March 1973 25p

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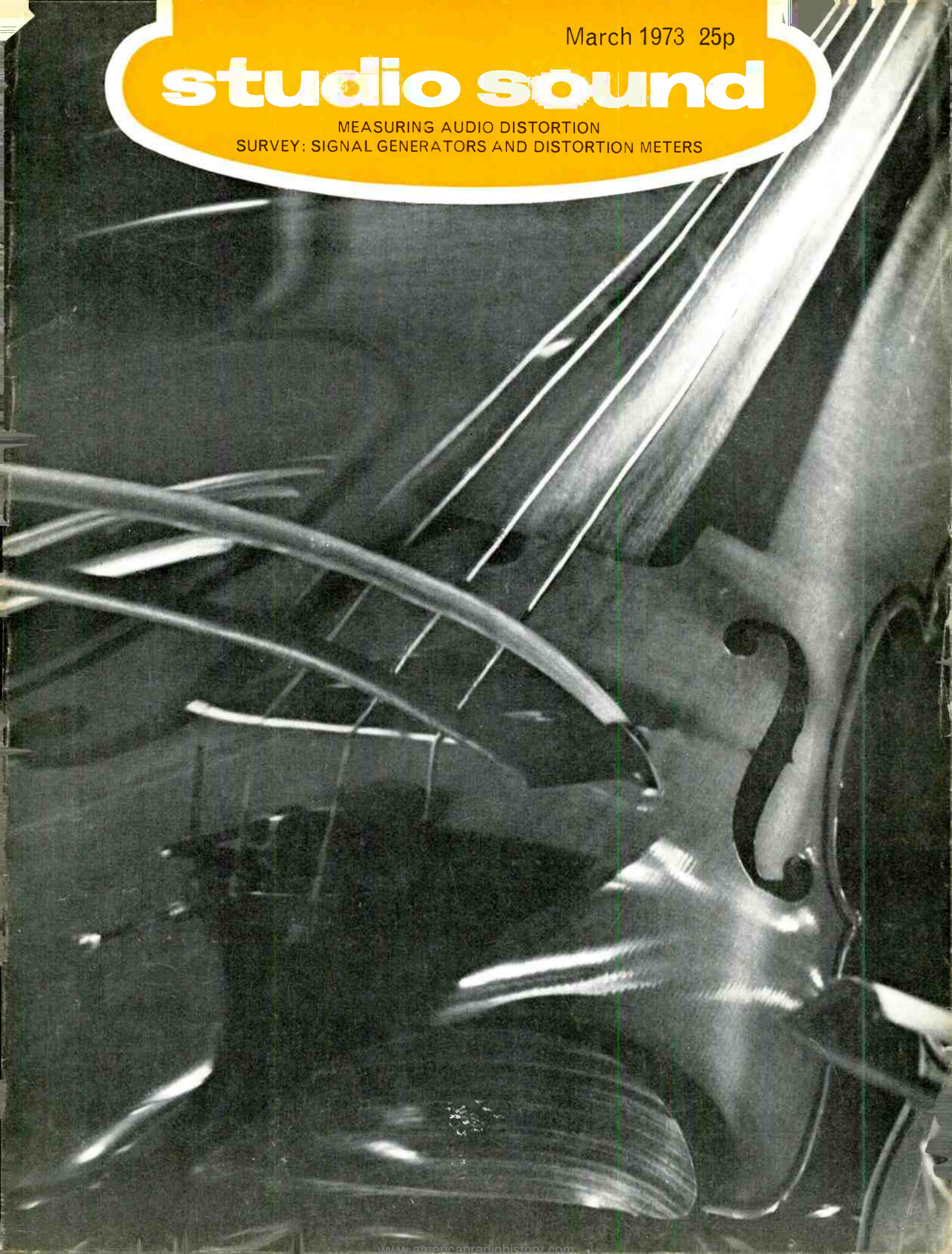

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CORRESPONDENCE AND ARTICLES

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

Articles or suggestions for features on all aspects of communications engineering and music will be received sympathetically. Manuscripts should be typed or clearly handwritten and submitted with rough drawings when appropriate. We are happy to advise potential authors on matters of style.

BINDERS

Loose-leaf binders for annual volumes of STUDIO SOUND *are available from Modern Bookbinders, Chadwick Street, Blackburn, Lancashire. Price is 85p. Please quote the volume number or date when ordering.*

MARCH 1973 VOLUME 15 NUMBER 3

GOOD TASTE HAS STRUCK AGAIN. This time in the shape of a North London resident, Mr R. McWhirter, 47. The action of this one individual resulted in the Court of Appeal postponing a television documentary on the American Pop-art painter Andy Warhol when neither the judges nor the complainant had troubled to see the production. McWhirter had read newspaper previews of the film and was evidently surprised at Warhol's behaviour. Perhaps he was unfamiliar with Warhol's unconventional paintings—of which some examples are, in our opinion, a valuable progression in the field of static art.

We had assumed Warhol's motivation to be primarily that of collecting money and were unaware that the program had even been scheduled. Thanks to Mr McWhirter's effort, our gentle minds were corrupted by subsequent newspaper accounts of dialogue filmed in a bed with producer David Bailey apparently naked.

Frankly, we find amateur censors a greater threat to the long-term public well-being than is the randomly identified 'pornography' they strive to conceal. The very word 'porn' (the 'ography' is more recent) is intangible in definition, relating to 'obscene'—'repulsive, filthy, loathsome, grossly indecent'—all dependent on the life style and mental programming of the beholder. Many of us would apply all four adjectives to the tobacco smoking addiction. Homosexuals might apply them to the activities of heterosexuals . . . and vice versa. It reflects poorly on the education of amateur censors that they fail to appreciate the broad range of human activity.

If the BBC and IBA, as the nation's prime information media, concentrate excessive attention on any one aspect of past or modern life, this alone deserves condemnation. Their prime purpose is to reflect humanity. Where they choose to guide it towards this religion rather than another, this politic, that technology, this or that life style, they wield a potentially dangerous influence over public thought. This influence is safer in the hands of a body such as the Governors of the BBC than in those of any strongly biased group of individuals.

In passing, let it be mentioned that the Victorian era—privately one of the most 'obscene' in recent times—hid its sexual, financial and alcoholic corruption beneath a superficial culture of unparalleled 'purity'.

SUBSCRIPTIONS

STUDIO SOUND, *published monthly, enables engineers and studio management to keep abreast of new technical and commercial developments in electronic communication. The journal is available without charge to all persons actively engaged in the sound recording, broadcasting and cinematographic industries. It is also circulated by paid subscription to manufacturing companies and individuals interested in these industries. Annual subscription rates are £3 (UK) or £3.30 ($8 or equivalent) overseas.*
STUDIO SOUND *is published on the 14th of the preceding month unless that date falls on a Sunday, when it appears on the Saturday.*

PAST ISSUES

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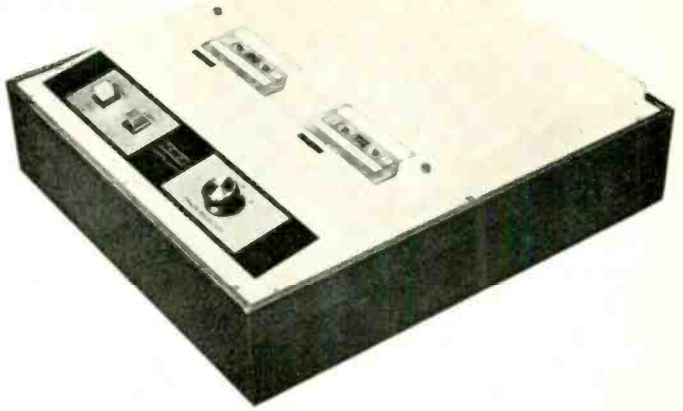

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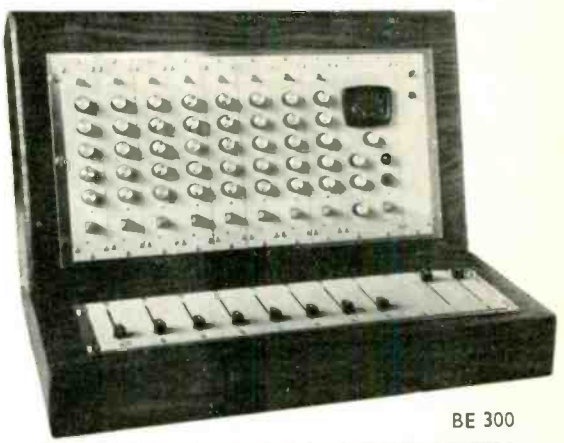

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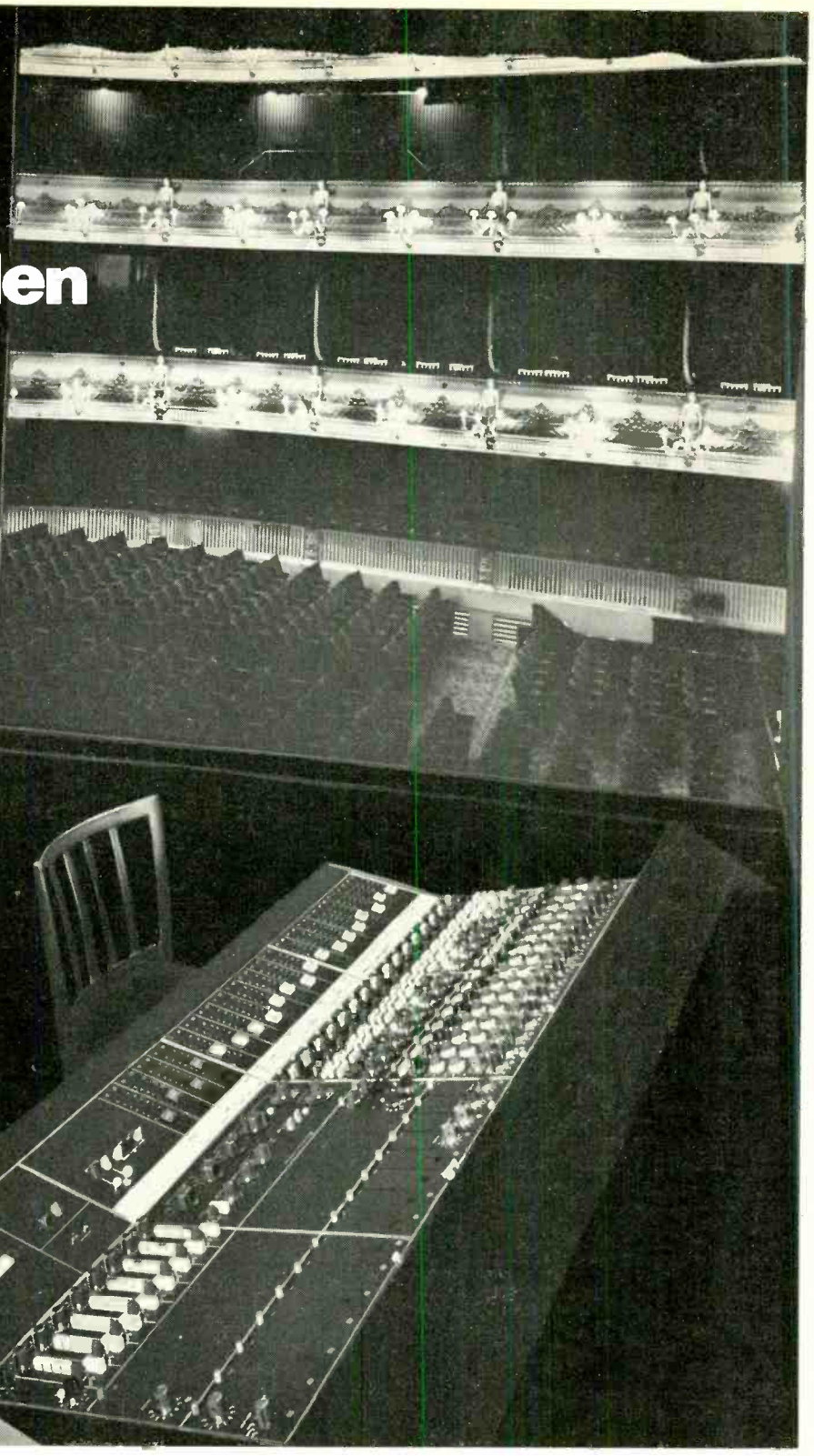

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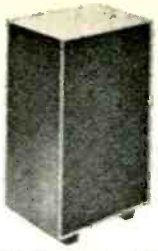

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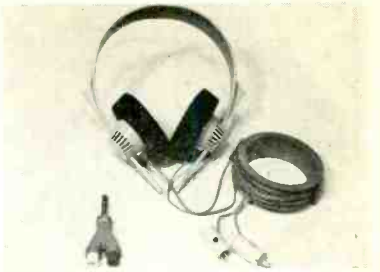

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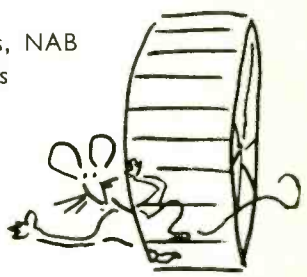

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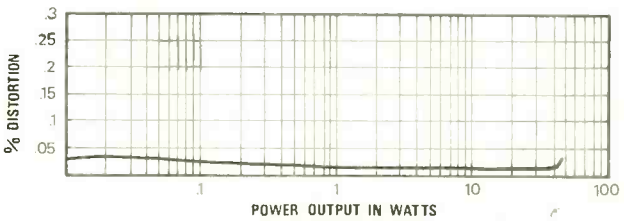

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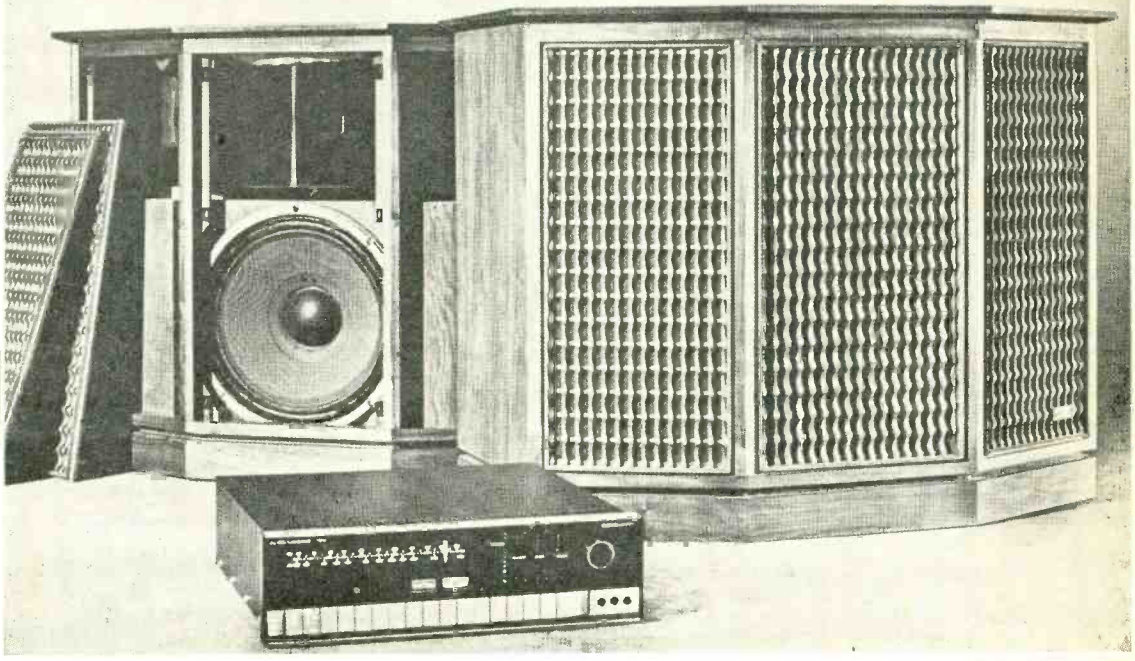

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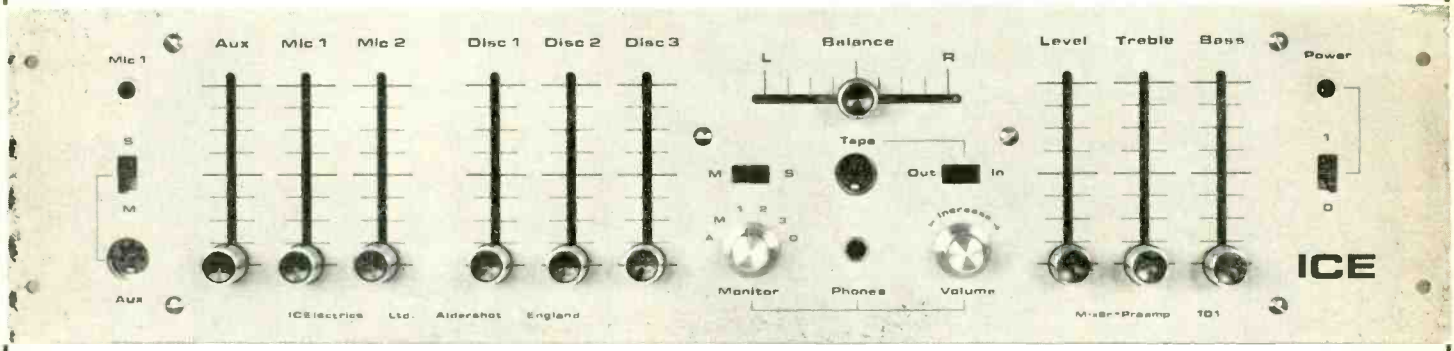

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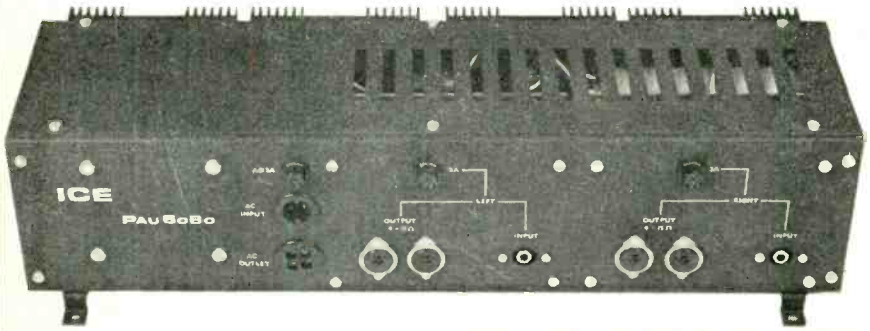

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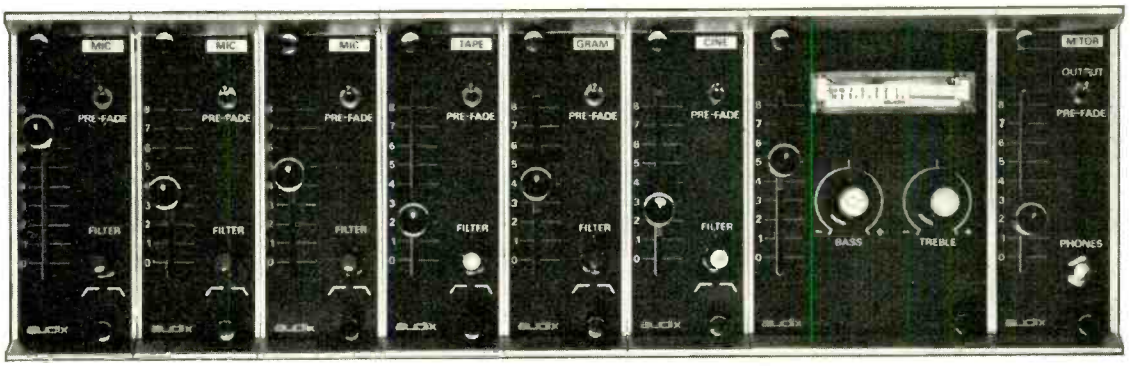

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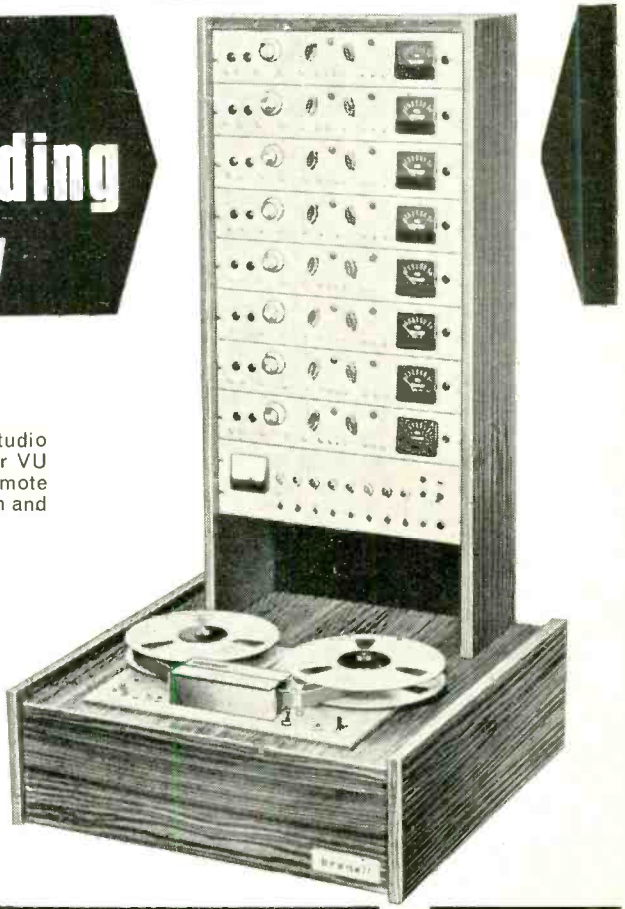

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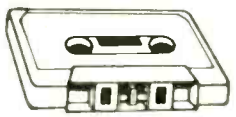

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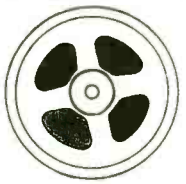

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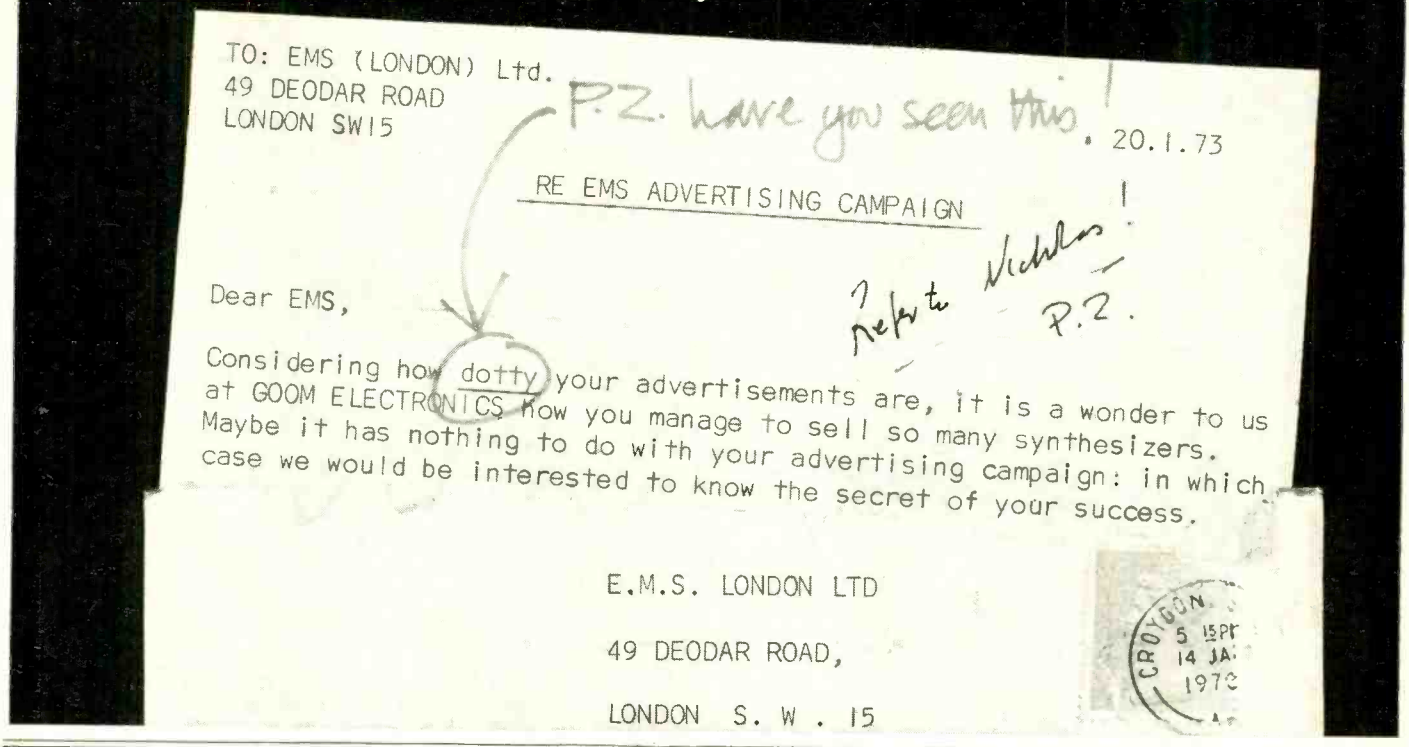

TO: EMS (LONDON) Ltd.
49 DEODAR ROAD
LONDON SW15

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RE EMS ADVERTISING CAMPAIGN

I refer to Nicholas' P.Z.

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5"	600'	30p	87½p	900'	40p	£1·17½	1200'	62½p £1·85	5" 9p
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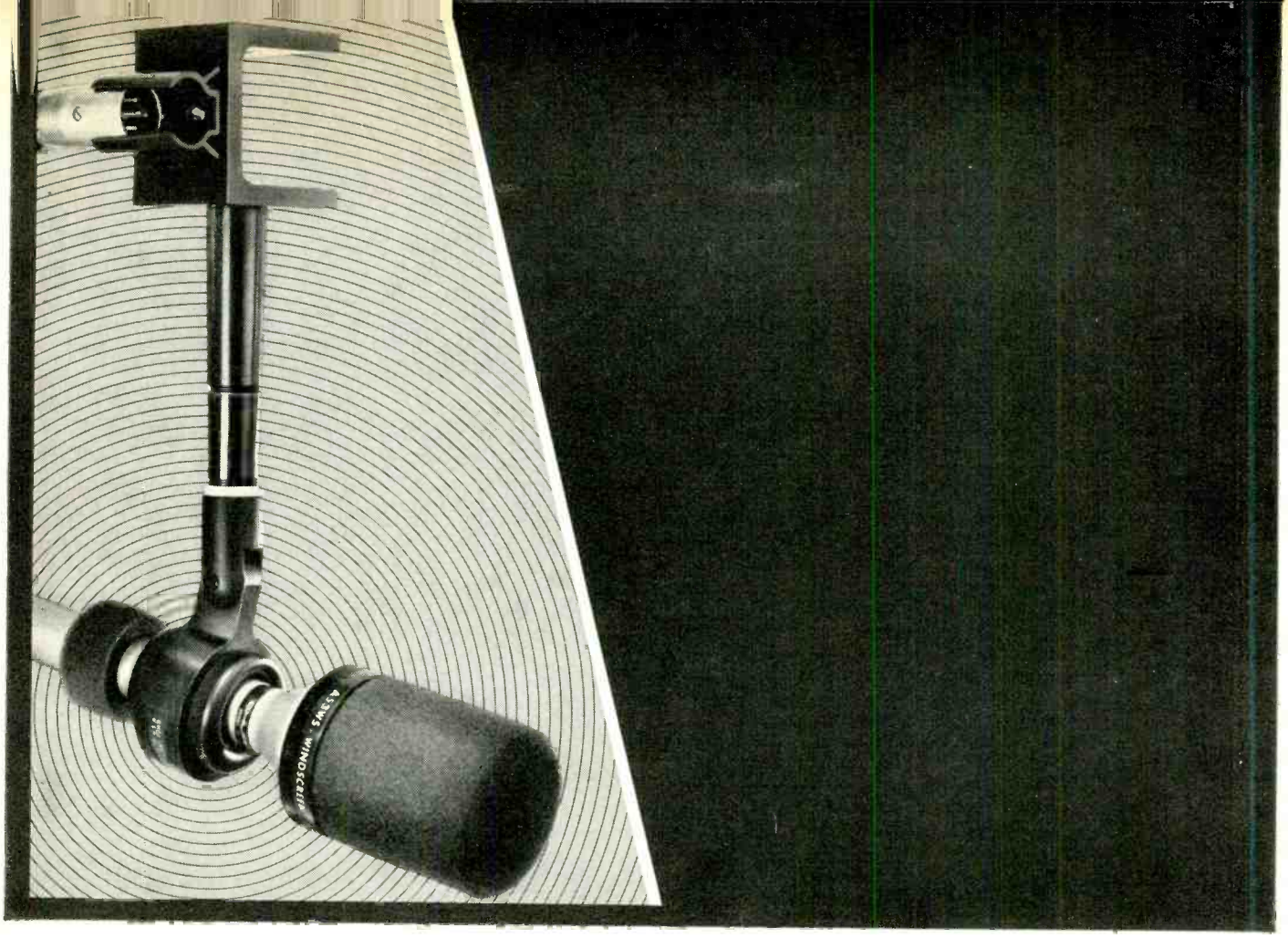

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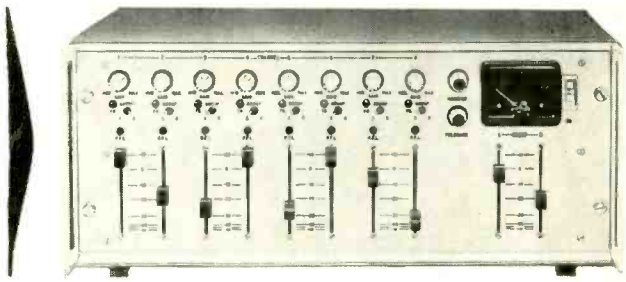

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NEWS

Receiver in Command

A RECEIVER MANAGER was appointed for Command Studios on December 27, 1972. No statement was available from Command, their creditors or their receivers — Thomson McLintock & Co. At the time of going to press, a number of prospective buyers had already expressed an interest in the studios. One source commented that Command's business improved remarkably at the beginning of the year. The receiver will probably try to make the studios pay under their present owners but, if that proves impossible, will sell Command to repay creditors. If Command cannot be sold whole, the premises and equipment could be sold piecemeal.

APRS form Engineer's Guild

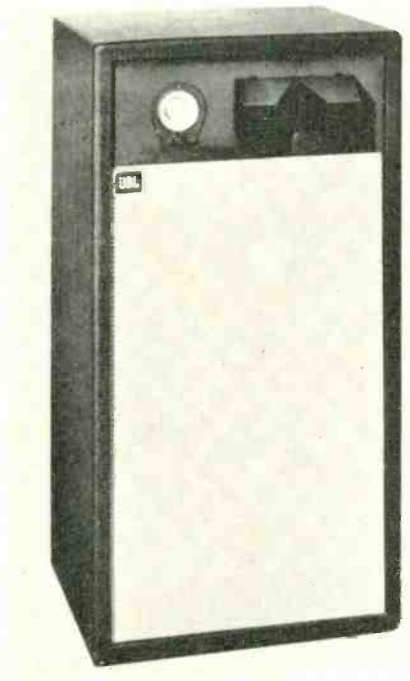
AN INAUGURAL MEETING of the Engineers' Guild was held by the Association of Professional Recording Studios on January 31. Held at the Holland Park premises of Lansdowne Studios, the meeting saw the discussion of draft rules and an outline plan for future Guild activities. Membership is open to all sound recording engineers who have been thus employed for one year or more; it will *not* be restricted to the staff of APRS members. The draft rules provide for discussion on any technical subject of interest to members but excludes all matters under the general headings: conditions of employment, wage rates, trade unions and politics. Further information is available from the APRS secretary: E. L. Masek, 23 Chestnut Avenue, Chorleywood, Herts WDS 4HA.

Film '73

ARRANGEMENTS ARE being finalised by the British Kinematograph, Sound & Television Society for Film '73—an international film and tape technology conference and exhibition. This will take place at the Royal Lancaster Hotel from June 25 through 29. Delegates attending the conference can avoid paying VAT on their registration fees if these arrive before April, honorary treasurer Mr Harry Manley pointed out following an organising committee meeting. Further information is available from Paul McGurk, BKSTS, 110-112 Victoria House, Vernon Place, London WC1B 4DJ.

Hong Kong to gain two more tv stations

A BILL AMENDING the Television Ordinance was introduced before the Hong Kong Legislative Council in January. As soon as the Bill becomes law, tenders will be invited for two new television stations. This will give the Colony a total of three stations, two broadcasting in both Chinese and English and the other in Chinese only. Announcing this, Mr Nigal Watt (Commissioner for Television and Films) said he expected the tender period for the second licence to be open for three months



while the third (Chinese only) would be open for up to an additional nine months. It was, however, the Government's policy to bring both services into operation with the least possible delay. Regarding broadcast advertising time, the present ten per cent of total transmission time would be retained but the number of advertising minutes in any one hour raised from seven to ten. The Bill further proposed that the rate of royalty be assessed on the net profits of a station rather than, as at present, on its gross takings. Meanwhile, a temporary extension to their wired service (RTV) is being offered to Rediffusion Television until the first of the two new stations commence broadcasting.

People

MR J. STEVENSON has been appointed to the board of EMI Sound & Vision Equipment Ltd, Hayes. He becomes director of operations for EMI Industrial Components, one of five divisions comprising this £9,000,000 subsidiary of the EMI Group. For the past five years, Mr Stevenson was director and general manager of Bowthorpe Power Equipment at Bridgend, Glamorgan.

Mr Ken Gledhill joins the board of Farnell Electronic Components Ltd, Leeds, as sales and marketing director. This follows ten years in the capacity of sales manager. Mr Ian Johnstone, who has served the company for a similar period as sales office manager, has been appointed executive director and will be responsible for internal administration.

At Sound Techniques, Mildenhall, Mr Ronald Pender has been promoted to the position of senior sales and service engineer.

Portable loudspeaker

TWO 380 mm JBL bass drivers with 100 mm edgewound voice coils rated at 180W rms are incorporated in a new series of portable loudspeakers available from Feldon Audio. The design is based on the *1326 Studio Monitor* developed by Feldon in association with EMI Research and offers increased power handling, greater efficiency and extended bass response permitting auditorium sound levels. Crossover points are 800 Hz and 7 kHz sloping at a variable 12 dB/octave. The system may alternatively be bi-amplified.

Further information: Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH.

Led incremental ppm

DETAILS OF A newly developed incremental peak program meter using light emitting diodes have been received from Digital Design, Norway. Three versions of the meter are available, the *521* incorporating 52 leds and covering 50 dB in one scale with 1 dB resolution. This can be supplied with 20 or 40 dB additional gain if desired. Model *521* is housed in an *A1* European standard module (190 x 40 x 117 mm) while the simpler *162* version comes in *B1* format (95 x 40 x 117 mm). The latter unit features a 16 led display covering 28 dB in one range with 2 dB resolution. Model *163*, again to the *B1* standard, employs 16 leds to cover 43 dB with 3 dB scale resultion.

Manufacturers: Digital Design, Box 1220, 7001 Trondheim, Norway.

25 mm tape winder

A HIGH SPEED winder for 25 mm video, instrumentation or industrial audio magnetic tape is now available from Leevers-Rich. Model *LR500* accepts spools of up to 356 mm diameter and winds in either direction at speeds variable up to 12.7 m/s. A choice of three tensions is incorporated to suit tapes of different thickness and dry tissue wipers are fitted to remove superficial dirt and oxide. Dimensions are 635 x 483 x 609 mm (hdw), the weight 34 kg, and the price £335.

