MAY 1969 2s 6d

tape recorder

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- 16 watts per channel
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FM 87.5-110 mc

Sensitivity
AM 300 (uV/m at 30 dB)
FM 3 (uV/m at 30 dB)

Image Rejection
AM more than 35
FM more than 35

Frequency Response
30—18,000 ± 1 dB (c/s)

FM Distortion
Less than 3%

FM MPX Separation
25 (dB at 1,000 c/s)

Output Effective Power
16W + 16W RMS (at 0.5% distortion)

Controls
Noise filter,
Rumble filter,
Loudness, AFC

Power Consumption
120 VA
(VA at maximum signal)

Motor
4-pole induction

Tone arm
Inside force canceller, static balanced pipe arm

Wow & Flutter
Less than 0.25%

Frequency Response
20-20,000

Stylus Pressure
3 gr.

Dimensions
24½" x 16" x 11¾"
(620 x 407 x 300 mm)

Weight
41 lbs

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7" 1200' } Except Agfa	36/7	29/6

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4" 450'	14/9	12/-
4¼" 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

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8¼" 2400' (Metal Reel)	84/3	67/6

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4" 600'	26/-	21/-
4¼" 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	LIST PRICE	OUR PRICE
3" 450' Not Scotch	22/3	18/-
3" 600' Scotch only	24/10	19/9
4" 900'	40/-	32/3
*4¼" 1200' Agfa, BASF only	50/-	40/3
5" 1800' Not Scotch	67/2	54/-
5¾" 2400' } Agfa, BASF only	91/4	73/6
7" 3600' } Agfa, BASF only	116/6	93/6

COMPACT CASSETTES	LIST PRICE	OUR PRICE
C.60	17/6	14/3
C.90	25/-	20/3
C.120	33/6	27/-

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551-16	1650' on 5¾" reel Double Play	55/-	33/6	97/6	189/-
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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/-

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SPECIFICATION

Frequency Range—60-14,000 *Hz*. **Signal to Noise**—45 *db*. **Wow and Flutter**—±0.25%. **Output Power**—2 *watts*. **Inputs**—*Mic.* 2*mV*, *Radio/Diode* 2*mV*, *Gram.* 100*mV*. **Power Supply**—*Mains Voltage* 110/250*v*. **Dimensions**—16½" x 11¾" x 5⅞". ● Mono recording and playback at 3¾ i.p.s. Takes 7" spools. ● Provision for mono playback of two parallel tracks. ● Monitoring facilities. ● Position indicator. ● Tone control. ● Socket for direct recording from Mic./Record player. ● Extension speaker socket. ● Stylishly housed in wooden cabinet. ● Complete with microphone, tape and spool.

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- **Endless loop cassette facility.**
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- **Independent tone controls giving full lift and cut to both bass and treble each channel.**
- **Retractable carrying handle permitting carrying by one or two persons.**

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D. K. Kirk, Tape Recorder

Recommended retail price £79:17:9

SPECIFICATIONS

Power requirements	DC 12V AC 110, 120, 220 or 240V, 50/60 Hz
Track	Dual
Reel	5 in. or smaller
Tape speed	3¾ ips (9.5 cm/s), 1⅞ ips (4.75 cm/s)
Recording time with 900 ft. (275m) tape	1.5 hours in total at 3¾ ips 3 hours in total at 1⅞ ips
Transistor	15
Diode	11
Frequency response	50 – 13,000 Hz at 3¾ ips 50 – 7,000 Hz at 1⅞ ips
Bias frequency	Approx. 55kHz
Motor	D-501F DC servo-motor
Speaker	3⅛ × 6¼ in. dynamic
Power output	Max. 1 watt
Jack	Microphone (1): sensitivity 0.195mV, impedance 600 ohms. Auxiliary (1): sensitivity 0.055V, impedance 100k ohms. Monitor (1): normal output 0.775V. Remote control (1). Speed control (1).
Power consumption	AC 6W
Battery life	10 hours recording with supplied batteries
Dimensions	12¼ in. (w) × 4⅕ in. (h) × 10¼ in. (d)
Weight	11 lbs. 13 ozs. with battery
Accessories	SONY Cardioid microphone F-85, 'D' size super batteries, 5 in. demonstration tape, 5 in. empty reel, power supply cord, connection cord, earphone
Optional accessories	Speed slow-down control RM-5, car battery cord DCC-2AW, carrying case

SONY
RESEARCH MAKES THE DIFFERENCE
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tape recorder

MAY 1969 VOLUME 11 NUMBER 5

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COVER PICTURE

Without doubt the most advanced magnetic recording equipment ever developed, the Ampex *VR-3000* colour battery video recorder frees the television cameraman from the confines of a mains power supply. Transverse scan is employed with a 38 cm/s linear tape speed to permit instant reproduction on NTSC/PAL/SECAM studio reproducers.

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. $4.30 & $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.

WRITING RECENTLY in *Amateur Photographer*, of all places, Bob Auger of Pye Records claimed that the Philips Compact Cassette presents a serious challenge to the disc as a domestic audio reproduction medium. Auger's ideas on four-channel stereo became more widely known than previously during the 1968 Audio Fair, where his recordings were played in public. Still only two dimensions, since the speakers are all in a lateral plane, but capable of moving the audience into the middle of the sound stage. He does not comment on the limitations of 4.75 cm/s tape quality but points out the versatility of the cassette as a four-channel medium. Auger rejects the disc on the grounds that it does not lend itself to more than two-channel reproduction and also because the market is swamped with so wide a choice of discs that the buyer cannot decide between a ten shilling mono *Messiah*, a fifteen shilling compatible, or the real thing at two pounds ten. And this is a failing?

Accepting that the public really wants four-channel sound reproduction, itself a debatable point at this stage, are we really to believe that the Philips cassette would have a greater sales potential than the more obvious 19 cm/s open reel tape medium? Having handled a large number of Musicassettes in the last few months, we have come to appreciate their ruggedness and convenience compared with discs. They cannot be damaged under normal conditions, they are more easily stored, and they lend themselves fairly readily to automatic changing. In these respects, cassettes are also superior to open-reel tape. Although less accident prone than disc, conventional magnetic tape suffers occasionally from tangling (depending on the transport mechanism) and also the small but ever-present danger of accidental erasure. The tape inside a Philips cassette is appallingly fragile but very well protected by the plastic casing. The danger of accidental erasure is almost nil, once the erase pips have been broken from the back of the cassette.

For all their virtues, however, Compact Cassettes have two major vices which must be overcome if the disc is to be rendered obsolete. Firstly, the recording quality must be improved. There is no subtlety in the difference between LP discs and 4.75 cm/s tape, whether the tape is inside or outside a cassette. There is a chance that disc quality *may* be equalled at 4.75 cm/s *if* Crolyn or something similar becomes a worthwhile commercial proposition, *if* Dolby techniques can be applied to domestic equipment, *if* overall wow and flutter can be kept consistently below 0.1%, *if* dropout can be eliminated and *if* manufacturing costs can be brought down to those of discs. Five *ifs*, every one of them demanding several years further research.

Is the solution to the quality problem really so intangible? We think not. In our opinion the answer is simply a 9.5 cm/s Compact Cassette recording system. Musicassettes appear to have settled on the 20 to 25 minutes per side duration which originated with the LP disc. This is achieved at 4.75 cm/s on triple play tape and could just as easily be obtained at 9.5 cm/s on the sextuple play tape developed for the *C.120* cassette.

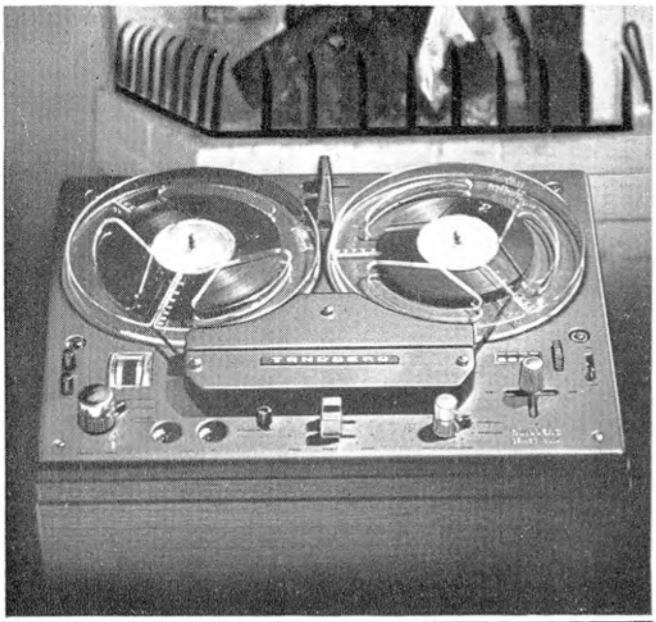
Is 9.5 cm/s good enough? The quality achieved at that speed on the new EMI ¼-track stereo tape records suggest that, for domestic reproduction purposes, it is. Improved copying plant and the use of low-noise tape are the secrets of EMI's success. The low-noise characteristic is achieved by using an exceptionally fine oxide particle coating. This ought to raise problems of print-through, particularly in the low-noise *C.120*, since the smallest particles of a coating are the first to suffer from printing. At its worst, however, print-through in a tape or cassette can hardly exceed the adjacent-groove crosstalk that occurs on many discs.

For four years we have deliberated on the vices and virtues of the cassette and we still hold the view that, as a recording implement, it is a non-starter. For domestic sound reproduction, however, we agree with Bob Auger that the time has come to take the Compact Cassette very seriously indeed.

FEATURE ARTICLES

REGULAR ITEMS

EQUIPMENT REVIEWS



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FRENCH AUDIO FAIR

THE ELEVENTH *Festival International du Son* took place in Paris from 6 to 11 March with 90 exhibitors from 13 countries displaying and demonstrating audio equipment and electronic musical instruments. Held in the giant Palais d'Orsay (due to be demolished next year), the event was accompanied as usual by live concerts, on-the-spot radio broadcasts, and a series of lectures on audio subjects.

Celestion, Connoisseur, Garrard, Goodmans, KEF, Leak, Acoustical, Radford, Wharfedale and Truvox represented the British audio industry.

The Danish Lyrec company exhibited a transistor studio recorder, the *TR504*, incorporating 38 and 19 cm/s tape speeds. A 19 and 9.5 cm/s ½-track stereo *H67B* was displayed by the French Henri Cotte company. Another French manufacturer, Paul Beuscher, demonstrated a 38 and 19 cm/s ½-track stereo *M68*. All three models take 30 cm spools.

The Belgian Carad *R.59* (illustrated) possessed the extraordinary feature of slide-axis spool turntables which could be set to accommodate 18 cm spools without overlapping the cabinet, or swung out to increase the spool capacity. A ½-track stereo recorder, the *R.59* operates at 19 and 9.5 cm/s. In its cheapest unit form, it sells in France for £175.

INCREASE IN TAPE AND FILM SHIPMENTS

SHIPMENTS OF tape recording and television films by the Emery Air Freight Corporation were 13.45% up in 1968, compared with 1967. 72,172 individual shipments in this category were carried during 1968, resulting in a 15.4% increase in revenues to £600,000. A wave of major news events, including the Robert Kennedy and Martin Luther King assassinations, the student disturbances and American elections, provided the stimulant for the increased tape and film traffic.

VIDEOTAPE PROVES LEGAL POINT

VIDEOTAPE WAS used in a Manchester court recently to provide supporting information for a damages claim. The claim was made by a Cheshire student aged 19, Christopher Povey, who received extensive injuries in a gymnastic exercise at Rydal School, Colwyn Bay. His solicitors, David Blank, Alexander and Company, engaged Group 70 of Manchester to make video tape recordings of Wray Stuart, a British Olympic gymnastics coach, demonstrating the exercise in which the fall occurred. The movement was reproduced in slow motion for the Judge. Damages of £78,398 were awarded against the governors of the school.

MICROPHONE WITH EARS

DUMMY EARS are featured on a new stereo microphone system originally developed for the US Navy and now being offered commercially. The system is based on a pair of *Bruel & Kjoer* capacitor microphones (costing some £500), mounted in an acoustically damped horizontal tube. It is claimed to enhance the 'cocktail party' effect (concentration on one voice in a crowd). Price of the *Environ-Ears*, including a matching preamplifier, is around £900. The manufacturers, *Listening Inc., Arlington, Mass.*, are now working on a version to suit other forms of microphone.

VIDEOTAPE ENTERS AMERICAN POLITICS

THE FACILITY of self-criticism offered by the video tape recorder was applied in recent years by British politicians and has lately extended to the American political scene. Senator Eugene McCarthy distinguished himself by being the first presidential candidate to take a VTR to a convention. Balloting results were recorded off the air at McCarthy's Hilton Hotel headquarters on a Panasonic *NV-8100D*. Two other models were used by his staff to record their own impressions of the convention.

BELL & HOWELL VTR 'STRONGLY RECOMMENDED'

THE BELL & HOWELL *2920* video tape recorder has emerged 'strongly recommended' from comparison with other models undertaken on behalf of the Swedish Ministry of Education. The tests extended over two months and covered all makes of VTR currently on the Swedish market. A panel of 320 people assessed the overall quality of reproduction on monitor receivers set in a separate room from the tape equipment. Their judgements were later analysed in a computer.

Three Bell & Howell models were submitted for evaluation, one incorporating editing facilities and another in prototype stage. The analysis was of monochrome performance though all three VTRs were capable of PAL colour, convertible instantly to any other system by the addition of a plug-in circuit board. A major fact in favour of the Bell & Howell models was their tape consumption, 30% lower than competing designs.

WORLD OF TAPE

APPEAL FOR TAPE LIBRARY

THE 'WEEK'S GOOD CAUSE' appeal in Radio 4 on Sunday, April 13. is being made by John Snagge on behalf of the British Library of Tape Recordings for Hospital Patients. The objects of the free service are to provide recorded books and music for patients who experience difficulty in reading. The organisation now has access to 250 books on tape and hopes, with financial support, to increase this figure.

RNIB VOLUNTEERS

THE ROYAL NATIONAL Institute for the Blind are requesting assistance from tape recording enthusiasts in fitting conversion units to old-style Talking Book players. Clarke & Smith cassettes are now being used on a large scale by the RNIB and the task of supplying new players and adapting old models has reached difficult proportions. Volunteers, who would be asked to devote an occasional evening to the task, aided by detailed service manuals, are welcomed on both a temporary and permanent basis. Offers of assistance should be addressed to *Royal National Institute for the Blind, 224 Great Portland Street, London W.1.*

Enthusiasts with good reading voices might also be interested in helping the *Tape Reading Service for the Blind, 32 Paton House, Stockwell Road, London S.W.9.*

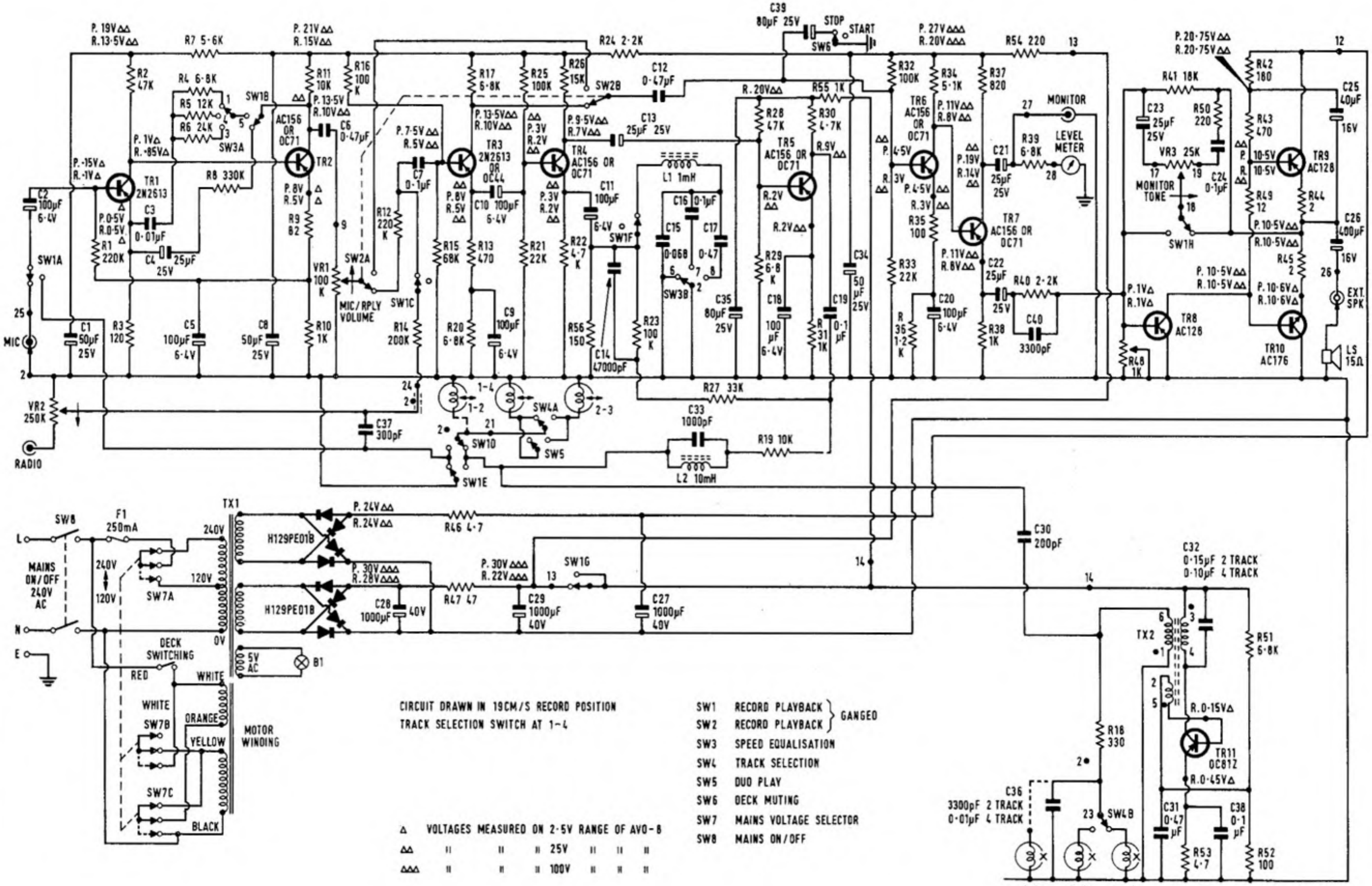
NATIONAL AND AKAI PRICES

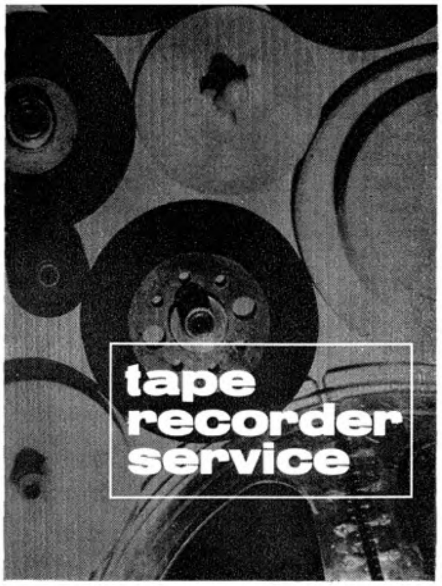
THE PRICE of the National *RS-766US* stereo tape unit was given as £17 13s. 7d. in its review last month, owing to the misinterpretation of a last-minute correction. This should have read £87 13s. 7d. Pullin Photographic Ltd. would also like to apologise for quoting the Akai *3000D* price as £89 5s. in an April advertisement. With purchase tax, the retail price is actually £99 10s.

NEXT MONTH

ALTHOUGH THE stereo tape recorder is basically a very versatile instrument, its flexibility is often limited by over-simplification of the track switching. F.W. Sutherland describes modifications to extend the facilities of an Akai *M8*. Studio microphone technique will be discussed by K. R. Wicks and Brian Haines will report on the High Court recording installation.

FIG. 1 TRUVOX SERIES 40 CIRCUIT DIAGRAM





TRUVOX SERIES 40

BY H. W. HELLYER

A MANUFACTURER'S philosophy must depend, to some extent, on the experience of his early working life. In which case, the guiding lights of Truvox would appear to have spent their formative years as service engineers!

This observation is prompted by a consideration of their service manuals; always detailed, always well presented, often containing the sort of information needed once in a blue moon but, when thus needed, indispensable. In the case of the *Series 100*, the *Series 40* we are looking at this month, and the *Series 54*, which will concern us in our final look (for the moment) at the products of this leading British company, the manual contains enough information to satisfy a do-it-yourself constructor. If anything, there is a waste of space in presenting layout drawings of more use in the factory than the retail workshop. But then, we may be merely enjoying the overspill of a manufacturer's private guideline, and should not carp.

In the case of the *Series 40* manual, there is a very peculiar paradox. The early part of the book deals with the mechanics of the deck, and leads on to the switching and electronics, before coming to the circuit depicted in our **fig. 1,** and the various adjustments that have to be made to ensure optimum performance.

The deck, of course, is the Magnavox *363*. And the cause for sad humour is that the information given by Truvox, both as to construction and adjustment, is ten times better than the makers of the deck ever deigned to give us themselves. In fact, for those who have other machines built around this now obsolete deck, allow me to offer a word of advice. Get the Truvox *40* manual and, though your problems may not be solved, they will at least be explicit!

Too often, oscillators are the weak link in tape recorder design. With transistors, it is by no means easy to obtain the power we require, match the unavoidable impedances, and preserve a sinusoidal waveform. Semiconductors being what they are when external faults crop up, it needs only a small change in working conditions for a thermal runaway to occur, and the result is ruin. So Truvox users who have had oscillator trouble should look to the modification suggested by the makers, which entails rebuilding the oscillator stage. This is not quite so frightening as it seems. In fact, it consists more of removing parts than re-fitting them, and the only additional bits needed will be one electrolytic capacitor to improve the supply line smoothing and the oscillator transistor itself.

The type used, and shown in **fig. 1,** has been the *OC81Z*. In an effort to obtain the required power and to smooth out discrepancies in tolerances, two may be found in parallel. Prior to this modification, we often found it necessary to go through a batch of *OC81Z* transistors to get a good waveform, and we cursed Truvox heartily for the bother.

The solution is to use the recommended silicon transistor, the *2S1002*. This means using also the Redpoint *5F-3* heat-sink. As the outer can of this silicon transistor is collector-connected and thus the heat-sink is common to the collector, great care must be taken to avoid the heatsink touching anything else. Truvox provide a modification kit which includes a new mounting screen with a clearance hole for the *2S1002*.

Remainder of the modification consists of removing the lower of the base bias resistors (100-ohms); removal of the 3.3 kpF capacitor (0.01 μF in the ¼-track models) across the erase head winding; direct feed to the erase head (i.e., short-circuit of the 330-ohm series resistor); change to 0.15 μF, if necessary, the value of the capacitor across the secondary of the oscillator transformer, which means shunting the 0.1 μF fitted on ¼-track models with the nearest preferred value, 0.047 μF. Remove the 0.1 μF emitter feedback capacitor normally fitted on the back of the board and add a 50 μF between supply line and chassis, positive to earth of course. As Truvox point out, it will be necessary to fit this component on the wiring side of the board to allow refitting of the output screen, etc., and the smallest variety of 25 V working voltage electrolytic you can get will be an advantage.

After all this, you should get a fair erase waveform, a measurement of 8-10 V AC across the head winding, and enough bias to obtain a good recording. It is thought in some circles that the less one gives the user to fiddle with, the better· I do not think this is the reason that Truvox have made their bias feed capacitor a fixed 200 pF. If we make it variable by using a fixed 180 pF and a 3-30 pF trimmer, we simply cut down the available voltage. I have tried this experiment, then modified it by increasing the bias feed to nearly double, adding a variable, and obtained good recording but noisy erase. I finally succeeded in selecting just the right value of components, then had to change the slightly worn R/P head later, finding the small change in head characteristics meant going over all this again.

But enough about oscillators; a few words on what my apprentice calls 'the electrics' and we can get our teeth into something more solid. First check for performance on this machine is undoubtedly the supply line voltage. I would say this should be a general rule on *all* transistorised equipment. So often, supplies are split into several different routes, all individually decoupled, and the trouble one experiences could be hum or distortion which eventually resolves to one section of the apparatus working outside its designer's ratings. So check those supply line voltages. They are given in **fig. 1** in some detail. The particular range of the meter with which they are measured is also indicated, and can be important. If in doubt, take readings above 10 V within 1% when using a 10 K/V meter, below 10 V try to get exactitude, or 0.5% at most. If your meter is less sensitive than this, start saving for a better one!

Ruthless? I'm sorry but this is the way one gets when faced with requirements that depend on the quality of one's measuring equipment. The difference of 1% in base-emitter voltage of a low-signal amplifying stage can be the difference between a good signal and a noisy one. At the output end, a slight change in driver characteristics will cause complete imbalance of the output section in a way that can only show up on the 'scope—or, of course, to one's ears.

