wireless world

NOVEMBER 1975 35p

EXCLUSIVE TELETEXT DESIGN

Teletext decoder

Audio Fair

Australia $A1.20
Belgium Fr. 61.50
Canada $1.50
Denmark Kr. 11.00
Finland Fmk. 6.20
Germany Dm. 4.50
Greece Dr. 45.00
Holland Dfl. 4.50
Italy L. 900
Malaysia M$3.25
New Zealand $NS1.20
Norway Kr. 10.00 incl. moms
Portugal Esc. 40.00
South Africa R. 1.10
Spain Ptas 80.00
Sweden Kr. 6.90 incl. moms
U.S.A. $1.50

NEW

Automatic fm/am Modulation Meter

How long does it take for you to make a series of modulation tests with the meter you are using? The M.I. TF 2304 Automatic Modulation Meter eliminates at least five manual operations for each test and even more per test when a series of measurements is to be made. That can save you hours in a production day.

When connected to a transmitter, the TF 2304 automatically tunes to the carrier frequency and automatically sets the level, all within a few seconds. Exceptionally efficient screening and a very low distortion mixer ensure locking to the wanted signal. It is only necessary to select the required mode and range and the meter will read either deviation or % depth. L.E.D. lamps indicate if the signal level is too high or low and a push-button inserts a 20 dB attenuator to extend the maximum input level to 1 watt.

The basic frequency range is 25-1000 MHz and there are 8 peak deviation ranges covering 1.5 kHz f.s.d. to 150 kHz f.s.d. and a.m. depth ranges of 30% and 100% f.s.d. all with a modulation frequency range of 50 Hz to 9 kHz. Modulation symmetry can be checked by push-button selection of positive or negative deviation and peak or trough amplitude.

The accuracy of modulation measurement is ±3% of full scale so transmitter deviation can now be set close to the permitted maximum with a consequent increase in efficiency.

The TF 2304 can be operated either from mains or internal rechargeable battery. It's small and light and there's a comprehensive range of accessories including a carrying case.

The price will pleasantly surprise you. Ask for full details.

mi: THE AUTOMATIC CHOICE

MARCONI INSTRUMENTS LIMITED,

Longacres, St. Albans, Hertfordshire, AL4 0JN. England. Telephone: St. Albans 59292. Telex: 23350.

A GEC-Marconi Electronics Company.

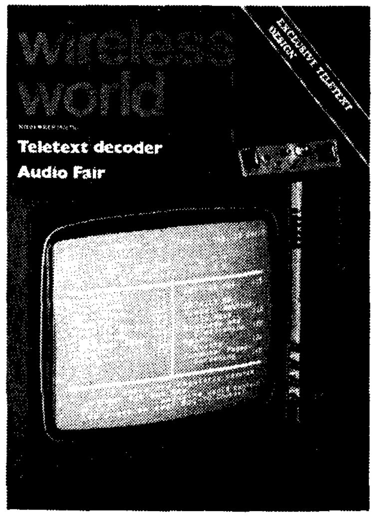
WW—001 FOR FURTHER DETAILS

wireless world

Electronics, Television, Radio, Audio

NOVEMBER 1975 Vol 81 No 1479

Contents



This month's front cover shows a colour TV receiver displaying a Teletext page, processed by the Wireless World Teletext decoder seen on top of the set (see page 498). *(Receiver lent by Thorn Television Rentals)*

IN OUR NEXT ISSUE

Microprocessors for computer control. What they are and how they work, with a table of types on the market

New audio amplifier design uses "current dumping" output transistors and feedforward distortion correction

Interference from pocket calculators can cause trouble. Measurements of electromagnetic radiation from three named calculators

Price 35p (Back numbers 50p, from Room 11, Dorset House, Stamford Street, London SE1 9LU.)
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620; Advertising 01-261 8339.
Telegrams/Telex, Wiworld Bisnespres 25137 London. Cables, "Ethaworld, London SE1."
Subscription rates: 1 year, £6 UK and overseas ($15.60 USA and Canada); 3 years, £15.30 UK and overseas ($39.80 USA and Canada). Student rates: 1 year, £3 UK and overseas ($7.80 USA and Canada); 3 years, £7.70 UK and overseas ($20.00 USA and Canada).
Distribution: 40 Bowling Green Lane, London EC1R 0NE. Telephone 01-837 3636.
Subscriptions: Oakfield House, Perrymount Rd, Haywards Heath, Sussex RH16 3DH. Telephone 0444 53281.
Subscribers are requested to notify a change of address four weeks in advance and to return envelope bearing previous address.

SIXTY-FIFTH YEAR
OF PUBLICATION

ibpa
International Business Press Associates

wireless world

Editor:
TOM IVALL, M.I.E.R.E.

Deputy Editor:
PHILIP DARRINGTON
Phone 01-261 8435

Technical Editor:
GEOFFREY SHORTER, B.Sc.
Phone 01-261 8443

Assistant Editors:
BILL ANDERTON, B.Sc.
Phone 01-261 8620
BASIL LANE
Phone 01-261 8043
MIKE SAGIN
Phone 01-261 8429

Production:
D. R. BRAY

Advertisements:
G. BENTON ROWELL *(Manager)*

KEVIN BURNAL
Phone 01-261 8515

ROGER PORT
Phone 01-261 8037

A. PETTERS *(Classified Advertisements)*
Phone 01-261 8508 or 01-928 4597

JOHN GIBBON *(Make-up and copy)*
Phone 01-261 8353

I.P.C. Electrical-Electronic Press Ltd
Publisher: Gordon Henderson

The dugs of war

It's a sad comment on our times that you can now get a degree in destruction. To be more precise, an M.Sc. in guided weapon systems, under the auspices of the Council for National Academic Awards. Look into the olive-grove of Academe and what do you see but a war-head pointing out at you.

This little fact is only a symptom of our permanent involvement in war technology. To adapt Von Clausewitz's famous saying, "Peace is nothing more than the continuation of war by other means." Commentators speak nowadays of "the industrial-military complex" and by this they mean that certain parts of manufacturing industry have become closely identified with, and commercially dependent upon, the production of military equipment. This is certainly true of electronics. The art of war has come to depend on rapid communication and information processing, continuous surveillance and accurate control of mechanisms. And why? Because electronics has made these things possible. But electronics technology itself has been greatly developed by the pressures of actual wars — for example radar and the electronic digital computer in the 1939-45 war — and it continues to be stimulated by our fear of aggression and our consequent need to maintain the nuclear and military balance of power. It is really a chicken-and-egg situation.

Even though the basic drives in this reproductive cycle are fear and profit, it is possible to draw up an impressive list of benefits. For example, one of the significant "spin-offs" of nuclear missile development was the integrated circuit. This has produced a revolution in the design of electronic equipment. Calculator chips, microprocessors, counters, decoders and the like have made possible, simply and cheaply, the kind of information processing operations which, in the days when there were only discrete active devices, would have been quite inconceivable in domestic and industrial applications. Military electronics business is becoming an important factor in the economy of industrial countries. In the UK the Ministry of Defence is the biggest single customer for electronics. Profits are made, dividends are issued, jobs are created, and the export of the military equipment helps to pay for the import of essential raw materials and food.

Although engineers and technologists are beginning to show concern about the effects of their work on the environment, they seem not to be worried by the use of their technologies for destroying life and property. Perhaps we have been bamboozled by the use of the word "defence" as a euphemism for war. More likely, we are just too far away to see the blood being spilt. Anyway, "it's just a job." As long as the milch cow of defence expenditure continues to provide a steady flow of cash there will be plenty of us — individuals and firms — lining up and ready to feed off it, without looking too closely at the implications.

Wireless World Teletext decoder

1 — The background

by Philip Darrington

The first of a series of articles on the Teletext television information display system and the construction of a decoder for use with domestic television receivers.

In succeeding articles of this series we shall describe the design and construction of the *Wireless World* Teletext Decoder. But, before we do that, it seems only sensible to make sure that readers are up to date with current activity in the field and have an idea of other systems which have been proposed. We will also describe the basic operation of Teletext and mention the techniques used to decode the transmissions for display on a domestic television receiver.

In the early years of "wireless", the vision of millions of people being entertained by transmissions was just not credible. Television was thought to be sheer science fiction and wireless itself was for the transmission of vital information. Even if it had been possible to communicate phonically, that was not the idea at all – ships were the real users of radio and if amateurs could derive pleasure from listening to marine morse traffic or Eiffel Tower time signals, so much the better.

Then, of course, radio telephony was developed and the entertainment possibilities were recognized. It is now an extraordinary and rather depressing fact that out of the few thousand megahertz available for radio transmission, nearly 600MHz are taken up by broadcasting stations, most of which put out entertainment of one sort or another. Sound is reasonably restrained in its use of bandwidth, but television occupies 566MHz – a staggering figure, particularly as the television signal contains so much redundancy. Anything designed to make better use of this signal is to be welcomed and Teletext is one way of doing that, in that a previously unused part of the waveform is used to transmit more information.

Many ways of using television transmissions to better effect have been proposed[1, 2]. Since the early sixties, test signals inserted in the field blanking interval have been in common use, and have been supplemented by coded data transmitted on lines 16 and 329 of each frame[3]. It apparently did not, at the time, occur to ORTF, who originally used the system, that the technique could be developed to allow the transmission of visible information, but the system was used for switching remote transmitters, identification for remote supervision purposes, etc.

Other systems of transmission aimed at "still" display, with or without sound and in colour or monochrome depend on the exclusive use of a television or sound channel. For instance, the NHK "A" system[4] is able to carry over 50 channels of colour still pictures, with sound, in the bandwidth of one normal television channel. The pictures are transmitted at the rate of one still per frame, together with a code to enable a magnetic disc memory in the receiving equipment to record a selected frame, which is then continuously replayed. Sound is multiplexed with video information and transmitted in the frame intervals.

The NHK "B"[4] system falls into the multiplexed television channel category, using uncoded signals. Three unused lines per field are used to transmit three lines of a still picture, which is magnetically recorded at the receiver. Sound is transmitted by the use of additional sound carriers at low level, spaced further in the spectrum from the vision channel than the original sound carrier.

In 1971, W. D. Houghton of RCA described the Homefax[5] system in which additional information was multiplexed with a broadcast television waveform to produce "hard copy" from an electro-optical printer, using a cathode-ray tube to produce the "printing" on Electrofax paper. The information, uncoded, was carried in an unused vertical interval line and transmitted in the normal way – each of these lines producing part of one line of a row of print on the receiver paper. Transmission tests of this system had been carried out in 1967, and improvements were being carried out in 1970. A method of data transmission not using the vertical blanking interval[6] was described by P. T. King of Hazeltine Research, Inc., at the SMPTE Technical Conference in 1973. In this system, known as an "add-on" type, a low-level subcarrier was inserted on the vision signal at an odd multiple of half the line frequency, a method which is well known in colour television circles as a method of avoiding interference between two signals in a common waveform. The added signal is shifted in phase from line to line and the visible effects are reduced. The actual frequency is chosen to be between 2 and 3MHz in the NTSC standard, because radiated energy is at a minimum in that region in a typical picture. The data signal is biphase modulated at 21 kilobits per second and at the receiver is synchronously detected, the data decoded and used to operate a character generator, which can, for example, produce subtitles in languages using the characters available.

These two techniques – the use of previously blank lines in the vertical blanking interval and the provision of a character generator at the receiving end – paved the way for Teletext. A system of this kind is able to carry more information, more flexibly, by leaving the receiver to do rather more of the work than an analogue or uncoded digital system. If the transmitted signal is made to carry instructions to the receiver on what to do, the receiver can then hold much of the information in store, releasing it when commanded to do so.

Peter Hutt of the IBA described an embodiment of this principle in a paper read to the IPC, 1972[7]. The system was named SLICE and was primarily intended for the labelling of programmes with a source identification. The information was carried on lines 16 and 329 in the form of 112 binary digits per line and, at the receiver, was read into a memory where a complete message was assembled. SLICE was the fore-runner of ORACLE and CEEFAX. (Hutt mentioned the possibility of a domestic information service in his paper.)

Teletext

ORACLE was developed by the Independent Broadcasting Authority in the light of its experience with SLICE and the BBC announced their own system, which was very similar and bore the name CEEFAX. (ORACLE is an acronym — Optional Reception of Announcements by Coded Line Electronics — CEEFAX is See Facts as pronounced by an adenoidal dyslexic.) There is little profit in trying to decide which organization hit upon the idea first, or which was on the air first, as the two were quickly and sensibly to agree on a common standard of transmission, in conjunction with BREMA[8]. Both names will probably continue to be used for each organization's broadcasts, but the generic term "Teletext" is now common, and will be used henceforth. Teletext has been broadcast on the present standard since September 1974 — the beginning of a two-year experimental period. The system uses a multiplex-with-vision type of transmission and uses lines 17 and 18/330 and 331 to carry coded information. There is no accompanying Teletext sound.