Manufacturer: Leevers-Rich Equipment Ltd, 319 Trinity Road, Wandsworth, London SW18.

Portable control desk

A MARK TWO version of the Chilton *10/2* portable control desk is now being produced by Magnetic Tapes Ltd. Basic facilities now include pfl and auxiliary send on all input channels, break jacks on all inputs and output groups, talkback, mono / stereo selection (channels One and Two), illuminated cue lights and a line/monitor switchable ppm. Basic price is £275.

Manufacturer: Magnetic Tapes Ltd, Chilton Works, Garden Road, Richmond, Surrey.

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DIARY

By John Dwyer

THE QUESTION going the rounds at the moment is 'Who the hell are Bonochord?', a question which I hope to answer next month. But there is one other takeover in the air which I find even more interesting than Bonochord's Neve purchase. At the last annual general meeting of EMI it emerged that at least one shareholder had been approached by 'a third party' with a view to selling his shares. Sir Joseph Lockwood, the chairman of EMI, remarked that he was aware someone had been 'sniffing around'.

At the beginning of this year a certain well-publicised non-event caused sharp rises in the value of EMI shares because of speculation about a possible takeover. The non-event was the appearance of Mr H. Hughes, an aircraft and electronics king and little-known recluse. EMI later denied that there was any truth in the rumours that Mr Hughes intended to bid for them.

What I find fascinating about all this is whether Mr Hughes, if indeed it is he who is 'sniffing around', will take over all of EMI, part of it, or indeed none of it. As I mentioned, Hughes already has a considerable electronics company of his own and the electronics division of EMI would be a sensible addition. The division would also, I think, be fairly cheap; now that EMI's Capitol subsidiary are out of trouble, EMI's main problem is that the electronics division made a profit of only £1,353,000 last year compared with £3,090,000 in the previous year, even though sales had increased from £13,593,000 to £17,165,000. 'Our electronics operation,' Sir Joseph told shareholders, 'failed to contribute a reasonable return on investment'. The reasons for the electronics division's poor performance are that not enough money is being invested in industry generally; if there is little investment that means that firms cannot buy new equipment, which means that they will not buy the electronics to control that equipment.

If the putative buyer of EMI were anyone other than Howard Hughes, the evidence, though circumstantial, would be therefore pretty conclusive. My guess is that, if Hughes does move in on EMI, he will in fact go for the electronics and leave the rest alone. But Hughes is a complicated character who has always had an interest in entertainment; he it was who directed *Hells Angels* and started RKO. He also designed a bra for Jane Russell —now there's a man to be reckoned with.

AIR studios will be among the first to go 24 track when they get their 3M 24 track machine in the coming summer. As mentioned in last month's 'News', they will also be getting a new 32/24 Neve desk, to replace the two and a half year old Neve they already have. The control room of studio Two, where the new desk will go, has already been fitted with four speakers for quadraphonic work. The speaker cabinets were designed by AIR'S Dave Harries.

AIR tell me that they will use the CBS system when they start cutting quadraphonic discs, partly because of AIR's links with EMI, who have already adopted the CBS matrix for all their releases, and partly because AIR say they have more confidence in a system which has been devised by a record company, a view which I have heard expressed more than once.

When I went into the control room of studio One, Roger Cook was in there mixing; he's in there so often in fact that I'm surprised AIR don't give the poor bloke a bed—he was sitting on the floor when I saw him. Studio One has an identical desk to that now in control room Two. There are full projection facilities for film work and studio One itself, designed by the ubiquitous Ken Shearer, will hold a maximum of 80 musicians, though a more comfortable number is between 50 and 60. There is complete isolation from the noise of Oxford Street outside because of the now familiar box-within-a-box construction of the studio. Bill Barringer took me on a tour of the projection room, the dubbing theatre and the reduction room. All of these can be linked either to one another or to any of the three main studios via a jumbo patch bay in a room off one of the corridors. AIR are doing quite a bit of film recording work now; the Third Ear band recorded the *Macbeth* soundtrack here, though I hasten to add, lest I incur the wrath of Shepperton's head of sound Nolan Roberts, that *Macbeth* was dubbed at Shepperton.

The projection room, now finished, has Philips projectors and Albrecht film record/replay machines. The machines are synced with the *Syntronic* system, which uses a photo-generator. Bill told me that the advantages of this system were that the sync pulses came from a much smaller generator which needs less run-up time than other methods. The Albrecht machines have been modified to take either 16 or 35 mm stock and the projection room has Cinemascope facilities. AIR employ a full time projectionist.

AIR dubbing

The AIR dubbing theatre is used for tape copying and previews, as well as dubbing. Film recordings can be made on either 16 track or mono 35 mm stock. Usually the musicians perform in one of the main studios and the sound is patched through to the dubbing theatre but it is possible to put a small group in the theatre itself.

The reduction room, where the mixing and overdubbing is done, has a 16/8 desk, again by Neve. On the day I was there, there were also a trolley of spare Dolby *301* units and a Moog synthesiser in the reduction room. I also got a closer look at Dave Harries's speakers; Bill told me that, when Richard Perry came in to do a Carly Simon album, he said he thought the speakers were the best in London. It was in the AIR reduction room that John Woods of Sound Techniques mixed the *Clockwork Orange* album.

Altogether AIR have one 16 track Studer, two 16 track 3M machines, nine or ten *A62* Studers, two *A80* eight track machines, and two new *A80* 6.25 mm machines, as well as a Studer *C37* and a *J37*. They also have two Kepex units, which they say they were pleasantly surprised with, a Countryman phasing box, a Universal filter unit, which most people agree is superb, five stereo EMT plates, and a concrete echo chamber.

AIR are usually pretty busy and recent recording work has included Medicine Head sessions produced by Tony Ashton; the Kings Singers, produced by Miki Anthony, and *Hamlet* recordings for the Argo label. John Williams, that great classical/jazz all rounder, brought his guitar in for some sessions and other recordings were made by Wings, Procol Harum, Matt Monro, Jon Hiseman, Elton John, Butterscotch, Brenda Arnau, Ralph McTell, T. Rex, Gary Moore Band, and Roger Cook and Herbie Flowers, who recorded as Roger and Herbie. Film work has included *Wembley Rock* for World Film Services; Ringo Starr's first Apple Films feature: *Count Downe;* Cat Stevens at the Albert Hall and *Quality Street*.

This month I accepted an invitation from managing director George Clouston to look round **IBC** studios. Mr Clouston had plenty to tell me. The company has just finished refurbishing and re-equipping its stereo cutting room, which will be equipped entirely with Neumann equipment apart from Ortofon cutting amplifiers and heads. The cutting room has been decorated, very well in my opinion, by W. Rossell Orme and Partners.

IBC have also finished building a new mixing console for themselves. Their previous desk was also a self-made product and has lasted six years now. It will still be in use but I will come to that in a moment. The new desk is a 32 input, 32 output desk with free grouping, seven built-in limiters—six mono, one stereo—three foldbacks and five echo systems.

The routing indication is of a type I haven't seen before. Behind a 'pot blue' glass screen the width of the desk are a row of digital display tubes which show the number of the track you are recording on or mixing from. The number shown above each channel, and hence the track being used, can be altered by a rotary switch on the channel. There is a 16 channel monitoring bank which provides the same facilities as any other channel apart from the equalisation. As well as the usual solo facilities, which they have called priority, they have put in a kill facility which will remove the channel on which the kill button is pressed. There is also a master kill control which will remove a number of channels in the same way.

Technical director Dennis King told me that

26 ▶

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continued

he and his three colleagues in the workshop had designed and built most of the desk themselves, apart from painting and so on. 'Microphone amplifiers are much the same these days,' he said, 'so there's nothing new there, but the equalisers are our own system.' There are three ranges: 35 to 640 Hz, 640 Hz to 14 kHz, and 700 Hz to 20 kHz. All these are provided with cut and lift and are infinitely variable. The eq button to bring these into circuit has been put at the front of the machine with the kill and priority buttons.

There are, as I remarked to Dennis and to Mike Claydon, the studio director at IBC, very few pushbuttons on the desk compared with some desks I have seen. Dennis King explained: 'We aren't manufacturers and so we can please ourselves about what we put on the desk. On other desks you will see impedance switches. We don't need them; we *know* what all our impedances are. You will also see phase switches on desks. We don't need them; we *know* that everything is in phase. If by some chance something is out of phase for some reason, we can use a phase transformer that we have. But I can only remember one occasion in the last five years when something of that kind has happened.' Dennis and Mike had a quick conference and decided that indeed it had happened only once in the last five years.

IBC say they have no intention of making desks for anyone else, as seems to be fashionable. They have other plans. Their basement, now largely unused, is planned as a third studio, and it is possible that the original desk studio A will go in there after IBC have reconditioned it.

The main studio A can take 45 musicians, though it has accommodated more. All the tape machines—one 16, one eight, one four, one stereo and one mono machine—are Ampex and both studios A and B have a full complement of Dolby units for all recording configurations. There are two mono and two stereo EMT plates and a large separation booth in studio A. IBC's rates are £25 an hour for studio A and £18 an hour for studio B, no matter how many tracks you use. Both studios are 16 track.

IBC have decided to expand to cope with the future demands of commercial broadcasting. IBC started as a commercial radio company back in 1925; as George Clouston said, they have come full circle. The founder of the company was Captain Leonard F. Plugge, MP, and a better name for the founder of a commercial radio company I cannot imagine. IBC moved into their present home at 35 Portland Place in 1937, when the company owned and operated Radio Normandy. That station closed when the Germans occupied France but IBC carried on producing wartime broadcasts.

After the last war, IBC carried on making radio programs as well as doing commercial recording. George Clouston and his partner, Eric Robinson, first came to the studio to record some shows for CBS. At that time George and Eric were in partnership to provide orchestras and musicians. The shows were for television series like 'Perry Mason', 'Wagon Train' and 'Have Gun Will Travel'. George and Eric used IBC for five years and eventually bought the company. It is ten years since they took over. IBC have now joined a consortium who have applied to the IBA for a licence to run London's news-only commercial radio station. I suggested to George Clouston that it was rather strange for a music studio to apply for the news station rather than the general entertainment station. He agreed that their decision had surprised many people. He said there would be a shortage of artists of a particular kind for the general station since it would be competing with Radio One, Radio Two and Radio London. 'The news-only station is an entirely new concept in this country. We've never had 24 hours a day news here before. I've spent some time in New York so I know quite a bit about these kind of programs : what we hope to provide is in-depth news.' He said that they would rely heavily on the normal news sources but that a member of the consortium was the head of Universal News Services and this would give them a considerable advantage.

Recent work at IBC includes recordings by Status Quo for 'Top of the Pops'. The recordings were produced by Gaff Management. Status Quo recently finished an album at IBC, as did Andy Bown, who also recorded for Gaff Management. Orbit Music brought in a new group called Shepstone Dibbins and Leon Henry Productions came in with the New Seekers. Robert Stigwood's organisation was responsible for a Bee Gees recording and Vicky Leandros came in for Phonogram.

The most memorable visit of the month, for me, was that to **Central Sound** in Denmark Street. Central have a 16 track studio which will hold 22 musicians. The control room is above the studio and linked to it by cctv.

I met Matt Geddes, director and manager of Central, a very friendly Scot who gave me some much needed coffee and a fag. When we had chatted for a while I got the impression that he was thinking: 'I know this is a good studio and so do my clients; as soon as you hear what we're doing you'll think so too'.

When a few minutes of his hospitality had soothed my pre-Christmas West-End nerves, he showed me round. The studio measured about 6 by 9m and has a drum booth in one corner. Matt showed me their Acherberg-Perzina piano, reconditioned by Roger Pick, and explained that it was one of the studio's main attractions. 'People can tell one of our recordings just by the piano sound we get,' Matt said. He tells me all the microphones in the studio are capacitor types. Central also have two *U47 fet i* Neumanns which Matt is very pleased with.

The studio, owned by Freddie Packham, went 16 track in July last year. The 20 channel desk was built for them by Sound Techniques and is linked to an Ampex *MM1000* 16 track tape machine. The desk has built-in Dolby units. Monitoring is by matched Tannoy Golds. There are two Ampex stereo machines in the studio and one Ampex mono machine. They also have an EMT stereo plate.

We went up to the control room where they were mixing just about the best sound I've heard in a long time. The two guys responsible

for this wonder were Ron Roker and Gerry Shurey, who were pretty excited about the sound themselves. Matt just stood on one side and smiled.

Ron and Gerry were producing on behalf of ATV music who, Matt tells me, use the studio a lot, as do Carlin, WEA and United Artists. The group they were recording was called Smile and was augmented by six violins, some vibes and tymps, and three brass players playing six part. The guitar part for the number, *Using Me*, was brilliantly played, I thought, by Chris Rae. 'Ron and Gerry write, produce and arrange all their own stuff,' Matt said, and Ron told me that he thought Gerry was one of the governor arrangers in the UK, which I can believe. Ron wrote *Storm in a Teacup* with Lynsey de Paul, and Gerry has done a lot of arranging work for Tony Macaulay with the Fantastics. The single I heard was cut at Apple early in January and released at the beginning of February. I think it deserves all the success it gets. The engineer was Simaen Skolfield.

As well as the Smile sessions, Central have been holding a three-day session by a group called Ro-Ro, which comprises Alan Ross and Graham Deacon, two well known session men, bass player Andy Sneddon, who used to be with East of Eden, and Rick Brown on organ. The session was held by CMC records and produced by Tony McPhee. Other visitors to the studio have been Ed Welsh, Tom Paxton, America, the Bee Gees, Easybeats, Lynsey de Paul, Barry Green of ATV music and Sylvie McNeil.

Marquee. I was hoping to be able to say more about the phasing device which Marquee have installed but they aren't quite ready to say anything about it yet, being in the middle of putting in a new desk. The desk is an MCI job and was flown, so Marquee tell me, from Florida to New York to Frankfurt to Washington to Frankfurt to Manchester to Frankfurt to Heathrow. I didn't think Frankfurt was so attractive but maybe mixing desks like to visit porn shops too.

I'm also told that the studio is now the busiest it has ever been, which is good to hear. Rory Gallagher's new album, which came out at the beginning of February, was recorded at Marquee as was the soundtrack for a film of Status Quo, Byzantium and Jade Warrior performing in the Marquee Club. I understand that the recordings were made 16 track and pulse synchronised to the cameras. A new group, Stapley Markstein, came in to do a debut album for Kaplan Kaye.

Gerry Morris made a solo album produced by Tony Atkins and engineered by Geoff Calver. Paul Brett came in to do a new single with engineer Geoff Calver and a Bobby Moon album was produced by Mike Redway and Alan Field.

Advision. One of those embarrassing occasions when we have to let slip how long it takes to produce a magazine—one F. Christmas came into Advision to do three 'Christmas on ITV' commercials for Halas and Batchelor. And that, friends, will be the last mention of Christmas 1972 in STUDIO SOUND and I mean that most sincerely, friends, I really do. Dennis Drinkwater of Telstar Productions dubbed 23 films at Advision for Thames's *Holiday '73*. Engineers for these were Andy Whetstone and Graham Middleton. The films were between seven seconds and two minutes long. Roger Cameron engineered for the Reg Varney film *Go For a Take*, produced by Century Films, as well as working on the Jimmy Tarbuck Show for the BBC.

Tv commercial Work: Roger Cameron mixed Golden Wonder Crisps and Babycham for Massius Wynne Williams—next month Alka Seltzer?—Gary Martin did a Schlitz beer track for Air Edel and Martin engineered some Bill Withers tracks for A & M.

Roger also engineered a new album for Jack Jones under Jack's own production as well as Howard Blake's four channel *Quadraphonic Fanfare* which will be heard before performances at the National Film Theatre.

CTS De Lane Lea. Humphries Holdings, owners of De Lane Lea, have appointed a new chairman, Mr W. M. Travers. Mr Louis Elman has won a contract to produce English versions of 13 more tv programs from Poland. The series of programs will be introduced by Christopher Lee for NBC.

Lion International. John Bentley fans will be sorry to hear that he seems to be in retreat. As I reported last month he has a large stake in Lion International which, it seems, he plans to sell any minute. He has already sold his toy firms: Triang, Chad Valley, Pedigree and Sebel. He also intends to get rid of his share of Barclay Securities. His latest brainstorm was to try and buy off the Federation of Film Unions by setting up yet another new company, Shepperton Studios 1973, and offering 50 per cent of the equity to the workers. He made the proposal in a letter to Alan Sapper, the secretary of the Federation, and used such phrases as 'worker participation' to guarantee two years work to the film workers—now where have you heard that before? Sad to say, Bentley will not now stand as a Conservative candidate.

Meanwhile Lord Goodman, Sir Max Rayne and Roy and John Boulting, who have now left the board of Lion International, have formed a new film production company, Charter Film Productions. They are putting in 'around £1,000,000'. Guess where from. The first film will go into production in the spring and will be called *Soft Beds Hard Battles*. The budget will be around £400,000 plus. As yet, they do not know where the film will be made but John Boulting said that 'it may even be made at Shepperton'.

Kolinor, Tel Aviv, Israel. Two film songs recorded by Chaim Topol in English. The film is *The Going Up of David Lev* and the two songs are *The Girl With the Red Ribbon* and *Chiribum*. (I know, I know, but that's what they said: *Chiribum*!)

Sound 80, Minneapolis. Nicely produced newsletter from Joyce Bosak tells me that the studio opened at the beginning of the year. Sound 80 are on the fortieth floor of the IDS skyscraper in Minneapolis. Bob Schultz, former president of Micside Inc and a music theory graduate from Valparaiso University, is in charge. 'The IDS studio will be primarily geared to the needs of advertising agencies and industrial users,' the newsletter says. 'Complete mono and stereo production facilities will be offered. In addition, a complete music and

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STUDIO VAN DE WATER

STUDIO VAN DE WATER are situated in the pleasant semi-rural region of Baarn, some 30 km south-west of Amsterdam and 10 km west of Hilversum, the centre of Dutch recording and broadcasting. The premises is one of several light-industrial plants in a group surrounded by private houses. This group contributes little noise to its neighbours and in turn enjoys a quiet and clean environment. A minor road carries light traffic past one side of the estate; the nearest heavy traffic is a good 1.5 km distant on the road from Amersfoort to Amsterdam. Aircraft noise is virtually non-existent since air traffic is banned from the neighbourhood of the Dutch royal palace (2 km distant).

To trace the history of the studio, we must look to the career of its owner—André Van de Water. He worked in Dutch radio and television broadcasting from 1947 and, in 1955, left Dutch Television as chief of the sound department. He then joined Philips, specialising in location recording. When Latin American music of the Los Paraguayos style became popular in Europe, he travelled to South America and there, with transportable equipment and a producer-cum-talent-scout, he went in search of promising material. Later work for Philips included many recordings of Robert Stolz and his Opera Orchestra taped on location in Vienna. In 1964 he decided to form his own studio.

The first recorder André owned was a monophonic Revox. On this he produced commercial programs for Radio Veronica and Radio REM. This met the cost of a stereo Philips *PRO 36* which, after modification to the input amplifiers and transport, he used for classical music recording. A Neumann *U67* stereo pair was employed for all location classical work. A church in the village of Soest, 5 km from Baarn, was his preferred location and there he recorded many sessions with leading symphony orchestras. His last recording there was with the opera soprano Christine Deutekom, resulting in her first (and successful) disc. By now, non-classical work demanded multimicrophone facilities and these were provided on a Van de Water-built 6/2 mixing desk.

In 1967, Studio Van de Water took over part of the former stables of a castle at Nederhorst den Berg. The rooms proved ideal, both in shape and structure. A modified 8/2 Philips *MD* desk was incorporated in the control room.

By 1970, the castle facilities were outgrown and Studio Van de Water entered their present premises. The tinted area of **fig. 1** shows the layout adopted during that year. Since then, an adjacent paper store and garage have been demolished to permit the addition of a second control room and studio. Owing to the high weight of bulk paper, the former lessor had a 500 mm thick concrete floor constructed in segments over a 1.5m bed of white sand. All the studios and control rooms were built on this surface which offered ideal insulation against groundborne noise. Building of the extension (studios Two and Three and control room One) started in February 1972 and was completed in August. Virtually all the planning, including sound isolation, air conditioning and cabling, was carried out by André and Dick Swaneveld.

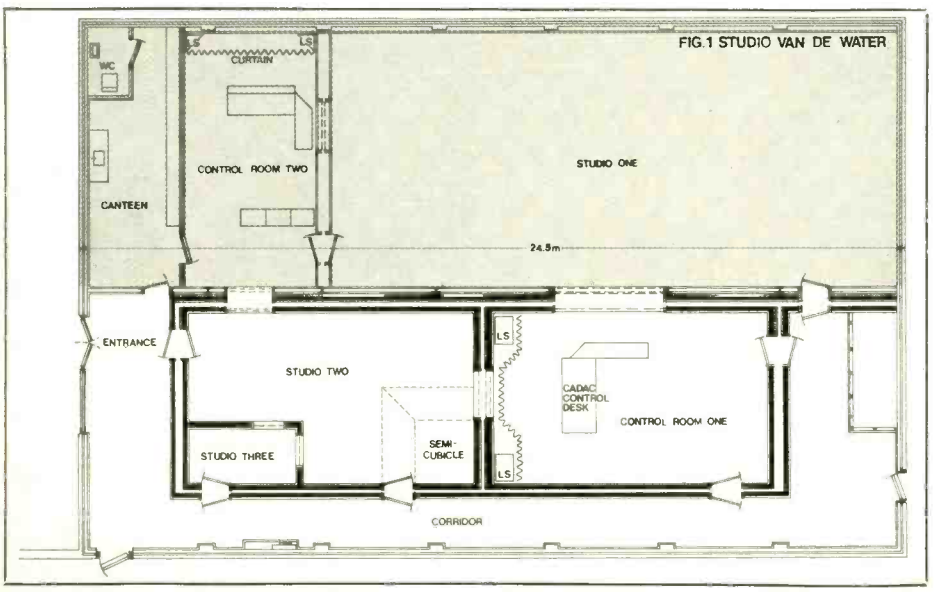

FIG.1 STUDIO VAN DE WATER

Dick joined the studio in 1971, four months before the Baarn extension was commenced. In 1961 he went from technical school into Dutch Television where he worked on the audio side for some eight years. 'I left for the same reasons that André did. Conflicts arise if you want to do something another way when your colleagues have used a particular method for 40 years.' Dick joined an Amsterdam production group specialising in puppet films. As the group's sound engineer, he gained experience in film dubbing, studio recording and location recording.

With a former Dutch Television colleague, he produced several records in his spare time of which the most successful, *Bloody Mary*, held for three weeks at the top of the Dutch hit parade. Their plan was ingenious. They played through 1928 vintage records and based a vocal text on the discs they most liked. Dick and colleague sang the text, filtering the recording to shape the acoustic equivalent of a sepia photograph. Much of this work was done at Studio Van de Water since Dick and André were themselves former Dutch television colleagues. In October 1971, Dick joined the studio full time.

The Baarn studio extension commenced in February 1972. A major problem was the choice of mixing desk. Dick's experience of Cadac systems led to contacts with that company: 'We were looking for a desk designed from practical experience, not built by theoreticians in white overalls. If you live in Holland, you are inclined to look first to German desks as they have a very good reputation. We compared several German designs but found generally poor equalisation facilities. They only lift at 60 Hz at 10 kHz and usually only offer presence, rarely absence. We wrote to several companies and found that Cadac offered just the things we were looking for. The design was logical and the construction has proved good.'

For control room monitoring, Cadac loudspeakers and Audix amplifiers were chosen. Tailoring the frequency response of the system to suit the room proved an elaborate exercise, but the system was eventually adjusted to the overall characteristics of the installation at Lansdowne Studios where they had first heard the Cadac monitors and had decided to buy them.

Fig. 2 shows the layout of desk, recorder and monitors in control room One. The recorder, an eight track Ampex *MM1000*, sits to the left of the sound mixer. The Cadac loudspeakers are located well back from the control desk and are concealed by semi-opaque green curtains. The result is acoustically effective and visually attractive, the ceilings being dark brown cork tiles with suspended light rails to suit the working atmosphere. The floor too is lined with a cork tile and is raised 10 cm above the concrete base to permit cable ducting. No

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MANUFACTURERS OF AUDIO CONTROL EQUIPMENT FOR THE SOUND RECORDING INDUSTRY

continued

cable is visible in control room One. Studio One may be viewed through a window to the right while studio Two is visible between the two speakers.

Studio One may be seen in **fig. 3,** the control room window being visible on the right-hand wall. **Fig. 4** shows the smaller studio Two. Near the control room window is a lowered ceiling, a 1m thick trapezoid completely filled with rockwool to absorb the sound of a drum section. Sound absorbent screens, visible in the right-hand corner, are placed round the drums during a session. Two 10 cm thick layers of plastic foam line the lower surface of the trapezoid. The side plates are grey heraklith, also used for the ceilings in studio Two, studio Three and the surrounding corridor.

Fig. 5 illustrates a section of the wall between studio One and control room One. Proceeding from studio One, an active worm would encounter a first layer of softboard followed by 10 cm thick polystyrene tiles (for heat insulation), a second layer of softboard, then 10 cm of rockwool, 10 cm of brick (the original studio wall) and 10 cm of heraklith. A 15 cm airspace separates the heraklith surface from the conrrol room wall: 10 cm of brick with a final 5 cm layer of heracoustic. This formation is used throughout the premises except on the outer walls where a smaller (10 cm) air cavity was chosen. The alternative would have been too narrow a surrounding corridor **(fig. 6)**.

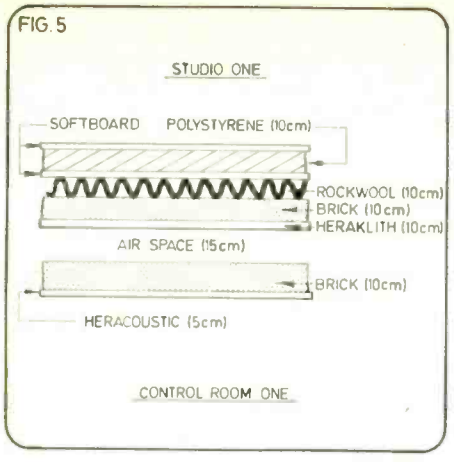
The walls are mechanically isolated from the floor by rubber blocks. Similarly, the studio ceiling is suspended from the overall ceiling by flexible chains. Rockwool lines the upper face of the false ceiling.

The studio design philosophy on reverberation was quite specific. Reflected sound was to be reduced to an absolute minimum since it is easier to add reverberation to an existing recording than to remove it. EMT stereo reverberation plates are housed in a small room behind control room One; a Studer *B30* provides delay. A Philips spring is used for special effects and a portable AKG *BX20* spring for mobile work.

Mobile recording

Mobile recording also forms a part of the Van de Water activity. An outside broadcast van purchased from Dutch Television provided the basis of a mobile control room. Dutch TV were asked to leave at least one video channel in the vehicle, giving the sound balancer visual contact with the performers. Nederlandse Televisie refused, apparently suspecting that an Ampex vtr would be installed for mobile telerecording. The van came complete with a 12 input two output mono sound desk which André modified for stereo. Two Philips stereo recorders are carried in the vehicle, 80 per cent of mobile work being orchestral. A single umbilical connects with microphones up to 100m distant and the power supply cable is of comparable length. A mere 30 minutes are needed to set up a mobile session. And if things become too warm, air cooling facilities are available . . . originally intended to stabilise the video equipment. Would videotape equipment eventually be added? André was doubtful. People would expect editing and assembling facilities which would take a large amount of space and very high capital investment. Besides, one Dutch company had already equipped a van with such facilities using IVC equipment.

The Van de Water attitude to microphone placement cuts across the multimic and stereo-pair camps. A week before my visit, the Dutch Chamber Choir had been recorded in an Amsterdam church using only two microphones. 'This was a completely balanced chamber choir,' Dick commented, 'so why plague your own balancing engineer by using several mics?'. The alternative, André emphasised, was to install the balance engineer as a conductor behind a conductor: 'For classical recording we choose microphone positions according to our experience of the church or location. We then make a test tape and listen to that with the conductor if he is willing to balance. The only time I had to change the microphone positions was with a Dvorak cello concerto. I raised the cellist 1m higher which made him a little closer to the microphones; he



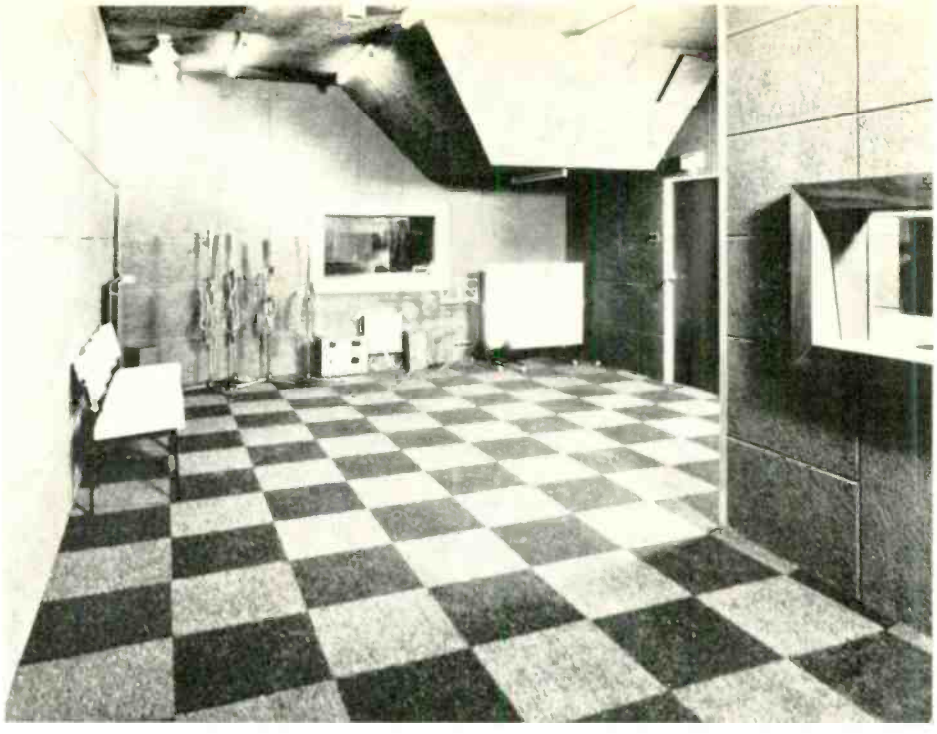
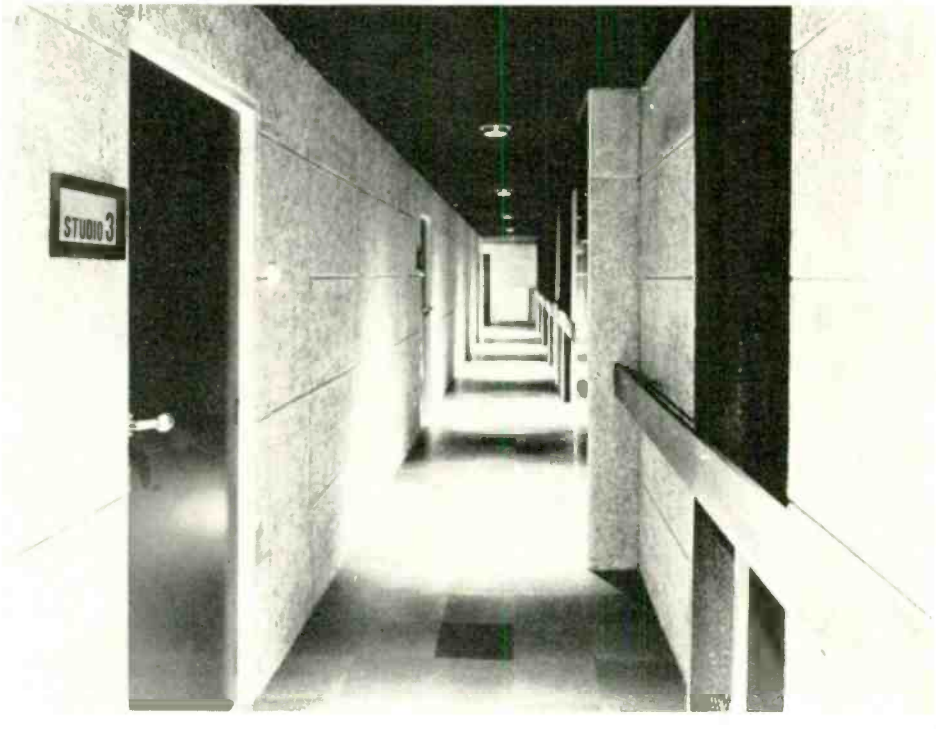


FIG. 2 (top left): Control room One.

FIG. 3 (lower left): Studio One with control room One window visible on right.

FIG. 4 (top right): Studio Two showing control room One window in end wall and studio Three window on right.

FIG. 5: (lower right): Sound-treated corridor.



was about 3 or 4m away. The whole recording was done with normal orchestral placements.' Traffic noise, he added, could be eliminated by careful choice of location. 'We once recorded the same choir here in the studio. It was not satisfactory because the extreme left could not hear the extreme right and they missed their cues. It is no problem adding the necessary reverberation or echo but a dead studio just wasn't right for the performers.'

Like most studios, Van de Water employ close-microphone techniques for light orchestral, pop and jazz music. Even in these cases, however, they do not always choose to work on the eight tracks available. 'Some musicians insist on working with eight track,' André said, 'but we prefer co-operation between the performers and the balance engineer as you can't create an atmosphere by mixing alone. Recording jazz direct on two tracks often produces marvellous results, in addition to being cheaper and easier.'

A close look at studio One **(fig. 3)** reveals no lesst han ten *U67* Neumanns, this being the studio's most frequently used microphone. For drum sections, the Electrovoice *RE20* dynamic is considered amply robust. An *RE11* is placed inside the bass drum, a location which fragmented the bass transducer of another seemingly robust dynamic. The AKG *D1000* cardioid has been found to combine robustness with a good bass response and this is preferred for amplified bass guitars. An excellent piano tone for jazz and pop is obtained by miking very close to the strings with an AKG *D110* (lavalier), taking advantage of the latter's inherent presence peak. This gives results superior to adjusting from the desk the response of, for example, a flat *U67*.

For the future, Studio Van de Water plan to convert their original control room (now control room Two) into a reduction suite. The existing Philips desk will be replaced by a second Cadac. Bowers and Wilkins loudspeakers are likely to be chosen as reduction monitors. Quadraphonic media are considered to be in too fluid a state to warrant specific investment in further monitoring and quad-effects equipment, an attitude shared by many London studios.

Session rates? Very reasonable considering the equipment, the clean and modern environment, and the combined musical and technical experience of the two engineers. Two track mastering is FL100 (£12), four track is FL125 (£15) and eight track FL160 (£20).

David Kirk

By Roderick Snell

PHILIPS N1500 VIDEOCASSETTE RECORDER

1972 (OR WAS IT 1971?) was going to be the year of the videocassette. Well, Philips just made it with their *N1500* recorder which started to appear last autumn, small quantities being delivered to educational users.

Although not yet on sale to the domestic user, the whole design philosophy, with its ease of loading, small cassette size and simple connection to the aerial socket of a normal television set, is clearly aimed at the home market. In their 1971 lecture on the vcr to the Royal Television Society, Philips drew attention to a predicted European market of colour television owners: 34,000,000 by 1976 and 80,000,000 by 1980. What percentage of these, they asked, might buy an easy to use colour record/play system that cost no more than a colour television set? However one looks at it, there is a formidable market.