Which brings us to the output stage. Here we find a very important adjustment for quiescent conditions, the driver base bias. This 1 K preset is easily accessible with the deck-plus-printed-circuit tilted for servicing. It should be set to give exactly 10.5 V at the centre point of the output pair, all other voltages being correct. The recommended test position is across the 400 μF electrolytic series feed to the loudspeaker. Test should be made with power on, no keys depressed.

A further noise test is a measurement across a 15-ohm dummy load in place of the loudspeaker. With volume and tone controls at minimum there should be less than 20 mV across this load (measured with a valve millivoltmeter). This is a wideband AC reading, not to be tried with an ordinary testmeter.

If hum is present, it may be necessary to check routing of cables and perhaps the position of the mains transformer, which is adjustable. An oscilloscope across the dummy load is useful here, rotating the mains transformer with the scope timebase locked on mains frequency. Make final tests with bolts tightened and recheck with the deck back in place.

Frequency response tests are quite simple. Spot frequency tests can be made, using a 1 kHz reference. At 19 cm/s, with output meter across the 15-ohm dummy load, inject 1 kHz to the gram socket and turn up the input gain until the meter needle sits over the N of the word NORMAL (don't blame me—that is what Truvox recommend!). Now record at 40 Hz, 1 kHz and 10 kHz and replay the recorded tracks, measuring the output. Each of the upper and lower frequency recordings should give an output within 5 dB of the output from the 1 kHz reference track.

On the ¼-track machines, the output from the lower track should be within 2 dB of that on the upper track.

A lot of the trouble, when discrepancy between tracks is noticeable, may originate in the head mounting. As can be seen from **fig. 2,**

(continued on page 193)

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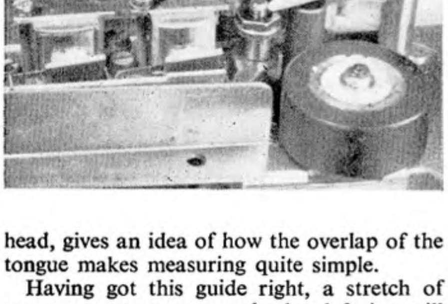
the heads are individually mounted on rocker plates and clamped to these rocker plates by an upper bar and two screws. So the adjustment of azimuth and height is co-incidental, and can be a bit bothersome. Perhaps this is why Truvox spend several pages detailing it in their manual. From practical experience, I can bypass the details and say that the first, vital test is for a truly level run of the tape through the head-block, and this means that the guide indicated by my pointer must be set correctly before anything else can be done. The dimension given is between the upper side of the lower guide face, i.e., the tongue on which the lower edge of the tape runs, and the lower edge of the pad and plate assembly, and this must be 11 mm. This may sound a bit awkward, but **fig. 2,** showing the top of the capstan and the pressure roller and an end-on view of the R/P head, gives an idea of how the overlap of the tongue makes measuring quite simple.

FIG. 2



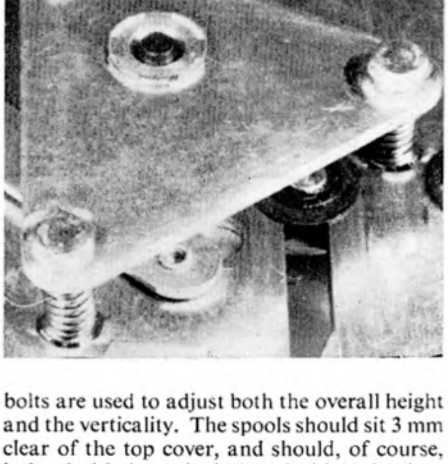
Having got this guide right, a stretch of transparent tape across the head facing will assist in primary alignment. If you do not have a properly prepared transparent tape, do not despair. It is a good idea to use a length of unwanted tape for various guide purposes, saving a nine- or ten-inch stretch in the middle, which can be wiped clean of the oxide backing with a spirit-dampened cloth (and a bit of patience). The reason for doing this in the middle of a stretch of tape is simply that this can then be spooled up at each side, the spools loaded and tensioned in outward directions to hold the tape against the head facings for these 'inspection' adjustments. Of course, transparent leader tape can be obtained, and a bit of this spliced in, if you don't want the mess and bother of removing oxide. (I know a few tape recorders capable of wiping a coating off in double-quick time, unaided, but that's another story.)

The top edge of the erase head gap should come just above the edge of the tape. Actual measurement is 200 μ. If it is a ½-track machine, the lower edge of the head gap should be just above the centre line. Etched tapes, with lines that mark correct head gap positions, make this adjustment easy, but I won't pretend that everyone should get this sort of aid. The initial judgement of the eye is quite satisfactory in most cases. The two adjusting screws are plainly visible in **fig. 2,** with the spring-loaded one nearest. The R/P head should be adjusted to bring the top edge of the gap just level with or a trifle below the edge of the tape, with no overlap. While doing this, try to get the gap as vertical as the naked eye will allow. The reason is that subsequent azimuth adjustment, if it is too drastic, will also tend to alter the height.

There should be no need to go through the procedure for azimuth adjustment. We all know why it is needed, I hope, what effect misalignment will have, and how to check for crosstalk. But at this point we can jump to what seems a rather remote adjustment—spool height and level. While we still have our test tape tightly drawn across the heads, let us rock the spools to and fro slightly by hand, and note that, provided the tape was initially wound on correctly, in the middle of the spool barrel, the run should be absolutely true, from centre of spool at left, through head channel and to centre of spool at right. Any discrepancy in spool height should show up and be cleared up right away.

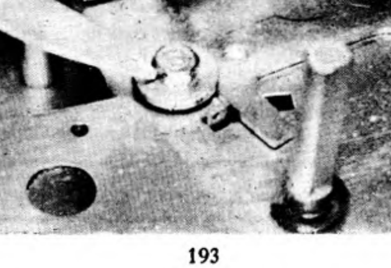
The turntables are complete assemblies that sit on spindles which go through the deck into triangular plates (**fig. 3**). Three spring-loaded bolts are used to adjust both the overall height and the verticality. The spools should sit 3 mm clear of the top cover, and should, of course, be level with the main deck and with each other. A ruler held across the faces of the two spools while they are slowly rotated shows up any tilt. Take a bit of trouble with this adjustment; so much depends on it.

FIG. 3



Having done this, we can revert to the head assembly and make sure first that the pressure pads are tilting on cleanly, with the phosphor-bronze springs not fouling at all (not uncommon) and the left-hand end of the assembly where a short length of spring blade is bolted to an upright bracket (**fig. 4**) is moving freely. The bolt indicated in this view is that under which the interlock lever slides, and we must check that this is clear of swarf, etc, and apply a thin smear of grease to help the action.

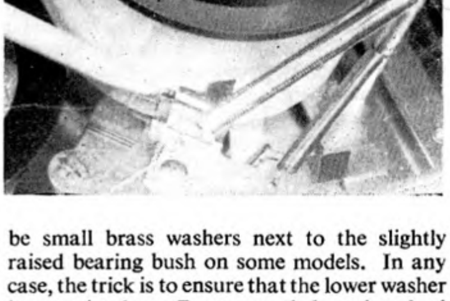
FIG. 4



At the other end of the pressure roller plate is the hairpin spring indicated in **fig. 5;** one which gives us a fair amount of trouble. When the start key is operated, the roller bracket should move inwards gently at first, then, when within 6 mm or so of its operating position, go on with a snap. The things that prevent this are usually maladjustment of the lever height nut, just obscured by my pointer, and also weakening of the spring, or someone's misguided attempt to improve matters by bending it. There are one or two modified ways of ensuring direct action, including Reps' clever autostop and pause method, but Truvox play it straight. They leave 75 μ clearance between height adjusting nuts.

The pressure roller itself is the same as the old Collaro *Studio*, and is simply secured by the 6BA nut above a plastic washer. There may be small brass washers next to the slightly raised bearing bush on some models. In any case, the trick is to ensure that the lower washer is not gritted up. Remove and clean the wheel and its boss, the spindle and the washers, and refit with a single drop of oil. Then, after tightening, spin it freely and add a drop or two of oil to the reservoir at the top (felt ring).

FIG. 5



Unfortunately for the next point, my camera did a Ford on me, going on strike at the crucial moment. I was aiming for a shot of the on-off switch between and below the spool carriers. This joker is operated by a rather flimsy lever, in turn moved by the slide plate assembly which the function keys actuate. The usual trouble is intermittent action, sometimes so subtle as to seem like loss of power. The answer is to reposition the switch by slackening its holding screws, putting the deck to 'On'. Meter the power supply lead (with fuse removed to take off the transformer resistance) and move the switch until definitely active. Then recheck on all functions: it can be erratic. Watch out for a fouling blade and, if you remove the switch cover fibre plate, do not lose the small spacer. Be careful when retightening. It is easier to remove the rewind idler and do this job in comfort than to risk a split switch casing.

Speed change ramps are always a problem, and the *363* is no exception. The trouble is that the fine height adjustment is hidden. Look for the screw just between the head plate assembly and the left end of the pressure lever. Turn anti-clockwise to raise the flywheel idler position: make sure this clears the next lowest flange of the motor pulley.

(*continued overleaf*)

The other idler engaging the pulley is also ramped (**fig. 6**) and is used for clutch action, driving the lower drum of the assembly for take-up and rising on its ramp to drive the fixed upper drum for fast wind. (Fixed, that is, to the spool carrier assembly, not the deck.) The usual trouble—apart from an almost unavoidable rattle of the triple slider quadrant on which the idler is mounted—is that the ramp does not act cleanly enough, and the spring seems sluggish. Clean the spindle, spring and bracket holes, lubricate the idler spindle moderately, and smear a touch of Molyslip on that damnable quadrant. File away a bit of the top of the motor fixing screw to help stop rattle, if it is troublesome.

Above all, watch for the idler attempting to slip into the recess between the two drums.

If it does this, look for trouble, not with the idler itself, but with the felt between the drums which is preventing freedom to spin. Clean spindles and felt thoroughly, making absolutely sure the spool spindle is vertical, lubricate where needed and try again.

Brakes are perhaps the most important single factor of the Magnavox *363* deck. The whole subject was covered by William Henry in the March *Tape Recorder*, and photo **B** on page 110 showed a view of the small brake bracket and pivot which gives us all the trouble. Our **fig. 5** presents an alternative view and shows also the nail-headed pin that can so easily loosen. In fact, what with spool carrier spindles that loosen where they are clamped into the triangular plate of **fig. 3**, and these annoying brake pivots, this is rapidly becoming known in our workshop as the 'wobble-pin deck'.

Changing the brackets is no answer: spares are running down for these decks. Repair is not difficult, though tedious. The answer is to adjust the brake clearances first, using a feeler between carrier drum and brake pad. Having adjusted both the upper and lower bushes, check for lack of play in the linkage rod, then tighten the bush-securing screws, heat up a 100 W soldering iron and make sure the top of the nail-head pin is tight by soldering it to the brake arm. I have found this method more efficacious than attempting to burr the clamping of the pin with hammer and punch—a method that seldom holds for long. Feelers—oh yes—0.036 inch left and 0.064 inch right. And they must be exact, believe me!

FIG. 6

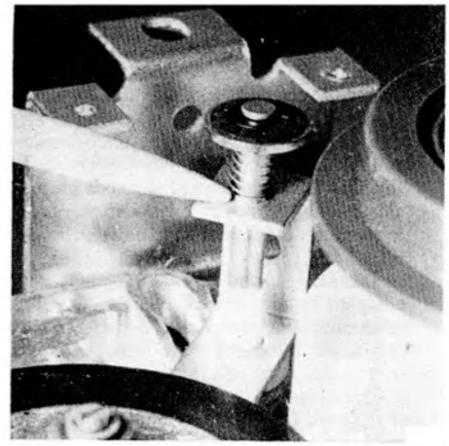
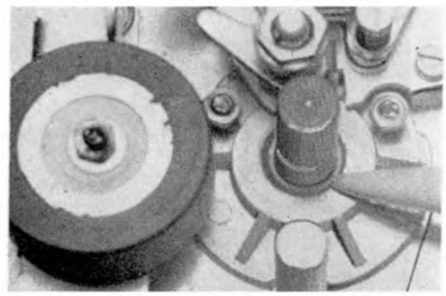


FIG. 7 Upper flywheel bearing and pinch wheel



THE SOUND STUDIO

PART TWO STUDIO ACOUSTICS BY K. R. WICKS

A STUDIO which is to be used for sound broadcasting or recording will obviously need to be insulated from outside noises. These may enter the studio in two ways, either through the structure of the building or directly through the air.

The degree of insulation required will vary considerably, depending on the purpose for which the studio is intended. In a talks studio, the microphone might be about a third of a metre away from the speaker, and the level of any extraneous sound picked up would be small compared with the level of the speech.

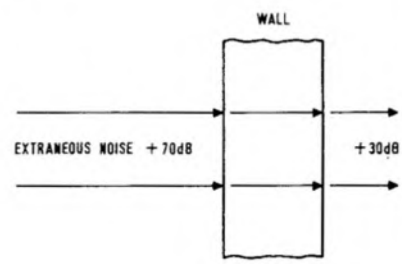
Orchestral studios require greater sound insulation, as a background noise level considered acceptable in a talk studio might seriously mar a passage of quiet music. It is usually necessary in an orchestral studio for the studio manager to contract the dynamic range of the music, using the main gain control of the studio mixer. This entails decreasing the level of the loudest passages and increasing the level of the quietest passages. Unfortunately, the latter means that the background noise level will also be increased. Moreover, extraneous sounds are generally more annoying when listening to music than when listening to speech.

Speech and music are examples of the type of sound which is generally airborne. Reduction of the *direct* entry of airborne noise is relatively simple, involving the use of airtight windows and doors. Windows are double glazed, and a pair of doors separated by a vestibule is commonly used, but these precautions demand the installation of an air conditioning system, which can itself introduce airborne noise into the studio. This is dealt with by fitting acoustic filters in the air supply piping.

The term *airborne noise* also covers sound which is carried through the air to the outside of the studio, vibrating the partition (wall, floor or ceiling), resulting in the transmission of sound to the interior.

When a sound wave strikes a wall, part of the energy is reflected, part is absorbed and transformed into heat, and the remainder is transmitted through the wall as unwanted noise. The overriding factor which determines the amount of sound transmitted is the mass per unit area of the partition, and effectiveness as a sound insulator is indicated by the *reduction factor*, which is the number of decibels by which the sound pressure is reduced in the process of passing through the partition (**fig. 1**).

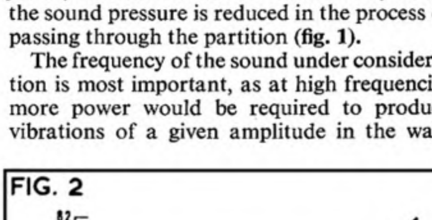
FIG. 1



THE REDUCTION FACTOR OF A WALL IS THE NUMBER OF DECIBELS BY WHICH THE SOUND PRESSURE OF AIRBOURNE NOISE IS REDUCED WHEN PASSING THROUGH THE WALL. IN THIS EXAMPLE, THE REDUCTION FACTOR IS 40dB

The frequency of the sound under consideration is most important, as at high frequencies more power would be required to produce vibrations of a given amplitude in the wall.

FIG. 2



Thus it follows that less sound will be transmitted to an adjacent room at high frequencies than at low frequencies. For a theoretically perfect partition, the reduction factor will increase by 6 dB/octave, although the fact that any practical wall has a resonant frequency modifies this relationship. The resonant frequency of the wall is determined by its density and stiffness. As this frequency is approached, sound waves of a given intensity cause greater vibrations of the wall, and thus greater transmission of sound, this occurrence being called the *coincidence effect*. As a result of this, the curve showing sound reduction against frequency tends to take on the shape shown in **fig. 2**, and the region where reduction decreases with increase of frequency is known as the *coincidence zone*, the width of which depends on the mechanical damping factor of the material used to make the partition.

Where sound reduction figures are quoted without mention of frequency, it is usual to assume that these are average figures over the 100 Hz-3.2 kHz range, most airborne extraneous noise falling into this band.

For normal building materials, the Reduction Factor will be improved by five dB each time the thickness of the wall is doubled, although where the partition is relatively light (below about 110 kg/m^2) the improvement brought about by doubling the thickness is even smaller. The average wall transmits little sound, mainly because of the losses at the boundaries of the wall, so in practice, double walls are often used instead of a single wall. **Fig. 3** shows various walls with a sound source on the left, the numbers representing sound pressure levels in decibels. It would be reasonable to suppose that, since one wall gives 40 dB of sound reduction, two walls would give 80 dB of reduction, however this is never achieved in practice. Because space is precious, the gap between the walls is restricted, and the closer the walls are together, the more they approximate to a single wall of double the original thickness. At the same time, the improvement in the reduction factor tends toward the 5 dB improvement expected with a double thickness wall. The reduction factor of a double wall

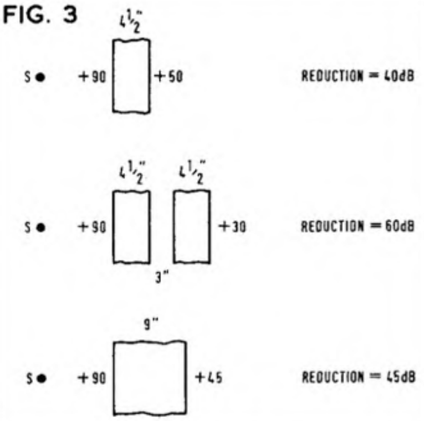
(continued overleaf)

increases with frequency at a greater rate than that of a single wall, and the insulation may be further improved by hanging a sound-absorbent blanket in the wall cavity, although this measure too has the characteristic of being more effective at high frequencies.

Insulation against airborne sound, therefore, usually boils down to the problem of eliminating low frequency sounds by using heavy walls of rigid material.

Structure-borne noise is sometimes referred to as *impact noise* and includes footsteps, hammering and similar noises. It is rather difficult to estimate the intensity of noise which will be carried through the structure of a building. Structure-borne noise can be less intense in the room in which the noise is made, than in (say) the room below, so the airborne noise reduction factor cannot be

FIG. 3



applied to this type of sound transmission.

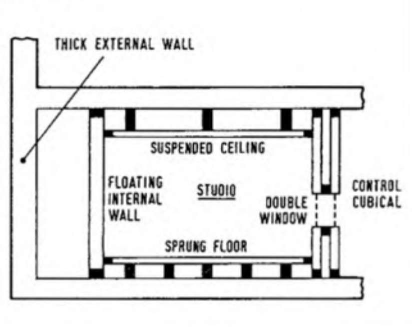
Where a high degree of insulation is required, it is usual to install floating floors and suspended ceilings, making use of resilient materials to reduce the transmission of vibrations (see **fig. 4**). As with airborne noise, difficulties are experienced mostly at low frequencies and the siting of studios relative to sources of LF vibrations is important. Until a few years ago, the BBC Home Service continuity studio was located in the basement of Broadcasting House and it was not unusual to hear the rumble of tube trains in the background during announcements, as the basement is very close to the underground line connecting Oxford Circus and Regents Park.

The studio is much more difficult to design than any other part of the chain of equipment associated with it. It is almost impossible to forecast with any degree of certainty what the acoustic properties of a studio will be when it is completed. There are many factors to be taken into account (and some disagreement as to which are most significant) so that it is common practice to adjust the design specifications of the studio as it is being built, various tests being carried out after each major stage of construction.

If a steady tone is sounded in a room and then cut, the sound intensity takes a finite time to die away. The factor causing this is known as *reverberation* and may be defined as a closely grouped series of sound reflections. When the tone has been cut, the sound waves in the room continue to be reflected by the room contents and boundaries, part of the wave energy being absorbed each time the wave strikes a surface. Eventually the sound becomes inaudible, the time taken for this to happen depending on the initial sound level, and on the absorbent properties of the materials used in the room. The main objective of acoustic design is to obtain a satisfactory reverberation characteristic, bearing in mind the type of sound material for which the studio will be used.

The pioneer of acoustic science was Professor Wallace Sabine of Harvard University, who carried out a great deal of important work at the beginning of this century. Sabine realised that the rate at which the room boundaries absorb energy determines the reverberation characteristics of the room, and he introduced the term *reverberation time*. This may be defined as the time taken after a

FIG. 4



steady note has been cut, for the sound intensity level to decrease to one millionth of its initial value (i.e. to decrease by 60 dB). One way of measuring this would be to sound a tone at such a level as to produce an intensity of 60 dB above the threshold of hearing, cut the tone, and then measure the time taken for the reverberant sound to become inaudible. Sabine used organ pipes to produce tones, and a stop watch to measure the decay times of various notes; the results showed that sound intensity decreases in an exponential manner and that the reverberation time varies with frequency. He produced a formula, based on his experimental results, which gives the reverberation time in terms of room volume, the surface area of the room, and α (alpha), the average *coefficient of absorption* of the room. The unit of absorption which he adopted was the *Open Window Unit*, sometimes referred to as *one Sabine*, this being the absorptive value of one square foot of open window (i.e. one square foot of total absorption), and the coefficient of absorption for any given material is equal to $1/n$ where n is the number of square feet of the material which gives the same absorption as one square foot of open window.

Thus the absorption coefficient for any material lies between zero (total reflection) and unity (total absorption).

The formula derived by Sabine was:

$$T = \frac{0.05\ V}{S\alpha}$$

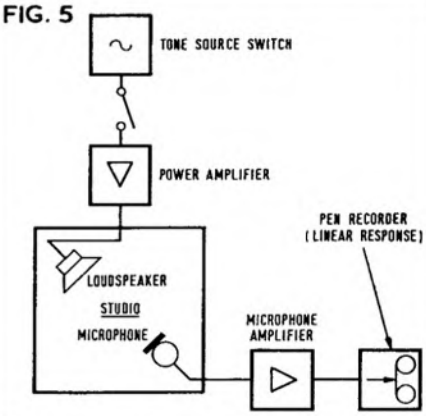
where T = Reverberation time in seconds
V = Volume of room in cubic feet
S = Surface area of room in square feet
α = Average coefficient of absorption.

This formula is often quoted without mention of the units of measurement but it is essential that the volume and surface area figures are in cubic and square *feet* respectively. This becomes obvious when one considers that for a 3 foot cube, $\frac{V}{S}$ is $\frac{1}{2}$ if feet are used, but if yards are adopted the ratio becomes $\frac{1}{6}$.

Sabine's formula was accepted for some time and it does in fact give an accurate answer for rooms where α is small. The formula is, however, inaccurate for rooms where α is greater than about 0.2, but here Sabine's experiments were restricted as the stopwatch was unsuitable for measuring the very short reverberation times associated with large values of α.

The trouble with Sabine's formula is that for a room with totally absorbent boundaries

FIG. 5



(α=1), it indicates some finite reverberation time dependent on the dimensions of the room, instead of the expected result, T=O.

During the 1930's, developments in the cinema and broadcasting prompted much study of acoustics, and Eyring derived a formula similar to Sabine's, but replacing the term α by minus $\log_e(1-\alpha)$.

$$\text{i.e. } T = \frac{0.05\ V}{-S\ \log_e(1-\alpha)}$$

This formula has since been shown to agree well with practical results obtained in rooms, and is widely used in acoustic design.

Nowadays, reverberation time is measured using either a high speed pen recorder, or an oscilloscope. The simple apparatus shown in **fig. 5** may be used. The level recorder is set in motion, and the tone cut by throwing the switch. The decay curve obtained by this simple method does not usually give a very good indication of room characteristics, as a single tone in a room produces standing wave patterns which undergo violent fluctuations when the tone is cut, making the resultant decay trace difficult to interpret. Such a trace is shown in **fig. 6**. Instead of a pure note, a warble tone may be used; this is simply a tone, the frequency of which is made to vary. If the centre of the frequency of the tone if f Hz and the rate of frequency modulation is g Hz, the resultant warble tone will have a spectrum consisting of the fundamental frequency (f)

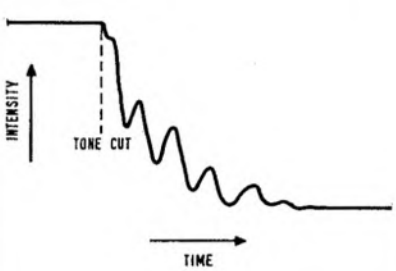
plus sidebands of frequencies $f+Ng$, where N is any integer (positive or negative). In a typical reverberation test, f might be made to vary between 450 Hz and 550 Hz at a rate of 5 Hz, thus producing a band of frequencies spaced 5 Hz apart around a centre frequency of 500 Hz.

The warble tone will still cause an 'acoustic pattern' to be set up in the room, but it is more complex, having less well defined maxima and minima than when a single tone is used. The fluctuations in the decay curve are relatively small when the warble tone is cut.

