and 6). **Output:** 250 mV **RMS** at 100 K for rated input. **Signal-to-noise ratio:** —65 dB ref 1 V RMS. **Frequency response:** 20 Hz - 20 kHz ±1 dB. **Harmonic distortion:** 0.05% at 1 V. **Battery:** Ever-Ready *PP6* or equivalent. Dimensions: 270 x 118 x 68 mm. **Price:** £11 19s.6d. **Manufacturer: D. J. Electronics (Hackney) Ltd., 170 Albion Road, London N.16.**

MY first reaction, on handling this unit, was disquiet at the extreme lightness of the box. This worsened when I removed the lid to find a matchbox size amplifier in one corner and a similar size battery in the other. Further tests showed that appearances were deceptive. The silicon *n-p-n* transistor amplifier had been carefully designed to have a high input impedance, very low noise, adequate overload margin and low distortion. The resistive mixer losses have been kept down to 10 dB so that the overall signal-to-noise ratio with practical microphone inputs is at least equal to any mixer so far reviewed, with the further advantage that input overload is

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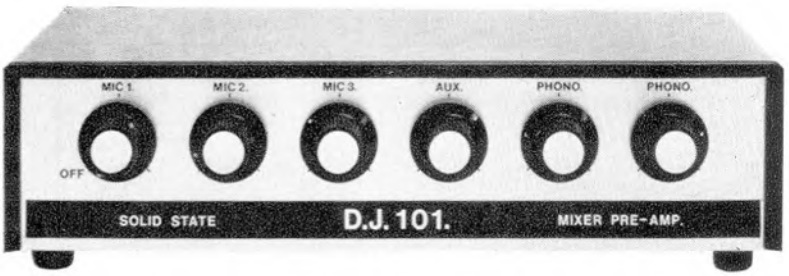


virtually impossible. I can only suggest to the manufacturers that they fit a half brick within the mixer so that its weight matches its excellent performance. Perhaps, after all, a heavy sheet steel box and a bigger battery would be more practical!

The circuit of the resistive mixer and amplifier is shown in **fig. 1** with the inputs required for 1 V output, where the total distortion is less than 0.5%. All controls are fully advanced. Waveform clipping commences at 1.5 V RMS output but, due to the heavy AC feedback, distortion is only 1% at 1.4 V output level. Distortion at the more normal 0.3 V output is 0.15%. Noise, in the form of a silky high frequency hiss, remains fairly constant at 0.6 mV output. Thus the specification figures are fully met but, as usual, we have to relate these figures to practical microphone outputs.

The specified rated input of 8 mV from a high impedance moving-coil microphone is obtained on close speech or singing at 10 cm or so from the microphone. With the normal gaussian distribution of peak to mean signal level of 12 dB, peak signals will only occasionally reach 1 V output level at full gain setting, and the specified signal-to-noise ratio of —65 dB will be realised. The more normal microphone output of 2 mV per μB on normal speech at 30 to 45 cm will give an effective signal-to-noise ratio of 53 dB with peaks just reaching 0.25 V output at full mixer gain control setting. Ribbon microphones are usually 6 to 10 dB down on moving-coil units, so that the signal-to-noise ratio will be reduced to about 45 dB and mixer hiss will just be audible on quiet signals. Crystal microphones cannot be used with this type of mixer, as considerable bass loss will occur if such a microphone is fed to the 50 K inputs. The line or phono inputs are unequalised, and have similar sensitivities, so that three pickups, or three tape recorder outputs, could be mixed at will with any or all of the microphone signals.