The Philips *N1500* is not being reviewed here as a potential luxury for the home, but rather because a modified version with the addition of video inputs is being offered by Pye Business Communications (a member of the Philips Group), and can be assessed as a new tool for the industrial and professional cctv user.

Although costing less than many other 12.5 mm vtrs, this machine has a surprising number of extra features. Assuming the normal type of Japanese 12.5 mm open reel recorder, the major differences of the *N1500* are:

(1) Compact Videocassette Format, only 155 x 138 x 470 mm in its library box.
(2) Colour recording included as standard.
(3) Built-in six channel uhf vhf tuner for off-air recording independent of tv set.
(4) An accurate 24-hour time switch built-in to the tuner to enable round the clock off-air recording.
(5) Uhf sound and vision modulator built in. This permits colour replays into a domestic tv set through its aerial socket.
(6) The likelihood of several other European and Japanese firms building compatible machines under licence. Previous experience with claims for such licences dictates caution here but Thorn AEI in the UK are definitely developing a vcr. More details of this and similar plans will be given when they are nearer fruition.

Electronic features

The rf, or front-end, electronics consist of three sections.

(1) An off-air receiver with six pre-tuned uhf or vhf channels selected by the pushbuttons on the right-hand side of the machine. This feeds separate demodulated sound, luminance and chrominance signals to the recorder section of the vtr (the fact that luminance and chrominance information are separated is the reason for the standard version not accepting PAL coded colour signals).

(2) A modulator converts the sound and vision signals on playback to a uhf signal suitable for direct connection to the aerial input of a domestic tv set. The modulator frequency can be set to suit a spare channel on the receiver.

(3) An aerial amplifier feeds rf signal from the aerial to both the tv set and the recorder. This unit has its own power supply permanently on, so the aerial leads do not have to be reconnected when the television is used on its own.

Two problems in recording colour signals on a 12.5 mm vtr are, firstly, the broadcast PAL coded colour information centred at 4.3 MHz is outside the bandwidth of all low cost systems. Secondly, the short-term timing errors which are visible as jitter on a monochrome picture cause serious colour errors unless some form of line-by-line timing correction is used. Some earlier low bandwidth colour systems solved the first problem by reducing the PAL subcarrier from 4.3 MHz to 2 or 2.5 MHz, as for example the Sony *CV5000*. This made the colour sidebands most noticeable, particularly on a tape replayed on a monochrome receiver. Also, the recorder's noise level at these frequencies degraded the chrominance information by no small amount. In the Philips system, the PAL subcarrier is reduced to 560 kHz by heterodyning with a 4.99 MHz oscillator and is then used to *amplitude* modulate the normal fm signal to the record heads (see **fig. 1**). On playback, the colour component is separated from the luminence carrier and remixed with the 4.99 MHz oscillator so the original 4.3 MHz subcarrier is regenerated. Thus, under most circumstances, the colour signals do not degrade black and white pictures.

Dropout compensation

Another unusual feature for a low cost machine is the dropout compensator. This valuable asset is an expensive extra on some studio and broadcast recorders but is in fact *more* useful on a system such as this. Dust particles and oxide faults, causing monetary loss of contact between head and tape, normally result in objectionable line flashes. The compensator uses the well established method of replacing this missing information with that of the previous line. If the fm carrier from the tape falls below a preset level, an electronic switch connects the video output circuit to an alternative amplifier-demodulator chain which includes a delay of exactly one line (64 μS). If, for example, line 310 is lost through dropout, line 308 is put in its place. Colour information is not restored and the system cannot cope with dropouts lasting more than 64 μS. But at least 95 per cent are eliminated and those that are longer seem to cause a less annoying flash on the *N1500* than on many other machines. **Fig. 2** shows a still frame testcard with three lost lines at the centre of the picture. Tapes are normally considered worn out when the dropout rate exceeds a certain amount; this compensator will probably double the useful lifetime.

As far as I know, the Shibaden *SV700ED* is the only other 12.5 mm vtr with a capstan servo, which is needed as part of the electronic editing system unique to that machine. Here, the capstan servo is used to lock the recorder to the vertical sync pulses on record and the 50 Hz mains on playback. As with the Shibaden, this feature can be used to work synchronously with cctv systems by locking the studio pulse generator to the mains.

Another feature which will be welcomed by studio users is the sync processor, which is active on playback. The as-recorded syncs are stripped from the video signal on playback and

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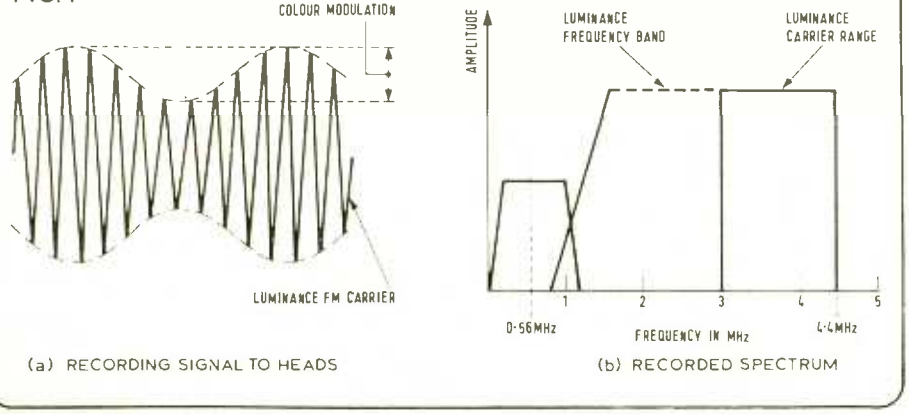
FIG. 1



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(b) RECORDED SPECTRUM

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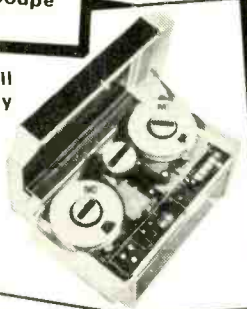

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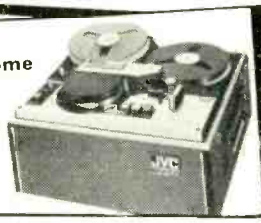

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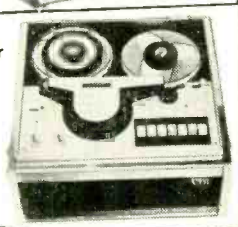

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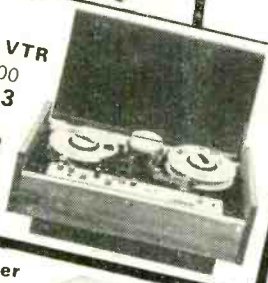

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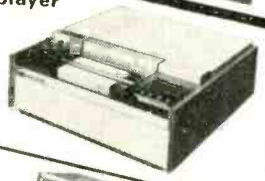

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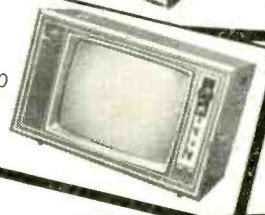

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replaced by clean rectangular pulses which are well suited for synchronising a studio pulse generator or a camera. A Link *101* camera used this way synchronised perfectly, allowing the camera and vtr outputs to be mixed and cross-faded.

This extra point, in addition to the normal drum servo and sound and vision record/play circuitry, makes the *N1500* a very complex system. An idea of the extensive area of discrete components on printed circuit boards is given by **fig. 3.**

Mechanical features

The top deck reveals, when the cover is removed, from left to right: the power supply unit and head drum motor, cassette and head drum, mechanical pushbutton assembly and capstan motor with fan, and finally the rf unit and timer.

The cassette is a small rectangular plastic box measuring 125 x 144 mm, containing two single-sided spools mounted one above the other on a common axis, enabling them to be driven by concentric hubs in the player. When playing, the tape leaves the lower spool via a single nylon roller, passes out and diagonally around the drum, as shown in **fig. 5(a).** On re-entering the cassette, there is another rotating nylon guide level with the top spool, a gap of about 55 mm and a fixed guide before the take-up spool. A circular hole in the underside of the case and a rectangular cut in the side between the last two guides allow access of capstan and pinch roller respectively, in exactly the same way as the Philips *C60* sound cassette. Both the rotating nylon guides are loosely mounted in the cassette case and are engaged by vertical spindles fixed to the recorder. These important elements in the tape path thus have a precise position relative to the head drum assembly.

Auto-threading

The automatic tape lacing is simple and ingenious considering the difficulty some operators have with this task on open-reel equipment. The head drum and guide assembly is eccentrically mounted on a circular base which can itself be rotated back and forth through about 180° by a small dc motor. The 'business end' of the cassette between the nylon rollers is open and another cut-out on the underside allows access of a moving tape guide which extracts the tape. The exposed section of tape is covered by a spring flap when out of the machine, and is opened automatically on loading. Pressing the 'eject' key raises an open metal cage on top of the deck, into which the cassette can be slid. This assembly is then lowered into the machine, when the two spindles engage the guide rollers, the capstan spindle goes through the circular hole in the underside of the cassette, and a tape guide on the drum assembly engages the tape from within the loop (**fig. 5a**). Turning the power on itself starts the lacing cycle: the drum assembly, driven by its separate dc motor, is rotated through nearly 180°, pulling the tape out of the cassette, past the erase head, around the guides and the drum, which has now moved close to the cassette (**fig. 5b**). Turning the power off reverses this cycle.

Head drum and capstan are driven by separate ac motors through small diameter neoprene belts, and the speed control is obtained in each case by eddy current brakes on the aluminium discs easily visible in the deck underside photograph of **fig. 4.**

The video drum differs from other vtrs (except the Philips *LDL 1000*) in that the top half rotates and also carries the video heads. So, instead of the usual gap between top and bottom half of the drum through which the heads protrude, a much narrower gap is possible. **Fig. 6** gives a close-up of the drum with one head visible and also shows the unusual spiral grooves milled into the surface of the top section, which rotates in the direction of the tape movement (and gives, so the makers claim, improved stability).

Tests were less thorough than planned due to a number of technical problems which halved the time available for the review. In fairness to the manufacturers, the machine tested was a demonstration model and had had very heavy use for a few months. This suited me as possible weaknesses were thus more likely to show up and one could see how the machine performed when the initial gloss had worn off.

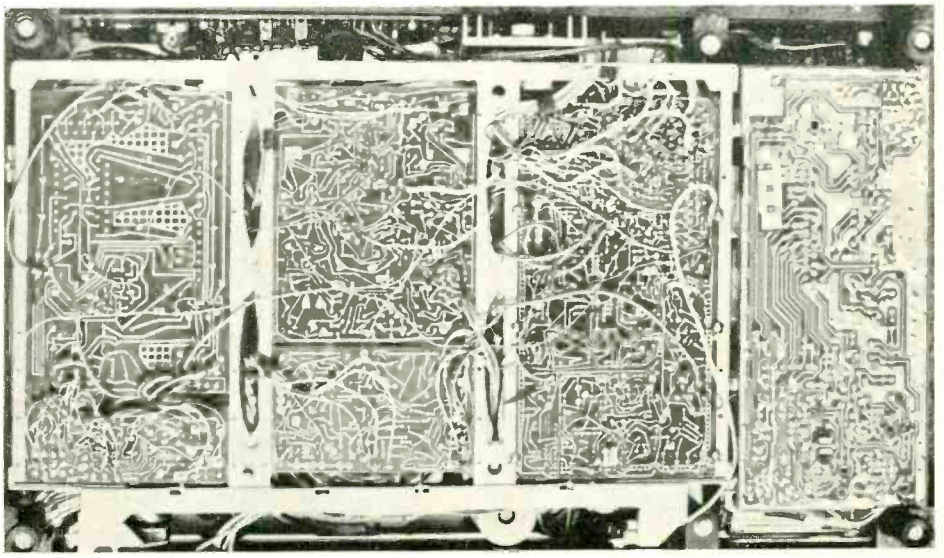
The rf modulator system made quick checks very easy. I merely plugged the rf output into my monochrome receiver/monitor and tuned it in. I was able to tune in the player's output but not any off-air signals, as if the E to E mode were out of action. Here one noticed a first peculiarity of the machine: if left on but not actually playing for more than 60s (45s in the specification), it went into the unlace routine and then turned off. This is fine after the tape has run out at the end of a time-switched off-air recording but is a nuisance if one has set up for recording and is poised over the start key.

Real disaster struck when I tried the second cassette. There was an expensive grinding noise and, removing the top cover, I found the cassette flap had no spring, had failed to open, and was jammed against the drum. Examination with a magnifier showed one of the ferrite video heads to have become uncemented from its mounting. The recorder was reluctantly returned to the Croydon service department and the review postponed for several weeks until another slot could be found in its heavy demonstration schedule.

On return, two new faults were apparent but it was then decided to complete the tests as far as possible as the review was already overdue. Firstly the drum servo was slow to synchronise and took ten minutes or so to become steady even though the tests were done at 20°C. This did not appear to be a new fault as the test tape had, apart from the first two minutes, been recorded throughout with a faulty tracking. It was easy to make allowances for the slow warm-up, but I then found the tuner section was still wrong, making colour tests difficult as I had been relying on a straightforward colour receiver for these. However, the video input and output mode allowed the recording of PAL coded signals from my receiver/monitor. Aside from the aforementioned servo problem, the recorded pictures were stable with very low 'jitter' and a better than average signal-to-noise ratio. Noise on the BBC test card shown was only −38 dB at mid grey levels but this was due to the incoming signal. On our own camera the Marconi resolution card (**fig. 8**) gave an excellent −42 dB. Resolution was 220 lines for −26 dB modulation, which is as specified, and limiting resolution was just above this at about 230 lines. This corresponds to the 2.7 MHz in the specification. Subjectively the Philips system works very well, with very little increase in noise and apparently full colour bandwidth. The usual PAL subcarrier was visible on replay into a monochrome set, but the colour-killer button eliminated this.

The sound performance was very good by vtr standards, the −3 dB points being at 70 Hz and 10 kHz when measured at −12 VU. Limiting occurred at only +4 VU, but this is normal for video tapes. Noise was low at 44 dB below 0 VU, excluding hum. The sound agc was fortunately optional and had a very wide signal handling capacity and a very long recovery time constant of exactly 1 dB/s over a range of 40 dB. Thus, although it would take 10s to restore a 10 dB cut in programme level, this

FIG. 3 Printed circuit boards in the N1500



choice works a lot better with music than do most of the Japanese agc systems which seem to behave more like soggy limiters.

Wow and flutter hovered around 0.1 per cent peak DIN weighted, with occasional peaks to 0.15 per cent.

The pushbuttons were mechanical but nonetheless difficult to catch out and one could not snarl the tape in the machine although I did notice that, if the tape was the slightest bit loose in the cassette before loading, it would foul the drum when pressed down and add a few crinkles to the tape.

The time switch was easy to set and it was not difficult to achieve an accuracy of ±2 minutes.

The absence of any still frame facility was regretted as the machine was clearly able to give quite good still pictures.

Considering the facilities included, the machine is quite small and very low priced. The colour coding system works very well but the resolution is definitely inferior to the best open-reel recorders. Users of the Sony *CV2100* or the Shibaden *SV700* for example might find the pictures of the Philips rather 'soft'. As explained in earlier vtr reviews, the resolution is a function of the small drum size (105 mm) and the low carrier-frequency range of 3 to 4.4 MHz.

The choice of vertically stacked reels in the cassette reduces its length, but might well produce problems which will not become evident until the one-hour cassettes are released. The very short path length between the second roller and the head drum means that small errors in location could give tracking problems between machines. Also, this small cassette size necessitates the use of very thin (17 μm) tape to achieve the one-hour playing time that must surely be the minimum for home use, although the currently available 45-minute cassettes do satisfy most educational users. While still on tape, the cost per hour is high, being £19.40 (based on £14.50 for the 45 minutes). The new generation of Japanese 12.5 mm open reel recorders cost educational users about one-third of this and even the studio quality 1VC 25 mm machine only costs about £17.50 per hour.

It should be clear from this review that the Philips vcr system, having arrived about a year ahead of its rivals, is set fair to capture some of the enormous home market that is the dream of the media men. If the technical problems described are really of a teething rather than fundamental nature, wide acceptance, at least in Europe, is likely. Both the Sony and EIAJ/1 systems, which have plenty to recommend them, are getting very near to being released. When they are, there will be strong competition for the Philips vcr. In the meantime, with several program companies offering VCR transfer facilities, and the extremely good value of the machine, it is worth consideration as an industrial and educational tool.

FIG. 2 (left): Still frame testcard (see text).

FIG. 4 (bottom left): Deck underside.

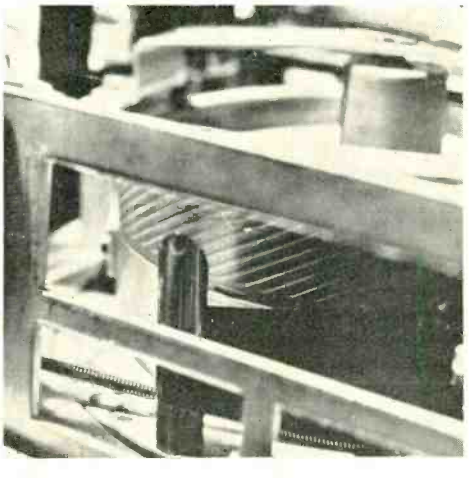
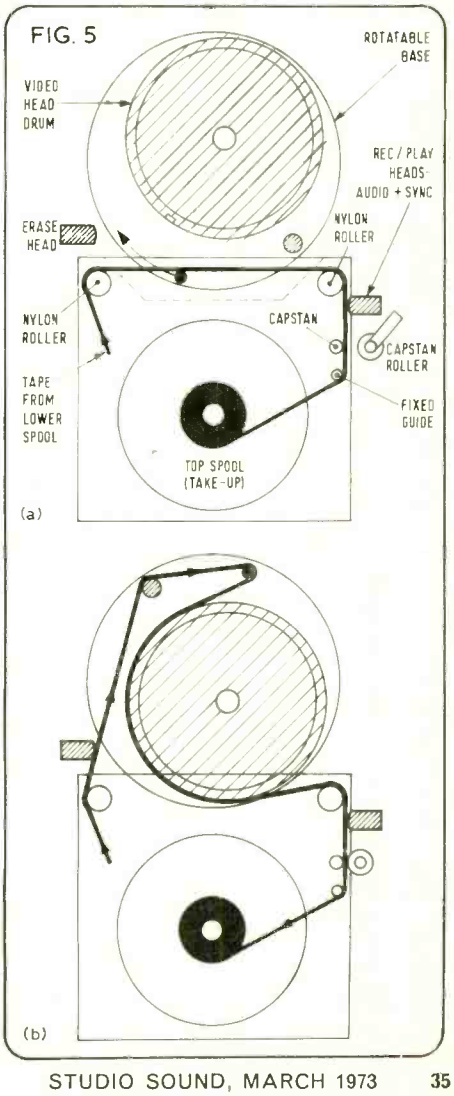


Fig. 6 (bottom centre): Drum close-up showing a video head.



3M present a professional a lot less for

The 3M M79 professional recorder is 27″ wide, 24″ max. deep and around 4′ tall. It's the most compact professional recorder you can buy. But the M79 gives you a lot more – or less (depending on how you look at it) – than just mere space saving. Look at this.

Less hum – because of DC power throughout. Less noise – Normal SNR 64 db, Sync SNR 64 db. Less weight – the M79 weighs under 300 lbs. for 24 track. Less reeling time – it spools at 500 i.p.s. Fewer boards – because of unified channel electronics. No goofs – interlocked record logic and bias/erase integrity. No loops – mode-to-mode transport logic and dynamic breaking. No clutter – the Isoloop deck and modular design see to that.
No service problems – London-based service department.

and a professional tape

3M have been at the forefront of recording tape development for many years. Now they offer a new dimension in recording perfection with their new Scotch 206 professional tape.

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After several years of laboratory research 3M have developed a proprietary oxide which makes possible a 3 db increase in signal-to-noise ratio. This means you have the latitude to capture the extremes of frequency and output without sacrificing any pure sound quality.

Scotch 206 tape also considerably reduces accumulated noise on multi-track recordings – a major problem up to now. It is also very tough, resists scratching and prevents drop-outs caused by tape debris.

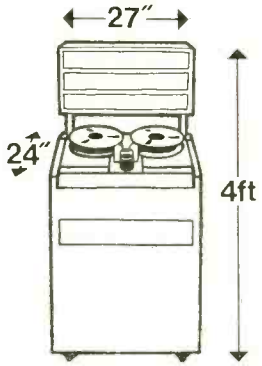
2. A new matt back coating
The new back coating improves the tape's handling characteristics, prevents slipping and ensures more uniform winding.

It also helps to guide the tape more accurately across the recording heads, reducing expensive head wear.
The backing is tougher, more scratch-resistant than its rivals. And since it is electrically conductive, dust and dirt are not attracted and held to it.

Scotch 206 tape is compatible with any professional recording system and is available in ¼″, ½″, 1″ and 2″ widths.
For further details of Scotch 206 tape and the M79 recorder range, contact: E. R. Haworth, Magnetic Products, 3M United Kingdom Limited, 3M House, Wigmore Street, London, W1A 1ET.

recorder that gives you your money-

The M79 also gives you the best servo around, 3 set speeds, built-in variable speed, CCIR/NAB/AES equalisation.



There are also several useful accessories. Like the 3M synchroniser/reader for synchronising audio recorded material to video recorded material. And the compact 'Selectake' unit which automatically locates a pre-selected tape position.

There are three M79 models (24, 16 and 8 track). All the basic units are the same size and have been designed so that the 8 and 16 track models can be expanded when required.

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Inside Sound Techniques

BY JOHN DWYER

Until comparatively recently, many manufacturers and studios considered London premises essential to their commercial survival. The noise, overcrowding and grime of the metropolis are now driving increasing numbers of companies out into more natural surroundings. John Dwyer looks at one of the fortunate escapees.

SOUND TECHNIQUES began as a recording studio in 1965. Geoff Frost and John Woods met at Levy's sound studios and, just before CBS took it over, they decided to open a studio of their own. They looked around for a suitable desk but found nothing they wanted, so they decided to build one themselves.

After that they began to make consoles for other studios and, in their first three years as manufacturers, had supplied two Hollywood Studios—Sunset Studios and Elektra Records—as well as making desks for De Lane Lea's Kingsway studio and Trident studios, both in London.

Three years ago they moved the production side of the firm to Mildenhall in Suffolk. The business had grown so much that they needed more space but without London overheads and with an opportunity to buy still more space nearby if the business grew bigger. Since they moved to the Suffolk industrial estate they have spread from the one building they originally had into another not far away. The second building is where all the equipment is made and the first is now almost all office space.

Ian Levene, Sound Techniques' general manager, joined the firm in August 1972. He had started his career with the Rank Organisation and, after seven years, went to IBC to become chief engineer. Seven years at IBC were followed by ten years as sales manager at Ampex, where he was responsible for selling sound and television studio equipment. I asked him why he had come to Sound Techniques. 'I think it's an exciting opportunity,' he said. He added that the customer who is buying a desk usually has to adapt to what the manufacturer has but, by paying attention to all the permutations and combinations that are available, Sound Techniques aim to give the customer what he wants. 'We have to give the customer good value for money at a price he can afford.'

So far Sound Techniques' biggest project has been the De Lane Lea building at Wembley, a contract worth £200,000 to them. Work started on August 6, 1969, and the project was finished in the autumn of 1971. There are three studios, accommodating 130, 35 and 20 musicians respectively, as well as extensive wide screen film sound track facilities. The whole complex cost £770,000.

From Sound Techniques De Lane Lea wanted three 16 output consoles, two four output remix consoles, 110 sets of tape record/replay electronics, 54 monitor amplifiers, 15 sets of film record/replay electronics, two mono stereo disc cutting consoles, 13 digital footage counters and stop clocks, 13 patch-in universal equalisers, and eight high/low pass filters.

The Wembley studio was one of the first where digital techniques were used on a large scale to simplify recording work. Over 4,000 dual in line transistor logic integrated circuits and 10,000 diodes were used to control the operation of all the record and replay lines to and from the tape and film machines and Dolby units; 20 Dolby units were put in each control room and of these any number had to be switched across the input or output lines of any recorder at the push of a button.

This experience in logic design has now led them into other areas of electronics. As Ian Levine explained: 'An electronics firm can do other things than sound recording. You can expand any way you like, in fact, though obviously you will start off with the things you know best.'

An example of this expansion is the Sound Techniques digital stopclock. This gives a five digit readout of elapsed time using three controls: start, stop and reset. Sound Techniques sell between 20 and 30 of these each month, works manager Cyril Jones told me, mostly to customers who want to use them for photography.

But their main commodity is still the *System 12* desk they developed, which was introduced at the APRS exhibition in 1971. Geoff Frost explained that there seemed to him to be a gap in the market in the range around £5,000. You could buy tatty equipment for less and very elaborate mixers for a great deal more, but the expensive mixers, which were what any studio had to have if they wanted to record to professional standards, provided more facilities than most of the smaller studios could possibly want. His idea was to cut out all the unnecessary frills that previous desk salesmen had persuaded customers they would need and to provide a desk that would do everything essential at a reasonable price.

At the moment, about half the value of Sound Techniques' sales of consoles is contributed by the *System 12*, the rest being contributed by the custom built desks. In terms of numbers, about four *System 12* desks are produced for every custom desk.

Sound Techniques attach great importance to the fact that all the desks, whatever their type, are designed in the light of experience gained in the Sound Techniques studio in Chelsea. I'm told that no test sessions are held; the equipment is tested in the studio under normal working conditions. Any comments that the three engineers—Vic Gamm, Roger Meyer and Jerry Boys—make are taken into account in modifying the product before it is finished. For example, to eliminate unnecessary functions from the *System 12* there

would be long discussions about whether this or that feature was essential.

John Woods, studio manager at Chelsea, still does some engineering but his main tasks are to evaluate new equipment, develop prototypes for the studio and liaise between the user and the maker of equipment.

The *System 12* is capable of recording 16 tracks simultaneously and carries a price of £5,377. The basis of the system is that the customer is sold a frame fitted with a power supply, an ancillary unit and a self-supporting floor stand.

The customer can then choose which units he wants and how many of each. As Geoff Frost explained to me, the desk can be built up into 12 different systems, hence its name.

The frame is wired for 18 input units, eight output units, 16 track monitors, two monitor echo returns and an 'auxiliary four' unit; the latter provides a fourth auxiliary output for foldback and so on.

The input unit has a line/mic switch, a row of five routing buttons, and a mic switch. The equaliser section in the middle of the unit consists of three sets of rotary attenuator switches with a two position switch beside each. The high and low equaliser sections will boost or cut by 14 dB and the middle sections will boost by 14 dB. The six frequencies on the whole section are 8 and 10 kHz on the hf knob, 3 and 5 kHz on the middle section and 80 and 150 Hz on the lf section. Below this section are two auxiliary pots for echo or foldback and either of these can be switched in pre or post fade. Equaliser cut, normal and channel cut are provided on the same three position switch below the auxiliary section. The fader at the bottom of the unit is Penny & Giles' conductive plastic type.

The output unit has two master echo return pots, two meter line, line out switches and two faders.

The dual monitor unit has two sets of the following, one set above another, plus the jackfield for the whole deck: monitor gain control; 'auxiliary three' send control, driven from the monitor; monitor pan pot; solo button; monitor on/off switch; line in/out switch; four loudspeaker routing buttons; and a pan button.

The ancillary unit, supplied as part of the main frame, comprises a section of jack bay, a talkback mic, an oscillator level and an oscillator frequency control—there are six frequencies, three auxiliary feed masters, auxiliary solo selection and on/off switches, remix switch, monitor line in/line out master switch which changes all the monitors, master monitor gain which controls all the monitor gains, cue switch and an oscillator/talkback selector switch.

Sound Techniques seem to have given a lot of thought to mixer access, both in terms of plugging into it and getting at the wiring; inputs and outputs are on Cannon *XLR* which are beneath a hinged plate at the back. All the looms are also along the back and all the standard frames are wired the same so that extras can be added without too much trouble. The meter panel is wired for eight illuminated Sifam type VUs; ppms are not normally fitted although Sound Techniques are looking at the possibility of providing ppms in the future.

Testing seems to be thorough; not only is each unit tested but each pc board is tested on the bench and each wire is buzzed for continuity as it is wired in on a test frame. Every switch is tested individually. There are about 20,000 joints and 22,500 nuts and bolts on each mixer so the whole assembly is given a good rattling to see if any faults develop.

About two-thirds of Sound Techniques' 230 m² floor space is devoted to production, the rest being stores and offices. The production team of five men are all qualified prototype wiremen, Cyril Jones told me, and their work often involves testing and ordering as well as production work.

Only a tenth of the work carrying the Sound Techniques label is made outside the Mildenhall factory.

Even the metalwork is cut and drilled at Sound Techniques, using long reach tools and extensive jigging. Aluminium front panels are grained and anodised at Mildenhall but a London company do the lettering. Sound Techniques design all the printed circuit boards they use although the boards are made by a sub-contractor.

Recently Sound Techniques added two new consoles to the *System 12* standard range. The two new desks are called the *Super 12* and the *Broadcast 12*. The *Super 12* is a 30 input, 16 or 24 output console built in the *System 12* format. The input units have equalisation at six bass, six middle, and six top frequencies with switchable high/low filters and pfl. Like the *System 12* the *Super 12* has direct outputs to the tape machines and 16 or 24 main signal busses, but there are four echo send busses on the later model compared to two on the *System 12* and two foldback busses. The new unit also has a fitted digital stopclock.

The *Broadcast 12* desk offers a choice of input units from standard units with pfl to dual 'flat' line level inputs. Each desk is fitted with full transmission rehearse busses and change-over power supply units. The desk also has ppms and gram and tape replay units. Geoff Frost said that the unique feature of the three ranges is that all the units and modules are interchangeable between one system and another. All the ranges should be available from stock. The price of *Super 12* will be about £15,000 and that of a medium size *Broadcast 12* will be about £3,500.

Now that four channel recording has lost much of its appeal as a talking point in studios there is considerable interest in automatic mixing. You can't go to many studios these days without hearing either 'It won't catch on', the usual gloomy forecast for anything unusual, or 'Of course, when we get automatic mixing

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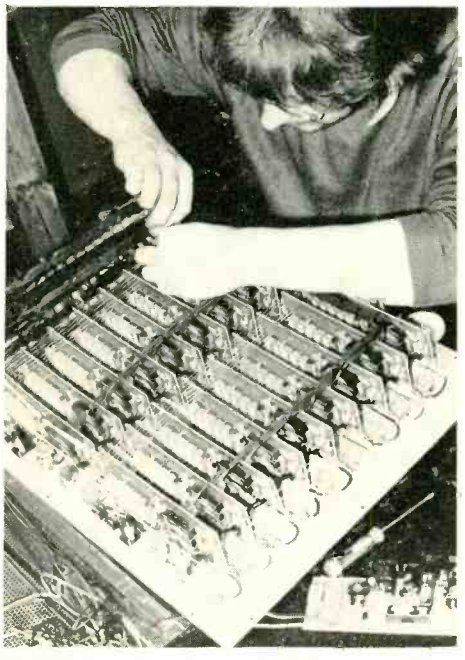

Far left: Geoff Frost with a *System 12* input unit

Below left: Sound Techniques mixer undergoing assembly

Far right: Assembling and **(below right)** testing Sound Techniques electronics around a Scully 16 channel tape transport

continued

we'll be able to . . . ' As far as designing such equipment goes, Geoff Frost thought it was time the same techniques long available in the machine tool industry should be available to make life easier for the mixing engineer. 'There is still some mystique surrounding automatic faders, logic switching systems and computer controlled mixing desks,' he said, 'due in part to some studios being somewhat isolated from the rest of industry where these techniques gained a foothold many years ago and are now regarded as commonplace.

'The reasons for requiring these systems in industry are now a reality in many studio control rooms. That is a repeatable—in part at least—and complicated task to be performed and where time is money.' Geoff considered that the use of these techniques can free the operator of the desk to be more creative. His description of how such a system would be constructed is as follows:

'A basic scheme for such an automated knob is shown in **fig. 1**.

'The analogue to digital converter must be fast enough to produce its settled output before the next clock output arrives but it must allow enough time for the input multiplexer to settle.

'The period for the above is determined in the main by three considerations, namely: (a) the number of channels or facilities to be serviced; (b) the maximum allowable time between samples to ensure that no relevant information is lost or ignored; (c) the definition required.

'The latter also, of course, defines the number of data bits required; a basic octal notation will be more satisfactory as, although binary-coded decimal is easier to understand initially, it is very inefficient in the number of bits it requires for each decimal decade.

'As the number of channels is increased, and the period between samples is decreased, the demands put upon the analogue to digital converter are increased. The counter type converter is a simple and low cost device, and does not require the use of a preceding sample and hold facility, but it has the severe disadvantage of a low operating speed. For any large system, the successive approximation type of converter will have to be used. This needs an analogue gate but, for applications like the one under discussion, the approximation converter can be up to 30 times faster than a counter converter.

'Gating will follow the converter to provide an 'up-date' choice. Obviously, the first time round, data will be taken in turn from each device; but a choice will be available on replay between using the recorded data or an 'up-date' facility, which means "ignore the recorded data for that device, and use new direct data instead".

'The device's address can now be added in with the data itself, and with the inclusion of a parity (error-checking) bit or bits would make up one complete "word".

'Before this assembled "word" can be recorded on tape or any other such medium it has to be converted to serial form. A clock generator and shift register perform this function but, as the word flow is slowed down by this process, care has to be exercised that a build-up of parallel words does not form a queue in front of this parallel - to - serial converter.

'The replay function will follow a similar process, but in reverse; out of interest, this is described in the alternative form of the flow chart in **fig. 2**.

'It is regrettable that, if there are *x* mixer manufacturers, the record industry is going to be presented with *x* different methods and formats of the serialising data, address, etc. It would be nice if this could be standardised in the same way that 16 tracks on 50 mm tape is a 'standard' so that any process control technique used in one studio could be continued in another. We have only to look at the recent chaos caused by the unilateral setting of 'standards' in quadraphonic recording to realise how important some form of standardisation is going to be.

'In addition, once we are automating more than one or two functions per desk, we shall be using mini-computers to control these and other decisions. Therefore the format should preferably consist of a 16 bit binary word. Each manufacturer could, if agreement is not reached, then provide a simple (we hope!) interface adaptor for use with any 16 bit system.

'With the advent of 24 tracks on tape machines, 24 individual switches on each unit (input and output) would take up an inconvenient amount of room on any medium to large mixing desk.

'We can probably take another page here out of "process control". Instead of the conventional switches on each unit, we can have a central push button unit from which we can select our routing assignment in one small area, the switched functions showing up on the "switched units" in a fairly conventional way.

'**Fig. 3** shows the way in which inputs and outputs would be arranged: though looking at only one unit tends to oversimplify the situation. The switch unit can be functioned in two main ways: (1) a calculator-like nest of buttons; (2) three rows of individual buttons for inputs (replay); input units themselves; and desk outputs.