Another improvement on the simple apparatus of **fig. 5** consists of using an amplifier having a logarithmic response to feed the level recorder or oscilloscope. Instead of an exponential curve, a straight line decay graph is obtained, and the computation of T is simplified.

A small studio to be used only for speech will require a very short reverberation time to ensure maximum intelligibility. Long reverberation times are associated with large studios used for orchestral music. The reverberation causing the individual sounds to 'blend' together. For a studio where a variety of sounds are to be encountered, a short natural reverberation time is required, longer times being obtained when necessary by the use of artificial reverberation.

FIG. 6



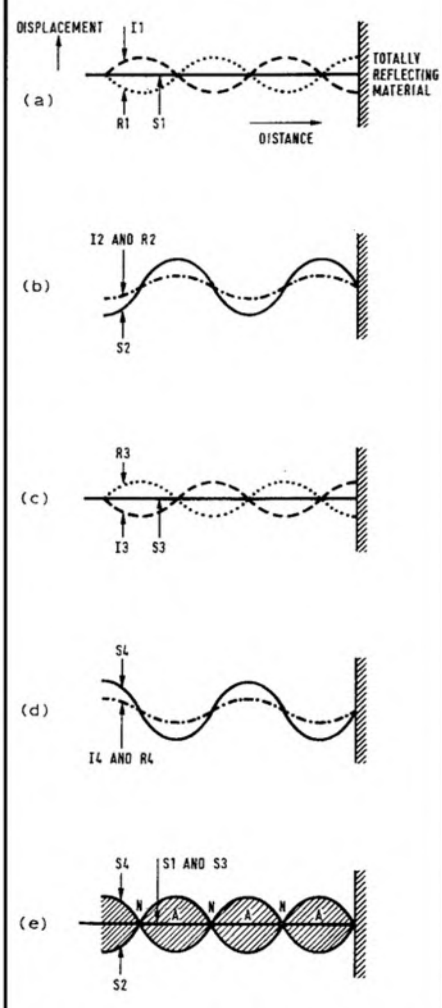
Typical reverberation times are listed below:

Drama	0.3 s
Talks	0.3 s
Orchestral (small)	0.9 s
Orchestral (large)	2.0 s

As far as the variation of reverberation time with frequency is concerned, many studios are designed with a reverberation time which is virtually constant over the audio range, which ensures good intelligibility of speech, though the LF reverberation time is often made longer if the studio is used for music as well, as it is generally considered that this will improve the quality.

When two sound waves of equal amplitude and frequency travel in opposite directions, a standing wave pattern is set up. This situation is usually caused by the reflection of a wave and is characterised by a series of pressure nodes (minima) and antinodes (maxima) occurring in the medium. In **fig. 7,** the incident wave is travelling from the source to the wall, which is assumed to be a perfect reflector striking it normally. The sound waves have been represented here by the *displacement* graph (as opposed to pressure), and the displacement of particles touching the wall must be zero. (Sound waves being *transverse*, the particles of the medium are displaced along the line in which the sound travels, so that a displacement of particles normally in contact with the wall would imply that they actually enter the wall, or move away from it leaving a vacuum.) Since the displacement at the wall must be zero, it follows that in **fig. 7a,** the reflected wave must be in anti-phase with the incident wave *at this instant*, and the resultant displacement obtained by adding the incident and reflected waves is zero at all points. **Fig. 7b** shows the situation a quarter of a period later, the incident wave having effectively moved to the right, and the reflected wave to the left. The waves are now mutually in phase, giving rise to a resultant displacement wave of twice the amplitude produced by the incident wave alone. Another quarter period later, the component waves are out of phase again **(c),** giving zero displacement at all points. A further quarter period later, the waves are again in phase **(d),** giving a double amplitude displacement curve but in the opposite direction to that previously obtained. The situation reverts to that of **(a)** after another quarter period and it can be seen from **(e),** which shows the four resultant curves obtained, that an acoustic pattern is formed, some particles being permanently at rest, whilst others are continuously subjected to double amplitude vibrations about their mean positions.

FIG. 7 STANDING WAVES

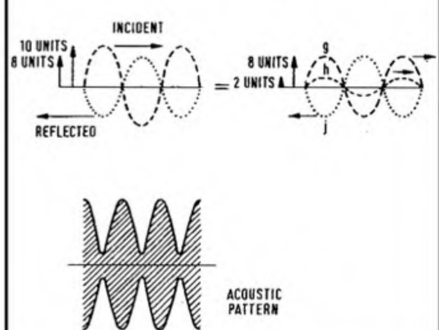


- - - - - - I = INCIDENT WAVE, TRAVELLING LEFT TO RIGHT
.... R = REFLECTED WAVE, TRAVELLING RIGHT TO LEFT
———— S = ALGEBRAIC SUM OF I + R

As was shown in Part One of this series, the sound pressure wave is a quarter wavelength out of phase with the displacement wave, so that pressure nodes occur at displacement antinodes, and vice-versa. (The effect known as *pressure doubling* occurs at the wall surface as this is a pressure antinode, the maximum instantaneous pressure being double that produced by the incident wave alone.)

In practice, perfect reflection does not occur, and the nodes and antinodes are less well defined with surfaces which are poor reflectors. If, for example, a wall is such that when an incident wave of amplitude ten units strikes it, a reflected wave of eight units is obtained (**fig. 8**), it is convenient to consider the incident wave as the sum of two waves, g and h, g having an amplitude of eight units, and h, an amplitude two units. The reflected wave (j), plus the incident wave (g), can be considered to form a standing wave pattern, while the wave h can represent the incident component which is not reflected by the wall, so the resultant acoustic pattern may be regarded as a stationary wave plus a normal progressive wave. All particles in the medium are in motion, but a pattern of maxima and minima is still produced.

FIG. 8 ACOUSTIC PATTERN PRODUCED BY PARTIALLY REFLECTING SURFACES



In a room the situation is complicated, as successive reflections of sound waves occur between parallel walls so that patterns which would otherwise be formed by each wall may be destroyed by the interference of other sound waves. The conditions required for a stationary wave to be set up (i.e. for *resonance* to occur) between parallel walls is that the distance between the walls is an integral multiple of a half wavelength of the sound. Thus for any pair of walls there is a series of resonant frequencies, at which large pressure variations occur in the room. For a pair of walls L feet apart, $L=A\frac{\lambda}{2}$ where A is any integer and λ is the wavelength. Since $\lambda=\frac{V}{f}$ where V is the velocity of sound and f the frequency, it

(continued overleaf)

follows that $L=A\frac{V}{2f}$ giving $f=\frac{V}{2}\frac{A}{L}$. Thus the lowest resonant frequency is $\frac{V}{2L}$, resonance occurring also at $\frac{V}{L}$, $\frac{3V}{2L}$, etc. Resonance between one pair of surfaces is said to be in the *first order mode*. In a simple room there are three pairs of surfaces which cause first order resonances but, in addition, further resonances are set up by energy flowing between two pairs of surfaces (second order mode), and between all three pairs of surfaces (third order mode).

All resonant frequencies are given by *Rayleigh's equation:*

$$f=\frac{V}{2}\left(\frac{A^2}{L^2}+\frac{B^2}{W^2}+\frac{D^2}{H^2}\right)^{\frac{1}{2}}$$

where V is the velocity of sound,

L, W and H are the room dimensions

A, B and D are any integers.

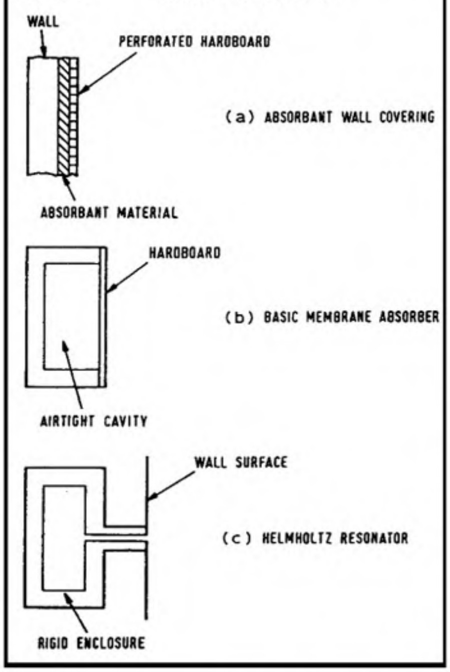
For first order modes, any two of the factors A, B, D are equal to zero, the formula reducing to $f=\frac{VA}{2L}$ as previously obtained. Frequencies at which second order modes occur have resonances which are calculated by putting only one of the factors equal to zero, and for third order modes none are zero.

If Rayleigh's equation is applied to a room, and a list of the resonant frequencies obtained, it will be found that the frequency difference between LF resonances is much greater than the difference between HF resonances. For a very large room, the widely spaced resonant frequencies are below the audio range, and the resonances which occur inside the audio range are so closely grouped as to be virtually continuous. In a small room, however, the widely spaced resonant frequencies will fall within the audio range, giving rise to excessive bass boom around the resonant frequencies, and to a generally poor reverberative quality in the LF range.

Special treatment of studio surfaces is necessary to obtain the required reverberation times at all frequencies. Above 500 Hz porous materials such as curtains, glass fibre, and carpets are used to achievethe required absorption, the friction between air particles and the pores of the material, causing part of the sound energy to be converted to heat, and then absorbed. Such absorptive materials are more efficient at high frequencies since the particle velocity is higher and the frictional losses consequently greater. Maximum absorption at a given frequency occurs when the porous material is placed at a distance $\frac{\lambda}{4}$ away from the wall, since a displacement antinode occurs (**fig. 7e**), giving maximum particle velocity and greater heat losses. It follows that for absorbent materials applied directly to the walls, the absorption coefficient decreases as the frequency is lowered, because the velocity antinode is progressively farther from the absorber. Sometimes, the absorbent material may be sandwiched between the wall and a perforated panel, the latter being used to reflect high frequencies and thus prevent too much absorption occurring in this region (**fig. 9a**). The absorption coefficient at high frequencies is determined by the percentage of the area covered by holes.

At low frequencies, absorption is usually provided by *membrane absorbers*, which consist of a panel of non-porous material such as hardboard covering an airtight cavity (**fig. 9b**). The hardboard acts rather like a drumskin, having a fairly low resonant frequency at which it is a very efficient absorber.

FIG. 9 SOUND ABSORBERS



Another common type of absorber is the *Helmholtz Resonator* illustrated in **fig. 9c**. This consists of a volume of air contained in a rigid enclosure, and connected to the room by a narrow passage. At the resonant frequency, sound energy is converted into heat by friction of air particles in the neck of the resonator, and these losses may be further increased by a sheet of gauze stretched across it.

The basic Helmholtz resonator is a sharply timed device but much use is made of variations on this type of absorber. Panels containing many slots or perforations can be used to cover a cavity, this arrangement acting as a series of low efficiency absorbers, operating over a wider frequency range than the simple resonant absorber.

The studio should be situated as far away as possible from known sources of noise, and the acoustic insulation techniques previously described should be applied. The dimensions of a studio should not bear a simple relationship to each other as more than one mode of resonance will take place at some frequencies, giving rise to bad distribution of the resonance spectrum. The LF resonances should be calculated using Rayleigh's Equation, and verified experimentally using a tone fed to a loudspeaker in the room, the sound being picked up by a microphone in the corner of the room (where a pressure antinode exists for all resonances) and fed to a sound level meter. If the frequency of the tone is varied through the audio range, distinct peaks on the meter will indicate the resonant frequencies and their distribution. In a small room, an even distribution of LF resonance is required in order to obtain satisfactory sound quality, and rooms with simply related dimensions such as 1:2:3 usually prove unsatisfactory.

The reverberation time of the studio can be calculated using Eyring's formula, and measured at various frequencies using warble tone. The absorptive properties of the studio should be adjusted using resonators and porous materials until the desired results are obtained.

A reverberation time calculated for the simple untreated room illustrated in **fig. 10** is shown below, values for T being obtained at two frequencies.

Surface	WALLS	CEILING	FLOOR
Material	Brick	Plaster on Lathe	Wooden Boards
Area (ft^2)	352	120	120
α *(at 128 Hz)*	0.02	0.3	0.3
Absorption (Sabins)	7.0	36	36
α *(at 2048 Hz)*	0.05	0.04	0.1
Absorption (Sabins)	17.6	4.8	12.0

TOTAL AREA 592

Total Absorption at 128 Hz .. 79

Total Absorption at 2048 Hz .. 34.4

At 128 Hz, average value of $\alpha=\frac{79}{592}=0.133$

Using Eyring's formula $T=\frac{0.05\,V}{-S\log_e(1-\alpha)}$

The reverberation time obtained at 128 Hz is:

$$\frac{0.05\times 960}{-592\log_e(1-0.133)}=\frac{48}{-592\log_e(0.867)}$$

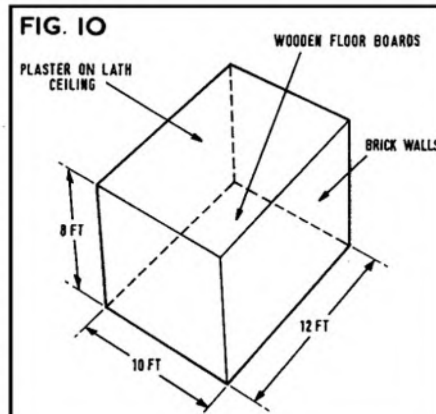
$$=\frac{48}{592\ (0.143)}=\underline{0.57\ s}$$

At 2048 Hz the value obtained for T is **1.35 s.**

For this room the reverberation time is shorter for low frequencies as the ceiling and floor tend to act as membrane absorbers at low frequencies, thus reflecting less sound and reducing the reverberation time. A carpet would be necessary to reduce the noise made in the studio, and it would have the effect of increasing the HF absorption without seriously impairing the absorption at low frequencies. The walls would require treatment with porous material, and it should not be difficult to obtain fairly even reverberation - time / frequency-characteristic suitable for a general purpose studio.

Next month different types of microphones and their uses will be discussed.

FIG. 10



SOUND WORKSHOP

CHOOSING AN OSCILLOSCOPE BY F. C. JUDD

OF all the electronic measuring instruments, the oscilloscope is perhaps the most valuable. It will display the waveform of any alternating current or voltage and measure the amplitude and frequency. It can be used to measure phaseshift, the duration of a single cycle or part of a cycle, and DC voltage and current.

It is not my intention to describe how the oscilloscope works. There are plenty of textbooks that deal adequately with this. More important for us are the requisite facilities of a useful instrument. To be of any real value the screen should be at least 7.6 cm in diameter. The most common trace colour of the oscilloscope is green, and the 'persistence' (time taken for the illuminated area to fade) is usually short. The green trace is quite suitable for photographing. For audio, the time base frequency need only extend to around 50 kHz, which provides waveform display up to 100 kHz or so.

The 'Y' plate amplifier plays a very important role in the oscilloscope and, for accurate work, must have a very wide bandwidth, complete freedom from distortion and phaseshift, and a high input impedance. Some oscilloscopes also have a separate 'X' plate amplifier which can be coupled to the X plates in place of the time base. This must have a performance similar to the Y plate amplifier.

Oscilloscopes are not exactly cheap and a versatile new one would cost about £100. For example, the Knight-kit *KG-635*, assembled, tested and calibrated, costs £110 10s. (as a kit £80 8s. 4d.) and the Grundig *W2/13* retails at £106. There are a few available at around £25 and although these are quite suitable for general audio and radio servicing, they are very limited when it comes to making accurate measurements. It is possible to buy top grade oscilloscopes secondhand, and instruments originally costing £200 or more can be had for as little as £20 to £30. However, be careful when buying secondhand and, unless there is some guarantee of condition and performance, insist on being able to check the instrument over before purchase.

The oscilloscope can show what no other electronic measuring instrument can and that is an actual picture of the waveform of an alternating voltage or current. Moreover it will show any distortion of a waveform which may be present in a circuit. Some oscilloscopes, like the Cossor *1049 Mk 3* used for the photographs in this article, have double traces derived by splitting the electron beam. This allows direct comparison between an original waveform and any changes made to it by a circuit. An ordinary single trace oscilloscope can be adapted for double trace display by an external electronic circuit, though the double trace facility is not essential even for serious work.

As with any amplifier system, the Y amplifier in an oscilloscope can be overloaded to the point of causing violent distortion. For this reason it is important to establish that the signal coupled to the 'scope is within the Y amplifier range as indicated by the input attenuator calibration. Secondly, and to avoid the often small amount of trace distortion, the displayed waveform should never be higher than about one third of the tube diameter, except when measuring amplitude. Never connect voltages higher than the 'scope input rating and avoid running the tube at full brilliance for longer than is necessary, particularly with no input signals.

Because of its very high input impedance, the oscilloscope is rather like a valve voltmeter since it imposes virtually no load on the signal source. However, unless the 'scope has a calibrated DC Y amplifier, it is only suitable for measuring fairly large DC voltages by direct connection to the Y plates. The basic principle can be demonstrated by connecting the X and Y plates as shown in **fig. 1.** The resistor R should be not less than 1 M and, before connecting the voltage, the spot should be at the centre of the tube at A. When the voltage is applied, the spot will move towards point B. The distance d over which the spot has moved is now measured in mm. If S is the sensitivity of the Y plates in mm/V then $V=d/S$. For example, if the sensitivity is 0.3 mm/V and $d=30$ mm, then $V=30/0.3$ or 100 V.

Fig. 2 shows one cycle of a sine-wave. The oscilloscope will simultaneously display one or more complete cycles in exactly the same way but remember that it is showing the peak-to-peak voltage (the full excursion of the trace between the positive and negative peaks of the wave). The true peak voltage is the amplitude of the positive (or the negative) peak from zero. In audio work it is more usual to consider the RMS voltage which is 0.707 of peak V but remember this applies only to pure sine waveforms. It is important therefore to understand fully the calibration of the Y amplifier which should be dealt with in the manufacturer's instruction book.

One of the most simple and accurate methods of determining frequency with an oscilloscope is by the Lissajous method. Signals of a known frequency are coupled to

(continued overleaf)

FIG. 1 BASIC METHOD OF MEASURING DC VOLTAGE WITH THE OSCILLOSCOPE

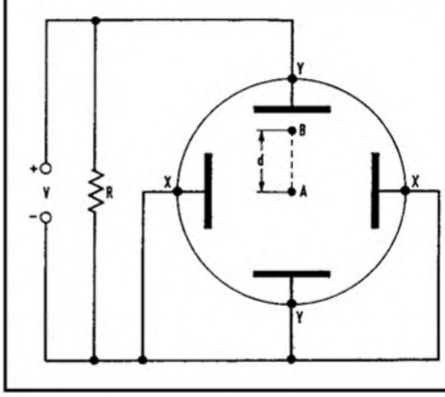


FIG. 2 ALTERNATING VOLTAGE MEASUREMENT

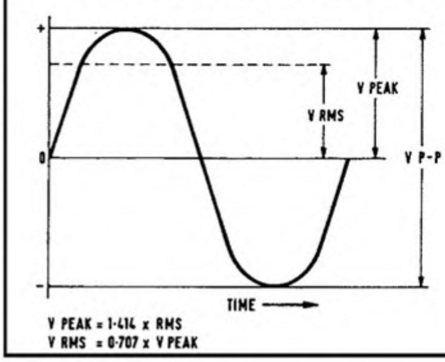


FIG. 3 LISSAJOUS PATTERNS IN FREQUENCY COMPARISON

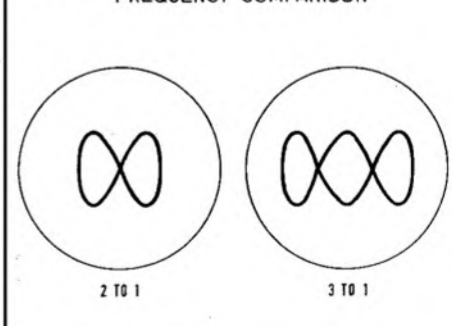
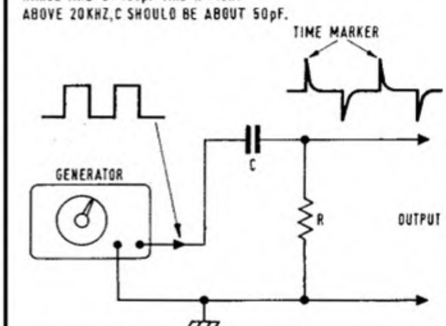


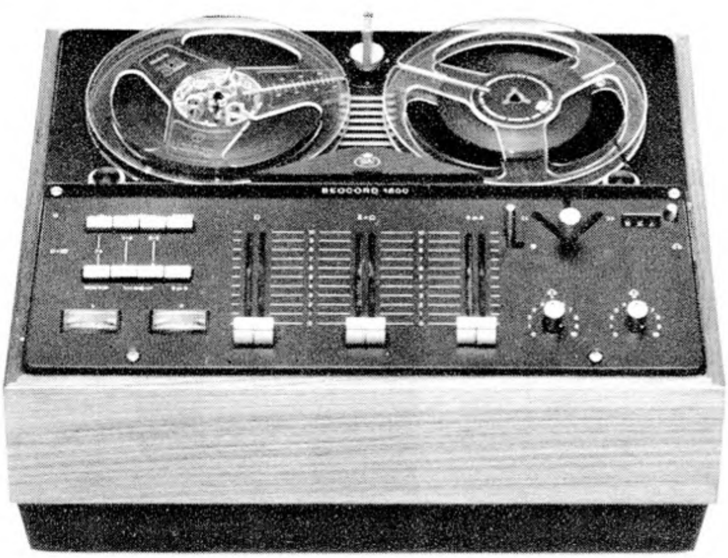
FIG. 11 METHOD OF PRODUCING TIME MARKER 'PIPS' FROM A SQUARE WAVE.
THE TIME CONSTANT FORMED BY C AND R MUST BE FAIRLY SHORT IN ORDER TO PRODUCE SHARP 'PIPS'. AVERAGE VALUES FOR THE AF RANGE ARE C = 100pF AND R = 10K.
ABOVE 20KHZ, C SHOULD BE ABOUT 50pF.

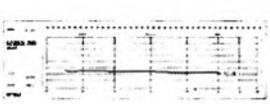


A brilliant new stereo tape deck –the Beocord 1800

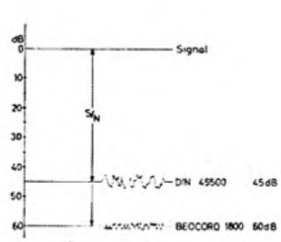
Made by Bang & Olufsen for those who consider design and quality before price.

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.

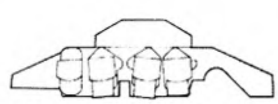




Wide Frequency Response
$7\frac{1}{2}$" sec : 20-20,000 Hz.



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)

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 ½ track version
(¼ 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.

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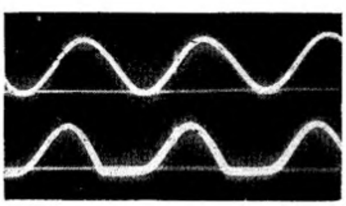
the X plates (directly or via an amplifier) and those of the unknown frequency to the Y plates. The amplitude of both signals should if possible, be the same. A circle will be formed when the signal of known frequency exactly equals that of the unknown, provided both signals are sinusoidal. This is known as a 1-1 Lissajous pattern. If the frequency of one signal is twice that of the other, then a pattern of two loops will be formed like that shown in **fig. 3.** If the frequency of one signal is three times that of the other, a pattern of three loops will be formed, and so on.

The photographs illustrate ways in which an oscilloscope can be used and show waveforms from which secondary information can be obtained. **Fig. 4** is a double beam display showing the output signal levels at 1 kHz from the two channels of a stereo tape recorder (off

FIG. 4

tape). It shows not only the amplitude of both signals to be the same but also that there is negligible phase difference between the two. **Fig. 5** shows the effect of half-wave rectification, and the difference between the input

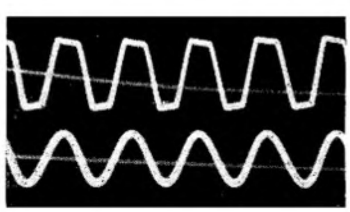
FIG. 5



sine-wave and the rectified signal which now contains only the positive peaks.

Fig. 6 (upper trace) shows severe clipping at the output stage of an audio amplifier, due to excessive gain. The lower oscillogram shows

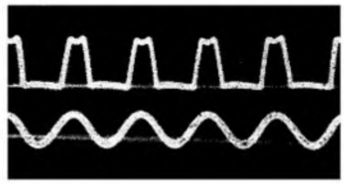
FIG. 6



the input sine-wave signal. Another example of clipping distortion is shown in **fig. 7.** Here the lower trace is of the sine-wave input signal whilst the upper trace shows the effect of overloading at the input stage of a pre-amplifier. The small depressions at the peaks of the upper trace are due to reverse current effects in the input transistors employed in the preamplifier.