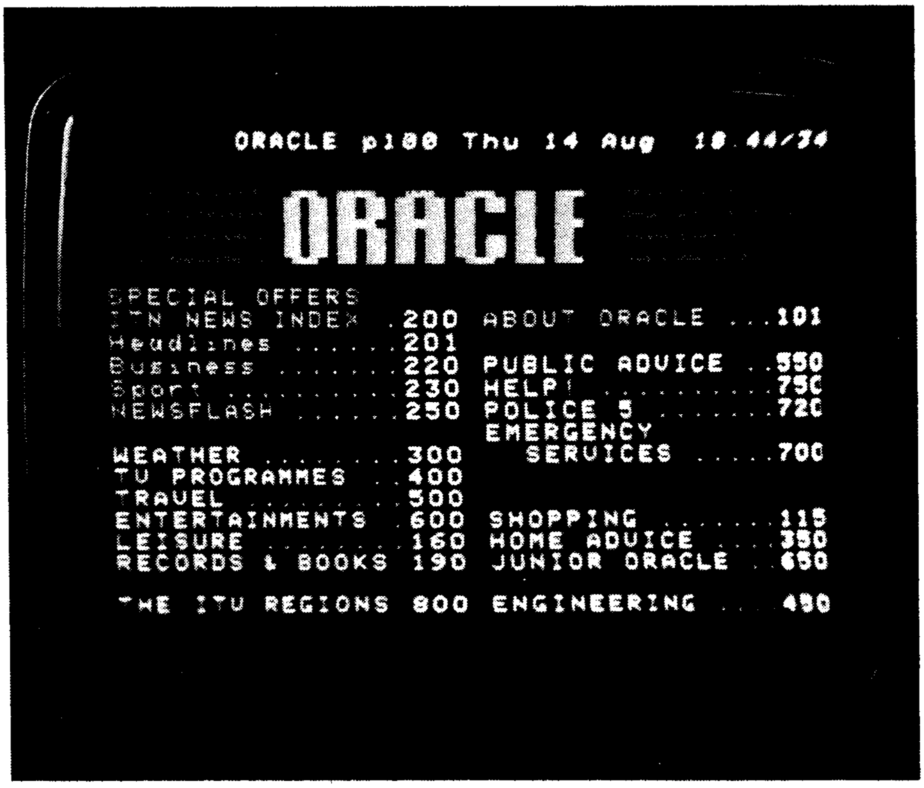


Fig. 1. The main index page (p. 100) of ORACLE for August 14, 1975, produced by the W.W. decoder on a Thorn colour receiver.

Before proceeding further, a look at the facilities offered by a Teletext transmission and a résumé of some of the specification will be a help when considering the equipment needed in the receiver. Briefly, the Teletext page consists of 23 rows of 40 characters each, plus a page header, which is only partly displayed. As seen in Fig. 1, the header gives the name of the service (Ceefax or Oracle), the page number, the date and the time. The time display is continually changing and is always visible.

Visible characters are either capitals or lower-case letters assembled on a 7 × 5 dot matrix and in one of six colours or white: diagrams or low-resolution "pictures" can be assembled by the use of a block of cells on a 3 × 2 pattern, each of which can be "on" or "off", in colour. A variety of other symbols (commas, brackets, @, £, etc.) can also be shown, and the set of characters is known as the ISO-7 code, which is a version of the ASCII code with some of the "National usage" characters substituted. Characters can be made to flash on and off, though our own feeling is that this will be used rather less when the service is finally in use than it is now, if it infuriates other people as it does the writer.

The Teletext editing teams can use the pages in three different ways, the norm being single pages which appear when selected by the viewer at any time and which are up-dated perhaps once or twice a day. A second type is one of a group of, perhaps, four such pages which change at about one minute intervals. They will usually be on a related topic, such as sport, and are identified by the letters A B C or D, the relevant letter being in a different colour so that the viewer knows which point in the set of pages has been reached. This type is really the same as the first variety, but pages are changed automatically at minute intervals. The third kind of page can be selected by the time-code on the header, so that it can be received, placed in store and read out at a convenient time.

The data to be displayed can be presented as a complete page or, in the case of news flashes or subtitles, can be inserted in a blank rectangle on the screen, leaving the rest of the picture visible. The full page can be superimposed on the picture, but in our experience this is a good way to ruin one's eyesight.

A typical magazine has the capacity of 100 pages. Four lines are transmitted per television frame and there are 24 lines per Teletext page. A full magazine would therefore take 600 frames or 24 seconds to cycle. The BBC and IBA appear to differ on what they consider acceptable access times; the BBC suggest a typical time of 12 seconds (for an unspecified number of pages) while a recent check on Oracle gave an access time of 28 seconds for well over 100 pages. The theoretical time can be reduced considerably by not transmitting blank lines, a practice which is already followed by the IBA and which the BBC intend to change to shortly (they already omit blank lines at the bottom of a page).

To select a Teletext page, one first switches the signal path through the decoder, selects a page by means of thumbwheel switches or a set of push-buttons and waits for the selected page to be assembled.

Teletext signal

The method of transmission of the Teletext data is of interest at this point. As has been said, the data signals are carried by lines 17 and 18 and the corresponding lines in the alternate field, 330 and 331. The choice of lines is influenced by the need to avoid the early part of the vertical blanking interval and the few lines near the start of the video signal (lines 23 and 336). If early lines were used, it is possible that data would appear on the field flyback on some receivers and if lines later than 18/331 carried the information, receivers with incorrect picture height adjustment or with a downward-shifted picture might show the data as an extremely "busy" pattern of dots at the top of the screen – this sometimes occurs even with the present line allocations. A further reason for avoiding lines 19/332, 20/333 is that they are currently used for insertion test signals, which are often visible but, being static, are not obtrusive.

A form of binary code is used for the data, known as non-return-to-zero, which possesses the advantage over a complemented-element code of a reduced bandwidth requirement. As its name suggests, the resulting waveform is not a continuous train of pulses, but rather a series of voltage levels. A typical sequence is shown in Fig. 2(b), where it is seen that a "1" level does not automatically return to zero at the end of the pulse and if the succeeding level is also 1, the voltage merely stays up — similarly with a succession of "0". One result of this is seen in Fig. 2(c) where a train of the form 0 1 0 1 0 1 etc. turns out to be a square wave at half the repetition frequency of the clokc. As transmitted the pulses are "raised-cosine" in form and the square wave becomes a half-clock-frequency sinusoid.

The diagram in Fig. 3 shows one line of the complete picture frame. A complete line occupies 64µs, of which about 12µs are taken up with the synchronizing pulse, back porch with colour burst and front porch. The first 40 of the 360 bits are concerned with clock synchronization (in a manner similar to that of the colour burst), a series of bits which constitute a "start" sequence and 16 bits for control and row address information. The rest of the line contains 320 bits for display and control. Figure 4 shows the layout of information in the line.

Coding

All transmission paths are subject to errors, and television has its share. Noise can be a problem, but the type of distortion caused by multipath propagation is perhaps the deadliest source of error. Both BBC and IBA have done work on this in the U.K., Sweden and Germany, and have come to the conclusion that Teletext transmissions are fairly robust, but require a good performance in the receiver. This relative invulnerability to attack is assisted by the application of code protection — additional bits of information transmitted with the data.

Code protection is applied in two levels. Data bits which are intended for addressing and control are heavily protected, while those used to produce the displayed characters are protected rather less. The transmitting authorities consider that the occasional error in, or rejection of, a character is not serious as it will quite probably be corrected on the succeeding transmission of the page, but that an error in an address would lead to complete nonsense and must be avoided in the presence of the average amount of noise and ghosting.

The character code is basically 7-bit ISO-7 and is protected quite simply by means of a parity bit, giving odd parity. This means that if the total of "1s" in the basic 7 bits is odd, the parity bit is "0". An even total of "1"s in the 7 bits dictates a "1" parity bit to maintain an odd overall total. On examination at the receiver, any byte (the name for a "word" of 8 bits) with an even number of "1"s is seen to contain one error and is rejected. Previously-correct words in a display will not, therefore, be overwritten by an incorrect one and the effect is a reduction in errors in succeeding pages. Double errors, preserving odd parity, are not rejected and will be written.

Address data bits, on the other hand, are more heavily protected by being transmitted in a type of code which will detect 2, 4 or 6 errors in the byte and will detect and *correct* a single error. This type of code was described by R. W. Hamming in a classic paper[9] in 1950, and is known as the Hamming code. It takes the form of four parity bits in positions 1, 3, 5 and 7 of the eight-bit byte (the addresses are in a four-bit code). Three of the parity checks are associated with groups of three of the four message bits and the overall parity check covers all message and parity bits. Failure of the overall parity indicates an error and the position of the error is identified by the checks on the groups of three bits. If the overall parity appears true, but the individual checks show that a correction is required, there will have been a double error and the byte will be rejected as unusable.

Figs. 3 and 4 indicate that the bits at the beginning of the line are not concerned with the displayed message. Three groups of bits are transmitted, of which one is two bytes (16 bits) designed to lock the receiver's clock in frequency and phase with the transmission, in a similar manner to the way in which the colour burst dictates phase in a colour receiver. The 16 bits are termed the *clock run-in* and consist of a train of 1 0 1 0 1s. It is a penalty of the n.r.z. code used that this run-in is necessary, as it entails a code which is not self-clocking. In other words, unless the data are of the 101010 variety, which conveys no information, the transitions do not occur at every interval, and the data pulses themselves could not be used as a clock source, if it were not for the choice of odd parity for the protection code, ensuring at least one transition per character, which can be used to refresh the clock generator. The 16-bit burst of 3.5MHz is also detected and used to identify the transmission as Teletext and not some other data system such as SLICE (IBA), ICE (BBC) or insertion test signals.

The second group of 8 bits forms the framing code, which is always the same and is used to indicate the start of the first 8-bit word. The order of bits used is 11100100 – an arrangement which is designed to avoid errors. A common way to detect the framing code is to pass all data through an 8-bit shift register and to examine the parallel outputs of the register. There will be only one step, when the register contains all eight bits of the framing code, when the above order of bits is present at the outputs of the shift register and gives a positive comparison with the "permanent" word used for detection. The framing code is shown in progress through the shift register in Fig. 6, which indicates that, even in the presence of bits from the clock run-in (c.r.i.) and succeeding information, a maximum of 5 bits "look like" the framing code. By means of more or less extensive circuitry, the framing code detector can be made to recognize the code in the presence of one error.

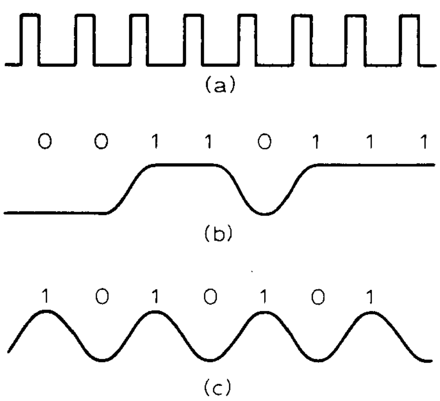
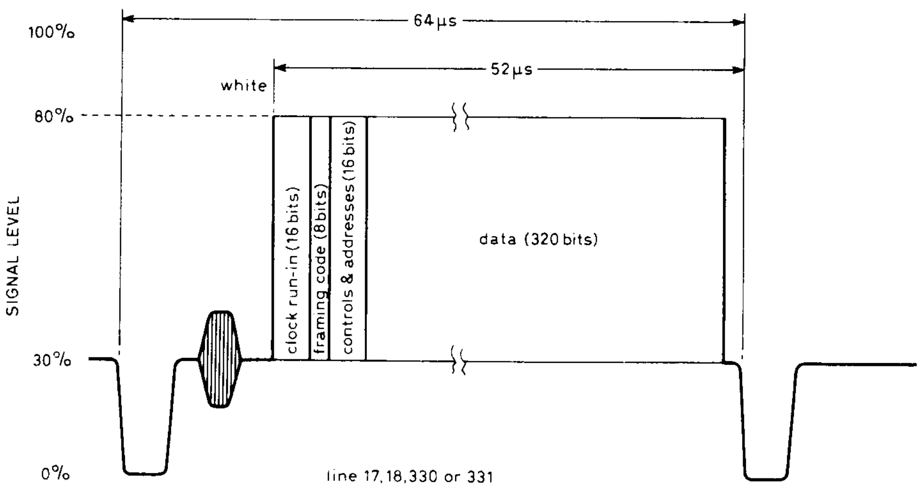


Fig. 2. The non-return-to-zero method of transmitting binary information is at (b) with the attendant clock at (a). A succession of 101010 etc. gives a half-clock frequency waveform and, if the pulse shape is a raised cosine, as used in Teletext, the result is a sinusoid at 3.5 MHz.

Fig. 3. A line of Teletext data. Sync. pulses are the 30% pulses and the colour burst is on the back porch.