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FIG. 1

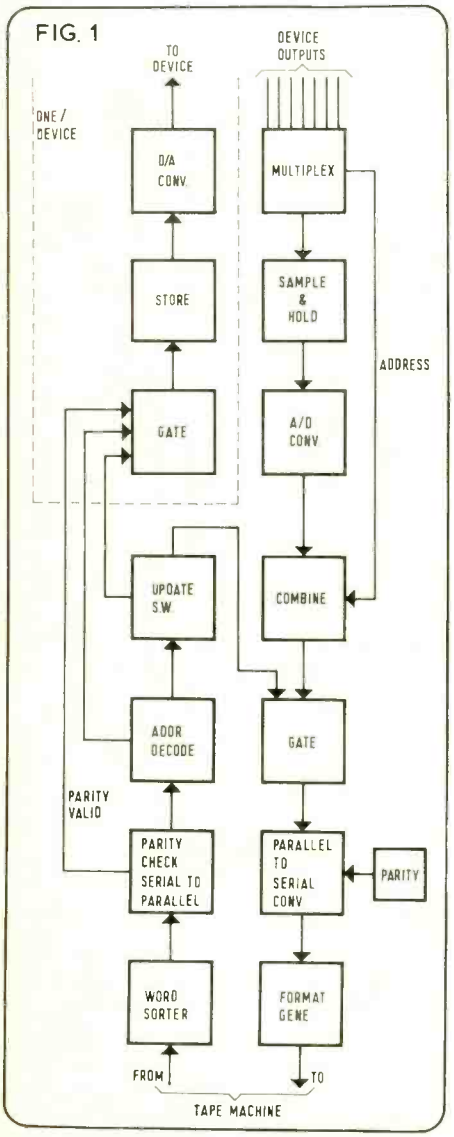
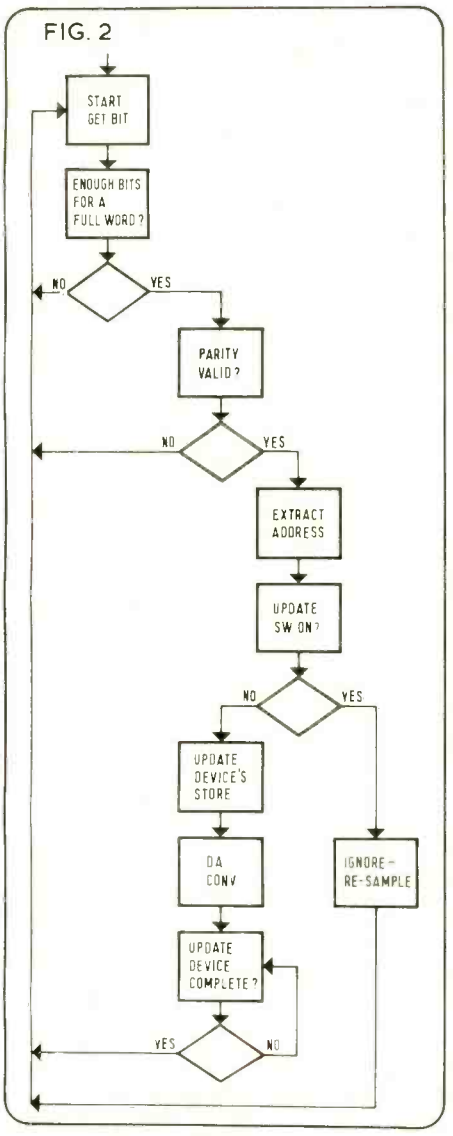


FIG. 2



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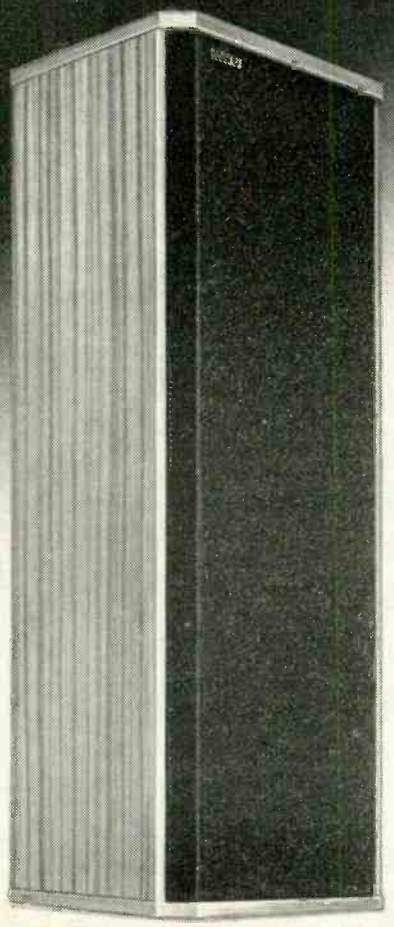

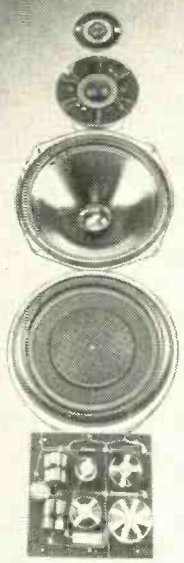

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continued

'Both the above requiring the addition of such switches as "set", "reset," and so on.

'The detail of precisely what button does what can be left to the customer's choice, the actual work being performed by sealed long life reed relays controlled by reliable TTL, packaged out of harm's way.

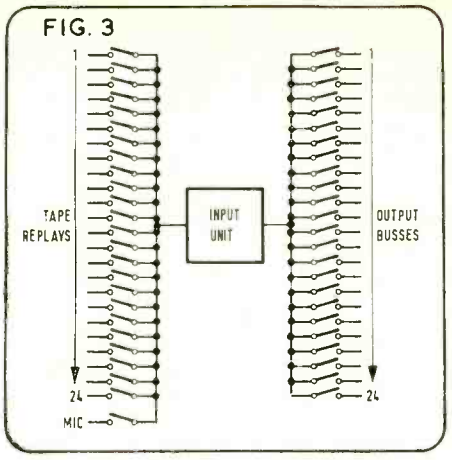
'Apart from saving space, we can also save a considerable amount of labour, and the cableform can now be reduced by more than half. This results in a real benefit to the customer as, though the complete desk price remains the same, greater flexibility and greater reliability have effectively been produced with no increase in cost. These relays can also be pre-programmed as and when required by the customer.'

The Sound Techniques team are very proud of their newly installed computer facilities. As Ian Levene said: 'Computerisation will take a lot of the dog work out of the system. We'll be able to do anything we like with it. Right now it enables us to make a rapid assessment of cost and to assess the profitability of projects quickly.'

Geoff Frost explained what the system could do: 'We can make it reorder for the stores. If for example I punch in "Make ten *System 12* desks" it will make out a list, look at the stores, order what we're out of and issue works orders. It will also tell me how the job is going by printing a bar chart.

'Testing equipment is a boring job but it needs skill. You have to do it twice and you reach the point where the sheer complexity of the equipment transfixes you. We should be able to plug a desk into the computer and the computer will list all the faults. It will design desks for you if you have the hardware.'

FIG. 3



The computer is brought up to date every day. Manufacturers' data received, new product designs and even, though the thought terrifies me, magazine articles can be regurgitated if the right program is fed in. Geoff says that the present system can handle and reference up to 100 four-drawer filing cabinets of information.

At the moment, programs are being written for stock control, mixer design and testing of a new range of mixers to be called the *Major*, about which Geoff said: 'Everything in this desk is new but well tested. We believe that a potential customer who is prepared to pay up to £40,000 for a large desk deserves to have all the latest techniques and systems that are available.'

I asked Geoff Frost to explain some of the problems of giving the customer 'good value for money at a price he can afford'—it sounded easy enough to say but wasn't it a little more difficult to carry out. He agreed: 'Very often people don't know what they want. It's probably lack of technical ability, technical knowledge. We also have to assemble forward-looking ideas, whether they are in hardware or operating procedures, so that when he gets it it isn't out of date. Also, it mustn't go wrong, and we've learned that complexity means it's more likely to fail and that means you have to service the equipment.' The servicing side of things seems to be well covered even though they try to avoid the necessity for it. 'If the customer has a component failure before 4 pm,' Geoff told me, 'by nine o'clock that evening he will have a new unit'.

Finally I asked Geoff if moving from London presented any problems. He said that the move itself was easy enough; under the GLC scheme all the moving expenses were paid for. 'It's just as hard to find the right staff in London as it is here; we tend to take people only if they're very good.' He also emphasised that the factory was only 90 minutes from London by car.

Another important point he made was that living and working in rural surroundings brought many additional benefits; travelling to work was much easier and that seemed to improve the efficiency of the operation because of the better state of everybody's nerves.

Certainly Mildenhall looked a pleasant place to work in, even though the occasional air force plane landing or taking off made enough noise to be a bit trying. But when you think that no one at Sound Techniques has to put up with the London rush hour, the odd noise from a jet plane seems a small price to pay.

continued

sound effects library will be available. Plans also call for the installation of an electronic music synthesiser for creating special music cues and effects.'

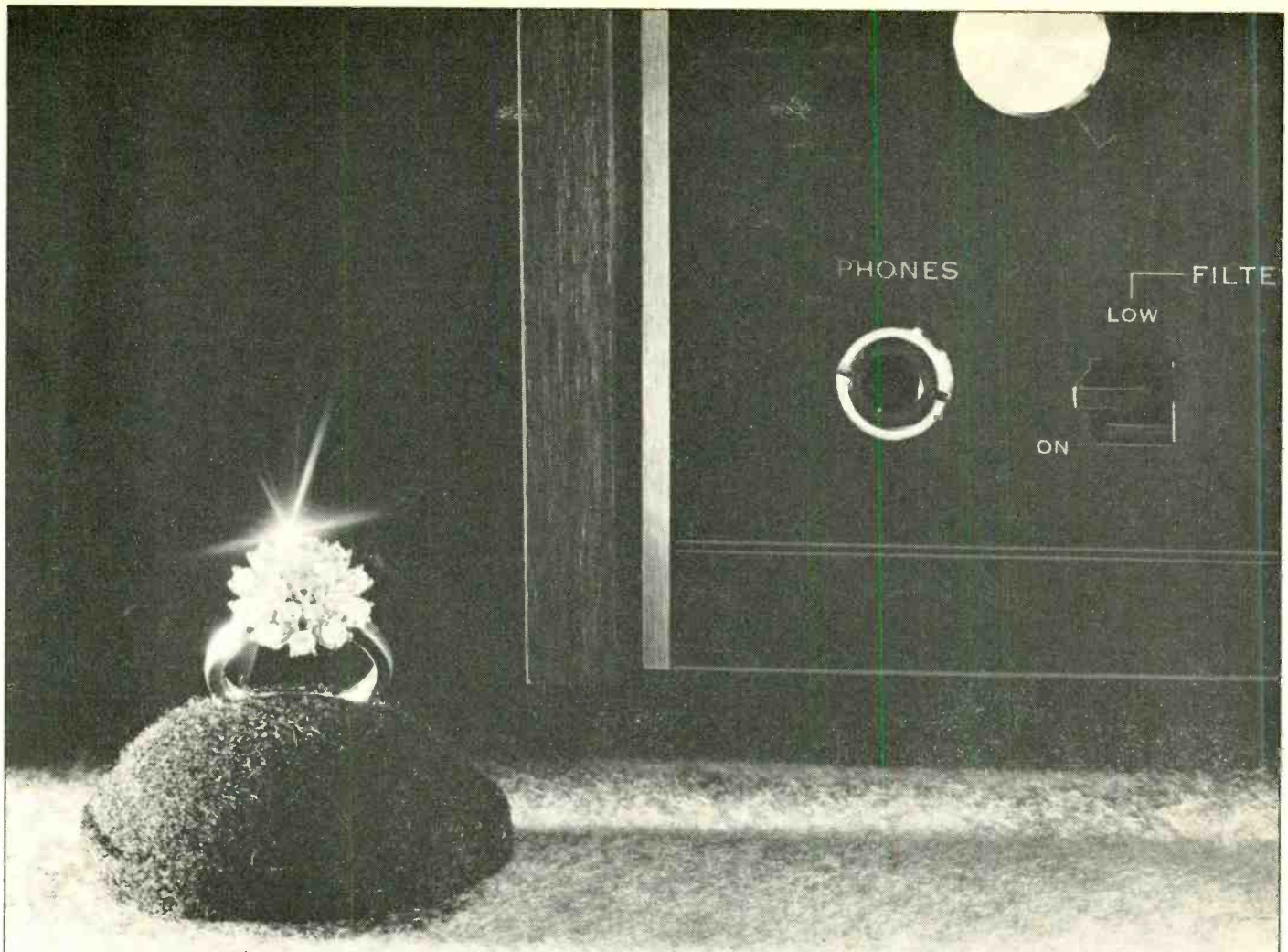
Sound 80 has three divisions: systems, run by Gary Erickson; recording studios and production, run by chief engineer Tom Jung; and what they call creative services, directed by the president of Sound 80, Herb Pilhofer. Creative services provide composing, arranging and recording talent.

Recently Herb composed, orchestrated, produced and conducted the musical score for a 'mini-musical' promoting the four ABC radio networks. This four channel musical soundtrack was used behind a group of actors who toured the states playing to 'media people and clients in major markets'. The show attracted the following comments from Variety critic Jack Hellman: 'Whoever called radio 'old hat' had better revise his thinking. If it wasn't so trady it may have well served as a summer replacement on ABC's tv network and take some of the curse off reruns, now a political football to be kicked around.' The show was produced by Communico of St Louis, Missouri.

Peter Yarrow and Phil Ramone of 247 productions produced an lp by a New York group called Lazarus. The album, which will be released on Warner Bros, was recorded at Willmar Junior College with a Sound 80 portable 16 track facility. That facility sounds very interesting and, as soon as Joyce sends me any more information about it, I'll be glad to pass it on.

Johnson and Drake, two songwriters, have just finished a demo lp of their 'original piano-oriented pop/folk/rock material'. At the time of writing they had not yet found a label for it. Tim Kerr, a Columbia producer, has done a session with the Reasons which will eventually go out on the Uncle Sam Label; Dixieland lp cut by Dick Ramberg; albums by Larry Rose, Brustad Sisters, Jay Meyers, Jimmy Jenson, Art Perri with Soul's Harbor sidemen, Los Valentinos and Tom Paske, who recorded his at Dulano's. Art Bradley produced three Jerry Hegarty singles and Bob McMullin, a Canadian, collaborated with Herb Pilhofer to produce a religious album with the Gamble Folk trio and local backing musicians. Herb also worked on commercials for Farmers Union Central Exchange, Blue Shield of California, Lincoln Del, La Belle Stores, First National Bank of St Paul, Hormel Brown and Serve, and Northwestern Bell. All involved some composing or arranging by Mr Pilhofer and he also wrote a song for the State of Montana, commissioned by Wilson Griak.

Finally, I think Anthony Thorncroft should be ashamed of himself for making only one passing mention of pop music in his recent survey of the recording industry for the *Financial Times*. His attitude is so common, though, that I sometimes wonder if it's worth kicking against; some of the recording industry's greatest enemies operate from within, even though each of them knows that without pop there would *be* no recording industry. They vary from the magazine or newspaper that has columns headed Music, Jazz and Pop to that coterie of knob twiddlers and watt-watchers who persist, at their monthly gatherings in the West End, in saying that pop music is 'deliberately distorted' and that it therefore has no place in any serious discussion of music or the recording of music. Let some of them walk into Apple or AIR or Advision or Zella and say that the engineers have deliberately distorted most of their pop recordings and I shall personally adjudicate as to which of them holds the record for the longest stay in hospital.



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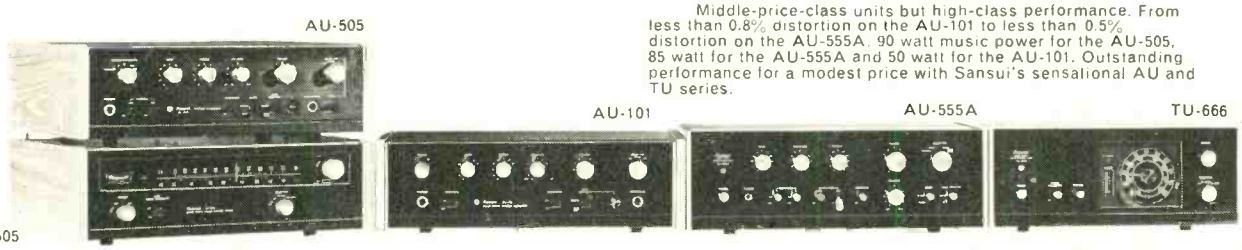

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Distortion: Cause and Effect

TONY EDEN

In this, the first of two articles, the author outlines the nature of audio distortion and the methods by which it is measured. A typical distortion factor meter is analysed.

DISTORTION may be defined as a change occurring in a waveform during the course of its transmission. Since a waveform varies in two respects—frequency and amplitude—distortion can likewise arise in both of these. The former is known as linear distortion, because the transfer characteristic is linear, and the latter known as non-linear distortion because it arises from there being a non-linear amplitude transfer characteristic. The nature of these two forms of distortion will now be discussed.

Linear distortion is caused by a variation of output with frequency and is often encountered in amplifiers under three main conditions:

(a) Because a limited frequency response cannot be avoided in the design.

(b) Where the response is deliberately curtailed outside the frequencies of interest.

(c) Where the response of the frequencies of interest is deliberately altered.

With modern amplifiers it is almost always necessary to curtail frequencies outside the audio band since the response would otherwise extend well into the radio band which could introduce a number of interference problems. The measurement of frequency response calls for little comment, an oscillator and voltmeter being all that is required.

In curtailing or altering the frequency response of an amplifier, the phase response of the amplifier can also change with frequency. Phase distortion, which is one form of linear distortion, can also produce problems in the design stage of amplifiers and, under certain conditions, may lead to oscillations in the amplifier. Although it is difficult for the ear to detect a change in phase with frequency, identical phasing is extremely important in setting up stereo equipment because in these conditions the ear becomes very sensitive to differences in phase between channels. A very useful instrument for qualitatively evaluating both the frequency and the phase response of an amplifier is the oscilloscope. By applying a square wave to the input of an amplifier and observing the resultant output on an oscilloscope, the performance of the amplifier can be assessed (see **figs. 1** and **2**).

Squarewave examination is a stringent test for an amplifier and can quickly reveal defects which require more detailed study. Such defects would not normally be uncovered by sinewave testing.

Non-linear distortion poses most of the problems, both from a design and from an analytical point of view. It can occur under a variety of conditions and hence some tests may reveal one form of distortion but not another. For this reason analysts have given names to various forms of distortion, such as harmonic distortion, intermodulation distortion, transient distortion and so on. They all come under the general category of non-linear distortion.

The most common form of non-linear distortion, harmonic distortion, will be described first as it is most widely quoted in amplifier specifications. It is also the easiest measurement to make and the one for which a comparison between amplifiers is most nearly valid. Harmonic distortion is the appearance of additional components at the output of an amplifier when a sinusoidal waveform is applied to the input. The input waveform is known as the fundamental frequency and the additional components at the output are known as the harmonics, the most important of these being the second, third, fourth and fifth harmonics. Higher order harmonics are usually so small that they can be ignored.

When making distortion measurements, it is always worth connecting an oscilloscope to the output of the device to be measured. By so doing, one can actually see that the amplifier is not being unintentionally overloaded or that oscillation, excessive hum or noise are present with the output. This simple procedure can save many hours of searching for high levels of spurious distortion. Unfortunately, the lowest level of distortion that can be detected by observation on an oscilloscope is between three and five per cent and the instrument is therefore of little direct use in the measurement of low distortion levels.

The simplest method of measuring harmonic distortion is to apply a 1 kHz sine wave to the input of an amplifier and measure the output by means of a distortion factor meter. This instrument receives the amplifier output, suppresses the fundamental by means of a tunable rejection filter, and measures the residual amplifier output on an ac voltmeter. The residual output may consist of:

(a) Harmonics generated by the amplifier under test.

(b) Harmonics generated by the oscillator.

(c) Noise from the amplifier under test.

(d) Noise and distortion introduced by the distortion factor meter.

(e) Any element of the fundamental that was not suppressed.

The elements (b), (c), (d) and (e) limit the level to which useful distortion measurements can be made. By good design (b), (d) and (e) can be reduced to very low proportions and one can usefully measure down to about 0.05 per cent distortion. However the noise generated by the amplifier can pose a serious problem and make reliable readings below this level extremely difficult.

An example will show why. Consider the case of a measurement on an 80 dB (10,000 times) gain 200 ohm microphone amplifier. If a distortion measurement is required at a typical microphone output level, this would demand a signal level of about 200 μV. The output signal would therefore be 2V. Now if this amplifier had a noise figure of 2 dB with a 200 ohm source, measured on a 20 kHz bandwidth, this would produce about 3.2 mV of noise at the output. Therefore the lowest distortion level that could possibly be measured before the harmonics become lost in noise is

$$\left[\frac{0.0032}{2} \times 100\right]$$

per cent, which comes to 0.16 per cent. The fact that the noise component is present with this type of measurement thus constitutes one of the major limitations of the use of the method. The problem is not so apparent at high output voltage levels or, in the case of power amplifiers, at high power levels, and this is why the measurement should be made at as high an output level as practicable. The advantages of the method are that it gives a total harmonic distortion content measurement in one reading and that the necessary equipment is cheap and simple to use.

J. E. Sugden produce a distortion factor meter which is a very reasonable buy but

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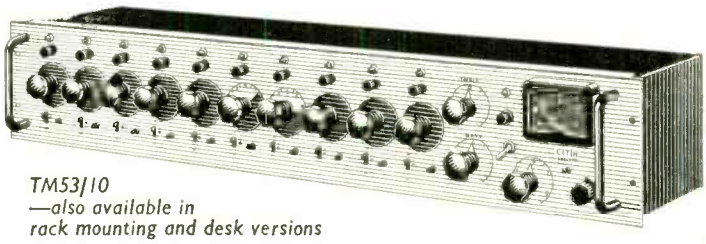

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continued

rather time-consuming to use. Radford also produce a distortion factor meter which has rather more facilities than the Sugden instrument and which incorporates its own meter. On the other hand equipment that will satisfy most requirements is very simple to construct.

Distortion in an amplifier does not change suddenly with a change in frequency but increases slowly from a minimum level which usually occurs at about 1 kHz. Hence it is usually sufficient to measure distortion at a few spot frequencies, say 100 Hz, 1 kHz and 10 kHz. This simplifies the construction of the rejection filter and all that is required is a control to tune precisely the filter to the oscillator frequency. While the filter can give up to about 80 dB rejection of the fundamental frequency, it also reduces the second and third harmonics by about 5 dB and 2 dB respectively thereby making it very difficult to obtain a meaningful value for the total distortion content. To make the tuning band of the filter narrower, negative feedback is applied over the whole circuit and this has the effect of attenuating the second harmonic by less than 1 dB and the third by less than 0.2 dB. Therefore reasonably accurate measurements of total distortion are possible.

There are a number of filter circuits that can be used to suppress the fundamental frequency such as the Wien bridge, the bridged-T, and the twin-T networks. The advantage of the twin-T network is that the attenuation of the circuit is 0 outside the rejection range, as against the other mentioned circuits which have about 10 dB attenuation. Hence the twin-T network is most widely used in the design of commercial distortion factor meters today.

A very simple switched frequency circuit for a distortion factor meter is shown in fig. 3 which is capable of measuring distortion down to about .05 per cent if permitted by the noise of the amplifier and the distortion content of the oscillator. The output should be fed into a sensitive millivoltmeter (e.g. the Levell *TM3B*) and the 'through' voltage noted first and checked on an oscilloscope to ensure that the test amplifier output is not being overloaded. Then the frequency switch is switched to the appropriate frequency and the coarse control adjusted to minimise the deflection on the meter. The sensitivity of the millivoltmeter will have to be increased as the coarse and then the fine control nulls the fundamental frequency completely. When this occurs, the reading is that of the total distortion content plus the other components such as noise. The distortion content can then be calculated as follows: if the through voltage was 5V and the residual reading 15 mV then the distortion content would be $\left(\frac{.015}{5} \times 100 \text{ per cent}\right)$ or 0.3 per cent. It is worth taking a quick measurement of the noise by switching off the oscillator and measuring the residual noise component. For meaningful results the noise level should not be greater than about 5 mV and preferably lower; that is, at least 10 dB below the signal to be measured.

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FIG. 1 TYPICAL AMPLIFIER FAULTS USING SQUARE WAVE INPUT AND OBSERVING OUTPUT ON OSCILLOSCOPE

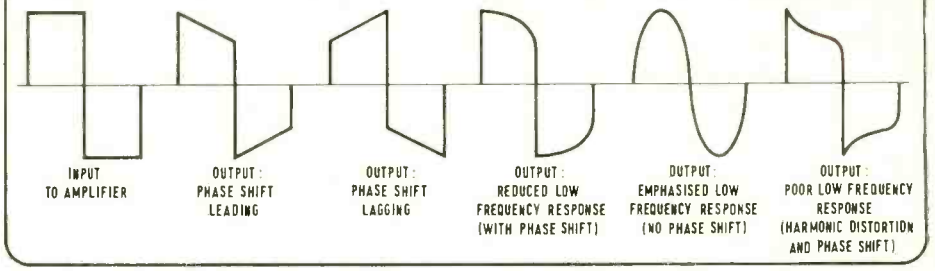


FIG. 2

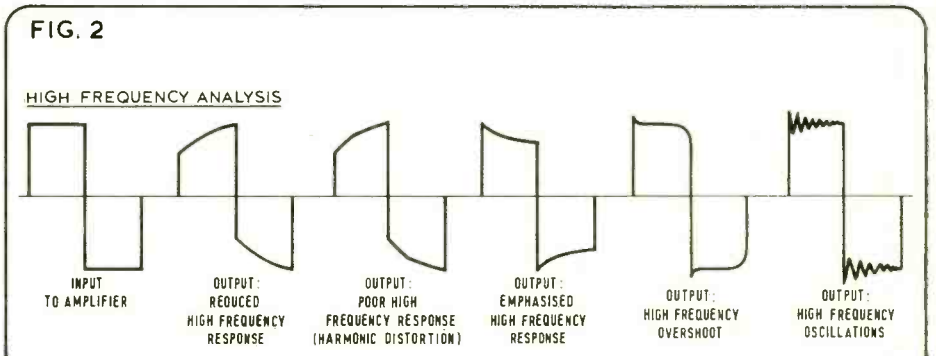


FIG. 3 OUTLINE FOR SIMPLE DISTORTION FACTOR METER

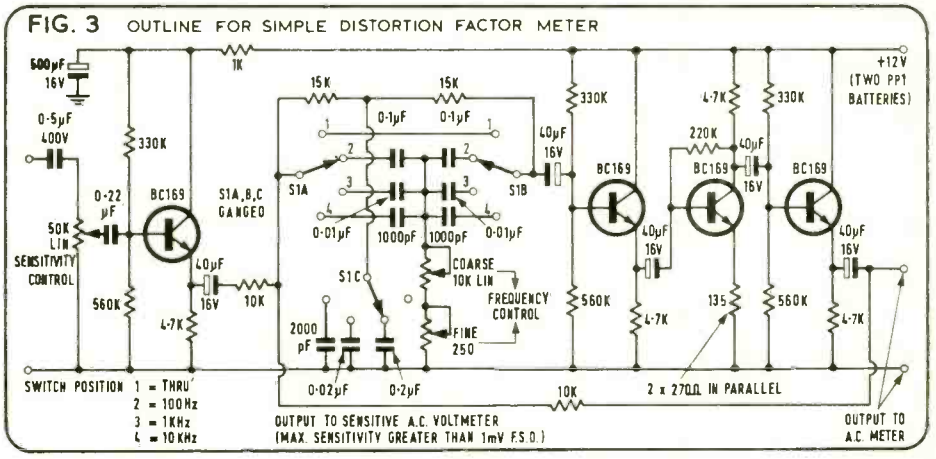
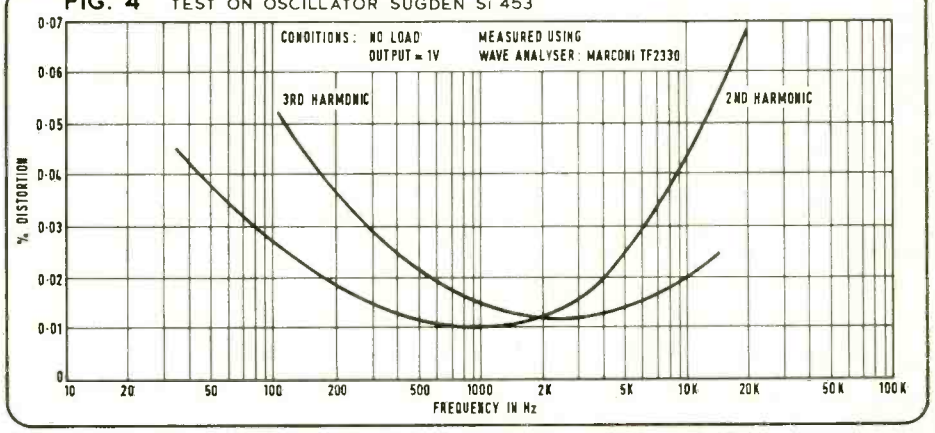


FIG. 4 TEST ON OSCILLATOR SUGDEN SI 453



DISTORTION

continued

The ability to make accurate measurements of distortion is not only dependent on the factors mentioned above but also upon two factors within the oscillator and one in the ac voltmeter. Firstly, the purity of the sinewave can dictate the level to which measurements can be made and the distortion of the oscillator should be checked first. As a rough guide, the distortion of the oscillator should be less than one fifth the minimum distortion to be measured in the amplifier. A good oscillator today can have a distortion at 1 kHz of about .02 per cent. See **fig. 4** for example (the Sugden *Si453*, Levell *T6200* range or, for really low distortion, the Radford and measurements on amplifiers are thus reasonably accurate down to about 0.1 per cent.

The second factor is that of oscillator frequency stability. If the frequency is changing all the time, even by as little as 10 Hz, the null filter will have to be returned and this can make measurements extremely tedious. Two procedures which greatly minimise frequency drift are, on battery operated oscillators, to use new batteries or a good stabilised mains supply; secondly, to allow the oscillator time to settle down after switch-on. With battery-powered oscillators, allow at least half an hour and with mains operated equipment several hours if possible.

The accuracy of measurement is also partially determined by the type of ac voltmeter. Many commercial ac voltmeters come under the category of average-reading types which are calculated to read rms volts when a sinusoidal input is applied. A complex wave such as the residual components of distortion can therefore give misleading results (see **fig. 5**) and make accurate measurements difficult. A peak reading ac voltmeter would be a better proposition when using a distortion factor meter, since the ear is more sensitive to peaks than to the average value when detecting distortion.

The most serious limitation of the use of a distortion factor meter is that it measures noise in with the harmonics. Since noise stretches right across the frequency spectrum the only way to remove it from the measurement is to measure selectively only those frequencies of interest i.e. the harmonics. This necessitates measuring each harmonic separately and the total distortion has to be calculated as follows:

$$D\ Total = \sqrt{\frac{(V_2)^2 + (V_3)^2 + (V_4)^2 + \ldots}{(V_1)^2}}$$

where D Total = Total distortion
V_1 = Fundamental distortion
V_2 = 2nd harmonic voltage
V_3 = 3rd harmonic voltage
V_4 = 4th harmonic voltage

The name given to this type of analysis is wave analysis and it can be extremely useful in helping to evaluate the performance of an amplifier under three main conditions: firstly, where it is required to measure selectively individual components of a waveform, particularly where there are large differences in level between the components, and where the smaller signals are partially obscured by broadband noise; secondly, to determine the noise characteristics of an amplifier, since the bandwidth of the selective amplifier is well defined. Some commercial instruments have variable bandwidths and this facilitates the measurement of noise over discrete frequencies; thirdly, for frequency response testing, particularly at low voltages or power levels where the signal may be affected by the noise. It allows each frequency to be measured without the presence of noise or distortion.

The simplest method of wave analysis is to use a variable tuned amplifier which feeds into a sensitive valve voltmeter. A number of older types of commercial equipment used this principle and it is capable of producing good results. The main disadvantage with the method is that the response characteristic of the tuned amplifier is usually a constant percentage of frequency throughout the tuning range. Hence its bandwidth measured in Hertz increases as the frequency increases. The selectivity of the tuned circuit is one of the main factors which limits the level to which distortion measurements can be made. For example, if it is required to measure distortion components down to 0.1 per cent then the tuned circuit must be capable of having a selectivity greater than one part in a 1000 (0.1 per cent) per octave. In other words the selectivity of the circuit should be such that the fundamental, one octave away from the resonant frequency, is attenuated by at least 60 dB.

Another type of 'wave analyser' (or 'frequency analyser') that is widely used is the heterodyne type; for example, the Marconi *TF2330*. This employs the same principle as a 'superhet' radio in that the frequency to be investigated is mixed with a signal from a local oscillator. The resultant signal is passed through an intermediate frequency amplifier which is a fixed frequency, narrow bandwidth amplifier **fig. 6**. Hence, in this type of equipment, the bandwidth is constant over the frequency range.

There are variations on the basic wave analyser such as the spectrum analyser. This instrument not only incorporates wave analysing facilities but also has a low distortion oscillator which is tuned synchronously with the analyser. Hence all the frequencies of interest can be scanned and the results displayed on an oscilloscope or pen recorder.

Wave analysis suffers from some of the same defects as distortion factor measurements. The distortion measurement is limited by the distortion of the oscillator and the frequency stability of the oscillator is very important.

The major advantages of wave analysis are, firstly, that distortion components can be measured in the presence of wideband noise—hence lower levels of distortion determined with reasonable accuracy—and, secondly, that the individual components of distortion can be identified, which is very useful at the design stage of equipment and for the diagnosis of faults in the maintenance of equipment.

The two methods so far described are used to analyse the distortion of a single sinusoidal waveform at frequencies in the audio spectrum (often known as harmonic distortion analysis). Next month the various forms of distortion which involve more than one frequency will be discussed, as well as the means of analysing them.