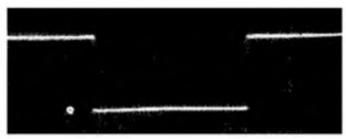
The frequency response and other characteristics of an amplifier can be determined by what is known as square-wave testing. A square-wave of 1 kHz fed into an amplifier with a perfectly uniform frequency response

FIG. 7



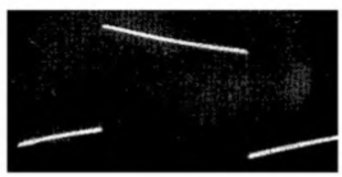
up to around 25 kHz should emerge as a square-wave with little or no alteration. Bass response can be checked in much the same way. **Fig. 8** shows a perfectly uniform square-wave (ratio

FIG. 8



1-1) from an audio generator. The same square-wave is shown in **fig. 9** as it appears at the output from a power amplifier. The

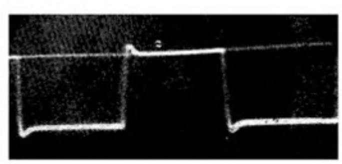
FIG. 9



sloping top and bottom indicates a falling response at the lower frequencies.

Another example of amplifier performance is shown in **fig. 10.** This is a 1 kHz square-wave as seen at the amplifier output and the 'pips' at the trailing and leading edges indicate

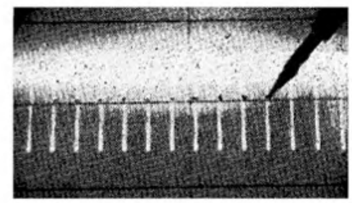
FIG. 10



'ringing' (the start of a spurious HF signal), due to resonant elements in the amplifier—probably in the treble control network.

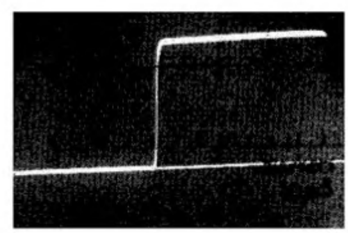
One fina example and this can also be applied to amplifier testing, is that of measuring the 'rise time' of the leading edge of a square-wave after it has been passed through an amplifier. A fast rise time indicates good treble response but it is necessary first to calibrate the oscilloscope time trace in terms of micro-seconds. Sharply defined time markers can be derived from the square-wave output of a sine/square-wave audio signal generator by differentiating the square-wave as shown in **fig. 11.** The positive or negative going pips may be rectified out by means of a crystal diode. The pips are of course directly related to the frequency of the signal from the generator, each positive (or negative) going pip being equal to one cycle of the signal. If, for example, the signal frequency was 1 kHz, each pip would represent an interval of 1 mS. This is much too long a duration for amplifier testing, as it is usual to employ a square-wave with a rise time (time taken for the leading edge to travel from zero to maximum amplitude) of around 1 µS. Therefore a much higher frequency must be used for producing the time markers. **Fig. 12** shows 10 µS markers (derived from a differentiated 100 kHz signal)

FIG. 12



aligned on the oscilloscope. The intervals are then marked in ink on the tube screen, or its graticule in ink. The time base speed control must now be left set since any change in this would render the calibration marks quite useless. The square-wave to be examined (usually at a frequency of 1 kHz) is now connected to

FIG. 13



the 'scope input and its frequency adjusted a little one way or the other until it locks on to the time base. The X shift control is then adjusted so as to line up the bottom of the leading edge of the square-wave with one of the markers. As can be seen in **fig. 13** the rise time of the 1 kHz square-wave occupies only a little over 0.1 of the distance between two markers and is therefore a little over 1 µS. The small curvature at the top is due to stray capacity in connecting leads and at the input of the oscilloscope.

a silicon transistor stereo tape amplifier

PART TWO

BY T. J. MELVILLE

THE design of the oscillator incorporated into my system is shown in **fig. 4**. The circuit consists of two transistors in a monostable multivibrator, operating in the Class D, or saturated switching mode, to reduce power dissipation in the transistors to a minimum, and to increase efficiency.

The construction of this particular piece of paraphernalia proved to be by far the most vexatious, in spite of the design's apparent simplicity. However, it is believed that most of the red herrings and potential electric fires have been caught and disposed of. Basically, the problem is that so many variables have to be taken account of, that no straightforward 'do this and it will work' circuit can be given, and hence the number of asterisks on the diagram reproduced. But, if the suggestions to be given are heeded, an adequately powerful oscillator that does function as desired can be built without a surfeit of fuss.

The first item to consider is the choice of operating frequency. If this is too low (say below 55 kHz), beat notes in the audible range will be produced when a multiplex switching tone (38 kHz) is mixed with the tone generated by the oscillator. If the frequency is too high, the losses in connecting wires and the tape heads themselves will prevent the system ever working properly. Further, if the frequency is too low, the design of an effective bias trap would become very difficult. A bias trap is necessary to reduce intermodulation in the output stage of the recording amplifier. But again, if the frequency were too high, the problems caused by spurious radiation from the ferrite transformer and high voltage bias connecting wires would be impossible to deal with. I chose a frequency of 75 kHz, though I would be rash to imply that this is a perfect compromise.

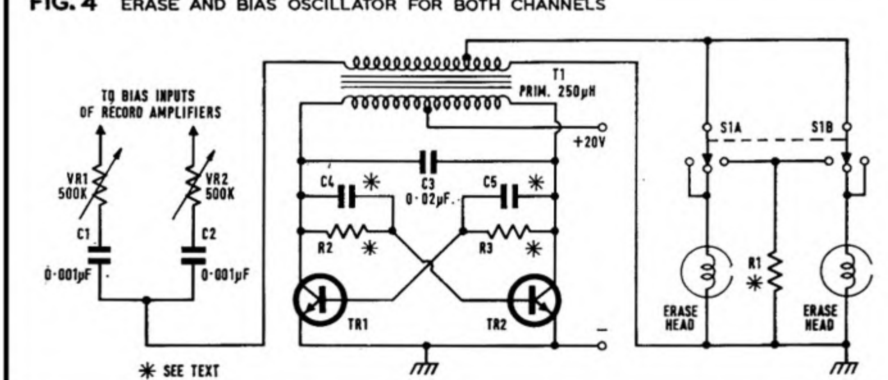
The next consideration is the transistors to be used. With a supply voltage of around 20 V, the p-p voltage developed across the primary of T1 in **fig. 4** is in the order of 120 V, and peak V_{ce} for each transistor is then 60 V To be on the safe side, the transistors used should be capable of working at voltages somewhat higher than this; Texas *2SO18's* (V_{cb} and V_{ce} both 100 V max.) were chosen for the prototype as they were available quite cheaply. These types can also dissipate up to 4 W with heat sinks. In theory, heat sinks should not be necessary if dissipation is kept low, but their use is strongly advised, especially when setting up, to avoid possible catastrophes. I used small pieces of steel sheet (12 sq. cm.) curled over at one end, and clipped over the metal headers of the transistors. These became quite warm during the 'research' period but were still barely tepid, once the system was set up correctly, even after the equipment had been on for several hours. It should be pointed out that the headers of the transistors are 'live' so the heat sinks must be kept floating.

The frequency of the oscillator is determined by C3 and the inductance of the primary of T1. A medium wave ferrite aerial is used for the transformer, which, on the face of it, is a highly unorthodox object to use as a low frequency transformer. However, the Repanco *FS3* has a very suitable inductance (approximately 250 μH for the red/black winding; the green/blue one should be ignored): the Q of the tuned circuit should not be too low if a reasonable sine-wave is to be produced, and yet not too high if the load on the secondary winding is not to distort the waveform unduly. The *FS3*, of course, has no centre tap, so one has to be provided for it. My sample, admittedly a rather elderly one, had 64 turns on the red/black winding, so 32 turns were counted off, a small piece of cardboard inserted under the wire, the silk covering removed at this point and a connecting wire soldered on. The secondary consists of 300 turns of 34 swg. copper wire (enamelled or silk covered), random wound over the 'primary' as it now becomes, and *in the same direction* as the latter. If necessary, the wire can be held in place with molten candle wax. The secondary should be tapped at 40, 50 and 60 turns for the erase heads; the whole of the winding supplies the bias for the recording heads.

As shown on the diagram, C3 is a .02 μF capacitor, which should resonate with a 250 μH coil at 71 kHz, but due to inductance loss in the transformer when the secondary is loaded, the actual frequency is around 75 kHz. The precise frequency is not critical, but it is an idea to check it on a long-wave radio set, if possible, or better, with a frequency meter or oscilloscope. Virtually any sinusoidal oscillator produces harmonics, and this one is no exception. Even if the RF harmonics are very weak compared with the power developed at the fundamental frequency, they will still be strong enough to be picked up by a portable radio close by, since a ferrite transformer unfortunately acts as a highly efficient radiator. Twiddle the tuning knob on the radio until two adjacent harmonics are found. (A radio with a tuning meter is ideal.) The difference in frequency between them is the frequency of the fundamental.

Those who wish to change the frequency of the oscillator can easily do so by experiment, using a radio set as a check. Those who perform well at algebra can calculate the value of C3 from the formula:

FIG. 4 ERASE AND BIAS OSCILLATOR FOR BOTH CHANNELS



a silicon transistor stereo tape amplifier

$$f=\frac{1,000,000}{2\pi \times \sqrt{L \times C}}$$

where f is the frequency in kHz, L the inductance in μH and C the capacitance in pF.

The reactive capacitance of C4 and C5 and the resistance of R2 and R3 must be accurately determined if transistor saturation is to occur at the correct part of the cycle. Their values can be worked out on paper, provided the transistors' current gain (H_{FE}), the supply voltage, the current drawn, and the working frequency (on which C4's and C5's reactance depends) are precisely known. However, all these supposed constants vary according to the load on the secondary of T1 and, in fact, I wasted reams of paper struggling with equations like 'How many milliamps make five?', only to find myself defeated. The oscillator is fed from the power supply via a voltage-dropping resistor, and so as soon as one alters the current, the voltage also changes. Using a stabilised supply would help to some extent but would not stabilise the transistors' H_{FE}.

Eventually, armchair theorising was abandoned, and the well established and highly reputed method of trial and error was adopted. It is suggested that would-be frustrated constructors do the same. All that are required are some capacitors and resistors of various values (capable of a high working voltage), two 100 K potentiometers and a multimeter. The design is built on tag boards to facilitate the substitution of components, two .001 μF 400 V DC working capacitors are wired in for C4 and C5, and the pots are used as variable resistors for R2 and R3.

The erase winding of T1 is connected to both halves of the stereo erase head (or to the one mono erase head), using the 60 turn tap. The supply voltage dropper in the prototype is a 50 ohm resistor, but it is suggested that a resistor of at least 100 ohms be used to start with. A 200 ohm pot would be a useful substitute. The multimeter is connected across the erase heads to measure the erase output. An ordinary test meter is, of course, quite incapable of giving correct readings at 75 kHz, and, ideally, a valve voltmeter should be used, but a multimeter should give *relative* readings quite satisfactorily. With the pots at maximum resistance, connect up to the supply, and decrease the resistance of each pot in alternate steps until the meter gives a maximum reading. If an increase is unobtainable, reduce the values of C4 and C5 to, say, 820 pF. The maximum voltage available at the 60-turn tapping should theoretically be about 40 mV RMS, if the DC supply is 20 V. Change the value of the dropping resistor so that the supply does reach that level. Next, with the meter still connected, wire up the erase heads to the 50 and 40-turn tappings, readjusting the pots slightly. If the voltage *rises* on a *lower* tapping the higher one was being overdrawn: select the tapping which gives the highest output.

Next, acquire a highly modulated tape and attempt to play it back with the erase heads in operation. Provided the heads are correctly positioned, complete erasure should be achieved. If it is not, one can increase the power of the oscillator to its maximum safe level by running it direct from the 28 V supply. At this voltage, the circuit will consume about 6 W, and at least 3 W should be delivered to the erase heads. If erasure is still unsatisfactory, the oscillator frequency is too high and should be lowered by increasing the value of C3.

At no time must the transistors be allowed to run hot. When maximum output is obtained from T1, the pots should be backed off slightly, until the meter just registers a decrease in voltage. The transistors will then be operating in an optimum condition. If they still run hot, the settings of the pots are too low, and too much DC bias is getting through. Ideally, R2 and R3 should be omitted; that is, all cross-coupling between the transistors should be capacitive, so preventing DC bias keeping them switched on all the time. However, if no DC bias were present, oscillation could not commence, since both transistors would remain switched off.

In practice, R2 and R3 should not fall below 8 K, if overheating is to be prevented. The pots should be removed from the circuit, and their settings measured on the multimeter. If below 8K, C4 and C5 should be increased initially to .0011 μF (by wiring 100 pF capacitors in parallel), and the setting-up process repeated. Eventually, the pots can be replaced by fixed resistors, or pre-sets can be left wired in.

On mono, only one erase head is used, of course, and so in a stereo system, a resistor, R1 replaces the second erase head in the load presented to T1. The value of R1 should be determined using the test meter: the relative voltage should be the same on both mono and stereo. Changing an inductive load for a resistive load alters the frequency of the oscillator slightly. But, using a frequency meter, the change on the prototype was found to be an increase of only 3 kHz on mono, and this does not affect the operation of the oscillator adversely.

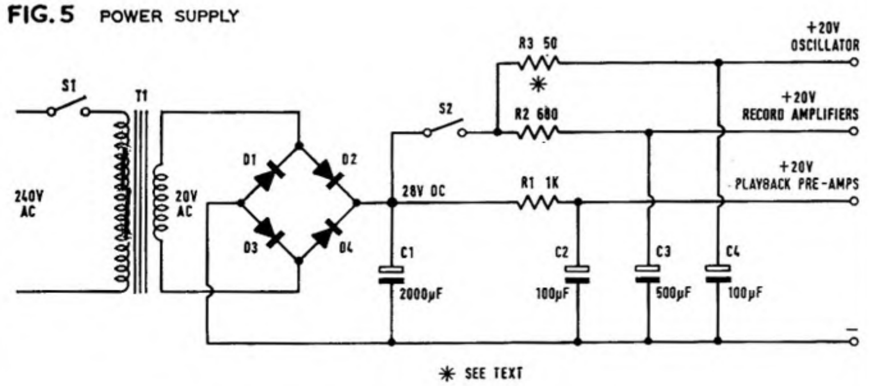
Durham Supplies of *175F Durham Road, Bradford, 8*, supply ¼-track Mu-metal Marriott heads (for BSR decks) at 39s. 6d. a pair (i.e., 1 record/replay and 1 erase head). Using this erase head, T1's secondary is tapped at 40 turns, R1 is 470 ohms, R2 and R3 are 9.1 K, C4 and C5 are .001 μF, the DC supply is 20 V. at 150 mA., and the voltage dropper is 50 ohms, 1 W (47 ohms is nearest 10% preferred value).

As indicated earlier, problems are likely to arise from spurious radiation of the oscillator circuitry. Radiation at the fundamental frequency will be the greatest problem, and so it is advised that the oscillator should not be incorporated in the main unit, but should be housed in a box of its own close by. Using a ferrite 'aerial' does not aggravate the problem by any means. An ordinary pot core was assembled as a second version of T1 and was duly tried out. In fact, radiation from this turned out to be more difficult to deal with, since it was omnidirectional. The radiation from a ferrite slab, on the other hand, is highly polarised, and if mounted vertically at one side of the amplifier, it can be placed right up against the aluminium case with hardly any obnoxious effects becoming noticeable. With the ferrite slab left unscreened, but in a vertical position, interference on medium and long waves is also much reduced, which is essential if one wants to record from such a source. Ideally, the whole oscillator should be screened and this should be quite feasible, as long as all earthed metal is kept at least 5 cm. away from the actual ferrite transformer. If it is too close, losses due to radiation become so high that the circuit's output power is seriously reduced.

The wire carrying the bias into the main unit should be kept short and screened, but it was found that the lead connecting up the oscillator to the erase heads could be left

(*continued on page 205*)

FIG. 5 POWER SUPPLY



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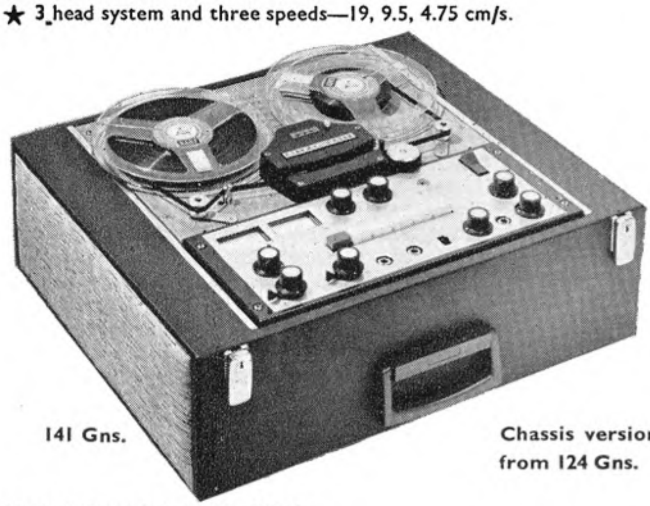

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unscreened. In spite of these precautions, however, the capacitor C1 in **fig. 2** (last month) has to be incorporated to stamp out any bias (or RF) present at the highly sensitive input of the recording amplifier. If necessary, C1 can be increased to .003 μF before appreciable treble attenuation occurs. No such bypass capacitor is required in the replay pre-amp circuit, due to the very high level of high-frequency attenuation in the design.

Returning to **fig. 2,** L2 and C12 constitute a tuned circuit, whose resonant frequency is that of the bias oscillator. This device blocks the bias fed to the recording head from reaching the collector of Tr3, and so causing distortion in the signal to be recorded. A Repanco *DRX1* was used for L2 in the prototype, though, as a reasonable Q is necessary if the tuned circuit is to be at all selective, extra wire was wound on, in series with the original L.W. winding, and in the same direction. Using 34 SWG silk-covered copper wire, as many turns were wound on as it was physically possible to accommodate on the former, using wax to hold them on. The inductance was then measured by wiring a 1.5 KpF variable capacitor (a three-gang 500 pF tuning capacitor wired in parallel) in parallel with it. Coil and capacitor were then connected across the erase winding of the oscillator transformer, together with the test meter. The latter read maximum when the capacitor was set for resonance at 75 kHz. Two iron dust cores are inserted to boost inductance and provide a means of adjustment when the variable capacitor is replaced by a suitable fixed one.

If the bias traps are to be incorporated into the main unit, the coils must be effectively screened. I used the aluminium containers that proprietary drugs such as aspirin are marketed in ; these were 3 cm in diameter, and can easily be cut to the required length. Although left with one end open for connections to be made to the terminals, each screening can should be long enough to enclose the bulk of the coil former, which can be jammed in with insulating tape. A solder tag is bolted onto the can for earthing purposes. With this accomplished, the inductance should be rechecked, as it tends to decrease with the coil thus encapsulated.

Inductance on the prototypes was around 7 mH with dust cores fitted ; to resonate at 75 kHz, a parallel capacitor of 642 pF would then have been required. A 680 pF 1000 V capacitor was fitted, and one dust core partially unscrewed and used for tuning. C11 earths the small amount of bias that still gets through the trap circuit. The latter can never be 100% efficient anyway, of course, and efficiency is slightly worsened by the inevitable but limited drift of the oscillator frequency. Both C11 and C1 will cut the treble response of the amplifier slightly, and hence one reason for having plenty of treble boost incorporated into the design.

Ready-made coils suitable for use as L2 are made by Osmor (Type *QT 6*). These have adjustable cores and a minimum inductance of 23 mH. With these, C12 will need to be 200-220 pF. Osmor coils would have been used in my system, but unfortunately I could find no local supplier who stocked them or could even obtain them at the time of construction.

With the whole system wired up, and with the main amplifier or headphones connected to the monitor output of the left-hand recording amplifier, feed a high level signal into the radio input. A signal generator set to 1 kHz is an ideal source, but noisy beat music is quite suitable. Set VR1 of **fig. 2** so that Tr1 is at the overload threshold, and a just noticeable distorted signal appears at Tr3. A resistor of a suitable value (usually a few kilohms) should be chosen for R18, so that the pointer of M1 remains at FSD with VR1 backed off slightly, i.e., with *no* audible distortion present in the signal reaching the meter amplifier. Next, connect the main amplifier up to the left-hand replay preamp, and set the tape deck in motion for recording on the left-hand channel. Set VR2 to a midway position and the bias level control (VR1 on **fig. 4)** to maximum ; adjust the core of L2 first for minimum hum, and then for minimum distortion. With the bias control at maximum, the treble response should disappear completely : back off the control to a point where the treble response seems overemphasised, but where distortion is not too apparent (distortion here being caused by lack of bias). Then, with M1 still at FSD adjust VR2 until the point is found where noticeable distortion reaching the playback system due to overmodulation of the tape just disappears. Finally, the whole process must of course be repeated for the right-hand channel.

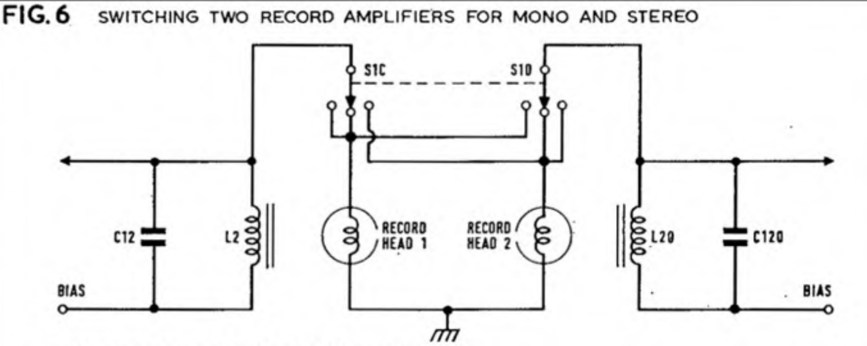
Different brands of tape require different amounts of bias, and although most full-price brands are now fairly consistent and egalitarian in their characteristics, cheap imported tapes have been found to vary widely. Consequently, the bias controls are fitted on to the front panel of the prototype, so that they can be adjusted for the optimum level with any type of tape.

The optimum level of bias applied to the recording head is, in fact, a compromise between low distortion and low tape noise on the one hand, and good high frequency response on the other. A high level of bias is required for the former, and normally a low level for the latter. However, as indicated before, treble emphasis in this recording amplifier design is very high, and, in practice, the tape has to be quite heavily *overbiased* for an overall flat response to be obtained. The advantages of this arrangement are that a greater dynamic range is obtainable in the recording process, since the signal-to-noise ratio of the signal actually recorded on to the tape is improved, and that occasional overmodulation, as might occur when recording classical music, results in such a low level of distortion that it ceases to be significant at all.

Figs. 4 and **6** show how mono/stereo switching is accomplished on the prototype. The outputs of both recording amplifiers are fed to one half of the recording head in the mono mode ; this means that the two amplifiers can be used to mix two different signal sources if desired. The disadvantages of this arrangement are that two doses of bias would reach the recording head, if one of the controls were not backed off, and that neither of the level meters indicates the *total* signal level reaching the head. I would agree that this set-up is not entirely satisfactory, but at least switching is kept uncomplicated. There is, of

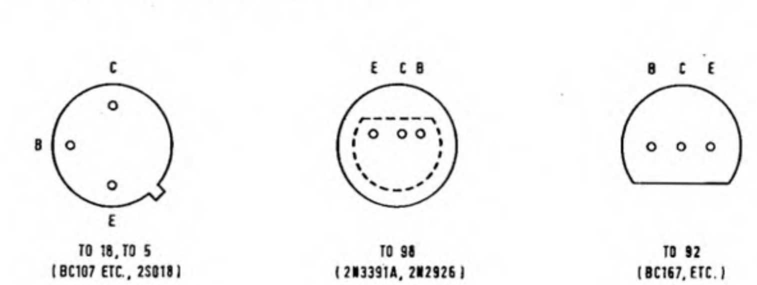
(*continued overleaf*)

FIG. 6 SWITCHING TWO RECORD AMPLIFIERS FOR MONO AND STEREO



NOTE: S1C AND S1D ARE GANGED WITH S1A AND S1B OF FIG. 4

FIG. 7 TRANSISTOR LEAD-OUT DIAGRAMS



course, no objection to using a more complex switching system, if the constructor feels this is necessary, or the mixing facility can be abandoned altogether.