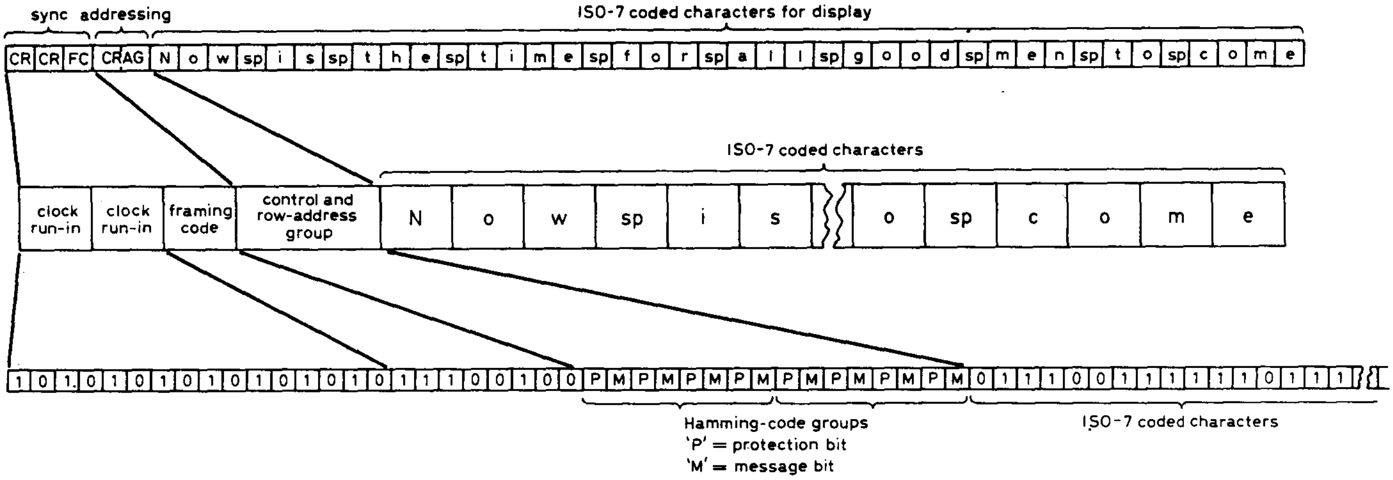


Fig. 4. A row of data. It is seen that each group of 8 bits (1 byte) has a separate function. Clock run-in and Control and Row address each have two groups.

Row addressing. The 16 bits following the framing code are concerned with the identification of the following data. Each of the 24 rows of characters must be identified and this is done by numbering each with a row number from 0-23 and a magazine number (1 to 8). The bottom line of Fig. 4 shows the layout of bits in the 16-bit group and also indicates the fact that these are protected by being Hamming-coded. As, at the moment, we are not concerned with protection, the bits marked "P" can be ignored, and the groups become 4-bit words. In fact, this is an artificial distinction, because they form one word of three bits and one of five. The first group of three message bits (marked "M") identifies the magazine, and the remaining five contain the row address in a pure binary code (00001 is Row 1, 10111 is Row 23). The least significant bit is transmitted first.

Data. The rest of the line is filled with data for display, the previous bits not, of course, being visible on the screen. Fig. 5 shows the complete set (in use until Sept. 1, 1975) of available characters and blocks for graphic displays, together with the address code (bits 1-7). Bit 8 is the parity bit and plays no part in the display. A slightly modified table will be used exclusively after September, 1976, and the system is now in transition between the two.

Decoding

The circuitry for decoding Teletext transmissions is extra to that in an ordinary receiver and is mainly digital in nature. When the services are established and commercial receivers are sold (several firms already have models), the decoders will be built in, but before that happens, many viewers will want to convert their existing receivers, an add-on unit being the obvious solution, with video signals into and out of the decoder. U.h.f. input and output will probably not be used, the cost of a colour modulator, for instance, being prohibitive.

The extra circuitry needed can be considered in three groups; data acquisition, storage and output processing. The detected vision signal is taken from the television receiver, having been disconnected from the video amplifier, and taken to the decoder, where clock regeneration, framing-code detection, parity checking, serial-to-parallel conversion and page selection are carried out. The selected and organized information is then passed to a store (either a multitude of shift registers or a random-access read/write memory) until the selected page is assembled. When this has been done, the store addresses the character generator in the output processor (a read-only memory containing the ISO-7 characters) which indirectly drives the guns of the display tube.

Input processor. This preliminary canter through the decoder is, of course, grossly over-simplified and a closer look at the sections is necessary, the first of these being the video processor which operates on the video signal to derive data and clock pulses. As has been said, the n.r.z. code in which data are transmitted, is not a self-clocking code and the decoder must contain its own clock. The clock run-in contained in the Teletext signal can operate as either a locking sequence for an oscillator which is continuously running, but which drifts out of phase with the Teletext clock between lines, or can be used to excite a passive oscillatory circuit which then rings for at least the duration of the Teletext line, being automatically in phase and frequency synchronization with the signal when the LC circuit is properly tuned. Each transition of the data "refreshes" the tuned circuit.

The diagrammatic input processor of Fig. 7 shows that the data is first passed through a serial-in, parallel-out store — the shift register, which is clocked at data rate. The register is 8 bits long and can contain one word, complete with its parity bit (4 parity bits in the case of Hamming-protected words). The 8 bits, in parallel, are examined by the framing-code detector for coincidence with the 11100100 "start" sequence which, when detected, resets a "divide-by-eight" counter to zero. The output of the counter is a pulse at one-eighth the rate of the clock and is used to identify correctly-framed words of 8-bit words in the shift register. In other words, framing-code detection indicates a reference point and the counter produces a pulse every eighth clock period which transfers the group of eight bits currently in the shift register, through latches, to the data lines. The output if the latch only changes when the counter indicates that the eight bits being presented to it are, in fact, a word. Complete characters are therefore presented on the eight, parallel data lines in serial form, reducing the 6.9375MHz rate to 867kHz.

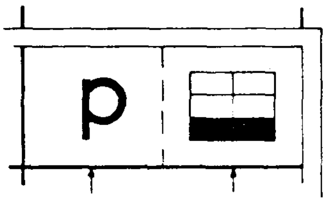
The parallel data presented to the latches are also examined by the Hamming-code checker which, as was seen, can correct one error and detect 2, 4 or 6 errors in address and time information. Following this block, an 8-bit latch finds and holds the 3-bit magazine address and 5-bit row address, referred to in Fig. 4, after a two-character holding time, inserted to allow the two four-bit words (or one three-bit word and a five-bit word) to be assembled.

Parity checks on character words are performed by the parity block, operating from the main data line, its output determining the acceptability or otherwise of a word.

The rest of the input processor is concerned with the selection of a page by the viewer, who will be provided with three thumbwheel switches or a keyboard with ten number keys and keys for several other functions. A page having been "dialled in", the row address latch block examines the row address words until row zero is detected — the page header — when the selector will examine the following address information to compare it with the required page keyed in by the viewer. On detection of the required page code,

b4	b3	b2	b1	Row ↓ \ Column →	0 ($b_7 b_6 b_5$ = 000)	1 (001)	2 (010)	3 (011)	4 (100)	5 (101)	6 (110)	7 (111)
0	0	0	0	0			SP	0	@ ② / @ ②③	P / P ③	②	p
0	0	0	1	1		Graphics Red	!	1	A / A ③	Q / Q ③	a	q
0	0	1	0	2		Graphics Green	"	2	B / B ③	R / R ③	b	r
0	0	1	1	3	①	Graphics Yellow	£ ②	3	C / C ③	S / S ③	c	s
0	1	0	0	4		Graphics Blue	$	4	D / D ③	T / T ③	d	t
0	1	0	1	5		Graphics Magenta	%	5	E / E ③	U / U ③	e	u
0	1	1	0	6		Graphics Cyan	&	6	F / F ③	V / V ③	f	v
0	1	1	1	7		Graphics White	'	7	G / G ③	W / W ③	g	w
1	0	0	0	8			(	8	H / H ③	X / X ③	h	x
1	0	0	1	9		Alpha^n Red	)	9	I / I ③	Y / Y ③	i	y
1	0	1	0	10		Alpha^n Green	*	:	J / J ③	Z / Z ③	j	z
1	0	1	1	11		Alpha^n Yellow	+	;	K / K ③	[② / [②③	k	{ ②
1	1	0	0	12	Flash	Alpha^n Blue	,	<	L / L ③	\ ② / \ ②③	l	| ②
1	1	0	1	13	Steady	Alpha^n Magenta	-	=	M / M ③	] ② /] ②③	m	} ②
1	1	1	0	14	End Box	Alpha^n Cyan	.	>	N / N ③	↑ ② / ↑ ②③	n	— ②
1	1	1	1	15	Start Box	Alpha^n White	/	?	O / O ③	_ / _ ③	o	DEL

control characters ④ (columns 1 and 2) to be displayed as spaces



character in alphanumerics mode — character in graphics mode

b_1	b_2
b_3	b_4
b_5	b_7

Graphics display rectangle showing the allocation of bit numbers to the individual cells

Notes
① This character code (position 0/3) is reserved for internal use by broadcasters
② UK version of national use character in the ISO-7 code
③ In the graphics mode when bit 6 = 0 the corresponding alphanumerics-mode character should be displayed
④ All character rows start in the 'Steady', 'Alphanumeric White' and 'unboxed' condition, without control characters.

Fig. 5. Characters possible in a Teletext display. Graphics are not in the ROM, being produced directly by the data bits.

the data which follows is written into the store, assuming that the parity checker is in agreement.

The outputs of the input processor are taken to the store and are (a) the 7-bit data (b) the "write" or "reject" command to the store (c) the row address and (d) the character address.

Store. Storage can take many forms, but the most convenient way to store the data while the page is assembled is the random-access memory, which is an array of semiconductor devices, often bistable circuits, set to "1" or "0" by input signals and which can be interrogated non-destructively when required by examining any desired location in the memory. No "order" is entailed: data can be lodged at any part of the memory.

Data are stored in 7-bit code as received from the 7-bit latch driving the data line in Fig. 7.

Display. The display of characters depends on the use of a large-scale integrated circuit — another form of store called a read-only memory. This is again an array of memory cells, but this time the pattern of bits read out of a given address in the memory is not under the control of the user. The form of the data is decided at the time of manufacture to perform a variety of functions, but the one in a Teletext decoder is a character generator, arranged to contain the characters shown in Fig. 5. Bits 1-7 in the configurations shown on the left, control the selection of display at the output. Bits 1-4 determine which row of character bits should be read out, while bits 5-7 indicate the column. For example, if the seven bits from the store were 0011010, bits 7, 6 and 5 (001) indicate that one of the undisplayed control characters in column 1 should be generated and bits 4, 3, 2 and 1 show that ROW 10 — alphanumerics, green — is required. The use of this invisible control character means that the visible, succeeding character shall be a green alphanumeric one, as opposed to the graphics alternative in columns 2, 3, 6 and 7. The next group of bits could be 1101001, in which case the result would be a green, lower-case "i" on the screen. A control character is not displayed, so that whenever the mode is changed — from alphanumerics to graphics or from picture to insert or from white to red — a space must appear.

There is one exception to this, and the space can be avoided when an alphanumeric character is needed close to graphics, with no control character space. Although the graphics characters are shown in Fig. 5, it is not meant to imply that they are contained in the ROM. Only the alphanumeric characters are held in the memory, the graphics being generated directly by the 7-bit code as received, as shown in Fig. 5. The area occupied by a character and its surrounding space can be separated into six "cells" which each have a bit of data allocated to them. All codes intended for display as graphics have a 1 as bit 6. However, if, while in the graphics mode, a code occurs with a 0 as bit 6, then those characters in columns 4 and 5 of Fig. 5 will be displayed — a limited selection of alphanumerics, termed "blast-through" alphanumerics.

Fig. 8 shows the output processor, complete with character generator and timing circuits, synchronized by line and field sync pulses. Characters are built up from dots at the 7MHz clock frequency and a dot clock is therefore required. The number of elements or dots in the width of a character is six (5 in the character and a space) and a 6-counter produces an output at each character. These two outputs are used to serialize the outputs of the ROM, and a 40-counter with a 6-line output is applied to the store, instructing it to provide successive character codes to the ROM which generates the pattern for each new character.

Line sync is also applied to a "divide-by-10" counter, which ensures that the store addresses the ROM for 10 lines in each character, giving 7 scanning lines for the character and 3 scanning lines space between characters. A 24-counter addresses the 24 rows of data in the store.

A further block in the display circuitry is the controls decoder which recognizes the control characters in columns 0 and 1 of Fig. 6, to produce RGB drives, blanking to provide a box for inserts and a "flashing" instruction. Graphics are produced, under command from the controls decoder, by the graphics generator on the principle previously mentioned and illustrated in Fig. 5.