FIG. 5

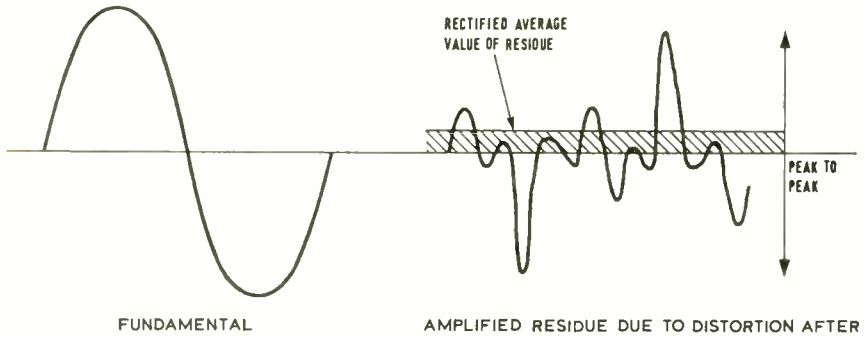
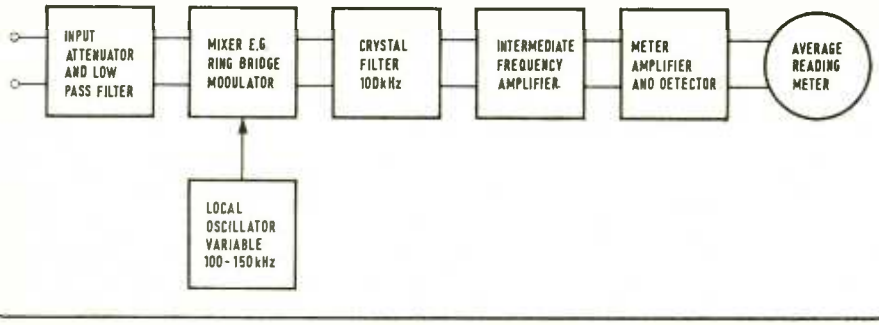


FIG. 6 SIMPLIFIED DIAGRAM OF WAVE ANALYSER TO MEASURE FREQUENCIES IN THE RANGE 0 TO 50kHz



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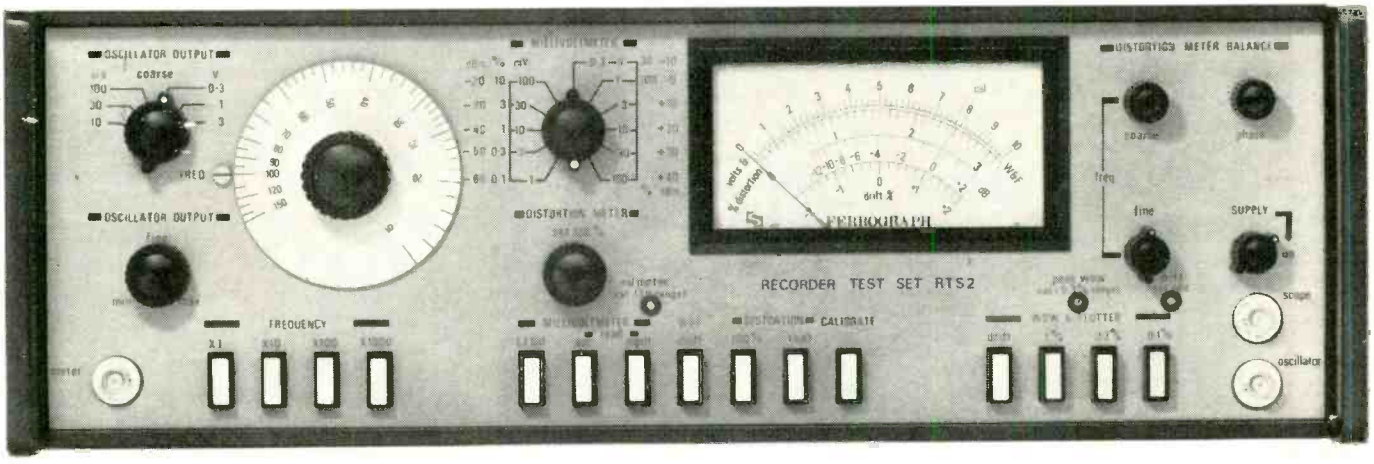

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Adret Electronique, Av. Vladimir Komarov, 78-Trappes, France.
Tel: 462 83 50.

Agents: Racal Instruments Ltd, Duke Street, Windsor, Berkshire.
Tel: 95 69811.

201

0.1 Hz to 2 MHz signal generator. Output frequency is controlled by eight digital dials with 0.1 Hz resolution. In addition, a calibrated search or interpolation oscillator provides smooth frequency control between all digital steps up to 100 kHz. Meaningful setting to 0.001 Hz. A separate calibrated variable oscillator covers the full 0.1 Hz to 2 MHz band without range change.
Fm and am modulation built in. Three internal modulation frequencies take care of most requirements while an external mode permits modulation from dc to 20 kHz. The output level is adjustable with a built-in pushbutton 0 to 99 dB attenuator and a ±1 dB vernier.
Accuracy: Coherent output frequencies are derived from a stable crystal controlled oscillator. Stability of 1×0^{-7}/day is standard while 2×10^{-9}/day is also available. Digital frequency selection and high spectral purity.
Programming capability: High speed remote programmability in addition to calibrated front panel frequency control. The digital oscillator is programmed by BCD signals while the search oscillator and variable oscillator are programmed by dc voltages.
Sweep generator: Narrow band and wide band sweeps are provided by the search oscillator and variable oscillator respectively. Internal sweep voltages (including an output to drive an oscilloscope horizontal amplifier) are provided by the internal fm modulator while external voltages of almost any waveform may also be used to sweep these oscillators.
PRICE: £2,035

301

0.1 Hz to 100 kHz generator. Output frequency is controlled by four digital dials and three range push buttons with resolution to 0.1 Hz. A separate calibrated variable oscillator covers the full 0.1 Hz to 100 kHz band without range change. This variable oscillator may also be fm modulated from an external waveform. The output level is exceptionally stable and is adjustable with a built-in calibrated level control. Outputs with 50 ohms and 600 ohms impedances are provided simultaneously.
Accuracy: Coherent output frequencies derived from a crystal controlled oscillator. Room temperature crystals are used for instant warmup and 3×10^{-5}/week stability. Digital frequency selection and high spectral purity.
Programming capability: High speed remote programmability in addition to calibrated front panel frequency control. The digital oscillator is programmed by BCD signals while the variable oscillator is programmed by dc voltages.
Sweep generator: narrow band and wide band sweeps are provided by the variable oscillator. External sweep voltages of almost any waveform may be used to sweep the oscillator.
PRICE: £690

ADVANCE

Advance Electronics Ltd, Raynham Road, Bishops Stortford, Hertfordshire.
Tel: 0279 55155.

J3

Balanced, floating, 600 ohms output. The main output, which is metered, gives 15V into 600 ohms (30V EMF). The frequency range of 10 Hz to 100 kHz is provided in four decade ranges, and the 6:1 reduction drive with capacitor tuning gives high resolution of frequency with minimum bounce.
Three additional outputs are available, a 1W low impedance output, a square wave output and a low distortion output.
Switched step attenuators give 60 dB of attenuation and the variable level control can be used to provide a further 20 dB of attenuation with negligible hum and noise on the output.
PRICE: £95

SG68A

Frequency range: 1.5 Hz to 150 kHz.
Distortion: 0.01% (20 Hz to 20 kHz).
Two modes of operation are provided, low distortion and fast settle. In the fast settle mode distortion is still less than 1% and amplitude bounce with change of frequency is greatly reduced.
In addition, a square wave output with rise and fall times of less than 100 ns is provided, and a maximum output of 4V is available on both sine and square waves. Output level control is achieved by means of a four range push button attenuator and a calibrated fine control. To minimise supply frequency induced hum, and for maximum portability, the instrument is powered by internal batteries, and these can be checked by means of a push button on the front panel. However, an ac power supply type BE2 is available as an optional extra, if required.
PRICE: £115

SG67A

Sine or square output over 1 Hz to 1 MHz. Battery operation for continuous laboratory operation not requiring power line isolation, an ac power supply BE1 may be specified as an optional extra. Sine and square outputs thermistor stabilised within ±1 dB at constant temperature for frequencies up to 200 kHz. Output level is fully variable from 250 μV to 2.5V rms into 600 ohms by means of a fine level control and a four position 60 dB attenuator. Square wave rise time is typically 50 ns at all frequencies.
PRICE: £55

SG65A

10 Hz to 100 kHz frequency indicated on horizontal scale. Two outputs are provided. One is a high impedance source with optional sine or square wave, continuously variable up to 6V rms on sine wave, and up to 9V peak to peak on square wave. Additionally a switched attenuator provides a 0-20-40 dB attenuated output. The other output is a low impedance source, available simultaneously and providing a sine wave with a maximum power of 1W into 4 ohms, within the range 50 Hz to 20 kHz.
PRICE: £29

HIE

Sinusoidal signal variable from 200 μV to 20V rms over the frequency range 15 Hz to 50 kHz. Square wave output variable from 1.4 mV to 140V pp. The HIE consists of a bridge type rc oscillator with thermistor stabilisation having three switched ranges followed by two stages of amplification employing negative feedback. Output level is selected by means of a five position decade attenuator and continuously variable control.
PRICE: £65

J2E

15 Hz to 50 kHz in three ranges. Contains an rc bridge oscillator connected to the output stage via a buffer amplifier. Overall distortion at full output power above 100 Hz is less than 2% (34 dB down on fundamental). The output level is monitored on a high grade meter and is adjusted by means of a 20 dB attenuator and continuously variable fine control.
PRICE: £75

Above: AWA *G231* and Bradley *235*

AWA

Amalgamated Wireless (Australasia) Ltd, 422 Lane Cove Road, Ryde, NSW, Australia.
Tel: 888 8111.

Agent: Marconi Instruments Ltd, St Albans, Hertfordshire.
Tel: 56 59292.

G231

Frequency range: 10 Hz to 30 kHz in 4 overlapping ranges and 3 bandspread ranges as follows: 10 Hz to 110 Hz, 100 Hz to 1,100 Hz, 1,000 Hz to 11,000 Hz. When any of these frequency ranges is selected in conjunction with the spread button, only the upper 30% of the selected range is obtained in the dial sweep. The fourth range is 10 kHz to 30 kHz.
Maximum departure of frequency from scale indication: 10 Hz to 100 Hz ±4%, 100 Hz to 30 kHz ±3%.
A two-speed drive is incorporated, with direct and 6-1 ratios for ease of adjustment.
OUTPUT:
Output level: maximum +22 dBm into 600 ohms. A meter scaled +2 to —20 dB monitors the basic output level which may be set by a fine level control having a 30 dB range. The basic output level may be further attenuated by a step attenuator which has a range of 0 dB to 80 dB in 10 dB steps. Each step is within ±0.25 dB of stated value when referred to the 0 dB step at 1 kHz.
Uniformity of level: ±0.3 dB from 10 Hz to 30 kHz when referred to 1 kHz.
Meter: ±0.1 dB from 10 Hz to 30 kHz. The actual output into a 600 ohm load resistor is within ±0.1 dB of 0 dBm at 1 kHz for a temperature of 25° C.
Source impedances: Nominally 40 ohms (equivalent circuit approximately 40 ohms in series with 180 μH) and 600 ohms, balanced or unbalanced. Either is designed to feed 600 ohm lines.
Return loss of 600 ohm output: at least 30 dB from 30 Hz to 15 kHz. At least 25 dB from 10 Hz to 30 Hz and from 15 kHz to 30 kHz.
Hum and noise: below —60 dB relative to output signal, or below —105 dBm, whichever is the greater level.
Frequency range: 10 Hz to 30 Hz, 30 Hz to 20 kHz, 20 kHz to 30 kHz, 30 Hz to 30 kHz.
Distortion maximum: 0.3% (—50 dB), 0.1% (—60 dB), 0.2% (—54 dB), 0.2% (—54 dB).
Output level: step attenuator calibrated in terms of output level. A fine control is also provided.
Source impedance (2-position switch): 40 ohms or 600 ohms.
Power (4-position switch): Ac mains or external battery (internal battery, when fitted, is trickle charged). Internal rechargeable battery (optional).
Meter: The output level in dBm which would be impressed on a 600 ohm load is read from the attenuator setting in conjunction with the clear-face mirror-scaled meter.
Wdh dimensions: 149 x 470 x 355 mm.
Weight: 7.26 kg.
PRICE: £315.

BRADLEY

G. E. Bradley Ltd., Neasden Lane, London NW10 1RR.
Tel: 01-450 7811

235 DIGITAL

Frequency ranges: 1 Hz to 10 Hz, 10 Hz to 100 Hz, 100 Hz to 1 kHz, 1 kHz to 10 kHz, 10 kHz to 100 kHz, 100 kHz to 1 MHz, 1 kHz to 10 MHz.
Standard (Internal): 10 MHz crystal unit in oven.
Accuracy: Set to 1 in 10^7. Provision for adjustment of frequency against local standard.
Stability: 3 parts in 10^8 per day (after 72 hour warm up). 1 part in 10^6 per year. Temperature coefficient 6 parts in 10^8 per °C.
External standard: Input frequency 10 kHz squarewave. Input level TTL, low less than 0.3V high more than 2.7V.
Outputs frequency stability: 5 parts in 10^6 (Typically 1 part in 10^6) measured over 1s period.
Frequency lock on time: less than 3s.
Maximum sine output level: 8V rms.
Attenuated output: 20 dB switched steps giving output ranges of 8V, 800 and 80 mV rms unterminated, with a further 7 position divider in 3 dB steps. (0 to —21 dB).
Attenuator accuracy: ±3% of setting up to 1 MHz. Less than 10% down at 10 MHz.
Amplitude settling time: Typically 3s after changing frequency 10s maximum.
Output impedance: 50 ohms ±3% or 600 ohms ±3% (600 ohms output usable up to 100 kHz only).
SQUAREWAVE OUTPUT:
Output level: Nominally 5V peak to peak unterminated, TTL compatible.
Output impedance: Less than 200 ohms.
Rise and fall times: Less than 30 ns (terminated).
Operating temperature range: 0 to 50°C. Specification maintained over 10 to +35°C.
Storage: —30 to +60°C.
Power supplies: 100 to 125V at 60 Hz or 200 to 250V at 50 Hz, 50W.
Dimensions: 420 x 140 x 250 mm.
Weight: 6 kg.
PRICE: £395

BROOKDEAL

Brookdeal Electronics Ltd, Market Street, Bracknell, Berkshire, RG12 1JU.
Tel: 0344 23931/5.

471

Frequency may be controlled manually or by an external voltage or by a combination of both.
Frequency range: 0.001 Hz to 1.1 MHz.
Total harmonic distortion: typ 0.05% (man/lin mode).
Frequency control range: 10^3:1 (linear). 104:1 (log).
Calibrated output: 3.16V rms to 1 μV rms. (μV levels are from a 1 ohm low-noise source.) Signal-off button.
PRICE: £265

472

Frequency may be controlled manually or by an external voltage. The control law is linear and the frequency span is two decades on any range setting.
Frequency range: 0.1 Hz to 1.1 MHz.
Total harmonic distortion: typically 0.1%.
Squarewave risetime: less than 30 ns.
Frequency control: 10^3:1 linear.
Output: sine or squarewave 5V rms to less than 500 μV rms from 600 ohms.
PRICE: £167

B & K

Bruel & Kjaer, Naerum, Denmark.

Agents: B & K Laboratories Ltd, Cross Lances Road, Hounslow, TW3 2AE.
Tel: 01-570 7774

1022 BFO

Logarithmic frequency range: 20 Hz to 20 kHz; incremental scale: —50 to +50 Hz.
Frequency accuracy: Incremental scale: ±0.5 Hz, main scale: 1% ±1 Hz.
Distortion: (2 dB below full indicating meter deflection, unloaded) 0.1% at 1 kHz.
Hum level: —70 dB.
Output attenuator: ±0.2 dB. Variable in steps of 10 dB from 125 μV to 12.5V.
Frequency scanning: A worm gear in the BFO permits the variable capacitor to be driven from the motor of the *2305* level recorder. Set and release of the drive operated with the aid of a magnetic clutch on the BFO. Provision is made for remote control of the clutch.
Frequency modulation: +250 Hz maximum.
Power supply: 100 to 240V ac, 50 Hz to 400 Hz.
Power consumption: 26W.
Hwd dimensions: 480 x 380 x 200 mm.
Weight: 15 kg.
PRICE: £464

DYMAR

Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts WD2 4LA.
Tel: 92 21297.

1525 AM/FM

Frequency range: A: 100 kHz to 44 MHz, B: 44 MHz to 92 MHz, C: 88 MHz to 184 MHz. (Range A is obtained by mixing Range B with a 90 MHz crystal oscillator).
Calibration accuracy: 0.01% at crystal check points which are every 1 MHz on ranges A & B and every 2 MHz on range C.
Main tuning: Through anti-backlash reduction gear (52:1) giving 24 revolutions for scale transversal.
Frequency readout: drum scale with an effective length in excess of 50 cm. Counter output available for precise frequency setting.

52 ▶

continued

Fine tuning: electronic tuning with approximately ±1 kHz range.
Frequency stability: at constant temperature after 1 hour's warm-up 0.001% over a period of 10 minutes.
Incremental frequency: calibrated frequency shift of ±25 kHz.
Calibration accuracy: 10%
External shift: +6V DC relative to a potential of —6V DC will shift frequency approximately ±25 kHz.
Amplitude modulation: continuously variable 0 to 50% (up to 90% depth uncalibrated).
Modulation setting accuracy: 5% of fsd.
Frequency range: 30 Hz to 10 kHz.
Frequency setting accuracy: 3% counter output available for precise setting of modulation frequency.
Envelope distortion: better than 3% at 1 kHz and 30% depth of modulation.
Frequency modulation: continuously variable. 3 ranges giving full scale deviations of 1.5 kHz, 5 kHz and 15 kHz.
External modulation Am/Fm: approximately 3V input into 10k ohms will modulate the carrier externally.
Accuracy: ±1 dB at 1 μV and above.
Leakage: less than 1 μV in a 50 mm loop search coil anywhere outside the instrument.
Counter output: approximately 50 mV into 50 ohms irrespective of attenuator setting.
AUXILIARY OUTPUTS:
Af oscillator: 30 Hz to 30 kHz in 3 ranges.
Frequency calibration: 3%.
Output voltage: continuously variable to 1.5V into 600 ohms.
Setting accuracy: 5% fsd.
If oscillator: 10.7 MHz crystal controlled.
Frequency accuracy: 0.001% 10° to 30°C.
Output voltage: approximately 0.5V into 50 ohm.
Internal battery: 24V (nominal) nickel cadmium rechargeable battery of 400 mAh capacity giving a typical operating time of 4½ hours between recharging. Batteries are recharged in situ by means of an internal charging circuit in 14 hours from a fully discharged condition (22V).
Meter: 64 mm movement calibrated 0 to 5 and 0 to 15 plus a scale of —1 and +1 dB for carrier setting. A 'check battery' push button connects meter across battery to read voltage directly.
Whd dimensions: 420 x 175 x 250 mm.
Weight: 10 kg.
PRICE: £535

Below: Farnell *ESG 1*

FARNELL

Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH.
Tel: 0937 3541. (London office: 01-802 5359)

ESG 1

Frequency range: 10 Hz to 1 MHz in five decade ranges.
Scale accuracy: ±3% of scale reading.
Harmonic distortion: 0.5% 10 Hz to 100 kHz; 2% 100 kHz to 1 MHz.
Square wave rise time: less than 200 ns.
Stability: variation less than 0.2% in 8 hours.
Output voltage: 12 MV to 12V peak to peak.
Output impedance: 60 ohms approximately.
Amplitude stability: ±2% 10 Hz to 100 kHz; ±5% 100 kHz to 1 MHz.
Sync output: greater than 5V pp.
Power requirements: ac mains 190 to 260V or 95 to 130V by internal connection change. Frequency: 50 to 400 Hz.
Hwd dimensions: 187 x 109 x 230 mm.
Weight: 2.4 kg.
PRICE: £39

LFM 2

Frequency range: 1 Hz to 1 MHz in six decade ranges.
Scale accuracy: to within ±3% of scale reading or ±0.25 Hz.
Harmonic distortion: less than 0.5% 10 Hz to 100 kHz; less than 2% 1 Hz to 1 MHz.
Square rise time: less than 150 ns.
Frequence stability: Typical stability over ±7.5% variation of nominal mains (after 30 minutes warm up) less than 0.004%, typical stability with temperature (after 30 minutes warm up) less than 0.03% per °C.
Amplitude stability: over ±7.5% variation of nominal mains, less than 0.2%; less than 0.3% per °C.
Output voltage: 1 mV to 12V pp.
Output impedance: 60 ohms calibrated into 600 ohms.
Sync output: greater than 5V p-p.
Ambient temperature range: 0 to 40°C.
Power requirements: 190 to 260V or 95 to 130V ac by internal link change, 47 to 400 Hz.
Batteries: 27V dc from three integral PP9 batteries. Life typically 70 hours for 3 hours use per day.
Hwd dimensions: 162 x 244 x 254 mm.
Weight: 5.33 kg.
PRICE: £69

FG 1

Frequency range: 0.02 Hz to 2 MHz in seven switched ranges.
Frequency dial accuracy: ±3% of range maximum 0.02 Hz to 200 kHz; ±10% of range maximum 200 kHz-2 MHz.
Output waveforms: sine, square and triangular.
Outputs available: the three waveform types available simultaneously from three low level output sockets. One of the three waveform types, selected by a switch, is available at the main output socket.
Low level triple output: 2V p-p from 600 ohms each.
Main output amplitude: 20V p-p maximum, adjustable with calibrated fine control down to 1V peak to peak into open circuit from a 50 ohm source resistance.
Output attenuator: 60 dB attenuation in 20 dB steps, Minimum output 1 mV p-p.
Output amplitude constancy: Less than 0.1 dB change with frequency from 0.02 Hz to 200 kHz.
Output offset: dc offset up to ±4V into open circuit on unattenuated output.
Sine distortion: less than 1% on ranges 0.2 Hz to 200 kHz.
Hwd dimensions: 152 x 337 x 234 mm.
Weight: 5 kg.
PRICE: £195

FEEDBACK

Feedback Instruments Ltd, Park Road, Crowborough, Sussex.
Tel: 089 26 3322.

TWG 500 VARIABLE PHASE

Frequency range: 0.01 Hz to 100 kHz continuously variable in seven decade ranges with calibrated fine control. A 20% range overlap at each end of the decade scale ensures continuity between ranges and effectively extends the frequency coverage from 0.008 Hz to 120 kHz approximately.
Accuracy: ±3% of reading from 1 Hz to 100 kHz ±5% of reading from 0.01 Hz to 1 Hz.
Stability: Drift less than ±0.1% (1 hour) after one hour warm-up period, constant temperature and supply voltage.
Jitter: Less than 0.02%, measured at 10 kHz.
Response: ±0.5 dB from 0.01 Hz to 100 kHz.
Waveforms: Sine, square and triangle—reference (0°) and Quadrature—together with variable phase sine wave are simultaneously available from two main output amplifiers and seven constant amplitude monitor outputs. Sine at 180° and 270° also available from monitor outputs.
Sine: five outputs at 0°, 90°, 180°, 270° and continuously variable from —180° to +180° calibrated. Distortion: less than 1%, 0.01 Hz to 10 kHz. Less than 4% at 100 kHz, typically 2.5%.
Square: two outputs at 0° and 90°. Rise time less than 3 μs via amplifiers, less than 0.3 μs via monitor sockets.
Triangle: two outputs at 0° and 90°. Linearity better than 1%. A wide variety of waveforms for simulation work may be produced by the use of a summing facility which enables separate outputs to be combined.
Phase accuracy: 90°, 180° and 270° less than ±1° relative to 0°. Variable phase setting accuracy. 0.01 Hz to 10 kHz less than ±2°. 10 kHz to 100 kHz less than ±4° typically 3°.
Main outputs: two main output amplifiers are connected by push button switches to any one of seven waveforms. Alternatively, the amplifiers may be isolated and used to amplify externally generated signals.
The two amplifiers are balanced for phase shift to within ±2° of each other at all frequencies up to 100 kHz.
Whd dimensions: 430 x 266 x 292 mm.
Weight: 8.7 kg.
PRICE: £428

TWG 501

Unless otherwise stated, this specification is given for operation at +25°C ±5°C.
Frequency:
Range: 0.01 Hz to 1 MHz continuously variable in eight decade ranges with calibrated fine control. A 10% range overlap at each end of the decade scale ensures continuity between ranges and effectively extends the frequency coverage from 0.009 Hz to 1.1 MHz, approximately.
Scale Accuracy: A maximum error of ±2% of nominal full scale on all decades. Also, for all ranges except the highest and lowest the frequency is within ±5% of setting.
Stability: Under constant line voltage, output load and temperature conditions, after half-hour initial warm up at 10 kHz.
Short term: ±0.05% over 10 minutes.
Long term: ±0.1% over 6 hours (typically).
Variation with line voltage (±10% line voltage variation): less than ±0.1%.
Jitter: typically less than 0.01% at 10 kHz.
Waveforms: Sine, square, or triangle are available by selection through the output amplifier and simultaneously at three monitor outputs:
Sine: total harmonic distortion less than 2%, 0.01 Hz to 20 kHz.
Square: rise time less than 60 ns via output amplifier. Less than 30 ns via monitor socket into a resistive load.
Triangle: linearity better than 1%. Time symmetry of all the above waveforms within 1% except on 0.01

to 0.1 Hz range where better than 5%.
Fast square wave: 0 to −5V ±0.4V peak unloaded from 50 ohms source impedance. Rise time 10% to 90% less than 15 ns. Total aberrations less than 3%. BNC socket output.
Trigger output: Alternate +ve and −ve going pulses 2V peak nominal into 50 ohms. Time constant of exponential decay 200 ns. Rise time 10% to 90%, less than 20 ns.
Output facilities:
Main output: the main output amplifier is connected by rotary switch to any one of three waveforms—sine, square or triangle.
Level: continuously variable up to 20V peak-to-peak from source impedance of about 25 ohms.
Maximum output: 20 mA.
Low level output: nominally 20 dB below main output when unloaded. Source resistance 500 ohms.
Monitor outputs: all three generated waveforms are available simultaneously on 4 mm sockets at 2 ±5% volts peak-to-peak into 1k ohms.)
Variation with frequency: ±0.1 dB up to 100 kHz ±0.5 dB from 100 kHz to 1 MHz.
Variation with time: typically less than ±0.5 dB over 2 hours at 10 kHz.
Variation with line voltage: ±0.1 dB for ±10% change at 10 kHz.
Variation with temperature: typically less than ±0.1 dB from −15°C to +50°C at 10 kHz, triangle or square; less than ±0.25 dB from 20°C to 30°C, sine.
Voltage control: The generated frequency can be controlled by an external voltage in the range −1.5V to +15V applied to the 'sweep in' jack, the dial control being rendered inactive. Input impedance greater than 100k ohms falling to 10k ohms outside the normal operating voltage range. Inputs from 0 to −1.5V reduce the frequency over approximately four decades from the lower frequency of each range or to 0.01 Hz, whichever is the greater frequency. Although not guaranteed, typical instruments will sweep to 0.001 Hz or below on the lower ranges.
VCF slew rate: a fast step function applied to the 'sweep in' socket results in an effective frequency control voltage whose slew rate is approximately 1V per 6 ns. Thus a decade sweep can be completed in 90 ns, less than 10% of one period at 1 MHz.
Power supply: 100-120V or 200-250V, 50 or 60 Hz; +18 to +24V and −18V to −24V each at 100 mA applied to rear socket.
Wdh dimension: 254 x 121 x 157 mm.
Weight: 2.2 kg.
PRICE: £99

VPO 230 VARIABLE PHASE

Frequency coverage: 1 Hz to 100 kHz in five 10:1 switched ranges with continuous adjustment in each range.
Phases: The reference and quadrature phases are related 0° and +90° ±0.25°. The variable phase control is scaled linearly in 2° divisions over 360° and marked 'Lead' and 'lag' up to 180° starting from 0°. Phase may be set to within 1° of any selected angle.
External driving: The instrument may be driven from any external voltage function with components in the 1 Hz to 100 kHz range.
The input impedance is 20k ohms and the minimum input is 1V peak for satisfactory operation. The shape of the waveform is not important.
Under these conditions, the equipment behaves as a tuned selective amplifier and may, under favourable circumstances, be used to extract the fundamental or harmonic components from a complex driving waveform.
Outputs: Reference, quadrature and variable phase—all available simultaneously. Identical power levels and controls on each channel. Instrument will deliver 10V peak into a high impedance load.
Output controls: calibrated 0 to 10 and marked at the 1 mW level for a load of 600 ohms.
Harmonic content of the output is generated mainly in the output stages and is due to the loading imposed by the 600 ohms attenuators. This can be as high as 2% but is typically 0.5% with the attenuators set for maximum output.
Output sockets and terminals: 4 mm.
Power supplies: single phase ac 100/120V or 200/250V 50/60 Hz 50 VA.
Wdh dimensions: 206 x 370 x 300 mm.
Weight: 11 kg.
PRICE: £232

GENERAL RADIO (USA)
General Radio Co (UK) Ltd, Bourne End, Buckinghamshire, SL8 5AT.
Tel: 062 85 22567.

1308

Frequency:
Range: 20 Hz to 20 kHz in 3 ranges.
Accuracy: ±3% of setting or ±1 Hz, whichever is greater.
Stability: warmup drift at full load, 0.3%.
After warmup: 0.003% short term (10 min), 0.03% long term (12 h), 0.04% from no load to full load.
Controls: continuously adjustable main dial covers decade range in 157.5°, vernier in 2 turns.
Output:
Voltage ranges: maximum of 4, 12.5, 40, 125 and 400V open circuit, continuously adjustable from 0 to max.
Power: 200 VA maximum, 50 Hz to 1 kHz.
Distortion (linear load): less than 1% (100 Hz to 10 kHz).
Hum: 0.3% of maximum output.
Amplifier:
Sensitivity: 2V for full output.
Input impedance: 10k ohms.
Power required: 105 to 125 or 210 to 250V, 50 to 60 Hz, 70 to 500W depending on load.
Whd dimensions: 485 x 180 x 414 mm.
Weight: 67 kg.
PRICE: £973 plus import duty

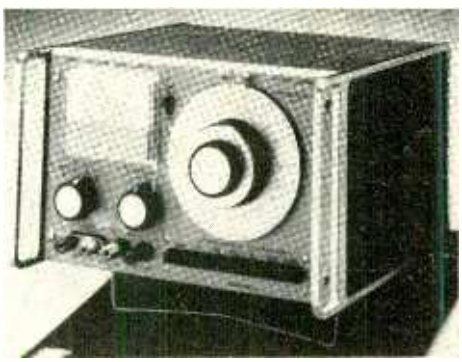
1309

Frequency:
Range: 10 Hz to 100 kHz in 4 decade ranges. Overlap between ranges 5%.
Accuracy: ±2% of setting.
Stability: 0.01% long term.
Controls: continuously adjustable main dial covers decade range in 305°, vernier in 4 turns.
Synchronisation: frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10V. Frequency dial functions as phase adjustment.
Output: Sine.
Power: more than 10 mW into 600 ohms.
Distortion: less than 0.05% (200 Hz to 10 kHz).
Hum: less than 60 μV independent of attenuator setting (less than 0.001% of full output).
Square wave:
Voltage: +5V p-p open circuit. Dc coupled output.
Impedance: 600 ohms, one terminal grounded.
Power required: 100 to 125 or 200 to 250V, 50 to 400 Hz 6W.
Whd dimensions: 205 x 155 x 210 mm.
Weight: 3.1 kg.
PRICE: £211 plus import duty

1310-B

Frequency:
Range: 2 Hz to 2 MHz in 6 decade ranges. Overlap between ranges, 5%.
Accuracy: ±3% of setting.
Stability: 0.03% long term.
Controls: continuously adjustable main dial covers decade range in 305°, vernier in 4 turns. ▶ 54

Below: Farnell *LFM2*



continued

Synchronisation: frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10V. Frequency dial functions as phase adjustment.
Output: power: more than 160 mW into 600 ohms.
Attenuation: 46 dB range.
Distortion: 0.25% (50 Hz to 50 kHz).
Hum: 0.02%.
Power required: 105 to 125, 195 to 235, or 210 to 250V 50 to 400 Hz to 12W.
Whd dimensions: 205 x 155 x 210 mm.
Weight: 3.6 kg.
PRICE: £164 plus import duty

HEATH-SCHLUMBERGER
Heath (Gloucester) Ltd, Gloucester GL2 6EE.
Tel: 0452 29451

AG-9U

Frequency: 10 Hz to 100 kHz, switch selected.
Output: 6 ranges 0 to 3 mV, 10 mV, 30 mV and 1V rms into external 600 ohm load or with internal load into Hi-Z, 2 ranges 0 to 3, 10V rms into a minimum of 10k ohms, —60 dB to +22 dB in 8 steps (0 dB = 1 mW into 600 ohms).
Distortion: Less than 0.1%, 20 to 20 kHz.
Valves: One *6AU6*, one-*EZ81*.
Power requirements: 200-250V AC, 50 Hz, 40W.
PRICE: £42 (kit: £31)

AO-1U

Sinewave:
Frequency range: 20 Hz to 150 kHz.
Output volts: 0 to 10V, 0 to 1V, 0 to 0.1V rms, into a high impedance load.
Distortion: Less than 1% 100 Hz to 20 kHz.
Frequency response: ±1 dB, 20 Hz to 50 kHz.
Squarewave:
Frequency range: 20 Hz to 25 kHz.
Output volts: 0 to 80V, 0 to 8V, 0 to 800 mV peak to peak.
Rise time: Less than 3 ms.
Power requirements: 115, 200-250V AC, 50 Hz, 30W.
PRICE: £27.50 (kit £16.50)

HEWLETT PACKARD (USA)
Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks. SL1 4DS.
Tel: 75 33341.