The recording amplifier will function well with heads of low and medium impedances, but is unlikely to do so with a high impedance head (above, say, .4 H). The higher the impedance, the higher the EMF fed to it needs to be. If too high, Tr3 of **fig. 2** will be overloaded before tape saturation is reached. If the use of a high impedance head is considered essential (if, for example, a ferrite type is to be used) Tr3 would need to be fed from a higher voltage supply (30-50 V), and at a higher current, if a sufficient EMF were to be developed across R15. Incidentally, the BSR (Marriott) head mentioned earlier seems to have a lowish impedance and performs well.

Fig. 5 is a design for a suitable power supply. Although all the different items in the system are intended to run from 20 V supplies, the voltage available is around 28 V. The latter is not particularly critical, provided the dropper resistors are selected appropriately. By having a 28 V supply, three separate 20 V outputs, decoupled from each other, can be obtained. The values quoted for C2 and C3 are the lowest practicable, if hum is to be minimised. The use of larger capacitors is quite in order. The function of C4 is not only to provide AC decoupling between the oscillator and the power supply, but also to provide automatic degaussing facilities for the erase and record heads when the supply is switched off (i.e., when S2 is opened). If the oscillator suddenly stopped functioning in midcycle, the poles of the heads would remain partially magnetised. But with the present arrangement, when the supply is cut off, C4 discharges and prevents any instantaneous cessation of oscillation. Since the oscillator transistors operate as saturated switches with a 20 V supply, they will still be operating as *unsaturated* switches even when the supply voltage has dropped to near vanishing-point.

It is worthwhile pointing out that the playback heads can also be degaussed when necessary, by temporarily plugging them into the record output sockets of the amplifier and switching on the oscillator for a few seconds. Although not shown on **fig. 5**, it is suggested that a quick-blow fuse (of 200-300 mA as suitable) be incorporated in the circuit between C1 and R1 and S2. The purpose of this is mainly to protect the oscillator transistors in the event of thermal runaway. It will also protect the rectifier diodes in the event of a short developing in the amplifier.

Now a word about hum-loops and how to avoid them. It has already been stated that the whole of the playback preamp circuit board should be earthed to chassis at only one point. The same goes for the record amplifier board. However, I found that hum-loops can also occur in the oscillator circuit, resulting in hum being recorded on to the tape by the erase heads. To avoid this problem, two earth return leads should be wired to the erase heads, one for each; at the amplifier end, the earthed terminals of the erase and record output sockets and the earth return lead from the oscillator should all be connected to chassis at one and the same point. It was found that R1 of **fig. 4** could fortunately still be earthed elsewhere, as could the record amplifiers.

On the prototype, individual screened plugs and sockets are used for each record and playback head (and for all other input and output connections, except for the erase output). This means that all connecting leads can easily be swapped round without the need for any complex switching. Thus, it is possible to use one half of the record head for playback, when making a multitrack recording requiring exact synchronisation between tracks. If a low or medium impedance head is used for replay, it can also be used for recording, and various pre- and post-echo effects can be produced quite easily. Anyone wanting a versatile outfit, therefore, should stick to good old phono connectors, and keep a couple of short leads handy for connecting inputs to outputs, etc. DIN plugs and sockets should be banished back to the Continent, where they belong!

COMPONENTS LIST

PLAYBACK PREAMPLIFIER (FIG. 1)

Transistors
Tr1 2N3391A (G.E.)
Tr2 BC 109B, BC 169B (Siemens), or 2N2926 yellow or green (G.E.)
Tr3 BC 107B, BC 108B, BC 109B, BC 167B, BC 168B or BC 169B (Siemens)

Resistors 0.25 W

R1 300 K 5%	R6 1 K 10%
R2 5.1 K 5%	R7 82 ohms 10%
R3 51 K 5%	R8 10 K 10%
R4 560 K 5%	VR1 50 K lin. preset
R5 47 ohms 5%	VR2 5 K lin. or log. preset

Capacitors
C1 50 μF 3 V electrolytic
C2 10 μF 25 V electrolytic
C3 .0056 μF 5%
C4 100 μF 3 V electrolytic
C5 25 μF 15 V electrolytic

Veroboard (9.5 x 9.5 cm for stereo).
Screened sockets.

Suppliers
Duxford Electronics, 97 Mill Road, Cambridge: 5% low-noise resistors 2d., subminiature skeleton pre-set pots 10d., C3 (poly.) 7d. Veroboard 3s. 11d.
Electrovalue, 32a St. Judes Rd., Egham, Surrey 50 μF 10 V, 10 μF 25 V 9d., 100 μF 10 V, 25 μF 25 V 1s., *2N2926/Y* 2s. 9d., *BC 168B* 2s., *BC 169B* 2s. 3d., miniature pots (ordinary type) 2s. 3d.
J. Birkett, 25 The Strait, Lincoln: *2N3391A* 4s. 6d.
Alpha Radio Supply Co., 103 Leeds Terrace, Leeds 7: Panel-mounting pre-set pots 1s. 6d. (for 50 K, 100 K pot + 100 K resistor across track must be used).

RECORD AMPLIFIER (FIG. 2)

Transistors
Tr1 2N3391A (G.E.)
Tr2 BC 109B or BC 169B (Siemens)
Tr3 and Tr4 as for Tr3 of **fig. 1**

Resistors 0.25 W

R1 39 K 10%	R12 2.2 K 10%
R2 220 ohms 10%	R13 330 K 10%
R3 62 K 5%	R14 33 K 10%
R4 47 ohms 5%	R15 10 K 10%
R5 47 K 5%	R16 2.2 K 10%
R6 100 K 10%	R17 3.3 K 10%
R7 68 K 10%	R18 see text
R8 100 K 5%	VR1 50 K lin. or log.
R9 4.7 K 10%	VR2 10 K lin. or log. preset
R10 22 K 10%	
R11 10 K 10%	VR3 20 K ditto

Capacitors

C1 .001 μF	C8 1 μF 15 V electro.
C2 25 μF 3 V electro.	C9 .02 μF or .022 μF
C3 200 μF 25 V electr.	C10 .02 μF or .022 μF
C4 100 μF 6 V electro.	C11 .003 or .0033 μF
C5 .002 or .0022 μF	C12 see text
C6 1 μF 6 V electro.	C13 1 μF 15 V electro.
C7 .33 or .35 μF	C14 (**fig. 3**) 50 μF 3 V electro.

Inductors
L1 3 mH   L2 see text

Two S.P.S.T. (D.P.S.T. for stereo) switches
Veroboard (12.8 x 9.5 cm for stereo).
Screened sockets.
For M1 (level meter) see text.

Suppliers as for **fig. 1** except Veroboard (5s. 6d.). For 10 K panel-mounting preset pot use 11 K type (Alpha Radio). 250 μF 25 V 2s. (Alpha Radio). .33 μF 1s. 3d., .0033 μF 7d. (Duxford), D.P.D.T. slide switches 2s. 6d. (Alpha Radio).
G. F. Milward, Drayton Basset, near Tamworth, Staffs: 1 μF 20 V 1s., .22 μF 6d., .001 μF, .0022 μF, .02 μF 3d.
Radio Experimental Products Ltd., 33 Much Park Street, Coventry: MW/LW aerial coil DRX1 (3s.) for L1 and L2 (see text).

Fig. 3 D1-4 any germanium diodes, 'surplus type' 6d. from Birketts.

OSCILLATOR (FIG. 4)

Transistors Tr1 and Tr2 2SO18 (Texas)
Resistors R1-3 see text
VR1 and VR2 500k lin. 0.25W
Capacitors C1 and C2 .001 μF (500 V AC or 1 kV DC)
C3 .02 or .022 μF (200 V AC or 400 V DC)
C4 and C5 see text
Inductor T1 M.W. ferrite slab aerial FS3 (see text)

S1 4-pole 3-way rotary switch (see also **fig. 6**). Not required for mono system. Tagboard for mounting components.

Suppliers *Alpha Radio:* S1 3/3, 6-way tagboards 6d. (two may be required)
R.E.P. Ltd.: FS3 7s. 6d.
L.S.T. Components, Coptfold Rd., Brentwood, Essex: 2SO18 10/- pair. .022 μF 400 V 3d (Milward's)

POWER SUPPLY (FIG. 5)

D1-4 100 V 500 mA silicon diodes
T1 mains transformer with 18-20 V secondary, at 500 mA.

Resistors R1 1k 10% 0.25 W (2.2 K mono)
R2 680 ohms 10% 0.25 W (1.2 K or 1.5 K mono)
R3 50 ohms 10% 1 W (see text)
Capacitors C1 2000 μF 35 V electrolytic
C2 100 μF 25 V electrolytic
C3 500 μF 25 V electrolytic
C4 100 μF 25 V electrolytic

2 S.P.S.T. switches. Tagboard.

Suppliers 9-0-9 V transformer 11 s. from *Harverson Surplus Co. Ltd., 170 High Street, Merton, London S.W.19.*
400 V 500 mA diodes 1s. (Birkett's) 100 μF 25 V, 1s. 6d., 500 μF 25 V 2s. 6d. (Alpha Radio), 2000 μF 50 V 9s. (Electrovalue), R3 4d. (Electrovalue). *Halse Services, 36 Gloucester Road, Feltham, Middlesex:* switches 2s.

metrication

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

PART ONE

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.*

FIG. 1 IMPERIAL MEASURES

LENGTH	WEIGHT
Inch	Ounce
x 12	x 16
= Foot	= Pound
x 3	x 14
= Yard	= Stone
x 22	x 2
= Chain	= Quarter
x 10	x 4
= Furlong	= Hundredweight
x 8	x 20
= Mile	= Ton

FIG. 2 METRIC SYSTEM PREFIXES

		Abbreviation	
x One Million	1 000 000	mega	M
x One Thousand	1 000	kilo	k
x One Hundred	100	hecto	h
x Ten	10	deca	da
÷ 10	0.1	deci	d
÷ 100	0.01	centi	c
÷ 1 000	0.001	milli	m
÷ 1 000 000	0.000.001	micro	μ

'METRICATION' is a word now often heard, and usually referred to with disgust as one of these revolting foreign ideas that we get foisted on us nowadays.

I hope to show that metrication is far from revolting and that, except in a few cases, the only merit of the units which we are now using is that we are familiar with them—or are we? Who can define a bushel or a peck?

Almost all measurements consist of a pure number either as a cardinal as in 'four cows' or as a ratio like 'there are four times as many cows in this field as in that field'. In some cases the unit associated with the cardinal number is more difficult to define and realise, like 'pounds per square inch' or even just 'inches'.

For the purposes of trade and commerce, it was found necessary, very early in the development of civilisations, to define and maintain stable standards of length and mass. In more technical communities, a standard of time also needs to be agreed, and the whole of science and technology can be measured with only two more, a standard of temperature interval and a standard of luminous intensity. In addition, to tie in the electrical units, a number has to be assigned to either the permeability or the permittivity of free space. The former leads to the electromagnetic system of units, and the latter to the electrostatic system. The two systems lead to the same result: it is just that the derivations are different.

The need to measure things arose quite early in the history of man. Distances and areas are needed in surveying and in the transfer of land. Weights and lengths are needed in trade. Early man tended to take as his definitive units the things which he could easily obtain, and which appeared to be of a convenient size and reasonably stable. Different nations used different systems, and there was not always any fixed relationship to the systems of other nations. Some of them even varied somewhat from place to place inside one country.

Almost all of these old National systems have now disappeared—superseded by the metric system. The only important non-metric system still remaining is our Imperial system, based on the foot, the pound and the second. This is at present used in the United Kingdom, the North American continent, and in some of the members of the Commonwealth. It is steadily being abandoned even by those who now employ it.

The length standards of the Imperial system were originally independent. The inch was the length of the first joint of the thumb (the French for 'inch' is *pouce* which means 'thumb'). The foot, as its name implies, was the length of a foot. The yard was a pace. It was eventually found desirable to inter-relate these independent measures, and convenient round numbers were taken to express the relationships. Hence 12 inches to the foot and 3 feet to the yard.

A yard is rather short for measuring the distance between towns, so the Imperial system adopted a form of metric unit, the old Roman 'mille passus' or 'a thousand paces'. The Romans, being rather short Italians, took rather shorter steps than we long-legged Anglo-Saxons, but they also reckoned a pace as *Left*-Right-*Left*, so a thousand of their short double paces were about the same as 1760 of our single paces.

The extraordinary hodge-podge of the Imperial system has resulted from the bringing together of units which were originally individually developed, defined and named. The advantage of an inter-related system is that one only needs a standard of one of them: the others follow by arithmetic.

As if our system was not bad enough, we have still got some old units left over, usually relating to specialised trades. For example the apothecaries' grains and scruples, the jewellers'

(continued overleaf)

FIG. 3 DEFINITION OF THE METRE

1 Metre = 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the energy levels $2p_{10}$ and $5d_5$ of the krypton-86 atom.

FIG. 4 RE-DEFINITION OF THE SECOND

by the 13th General Conference of Weights and Measures.

The Second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.

**Standards Laboratory, Hawker Siddeley Dynamics Ltd.*

pennyweight and troy ounce, the bushel used only with corn, the chaldron, used only in the North-East for coal, the hand used in measuring the height of horses, and the rod (5½ yards and now obsolete) used for allotments. The fathom (6 feet) is used nautically and in measuring the depth of water. However, the height of a pier above water-level is measured in feet. How complicated can you get?

The Imperial system has two sets of volume measures; one for solids, the logical cubic inch, cubic foot and cubic yard (the latter is also used for semi-solids like sand and concrete) and a series used with liquids—the gallon, pint, fluid ounce, fluid drachm and minim. This series is defined as the gallon being that volume of water which weighs ten pounds.

That any of us is able to work in and use the Imperial system at all means that we have got excellent memories, as we have to remember sets of arbitrarily named units, often different in another field, and related by arbitrary numbers. Or are we so good? How much is a gill? Or a rood?

Fig. 1 lists the names and relationship between the units of two of the Imperial measures—those for length and weight. Note that there is no logic in the sequence of names and that no two of the ten multipliers are the same. Conversions are very difficult and we have to use ready reckoners or desk calculators for all but the simplest of them.

The metric system, devised by the French at the time of their Revolution was the first consistent system of units. They adopted a single unit of length, the metre and a single unit of mass, the gramme. To avoid inconveniently large and small numbers when measuring actual things, they adopted multiples in a decade series, but the name of the unit stays the same as in milli*metres* and kilo*metres*. Similarly the prefix stays the same whatever the unit, as in *kilo*metre and *kilo*gramme.

Fig. 2 gives the 'multiplier' and 'divisor' prefixes of the metric system, and their abbreviations. They go in decade steps up to a thousand times and down to a thousandth but the next multiplier and divisor are a thousand times larger and smaller. There were no other multipliers in the original form of the metric system.

HUMAN HABIT

This choice of the prefixes in a decade series springs from the human habit of counting in tens because most of us have ten digits on our hands.

It is interesting to note that in the non-metric countries, there is a strong tendency to work in twelves as in the dozen, gross and great gross. Twelve inches to the foot, twelve pence to the shilling, twelve troy ounces to the pound and so on.

The benefits of the metric system are so obvious that science and the science-based industries have always used it, and I am sure that all of us did our school science in centimetres and grammes. Later on, at universities and technical colleges, the engineers among us got bogged down in the old traditional units.

The cinematograph industry, due to the early influence of the French, always has been a metric one, but the gramophone and tape recording industry, due to the British and American influence, is firmly founded on the inch: the tape speed of 19.05 cm/s is really 7½ inches/s. One day, perhaps, this will be rounded off to 19 cm/s exactly, or even better, to 20 cm/s, though this latter change would raise the pitch of all old-style recordings by nearly a semitone.

As is now well known, this country proposes to convert its industry and commerce to the metric system over the next few years, so for an introduction we may as well look in some detail at what this metric system actually is.

The metric system which most of us learnt and used at school, was one based on the centimetre, the gramme and the second—the c.g.s. system. The gramme was intended to be the mass of a one cubic centimetre of water—actually it was not quite right, and the gramme was actually defined in terms of a particular lump of metal. For example, in magnetics one line per square centimetre is called a gauss, and so on.

Unfortunately, the c.g.s. system is not a fully coherent one, that is to say, odd multipliers come in to the definitions of some of the units. Factors of ten and 4π appear, quite correctly, but they have to be looked up or remembered.

In the formula for magnetising force,

$$H = \frac{4\pi NI}{10\,l}$$

Where H is in oersteds
NI is ampere-turns
and l is in centimetres.

In a really logical system of units, the 4π and the $\frac{1}{10}$ would not be present.

If we take not the centimetre and the gramme as our references, but the metre and the kilogramme, and adopt a different value for the permeability of free space, everything drops into place, and we get a coherent system.

The form of the metric system which we and the rest of the world are adopting is one based on the metre, the kilogramme, the second and the ampere, or the MKSA system. With a few extra conventions and rules, this is called the 'International System of Units' or (in its original French title) the 'Système Internationale d'Unités which is abbreviated to the 'Système Internationale' or 'SI'.

All measurements can be carried out using only six basic definitions: length, mass, time, luminous intensity, temperature interval and an electrical definition. I will deal first of all with luminous intensity and temperature interval and then dismiss them.

Luminous intensity used to be defined in terms of 'standard candles', which were very difficult to reproduce accurately. The SI unit is the Candela (abbreviation cd). Its definition is—'The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600000 square metre of a black body at the temperature of freezing platinum under a pressure of 101,325 Newtons per square metre'. It is most unfortunate that the first SI definition I have to deal with is not a coherent one; if it were, it would be 'one candela per square metre'. The awkward definition was adopted as a matter of expediency to make the definition approximately fit an actual luminance already defined in another way—the old 'candlepower'.

A scale of temperature only requires a starting point and a definition of slope and an agreement as to what will define an even slope. The starting point is no problem—absolute zero: 273.15° Celsius or zero degrees Kelvin. It has been agreed that equality of temperature steps will be determined on the thermodynamic scale, that is that equal temperature increments involve equal increments of thermodynamic energy. These are the intervals which would be determined using a constant volume gas thermometer and a perfect gas.

All that now needs to be done is to assign a numerical value to a 'fixed point'. The fixed point that is used is the 'triple point' of water, and it is assigned the value of 273.16° K. The triple point of water is that temperature where pure water is in equilibrium with ice and its water-saturated vapour. The triple point of water is 0.01°C higher than the ice point. It is used as it is more exactly reproducible than the ice point.

The size of the degrees in the Kelvin and Celsius scales are identical. They have just different starting points; absolute zero for the Kelvin scale, and the ice point for the Celsius scale.

I have used the term 'Celsius' in place of the more familiar 'centigrade'. This is in accordance with an international resolution because a 'centigrade' is a hundredth of a 'grade', and in France a 'grade' is 1/100th of a right angle. The term 'Celsius' is now therefore preferred, as it is the name of the gentleman who first proposed the scale, and luckily his name begins with a C, so that we can continue to write '20.01°C'.

CONVERTED IN PATCHES

I do not want to do more than mention the Fahrenheit temperature scale. It is nowadays not used in science, and in this country is being rapidly superseded, but some diehards are holding on very tight to it. For my part, I have converted in patches: atmospheric temperatures are Celsius and so are heat treatment temperatures and so are all environmental testing temperatures. My own body now runs at about 36.9°C, though at home we still have a Fahrenheit clinical thermometer. A nice warm swimming bath, however, is still 72°F.

The temperature scale used in the SI is the Kelvin scale, with a zero at absolute zero. We are forced to use this in many calculations because of the laws of physics: for example thermal noise power. However, because of familiarity, most day-to-day measurements are carried out in the Celsius scale, with zero at the ice point. Since the temperature interval is the same in both scales, this is a satisfactory compromise, and allows us to use familiar units. By a recent decision of the 13th General Conference on Weights and Measures, we should not nowadays refer to a temperature as so-many degrees Kelvin or °K; the unit is now called the Kelvin, temperatures are so-many Kelvin or so-many K.

So much for the more esoteric units.

For many years, the unit of length, the metre, was defined as the distance apart of two marks on a particular lump of metal. This is known as a 'material standard', and is a simple and easy way of defining something. Material standards are liked by the lawyers as they are things which can be seen and touched, but they have

(continued on page 213)

a stereo boom for fifty shillings

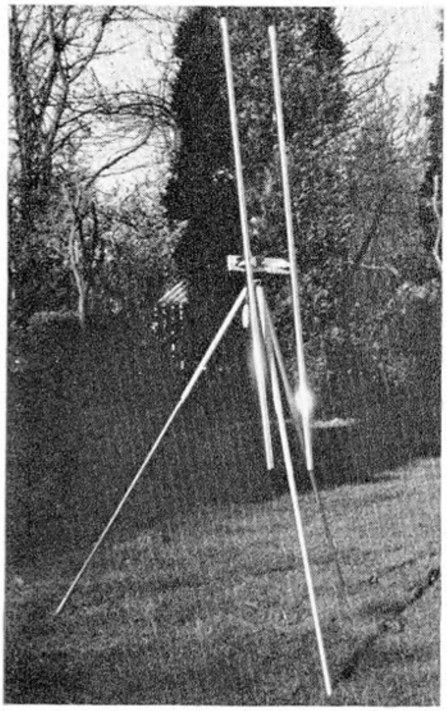
BY DAVID KIRK

HAVING survived for ten years on improvised and borrowed microphone stands, I recently decided to construct a a boom, and if necessary a stand, of my own. The idea was prompted by J. S. Frost's February article 'An Inexpensive Microphone Boom', though his design displayed three disadvantages. It assumed the constructor already possessed a commercial base and stand, it could not be made without specific taps and dies, and it did not seem suitable for stereo microphones.

A good commercial stand and boom can easily swallow the best part of £20 and the first object of the exercise, after versatility, was to save money. The problem of constructing a stand was surmounted without difficulty when I realised that a camera tripod, purchased some years ago for cine and slide photography, was rather more stable than the majority of commercial microphone stands. It was fitted with a small but robust pan/tilt head and telescoped down to a smaller and very much lighter size than the widely used Reslo *MS100A*. The price of the Yashica tripod was around £5, against £7 10s for the *MS100A*.

Camera and microphone mounting threads are not interchangeable (cameras came first, so the photographic industry is not to blame) but a local ironmonger identified the tripod mounting screw as a ¼ inch Whitworth. The original screw was 18 mm long, of which only about 7 mm protruded above the tripod head. Several longer replacements were therefore purchased to accommodate a decent thickness of wood. I had no hesitation in preferring wood to metal, for the boom support, as it is less prone to rattles and ringing. It is also easier to work.

Fig. 1 shows the dimensions of the support, two steel tubes being pinched in similarly



chromed towel rail brackets. The tripod proved stable over a wide range of boom positions, two-thirds forwards plus the weight of two fairly heavy ribbon or dynamic microphones causing no excessive imbalance.

The one critical factor in choosing the boom components is the diameter of the tubes. An outer diameter of 19 mm and 17 mm internal dimension proved remarkably convenient since the female DIN employed with most Continental dynamic microphones (Philips, AKG, Sennheiser and Beyer) slides very comfortably inside the tube. A perfect scratch-free fit (**fig. 2**) was obtained by lining the inner tube wall with a single layer of Sellotape. A few strips of this film also prevent cable damage when ribbons are suspended vertically.

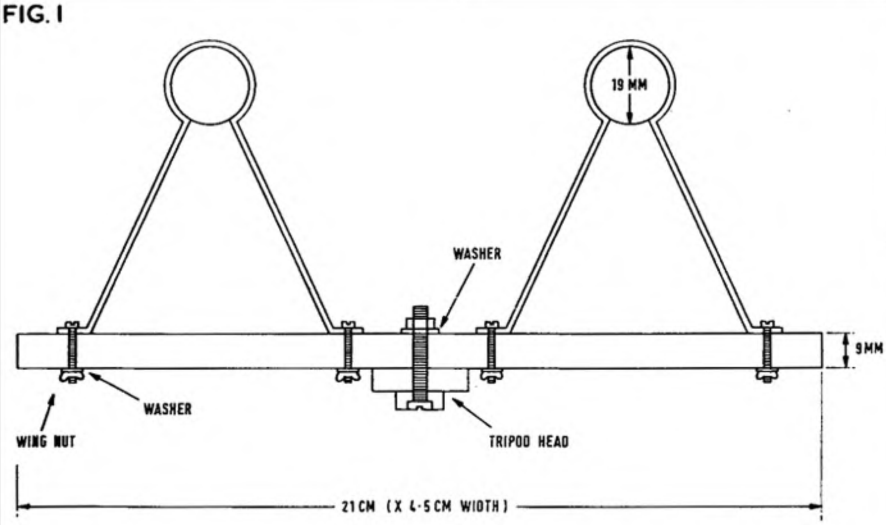
The 19 mm outer diameter is almost exactly the size of the Philips *EL6042* omni-directional dynamic microphone. *Pye TVT Service Department, Beddington Lane, Croydon, Surrey* can supply the complete mounting assembly for this microphone at 18s. Fitted back-to-front it provides the boom with standard-thread microphone mounting facilities. **Fig. 3** shows a Foster *FSA1* mount used back-to-front for the same purpose.