Finally, the interpolator can be used to obtain a slightly improved appearance to characters which include a diagonal (Y, Z, K, etc.). The principle is to take advantage of the fact that interlacing effectively provides 14 lines

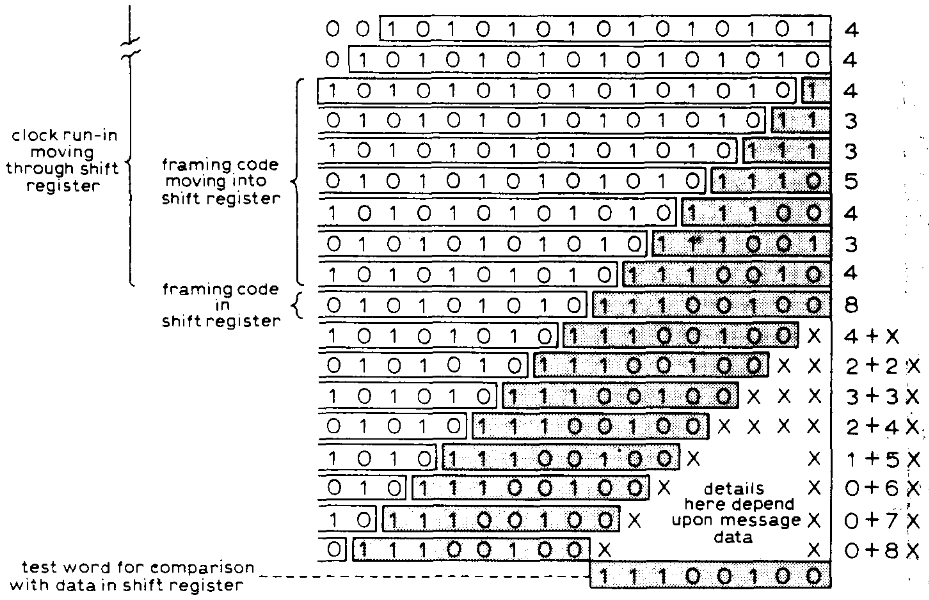
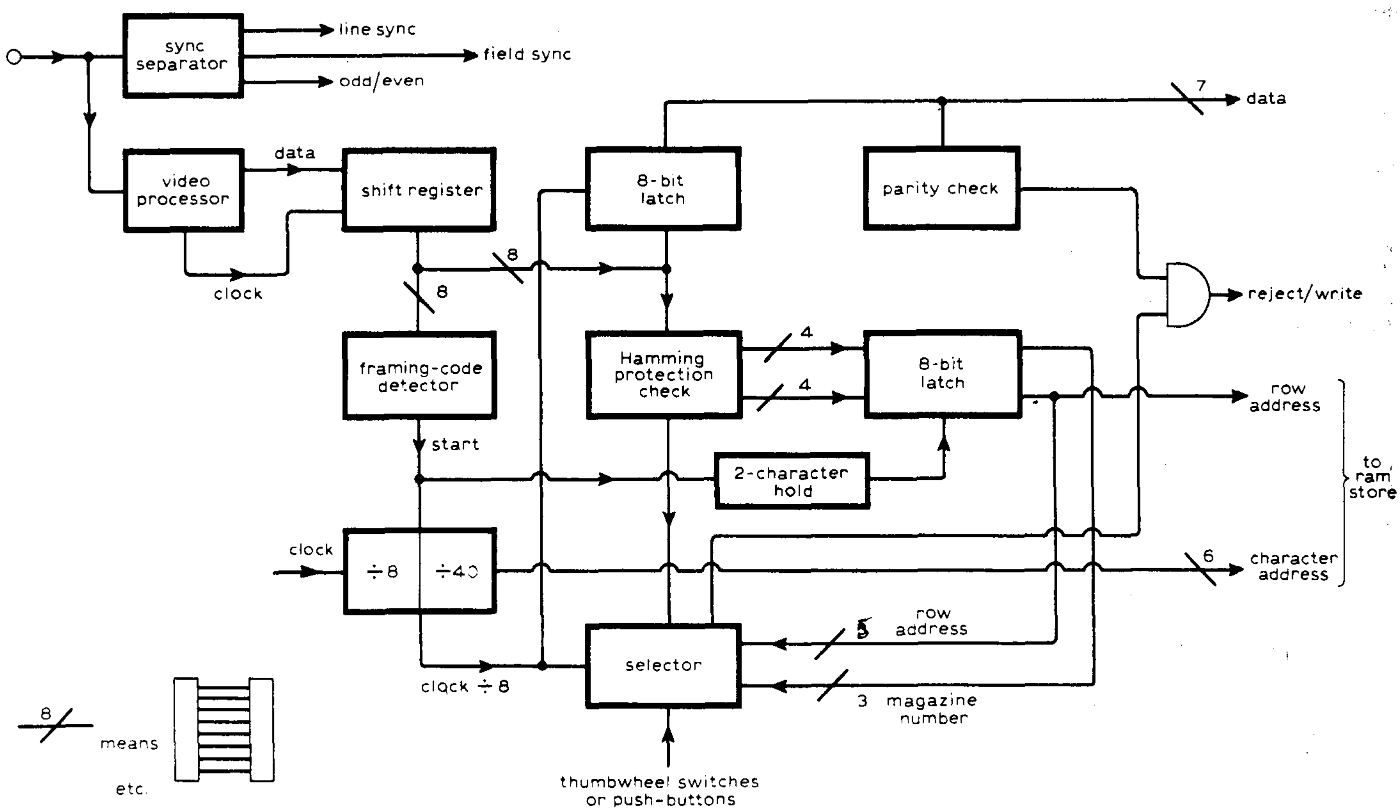


Fig. 6. The framing code in progress through the shift register, and in position on the 10th row down. At no time other than at coincidence are more than 5 bits in the register in correspondence with the reference word 11100100.

Fig. 7. The input processor block diagram.



in a character, not 7, and to "fill in" the steps produced by the 7 stored lines. An odd/even field command can be derived and used to synchronize the interpolator, which is also used to make the flashing signal effective.

That is the principle of the decoder, very briefly. In a short article, it is not possible to cover all aspects and it was not the intention. Forthcoming articles will describe the circuit in detail and provide complete information on the construction of a decoder that will differ from this general picture in several respects. Many savings in cost have been found possible by circuit changes which have also made possible a unit which is much smaller than envisaged.

(To be continued)

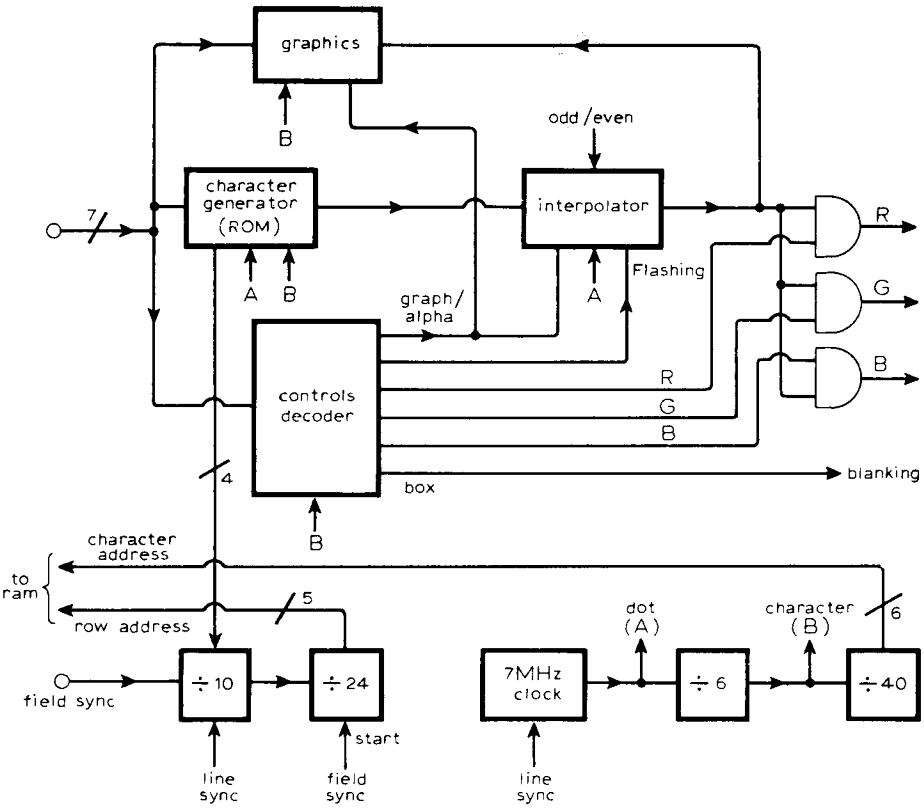


Fig. 8. A typical output processor.

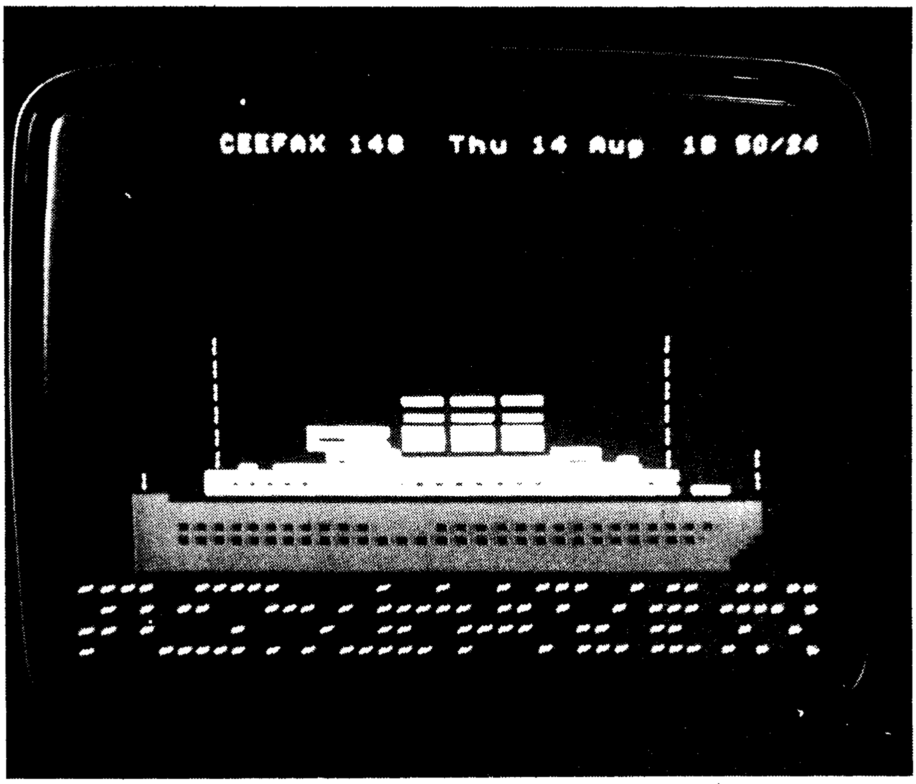
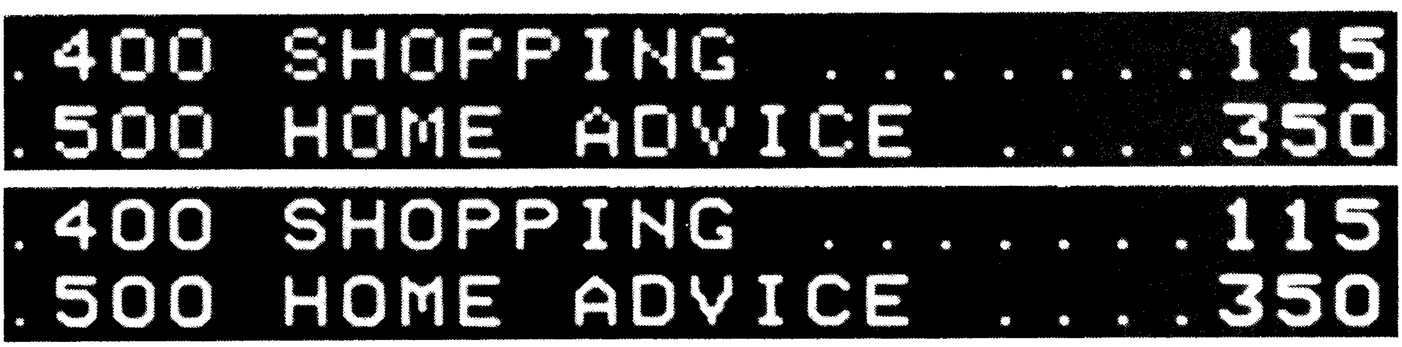


Fig. 9. An example of the use of graphics.

References

1. Gassman, G.-G. "Twelve Sound Channels during the Vertical Sync Interval of the Television Signal", ITT Chicago Spring Conference, June 1970.
2. Ball, J. D. & Wells, D. R. "Encoded captioning of television for the deaf". International Television Symposium, Montreux, 1973.
3. Guillermin, J., Dumont, J. & Guinet, Y. "Transmission of remote control and identification signals within audio and video channels in radio and television broadcasting", I.E.E. Conference Publication No. 25, November, 1966.
4. Numaguchi, Yasutaka. "Still Picture Broadcasting System", NHK Laboratories Note No. 174, January 1974.
5. Houghton, W. D. "Homefax – a consumer information system", *RCA Engineer*, Vol. 16, No. 5, Feb./Mar., 1971.
6. King, Patrick T. "A Novel Television Add-On Data Communication System", *Journal of the S.M.P.T.E.*, Vol. 83, January 1974.
7. Hutt, P. R. "A system of Data Transmission in the Vertical Interval of the Television Signal. IBC 1972 Conference Publication No. 88, pp. 131-140.
8. "Specification of standards for information transmission by digitally-coded signals in the field-blanking interval of 625-line television systems". Published jointly by BBC, IBA and BREMA. October 1974.
9. Hamming, R. W. 'Error Detecting and Error Correcting Codes," *Bell System Technical Journal*, Vol. XXVI, 2 April, 1950.

Fig. 10. Extracts from an Oracle index page, showing the normal appearance at (top) and the effect of character rounding (bottom). This is an IBA photograph taken from the screen of a studio monitor. On a domestic receiver, the effect is not as pronounced.



The consultants

An investigation of the role of independent engineering consultants

by John Dwyer

"Most consultants leave a trail of disaster in their wake . . . Most of the so-called household names I wouldn't let within two miles of our factory." This trenchant observation came from Raymond Cooke, managing director of KEF Electronics, who went on to say in a recent interview that he thought the name consultant was grossly misused: "Anyone with an Avo with a bent needle can set himself up as a consultant."

His view was echoed by Derek Bond of Ferrograph, who was in no doubt about the capabilities of consultants: 'It would be disastrous in my opinion to use these guys where you're committed to a tight production schedule, because they're just not suited to it. They are generally much more aware of the trends in basics but they haven't got a clue about equipment practice.'