COMMENT

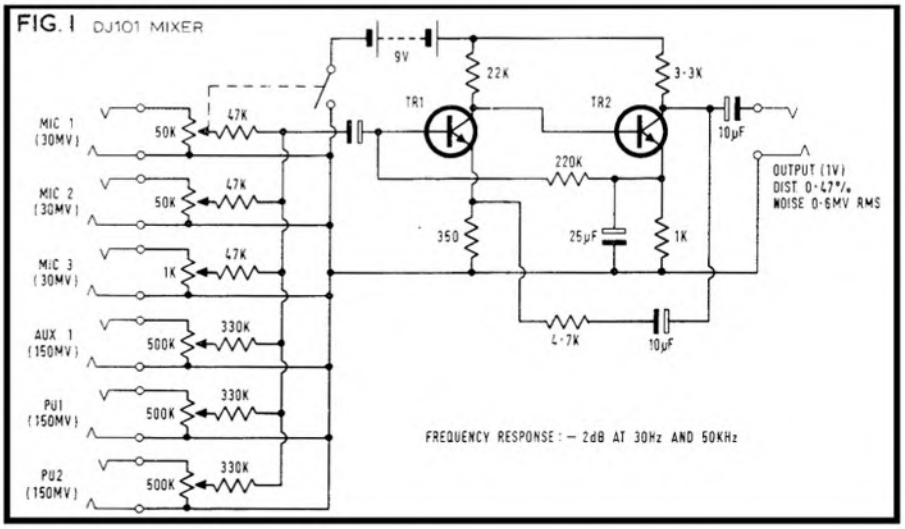
This is a good general-purpose mixer with adequate sensitivity and signal-to-noise ratio for medium to close microphone working which cannot easily be overloaded by any normal input signal.

I would like to see the index spot on the on-off control moved anti-clockwise so that minimum gain is at 7 o'clock and full gain at 5 o'clock, in line with the other mixer controls. As the flat on the spindle dictates the position of the knob, the actual control will have to be moved. The rest of the mixer controls have insulated spindles and care should be taken not to overtighten the knob grub screws.

When first tested on a recorder, the record level meter slammed over to full scale whenever the mixer was connected. This proved to be due to high frequency oscillation within the mixer at several hundred kHz. It was necessary to fit a 250 pF capacitor across the input of the amplifier to stop this oscillation before tests could be made. Apart from this initial snag, the technical performance of the *DJ101* mixer is highly satisfactory, and my only criticisms are of lack of robustness in the mechanical design.

A. Tutchings

FIG. 1 DJ101 MIXER



Here, replacement of worn out Imperial lathes by new metric lathes may be adequate to accommodate the rate of changeover but a certain amount of salvage may be possible, with the co-operation of the lathe manufacturers, by replacing the feed motion screws, nuts and thimbles with metric ones.

Milling cutters are also going to need replacement and the new metric cutters will have metric holes and keyways, so that they will only fit new metric milling machines.

A great many workshop tools and machines will not need changing at all, although they will eventually be replaced by metric equivalents of not quite the same size. For example, a 10 inch x 6 inch try-square will be replaced by a 250 x 150 mm try-square.

'Fastenings'—screws, bolts, rivets, etc.—are a problem, but not an insuperable one. Again the problem is the simultaneous availability of the designs, and the screws, nuts and bolts, with no one wishing to tie up large amounts of money and space in stock which is not going to be quickly used.

In most cases, the exact length of a screw or bolt is not critical, so the nearest standard metric equivalent length can be used as a replacement for an Imperial one, but the diameters are bound to be different. It is rare, however, for the diameter of a screw or bolt to be critical, and the nearest equivalent can usually be used as an alternative. If the replacement is smaller, then in many cases nothing needs to be done provided that the metric screw is not too sloppy in the Imperial hole. If the equivalent is too large, however, the hole may have to be enlarged (if it already exists), or the drawing may have to be altered to call up a larger size of drill.

This brings up the question of drill sizes. At present we have a fractional inch series, a number series and a letter series. The fractional inch series covers the same range as the number and letter sizes together. The fractional sizes are fully descriptive, but fractions are a very awkward way of describing a dimension. Most of us would have to think very hard to know whether 47/64 inch was larger or smaller than $\frac{3}{4}$ inch.

The replacement drills are in effect a preferred number series of millimetre sizes, whose description is an exact specification of their diameter. I can remember that a No. 33 drill is the clearing size for a 6 B.A. screw, but I cannot remember what its diameter is.

During the changeover period to the full adoption of the metric system—and this may occupy five to ten years with a further ten years of replacement spares for old equipment —the problem of interfaces between metric and Imperial components is going to be met repeaetdly. There is bound to be a period when a bought-out Imperial component has to be interfaced with a metrically designed main assembly. For this, the inch dimensions will have to be converted to millimetres by multiplying them by 25.4 and the resulting awkward dimensions accepted. One can foresee that the first batch of metric drawings are going to be subject to a crop of changes as their mating components progressively get re-designed.