A standard jack plug slides quite easily through the 17 mm inner diameter but

FIG. 2

FIG. 3

FIG. I



Cannon connectors will need adapting to jack. Plastic DIN plugs slide through but not easily. Alternatively the *EL6042* or *FSA1* mounting can be used and the cables suspended outside the boom.

I chose 112 cm lengths of tube for the boom as this was the maximum I could accommodate comfortably on the back seat of my car. The mounting is quite resilient and returns the tubes to parallel if the boom is accidentally deformed in storage. The vertical range of microphone positions, with the tubes clamped some 60% forward of the mounting bracket, is from ground level up to about 1.6 metres. This can be extended 25 cm or so by re-setting the clamps. The ideal height for crossed-pair orchestral recording, roughly that of a standing listener's ears, is accommodated without difficulty. The tripod contributes about one metre.

Two general points relating to the indoor use of stands and tripods: the legs must be placed on carpet or plastic foam. Secondly, a

(*continued on page 213*)

A CAPSTAN SERVO SYSTEM FOR STUDIO AND HOME TAPE RECORDERS

The principle of the Revox A77 capstan motor

BY ARTURO STOSBERG*

Based on a lecture presented to the 35th AES Convention, October 1968, and published by kind permission of the Audio Engineering Society

ONE of the prime requirements for high quality audio tape recorders is uniformity of tape movement. Basically, the long and short term stability have to be considered separately. Different aspects of the motor or drive systems are responsible for each.

In order to avoid changes of pitch in the recorded material, an absolute long term speed accuracy of $\pm 0.2\%$ is generally accepted to be adequate. The periodic and non-periodic alternating components of speed variations are called flutter and wow. Specifications often ask for flutter and wow values better than 0.1% RMS at 19 cm/s tape speed.

Today the hysteresis synchronous motor is in extended use as a capstan motor for high quality tape recorders. Unfortunately this motor type shows some negative properties which are listed below:

1. The motor speed is directly proportional to the power line frequency. This dependence has to be regarded as an important disadvantage in all cases where the power line frequency is not stable.
2. At synchronous speed, the generated torque depends on a phase angle difference. Mathematically, the motor is described by a second order system. In response to a load variation, the rotor shows a tendency toward damped speed oscillations (often called hunting). The amount of flywheel inertia is limited, otherwise the motor gets unstable. Speed disturbances are also generated by minute parasitic switching transients on the power line.
3. Periodic flutter caused by the poles of the motor. Often a flexible coupling (or belt drive) is required, together with an additional flywheel.
4. Low efficiency (below 10%) and heavy weight in reference to the delivered mechanical power.

Two further points have to be scored as advantages:

1. No parts exposed to wear.
2. No radiation of radio frequency interferences.

Design studies aimed at producing a constant speed capstan motor avoiding all the mentioned disadvantages of the hysteresis synchronous motor led to the development of a servo controlled drive system featuring a high slip eddy current asynchronous motor.

This motor consists of a conventional multiphase stator generating a circular rotating field. The rotor itself acts as an eddy current conductor as well as a flux return path. It is made out of pure magnetically soft iron. Torque pulsations, and therefore speed variations, are kept to an absolute minimum as the rotor is of completely homogeneous design without gaps for special conductors. It is possible to mount the capstan directly to the rotor without flexible coupling. No additional flywheel is required if an outer rotor design is chosen. Fig. 1 gives a cross-section of this motor type. The speed-torque characteristics of this high slip motor show a considerable load dependence of the rotational speed (fig. 2). Design studies proved the feasibility of a speed regulation by changing the motor voltage, instead of varying the supply frequency which would require a bulky motor drive amplifier. It turned out to be quite easy to change the drive voltage of the motor by inserting a bridge rectifier loaded by a single power transistor (fig. 3).

The actual motor speed is measured by a tone generator. A high precision gear of 120 teeth is cut into the rotor periphery. The teeth vary the magnetic flux in a pick up coil. The speed is thus transferred into a proportional frequency.

An electronic circuit analyses the momentary value and corrects any deviation from the desired frequency by variation of the motor supply voltage, as the speed reference acts as the resonance frequency of an LC-circuit.

Fig. 4 shows a schematic diagram of the complete capstan servo system. The circuitry can be divided into three main parts, namely:

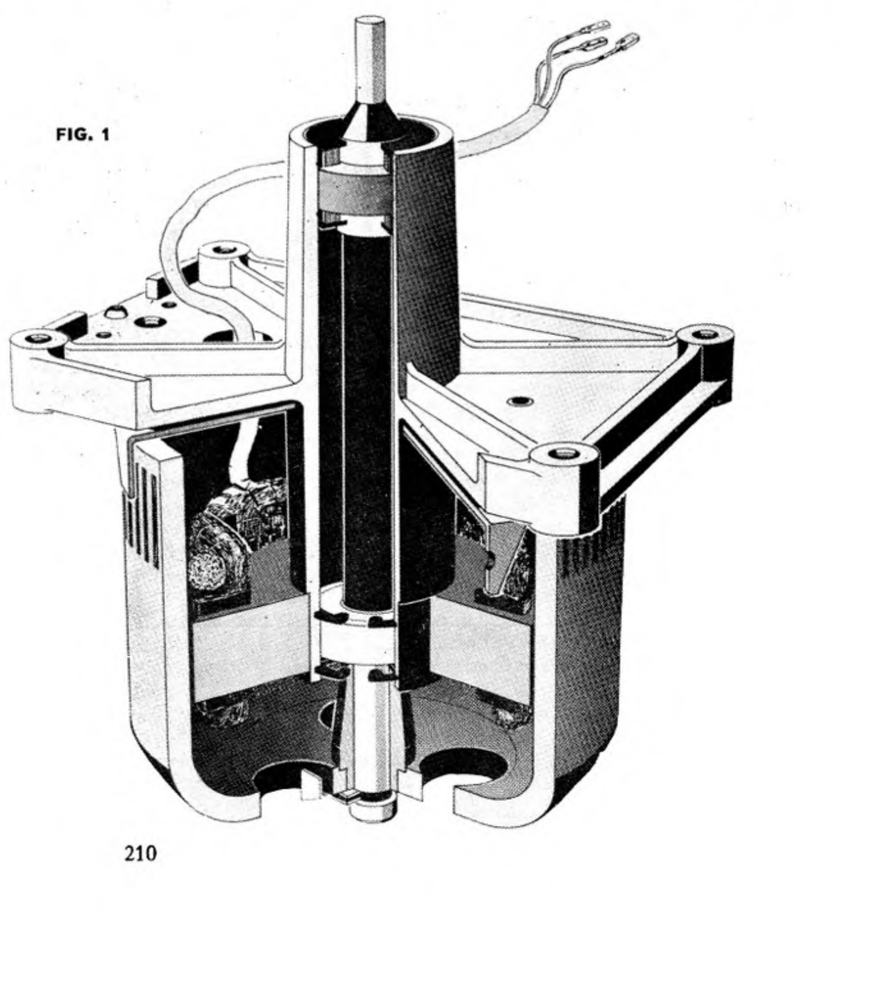
1. The tachometer amplifier and limiter.
2. The discriminator.
3. The DC-amplifier with power stage.

The tachometer amplifier acts as a limiter. All amplitude modulations of the tachometric signal are removed and a clean symmetrical square-wave signal is delivered to the discriminator. The amplitude of this signal is determined by the saturation voltage of the transistor stages and the DC supply voltage (22 V). DC coupling adjusts the operating points of the amplifier stages for best symmetry of the square wave signal.

The discriminator is actually an LC-slope detector which acts against a reference derived from the signal itself. Thus variations of the DC-supply voltage E_b causing variations of the driving square-wave signal will have little effect on the output signal of the discriminator. No special stabilisation of the DC-supply voltage is required. Speed adjustments are achieved by changing the resonance frequency of the LC-circuit. On this schematic diagram, two speeds are provided. The second and lower speed is trimmed by a small series

(*continued on page 213*)

FIG. 1



* *Willi Studer*

FIG. 2 TORQUE AS A FUNCTION OF MOTOR SPEED

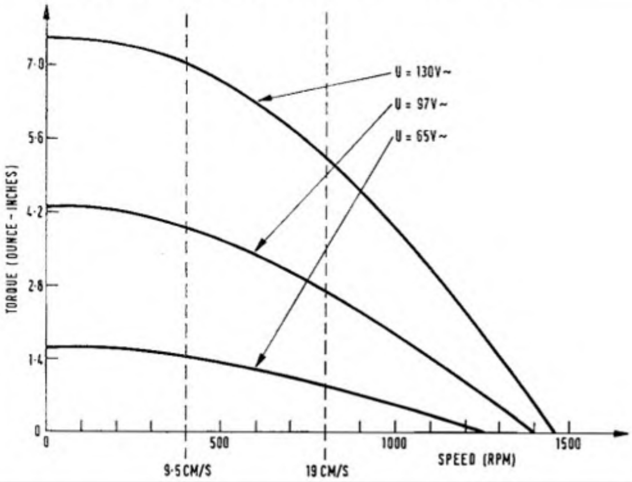


FIG. 3 SCHEMATIC DIAGRAM OF THE POWER STAGE

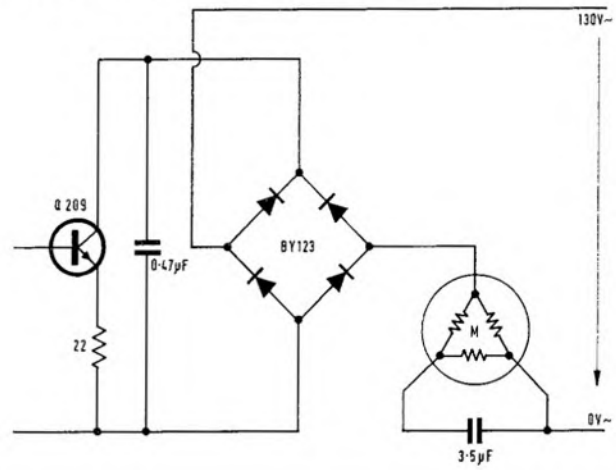


FIG. 4 THE COMPLETE CIRCUIT

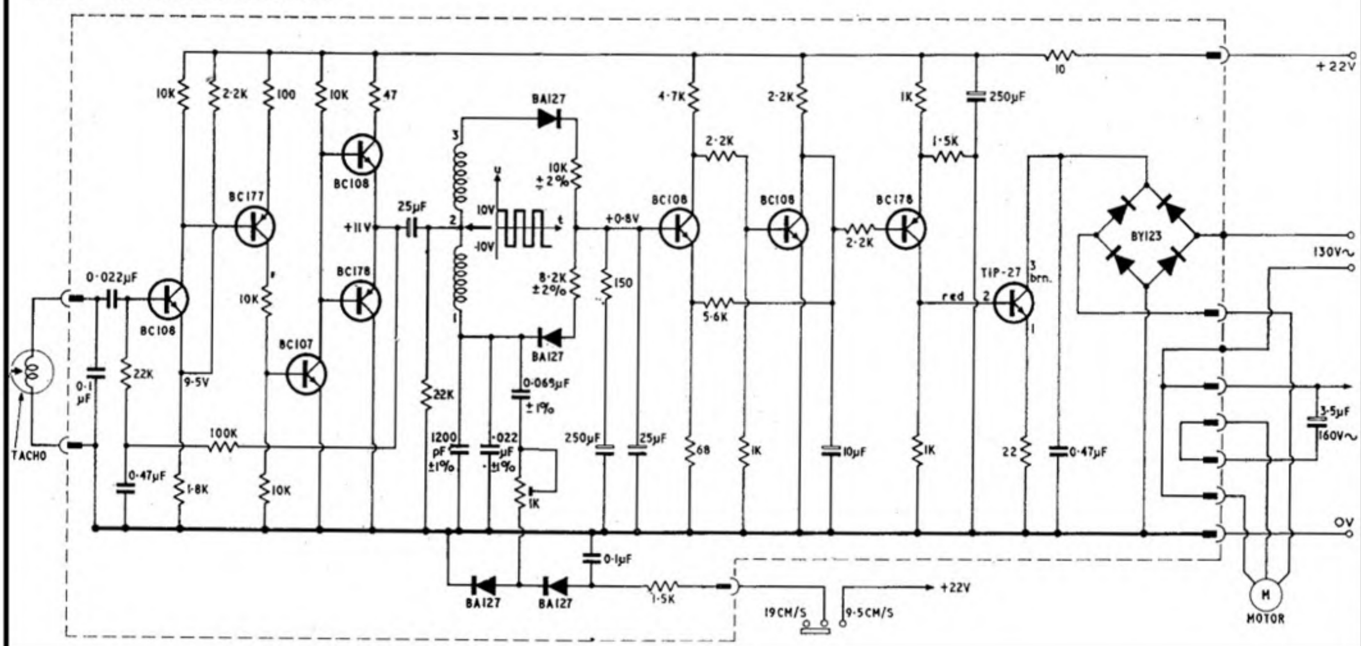


FIG. 5 CHARACTERISTICS OF THE DISCRIMINATOR

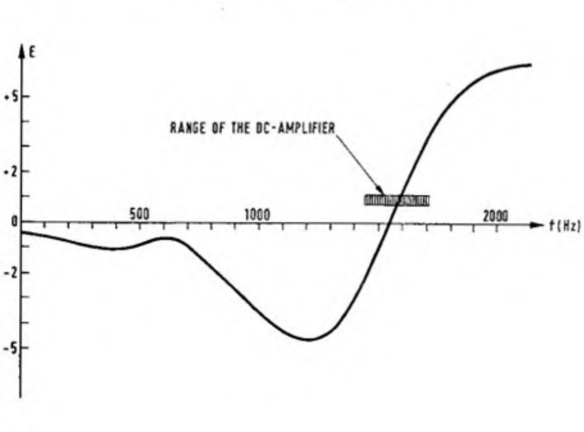
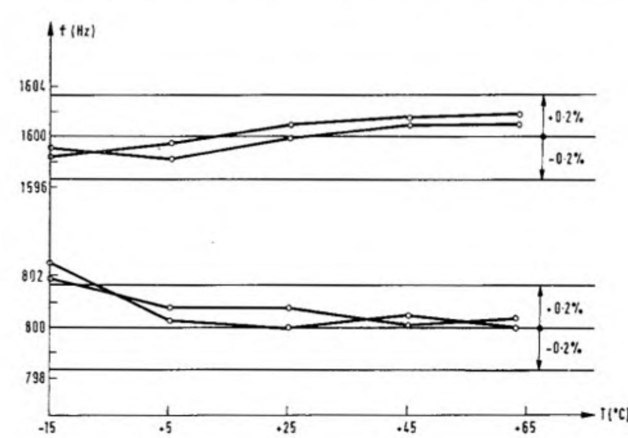
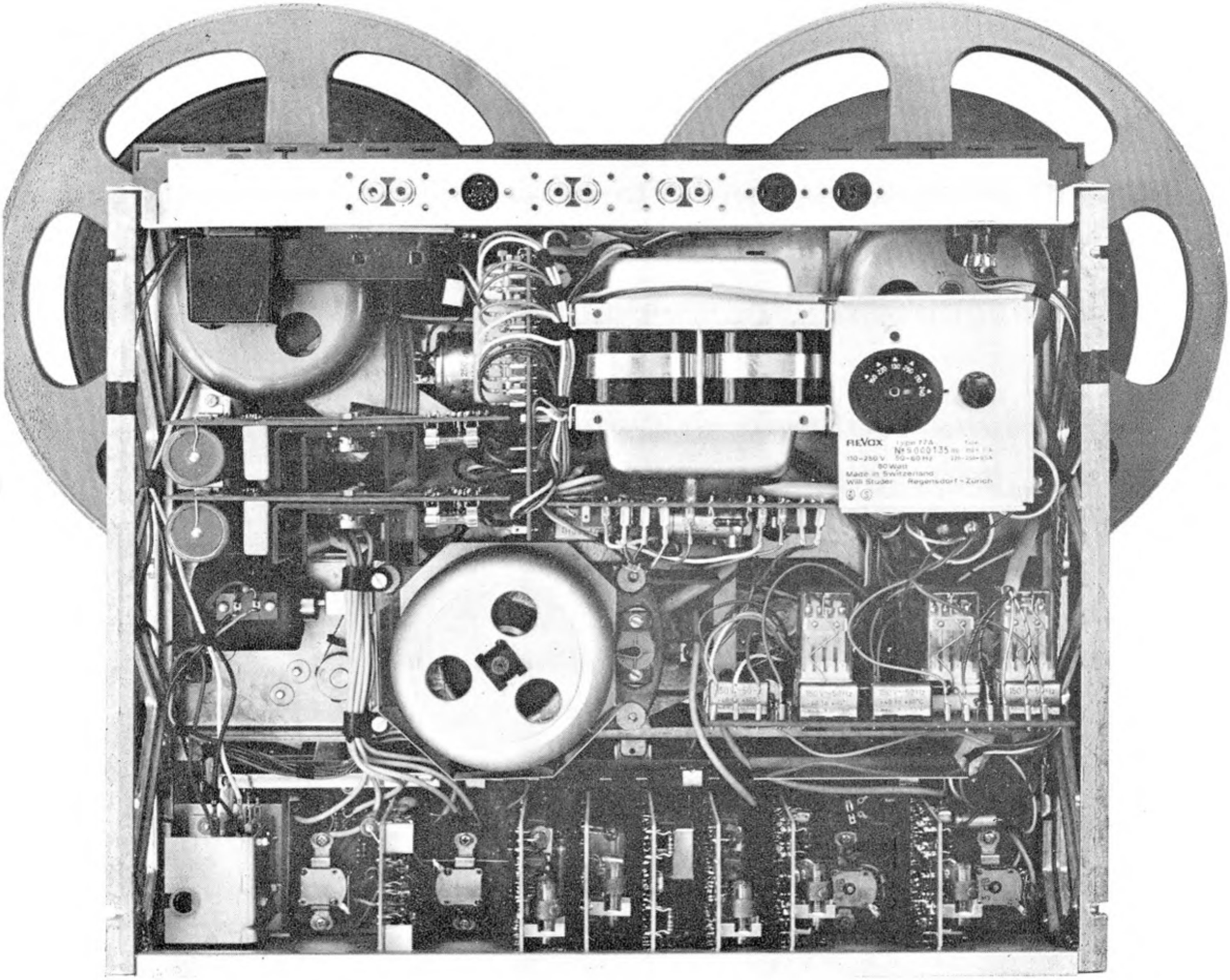


FIG. 6 TEMPERATURE DEPENDENCE OF THE COMPLETE SYSTEM





the inside story of Willi Studer

The Revox A77 is Willi Studer's brain child . . . born from years of experience designing magnetic recording equipment for the broadcasting and recording industries. This is a great recorder built to the highest Willi Studer standards of manufacture. For the discriminating music lover as well as the professional user Willi Studer has developed a matching range of high fidelity units which make full use of the outstanding performance of the Revox A77.

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REVOX

METRICATION CONTINUED

the disadvantage that, if they change for any reasons such as wear, secular change or vandalism, then in theory *all* the world's standards which derive from them have to be changed. In practice, when material standards are employed, the actual magnitude is maintained by the group average of the standard itself and a number of copies, rejecting any which have obviously changed. Thus a new value may occasionally have to be assigned to the standard. One gets the impression that this sort of activity has to be kept hidden from the lawyers.

Where possible, magnitudes are nowadays defined in terms of some natural phenomenon which is thought to be invariant and which can, using suitable equipment, be accurately reproduced. The me re is now defined as 1 650 763.73 wave lengths in vacuum of the orange line of Krypton 86. The 'official' definition is given in **fig. 3.**

We can thus define all lengths as multiples and sub-multiples of the metre, all areas as square metres, etc., and all volumes as cubic metres, etc. This avoids arbitrarily named area units like acres, and volume units like gallons and bushels.

No one has yet been able to propose a useful 'natural' standard of mass, and the definitive standard is still a particular lump of metal, 'the international prototype kilogramme' which is kept at the International Bureau of Weights and Measures (B.I.P.M.) at Sèvres near Paris. The originally intended definition of the gramme was the mass of 1 cubic centimetre of pure water at its temperature of maximum density. This, however, is an awkward measurement to carry out, and a material standard (actually one of a thousand grammes) was made for convenience in routine measurements. It was eventually found to be slightly 'wrong', and rather than have to adjust a great many mass standards, the definition was altered to refer to the lump of metal, and it is that definition which is still in force. As usual, blind reliance is not placed on a single object: the kilogramme is maintained in terms of the 'prototype kilogramme', and a number of its ccpies.

Althcugh it is nct part of the SI, the metric system has a named unit of area, the 'are'. One are (pronounced *air*) is 100 square metres. The are itself is almost never used; the unit used is the 'hectare', 100 ares or 10,000 square metres. One hectare is about 2½ acres. The unit is used in surveying and agriculture.

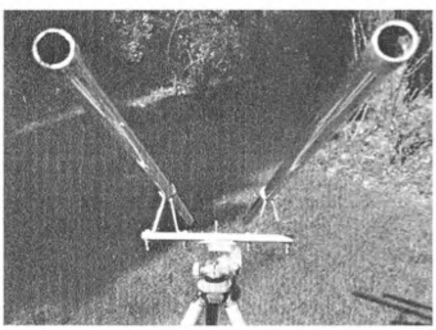
There is also a non-SI metric unit of volume, the litre, which is a cubic decimetre. The millilitre, one cubic centimetre, is also in use.

The unit of time in all the measuring systems is the second. For many purposes it is convenient to relate the second to the rate of rotation of the earth, but the earth is not very constant in its rate of rotation, and for scientific purposes one needs an invariant standard of time interval. The second is now therefore defined as 9 192 631 770 cycles of the caesium 133 frequency. **Fig. 4** gives the full official definition.

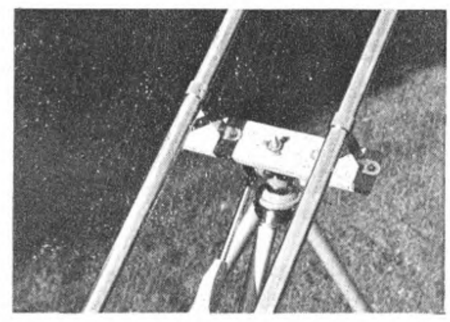
This defined second was equal to the second defined by the rate of rotation of the earth in the year 1900, but it now differs from it by about 3 parts in 10^8, i.e. 0.03 parts in a million. For purposes where time of day is required, such as navigation, an offset is applied to the standard frequencies so that the modified frequency corresponds to a smoothed 'time of day'.

Continued next month

A STEREO BOOM CONTINUED



liberal application of Sellotape at three or four points on the tubes will damp the ringing which occurs when jacks are fed through. The tubes did not ring audibly before the tape was added, even with microphones mounted as in **fig. 2.** But the precaution is worth taking. Do remember to earth the recorder, however, even if the original mains cable is only two-core. The unbalanced transistor microphone input stages incorporated in recorders of the Revox *A77* and Akai *X-360* category are prone to RF interference, electrical contact with the boom agravating a problem raised in the first place by long connecting cables. Earthing solves the problem. Still greater freedom is gained, on the Revox, by working through



low-to-high impedance transformers rather than the switchable low-impedance input stage.

A CAPSTAN SERVO SYSTEM CONTINUED

resistance which decreases the figure of merit of the resonance circuit.

The characteristic of the discriminator (voltage versus frequency) is to a certain degree similar to the well known ratio detector encountered in most fm-tuners. **Fig. 5** shows this plot. The range of the following DC amplifier is marked. As long as the discriminator delivers a signal below 0.7 V, the motor gets full supply voltage. When the signal rises above 0.8 V, the regulating series transistor is cut off.

The temperature coefficients of the inductance and the capacitance of the discriminator have to be matched in order to gain independence of the ambient temperature. Tracking ranges from -15 to $+65°C$ in which the final motor angular speed is held within $\pm 0.2\%$ are easily possible. **Fig. 6** shows some typical curves.

The following DC amplifier is of traditional design. AC components in the servo signal are removed by two RC-filters. In addition, a lag network is provided. It reduces the bandwidth of the closed loop system to the necessary degree to prevent the residual eccentricity of the tachometer gear from causing periodic speed variations. In addition this network improves the stability margin of the system and allows higher static gain.

The system can be classified as a velocity servo as the discriminator delivers a signal proportional to the motor speed. The non-linearity is caused by two reasons:

1. The motor generates a torque proportional to the square of the applied AC-voltage. $T = K \times E^2_{ac}$.
2. The generated torque decreases with rising speed. A linear approximation of this behaviour is possible (**fig. 2**).

Both effects together lead to a cubic system which, for a mathematical analysis, have to be replaced by a linear approximation.