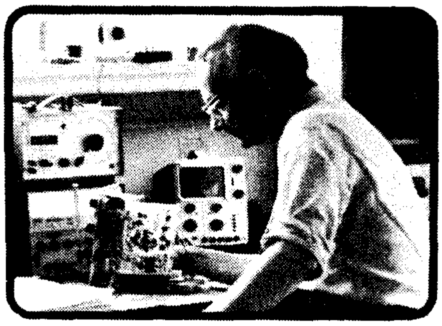
These comments seem particularly significant because they come from people who do employ consultants. At one time or another such diverse organisations as EMI, Plessey, Cambridge Audio, Rank, Garrard, Ferrograph, Sinclair, Marsden Hall, Strathearn Audio, Quad, Decca, Lecson, IMF, Metrosound, Audiotronics (Laskys), Technics, Sony, 3M, BASF, B&W, Capitol, Audio Devices and the BBC and IBA have used consultants, even though many of them denied that they did so. One or two firms, particularly in the hi-fi market, make such extensive use of outside contractors and advice that all they can be said to do is to market a product someone else has designed, made and put the client's name to.

As the foregoing list shows, there is no particular type of company that uses consultants more than another, but the reasons for which they use them tend to be similar. Peter Walker of Acoustical Manufacturing said: 'If we need expertise in a particular area or we're a bit busy we take on a consultant.'

Another common use of consultants is to assess equipment about to go into production, as Grahame West of National Panasonic explained: 'The reason is that we're totally involved in what we're doing and we can't see the wood for the trees. An outside person may be able to pick out things we hadn't noticed.'

Another reason for the need for assessment is to check that imported equipment, whether from a parent company or some other, conforms to its specifications and to British safety standards. British law is often more strict in these matters than foreign law.

The law, indeed, often provides consultants with work, perhaps the best known example being Hugh Ford's study of covert tape recordings, which was extensively publicised during the trial of the two Scotland Yard detectives who were bugged by *The Times* newspaper. James Moir, an expert in



Well known contributor to Wireless World, Peter Baxandall.

loudspeaker designing and assessment, noise problems in council flats, prisons, penthouses, and power stations, and electronic circuit design, was retained by Tandberg during their patent suit against Akai.

In manufacturing, free advice is plentiful but often such advice is not independent. You can't be sure a man selling i.cs is conveying the best way of doing a job, or purveying the best way of swelling his commission. You employ a technical consultant to get advice on a subject with which you are unfamilar, for which you are not equipped or your capacity is overloaded, in the hope that the advice will be free of commercial bias. This means not only that the consultant is not financially linked with any manufacturer but that ideally any private shareholdings he has are unconnected with his work. In another case, like that of Angus McKenzie, who has shares in EMI, Plessey and other firms, the consultant should agree to tell you what those shareholdings are. Mr McKenzie said he would be glad to tell any clients of his interests.

There are many other reasons for a consultant's need to be independent. One is that the potential client must not feel the consultant may be in competition with him. Another was advanced by Geoff Evans, founder and managing director of Warren Point: 'A supplier can only supply from what's in his brochure. An independent consultant can often find a supplier who suits what you want. The point is we can shop around.'

Warren Point have set up a company which supplies automatic test equipment, but they say they keep even that 'at arm's length.' Evans likes to think that the company has to wear two hats: 'The first is advisory, then there's the implementation hat. We're in touch with the implementation people, but not influenced by them. If you get your hands dirty you can advise, if you don't, you can't.'

Indeed, one of the major criticisms of consultants was that they tended to know a lot of theory and a lot less about the practicalities. Raymond Cooke explained his views more fully: 'A consultant soon runs to the end of his knowledge. A good example is the use of solid state devices. Those who use them on a large scale know a great deal more about these than the chap who does a "lashup" now and again . . . The specification is not enough. Most manufacturers will tell you that the running specifications are miles outside what they should be and the other parameters, the crucial ones, are not quoted, and those are the ones that let you down. Ask any manufacturer what his greatest problem is and he will tell you the variability of devices.'

Stan Curtis of Cambridge Audio said that one consultant had produced a superb design 'but it was too good. It would have been all right if we had only wanted to produce one a month.' In future they would use consultants for specific problems rather than hand over entire projects to them.

Production engineering is a specialised skill which some thought outside the ken of consultants, and one engineer remarked that the production engineer needed to be familiar with the constraints of the plant and staff, which would only be possible if the engineer were loaned to the client for a year or so, in which case the client may as well hire one himself.

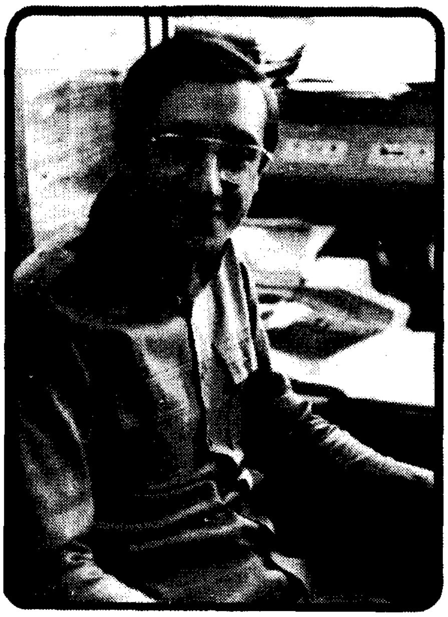
Yet many firms use consultants to advise them how to fill up spare production capacity, and let them see a new product through from design to production. The company of PA Consultants have often done this, perhaps the best example being Strathearn Audio, which had no product line at all before PA arrived. The Advanced Production Technology Unit of PA will develop, research, and produce a product, recruit and train staff, build any special production machinery and even make a small production line which can then be transferred to the client's plant.

Peter Baxandall, with far less commercial test gear at his command and a preference for using easily modified home-made equipment for much of his work, had a similar view. 'There are two schools of thought on this. One is that the designer does his sums and draws a diagram and that's the end of it, and if it hums and needs a bit of screening that isn't really his concern. I never take that view. The job of the good circuit designer is to see the thing through and these practical things are part of it.' To quote from Cherry and Hooper,† 'If pen and paper design is an art, then completion of the design to the hardware stage is an art of a higher order.'

He admitted he sometimes became absorbed in the merely interesting but unremunerative. Hugh Ford agreed. 'You're always looking for perfection, but you've got to give and take. You've got to compromise because the thing has got to be made to a price. Usually what you're doing is saying "These are the areas for improvement".'

On this, one observer, who has worked in most branches of electronic engineering, said he thought it was not the consultant's job to keep his own feet on the ground. 'For instance, if the consultant says the best way to do this is to use high vacuum technology, someone has to say to him "Well we don't want to get involved in that. What are the alternatives?" And he says this, this and this and the client says "We'll do *this* because we know how to do it".' There had to be continuous communication between client and consultant.

†Amplifying Devices and Low Pass Amplifier Design by E. M. Cherry and D. E. Hooper, Wiley, 1968.



Roger Driscoll, of the North London Polytechnic.

Geoff Evans of Warren Point even stressed the value of knowing how to use the client's old plant, say an oven, in the design of the new system, if that were what the client wanted.

Academics in consultancy

Because he thinks many consultants haven't got their feet on the ground John Deutsch calls himself a freelance computer systems designer, and he's particularly critical of the practical ability of many of his colleagues: 'They've overlooked the problems that can occur, and this is particularly true of academics. My job in the computer industry is to make the equipment do what the user wants. For example any systems where money is concerned have to be safe. There has to be a deliberate rigidity built into the system so that it's not easy to access once you've put the information in.'

His feeling about academics is widespread, and one commentator remarked about their 'Ivory Tower' approach. Roger Driscoll, lecturer at the North London Polytechnic, dismissed the charge: 'On the contrary the very fact that we have this close association with the press and with industry keeps us in touch.' Some might be churlish enough to argue that close association with industry is not the same as being in industry, but if one accepts that the academic community has a great deal to offer industry, there are still other sources of resentment against the academics. One that gives a great deal of contemptuous amusement is the perpetual paper chase through Milton's 'grove of Academe,' the ceaseless agglomeration of honorifics to add to the notepaper, a sense that scientific knowledge is of less importance than the acknowledgement of other scientists. Another reason for the resentment is even older.

It was perhaps best expressed by James Moir, a man who is obviously successful, drives a powder green Jaguar and owns a slice of Hertfordshire that extends, as he puts it, 'as far as you can see'. Yet he feels threatened by competition from the denizens of university departments that are equipped with public money. 'They're all at this,' he said. 'It even goes down to the technical colleges where the physics master has set himself up as an acoustic consultant. And not just acoustics, they're doing all kinds of other things as well.' The apogee of sheer cheek must have been reached in one individual who attended a symposium Moir gave some years ago. 'He took away the notes we handed out and said to himself "This looks like a good thing", and the next thing I saw was that he was advertising himself as an independent consultant.'

How did Roger Driscoll of the North London Polytechnic justify this use of public resources, presumably to fill his own pocket: 'The money isn't the thing that counts. My consultancy work helps the college because it is good for the recruitment of interested students. Our connections with the press and with local industry helps the students to become known in industry and make it easier to place graduate students when the time comes for them to leave college.'

He acknowledged that he was using publicly owned equipment but said that he didn't charge nearly as much as outside consultants. 'I estimate that my income from consultancy could be counted in hundreds of pounds before tax.' Until recently all consultancy fees at the N.L.P. used to go into various pockets but now a pool has been started into which the lecturers pay part of the fees they receive. 'It varies. It's usually about a third.'

About one in six of the lecturers at the N.L.P. did consultancy work, mostly because they were not in disciplines where such work was appropriate. Driscoll emphasised that the amount of free time lecturers had was exaggerated: 'The amount of time actually spent in the lecture room may seem small, possibly only five or six hours a week, but a considerable amount more, maybe 15 or 20 hours a week, is spent in preparation for lectures.'

Many of the reasons for or against using consultants are paradoxical. For instance, their non-involvement in manufacturing gives them independence, but that non-involvement may reduce their ability to help.

Cambridge Consultants used to be involved in manufacturing, and it was a none too happy experience. They set up three companies not long after the firm was founded in 1960, one of which was Cambridge Audio, now no longer linked with them. The consultancy service did well but the manufacturing interests foundered and dragged Cambridge Consultants down with them. The bankruptcy may still be having its effects.

Peter Baxandall: 'The consultant is dependent on being successful, because if he makes a mess of it it will get around. So he has to be careful not to take on the wrong job, either because it's too large or too difficult or it's likely to have an unsatisfactory outcome. He has to have a knowledge of the firm he's dealing with.'

Paying a consultant to learn

Another paradox of using a consultant is that the client, having called him in, has to brief him extensively, not just on one particular problem perhaps, but on the client's entire process, of which the consultant may have no previous knowledge. Thus the client is paying the consultant to gain knowledge and experience that may one day benefit the client's competitors.

Dr Robin Smith-Saville of Cambridge Consultants did not think this was a problem. 'First of all if you're working for the government they don't mind your learning at their expense. Secondly if a company is working with a product that is going to give them a good market they don't mind putting cash into it.' Bob Stuart of Boothroyd Stuart said they didn't charge clients for learning time. Others said that not knowing the process would be part of the objectivity the client was paying for. Many gained clients because of their experience of other manufacturers in the same business; many firms take on a consultant because they want to know what their competitors are doing. This particularly applies in consumer electronics, where many consultants may do a great deal of equipment reviewing for magazines.

Technical reviews for magazines are a fruitful source of revenue for consultants. This is not because the magazines pay well, as any consultant, particularly one who doesn't seem to need the money, will tell you, but because signed articles attract business. The consultants I spoke to did not advertise directly, though only one of them, Moir, indicated that he was aware of any restriction on doing so. 'Most professional people are prevented from advertising,' he said.

A spokesman for the I.E.E. admitted that their restrictions were largely imitative of the legal and medical professions. Rules 9 and 14 state: 'A member shall not, in self-laudatory language or in any manner derogatory to the dignity of the profession of electrical engineers, advertise or write articles for publication, not shall he authorise any such advertisement or article to be written or published by any person.' An explanatory paragraph later explains that the stress is on the word 'self-laudatory,' and the engineer must not suggest he is more competent than other engineers. He is not allowed, as a consultant, to 'improperly solicit' work.

Most of the consultants I spoke to said their work came either from personal recommendation or from people with whom they had worked before.

The relationship with the press introduces the extent to which the activities of consultants are secret. A difficulty here is that for a consultant to carry on his business successfully he must tell potential clients what he has worked on in the past and, if he over consciencious, this may put him in a difficulty. In practice this does not seem to present too much of a problem.

The most secretive consultant organisation perhaps, is PA, which started as Personnel Administration in 1943 when it was advising on Spitfire production. They now claim to be the largest consultancy in the world, with a world-wide staff of 2,000 and a staff of 100, many of them Ph.Ds, at their new research centre in the Hertfordshire countryside. To begin with they have taken elaborate precautions to make sure the firm is not taken over and its secrets plundered thereby. In the mid-fifties they made PA a profit making trust, which is now administered by 'three or four people of sound reputation' in the city and elsewhere. Unlike other consultants, who did not regard working at some future date for a present client's competitor a problem, PA undertake never to work for a competitor.

Angus McKenzie in his laboratory.

Potential recruits to PA, 90 per cent of whose consultants have degrees or a professional qualification, have to undertake not to leave to work for a client, and not only do PA give the usual undertaking not to disclose for whom they are working, but they bind the client contractually from telling anyone that they have PA working for them.