3310A

Output waveforms: sine, square, triangle, positive pulse, negative pulse, positive ramp and negative ramp. Pulses and ramps have a 15% or 85% duty cycle.
Frequency range: 0.0005 Hz to 5 MHz in 10 decade ranges.
Sine frequency response: 0.0005 Hz to 50 kHz ±1%. 50 kHz to 5 MHz: ±4%.
Reference: 1 kHz at full amplitude into 50 ohms.
Dial accuracy: 0.0005 Hz to 500 kHz all functions: (±1% of setting + 1% of full scale). 500 kHz to 5 MHz sine, square and triangle: ±(3% of setting +3% of full scale.) 500 kHz to 5 MHz pulse ramp: ±(10% of setting + 1% of full scale).
Maximum output on High: more than 30V pp open circuit. More than 15v pp into 50 ohms (except for pulses at frequency more than 2 MHz).
Pulse (frequency more than 2 MHz): more than 24V pp open circuit. More than 12V pp into 50 ohms.
Minimum output on Low: less than 30 mV pp open circuit. Less than 15 mV pp into 50 ohms.
Output level control: range more than 30 dB. High and low outputs overlap for a total range of more than 60 dB; low output is 30 dB down from high output.
Sine distortion (below fundamental): 0.0005 Hz to 10 Hz: more than 40 dB (1%). 10 Hz to 50 kHz (on 1 k range): more than 46 dB (0.5%). 50 kHz to 500 kHz: more than 40 dB (1%). 500 kHz to 5 MHz: more than 30 dB (3%).
Square wave and pulse response: less than 30 ns rise and fall times at full output. Less than 35 ns rise and fall times at less than full output. Less than 5% total aberrations.
Triangle and ramp linearity: 0.0005 Hz to 50 kHz less than 1%. Triangle symmetry: 0.0005 Hz to 20 Hz: less than 1%. 20 Hz to 50 kHz: less than 0.5%.
Output impedance: 50 ohms.
Sync output:
Amplitude: more than 4V pp open circuit, more than 2V pp into 50 ohms.
Rise and fall times: less than 20 ns.
Waveform: square for symmetrical functions, rectangular for pulse and ramp.
Output impedance: 50 ohms.
DC offset level:
Amplitude: ±10V open circuit, ±5V into 50 ohms continuously adjustable.
External frequency control:
Range: 50:1 on any range.
Input requirement: with dial set to low end mark, 0 to +10V ±1V will linearly increase frequency 50:1. With dial set at 50, 0 to —10V ±1V will linearly decrease frequency 50:1. An ac voltage will fm about a dial setting within the limits (1 less than f less than 50) x range setting.
Sensitivity: approximately 100 mV/minor division.
Input impedance: 10k ohms.
Operating temperature: 0°C to 55°C.
Power: 115V or 230V ±10%, 48 Hz to 440 Hz, less than 20W.
Weight: 2.7 kg
PRICE: £286

4204A DIGITAL

Frequency range: 10 Hz to 1 MHz, 4 ranges.
Frequency accuracy: ±0.2% or ±0.1 Hz (25°C.)
Frequency stability: ±10% line voltage variation: less than ±0.01%.
Change of frequency with temperature: less than ±100 ppm/°C.
Drift: less than 10 ppm/minute.
Frequency response: flat within ±3%.
Output: 10V (22 dBm) into 600 ohms (160 mW) 20V open circuit.
Output attenuator: 80 dB in 10 dB steps, less than ±0.5 dB error.
Output monitor: voltmeter monitors level at input of attenuator in volts or dB.
Accuracy: ±2% of full scale.
Flatness: ±1% at full scale, 10 Hz to 500 kHz. ±2% at full scale, 500 kHz to 1 MHz.
Distortion: less than 0.3% 30 Hz to 100 kHz; less than 1%, 10 Hz to 1 MHz.
Hum and noise: less than 0.05% of output.
Temperature range: 0°C to +50°C.
Power: 115V/230V switch, ±10%, 10W, 50 to 60 Hz.
Weight: 8.5 kg.
PRICE: £450.60

204

Frequency range: 5 Hz to 1.2 MHz in 6 overlapping ranges.
Dial accuracy: ±3% of frequency setting.
Hum and noise: less than 0.01% of output.
Output voltage: more than 2.5V rms (10 mW or +10 dBm) into 600 ohms more than 5V open circuit.
Output impedance: 600 ohms.
Output control: more than 40 dB range, continuously adjustable.
Output balance: more than 40 dB below 20 kHz. Can be floated up to ±500V peak between output and chassis ground.
Sync output: 10k ohms impedance (sine in phase with output); 1.7V rms open circuit; more than 100 mV rms into less than 100 pF.
Sync input: oscillator can be synchronised to an external signal.
Operating temperature: 0°C to 55°C.
Power: 115V ac or 230V ac ±10% 48 Hz to 440 Hz less than 4W.
Options: mercury batteries, approx 300 hr operation; line/rechargeable batteries (115V or 230V ±10%, 48 Hz to 440 Hz, less than 4W, 35 hr operation per recharge).
Whd dimensions: 130 x 155 x 203 mm.
Weight: 2.7 kg.
PRICE: £142.70

209A

Frequency: 4 Hz to ½ MHz in 6 ranges.
Dial accuracy: ±3% of frequency setting.
Hum and noise: less than 0.01% of output.
Output voltage: 5V rms (40 mW) into 600 ohms resistive load, 10V open circuit.
Output impedance: 600 ohms.
Output control: more than 26 dB range, continuously adjustable.
Output balance: more than 40 dB, below 20 kHz. Output can be floated up to ±500V peak between output and chassis ground.
Output voltage: 20V pp open circuit, symmetrical about 0V. Output can be floated up to ±500V peak.
Rise and fall time: less than 50 ns into 600 ohms resistive load.
Symmetry: ±5%.
Output impedance: 600 ohms.
Output control: continuously adjustable from 0 to full output.
Sync output: sine in phase with output (1.7V rms open circuit) impedance 10k ohms. (Frequency response at high frequencies is affected by capacitive loads).
Sync inputs: Oscillator can be synchronised to an external signal.
Operating temperature: 0°C to 55°C.
Storage temperature: —40°C to +75°C.
Power: 115V or 230V ±10%, 50 Hz to 400 Hz, less than 7W.
Whd dimensions: 131 x 155 x 204 mm.
Weight: 3.6 kg.
PRICE: £195.10

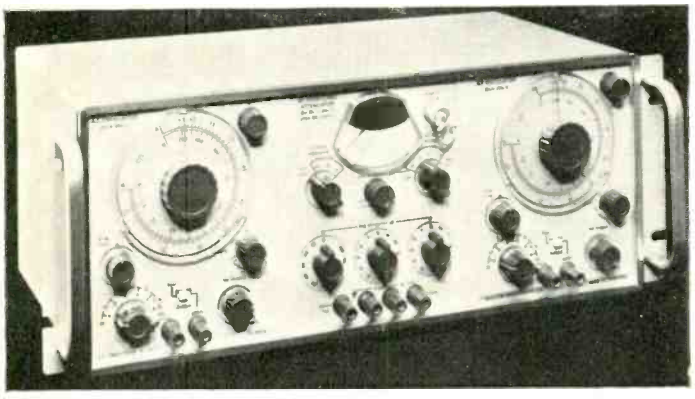
200AB

Frequency range: 20 Hz to 40 kHz in 4 ranges.
Bands: 20 Hz to 200 Hz, 200 Hz to 2 kHz, 2 kHz to 20 kHz, 4 kHz to 40 kHz.
Dial accuracy: within ±2% at normal ambient temperatures (includes warm-up and changes due to aging of tubes and components).
Frequency dial: 150 mm diameter, calibrated over 300° of arc. 90 divisions. Total scale length, 1.6 m. Vernier control for precise setting.
Frequency response: +1 dB over entire frequency range when working into 600 ohms load.
Distortion: less than 1%, 20 Hz to 20 kHz; less than 2%, 20 Hz to 40 kHz when working into 600 ohm load or higher impedance.
Output: 1W or 24.5V into a 600 ohm load.
Output impedance: less than 75 ohms from 20 Hz to 15 kHz. Output is balanced to ground and floating over entire frequency range (may be operated one side grounded, if desired).
Hum and noise: at least 66 dB below maximum rated output (less than 0.05% of rated output).
Operating temperature: 0°C to 55°C.
Power supply: 115 or 230V (must be specified), 50/400 Hz, 70W nominal, 85W maximum.
Whd dimensions: 191 x 292 x 305 mm.
Weight: 5.3 kg.
PRICE: £148.40

200CD

Frequency range: 5 Hz to 600 kHz covered in five overlapping ranges.
Ranges: 5 Hz to 60 Hz, 50 Hz to 600 Hz, 500 Hz to 6 kHz, 5 kHz to 60 kHz, 50 kHz to 600 kHz.
Dial accuracy: ±2%.

56 ▶

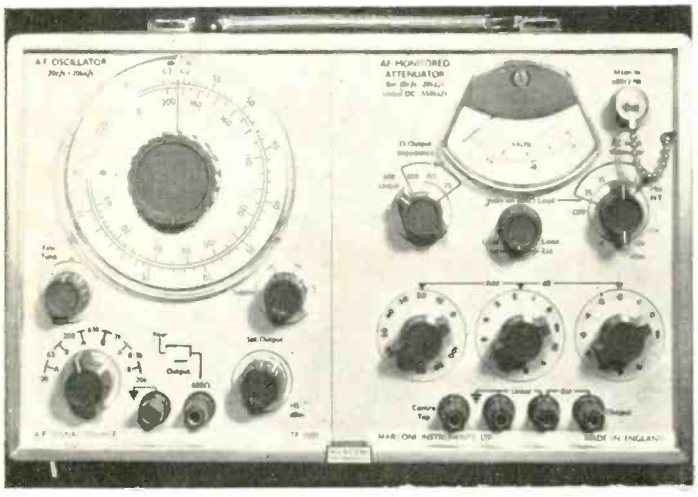


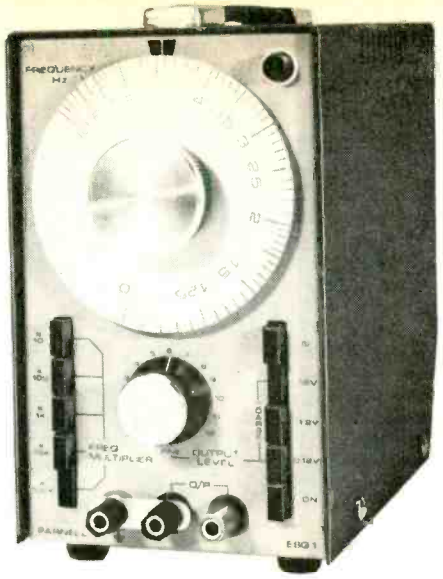
Top:
Hewlett Packard
3310A

High centre:
Marconi
TF2005R

Low centre:
Heathkit
AO-1U

Bottom:
Marconi
TF2000





Budget beater!

We're sure you'll quickly recognise the superior performance to cost ratio of the

FARNELL ESG 1 OSCILLATOR

It's unbeatable — it's also versatile — providing sine or square waves and an output you can really use.

It's easy to operate — with rapid push button multiplication of frequency and amplitude coupled with continuous adjustment too.

Signal distortion is low and the square waves are really square.

You can synchronize the ESG 1 to an external frequency standard for even greater accuracy and stability.

The very low output impedance minimises output voltage drop due to loading particularly at higher frequencies where unavoidable stray capacitance limits the usefulness of higher impedance oscillators.

FREQUENCY RANGE: 10Hz to 1MHz

VOLTAGE OUTPUT: 12mV to 12V pk pk

EXCELLENT SPECIFICATION

£36 U.K.!

You can buy two ESG 1 oscillators for one alternative make of comparable performance. Think about that. We'll gladly send you the full technical data.

Farnell Electronic Instruments Division

FARNELL INSTRUMENTS LIMITED · SANDBECK WAY · WETHERBY LS22 4DH
YORKSHIRE. TEL: 0937 3541 or 01-802 5359 (LONDON OFFICE) TELEX: 557294

Dial calibration: 150 mm diameter calibrated over 300° of arc. 85 divisions. Total effective length 1.98 m.
Frequency response: ±1 dB over entire frequency range (ref 1 kHz).
Output: 160 mW (10V) into 600 ohm rated load, 20V open circuit.
Output impedance: 600 ohms balanced and floating. Output is balanced to ground for maximum output. (May be operated with one side grounded if desired).
Output balance: better than 0.1% at lower frequencies and approximately 1% at higher frequencies.
Distortion: 0.2% from 20 Hz to 200 kHz; 0.5% from 5 Hz to 20 Hz and 200 kHz to 600 kHz.
Hum voltage: less than 0.1% of rated output. Decreases as output is attenuated.
Power: 115 or 230V ±10%, 50 to 1000 Hz, 90W.
Whd dimensions: 188 x 293 x 366 mm.
Weight: 9.9 kg.
PRICE: £170.10

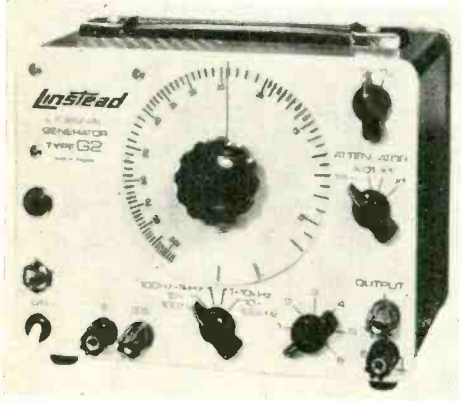
KROHN-HITE (USA)

Agents: International Instruments Ltd, Cross Lances Rd., Hounslow, Middlesex.
Tel: 01-570 6454.

4000

Frequency range: 0.1 Hz to 100 kHz.
Frequency accuracy: 0.1%.
Frequency response: ±0.01 dB.
Harmonic distortion: 0.01%.
Amplitude calibration: ±2%.
Amplitude stability: ±0.01% per hour.

Below: Levell *TG200* and Linstead *92*



Quadrature sine wave output and external synchronisation.
Weight: 6 kg.
PRICE: £501

4024

Frequency range: 0.001 Hz to 100 kHz.
Frequency accuracy: 0.1%.
Frequency response: ±0.01 dB.
Harmonic distortion: 0.01%.
Amplitude calibration: ±0.25%.
Amplitude stability: ±0.01% per hour.
Quadrature sine wave output and external synchronisation.
Weight: 8 kg.
PRICE: £672

4100A

Frequency range: 0.01 Hz to 1 MHz.
Power output: 500 mW.
Harmonic distortion: 0.02%.
Frequency accuracy: 0.5%.
Amplitude stability: 0.002%.
Frequency response: ±0.05 dB.
Internal impedance: 50 ohms.
Square wave risetime: 20 ns.
External synchronisation.
Weight: 8 kg.
PRICE: £334

4200

Frequency range: 10 Hz to 10 MHz.
Power output: 500 mW.
Maximum output: 10V rms.
Frequency response: 0.025 dB.
Harmonic distortion: 0.1%.
Amplitude stability: 0.02%.
Frequency accuracy: 2%.
Internal impedance: 50 ohms.
Auxiliary output, external synchronisation.
Weight: 5 kg.
PRICE: £222

4300

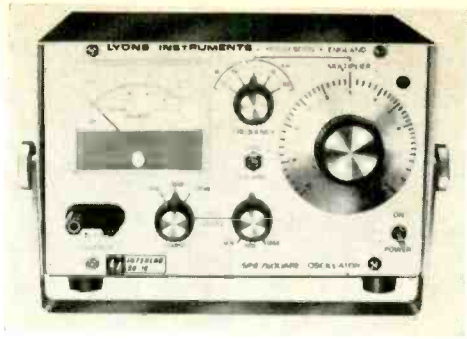
Frequency range: 10 Hz to 10 MHz.
Frequency response: ±0.025 dB.
Maximum output: sine: 10V rms; square: 20V pp.
Power output: 500 mW.
Sine harmonic distortion: 0.1%.
Frequency stability: ±0.002%.
Amplitude stability: ±0.02%.
Frequency accuracy: 2%.
External synchronisation.
Weight: 5 kg.
PRICE: £265

4030R PROGRAMMABLE

Frequency range: 0.001 Hz to 99.99 kHz.
Automatic frequency selection. Standard 1-2-4-8 digit code. Sequential or simultaneous programming
Frequency response: ±0.01 dB.
Harmonic distortion: 0.01%.
Amplitude calibration: ±0.25%.
Amplitude stability: ±0.01% per hour; ±0.001% for 10% line change. ±0.01% cycle-to-cycle; ±0.005%°C.
Quadrature sine wave output. External synchronisation. Optional square wave and positive or negative variable-width pulse.
PRICE: £836

4130R PROGRAMMABLE

Frequency range: 1 Hz to 1 MHz.
Sine and square wave output.
Frequency accuracy: 0.5%.
Harmonic distortion: 0.02%.
Frequency response: ±0.05 dB.
Amplitude stability: 0.002%.
Automatic/manual frequency selection. Automatic/manual amplitude selection BCD input code.
Weight: 9 kg.
PRICE: £669



4131R PROGRAMMABLE

Frequency accuracy: 0.1%.
Frequency range: 1 Hz to 1 MHz.
Sine and square wave output.
Harmonic distortion: 0.02%.
Frequency response: ±0.05 dB.
Amplitude stability: 0.002%
Automatic/manual frequency selection. Automatic/manual amplitude selection BCD input code.
Weight: 9 kg.
PRICE: £836

5000

Frequency range: 0.2 Hz to 3 MHz.
Waveforms: sine, square, triangle.
Auxiliary square wave: 5V pp, 15 ns risetime.
Dc offset: ±5V.
Amplitude control: infinite resolution.
Weight: 8 kg.
PRICE: £173

5100A

Frequency range: 0.002 Hz to 3 MHz.
Waveforms: sine, square, triangle, sawtooth.
External frequency control (VC): 1000:1.
Auxiliary square wave: 5V pp, 15 ns risetime.
Variable pulse width control. Attenuator plus vernier. External synchronisation.
Dc offset: ±5V.
Weight: 8 kg.
PRICE: £222

5400A

Frequency range: 0.002 Hz to 5 MHz.
Waveforms: sine, square, triangle, sawtooth.
Independent control of positive and negative pulse width.
External frequency control (VC): 1000:1.
Output: 30V pp.
Auxiliary square wave: 5V pp, 15 ns risetime.
Dc offset: ±10V.
Calibrated pushbutton attenuator and vernier.
Weight: 8 kg.
PRICE: £322

LINSTEAD

Linstead Electronics, Roslyn Works, Roslyn Road, London N15 5JB.
Tel: 01-802 5144.

G1

Frequency: 10 Hz to 100 kHz ±2% ±1 Hz covered in four decades controlled by a multiplier switch and variable control calibrated on a 140 mm diameter scale giving a total scale length of more than 762 mm.
Sine wave: 0 to 6V rms continuously variable. Distortion over the whole frequency range less than 1%.
Level variation with frequency: ±0.5 dB.
Square wave: 0 to 9V p-p. This waveform has no droop at low frequencies (output is dc coupled).

Rise time faster than 1 μS at high frequencies.
Level variation with frequency: ±2%.
0 to 1W into 3 ohms over the frequency range 50 Hz to 20 kHz.
Supply: 210 to 250V 40 Hz to 60 Hz 25 VA.
Dimensions: 210 x 165 x 150 mm.
Weight: 3.5 kg.
PRICE: £24

G2

Frequency: 10 Hz to 100 kHz ±2% ±1 Hz covered in four decades controlled by a multiplier switch and a variable control with 330° rotation on a 100 mm dial, giving a total scale length of over 1m.
Sine wave: 0 to 6V rms. Mid band distortion less than 0.5%. Distortion over the whole range less than 1%. Variation of level with frequency ±0.5 dB.
Square wave: 0 to 9V p-p. Rise time 0.5 μs over whole frequency range. Dc coupled for no droop at low frequencies.
Variation of level with frequency: ±2%.
0 to 1W into 3 ohms over the frequency range 50 Hz to 20 kHz.
Supply: 210 to 250V, 40 Hz to 60 Hz, 25 VA.
Dimensions: 210 x 166 x 150 mm.
Weight: 3.6 kg.
PRICE: £28

G5 (Provisional specification only)

Sine waves: 10 Hz to 1 MHz ±2%.
Output: 0 to 6V rms via 600 ohms attenuator; 0 to 6V a low impedance.
Output: 10 Hz to 100 kHz into 5 ohms; 2W at low distortion; 3W with 10% distortion.
Square waves: 10 Hz to 100 MHz, 0 to 9V p-p via 600 ohms attenuator. Rise time at high frequency: 500 μs.
PRICE: £32

LEVELL
Levell Electronics Ltd, Moxon Street, Barnet, Hertfordshire, EN5 55D.
Tel: 449 5028, 440 8686.

TG200

Frequency coverage: 1 Hz to 1 MHz in 12 overlapping ranges.
Frequency accuracy: ±2% ±0.03 Hz.
Output amplitude: 7V rms (20V pp on sine) source voltage that can be reduced to less than 200 μV.
Output impedance: 600 ohms ±1%.
Sine distortion: Harmonic content is less than 0.1% up to 5V output and less than 0.2% at 7V output from 10 Hz to 100 kHz.
Square wave rise time: less than 150 ns at all frequencies.
Sync output: sine wave in phase with the output, amplitude greater than 1V rms. source resistance 3.3k ohms.
Sync input: The frequency can be locked to an external signal over a range of ±1% per volt rms input up to 10V maximum. The frequency control then varies the phase of the output.
Power supply: Four Ever Ready *PP9* batteries provide 33V ±10% centre earthed supply. Current consumption is typically 11 mA on sine waves and 15 mA on square waves giving an average battery life of 400 hours on sine waves and 300 hours on square waves.
Power unit available.
Dimensions: 180 x 260 x 140 mm.
Weight: 4.5 kg.
PRICES:
TG200: Sine wave output only. No output meter: £42.
TG200D: Sine and square wave outputs. No output meter: £45.
TG200M: Sine wave output only. Output meter fitted: £52.
TG200DM: Sine and square wave outputs. Output meter fitted: £55.

201C

Frequency range: 20 Hz to 20 kHz in three ranges.
Ranges: 20 Hz to 200 Hz, 200 Hz to 2 kHz, 2 kHz to 20 kHz.
Calibration accuracy: ±1% calibration controls provided for standardising bands.
Dial: 150 mm diameter, calibrated over 300° of arc. Total scale length approximately 1.27 m.
Frequency response: ±1 dB over entire frequency range (ref 1 kHz).
Frequency stability: ±2%
Output: 3W maximum or 42.5V into 600 ohm load. One terminal at ground potential. 50V maximum no-load voltage.
Distortion: Less than 0.5%, 50 Hz to 20 kHz at 1W output. Less than 1%, 20 Hz to 20 kHz at 3W output.
Attenuator: 0 to 40 dB in 10 dB steps, concentric amplitude control varies output continuously zero to maximum at any attenuator setting.
Output impedance: 600 ohms ±10%, 20 dB, 30 dB and 40 dB settings. Less than 600 ohms, 0 dB and 10 dB settings.
Hum voltage: less than 0.03% of rated or attenuated output. (Amplitude control at maximum).
Power: 115/230V ±10% 30/400 Hz, 86W nominal 120W maximum.
Whd dimensions: 191 x 292 x 318 mm.
Weight: 7.2 kg
PRICE: £18.40

202C

Frequency range: 1 Hz to 100 kHz in five ranges.
Dial accuracy: ±2% under normal ambient temperature conditions.
Dial: 150 mm diameter calibrated over 300° of arc.
Frequency response: ±1 dB over entire frequency range (reference 1 kHz on X1K range).
Output: 10V into 600 ohms (160 mW), 20V open circuit.
Output balance: better than 0.1% at lower frequencies and approximately 1% at 100 kHz. Output is balanced to ground at maximum setting (may be operated with one side grounded if desired).
Output impedance: 600 ohms.
Distortion: less than 0.5% above 5 Hz, independent of load impedance.
Hum voltage: less than 0.1% of rated output. Decreases as output is attenuated.
Recovery time: less than 5s at 1 Hz.
Power supply: 115/230V ±10% 48 Hz to 440 Hz, approximately 75W.
Weight: 11.3 kg
PRICE: £203.20

203A VARIABLE PHASE

Frequency range: 0.005 Hz to 60 kHz in seven decade ranges.
Dial accuracy: ±1% of reading.
Frequency stability: ±1% including warm-up drift and line voltage variations of ±10%
Output waveforms: sine and square waves are available simultaneously. All outputs have common chassis terminal.
Maximum output voltage: 30V peak-to-peak open circuit for sinusoidal and square waveforms.
Output power: 5V into 600 ohms (40 mW); at least 40 dB continuously adjustable attenuation on all outputs.
Output impedance: 600 ohms.
Output system: direct coupled output is isolated from ground and may be operated floating up to 500V dc.
Distortion: total harmonic distortion hum and noise more than 64 dB below fundamental (less than 0.06%).
Frequency response: ±1% referenced to 1 kHz.
Square wave response: rise and fall time: less than 200 ns.
Overshoot: less than 5% at full output.
Phase range: 0 to 360°.
Accuracy: ±5° sine; ±10° square wave.
Power: 115 or 230V ±10% 50 to 1000 Hz, approximately 25W.
Wdh dimensions: 133 x 425 x 276 mm.
Weight: 9.17 kg.
PRICE: £719.10

LYONS
Lyons Instruments Ltd, Hoddesdon, Hertfordshire.
Tel: 61 67161.

SQ 10

Frequency range: 10 Hz to 1 MHz in 5 decade ranges with calibrated fine control.
Frequency stability: 0.04%/°C.
Calibration accuracy: ±3%.
Amplitude: 10V pp into 250 ohms or greater (3.5V rms sine). 5V pp into 100 ohms. 2.5V pp in 50 ohms.
Amplitude stability: ±1% variation over full frequency range, ±2% 10°C —30°C.
Calibration accuracy: ±3%.
Sine distortion: 0.1% at 3.5V rms into 600 ohms 50 Hz —100 kHz (typically 0.05%). 0.15% at 10 Hz, 0.5% at 1 MHz.
Square wave rise time: 100 ns (typically 50 ns).
Output impedance: 50 ohms ±5%.
Attenuator: 0 to 40 dB or greater in 20 dB steps with greater than 10:1 fine control.
Temperature: operating: 0° to 45°C; storage: —20° to +70°C.
Power inputs: 200/220/240V; 50/60 Hz.
Whd dimensions: 205 x 130 x 150 mm.
PRICE: £57

MARCONI
Marconi Instruments Ltd, St Albans, Hertfordshire.
Tel: 56 59292.

TF2000 OSCILLATOR/ATTENUATOR

Frequency range: 20 Hz to 20 kHz in six semi-decade bands.
Accuracy: ±1% ±0.2 Hz including warm-up.
Output: Direct into 600 ohms +15 dBm or 31.6 mW or 4.36 V.
Open circuit: At least 8.5V.
Control: At least 40 dB by continuously variable T-network.
Attenuator: 0 to 111 dB in 0.1 dB steps.
Residual loss: 0.01 dB.
Accuracy of attenuation: ±1% of dB setting ±0.2 dB.
Impedance: Unbalanced 600 ohms.
Balanced: 75 ohms, 150 ohms and 600 ohms.
Centre-tap: Connected to front panel terminal.
Internal load: switched internal termination effective for all impedance settings.
Level: between —117 dBm and +15 dBm.
Meter: voltage ranges: 1.5, 5, 15 and 25V fsd.
Accuracy: ±5% of fsd.
Level range: —6 dBm to +30 dBm.
Frequency response: ±0.2 dB between 20 Hz and 20 kHz.
Distortion:
Unbalanced output: 0.05% between 63 Hz and 6.3 Hz; 0.1% between 20 and 63 Hz and between 6.3 and 20 kHz.
Balanced output: (with matched load): Less than 0.1% between 50 Hz and 20 kHz. Less than 0.3% between 30 and 50 Hz.
Hum: below —80 dB relative to the output signal, or below —90 dBm, whichever is greater.
Use of attenuator for external signals:
Maximum input: +30 dBm or 1W or 25V into 600 ohms.
Input voltmeter: 1.5, 5, 15 and 25V fsd.
Accuracy: ±5% of fsd between 20 Hz and 550 kHz.
Level ranges: —6 dBm to +30 dBm.
Unbalanced output frequency range: dc to 550 kHz.
Impedance: 600 ohms.

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continued

Attenuation range: 0 to 111 dB in 0.1 dB steps.
Residual loss: 0.01 dB.
Attenuation accuracy: ±1% of dB setting ±0.01 dB at dc ±2% of dB setting ±0.2 dB between 20 Hz and 550 kHz.
Frequency response: ±1 dB between 20 Hz and 550 kHz.
Balanced output:
Frequency range: 20 Hz to 20 kHz.
Impedance: 75 ohms, 150 ohms and 600 ohms.
Attenuation range: 0 to 111 dB in 0.1 dB steps.
Residual loss: 0.2 dB.
Attenuation accuracy: ±1% of dB setting ±0.2 dB.
Frequency response: ±0.2 dB between 20 Hz and 20 kHz.
Internal load: switched internal termination, effective for all impedance settings.
Power requirements:
Ac mains: 190 to 260V and 95 to 130V, 45 to 500 Hz. 210 to 260V and 105 to 130V, 500 to 1000 Hz; 7 VA.
External dc: 65 to 90V, 60 mA.
Hwd dimensions: 200 x 290 x 270 mm.
Weight: 9 kg.
PRICE: £310

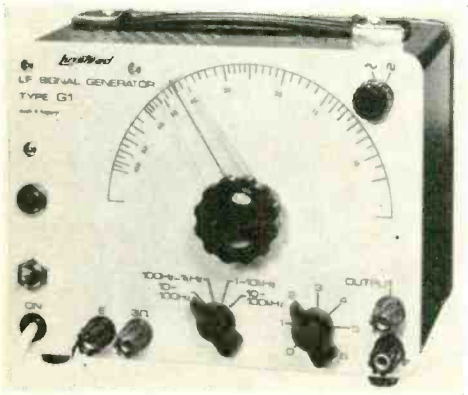
TF2100

Frequency range: 20 Hz to 20 kHz in six semi-decade bands.
Accuracy: ±1% ±0.2 Hz, including warm-up.
Output:
Into 600 ohms: +15 dBm or 31.6 mW or 4.36V.
Open circuit: at least 8.5V.
Control: at least 40 dB by continuously variable T-network.
Impedance: 600 ohms unbalanced.
Frequency response: ±0.4 dB between 20 Hz and 20 kHz.
Distortion: 0.05% between 63 Hz and 6.3 kHz. Less than 0.1% between 20 and 63 Hz and between 6.3 and 20 kHz.
Hum: below —80 dB relative to the output signal, or below —100 dBm, whichever is the greater.
AC mains: 190 to 260V and 95 to 130V, 45 to 500 Hz. 210 to 260V and 105 to 130V, 500 to 1000 Hz; 7VA.
External dc: 65 to 90V, 60 mA.
Hwd dimensions: 200 x 150 x 270 cm.
Weight: 4 kg.
PRICE: £170

TF2005R TWO-TONE SOURCE/ ATTENUATOR

The complete equipment comprises two *TF 2100* af oscillators and one *TF 2160/1* af monitored attenuator.
Frequency range: 20 Hz to 20 kHz in six bands (each oscillator can be adjusted independently).

Linstead *G1*



Reference amplitude: up to +10 dBm from each oscillator.
Attenuator range: 111 dB in 0.1 dB steps.
Harmonic distortion: less than 0.05% between 63 Hz and 6 kHz when using unbalanced output. Generally less than 0.1% under other conditions.
Intermodulation: below —80 dB with respect to the wanted signal.
Hum: below —80 dB with respect to the wanted signal.
AC supply: 95 to 130V or 190 to 260V, 45 Hz to 500 Hz; or 105 to 130V or 210 to 260V, 500 Hz to 1 kHz 14VA.
Dc supply: 65 to 90V; load 60 mA.
Hwd dimensions: 200 x 475 x 270 mm.
Weight: 6.5 kg.
PRICE: £490

NOMBREX
Nombrex (1969) Ltd, Estuary House, Exmouth, Devon.
Tel: 03-952 3515.

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Wien-Bridge controlled sine oscillator. Square wave produced by means of a Schmitt trigger circuit. Instrument powered by 9V battery and a rear mounted socket is provided for operation from external battery or power supply unit.
Frequency ranges: 10 to 100 Hz, 100 Hz to 1 kHz, 1 to 10 kHz, 10 to 100 kHz.
Frequency accuracy: ±5%.
Output voltage: 1 mV to 1V p-p ±3% sine and square.
Impedance: 1k ohm.
Distortion factor: sine distortion less than 1% on all ranges.
Rise time: Less than 100 µs for the square wave output in the lower frequency range; 300 µs in the upper frequency range.
Current load: 20 mA.
Lhd dimensions: 240 x 140 x 100 mm.
PRICE: £24.75

PHILIPS
Philips Nederland N.V, Boschdijk, Gebouw VB, Eindhoven, Holland.
Tel: 43 33 33.
Agents: Pye Unicam Ltd, Philips Electronic Instrument Department, York Street, Cambridge, CB1 2PX.
Tel: 0223 58866.

PM5105

Frequency range: 10 Hz to 100 kHz, sine and square.
Distortion: typically 0.3% at 1 kHz.
PRICE: £50

PM5126

Frequency range: 10 Hz to 1 MHz, sine/square. 10V rms output voltage. Second low ohmic output. Synchronisation facility for external standards Floating output.
PRICE: £185

PM5162

Four-decade sweep: 0.1 Hz to 100 kHz. Sine/square/triangular outputs. 1:10,000 sweep range. Variable sweep speed and width. Three sweep ratios. Single cycle sweep facility. External fm input. Frequency analog output. Two-speed dial drive.
PRICE: £245

PM5168

0.0005 Hz to 5 kHz, sine/square triangle/ramp. Hold facility. Adjustable dc reference level. Decade frequency selection with linear scale. Single shot and external triggering facilities. Two-speed dial drive.
PRICE: £210

PROSSER
Prosser Scientific Instruments Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich, IP7 6DQ.
Tel: 047 338 3005.

A104 VARIABLE PHASE

Frequency range: 0.0008 Hz to 100 kHz in 8 switched ranges.
Accuracy: ±1 division on a 240 mm scale length scale graduation 0.8 to 10 in divisions of 0.1.
Stability: ±0.01%°C.
Remote frequency sweep: two linear laws, selected by switch at rear.
Dc output and frequency: 0.2V/Hz range multiplier.
Sweep range: more than 2 decades.
Impedance: 50 ohms.
Protection: short circuit protected.
Amplitude stability: ±0.05%°C.
Distortion and linearity: Sinewave: 1% harmonic distortion; Squarewave: time symmetry ±1% rise and fall 100 ns; Triangle: linearity ±0.5%. Perturbation not greater than 5% of peak amplitude, nor of greater duration than 200 ns.
DC offset: Positive or negative offset of ±10V max may be set independently on both outputs.
Phase range: Continuously adjustable over a ±100°C range with 240 mm linear scale. Pushbutton switch adds a further 180° shift.
Remote phase sweep: linear law —30° phase shift per volt (added to front panel setting).
Maximum total phase shift: ±180°.
Additional 180° inversion by push-button. Maximum sweep rate 100 mV/µs (3°/µs).
Main outputs:
Function: sine, square or triangle wave may be selected by pushbutton switches for each of the two main outputs.
Amplitude: 20V maximum p-p, both outputs. Two fixed attenuators giving 0 to 60 dB in 10 dB steps with 2% accuracy. Two continuous fine controls calibrated 20 to 100% and in dB.
Dc output phase: +1V per 30° total phase shift (i.e. dial setting + remote phase sweep) ±180°.
Fixed level outputs (rear panel):
Impedance: 330 ohm.
Earth isolation: the signal low terminal can float with respect to the case up to ±350V peak.
Auxiliary power output: 5 pin socket giving stabilised ±18V ±12V. Maximum current 250 mA each.
Operating temperature: 0 to 40°C.
Dimensions: 430 x 127 x 344 mm.
Weight: 8 kg.
PRICE: £486.

RADFORD
Radford Laboratory Instruments Ltd, Ashton Vale Road, Bristol 3.
Tel: 0272 662301.

2A

Frequency range: 5 Hz to 500 kHz (5 ranges).
600 ohm 'T' attenuator. Internal or external load, switched.
Output voltage: 10V rms.
Output attenuation: 5k ohm potentiometer. Basically for interpolation with 600 ohm 'T' network. Variable attenuation of +2 dBm to 12 dBm read from monitoring meter. 600 ohm 'T' networks +20 dbm in 10 dB steps to —80 dBm when terminated.
Sine wave distortion: 0.005% max mid-band frequencies. 600 ohm terminated. 5k ohm attenuator unterminated 0.003% max mid-band frequencies.
Hum content of output: —100 dB.
Square wave conversion: Mark space ratio: 1:1.
Rise time: 200 ns.
Calibration accuracy: 1% fsd.
Mains input: 100 to 140V, 200 to 250V.
Dimensions: 260 x 450 x 210 mm.
Weight: 11 kg.
PRICE: £150

60 ▶

nombrex

MODEL 40
WIDE RANGE AUDIO GENERATOR
PRICE £24.75

★ 4 RANGES, 10 Hz-100 kHz.
★ SINE AND SQUARE WAVE OUTPUT.
★ DUAL CALIBRATED ATTENUATOR.
★ STABILIZED OUTPUT LEVEL 1 V.

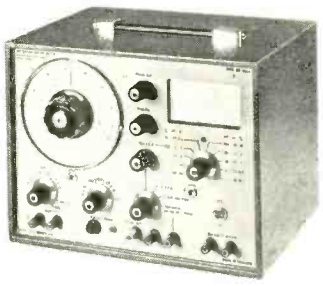
Send for literature on our complete range of instruments quoting Dept. 2.

Postage and packing 35p per unit extra. Trade and Export enquiries welcome.

NOMBREX (1969) LTD., EXMOUTH, DEVON.
Tel. 03-952 3515

NEW ROGERS DISTORTION FACTOR METER

Now available from Pact International Electronics the Rogers DM344A Distortion Factor Meter for accurate, rapid measurement of total harmonic distortion in audio amplifiers, recording and transmission equipment.



- Frequency range 20Hz-20kHz
- Attenuation greater than 80dB, second harmonic less than 0.5dB
- Total harmonic distortion range 100% F.S.D. to 0.1% F.S.D. in seven switched ranges.
- Harmonic bandwidth 100kHz
- Mains power supplies available as optional extra
- Price £140

Write for full details of the DM344A and other Rogers audio test equipment to the sole UK agents.