This motor has been accommodated in the Revox *A77*, with the following characteristics:

1. Tape speed: Tachometer frequency:
   19 cm/s 1.6 kHz
   9.5 cm/s 800 Hz
   Starting torque of the motor: 550 cmp equals to 7.6 inch-ounces.
   Supply voltage: 130 V/AC/50 or 60 Hz.
   Required torque at 19 cm/s with moving tape: 1 inch-ounce equivalent to 75 cmp.
   Motor voltage: 70 V AC.
   Power consumption: 7 to 13 W.
2. The steepness of the discriminator, together with the gain of the following amplifier, causes a passage of the motor voltage from 0 V to 120 V AC within 3 Hz frequency deviation at 1.6 kHz tachometer signal frequency. The system will react to a load variation from no load to full permissible load by a static speed variation of less than 0.1%.
3. Line voltage fluctuations of $\pm 20\%$ cause changes in the motor speed of about $\pm 0.05\%$.
4. Operating voltage fluctuations of $E_b = 22$ V $\pm 10\%$ cause variations in motor speed of 0.1%.
5. Changing the power line frequency from 50 to 60 Hz causes an error in speed of less than 0.05%.
6. Typical flutter and wow values:
   19 cm/s: 0.05% peak to peak, weighted according to DIN-standards.
   0.12% peak to peak linear.
   0.04% American standards (nearly unmeasurable).

The figures at 9.5 cm/s are about 1.5 times those measured at the higher speed.

TRUVOX R5 AND R25

TWO new recorders have been announced by Truvox, based on the existing *Series 50* and *Series 200* and toughened for educational, commercial and industrial applications. Both operate at 19, 9.5 and 4.75 cm/s, equalised to the new CCIR standards (70, 140 and 280 μS respectively), with 18 cm spool capacities.

The *R.5* incorporates $\frac{1}{4}$-track erase and record/play heads and achieves a claimed 30 Hz-17 kHz ±3 dB frequency response at 19 cm/s. Wobble is 0.14% RMS at this speed, signal-to-noise ratio being 48 dB. Output from the monitor amplifier is 6 W at 8 ohms, feeding two 18 x 10 cm speakers. All connection sockets are standard jack, microphone input being 50 μV at 25 K. Radio input is 50 mV at 200 K while the line output is up to 1 V (variable). An additional monitor output is fitted, supplying up to 1.5 V (variable). Fast wind speed is 120 seconds for 400m SP. Dimensions are 39 x 34 x 18 cm and the price is £61 19s. plus PT.

Model *25/2* features tape/source monitoring, a 10W monitor amplifier and a Papst drive motor. 19 cm/s wobble is 0.08% RMS, frequency response being 30 Hz-18kHz ±2 dB. Inputs are 1 mV at 50 K (microphone) and 50 mV at 200 K (radio); line output is up to 1 V. Signal-to-noise ratio of the half-track *25/2* is 50 dB while the $\frac{1}{4}$-track *25/4* is 48 dB. Both versions retail at £101 17s. plus PT.

Manufacturer: Truvox Ltd., Hythe, Southampton, Hampshire.

DYNARANGE CASSETTE

SCOTCH DYNARANGE tape is featured in the new *272 C90* cassette, giving 45 minutes playing time per side at 4.75 cm/s. Price is 25s. 1d. including case and index sheet. 3M already produce 30-minutes per side *C60* cassettes and will shortly be introducing a one-hour per side *C120*. The tape is produced at the 3M plant in Gorseinin, South Wales.

Manufacturer: 3M Company Ltd., 3M House, Wigmore Street, London W.1.

DE-SOLDERING TOOL

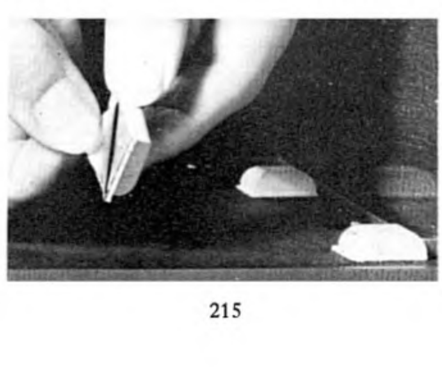
A DE-SOLDERING tool to suit the *DS-W60D* low-voltage temperature-controlled soldering pencil has been announced by Weller. The *DS-TCP* is completely portable, requiring no air line or pump, and may be operated with the hand holding the soldering iron. Similar attachments will shortly be available for the complete range of Weller soldering pencils.

Manufacturer: Weller Electric Ltd., Redkiln Way, Horsham, Sussex.

PROTECTOR PADS

PRESSURE-SENSITIVE protector pads and strips are now available to manufacturers from the 3M Company. Designed to prevent household and office items from slipping and scratching furniture, they are available in several colours and sizes. The self-adhesive surface is protected by a peel-off backing and will bond with metal, plastic, wood and glass.

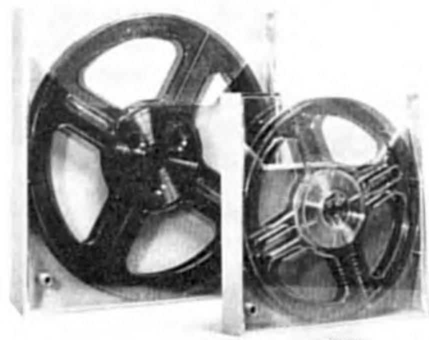
Manufacturer: 3M Company Ltd., 3M House, Wigmore Street, London W.1.



SPOOL STORAGE CONTAINERS

PLASTIC CONTAINERS for 18 and 14.5 cm spools have been announced by Cosmocord. Manufactured in grey Polystyrene with a transparent hinged front, they provide dustproof cover for tape and cine reels. Cosmocord are also now producing tape and cine spools in red, blue, green and clear Polystyrene. Sizes are 18, 14.5 and 12.5 cm, the 18 and 12.5 cm sizes being additionally available for Super 8 hubs.

Manufacturer: Cosmocord Ltd., Eleanor Cross Road, Waltham Cross, Hertfordshire.



GRUNDIG INTRODUCE NEW STYLES

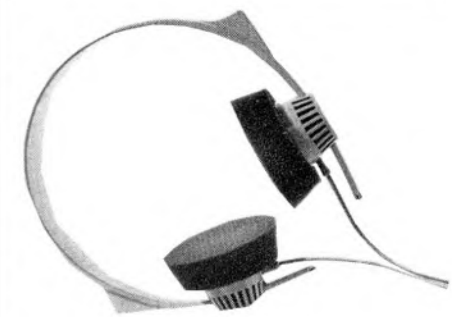
A RANGE OF new and restyled domestic recorders are being introduced by Grundig. The *TK144* (illustrated) is a $\frac{1}{4}$-track model operating at 9.5 cm/s. Wow and flutter are specified as less than 0.2% and signal-to-noise ratio as 45 dB with Grundig tape. Frequency range is 40 Hz-12.5 kHz; the specification 'largely meets' DIN 45511. Input sensitivity is 2 mV at 1.5 M (*microphone*), high level signals being fed through the supplied *SL32* attenuator lead. Outputs are 500 mV at 15 K (*line*), 11 V at 220 K (*earphone*), and 2.5 W at 5 ohms (*speaker*). The circuit comprises two valves, one transistor and two diodes. Recording level is indicated by a moving-coil meter. Spool capacity is 15 cm and the price is £47 13s. 1d. including *GDM 312* microphone, and 15 cm LP *GL 15* tape.

Manufacturer: Grundig (Great Britain) Ltd., London S.E.26. *(continued overleaf)*

FINE GAUGE SOLDER DISPENSER

MULTICORE SOLDERS' fine gauge dispenser is being marketed at 3s., skin packed on an instruction card. About the size of a pen, the dispenser contains 6.4 metres of 22 gauge 60/40 alloy 5-core Ersin Multicore. The solder is fed through a nozzle at the tip of the dispenser and is designed so that the wire cannot fall back inside.

Manufacturer: Multicore Solders Ltd., Hemel Hempstead, Hertfordshire.



LIGHT-WEIGHT HEADPHONES

ADAPTERS TO SUIT standard jack, Japanese and DIN monitor sockets are supplied with the *HD414* stereo headphones, newly introduced by Sennheiser. Cushioned foam ear pads are incorporated, bass response being extended down to 20 Hz, and treble up to 20 kHz, with cardioid capsules. The headphones cost £10 17s.

Distributor: Audio Engineering Ltd., 33 Endell Street, London W.C.2.

EAGLE STAND AND BOOM

A TWO-SECTION adjustable floor stand with 38 cm base extensions has been introduced by Eagle. The *FS.268* costs £7 10s. and telescopes from a minimum height of 99 cm to a maximum of 173 cm. A matching boom arm with angle lock and adjustable counter balance is available at £3 10s. Model *BA.132* has a 68.6 cm maximum extension and 170° vertical traverse. Also announced are the *SE.28* stereo headphones incorporating coaxial tweeters to give a claimed 20 Hz-20 kHz frequency range at 8 ohms impedance. Retail price is £10 10s.

Distributor: B. Adler & Sons, 32a Coptic Street, London W.C.1.

equipment reviews

TANDBERG 12X

MANUFACTURER'S SPECIFICATION (19 cm/s). Quarter-track transistor stereo tape recorder with cross-field bias, power amplifiers and side-facing monitor speakers. **Wow and flutter:** 0.1% RMS. **Frequency response:** 40 Hz - 18 kHz ±2 dB. (In amplifier mode 30 Hz-16 kHz ±3 dB.) **Signal-to-noise ratio:** 55 dB ref. peak recording level. **Spool Capacity:** 18 cm. **Tape speeds:** 19, 9.5 and 4.75 cm/s. **Modulation indicators:** Meters. **Sockets:** Three pin DIN (*microphone*), five pin DIN (*line in/out*) and five pin DIN (*pickup in/out*). Duplicate Phono inputs for *line* and *pickup*. **Output power:** 10 W per channel at 5% distortion. **Tone controls** 12 dB variation at 80 Hz (*bass*) and 8 kHz (*treble*). Combined record/play head. **Dimensions:** 39 x 29 x 18 cm (w x l x h). **Price:** £144 7s (including purchase tax). **Manufacturer:** Tandbergs Radiofabrikk A-S, P.O. Box 9, Korsvoll, Oslo 8, Norway. **Distributor:** Elstone Electronics Ltd., Hereford House, Off Vicar Lane, Leeds 2, Yorkshire.

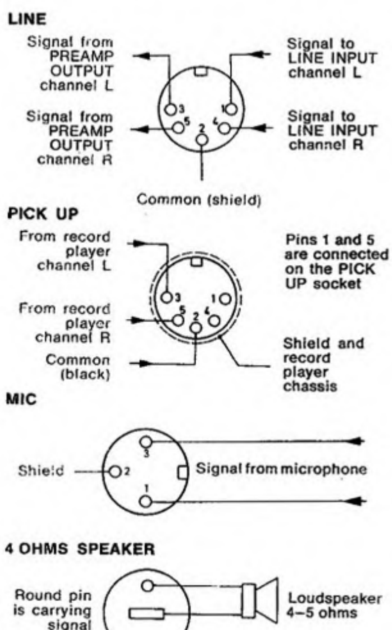
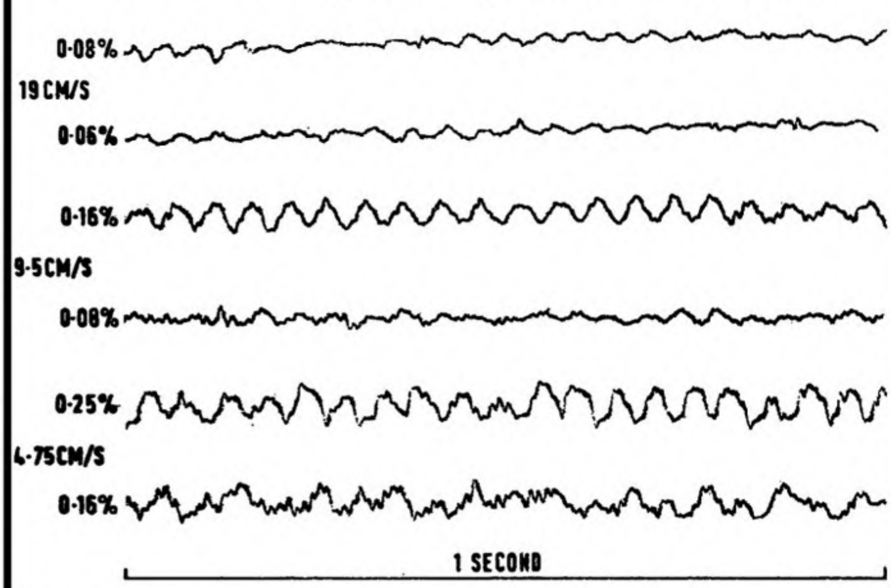


FIG. 2 TANDBERG 12X RECORD/PLAY WOW AND FLUTTER



THE early version of the *Series 12* stereo recorder was reviewed in November 1967. The general appearance of the *12X* is almost identical, but there are a number of minor modifications other than the major one of fitting a cross-field biasing system. The record level indicators are now meters instead of magic eyes; the tone controls now provide bass and treble lift *and* cut, and the treble control now moves clockwise for maximum treble. The equalisation is to NAB standards at all speeds and equalisation for both magnetic and ceramic pick ups is provided at the input. I should perhaps mention that switched phono equalisation is only provided on machines with serial numbers above *2237000*. The review machine number was only *2236291* and had fixed magnetic equalisation only. There were other small circuit changes, around the microphone input, microphone switching and the ganged input level controls, to avoid overload at extremely high input levels.

I had some earth loop hum trouble when I connected a 500-ohm microphone to pins 2 and 3 of the DIN plug and a little investigation showed that it was cured by using pin 1 as the microphone earth and the usual pin 2 for screening only. There seems to be less and less standardisation on microphone input connections nowadays; at one time all microphones used pins 1 and 2.

The circuit is somewhat confused by an incredibly complicated switching system which is not helped by the peculiar switch symbols of fig. 1. However, the main circuit blocks are straightforward and can now be discussed. The top left block is the equaliser amplifier and preamp output stage. On play it is fed directly by the playback head with feedback equalisation over the three DC coupled input stages for the three speeds. The gain to line output is fixed, and is not affected by the output stage volume controls or tone controls. The lower left block is the microphone, phono and line input amplifier with the first stage only used for microphone and with RIAA feedback equalisation for magnetic pickup on phono which is further modified by the magnetic/ceramic input slide switch which drops the gain and cuts the

(*continued overleaf*)

FIG. 3 TANDBERG 12X PLAY-ONLY RESPONSE (TEST TAPE TO LINE OUT)

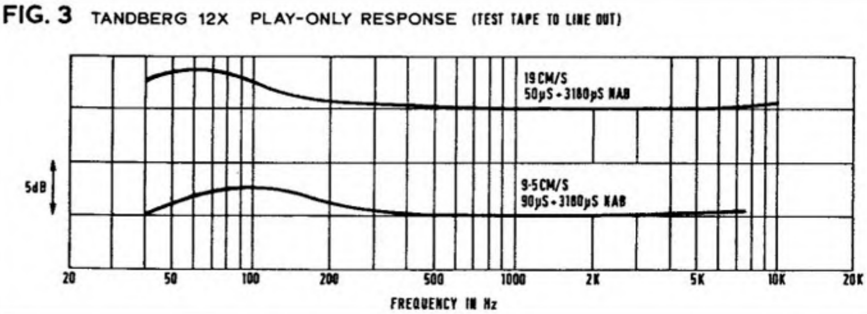
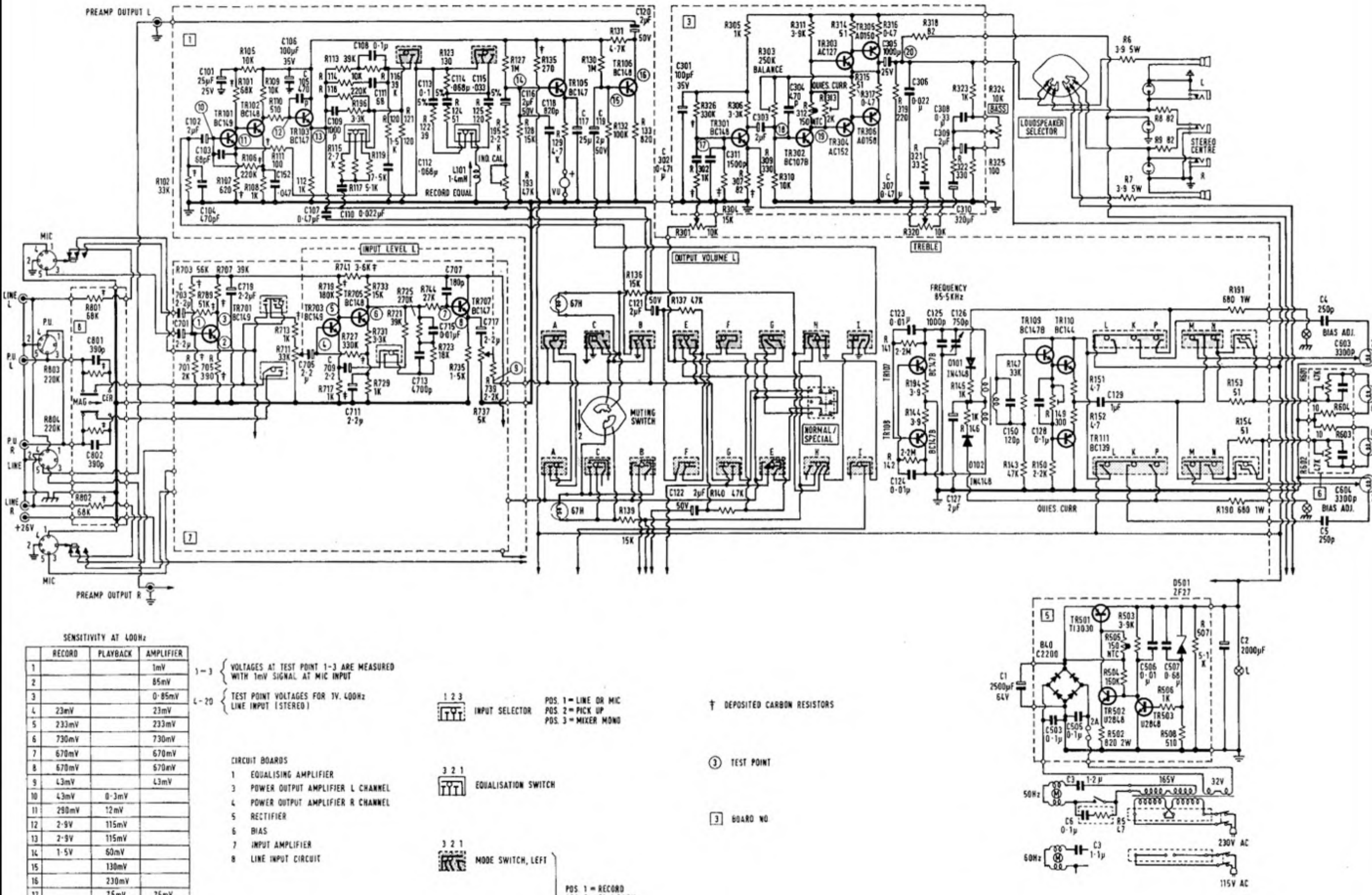


FIG. I TANDBERG 12X CIRCUIT DIAGRAM



SENSITIVITY AT 400Hz

	RECORD	PLAYBACK	AMPLIFIER
1			1mV
2			85mV
3			0·85mV
4	23mV		23mV
5	233mV		233mV
6	730mV		730mV
7	670mV		670mV
8	670mV		670mV
9	43mV		43mV
10	43mV	0·3mV	
11	290mV	12mV	
12	2·9V	115mV	
13	2·9V	115mV	
14	1·5V	60mV	
15		130mV	
16		230mV	
17		75mV	75mV
18		47mV	47mV
19		7·5V	7·5mV
20		6·5V	6·5mV

1 – 3 { VOLTAGES AT TEST POINT 1-3 ARE MEASURED WITH 1mV SIGNAL AT MIC INPUT

4 – 20 { TEST POINT VOLTAGES FOR 1V. 400Hz LINE INPUT (STEREO)

CIRCUIT BOARDS

1 EQUALISING AMPLIFIER
3 POWER OUTPUT AMPLIFIER L CHANNEL
4 POWER OUTPUT AMPLIFIER R CHANNEL
5 RECTIFIER
6 BIAS
7 INPUT AMPLIFIER
8 LINE INPUT CIRCUIT

1 2 3 INPUT SELECTOR — POS. 1 = LINE OR MIC, POS. 2 = PICK UP, POS. 3 = MIXER MONO

3 2 1 EQUALISATION SWITCH

3 2 1 MODE SWITCH, LEFT

1 2 3 MODE SWITCH, RIGHT

} POS. 1 = RECORD, POS. 2 = PLAYBACK, POS. 3 = AMPLIFIER

† DEPOSITED CARBON RESISTORS

(3) TEST POINT

[3] BOARD NO

bass for ceramic pickups. The output of this amplifier is fed to the top right equaliser block which now provides NAB bass and treble recording pre-emphasis and feeds the record head via the 15 K resistor R136. No bias is fed directly to the record head.

The erase and bias oscillator consists of a lightly loaded push-pull oscillator feeding a complementary pair power output stage which feeds the erase and cross-field biasing heads. As mentioned in an earlier review, the deep penetration of the cross-field bias to the full depth of the tape oxide layer demands a very low second harmonic content in the bias waveform if imperfections in the tape base or oxide thickness are not to be mercilessly exposed. I found that most modern tapes showed bias noise within 3 dB of bulk erased noise but a number of samples of older tape, which were quite quiet on orthodox recorders, showed LF noise up to 10 dB above bulk erased noise which was unpleasantly audible as rumble on external wide range speakers.

The pen recordings of **fig. 2** show that 25 Hz flutter is the main offender at all speeds and that this is due to an eccentric pulley or slightly bent shaft on the four-pole drive motor, which rotates at slightly less than 1500 RPM, or 23-24 revs per second. Such a steady sinusoidal waveform lends itself to almost perfect adding and cancelling in the cumulative record-play sequence, and this is shown by the top and bottom traces respectively at each speed. On a low wobble test tape, combined wow and flutter at 19 cm/s was steady at 0.06% and 0.08% at 9.5 cm/s. Wow-only readings were 0.03% and 0.04% respectively.

The play-only responses of **fig. 3** show exact NAB 50 and 90 µS equalisation at high frequencies with some bass rise which is mainly due to the use of a full-track test tape on a ¼-track head, where flux outside the actual track width is picked up by the gap at very long wavelengths. System noise, with no tape passing the heads, was very low at 55 dB below peak recording level (32 mM/mm).

Record-play tests from line input to line output produced the responses of **fig. 4** which fully meet the specification, but show evidence of slight under biasing on the upper track.

Bulk erased tape noise was 53 dB below peak recording level and tape erased on the machine ranged from 52 dB below peak to 42 dB below peak as explained earlier when discussing bias penetration. All the above readings are unweighted and weighting to the ear's response at low listening levels improves all readings by about 5 dB.

Nominal peak recording level (32 mM/mm) was obtained on my reference tape (BASF *LGS 35*) with the record level meter reading 0 dB. Distortion at this level was 2.7%, increasing to 3.4% at +3 dB on the meter. As Scotch *Dynarange* tape was supplied with an earlier Tandberg cross-field bias recorder, I tried it and found that reference peak level of 32 mM/mm was recorded at a lower meter reading of —3 dB where the distortion was only 1.5%, rising to 3.1% at +3 dB on the record level meter. This means that the above quoted

(continued overleaf)

FIG. 4 TANDBERG 12X RECORD/PLAY RESPONSE (LINE IN TO LINE OUT)

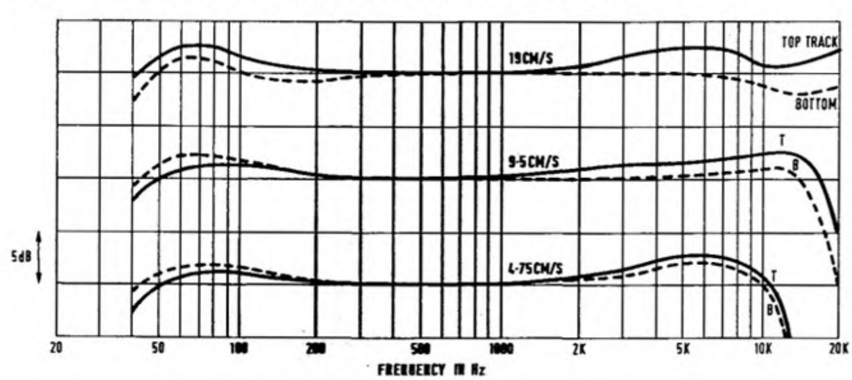
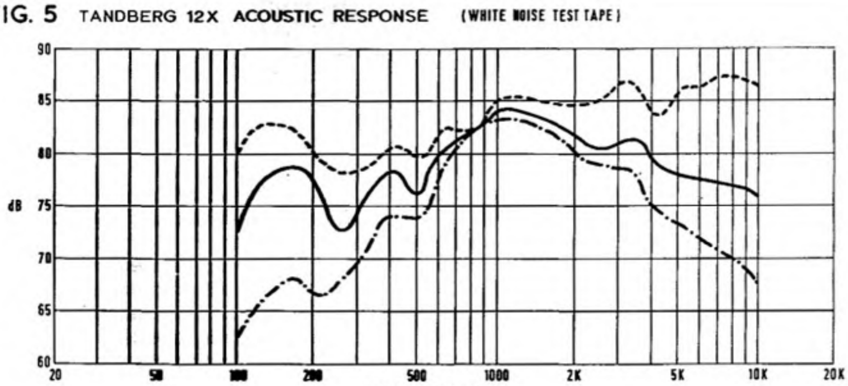


FIG. 5 TANDBERG 12X ACOUSTIC RESPONSE (WHITE NOISE TEST TAPE)



signal-to-noise ratios can be increased by 3 and 6 dB if distortion of 3% peak is allowed.