However, other parts of the PA organisation may be working for competitors and so some PA staff are not allowed into the PATS Centre International Laboratories in Hertfordshire. PA have made confidentiality a special part of their service. 'Our secrecy,' said Gordon Edge, 'is an added recommendation.'

One can see why clients should keep their use of consultants quiet, before a product goes on the market. What seems more strange is that the use of a consultant should be kept secret after that, particularly in electronic consumer products. Many firms insisted they did not use consultants even though incontrovertable evidence existed that they did.

Angus McKenzie offered a simple but appealing explanation: 'They feel their prestige will be much lower if the public is told that (the company) had to go outside their big empire. They like to think they've got all the best brains in the country under one roof."

One would have thought the public might be impressed by the resourcefulness of a company that used consultants. Graham West, of Technics, said: 'I think it's just pride. I think it's a mistake because it must be of benefit to them to let the consumer know they've taken a lot of trouble to make sure the product is correct.' Many suggested, however, that idea was much too complicated. Alan Hall-Williams, of Strathearn, said: 'Talking about whether or not a company uses consultants may cloud the issue.' The public didn't care as long as the product worked properly.

Gordon Edge thought the companies had better reasons: 'It's not pride. This is silly because the modern sophisticated company treats the consultant as one of the tools he has available to help him do the job. Firms don't rely on us to do all the R & D by any means and they buy the tools they need, use them and then turn the tool off.'

Sony UK's marketing manager said that Sony had never used consultants but thought the reason that other firms might want to conceal their own use of them was that 'maybe they don't want to lose the consultant to another manufacturer, or that he may sell a similar design to another manufacturer. That's the only danger I think.'

Perhaps some are afraid, like the sign writer who makes all the newsagents within five miles look as if they're under the same ownership, the use of a specialist consultant will produce uniformity. This might be true if the same consultant were asked to design similar products for competing manufacturers at the same time. As Hugh Ford said, this rarely happens: 'Ideas change, new products come on the market, new transistors, new i.cs become available so that's not a problem. It depends on the period of time that elapses between working for a client and his competitor. If there is a problem you can phone up the previous people you did the work for and say "Look, I've been asked to do this." Usually they don't mind but if they do, you tell the customer "I'm sorry I can't do it. I suggest you contact X".'

Peter Baxandall commented that he tried to avoid working for directly competing firms, and had, for instance, only accepted one audio amplifier design commission. In many cases there is no conflict because an amplifier costing £150 is a very different product from one that costs £50.

Many firms commented that a consultant would not appreciate their design philosophy as well as their own staff. Hugh Ford reported: 'In fact, I think this is a strong case *for* getting a consultant. Firms get dyed in their ways and they ought to bring somebody in to examine the end product. Manufacturers don't do this enough, and you'd be amazed at the awful clangers that have been dropped by even well known firms.' Bob Stuart also thought the complaint groundless: 'If a company is bringing in a consultant they must be wanting to change their image anyway.'

Although the consultant has no loyalty to the firm other than the fee, in Bob Stuart's words 'You want clients to come back to you.' Indeed he said he regarded this as a measure of a consultant's success. In each case research staff are not obliged to stay with companies forever, and consultants may provide better continuity then one's own staff.

In this connection Geoff Evans saw a problem for the client who went to a large-system house for a one-off system. 'They are basically production companies and they are prototype oriented. Their engineers are there to fill spare production capacity, so that the one-off job is given to the young graduates, with obvious results. They have a high staff turnover because the lad gets so far into the job, panics, leaves and usually leaves no documentation behind him when he goes.' The customer will get this equipment in the end, said Evans – probably one of the reasons he went to a large system house was that he knew it wouldn't go broke – but it will often be late, 'and usually if a firm can put up with late delivery it means that either they've ordered the thing at the wrong time or they don't need it at all. Most of his own staff, he said, had been at Warren Point for seven years.

One view often expressed was that having one's own staff on the premises was much more convenient than calling out a consultant when a problem occurred. This indeed, was the basis of Derek Bond's remark at the beginning of this article. On the other hand, in a recent article in the journal *Communications International*, Dr Robin Smith-Saville of Cambridge Consultants made the following point about consultants: 'In communications it would be rash to claim that they can do anything which is beyond the capabilities of the rest of the industry but they have outstanding skills in special areas. These skills coupled with their independence and accessibility give them their special role in the industry.' In what way accessible? 'I meant accessible as opposed to a specialist engineer in Marconi or one of the other large firms', he said. Often such an engineer couldn't be found when he was wanted.

One design manager, who wished to remain anonymous, said hiring a consultant was much more convenient than going through the business of advertising for staff, interviewing and waiting for the successful candidate to

Jonathan Pope, a consultant at PATS Centre.

work out his notice. In addition the R & D engineer needs to be kept fully occupied and has to be backed up with a great deal of expensive equipment in addition to the non-productive space he takes up.

Mike East, public relations adviser to Warren Point, said, 'In the present economic situation using consultants becomes more important not less. It's a shelter for many firms because they pay a fixed fee, there are no overheads and so they cost for it.'

As regards fees, there are various methods of computation. Boothroyd Stuart work on a flat fee plus a royalty. 'This gives us an incentive to ensure success, and it limits the client's costs at the beginning, the very time when he needs the money.' Roger Driscoll saw a snag: 'With a royalty payment you could become identified with the company.' On the other hand, many manufacturers do as Marsden Hall do, paying consultants on an annual retainer with an additional fee for specific projects. This too would identify the consultant with the company.

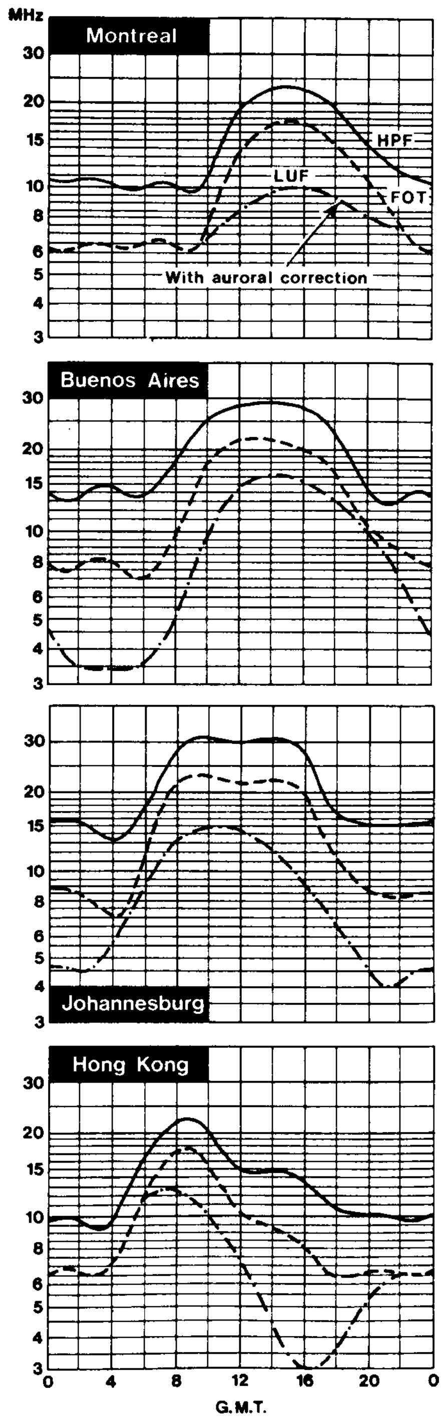
For £100 a day the client may buy the services of the large group consultancies. Individual consultants normally charge a great deal less, £50 a day upwards, although Angus McKenzie charges £100, he told me, which does seem just a little high. A university or college lecturer using borrowed equipment may charge £30 or £40 a day; one suggestion is that whatever they charge, and it could be raised to the usual rate, the money should be returned to the education service and the work counted as part of the duties for which the lecturers are already well paid, a productive means of lengthening that 26-hour week.

Whoever the consultant is, Derek Bond warns: 'Unless they pull their socks up and get a bit more production oriented we won't be using consultants much in future. If they're cheap we'll use them, but if they're not, we won't.'

HF predictions

Onset of winter conditions brings a notable increase in northern hemisphere mid-latitude daytime FOTs. The charts show how this effect is modified by differences in local time at the ends of a circuit. For example taking UK daytime as 07 to 19GMT and Hongkong daytime as 23 through 11GMT the complete path is in daylight from 07 to 11GMT. Similarly the Montreal path is not fully lit until 11GMT, since it lies to the west, but then continues lit until 19GMT as path length is relatively short.

The southern hemisphere is of course changing to summer conditions. Ionospheric control points for Johannesburg and Buenos Aires are at equatorial and lower mid-latitudes so their FOTs are not greatly affected however.



Meetings

NOVEMBER

LONDON

4th. IEE — Colloquium on "Piezoelectric and pyroelectric materials and applications" at 10.30 at Savoy Pl., WC2.

4th. IEE/RTS/BKSTS—"A dual-guage multi-standard telecine" by J. D. Millward at 19.00 at Savoy Pl., WC2.

5th. AES — "Blumlein in the low frequency jungle" by P. B. Vanderlyn at 19.15 at the IEE, Savoy Pl., WC2.

6th. IEE — Colloquium on "Electrical phenomena on insulating surfaces in gases and in vacuum" at 10.30 at Savoy Pl., WC2.

6th. IEE/IERE — Colloquium on "Distributed information systems" at 14.00 at 9 Bedford Sq., WC1.

10th. IEE — Discussion on "SAW resonators: a new challenge to conventional crystal filters and oscillators" at 17.30 at Savoy Pl., WC2.

11th. IEE — "Fuzzy algorithms — systems and control applications" by Dr E. H. Mamdani, Prof. P. K. M'Pherson and Dr B. R. Gaines at 17.30 at Savoy Pl., WC2.

11th. IEE — "A single axis tracking earth station" by D. W. Longhurst and "Investigation of step track aerial steering techniques" by R. J. Jones at 17.30 at Savoy Pl., WC2.

12th. IERE — Coloquium on "Wedding calculators to instruments" at 10.00 at 9 Bedford Sq., WC1.

12th. I. Phys./IEE — One-day meeting on "Compound semiconductors" at Imperial College, SW7.

12th. IEE — "The scanning acoustical microscope" by Prof. R. Kompfner at 17.30 at Savoy Pl., WC2.

12th. BKSTS. — "The history and use of slides" by Brian Coe at 20.30 at NFT2, National Film Theatre, South Bank, Waterloo, SE1.

13th. RTS — "RTS Convention in retrospect" at 19.00 at the Conference Suite, London Weekend Television, South Bank TV Centre, Upper Ground, SE1.

14th. IEE — Colloquium on "Reliability of solid state microwave devices" at 10.30 at Savoy Pl., WC2.

14th. IEE — Colloquium on "Standard computer interfaces — where next?" at 10.30 at Savoy Pl., WC2.

17th. IEE — "What the common market means to engineers" by G. L. E. Metz at 18.30 at Savoy Pl., WC2.

18th. IEE — Colloquium on "Field effect device applications" at 10.30 at Savoy Pl., WC2.

20th. RTS — "SECAM — the other European colour standard" by Michael Cox at 19.00 at the Conference Suite, London Weekend Television, South Bank TV Centre, Upper Ground, SE1.

21st. I.Phys. — Meeting on "Metals and metallic compounds" at 10.00 at the Lecture Theatre, Geological Society, Burlington House, Piccadilly, W1.

25th. IEE — Colloquium on "Radio interference and the BSI" at 10.30 at Savoy Pl., WC2.

25th. IEE/IERE — Colloquium on "Patient monitoring" at 10.30 at Savoy Pl., WC2.

25th. IEE/IEETE — Discussion on "Aids in the teaching and learning of electrical subjects" at Polytechnic of Central London, 309 Regent St., W1.

26th. IERE — Colloquium on "Industrial cathode ray tubes" at 14.00 at 9 Bedford Sq., WC1.

26th. BKSTS. — "The overhead projector — a versatile visual aid" by L. S. Powell at 19.30 at Thames Television Theatre, 308-316 Euston Rd., NW1.

27th. RTS — "Computers in support of the production and transmission processes" by R. C. Evens and C. Lashmar at 19.00 at the Conference Suite, London Weekend Television, South Bank TV Centre, Upper Ground, SE1.

27th. IERE — Two joint lectures on "The development of the Mediator project for air traffic control" at 18.00 at 9 Bedford Sq., WC1.

BEDFORD

18th. IERE — "Large scale integrated circuits for Teletext decoding" by D. Spicer at 19.45 at Room 7/1, Mander College.

BELFAST

4th. IERE — "Voice recognition by computer" by Dr R. Lingard at 19.00 at Cregagh Technical College.

BIRMINGHAM

19th. SERT — "The selection of the correct hi-fi record cartridge for a given system" by A. Munro at 19.30 at the Byng Kendrick Suite, University of Aston.

19th. RTS — 1975 Fleming Memorial lecture "Television: Parliament and people" at 19.00 at BBC Broadcasting Centre, Pebble Mill Road.

20th. CEI/IERE — "Space technology" by G. K. C. Pardoe at 18.30 at Vaughan Jeffreys Lecture Theatre, University of Birmingham (School of Education).

BRIDGWATER

11th. IEETE. — "Mobile radio communications" by Prof. W. Gosling, at 19.30 at Royal Clarence Hotel, Cornhill.

BRISTOL

19th. CEI — "Engineering for survival" by Prof. Meredith Thring at 19.00 at the Lecture Room, School of Chemistry, University of Bristol.