On the other hand, possibly slightly premature obsolescence may not be too bad a thing, as it enables a new and better design to be used. Technical progress is now so rapid that many equipments are now out-of-date long before they are worn out, so that the problem of Imperially dimensioned spares over the next 30 to 50 years may not be too serious.

The GPO state that this is a considerable problem to them, as the design life of a telephone exchange is 25 years, though in fact many are much older than that. However, judging by the performance of some exchanges, many of us would wish for immediate retirement of some of the elderly equipment.

I have so far said nothing about what has been presented as the main reason for metrication—the ability to make things the same size as the Continentals. This is because I do not think it is such a major reason as has sometimes been suggested.

Where interchangeability is essential, internationally agreed equivalents are already in use. This has always been true for all cinematograph films, magnetic tapes and gramophone records. The unit of time, the second, always has been international, so there has never been any problem with speed.

In many other cases, full interchangeability is not achieved now even inside this country: no one expects a Rover back axle to fit a Morris car, so that the fact that it will not fit a Citroen either is not very serious. But the use of a standard series of screws would be a great advantage and would ease the problems which one finds at present in repairing foreign equipment.

It is sometimes argued that it is not worth changing to the metric system while America remains on the Imperial system. Certainly at present America makes a very large amount of equipment to Imperial sizes. But America is already considering making the change, though as yet not very hard. I do not think America will hold out for very long against the metric rest of the world.

In conclusion: to change this country over to the metric system is going to require a great deal of effort, thinking, re-learning and money. Is it all worthwhile? Inches and pounds were good enough for my great grand-father! I think it is worthwhile, and even if I did not, the decisions have already been taken and the wheels of change are in motion.

It will be very pleasant to have the simple logicality of the measuring systems of science available in commerce and industry, and the lightening of the learning load on future generations is a tremendous advantage. The routine calculations of the engineering industry will be much simpler and, therefore, subject to fewer errors.

Moreover, the longer the change is delayed, the greater will be the magnitude of the task, as a greater quantity of equipment will need to be superseded or modified. It therefore behoves us all to do our utmost to help.

Changing to the Metric Systems: Conversion factors, symbols and definitions. Pamela Anderton and P. H. Bigg (N.P.L.) HMSO, 1969.

British Standard 3763: 1968: **The International System (SI) Units,** British Standards Institution.

British Standard 1637: 1950: **Memorandum on the M.K.S. system of Electrical and Magnetic Units,** British Standards Institution.

The Use of SI Units, P.D. 5686: 1967: British Standards Institution.

A Dictionary of Scientific Units: H. G. Jerrard and D. B. McNeill, Chapman & Hall, 1963.

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projector, and *flying-spot telecine* which is a more complex system using a flying-spot scanner as an illumination source.

The simplest form of *vidicon telecine* can be found in some educational CCTV units. Leeds University, for instance, started with a cheap industrial camera mounted in the centre of a long bench, at one end of which was a 50 x 50 mm slide projector and at the other end a Siemens 16 mm film projector. Both projectors had their lenses facing inwards towards the camera, which was mounted on a turntable so that its lens could be made to line up with either of the projector lenses. The whole assembly was carefully arranged so that all three units had their optical centres absolutely in line.

A more sophisticated form is the very new Bell and Howell Colour Film Chain. The heart of this system is the *Uniplexer*. As you can see from the photographs, it is a simple matter to fit the camera into the *Uniplexer* whenever needed and to withdraw it from the film chain pedestal to use it as a studio camera. The protective cover of the Uniplexer hask nock-out circles on the remaining two sides for use with a multiplexer. This permits the addition of one more film projector and a 50 x 50 mm slide projector to the system.