The dynamics of the record level meters were satisfactory, being midway between true VU meter and peak recording meter (due to the low impedance transistor feed combined with the storage of the 25 μF capacitor across the meter).

The acoustic response of one of the side-facing speakers was measured whilst playing a one-third octave white noise test tape at three settings of the tone controls. The solid line curve is with the tone controls centred, giving a nearly constant voltage feed to the speaker at all frequencies. The upper dotted curve is with full treble and bass, and, as expected, this gave the best sound balance when listening at a point directly in front of the recorder. The bass or treble cuts would normally only be used on poorly balanced recordings or noisy tapes.

Finally the recorder was tried on a few known prerecorded tapes feeding a pair of Goodmans *Maxim* miniature speakers with excellent balance and stereo placement, using full bass boost and a slight touch of treble boost. Such a test proves that the bass boost matches the falling bass response of such small speakers, and also allows almost full power output to be used with the lower efficiency speakers.

With the addition of a transcription turntable fitted with a good magnetic or ceramic cartridge and a stereo FM tuner, the Tandberg *12X* recorder forms the basis of a compact domestic reproducing system which can be housed on shelves or existing tables.

I should end by mentioning that the *12X* is one of the few self-contained stereo recorders which gives a good account of itself as a small scale stereo sound source. **A. Tutchings.**

BY CYRIL GRANGE

THE biggest problem with which the amateur outdoor recordist has to cope is that of unwanted noises caused by wind which can spoil an otherwise excellent recording. A utopian idea it may be but, if you want perfect recordings, you must try and choose a day when there is no wind.

The parabolic reflector is some help as it tends to reduce wind coming from the rear.

Birds quite often sing on a favourite tree branch, wall or housetop, in which case the microphone can be secured as close as possible to the singer so that the gain control can be kept fairly well back.

Remember that you can use quite a long lead (30 metres or more) from the recorder if the microphone is of low impedance, properly matched by a transformer to the recorder. By working this way, the recordist can keep well out of sight.

A number of firms supply windshields to suit their own microphones. Grampian produce a windshield for their *DP4*, *DP6* and *DP8* microphones which aim to reduce the air turbulence to a low value without affecting the microphone response. Audio Engineering provide shields for eight of their Sennheiser models while the London Microphone Company make a cheap type in the form of a bag. Prices vary from 4s. 6d. to £3.

A handyman can make a mono or stereo shield on the lines recommended in March by M. G. Skeet.

It is often possible to set up the microphone fairly well back in a shed, loft or house room, so that the microphone is in a pocket, as it were, of very still air.

The noise-cancelling microphone can be used in noisy situations and is insensitive to distant sounds. This has to be sited very close to the bird (say 10 to 30 cm) and is of value when recording young birds in the nest or animals in their burrow.

Both migrant and resident garden birds together produce, in April, May and June, one of nature's wonderful performances—the dawn chorus. It is the peak song time for the tits, chaffinch, wren, hedgesparrow, thrush, blackbird, robin, pigeon, willow warbler, goldfinch, greenfinch, blackcap, starling and sparrow. If your garden is in the country, the pheasant, cuckoo, linnet, skylark, yellow bunting, and meadow pipit may be within range.

The dawn chorus is the most exhilarating cacophony of bird sound we humans ever hear, though most of us are too sleepy to know !

The recording can be made through a window in the comfort of a house unless one desires to emphasise certain varieties or there is unwanted background sound.

A point here—a dawn chorus can be partly spoiled by the operator moving about in the garden. Some singers certainly slow down or cease if they are upset by movement, especially from prowling cats or excited children.

Everything must be checked and ready by sunrise. Possibly the robin will start off with a rather plaintive note which will soon expand and develop. It may be necessary to turn up the gain slightly so that the robin's note does not come out too weak and thin.

A blackbird may soon follow and then the song thrush ; and the time is appropriate to concentrate on the song of these two lovely singers because, if one waits, the best choristers will be swamped.

The singing mounts up to a peak in about 45 minutes when it may not be easy to distinguish the singer exactly. Changes in the choir also occur.

At its peak, when all the garden is full of song, one is inclined to believe that the phenomenon of song from these emotional creatures is brought about because the birds find the utmost pleasure in song. Singing for singing's sake and not because of the influence of hormones !

AN OCCASIONAL COMMENTARY

BY DROPOUT

column speaker

A MAJOR change has come into my life with the extension of stereo broadcasting to the area in which I live. For years I have enjoyed high-quality sound from discs and, when I changed to stereo, I began to find that I was ceasing to be the BBC disciple I had been for donkey's years. Somehow, mono music, at the standard of quality provided by provincial FM transmissions, ceased to have its former charms. Of course, FM is a huge step forward compared with AM; and for many years I rejoiced in it. But stereo really does add another dimension to musical reproduction, to the extent that one no longer listens to mono when another signal is available. I continued to listen to the admirable programmes with which the BBC keeps us up to date with musical developments; but for sheer pleasure it became the gramophone.

Then along came the Music Programme. Unhappily, it ceases to transmit at the hour when most men stand a reasonable chance of listening; but I do hear it in the car from time to time. It must be two years ago at least that the first rumours of stereo broadcasting extensions started to creep around, and I built myself a stereo tuner, using one of the admirable Heathkit sets. To my great astonishment, it worked as soon as I switched it on—proving beyond all doubt that the clear handbooks provided with these kits really are proof against fools. But of course I had no stereo transmissions on which to try the decoder; and there it was, all that time, sitting waiting while I fumed at the asterisks in the *Guardian* broadcasting summaries.

The great day came: I tuned in to a Prom performance of the *B Minor Mass*. My little red light came on, and there were orchestra and chorus, spread out between my speakers. I recognised at once that I was in the presence of perhaps the best signal ever to reach my room: make no mistake about it, on a live transmission BBC stereo quality is superb. Further, since radio-links now carry the transmission in place of land-lines, even the mono signals are greatly enlivened by an extended top and firmer bass. But my enjoyment was marred by a high background hiss, accompanied by a curious kind of warbling, which seemed to be modulated by the signal, and gave to everything a tizzy and distorted echo.

SLIGHT MODIFICATIONS

I then applied to Messrs. Daystrom, whom I found fully apprised of the problem. Slight modifications to the tuner were suggested, together with a degree of re-alignment of the decoder circuit. An improvement resulted; but still there was too much background for enjoyment. I therefore installed a new aerial array, with two folded dipoles to give greater forward gain, and carefully aligned on to the transmitter by instruments. I also added one of those excellent little aerial preamplifiers made by Holdings of Blackburn and now have almost as silent a background on stereo as on mono. When I reflect that I must be 50 miles from Sutton Coldfield as the waves travel, that is good going. I am nearly 200 metres above sea level, of course; and that must help. The operation has cost me a few pounds, of course, but is is money well spent. I recommend that you take the necessary steps yourself.

At the same time, enjoyment is not unalloyed You will find whole evenings with not a single half-hour of stereo music; and you will find others during which the only stereo offered is a lieder recital, an organ or a solo instrument. Admittedly, all these sound better in stereo; but the choice is curious, to say the least. The Music Programme offers many more hours of stereo; but I wonder just how many of those who listen to that programme have the opportunity to sit down and enjoy the stereo dimension. The BBC assures me that many more people listen to the radio during the day than in the evening. I believe them; but I still wonder how many of them are able to give that attention to it which is demanded by great music finely reproduced. 'Woman's Hour' is a cheery accompaniment to washing-up, as are, for those who like them, the offerings on Radios One and Two. A Schönberg symphony or the *Liederkreis* is another matter. And who, for heaven's sake, wants music of *any* kind at five-past-seven in the morning? I'm barely alive at that hour, let alone conscious of musical genius. By 10 a.m., now, things are different. The complete series of Beethoven quartets at 11 a.m. on Sundays has a fervent disciple in Dropout. As a listener to the Third Programme since its first transmission, I should hate to see it go; but if there is no other wavelength for it, ought not the Music Programme to claim at least some of its time?

CLASSIFIED ADVERTISEMENTS

Advertisements for this section must be pre-paid. The rate is 6d. per word (private) minimum 7s. 6d. Box Nos. 1s. 6d. extra. Trade rates 1s. per word, minimum 15s., Box Nos. 2s. 6d. extra. Copy and remittance for advertisements in JUNE 1969 issue must reach these offices by 17th APRIL addressed to : The Advertisement Manager, Tape Recorder, Link House, Dingwall Avenue, Croydon CR9 2TA.

Replies to Box Nos. should be addressed to the Advertisement Manager, Tape Recorder, Link House, Dingwall Avenue, Croydon CR9 2TA, and the Box No. quoted on the outside of the envelope. The district after Box No. indicates its locality.

SITUATIONS VACANT

Hi-Fi and Tape Recorder salesman required by R.E.W. (Earlsfield) Ltd., at their Tooting branch. Good pay and conditions. Apply the Manager, 266 Upper Tooting Road, London S.W.17. Tel. 01-672 9175 or 672 8267.

Wanted—young man interested in tape recorders—apply Magnegraph Recording Co. Ltd., 1 Hanway Place, W.1.

Junior Service Engineer for NAGRA, the world's finest professional portable tape recorder. An excellent opportunity has arisen for a young engineer to work in our service department. The successful applicant will be an enthusiastic and diligent worker with a good understanding of basic tape recorder principles and a standard of workmanship consistent with the quality of the product. Good salary and conditions. Existing holiday arrangements honoured. Please send full details in writing to: Managing Director, Hayden Laboratories Ltd., East House, Chiltern Avenue, Amersham, Bucks.

Tape Recorder Engineer required, experienced most makes. Telesonic, 92 Tottenham Court Road, London W.1. 01-636-8177.

MISCELLANEOUS

Skilled tape recorder repairs carried out by expert personnel of many years' experience backed by extensive test equipment: Wow and flutter meter, audio valve voltmeter, audio generator, oscilloscope, etc., with final test performance figures quoted if required—Ferrograph specialists. Tape Recorder Centre, Tel-Lee-Radio, 220 The Broadway, Wimbledon, S.W.19. 01-542-4946.

The Viennese Light Music Society invites applications for membership from those who are interested in the rare works of the Strauss-Familie, Ziehrer, Lanner and other composers of light music. Vast catalogue of available recordings, meetings, concerts, etc. Further details from: The Secretary, 433 Wisden Road, Stevenage, Herts.

FOR SALE—TRADE

Blackburn has Lancashire's leading Hi-Fidelity/Tape Recorder stockists and Electronic Engineers at Holdings Audio Centre, Mincing Lane/Derwent Street, Blackburn (Tel. 59595.)

Ferrograph Series 7 and Revox A77, brand new, tested and fully guaranteed. 10% discount for cash. Second-hand models sometimes available. Box 547 (Kent).

Always be careful (and money-wise) before buying quality equipment. Send your requirement list to Audio Supply Association for evaluation and quotation. See below . . .

If quality matters consult first our 70-page photographically illustrated catalogue with technical specifications (5/6). Members enjoy unbiased advisory service, preferential terms. Membership 7/6. Our associates also manufacture records from your own tapes, or record the Master at our studios (Steinway Grand). Bulk terms for choirs, fund-raising. Please specify requirements. Audio Supply Association, 18 Blenheim Road, London W.4.

Discount and Service. We are the only dealers offering big discounts on all hi-fi, tape recorders, radio, record-players, etc., plus servicing facilities. Our highly trained engineers can service all equipment supplied by us. All equipment is brand-new, guaranteed and supplied in makers sealed cartons. All makes supplied—return of post service. Send s.a.e. with your enquiry and we will quote same day. DISCOUNT AUDIO (TR), 192 Broadway, London S.W.19.

STUDIO FACILITIES

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

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

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

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

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

Location Specialists. Full mobile stereophonic recording facilities. Write or 'phone Richard Daniel, 4 Latham Road, Twickenham, Middlesex. 01-892-9599. 01-534-0066.

Pressing Specialists. Stereo/mono discs manufactured from your tapes, e.g. 99 off 7" EP Mono 10/4 each. 99 off 12" LP Mono 15/- each. Mobile recording service available. Please send for full particulars. North Surrey Recording Co., 59 Hillfield Ave., Morden, Surrey. 01-648-6345.

Eden Studios Ltd. The professional's recording studio. Tape-to-disc and mastering at competitive rates. Please send for leaflet. Eden Studios Ltd., 11 Eden Street, Kingston-upon-Thames, Surrey. 01-546-5577.

FOR SALE—PRIVATE

Truvox 102 three-speed tape transport with ½-track erase, record and play heads, as new, £25. **Walchris 53M** ribbon microphone (16 gns new), VGC, £8. **Eagle SE21** stereo headphones (£9 18s.), VGC, £4 10s. Exchange considered with **Ferrograph** or **Brenell.** Box 549 (Surrey).

Eagle TC450. Quarter-track stereo tape unit with record and replay preamplifiers. Mint condition, hardly used. Bargain £50 o.n.o. Box No. 548 (Surrey).

WANTED

Lee Electronics. The Tape Recorder and Hi-Fi Specialists wish to purchase good quality Tape and Hi-Fi Equipment for cash. 400 Edgware Road, W.2. Phone PAD 5521.

Highest prices offered for good quality Tape Recorders and Hi-Fi. R.E.W., 266 Upper Tooting Road, London, S.W.17.

GOOD QUALITY TAPE RECORDERS AND HI-FI EQUIPMENT PURCHASED FOR CASH. TELEPHONE 01-472 2185.

Cash for your unwanted records. Good prices for C. & W., Jim Reeves, Andy Williams, Engelbert, etc. Send list with s.a.e. for free estimate. Duckworths Records, Bottesford, Notts NG13 0EF.

POST THIS COUPON

FOR A REGULAR COPY OF

TAPE RECORDER

Subscription Department, TAPE RECORDER, Link House, Dingwall Avenue, Croydon, CR9 2TA.

Please send me a copy of each issue of TAPE RECORDER for .... months commencing with the ...... issue for which I enclose remittance of £.........s..........d.

Name ....

Address ....

.... T.R.

Home and Overseas 30/- (12 months) 15/- (6 months). U.S.A. $4.30 (12 months)

UP TO 50% OFF!

BRITAIN'S ONLY TAPE RECORDER MART

specialising in the SALE, EXCHANGE and PURCHASE of every make of high quality Tape Recorder. Brenell, Ferrograph, Ampex, B & O, etc., we have the lot!

Fantastic savings of **up to 50 per cent off** original list prices for **Personal Callers only.** Our stocks change daily—**call today**—well over **100 models to choose from—all guaranteed** —you pay **no tax** on secondhand machines.

TYPICAL BARGAINS

ALL WITH 3 MONTHS WRITTEN GUARANTEE
(Note: M = Mono, S = Stereo, BP = Battery Portable, 4 = 4 track, 2 = 2 track)

AKAI M8 (S/4)	**Our price ONLY 79 gns.**
AKAI M6 (2/4)	**Our price ONLY 62 gns.**
AKAI M7 (S/4)	**Our price ONLY 69 gns.**
AKAI 1710W (S/4) Brand New List £109 17 3	**Our price ONLY 85 gns.**
BRENELL STB2 TAPE UNIT (S/2)	**Our price ONLY 89 gns.**
BRENELL Mk. 5 (M/2)	**Our price ONLY 39 gns.**
FERROGRAPH 4/AN (M/2)	**Our price ONLY 49 gns.**
FERROGRAPH 5AN (M/2)	**Our price ONLY 59 gns.**
FERROGRAPH 631 (M/2)	**Our price ONLY 69 gns.**
GRUNDIG TK20 (M/2)	**Our price ONLY 15 gns.**
GRUNDIG TK30 (M/2)	**Our price ONLY 29 gns.**
GRUNDIG TK6 (BP/M/2)	**Our price ONLY 35 gns.**
GRUNDIG TK40 (M/2)	**Our price ONLY 35 gns.**
GRUNDIG TK41 (M/4)	**Our price ONLY 35 gns.**
GRUNDIG TM60 (S/2)	**Our price ONLY 39 gns.**
GRUNDIG TM46 (S/4)	**Our price ONLY 49 gns.**
GRUNDIG TK46 (S/4)	**Our price ONLY 52 gns.**
GRUNDIG TK340 (S/4)	**Our price ONLY 75 gns.**

NOTE:—THESE ARE NOW EVEN BETTER VALUE AS YOU PAY NO TAX ON SECONDHAND RECORDERS

PHILIPS EL3301 (BP/M/2)	**Our price ONLY 17 gns.**
PHILIPS EL3536 (S/4)	**Our price ONLY 45 gns.**
REPS R10 (M/2)	**Our price ONLY 35 gns.**
REPS R10 (M/4)	**Our price ONLY 35 gns.**
REVOX E36 (S/4)	**Our price ONLY 69 gns.**
REVOX 736 (S/2)	**Our price ONLY 85 gns.**
SANYO MR939 (S/4)	**Our price ONLY 72 gns.**
SANYO MR929 (S/4) Brand New List £95 10...	**Our price ONLY 79 gns.**
SONY TC260 (S/4) Brand New	**Our price ONLY 79 gns.**
SONY TC500 (S/4)	**Our price ONLY 59 gns.**
TANDBERG 1241 (S/4)	**Our price ONLY 69 gns.**
TELEFUNKEN 75 (M/2)	**Our price ONLY 19 gns.**
TELEFUNKEN 97 (S/4)	**Our price ONLY 49 gns.**
TELEFUNKEN 85KL (M/2)	**Our price ONLY 39 gns.**
TELEFUNKEN 204E (S/4)	**Our price ONLY 69 gns.**
TELEFUNKEN 204E (S/4) Brand New	**Our price ONLY 95 gns.**
VORTEXION WVB (M/2)	**Our price ONLY 55 gns.**

PERSONAL CALLERS ONLY

NEW TAPE RECORDERS

We also stock every make and model of New Tape Recorder plus a complete range of accessories.

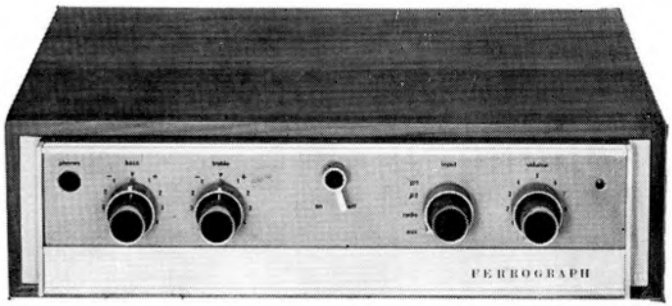
— *Part of the NuSound Organisation* —

THE TAPE RECORDER MART

242/4 PENTONVILLE ROAD, LONDON, N.1

(200 YDS. KINGS CROSS) TERminus 8200 (HALF DAY THURSDAY)

Ferrograph F.307 – a new stereo amplifier



the quality companion for the Ferrograph Series 7 tape recorders and any good Hi-Fi system

Ferrograph's Stereo Amplifier Type F307 was developed alongside the Ferrograph New Generation Series 7 Tape Recorders, to the same standards of quality and reliability. It is an integrated stereo amplifier with a unique combination of facilities, compatible with all Ferrograph Series 7 and with other top-quality recorders and Hi-Fi systems.

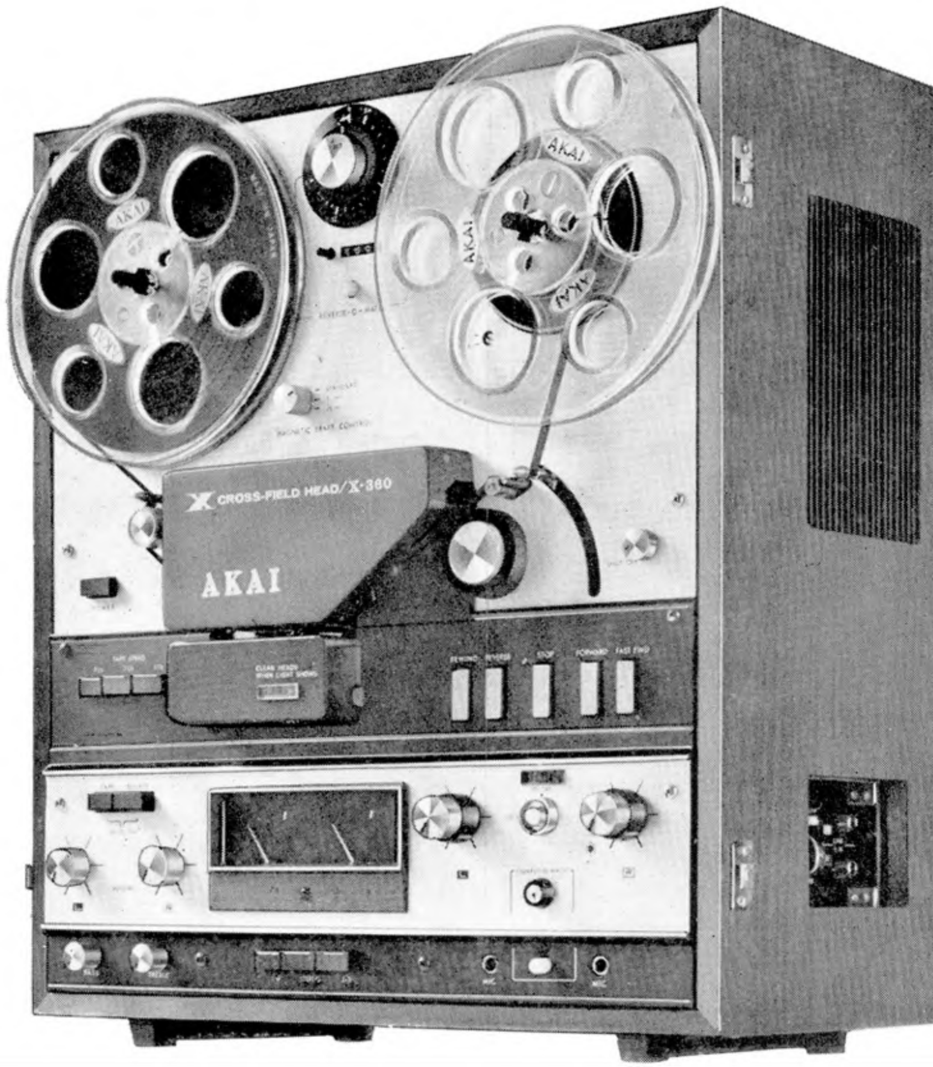
Features include: independent adjustment of each channel for tone and gain; high power output; frequency response 15 Hz to 30 kHz +1, −3 dB; minimal distortion, hum and noise; choice of four inputs.

See and hear this new instrument at your local Ferrograph stockist or use the coupon on page 185 for details and name of nearest Ferrograph specialist.

FERROGRAPH

The Ferrograph Co Ltd
Mercury House, 195 Knightsbridge, London SW7
Telephone: 01-589 4485

AKAI X-360
EVERYTHING
Technical Perfection
Superior Sound Complete Quality



Model X-360

AKAI's X-360 combines all the outstanding features of modern stereo tape recording. The magnetic (non-slip) brake and the 3-speed motor for capstan drive are two outstanding assets. AKAI's own unique CROSS-FIELD HEAD design offers amazing frequency response along with perfect high fidelity even at low-low tape speed. Then there are three automatic features that put the X-360 decidedly ahead, automatic volume control (Comput-O-matic), automatic dust minder, and automatic continuous reverse (Reverse-O-matic). For the increased stereo enjoyment, use the matching amplifier AA-8000 and the matching speakers SW-150. You'll find them a perfect match.

AKAI®

AKAI ELECTRIC CO., LTD.

Pullin Photographic Limited: 11, Aintree Road, Perivale, Greenford, Middlesex, Tel: 01998-1541