BROMLEY

12th. IEETE. — "Electronics in commercial vehicles" by G. Leonard at 19.30 at Bromley College of Technology, Rookery Lane.

CAMBRIDGE

27th. IEE/IERE — "Videodisc" by speaker from Mullard at 18.00 at The University Engineering Laboratories, Trumpington Street.

CARDIFF

12th. IERE — AGM South Wales Section followed by "The Omega system of navigation" by R. C. V. Macario at 18.15 at the Dept. of Applied Physics and Electronics, UWIST.

CHATHAM

27th. IERE — "Recent advances in calculator technology" by R. Bradbeer at 19.00 at Medway and Maidstone College of Technology.

COLCHESTER

12th. IEE — "Techniques and achievements of radio astronomy" by Prof. A. Hewish at 19.00 at University of Essex.

HEMEL HEMPSTEAD

20th. IEE — "Thermal imaging — techniques and applications" by W. Lawson at 19.30 at Dacorum College of Further Education.

HULL

12th. SERT — "U-matic video cassette" by a representative of Sony (UK) Ltd at 19.00 at Hull College of Technology.

IPSWICH

5th. IEE/IERE — "Viewdata — an interactive information service for the general public" by S. Fedida at 18.30 at The Great White Horse Hotel, Tavern Street.

LEICESTER

11th. IEE/IERE — "Dolby noise reduction system" by I. Hardcastle at 19.00 at the Lecture Theatre, Chemistry Dept., Leicester University.

LINCOLN

20th. SERT — "Receiving aerials" by R. S. Roberts at 20.00 at the Refectory of Lincoln Technical College.

LIVERPOOL

12th. IERE — "Radio astronomy" by Dr A. G. Lyne at 19.00 at the Dept. of Electrical Engineering and Electronics, University of Liverpool.

MANCHESTER

13th. IERE — "Radio astronomy — bird's-eye view" by Miss Hilary Exton at 18.15 at the Lecture Theatre R/H10, Renold Building, UMIST.

27th. SERT — "TCE 9000 colour television chassis" by K. Harris at 19.00 at the Lecture Theatre C10, Manchester Polytechnic.

NEWPORT, I.o.W.

14th. IERE — "Hybrid integrated microwave amplifiers" by Dr S. J. Hewitt and R. S. Pengelly at 19.00 at Isle of Wight College of Arts and Technology.

NORWICH

12th. IERE — "Communications of the future" by Dr P. D. Whitaker at 19.00 at The Audio Visual Centre, University of East Anglia.

PLYMOUTH

13th. IEE/IERE — "ORACLE — a broadcast information service" by D. Wood at 19.00 at Plymouth Polytechnic.

PORTSMOUTH

26th. IERE — "Future trends in primary radar systems" by K. Milne at 19.30 at Portsmouth Polytechnic, Park Road, Room ABO 11.

READING

3rd. SERT — "Medical instrumentation" by P. Sibley at 20.00 at the Post House Hotel, Basingstoke Road.

4th. IERE — "Electronics in medicine" by Dr D. W. Hill at 19.30 at Caversham Bridge Hotel, Caversham Road.

REDHILL

11th. IEE — "MADGE — helicopter landing system" by H. L. Derwent at 19.30 at Mullard Research Labs, Cross Oak Lane, Salfords.

SHEFFIELD

19th. IERE — "Electronic control and communications on motorways" by Supt. Hambrey at 19.00 at Dept. of Physics, Sheffield University.

26th. IERE — "Signals and systems — what do we know?" by D. Brook at 18.30 at Sheffield Telephone House, Charter Square.

SLOUGH

5th. I. Phys. — One-day meeting on "Physics of detection and surveillance" at the Fulmer Research Institute, Stoke Poges.

SOUTHAMPTON

12th. IERE — "V.h.f./f.m. broadcast reception" by R. S. Broom at 19.30 at Southampton College of Technology, East Park Terrace.

19th. IEE/IERE — "Application of semiconductor devices to protection" by M. C. S. Simpson at 18.30 at Lanchester Building, University of Southampton.

UXBRIDGE

28th. IEE — "Some aspect of artificial intelligence" by Prof. I. Aleksander at 18.30 at Brunel University, Kingston Lane.

WHITBY

11th. IERE — "Fly-by-wire flight control systems" by Flt.Lt. P. L. Hills at 19.00 at Botham's Cafe.

Tickets are required for some meetings: readers are advised therefore to contact the society concerned.

News of the Month

IEE to resign from CEI

The Institute of Electrical Engineers has decided to give notice of its intention to resign from the Council of Engineering Institutions on December 31 next year. A statement by the IEE's President, James H. H. Merriman was issued as follows.

"As you know, we have endeavoured, with colleagues in other institutions, to secure a reform of the CEI that would make it representative of individual Chartered Engineers, regardless of their specialisation, who would freely elect its governing Board. We consider it essential to eliminate, or at least substantially dilute, responsibility of the Board to the institutions because we are sure this has been the main cause of the CEI's inability to act promptly and effectively. It is excessively difficult for fifteen sovereign institutions- probably more in the future — to reach agreement on important matters.

"The constitutional changes agreed by twelve of the fifteen institutions at the CEI meeting on 24th July, by which each institution will elect one representative on the Board, would not, in our view, dissociate the CEI from the overriding influence of the institutions. We considered that this decision represented the limit to which a majority of other institutions were prepared to go to meet our views, and that further progress could only be expected to take place, if at all, in a future far more distant than we believe our members would tolerate. In these circumstances, our council thought the only proper course was to give notice of resignation . . . In the meantime, we shall play our part in the CEI in a constructive and conciliatory manner so that if, at the end of the day, we decide we must withdraw, we may do so without rancour, and in circumstances that will enable us to collaborate in friendship with the other engineering institutions and with the CEI itself."

Buy British audio

September saw the announcement of two campaigns intended to promote British audio products both here and overseas. The first starts with a recent exhibition at the Design Centre, Haymarket, and is promoted jointly with a group of 18 well known retailers from all parts of the U.K.

Based on the slogan "the best of British", the advertisements list the dealers who have joined the group and outline the advantages of a new guarantee and service agreement offered. In each instance, the dealers are promoting British made products and providing a passport-like document, with each purchase. This offers a two-year free parts and labour guarantee on listed British items, purchased and entered in the document, with the exception of the pick-up cartridge stylus.

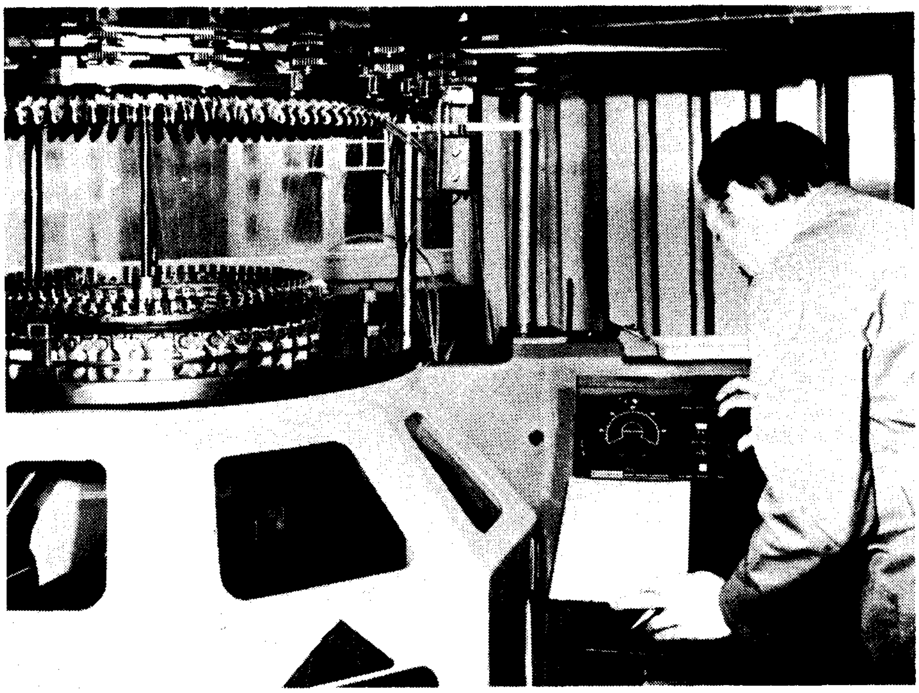
Parallel to this campaign a loose grouping of a number of well known British manufacturers has been created to improve overseas promotion and exhibition activity. The impetus to this movement came from what one spokesman called "the poor stand location and tatty appearance" of the joint British stand at this year's Chicago Consumer Electronic Show.

The group plan to start a twice yearly promotional magazine which will be circulated among some U.K. dealers and extensively in potential overseas markets. The magazine is to be edited by Denys Killick, the technical editor of *Cassettes and Cartridges*.

Just how successful this latest idea will be is difficult to judge, since it is embryonic, but one leading British manufacturer, Rank-Audio Visual, pointed out that they and some other companies could be embarrassed by such a campaign, since they have a foot in both camps, importing Japanese products as well as making Leak and Wharfedale products. The comment was made that British products should be offered on the basis of a direct technical and quality comparison, not relying on patriotism to boost sales.

Push-button 'phones introduced

Push-button telephones will become generally available to customers in London next spring and elsewhere later in 1976. Calls are made by keying (see photograph), which is easier than dialling and enables users to put numbers into the telephone faster. Called the SC Keyphone, it is interchangeable with an ordinary dial telephone and may be used on most exchange lines and extensions. It uses an m.o.s. microcircuit designed by Pye TMC engineers which translates the keyed number into a chain of pulses identical to that produced by conventional rotary dial telephones. The Post Office's new D4000 specification has been drawn up to ensure that equipment incorporating m.o.s. circuits will achieve a 30-year fault-free lifetime and requires that test circuits designed to check process and production parameters be regularly submitted to the P.O. for accelerated life-time testing at extremes of temperature. Following successful market trials in London and the provinces, the P.O. has now placed contracts with GEC Telecommunications and Pye TMC for a total of 145,000 SC Keyphones. They will be offered to



Vernon H. Cooper Ltd's new yarn speed monitor can be used in conjunction with all types of knitting machines, both circular and flat and having varied rates of feed. The monitor incorporates EMI's electronic fabric control system.

Britain's telephone of the future is the self-contained Keyphone – see news item for details.

customers at an extra rental of £4 a quarter and there is an installation charge of £5.

Data buoy commissioned

The UK National Data Buoy was formally commissioned at Lowestoft on Friday, August 22 and is expected to be in position reporting automatically on sea and weather condition in the North Sea, in the early autumn (see 'Electronics in Oil', Jan. 1975 issue, p.8). The items of equipment have been supplied by Harwell's Electronics and Applied Physics Division. One of these measures the rate and direction of movement of the water while the other produces electric power for the buoy's instrumentation. In the current meter, ultrasonic pulses pass horizontally between two pairs of transducers mounted at right-angles to each other on spars projecting beneath the buoy. Differences between the times taken for the pulse forward and return journeys are measured electronically and combined with the buoy's compass bearing to give true direction and speed of the water's movement.

The thermomechanical generator, which powers all the buoy's instruments and the sea-to-shore communications system, is a Harwell development of the Stirling Cycle Engine and provides a continuous output of 25W from the combustion of 200kg/year of propane gas.

New computer breed

The Science Research Council has made a grant of £8,000 for work on a graphically patched hybrid computer being undertaken by Mr Peter Atkinson of the Department of Engineering and Cybernetics at Reading University. In a hybrid computer, simulation runs on the analogue computer are controlled by a digital machine which also logs data. Once a problem has been programmed it can then be left on the hybrid computer to run itself until the problem has been solved. The one remaining difficulty at present is that the analogue machine has to be wire connected ("patched") by hand before the programme may be run. The patching must be carefully checked for errors and this process is time consuming. Earlier work by the investigator has shown that digital computers may be automatically programmed to solve simulation problems by drawing up the block diagram of the system to be simulated on a cathode ray screen. The object of this present research is to produce a small demonstration system which allows the analogue component of a hybrid computer to be similarly automatically patched up by drawing a block diagram on the c.r.t. screen. The digital computer will be programmed to recognize the system's topology and will make connections between the analogous blocks in the analogue machine. The numerical values of the elements within each block will then be typed into the digital computer via a conventional teletypewriter keyboard and the digital computer will set up the component values in the analogue machine.

This research is not the first attempt to produce an automatically patched hybrid computer but it possesses new features which ease the solution of the problem considerably.