With *flying-spot telecine*, a moving spot of light is produced on the screen of a cathode ray tube and this spot scans each film frame in turn to produce an electrical output from a photomultiplier. It has the disadvantage of not being able to cope satisfactorily with the American standard of 60 fields per second. Among its advantages is the ability to produce pictures of the very highest quality from slides or test cards. It is therefore very suitable for station identification signals. Although there is a tendency to prefer vidicon telecine now that these cameras have better electron optics, the flying-spot system also continues to improve and the latest Rank *Cintel* equipment does produce superb colour signals. A few years ago the vidicon was considered to be very much inferior to the scanning spot of light. Now it is recognised that the vidicon has many characteristics suitable for use in telecine where the light level need not be very high. One of these is the fact that the vidicon tube will store a picture until the next picture is flashed on to it. This storage principle gives greater scope to the handling of over-dense or inferior filmstock, often met in news coverage, and also in the presentation of high contrast feature films on television. There is also the question of economics, for the flying-spot can cost more than three times the price of one good vidicon channel.

Court. All the progressively minded Clerks see the advantages recording methods have to offer in making the Court function more efficiently. At the moment many of them spend a lot of their time keeping notes in longhand of what is going on in Court and they have to stop the proceedings while they look up points of law or advise the Magistrates. If someone, and there seems to be no no reason why it should not be an outside agency, could make a definite offer to arrange the recording and transcription of the proceedings, the Clerk may well be very glad to employ such services.

The only problem recording enthusiasts would have to surmount is how to give High Court service on a Magistrates Court level. The service would have to cost less than the existing arrangements and be completely reliable with no possibility of a breakdown.

In the Higher Courts technical employment difficulties would arise ; however anyone who has a complete working system capable of saving staff and money is not going to go unheard.

I would like to thank Mr Smith of the High Court Mechanical Recording Department, Mr Goodman of the Marylebone Juvenile Court and Mr Kerby of Dictaphone for their kind assistance.

the *R4* and *R5* models, which have lid clasps and handles, and jack sockets in place of DIN sockets for the benefit of schools, so maybe the loose board was a 'oncer'. Let us live in pious hope.

There are circuit differences between the *Mark 1* and *Mark 2*, one of them the modification mentioned at the outset, i.e., replacement of R36 with a variable 220-ohms preset and the fitting of two diodes in series in place of D1. Our circuit is deliberately that of the *Mark 1*, so that reference can be made. Crossover distortion, obvious at low levels, and always accentuated by operation on a power supply below par, can be largely eliminated by the small modification and adjustment of the standing current in the output transistors. To do the job properly, the adjustment of RV5 for equal clipping top and bottom of a sine wave output at maximum power should be carried out—or at least checked—after doing this kind of modification.

Other points about the *Mark* 2 are provision of a 5K preset in place of R30, to allow meter setting to be made accurately, and power amplifier drive from the emitter follower instead of the previous stage. This small modification can be effected by cutting out C19 and taking the top of RV3 (and the new preset) to the junction of C18 and R22.

Space precludes our giving all the setting up procedures and voltages but, for those who need this information, we are always willing to provide it.

I cannot finish without mention of the on/off switch, a very weak point with earlier *R52* models, and, as far as I can see, unaltered on later production runs. It is ganged to the volume control—though this is not always indicated—and tends to jam permanently open or closed. The control is a special Davall low-noise type, 10K logarithmic. If replacing with any alternative, you will have to cut off the plastic spindle and fit a coupler to the shortened new spindle to retain those low-noise properties. Better, of course, to use the right type, and pray they have improved the construction.

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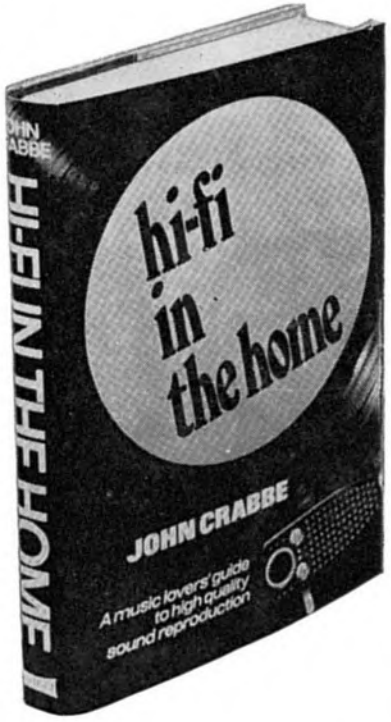

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