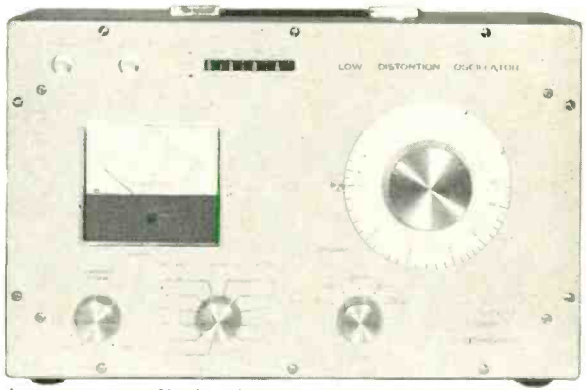
PACT INTERNATIONAL ELECTRONICS LIMITED
PO Box 19, Orchard Road, Royston, Herts SG8 5HH
Telephone Royston 41171

RADFORD

AUDIO MEASURING INSTRUMENTS

Two instruments having a superior performance than any others of this type regardless of price. Now accepted as standard equipment by Broadcasting Authorities, recording studios, magazine equipment test laboratories and audio research and development laboratories all over the world.

LOW DISTORTION OSCILLATOR

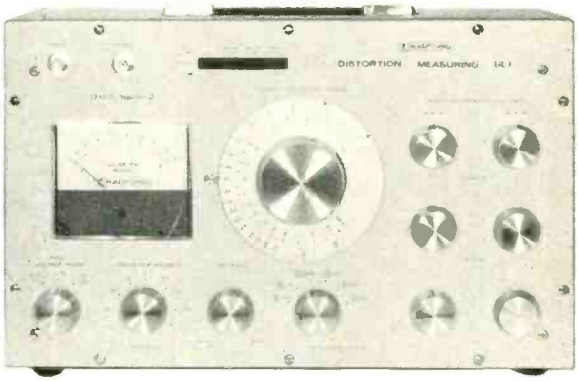


An instrument of high stability providing very pure sine waves and square waves, in the range of 5 Hz to 500 kHz. Hybrid design using valves and semiconductors.

Specification

Frequency Range:	5 Hz-500 kHz (5 ranges).
Output Impedance:	600 Ohms.
Output Voltage:	10 Volts r.m.s. max.
Output Attenuation:	0-110 dB continuously variable.
Sine Wave Distortion:	0.005% from 200 Hz to 20 kHz increasing to 0.015% at 10 Hz and 100 kHz.
Square Wave Rise Time:	Less than 0.1 microseconds.
Monitor Output Meter:	Scaled 0-3, 0-10 and dBm.
Mains Input:	100 V.-250 V. 50/50 Hz.
Size:	17¼ x 11 x 8in.
Weight:	25 lb.
Price:	£150.

DISTORTION MEASURING SET



A sensitive instrument for the measurement of total harmonic distortion, designed for speedy and accurate use. Capable of measuring distortion products as low as 0.002%. Direct reading from calibrated meter scale.

Specification:

Frequency Range:	20 Hz-20 kHz (6 ranges).
Distortion Range:	0.01%-100% f.s.d. (9 ranges).
Sensitivity:	100 Mv.-100 V. (3 ranges).
Meter:	Square law r.m.s. reading.
Input Resistance:	100 kOhms.
High Pass Filter:	3 dB down at 350 Hz. 30 dB down at 45 Hz.
Frequency Response:	±1 dB from second harmonic of rejection frequency to 250 kHz.
Power Requirements:	Included battery.
Size:	17¼ x 11 x 8in.
Weight:	15 lb.
Price:	£120.

Descriptive technical leaflets are available on request.

RADFORD LABORATORY INSTRUMENTS LTD.
BRISTOL BS3 2HZ
Telephone: 0272, 662301

continued

RADIOMETER

Radiometer A/S, Emdrupvej 72, DK 2400, Copenhagen NV, Denmark.
Agent: International Instruments Ltd, Cross Lances Road, Hounslow, Middlesex.
Tel: 01-570 6454.

MS27 AM/FM

Frequency coverage: 0.3 MHz to 240 MHz in 5 ranges.
Calibration: 500 kHz crystal calibrator.
Frequency stability: typical 10 ppm/10 min after 1 hour warm-up.
Incremental tuning: ±50 kHz (2 kHz divisions).
Carrier output: 0.1 μV to 0.1V into matched load in 2 dB steps.
Output impedance: 50 ohms and 75 ohms BNC connector.
Stray radiation: negligible.
Fm: 0 to ±75 kHz full-scale deviation, up to ±600 kHz in the higher frequency ranges.
Distortion: less than 1% at ±75 kHz dev.
Residual fm: typical 0.5 ppm.
Output: 15V (3k ohms source).
External mod: approximately 3V into 200k ohms; 10 Hz to 60 kHz.
Wdl dimensions: 565 x 275 x 350 mm.
Weight: 23 kg.
PRICE: £550

HO32 (BEAT-FREQUENCY)

Frequency range: 10 Hz to 21 kHz.
Stability: 2 Hz after one hour.
Output impedance 3 ohms to 2k ohms switched.
Distortion: less than 0.1%, 50 Hz to 10 kHz below 10V.
Attenuator output: 300 μV to 100V in 10 ranges.
Transformer output: maximum 4W, output imp: 5 to 500 ohms.
Wdh dimensions: 400 x 180 x 260 mm.
Weight: 11 kg.
PRICE: £201

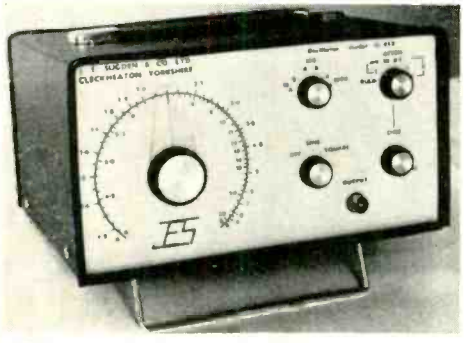
RI

Racal Instruments Ltd, Duke Street, Windsor, Berkshire, SL4 1SB.
Tel: 95 69811.

422

Solid-state crystal monitored digital display instrument with a frequency range of 0.005 Hz to 50 kHz. 10V square and sine outputs via inbuilt matched 600 ohm 80 dB attenuator. Unattenuated 5V p-p triangular output also provided. Unique features include 'zig-zag' ranging of a coarse 'spin' tuning control which makes for fast, accurate frequency selection with zero settling time. Six-digit high resolution presentation of the output frequency eliminates frequency selection and resetting ambiguity.
Frequency accuracy: up to ±2 parts in 10^5.
PRICE: £495

Below: Sugden *453*



ROGERS

Rogers Developments (Electronics) Ltd, Rodevco Works, 4/14 Barmeston Road, Catford, London SE6.
Tel: 01-698 7424/4340.

Sole UK agents: Pact International Electronics Ltd, PO Box 19, Orchard Road, Royston, Hertfordshire, SG8 5HH.
Tel: 0763 41171.

Frequency range: 6 Hz to 60 kHz in eight third decade bands.
Accuracy: ±3% 20 Hz to 20 kHz.
Output amplitude: within ±0.5 dB 20 Hz to 20 kHz.
Output: into 600 ohms: 1V (+2 dBm) open circuit: 2V. Source impedance 600 ohms unbalanced. Output control approximately 40 dB range (T pad).
Distortion (2nd harmonic predominates): less than .05% 100 Hz to 10 kHz. Less than 12% 20 Hz to 20 kHz (typically .015% at 1 kHz).
Stability: one part in 10,000 per hour, one minute from switch-on (constant temperature).
Sync output: 2V from a source impedance of 2.5k ohms.
Power supply: Two *PP9* batteries. (300 hours life with average used). Mains power units available.
PRICE: £62.50

RHODE & SCHWARZ

Rhode & Schwarz, 8,000 Munich, Postbox 801469, West Germany.
Tel: 0811 4129-1

Agent: Aveley Electric Ltd, Roebuck Road, Chessington, Surrey KT9 1LP.
Tel: 01-397 8771.

BN 40870

Frequency range: 50 Hz to 50 kHz (in three subranges).
Frequency adjustment: continuous, ganged with indicator tuning.
Setting error: less than ±3% (less than ±5% at scale settings more than 4).
Temperature coefficient of frequency: less than $\pm 3 \times 10^{-4}$/0°C.
Output EMF: sine or square, switch-selected.
Distortion: less than 3%. Typical value: 2%.
Sine: 3V rms ±10% (max).
Square: 8V pp ±10% (max).
Rise and fall time: less than 1 μs (10 to 90%).
Frequency response of output emf:
In each subrange: ±2% (ref value 1 on the tuning scale).
Over the total range: ±5% (ref 1 kHz).
Source impedance: 50 to 220 ohms (depending on output emf).
Continuous voltage adjustment: 20 mV rms to 3V rms (sine). 50 mV p-p to 8V p-p (square).
Connectors: BNC socket on front panel and at rear.
Indicator:
Frequency range: 50 Hz to 50 kHz (in three subranges).
Frequency adjustment: continuous, ganged with generator tuning.
Tracking error: Less than ±3% (less than ±5% at scale settings more than 4).
Sensitivity of indication:
Linear: fsd at 5 μV ±20% (referred to setting 1 of tuning scale); sensitivity can be continuously reduced for fsd at 50 mV.
Logarithmic: fsd at approx. 50 mV at 1 kHz, 20% deflection at 5 μV, sensitivity can be continuously reduced for fsd at 30V.
Input impedance: 1M ohms ±10% shunted by less than 80 pF.
Maximum permissible input voltage: 30V rms.
Connectors: BNC socket on front panel and at the rear; outer conductor can be disconnected from RC generator chassis by slide switch.
AC output:
Source impedance: less than 2k ohms.
Output emf: 100 mV (with fsd in the linear mode).
Nominal temperature: +10 to +35°C.
Power supply: 115/125/220/235V ±10%, 47 to 63 Hz (4 VA)).
Whd dimensions: 162 x 238 x 242 mm.
Weight: 3 kg.
PRICE: £617

SUGDEN

J. E. Sugden & Co Ltd, Carr Street, Cleckheaton, Yorkshire, BD19 5LA
Tel: 09762 2501.

453

Frequency coverage: 13 Hz to 30 kHz in 6 ranges.
Maximum output: 2V rms.
Output impedance: less than 500 ohms at any attenuator setting.
Output stability: +0.2 dB.
Calibration accuracy: ±5%.
Total harmonic distortion: .05% at 1 kHz and typically .03%.
Square wave rise time: 0.5 μs.
Dimensions: 260 x 130 x 180 mm.
Weight: 5 kg.
PRICE: £40

WAVETEK (USA)

Agent: Fluke International Corporation, Garnett Close, Watford, WD2 4TT.
Tel: 92 27769/27760

110

Sine, square, and triangle function generator. Complete plug-in printed circuit board construction, silicon semiconductors throughout. Six simultaneous outputs over 0.0005 Hz to 1 MHz. All outputs may be shorted simultaneously with less than 0.5% change in frequency.
PRICE: £224

111 VCG

Sine, square, triangle, and ramp waveforms. Control of frequency by external voltage, either dc programming or wideband ac frequency modulation. The instantaneous frequency of these waveforms is determined by the combination of the dial setting and the externally applied voltage. Frequency shift keyer.
PRICE: £296

112 TRIGGERED VCG

Control of frequency by external voltage, dc programming or wideband ac fm triggers from a manual front-panel control or from an external pulse or gate. If a gate signal is applied, the generator will operate until the gate is removed. The trigger start/stop point is adjustable over 360°. Trigger level and polarity may be selected from front-panel control. Generates sine, square, triangle and ramp waves simultaneously in fixed-phase relationships. The frequency of these waveforms is determined by the combination of the dial setting and the externally applied voltage. The VCG input is in parallel with the frequency dial.
PRICE: £376

113 DIGITAL VCG

Source of sine, square, triangle and ramp waveforms. Pushbutton control of frequency, function and amplitude, plus voltage control of frequency by

external input—either dc programming or wide-band ac frequency modulation. Amplitude controlled by 50 ohms attenuator that offers 10 dB steps from 0.1V to 10V p-p. Both frequency and amplitude may be controlled by vernier controls that allow overlap between the digitally selected values. Resolutions of the frequency vernier allows 4-digit control. Frequency pushbuttons may be switched over to a 1-turn control for frequency search.

A special pushbutton position is provided to give 30V peak-to-peak output with a vernier control. All waveforms are available by selection on the front panel output. Fixed amplitude outputs of each waveform also are available on the rear panel.
PRICE: £428

114 SWEEP/TRIGGER VCG

Two independent generators. The first generator is sine, square and triangle; the second is a ramp generator for sweeping the frequency of the first. Both may be operated continuously or triggered with independent frequency control. In the triggered mode, the start/stop point may be continuously varied through 360°. Also, sine² pulses are available from the offset sine output in the triggered mode. The sweep-and-hold mode allows static setting of both start and stop frequency Terminals provided for external voltage control of frequency either dc programming or wideband ac frequency modulation.
PRICE: £428

115/6 TRIGGER-PHASE LOCK VCG

Sine, square, triangle and ramp waveforms with trigger and phase-lock capabilities. Tone burst operation from 2 to 256 cycles in binary increments. Dc programming or wideband ac frequency modulation. Trigger capability allows triggered or gated operation from an external pulse or gate and single cycle operation (or tone burst, model *116*) by manual pushbutton. Phase-lock operation converts the generator to a slave unit where the frequency is locked to an external frequency input, such as a crystal or master system clock; the relative phase of the two sources is controllable over 360°.
PRICES: £403 *(115)*
£458 *(116)*

130 OSCILLATOR/FUNCTION GENERATOR

Sine, square, and triangle waveforms over 0.2 Hz to 2 MHz. Outputs selectable and variable from a 50 ohm source with an auxiliary sync output for scope or system timing.
PRICE: £161

131A OSCILLATOR/VCG

Sine, square, and triangle waves. Frequency may be modulated or dc-programmed; the instantaneous resultant frequency is the sum of the dial setting and the externally applied voltage. A positive voltage increases frequency and a negative voltage decreases frequency. The output waveforms (0.2 Hz to 2 MHz) are selectable and variable from a 50 ohms source and an auxiliary sync output is available for scope or system timing. Model *131A* can be swept over a 1,000:1 ratio and is designed so that the audio range of 20 Hz to 20 kHz may be covered in a single sweep without changing ranges.
PRICE: £214

134 SWEEP/TRIGGER VCG

Two independent generators. The first generator gives sine, square and triangle waveform outputs. The second is a triggered ramp and sawtooth generator which supplies the voltage for sweeping the frequency of the first. Both may be operated independently in the continuous or triggered mode with independent frequency control. Terminals for external voltage control of frequency—either dc programmed or wideband ac modulation. The *134* can be used in continuous, triggered, gated, continuous with sweep, triggered with sweep, or tone burst modes.
The output waveforms, from 0.2 Hz to 2 MHz, are selectable and variable from a 50 ohms source. The sweep output (0 to +5V) is proportional to the frequency of the main generator when in the sweep mode. The instrument may be swept over a 1000:1 ratio and is so designed that the entire audio band from 20 Hz to 20 kHz may be covered without range change.
PRICE: £268

135 LIN/LOG SWEEP GENERATOR

Sine, square, and triangle waveforms which may automatically be swept in frequency up to a 100:1 ratio. Voltage controlled generator with sine, square, and triangle waveform outputs, and triggered ramp and sawtooth generator which applies the voltage for sweeping the frequency of the first in either a linear or logarithmic mode. Both generators may be operated independently in the continuous or triggered mode with independent frequency control. Terminals for external voltage control of frequency either dc programmed or wideband ac modulation. The instrument may be swept over a 1000:1 ratio and is so designed that the entire audio band from 20 Hz to 20 kHz may be covered without range change.
The frequency sweep may be selected as either a linear function for use in narrow band linear sweep applications, or logarithmic function, normally used in wideband (1000:1) sweep testing.
PRICE: £376

136 VCG/VCA

Sine, square, and triangle waveforms may be externally voltage controlled in amplitude and frequency. Amplitude level can be continuously controlled from dc step programming through 100% amplitude modulation to suppressed carrier am. The frequency can be continuously controlled either by dc programming or by wideband modulation up to a 1000:1 ratio.
PRICE: £322.

150/155 PROGRAMMABLE VCG

Sine, square and triangle waveforms for automatic system application. Model 155 has local and remote digital control (model 150 remote only) of frequency, function and amplitude. Both generators may be controlled by analog voltage in the following manner: the frequency may be programmed or modulated by an ac or dc signal. Generator output may be initiated by means of a trigger which will generate one complete cycle, and/or a gate input which will provide a signal burst of an integral number of cycles for the duration of the applied gate. In the *155*, programming is accomplished using front-panel switches. The frequency range consists of 8 decade ranges with 3 decimal digits of resolution covering 0.01V to 10V p-p. Output range scaling is accomplished using an attenuator with 50 ohms output impedance on all ranges. All specifications require that the output be terminated by a 50 ohms load. All controls may be activated remotely by contact closures through a 50-pin connector on the rear panel of both models. The 3-digit control of frequency and amplitude is 8421 BCD coded with only 12 lines required for each. The ranges and functions are controlled by 1 line per function. Standard interface options are available so that any logic input may be converted in the instrument to provide proper information control. The series 150 programmable VCGs may be driven by computers, punched cards, or tape and servo switch devices.
PRICE: £620 *(150)*
£742 *(155)*

MODEL 157 PROGRAMMABLE WAVEFORM SYNTHESISER

Sine, square and triangle waveforms generated over 100 μHz to 1 MHz. 0.01% frequency accuracy. 1,000:1 VCG. Triggered/gated operation. Selectable amplitude to 10V p-p. All parameters programmable. The frequency, function and amplitude of the generator can be controlled locally with front-panel switching or remotely by BCD programming. Frequency accuracy is 0.01% of programmed frequency with 5-digit resolution on each of 10 ranges. The output voltage level can be programmed from 1 mV to 10V, peak-to-peak, in four ranges with 0.2% accuracy and 3 digit resolution.
PRICE: £1,620

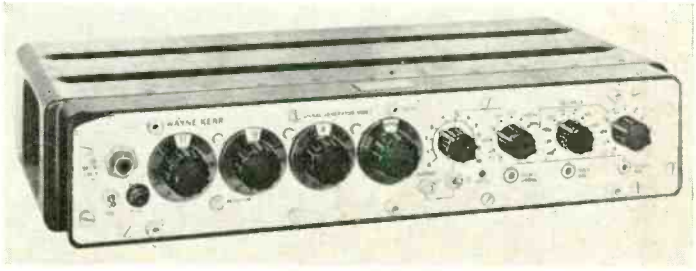
WAYNE KERR

Wayne Kerr Co Ltd, Durham Road, Bognor Regis, Sussex, PO22 9RL.
Tel: 02433 4501.

S501 AUDIO/VIDEO

Frequency ranges: 10 to 130 Hz, 100 Hz to 1.3 kHz, 1 to 13 kHz, 10 to 130 kHz.
Frequency accuracy: ±1% of indicated value.
Frequency stability: ±0.1% (4 to 6 hours after more than 1 hour).
Waveform distortion: less than 0.1%.
Output level: —70 to +10 dB on 1 mW in 1 dB steps at 600 ohms bal or unbal, or 150 ohms bal. 0 to 10V rms sinewave, continuously variable into 100 ohms 0 to 10V pp square-wave, continuously variable, into 100 ohms.
Level accuracy: 600 ohms unbal: better than ±0 5 dB; 600 ohms bal: better than ±1 dB; 150 ohms bal: better than ±1 dB; high level: +0 25 dB.
Output impedance: 600 ohms ±2%, 150 ohms ±4%, high level: less than 2 ohms (all settings)
PRICE: £370 (Not available one-off. Contract enquiries welcome).

Left:
Wavetek *VCG*



Right:
Wayne Kerr
S501

Survey: audio distortion meters

AMALGAMATED WIRELESS (AUSTRALIA)

Agents: Marconi Instruments Ltd, St Albans, Hertfordshire.
Tel: 56 59292

F240

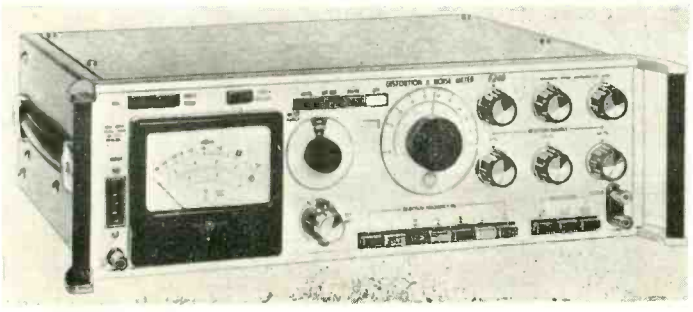
Level and noise measurements:
Input: 600 ohms terminating
Bridging: 10.7k ohms.
Return loss of terminating input: not less than 25 dB from 10 Hz to 60 kHz.
Sensitivity: 100 μV or —78 dBm for fsd.
Frequency response: 10 Hz to 30 kHz ±0.2 dB (balanced); 10 Hz to 60 kHz ±0.2 dB (unbalanced).
Meter ranges: —80 dB to +30 dB in 10 dB steps.
Low-cut filter: —0.5 dB at 400 Hz, —34 dB at 50 Hz.
High-cut filter: —1 dB at 15 kHz, —15 dB at 30 kHz.
Distortion factor measurement:
Fundamental range: 10 Hz to 30 kHz in 7 semi-decade ranges.
Distortion factor ranges: 0.01% to 100% fsd in 9 semi-decade ranges
Harmonic measurement range: 100 kHz
Residual distortion and noise:
Balanced input: typically 0.05% at 30 Hz and 0.003% above 300 Hz.
Unbalanced input: typically 0.003%.
Input levels: 0.25V to 30V.
Power supply: 6 x 1.5V size C cells.
Input connector: 3-way Siemens.
Hwd dimensions: 149 x 470 x 355 mm.
Weight: 7.2 kg.
PRICE: £330

CROWN INTERNATIONAL (USA)

Agents: Macinnes Laboratories Ltd, Stonham, Stowmarket, Suffolk, IP14 5LB.
Tel: 044 971 486.

IMA

Im ranges: 0.1, 0.3, 1, 3, 10, 30, 100% full scale on separate IM meter.
Residual im: less than 0.005% with internal generators. Typically less than 0.003%.
Accuracy of im scales: 5% of full scale (±005% on 0.1 fs range).
Range of tracking: 45 dB in 5 dB (±1%) increments.
Input impedance: 100k ohms (maximum) and 45k ohms (minimum), depending on setting of input level control.
Necessary hf input: 17 mV minimum.
Lf hf voltage ratio: internal generators continuously adjustable from 00:1 to 1:1 by hf level on front panel. Ratio is read by reading voltage on calibrate meter.
Low: 60 Hz low distortion oscillator (less than 0.1% THD) synchronised with ac line.
External oscillator input: One terminal grounded, 5.6k ohms internal impedance, 10 to 150 Hz.
Outputs: 10k output impedance scope A and scope B showing hf envelope and demodulated im signal.
Output impedance: 600 ohms for all settings of output level control and master attenuator.
Output level: 25V peak (maximum) for either internal generator or any generator combination—internal or external. Level is adjustable by a 40 dB attenuator (in 10 dB steps) concentric with 15 dB variable (fine) control.
Slide switches: Ext-int hf generator; ext-int lf generator; cal-out meter; ac power; mantrk tracking allows meter input and output controls to remain set when testing over a range of levels using the master attenuator (automatically tracking the two adjustments, input and output level, in 5 dB increments).
Rotary controls: output level controls. Hf level control, master attenuator switch, im range, input level control (continuously adjustable pot).
Semiconductor complement: 53 transistors, 12 diodes, 2 fets and one zener diode.
PRICE: £395.



AWA *F240*

DYMAR

Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Hertfordshire, WD2 4LA.
Tel: 92 21297.

765

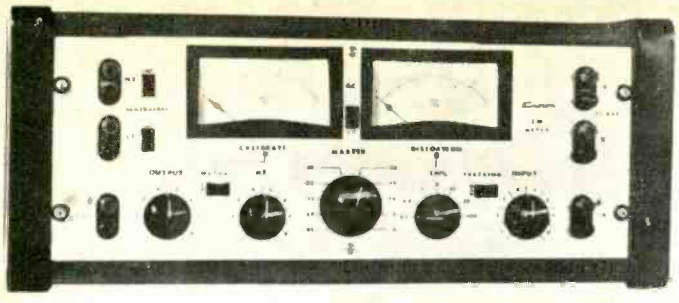
Frequency range: 20 Hz to 20 kHz in six bands of 3.2 to 1 frequency ratio.
Sensitivity: 300 mV to 10V.
Input impedance: 100k ohms and 20 pF.
Distortion factor: 7 ranges from 100% to 0.1% fsd in 10-3-1 sequence.
Accuracy: The mean value of residual components or of noise are measured within 3% fsd.
Rejection filter: At fundemental frequency: 80 dB; at second harmonic: not more than 0.5 dB for fundamental up to 2 kHz; 1 dB for fundamental between 2 and 6 kHz. 2 dB for fundamentals greater than 6 kHz.
Inherent noise: less than 0.01%
Low frequency filter: when measuring fundamental of 1 kHz and higher, a high pass filter can be switched in giving a low noise frequency cut of 3 dB at 400 Hz and 20 dB at 50 Hz.
Output: 500 mV from an impedance of 600 ohms when the meter has full scale deflection.
Voltmeter range: 7 ranges from 10V fsd to 10 mV fsd in 10-3-1 sequences.
Accuracy bandwidth: 3% between 100 Hz and 30 kHz, 30 Hz to 100 kHz (—0.5 dB).
Power supplies: mains or 24V nominal Nickel Cadmium rechargeable battery of 400 mAh capacity giving a typical operating time of 20 hours between recharging. Batteries are recharged, in situ, by means of an internal charging circuit, in 14 hours from a fully discharged condition (22V).
Meter: 125 mm movement with mirror backed scale calibrated 0 to 10, 0 to 3, and a dB scale of —12 to +2 dB for relative measurements. A 'check battery' pushbutton connects meter across battery to read voltage directly.
Whd dimensions: 420 x 165 x 200 mm.
Weight: 6.3 kg.
PRICE: £195

FERROGRAPH

Ferrograph Co Ltd, 442 Bath Road, Cippenham, Slough, Buckinghamshire, SL1 6BB.
Tel: 062 86 62511.

RTS-2 TEST SET

Recorder test set comprising signal generator, distortion meter, millivoltmeter and wow and flutter meter.
Generator section:
Frequency coverage: 15 Hz to 150 kHz in 4 ranges.
Distortion: less than 0.025% at 1 kHz; less than 0.08% over range 100 Hz to 20 kHz.
Frequency response: ±0.2 dB over range 15 Hz to 150 kHz.
Output level: maximum 3V into open circuit; +8.5 dBm into 600 ohms load.
Output attenuator: Course: six 10 dB steps. Fine continuous over approx. 15 dB range. External: for



Crown *IMA*

insertion in oscillator lead, fixed, 40 dB.
Output impedance: maximum 450 ohms with external attenuator 50 ohms (dependent on attenuator setting).
Millivoltmeter:
Indication: Average reading meter calibrated in rms for sinusoidal inputs.
Ranges: 11 in 10 dB steps from 1.0 mV to 100V fsd.
Input impedance: 2M ohms (no dc path).
Accuracy: within ±2% fsd over range 30 Hz to 20 kHz.
Frequency response: ±0.2 dB over 10 Hz to 150 kHz.
Wow and flutter meter:
Peak wow and flutter measurement using a carrier frequency of 3.15 kHz provided by an internal oscillator.
Carrier frequency: 3 kHz.
Frequency response: Weighted to DIN *45507*. Maximum response at 4 Hz (3 dB points 1.2 Hz and 12 Hz).
Meter response: Average reading calibrated in peak values for approx. sinusoidal wow and flutter waveforms.
Input requirement: 35 mV to 5V.
Sensitivity: 3 ranges 0.1%, 0.3% and 1% peak fsd.
Drift measurement: centre zero for mean frequency as mean internal oscillator. Scaled ±2% for measurement of mean speed changes: also indicates slow cylic wow rates with peak reading under 1 Hz. Oscilloscope output provided for visual examination of wow and flutter waveform or for connection to an external analyser.
Distortion section:
Total harmonic distortion measurement by rejection of a fundamental frequency in the range of 400 Hz to 1.1 kHz.
Second harmonic rejection: less than 0.25 dB.
Bandwidth of harmonic measurement: 15 Hz to 20 kHz with optional 2f cut (turnover 400 Hz approx.) for rejection of hum and other lf noise components.
Minimum reading: 0.05% (distortionless source).
Minimum input signal: 100 mV (smaller inputs may be used with increased minimum distortion reading).
Input impedance: 100k ohms. Oscilloscope output provided for visual examination of distortion waveform or for connection of external filters. Provision for use as variable sensitivity meter with bandwidth of 100 kHz by use of 'set level' control (e.g. for frequency response measurements where no external gain controls exist).
Power supply: full stabilised. 105 to 120V, 50 to 60 Hz, 12 W, 200 to 250V, 50 to 60 Hz, 12W.
Wdh dimensions: 441 x 254 x 143 mm.
Weight: 5.9 kg.
PRICE: £250

LYONS
Lyons Instruments Ltd, Hoddesdon, Hertfordshire.
Tel: 61 67161

D10

Distortion range: 0.3% fsd to 10% fsd in 4 ranges. Measured as average level of total harmonic content and average level of total signal.
Frequency range: 10 Hz to 100 kHz (fundamental) in 4 decade ranges.
Amplifier passband: typically ±1 dB to 500 kHz, —6 dB at 1 MHz.
Input impedance: 10k ohms.

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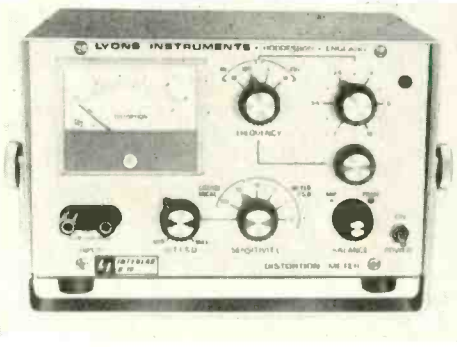
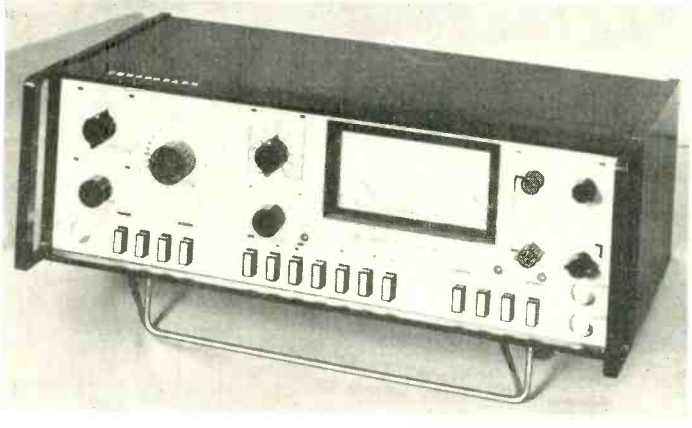




Above: Lyons *D10*

Right: Ferrograph *RTS-2*

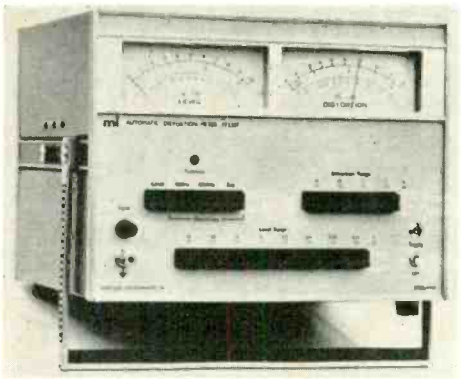
continued

Input level: 200 mV to 5V rms.
Fundamental rejection: better than 10,000:1.
Intrinsic distortion: less than 0.05%.
Calibration accuracy: ±1% full scale, ±2% of reading.
Power input: 200/220/240V: 50/60 Hz.
Whd dimensions: 205 x 130 x 150 mm.
PRICE: £68

MARCONI
Marconi Instruments Ltd, St Albans, Hertfordshire.
Tel: 56 59292.

TF2331

Frequency range:
Fundamental: 20 Hz to 20 kHz in six ranges.
Total bandwidth: upper —3 dB limit nominally 100 kHz or 20 kHz switch selected.
Filter characteristics:
Calibration accuracy: ±3%.
Fundamental rejection: 80 dB.
2nd harmonic attenuation: less than 0.5 dB for fundamentals up to 1 kHz. Less than 1 dB for fundamentals up to 6 kHz. Less than 2 dB for fundamentals up to 20 kHz.
Lf cut: can be introduced below 400 Hz to reduce hum components.
Weighting: approximates to CCIF broadcast network; set for 8 dB attenuation relative to CCIF curve.
Distortion measurement:
Range: seven ranges with full scale indications from 0.1% to 100% distortion factor.
Instrument distortion: less than 0.025% from 200 Hz to 6 kHz Less than 0.04% elsewhere.
Measurement accuracy: ±2% fs ±1% of reading between 200 Hz and 12 kHz; ±2% fs ±2% of reading between 20 Hz and 100 kHz.



Minimum input level: 750 mV (less than 0 dBm into 600 ohms).
Maximum input: 30V (+32 dBm into 600 ohms).
Noise measurement (tone off):
Range: 0 to 72 dB relative to reference level.
Instrument noise: less than 200 μV equivalent input.
Voltage measurement:
Voltage range: 1 mV fsd to 30V fsd (ten ranges).
Accuracy: ±2% fs ±1% of reading between 200 Hz and 12 kHz.
Voltmeter input impedance: nominally 1M ohms or 600 ohms.
Indicator: Mean-voltage-level meter calibrated in rms volts (sine) and per-cent distortion, with additional dBm scale.
Rf input:
Frequency range: 500 kHz to 500 MHz.
Input impedance: 50 ohms, Type *N* connector.
Amplitude range: 1 to 4V at maximum modulation depth.
Power requirements: 95 to 130V or 190 to 260V, 40 to 500 Hz; 18 to 45V, 25 mA.
Hwd dimensions: 280 x 440 x 280 mm.
Weight: 8.16 kg.
PRICE: £320

TF2337 AUTO

Fundamental frequency range: 400 Hz or 1 kHz ±10% using the internal filters. 30 Hz to 10 kHz using the external filter facility.
Distortion measurement ranges: 0 to 1%, 0 to 3%, 0 to 10%, 0 to 30% fsd, +5% fsd accuracy.
Fundamental rejection: 56 dB.
Input requirements: minimum of 3 mV. Maximum of 30V.
Level measurement ranges: 0 to 0.01V, 0 to 0.03V, 0 to 0.1V, 0 to 0.3V, 0 to 1.0V, 0 to 3.0V, 0 to 10.0V, 0 to 30.0V fsd.
Frequency response: 20 Hz to 50 kHz ±0.5 dB.
Accuracy: ±5% fsd in each range.
Input impedance: 100k ohms ±10% unbalanced. Parallel capacitance less than 50 pF.
Power requirements: 100, 115, 200 or 230V, 50 to 60 Hz 6 VA.
Hwd dimensions: 200 x 270 x 250 mm.
Weight: 6 kg.
PRICE: £214

TF2330A WAVE ANALYSER

Working range: 20 Hz to 76 kHz.
Accuracy: ±1% ±5 Hz.
AFC: tuning remains locked to input frequency over ±100 Hz drift.
Waveform analysis range: measurements down to —75 dB with respect to any fundamental level between 30 mV and 300V. For fundamental levels below 30 mV, the measurement range is progressively reduced.
Selective voltage measurement range: 3 μV to 300V in 15 ranges of 30 μV to 300V fsd in 1 to 3 to 10 sequence.
Accuracy: ±5% of full scale.
Selectivity: ±3.5 Hz bandwidth at least 3 dB down; ±20 Hz bandwidth at least 45 dB down; ±80 Hz and above at least 80 dB down.
Internal noise and distortion: residual hum and noise, and distortion to measured signal at least 80 dB down.
Input resistance: 100k ohms on maximum attenuator settings between 30 mV and 1V: 1M ohms on settings between 3 and 300V.
Rf input frequency range: 100 kHz to 500 MHz.
Input impedance: 50 ohms (Type *N* connector).
Amplitude range: 1 to 4V rms at maximum modulation depth.
Restored frequency output: 20 Hz to 76 kHz. Output variable up to 2.8V pp out of 600 ohms source, when meter reads fsd.
BFO output range: 20 Hz to 76 kHz.
Output: variable up to 2.8V pp out of 600 ohms source.
Response: flat to within ±0.1 dB over frequency range, terminated or unterminated.
Recorder output: 100 μA ±2% into 2.5k ohms. Recorder input to be isolated from ground.
AC mains: 95 to 135V and 190 to 260V, 45 Hz to 1 kHz, 4 VA.
External dc: 18 to 30V 110 mA, maximum positive earth.
Hwd dimensions: 280 x 470 x 280 mm.
Weight: 31.1 kg.
PRICE: £690

NORTRONIC
Nortronic A/S, 1380 Heggedal, Norway.
Tel: 79 77 21.

Agents: Prosser Scientific Instruments Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich, IP7 6DQ.
Tel: 047 338 3005.

803

Oscillator frequency range: 20 Hz to 20 kHz.
Waveform: sine, synchronising pulses also available.
Output impedance: less than 10 ohms (maximum current 10 mA rms), short circuit protected.
Tuning: automatic sweep or manual from frequency control circuits.
Maximum input amplifier output: 5V rms.
Gain: —20, —20, 0, 10, 20, 30, 40, 50 or 60 dB.
Input impedance: 100k ohms, overvoltage protection.
Bandpass filter frequency range: 20 Hz to 20 kHz.
Bandwidth: 5% 1/3 octave, 1/1 octave.
Attenuation in passband: 0 dB.
Tuning: automatic sweep or manual from the frequency control circuits.
Frequency tuning range: 20 Hz to 20 kHz in one range, automatic or manual.
Frequency indication: meter with logarithmic scale (constant relative resolution). 0.005 to 0.001 to 0.05 to 0.1 to 0.2 to 0.5 to 1 to 2 oct/s. Sweep speed is proportional to frequency, whereby minimum time of analysis is obtained.
Sweep control: manual, automatic and/or remote can be supplied. Sweep can be stopped anywhere,

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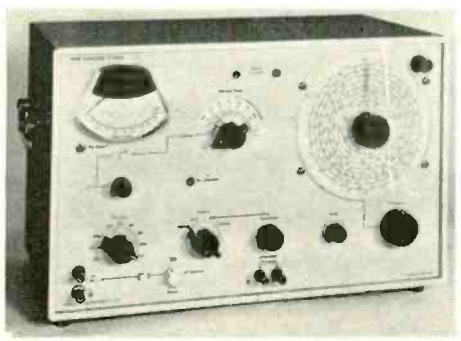
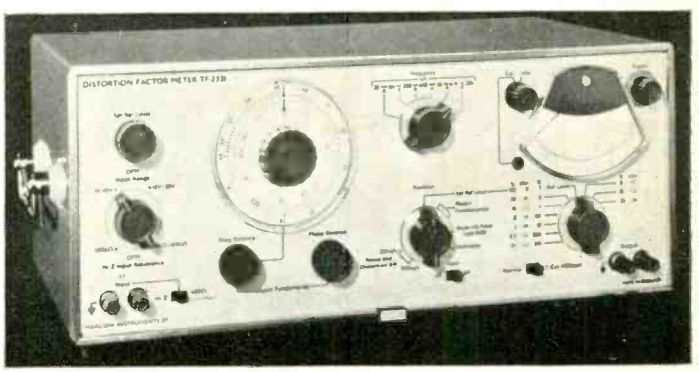
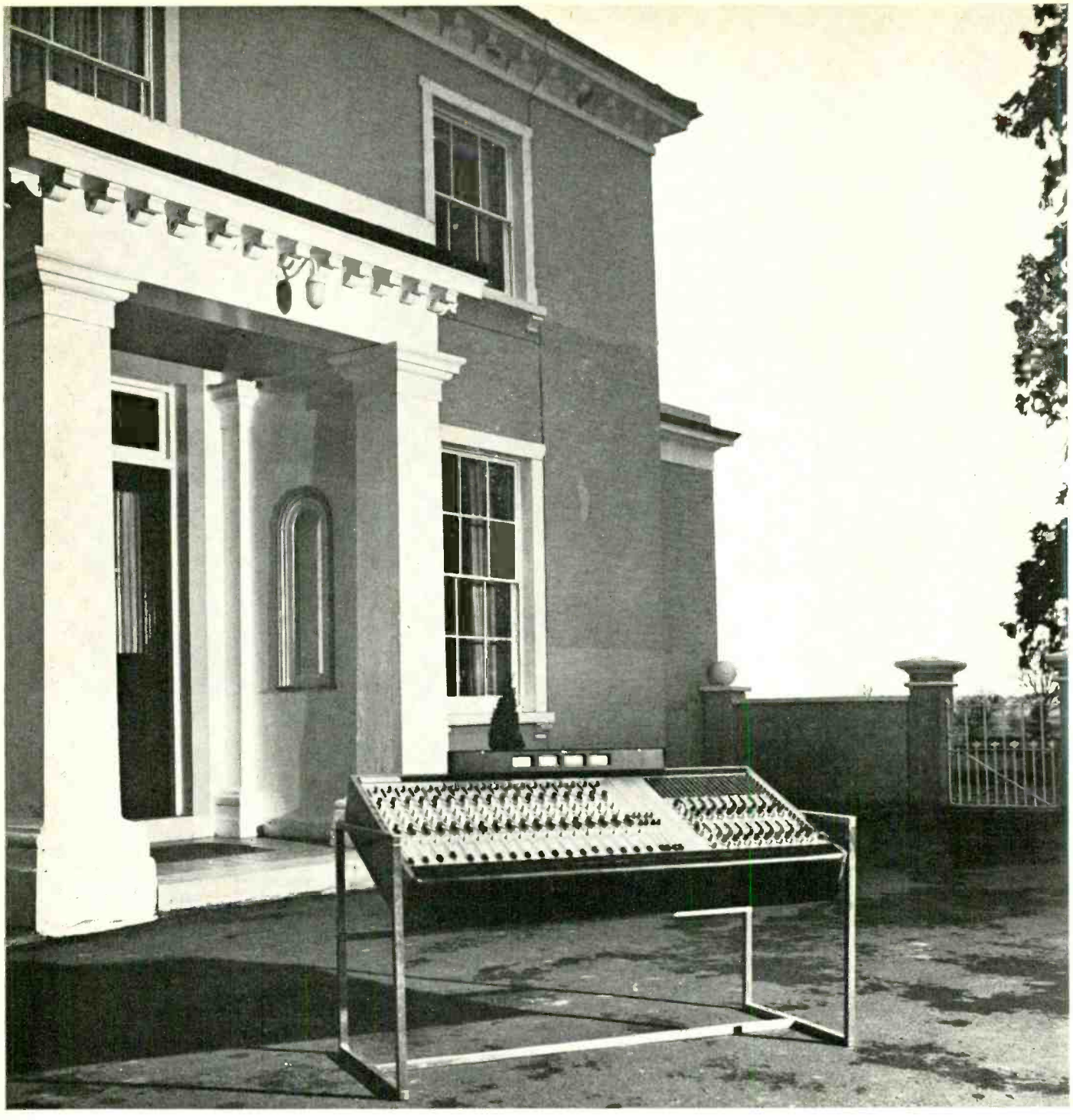


Above left: Marconi *2337*

Left: Marconi *2330A*



Right: Marconi *TF2331*



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and fine decrease/increase of the frequency can be tuned by a pushbutton. Sweep speed can be changed during the sweep.
Output: 0 to 100 mV proportional to log f (for x-y recorder).
Detector: true rms and average value.
Dynamic range: 50 dB.
Scale: +10, 0 to —10, —20, —30, —40 dB (0 dB= 1V rms).
Output: 0 to 100 mV proportional to dB value.
Bandwidth: 20 Hz to 20 kHz.
PRICE: £1,601

RADFORD
Radford Laboratory Instruments Ltd, Ashton Vale Road, Bristol 3.
Tel: 0272 662301.

DMS 2

Frequency range of measurement: 20 Hz to 20 kHz (6 ranges).
Distortion per cent range of measurement: 0.01% to 100% fsd (9 ranges).
Accuracy of distortion range attenuator components: 1%.
Input voltage range of measurement: 100 mV to 100V (3 ranges). (100 mV —1.0V range not operative on 0.01% and 0.03% fsd ranges).
Meter: 100 μA fsd.
Scales: 0 to 10, 0 to 3.
Calibration: sensibly square law. Measures true rms values except on very peaky waveform.
Harmonic response: to —1dB (2nd harmonic).
Rejection frequency tuning stability: better than 1 part in 10^4 (over 1 hour).
High pass filter response: —3 dB, 400 Hz —30 dB, 40 Hz approx.
Dimensions: 260 x 450 x 210 mm.
Weight: 10 kg.
PRICE: £120

RADIOMETER
Radiometer A/S, Emdruvpvej, 72, DK2400, Copenhagen, NV, Denmark.

Agents: International Instruments Ltd, Cross Lances Road, Hounslow, Middlesex.
Tel: 01-570 6454.

BKF6

Frequency range: 20 Hz to 20 kHz fundamental.
Harmonic components: 10 Hz to 200 kHz.
Tuning filter: Wien bridge selective amplifier.
Distortion range: 0.3% to 100% fsd.
Fundamental rejection: more than 80 dB.
Second harmonic attenuation: less than 0.3 dB.
Input sensitivity: 110 mV for fsd (300V max.).
Meter: rms rectifier, linear scales.
Accuracy: 3% of fsd.
Wdh dimensions: 490 x 210 x 250 mm.
Weight: 14.5 kg.
PRICE: £298

FRA3 WAVE ANALYSER

Frequency range: 10 Hz to 60 kHz and 10 Hz to 6 kHz.
Tuning scales. 6.9m equivalent length. Flywheel tuning dial engraved every 10 Hz (1 Hz).
Accuracy: 0.3%.
Incremental scale: ±100 Hz.
Selectivity: 6 bandwidths ±3 Hz to ±100 Hz. 10 Hz to 300 kHz ±1 dB broadband.
Sensitivity: 30 μV to 300V fsd.
Lowest detectable level: 2 μV.
Dynamic range: 80 dB.
Meter: rms rectifier, linear scales 0 to 1 and 0 to 3.
Accuracy: 5% of fsd.
Distortion: —95 dB harmonic components.
Noise: —105 dB.
Input impedance: 1M ohms and 45 pF, unbalanced.
Superposition: with external signal (B signal), fulfills SMPTE intermodulation standard.
BFO: 10 Hz to 60 kHz, 0 to 4V, 600 ohms harmonics —90 dB, tunes to same signal as analyser, ±2 kHz.
Whd dimensions: 490 x 355 x 340 mm.
Weight: 37 kg.
PRICE: £1,095

ROHDE & SCHWARZ
8 Munich 8, Muhldorfstr, 15 West Germany
Tel: 401981.

Agents: Aveley Electric Ltd, Roebuck Road, Chessington, Surrey, KT9 1LP.
Tel: 01-397 8771.

PBO 201

Pass band of each switch-selected filter: 1 octave.
Attenuation in the filter out position: 3 dB ±0.2 dB.
Noise voltage at filter output: less than 30 μV rms.
Permissible filter input voltage: maximum 3.5V (sine).
Characteristic impedance: 600 ohms ±5%.
Input and output connectors (different from DIN *45651*): BNC and coaxial 1/3.9 mm sockets.
Power supply: Four cells or 6V storage battery.
Dc current drain: 100 mA max.
Operating life using dry cells or storage battery: 10 hours.
Whd dimensions: 212 x 88 x 158 mm.
Weight: 1.8 kg (without power supply).
PRICE: £316

PBO 49200

Frequency range: 31.5 Hz to 22.4 kHz.
Pass band of selectable filter: 1 octave.
Maximum filter input voltage: 8V rms (sinewave).
Variation of pass-band insertion loss when input voltage is raised from low value to 8V rms: less than ±0.5 dB.
Characteristic impedance: 600 ohms.
Type of network: unbalanced network, three-circuit Chebyshev type.
Attenuation of magnetic fields: 40 dB.
Whd dimensions: 286 x 227 x 226 mm.
Weight: 10.5 kg.
PRICE: £354

ROGERS
Rogers Developments (Electronics) Ltd, Rodevco Works, 4/14 Barmeston Road, Catford, London SE6.
Tel: 01-698 7424/4340.

Sole UK Agents: Pact International Electronics Ltd, PO Box 19, Orchard Road, Royston, Hertfordshire, SG8 5HH.
Tel: 0763 41171.

DM344A

Frequency range: 20 Hz to 20 kHz for fundamental in six third-decade bands.
Attenuation: fundamental greater than 80 dB, second harmonic less than 0.5 dB.
High pass filter: —20 dB at 50 Hz —1 dB at 500 Hz.
Total harmonic distortion range: 100% fsd to 1: fsd in seven switched ranges.
Harmonic bandwidth: 100 kHz.
Input level: minimum —500 mV, maximum —30V.
Input impedance: filter: 10k ohms or 600 ohms (100V overload protection).
Voltmeter: 1M ohm.
Voltmeter range: 30V —1 mV fsd in ten ranges +30 dB to —70 dB.
Bandwidth: 10 Hz to 100 kHz ±0.5 dB (100V overload protection any range).
PRICE: £140.

SIEMENS
Siemens AG, Bereich Weitverkehrstechnik, Nachrichtenmessgerate D - 8000 Munich 70, Hofmannstr. 51, W. Germany.

Agents: Siemens Ltd, Great West House, Great West Road, Brentford, Middlesex.
Tel: 568 9133.

D2040

Built-in counter with numerical display. Resolution 1 Hz; the frequency display immediately follows the setting since 25 measurements occur per second. Automatic frequency control (AFC). Frequency display of the measuring voltage up to 1 Hz. Numeric display of the set sensitivity with indicator tubes. Variable-frequency band-pass filter.
All the functions are capable of remote control.
PRICE: £2,492

SUGDEN
J. E. SUGDEN & Co Ltd, Carr Street, Cleckheaton, Yorkshire, BD19 5LA.
Tel: 09762 2501.

452

Sensitivity: 1V rms.
Millivoltmeter output 350 mV approximately 1V p-p.
Minimum measurable distortion: 0.01%.
Input sensitivity: 300 mV rms.
Millivoltmeter output: 100 mV rms.
Mirimum measurable distortion: 0.05%.
Millivoltmeter output: 1V rms.
Desired attenuation of fundamental: 80 dB.
Undesired attenuation of second harmonic: 1 dB.
Undesired attenuation of third harmonic: 0.25 dB. Off tune frequency response extends beyond 60 kHz within 0.5 dB.
Tuning frequency range: 15 Hz to 20 kHz.
Input impedance: 250k ohms.
Power requirements: two internal 9V batteries (Ever Ready *PP9*).
Semiconductors: 3 transistors (2 x BC109, 1 x BCY72).
PRICE: £30

WOELKE
Technische - Physikalisches Laboratorium, 8 Munich 2, Nymphenburger Str. 47, West Germany.
Tel: 0811 593551

Agents: Lennard Developments Ltd, 206 Chase Side, Enfield, Middlesex EN2 0QX.
Tel: 01-363 8238.

ME301

Mains supply: 110 to 125V or 200 to 240V, 40 to 60 Hz.
Frequency range: Direct —0.5 Hz to 20 kHz. Filter —1 to 3.2 Hz, 3.2 to 10 Hz, 10 to 32 Hz, 32 to 100 Hz, 100 to 330 Hz.
Bandwidth: 10% (response down 3 dB).
Filter damping: 0 ±1 dB.
Block damping: more than 40 dB pro octave.
Input resistance: more than 9k ohms.
Output resistance (Basic resistance): less than 200 ohms.
PRICE: £285

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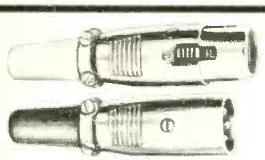

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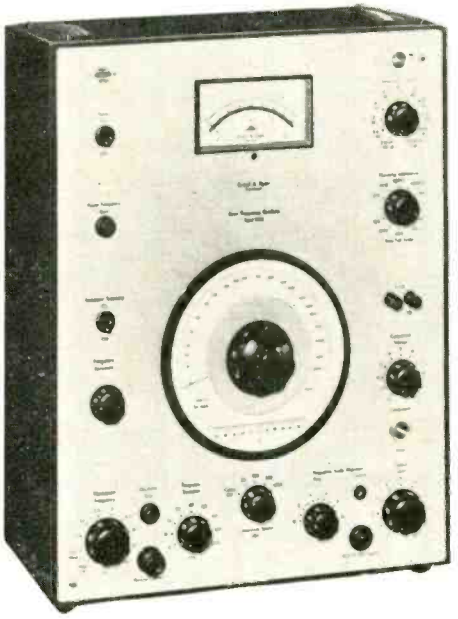
BRUEL & KJAER

1022 OSCILLATOR

MANUFACTURER'S SPECIFICATION

See Survey of Audio Oscillators



THE Bruel & Kjaer *1022* beat frequency oscillator is I believe a unique instrument. Not only is it a conventional audio oscillator covering the range 20 Hz to 20 kHz but it includes facilities for frequency modulation, external control of the output voltage and also remote control.

Reference to the block diagram of the unit (**fig. 1**) shows that the audio frequency is obtained by beating a 120 kHz 'fixed' oscillator with a 120 to 100 kHz variable oscillator. The resulting beat is passed through a low pass filter to remove the unwanted high frequency from the oscillators, and thence to an output amplifier which can either feed a power output of up to 2.5W or an attenuator which provides outputs from 120 μV to 12V in 10 dB steps, in association with a variable control. The output voltage is metered by an average detecting meter which is calibrated in terms of rms output.

The so-called 'fixed' oscillator can be frequency modulated by a varactor diode system which is fed either from an internal sawtooth generator with its repetition frequency switched between 1 Hz and 25 Hz (also providing various frequency deviations between ±10 Hz and ±250 Hz) or from an external source which may provide frequency deviations up to ±300 Hz. Following the 'fixed' oscillator is the regulating amplifier which permits external control of the audio output voltage in accordance with the amplitude of an audio signal applied to the compressor input.

The variable oscillator can be either controlled manually, or its variable capacitor element may be mechanically driven from an external source by means of a flexible drive shaft which is provided with the instrument. The main frequency dial coupled to the variable capacitor has an accurate logarithmic scale from 20 Hz to 20 kHz. It is supplemented by an additional incremental capacitor which has a linear scale calibrated ±50 Hz which may be used for fine tuning or providing small frequency offsets and also to extend the range of the oscillator to 10 Hz at the price of increased distortion.

Initial frequency calibration is carried out by setting the frequency dial to 50 Hz, pressing a 'power frequency beat' button, and adjusting the 'frequency scale alignment' control for a zero beat. Once this has been done the entire frequency scale is correct and no further calibration is required.

The *1022* oscillator is designed to be coupled with other Bruel & Kjaer instruments for the automatic recording of various electroacoustic phenomena. In conjunction with the *2305* level recorder (which was the subject of a previous review) this oscillator enables the automatic plotting of frequency response data between 20 Hz and 20 kHz on preprinted recording paper at the press of a button, without further manual intervention. The plotting of the frequency response of microphones and loudspeakers is facilitated by the 'compressor input' which may be used to provide a relatively constant sound pressure level without the use of anechoic conditions as shown in the diagram (**fig. 2**), provided that excessively reverberant conditions are not used.

A further feature is the rapid oscillator stop facility which may be used in conjunction with the Bruel & Kjaer level recorder for the automatic plotting of the reverberation time characteristics of rooms.

The mechanical system

The mechanical drive to the oscillator's tuning capacitor is either manual direct drive from a large front panel knob, which combines a slow motion drive which is operated by a smaller concentric knob, or by means of a remote flexible cable which is supplied with the instrument. The latter drive is via a worm gear which is followed by an electromagnetic clutch; this clutch is either operated by a front panel toggle switch or may be operated by a remote switch connected to the remote control socket.

Tuned frequency is indicated by a large diameter (150 mm) illuminated scale which bears logarithmic calibrations and is extremely easy to read; the knife-edge scale pointer is directly attached to the main tuning shaft. The main shaft is also equipped with two adjustable

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FIG. 1 B & K 1022 OSCILLATOR BLOCK DIAGRAM

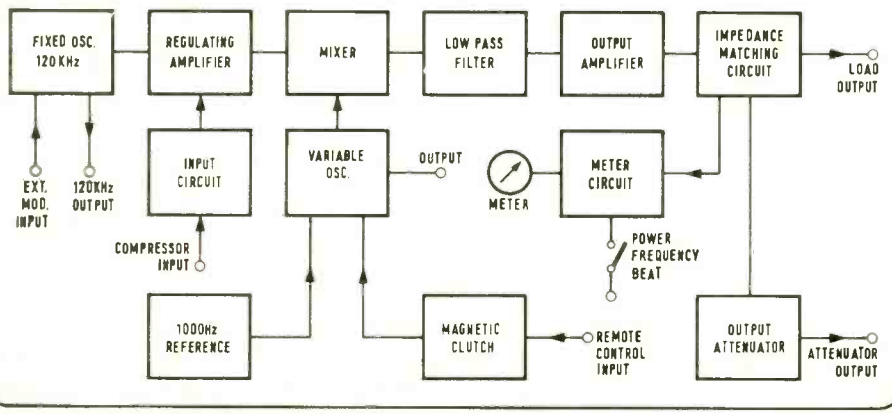
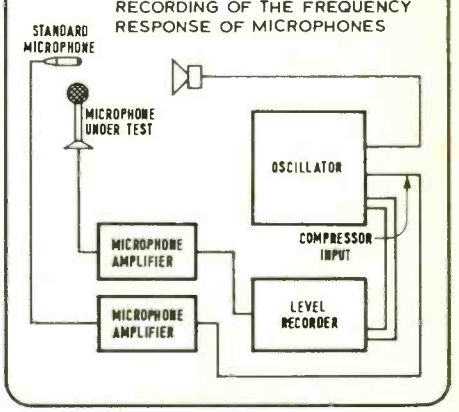


FIG. 2 SET-UP FOR THE AUTOMATIC RECORDING OF THE FREQUENCY RESPONSE OF MICROPHONES



continued

cams which can be arranged to operate a microswitch at any two chosen points of rotation of the tuning capacitor which rotates throughout 360°. The idea of this system is to permit the automatic stopping of the oscillator at points outside the calibrated section of the frequency scale, or to permit the oscillator to be operated over any chosen range of frequencies. The same switch contacts may also be used to lift the pen on the Bruel & Kjaer level recorder when making frequency response plots.

A supplementary tuning capacitor, which provides tuning of ±50 Hz about the main tuned frequency, has its calibrated scale horizontally disposed below the main scale, but within the main scale diameter. This scale is also illuminated and very clearly calibrated such that it can be readily tuned within 0.5 Hz of the desired offset in frequency.

There are no other moving parts in the instrument and its general construction is to an extremely high standard.

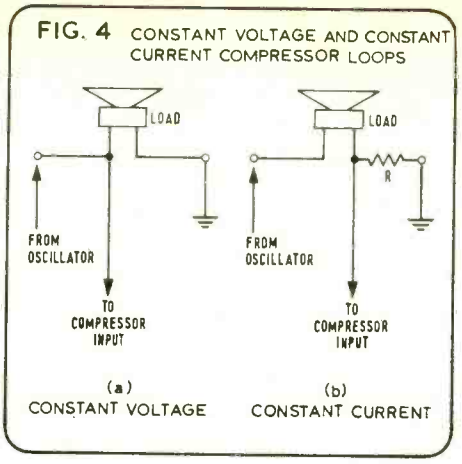
The electronics

This latest version of the Bruel & Kjaer oscillator is fully solid state and, while its specification is virtually identical to the earlier valved model, the review sample showed some improvement in performance. There have also been minor changes in styling which make no difference to the operations of the instrument.

The first point of interest to be investigated was the accuracy of tuning, which rather surprisingly is not quoted in the specification in the instruction manual but is quoted in the manufacturer's full catalogue as one per cent, ±1 Hz for the main scale or ±0.5 Hz for the incremental scale.

Spot checks on the calibration of the main scale provided the following results, which are well within the specification quoted above:

Similar spot checks on the incremental scale gave rather more variable results, but in all cases the frequency offset was within the specified ±0.5 Hz.



Tuned Frequency	Actual Frequency	Error
20 Hz	19.9 Hz	−1.0%
40	40.0	0
70	69.8	−0.28
100	100.5	+0.50
200	200.6	+0.30
400	400.5	+0.13
700	699.0	−.05
1 kHz	1.005 kHz	+0.50
2	2.007	+0.04
4	4.010	+0.25
7	6.993	−0.01
10	9.961	−0.39
15	15.005	+0.03
20	19.964	−0.18

An additional feature of the oscillator is a '1 kHz ref' pushbutton which provides a 1 kHz alignment tone when the oscillator scale is aligned to the point where it would come to a stop when used for automatic frequency response plotting in conjunction with the Bruel & Kjaer level recorder. This reference tone was measured as being 0.35 per cent too high, which is quite satisfactory.

The frequency stability was found to be excellent. After a five-minute warm-up period the stability was better than 0.02 per cent at nominal incoming mains voltage, and did not change when the mains voltage was dropped by 25 per cent! Similarly, loading the oscillator did not have any measurable effect on frequency.

In addition to the audio frequency outputs, two rear panel sockets give access to the outputs of the fixed and variable oscillators for connection to other Bruel & Kjaer instruments. The output frequency of the nominal 100 kHz oscillator was found to be 99.9986 kHz at a voltage of 0.22V rms and a total harmonic distortion of two per cent—no doubt this output could find other applications!

Attention was next paid to the audio output sections of the oscillator. In order, these consist of an output potentiometer, a power amplifier, output matching transformer, output attenuator, and metering circuits.

The oscillator output may be taken from the matching transformer which will provide the following output voltages up to a maximum output power of 2.5W.

Minimum load	Maximum voltage
6 kΩ	120V
600 ohms	40
60	12
6	4

Alternatively the output may be taken from the output attenuator which had a source impedance of 52 ohms and is calibrated for full scale outputs between 12V and 120 μV in 10 dB steps. Both outputs are controlled by the output level potentiometer and are metered, which means that calibrated outputs as low as 10 μV can be readily obtained.

The attenuator accuracy was within 0.08 dB ±0.02 dB over its entire range at 1 kHz, which is substantially better than the manufacturer's specification of two per cent.

The metering accuracy on both the attenuator output and on the power outputs was found to be better than ±one per cent of the actual voltage output at meter indications above one-third full scale deflection.

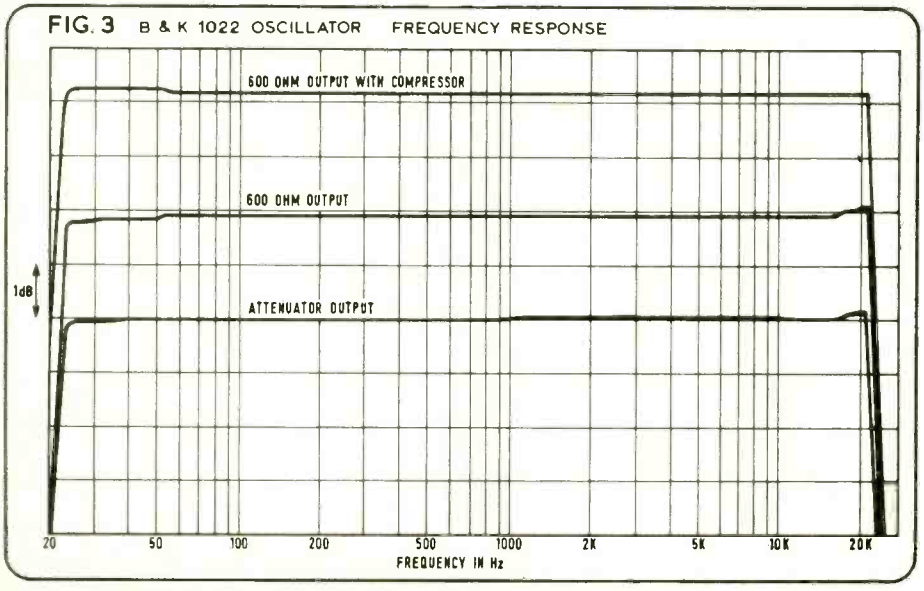
Distortion at the power output is specified as being higher than that at the attenuator output, so both outputs were investigated with some care and provided the following figures for total harmonic distortion (power output at 2.5W into 6 ohms):

Frequency	Distortion
20 Hz	0.26%
200	0.05
1 kHz	0.15
10	0.05
20	0.215

Attenuator output at 10V into high impedance was measured as:

Frequency	Distortion
20 Hz	0.125%
200	0.022
1 kHz	0.02
10	0.038
20	0.125

This performance is well within the specification and represents a useful improvement on the earlier model of this oscillator which left something to be desired when measuring good audio equipment. As a matter of interest, the individual harmonics were measured at 1 kHz from the attenuator output and found to be 0.01 per cent second harmonic and 0.006 per cent third harmonic.



72 ▶

continued

Noise and hum were measured from the attenuator output and found to be extremely low with hum being –94 dB at 50 Hz and –95 dB at 150 Hz with no measurable 100 Hz component. Wide-band noise was measured at greater than –80 dB and found to consist mainly of breakthrough from the high frequency beating oscillators.

Fig. 3 demonstrates that the flatness of the frequency characteristic from both outputs is within ±0.1 dB over the entire frequency range without the use of the compressor facility which can provide a useful improvement even on this performance.

The compressor arrangement consists of a voltage controlled amplifier which controls the output voltage of the oscillator and has a high gain such that a 1 dB change in input to the compressor will produce an output voltage change from the oscillator of about 40 dB in the active region. The compressor input only required 560 mV to reach its active region at maximum compressor input gain (a front panel control) so it is a very simple matter to arrange feedback from the oscillator output to produce either constant current into a load, or constant voltage, as shown in **fig. 4**. The compressor speed may be switched between 30/100/300 or 1,000 dB/s to suit particular requirements, the lower speeds being particularly useful for producing constant sound pressure levels under reverberant conditions by feeding the oscillator output to a loudspeaker and feeding the compressor input from a standard microphone, located at the point where constant sound pressure level is required.

It was found that the compressor speed tended to vary according to the rate of change of the compressor input but this is of little consequence because the speed required in practice is a matter of trial and error for any particular application.

The input impedance to the compressor amplifier was found to vary to a limited extent between 20.7 and 21.5 kΩ according to the setting of compressor gain but such small changes are unlikely to be of any significance.

The frequency modulation facility is included in the oscillator in order to reduce room resonances upsetting the results when undertaking sound insulation or reverberation time measurements.

An internal sawtooth generator or an external source may be used to provide the frequency modulation. The internal generator has eight switched frequencies between 1 Hz and 25 Hz which were found to be accurate within four per cent of their nominal and to provide a slowly increasing frequency followed by a rapid drop of frequency. If an external generator is used, any modulation waveform can be injected and frequency modulation up to ±300 Hz is possible via the remote control socket which has a maximum sensitivity of 4.98 mV/Hz.

When using the internal sawtooth generator, the modulation depth may be selected by a nine-position front panel control which has increments between 0 Hz and ±250 Hz with a measured accuracy in the order of ±12 per cent.

If more accuracy is required, for instance when checking wow and flutter meters, it is a simple matter to calibrate the external modulation input by applying a dc input and measuring the oscillator's output frequency, and then substituting the required modulation waveform and adjusting its amplitude to have the same peak values as the dc calibration voltage by means of a dc-coupled oscilloscope.

The specified distortion from the attenuator output of 0.2 per cent at the frequency extremes leaves something to be desired but the review sample was measured at 0.125 per cent at 20 Hz and 20 kHz, falling to 0.02 per cent at 1 kHz. Anyhow, distortion figures in excess of 0.2 per cent are all too common in even the most expensive oscillators.

The versatility of the instrument is exceptional, output voltages and impedances being most sensible as is the attenuator which is one of the few which can be used directly to low level microphone inputs giving directly read signals in the order of tens of microvolts.

This latest version of the Bruel & Kjaer *1022* oscillator is a substantial improvement over the earlier valved version and I have no hesitation in giving it the strongest recommendation in its own right. With the B & K level recorder, it provides the facility for quick automatic recording of frequency responses to within about 0.2 dB; there is much to be said for properly recorded data.

H. D. Ford

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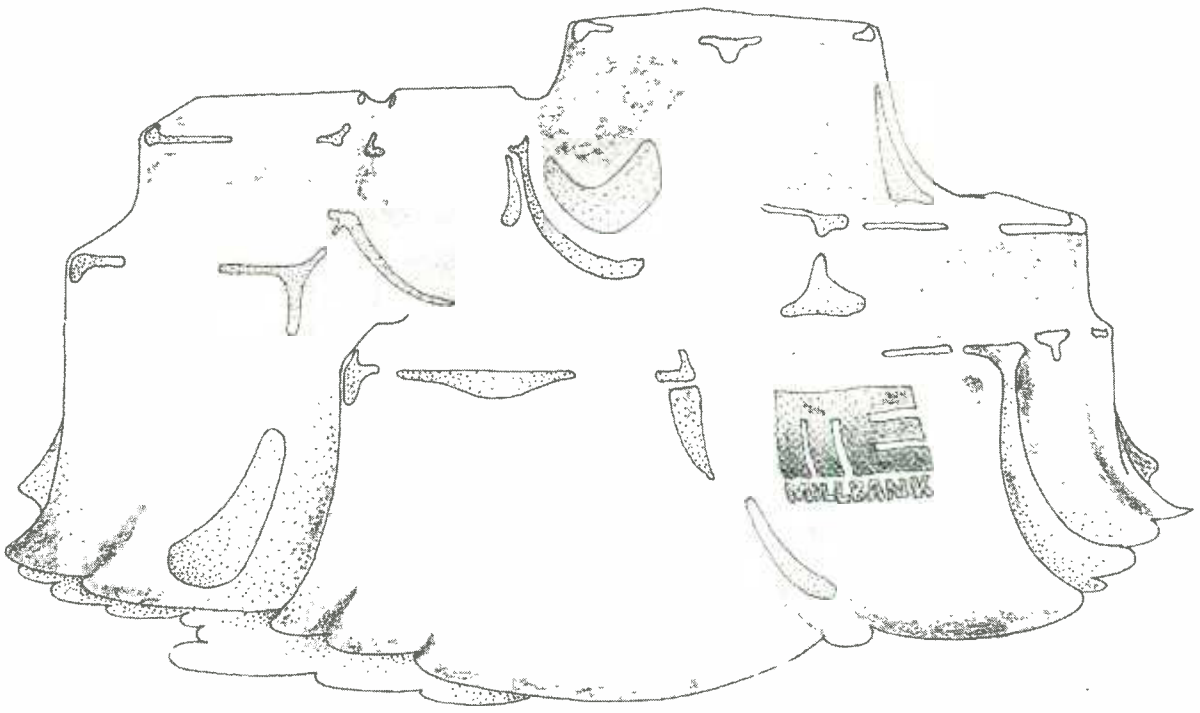

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