No interference from experimental tube train

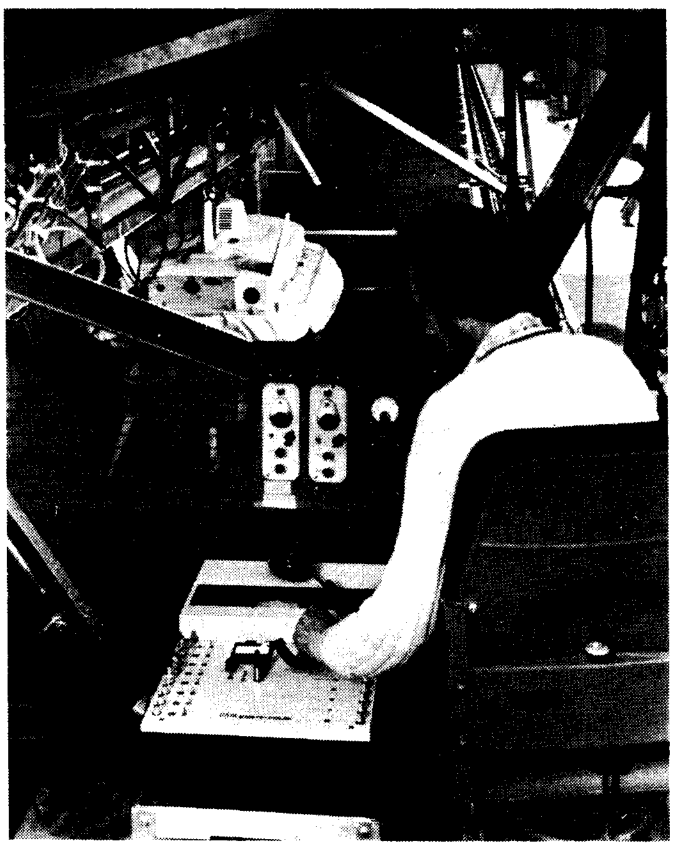
Measurements have been made to monitor interference signals induced in the running rails by London Transport's experimental tube train and it was found that resolved signals were obtained at considerably lower levels than expected. The train is experimental in that control of the traction motor's power unit is solid state, employing thyristors rather than banks of resistors. The result is a 5% saving in power, smoother control and less maintenance. Interference from the power unit could have affected vital signalling information but the tests have showed that operation of the train does not introduce spurious signals of sufficient level to affect running safety. While operating, interference in the region 500-600Hz was expected while on starting, a frequency of 16Hz could have been induced from the motor. The Fenlow instrumentation recorder used for monitoring the signals has facilities for recording on up to four channels using standard ¼in magnetic tape at a speed of 7½ i.p.s. Signal to noise ratio is better than 43dB and linearity is 0.5%.

Briefly

And now Roberts Video. Roberts Radio has entered the colour television market and will operate Roberts Video from the same address and will trade within the same sales policy.

Electrical safety. The Department of Prices and Consumer Protection have just released information on the new guidance document dealing with the Electrical Safety Regulations 1975. This is available from HMSO.

Bathtime at the British Hovercraft Corporation has now advanced beyond the rubber duck stage to the remotely controlled model hovercraft which is here undergoing hydrodynamic tests using an SE Labs eight-channel portable magnetic tape recorder.



Letters to the Editor

VANISHING COMPONENTS SHOPS

Can anyone tell me what has happened to the service that used to be provided by London's electronic component shops? I have been aware that the situation had deteriorated, but not until two recent occasions, when I attempted to make purchases in such shops, how far the deterioration had gone.

There was a time when you could take your "shopping list" for whatever equipment you were building to one of a score of shops in Edgware Road, Tottenham Court Road, and Lisle Street with a high probability of getting your requirements met, if not in one shop, in two, at the most. And these shops were manned by people with actual experience of circuitry, radio hams and the like. Now all these shops are owned by two or three big chains and staffed by salesmen who, generally speaking, know nothing about electronics and in many cases have only a limited grasp of English. Look in the advertising pages of this magazine: most of the component suppliers are in the North of England or in the West Country, which means buying components blind as no one seems to give manufacturers' type numbers of the components they advertise and therefore volume and configuration of these items remain a mystery until purchase has been made.

Perhaps other readers would tell us how they manage to build complex electronic equipment to professional standards, using miniature close-tolerance components with such an impossible supply situation — or do they all use their employers' stores?

Perhaps one of the tycoons who own these super-chains of resistorless capacitorless radio shops will tell us why we are not getting the service we used to get and which, judging by the number of electronic magazines sold, many would be eager to take advantage of. Maybe such tycoons don't regard it as their function to provide a service – only to make a profit!

Perhaps, moving into the area of pipe-dreams, someone will open up an experimenters' materials supply supermarket, not just for electronics but also where one could buy optical components, mechanical engineering materials, chemicals, specialist photographic materials . . . let others add their special needs! And all at 8% VAT!

B. W. B. Pethers,
Welling,
Kent.

PEAK READING LEVEL METER

On some of the issues raised by Messrs Dawson and Evans in October letters we find ourselves in agreement. In mid-1972 we built a resistor chain/comparator instrument, but later investigated the analogue/digital approach because this seemed a powerful and flexible method.

We appreciate that our design seems complex, but the two-channel prototypes were built for the authors' satisfaction and as a demonstration of the principle, not really for presentation as a design for construction — hence the absence of p.c.b. layouts. However, if one considers the application of our design to a multichannel system — e.g. on a 24/8 mixing console where 32 channels are to be monitored — it can provide a simple and economic solution, as we need use only *one set* of logarithmic, clock and display logic; we then multiplex sequentially:

(a) 1 out of 32 rectifier/storage capacitor outputs into the reference capacitor (C_9, Fig. 3)

(b) 1 out of 32 columns of l.e.ds, enabling that column alone to respond to the previously processed input signal.

Very little circuitry is needed to effect the multiplexing, the power consumption per channel is greatly reduced and calibration of the logarithmic intervals for all channels simultaneously is by a single potentiometer setting.

A digital system can permit variations in dB increments: for example, a system of 1 dB resolution may be designed so that each step is displayed at the highest levels, every other step at mid-levels for 2 dB resolution and 1 out of 4 at low levels for 4 dB resolution.

Referring to the question of drift, we should like to point out that:

(a) The capacitor C_9, Fig. 3, is a polystyrene type, as was mentioned in the article as submitted for publication but subsequently omitted on publication.

(b) The reference voltage, V_{REF}, tracks the 10V zener sub-rail voltage to almost 99%.

(c) The hysteresis drift in the 74132 clock oscillator is typically less than 1% over a 25°C free air temperature change.

Our prototypes do indeed dissipate heat, but this is minimised by the use of a 20V + 5V power supply; they were designed in 1973 and our article had been awaiting publication for some eighteen months. If we were now to up-date its design, we should certainly use c.m.o.s. logic, greatly reducing power consumption.

We consider the suggestion of a series l.e.d. chain an excellent one and are grateful for this.

For domestic/prototype use, the low-cost 748 amplifier has an acceptable h.f. performance, but we would agree with Messrs Dawson and Evans that for professional purposes faster devices should be used.

We are not concerned to attempt to imitate the inertia of a moving-coil instrument, nor do we claim to have produced a direct replacement for the BBC p.p.m.; we simply used the BBC specification for rise and decay times as a guide – other tastes or standards could easily be accommodated.

In 1973 the price differential between red and green l.e.ds determined our preference – that differential has now changed.

We would like to thank Messrs Dawson and Evans for their interest and suggestions, but feel that they may have mistaken our intentions somewhat.

S. F. Bywaters and J. E. West,
London, NW11.

"SORTING OUT SIGNS"

In his article in your September issue, on conventions in circuit and phasor diagrams, A. T. Morgan introduces it with the words "it is important to be logical and consistent. This article outlines a logical system . . ." And he goes on to repeat "logical and consistent" and "logical" with reference to the system he is about to commend. At the same time he is kind enough to refer to my book "Phasor Diagrams", but by contrast describes the system therein merely as "new and interesting". As for newness, it was given embryonically in *Wireless World* and *Electrical Review* more than 24 years ago, and fairly fully in *Electrical Review*, Jan. 1, 15 and 22, 1954). He finishes, in a Summary, with the observation that if his instructions are followed "no confusion should arise." So one reads on with high hopes.

His Figs. 1 and 3 show two opposite conventions for indicating positive directions of voltage and current, and Figs. 2 and 4 show the corresponding opposite phasor diagrams. But instead of coming down *logically* on one side or the other, Mr Morgan tells us neither is better than the other and we can take our pick as fancy moves us! This does not strike me as the emphatically logical and consistent approach we had been promised. And as for no confusion, I can hardly think of anything more likely to give rise to it.

Mr Morgan's opposing conventions are of course familiar, and in a recent paper* I showed that the existence of this conflict of viewpoint was due to the use of totally unnecessary arrows in circuit and phasor diagrams, and that the dispute just did not arise if my system was used. My claim that whatever arrow methods can do, even when used in such a way as to be valid, those I advocated can do better (often very much better) still after more than two decades does not appear to have been refuted. So what is the point of clinging to arrows, etc., with resulting diversity of conventions, risk of confusion, greater complication and restricted capability (strikingly exemplified in "Phasor Diagrams") when there is no need?

As regards restricted capability, it is significant that out of Mr Morgan's 35 diagrams no fewer than 25 are devoted to the simple series circuit. Parallel circuits are not mentioned at all (nor Kirchhoff's current law), except one complicated circuit (Fig. 18) for which again significally no phasor diagram is attempted. It would ne interesting to see Mr Morgan's phasor diagram for a two-stage amplifier with feedback, such as Fig. 7.63 in "Phasor Diagrams."

Fig. 1, a simple generator-and-resistor series circuit, shows, in variety (b), two voltage arrows pointing in the same direction around the circuit, both of them in the same direction as the current and therefore, one might think, in phase with it. But Mr Morgan says that the two voltages are opposite, and shows them so in the phasor diagram. Is that not likely to confuse? Especially when the reader has just been given two versions, each upside down relative to the other. Even after one of these has been selected for the remainder of the article. Figs. 15 and 16 show two different phasor diagrams for the same transformer. One of the features of the arrowless system is that every circuit has one and only one correct general phasor diagram shape; a fact that should endear it to student and exam paper marker alike!

Regarding the claim for consistency, one notes that some of the phasor diagrams have been drawn on the closed-figure principle while others are of the star form. Some of the current arrows are incorporated in the wiring; others are drawn alongside like the voltage ones. The same kind of arrow is used for both voltage and current. The usual convention of E for e.m.f. and V for p.d., upheld by the BSI, is reversed for no apparent reason. Since one undoubted merit of the system is that it does not necessitate distinguishing between e.m.fs and p.ds (just as well, since nobody, not even the BSI, has been able to define them in such a way that all can agree about which is which) one wonders why Mr Morgan bothers to use different symbols for them.

I am confused by a phrase near the top of the last page: "If the force F moves in the direction of the force." There are two obvious errors in Fig. 10(b), and eqn. 3 does not agree with the text.

I feel that Mr Morgan's article tends to confirm the case I put in "Phasor Diagrams", that "conventional methods of dealing with circuit and phasor diagrams" are so confusing and inadequate at best that it is a waste of time trying to bolster them up. Why not make a clean sweep of them, as was done so expeditiously with the c.g.s. systems of units?

M. G. Scroggie,
Bexhill,
Sussex.

* "An Unnecessary Controversy." *Int. J. Elect. Enging. Educ.*, Vol. 12, pp. 125-8.

Mr Morgan replies:

First of all, I would like to point out some printing errors in my article.

Page 436, column 2, the last equation should read

$$v = iR \text{ and } e_R = -iR$$

Page 439, column 2, equation 3 should read

$$V_2 = -ZI_2$$

In Fig. 10, (a) and (b) the equation should read

$$V_Z = IZ$$

I will now try to answer Mr Scroggie's points.

It seems to me that what Mr Scroggie is saying is that no method is acceptable or can possibly be clear and logical unless it is the Scroggie method. I am well aware of the fact that Mr Scroggie's "new" method has been published from time to time over a period of over 20 years. However, it has still not been generally accepted and although I find it "interesting" and perfectly acceptable I certainly do not agree that it is the only acceptable method.

As explained in my paper, what I have tried to do is to take the traditional methods, which my students find in all the text books they read, and try to clarify the points which cause confusion.

I do indeed show two different conventions in Figs. 1 and 3, but as clearly explained in the article, I see no logical reason why one *must* be used in preference to the other. I have my own preferences, of course, but I do not wish, as Mr Scroggie appears to do, to force these on all other readers. All I ask is that the chosen conventions be clearly stated and that the writer then sticks to them. Having personally chosen in my paper the conventions of Fig. 1(a) and 3(a), I have not departed from this subsequently. Fig. 16, as stated in the article, is an example of a way of dealing with the transformer which is often used but which I do not find acceptable for the reasons stated.

The length of my article was obviously restricted for publication purposes and the reason that considerable attention was paid to series circuits is because this is where the confusion often starts, i.e. right at the beginning. If the basic principles as outlined for series circuits is well understood, I don't think Fig. 18 would necessarily be described as "complicated". The method of dealing with it has been carefully outlined. The reason I have not attempted to draw a phasor diagram for Fig. 18 is because I don't see any useful purpose in doing so. The circuit would be solved from the equations as given.

I just cannot understand why Mr Scroggie thinks that in Fig. 1(b) the fact that both voltage arrows point the same way round the circuit as the current arrow indicates that all three quantities are in phase. As explained quite clearly, the arrows only indicate the chosen positive directions. If two quantities are in phase, they are always positive together and negative together. If in antiphase, vice versa. Clearly in Fig. 1(b) if v is positive, then eR must be negative. Positive in one direction is the same thing as negative in the opposite direction.

Mr Scroggie apparently objects to my drawing some phasor diagrams closed and others in star form. As far as I am concerned this is perfectly acceptable as phasors, like vectors, have only magnitude and direction (with respect to other phasors). I agree it would be nice to have only one way of drawing the phasor diagram for a given circuit, but I live in a real world and I have to teach my students to understand the text books which they are likely to read.

The point about type and position of current and voltage arrows, I feel, is rather trivial as it doesn't affect the *understanding* of the diagrams.

I am not interested in the distinction between e.m.f. and p.d. for my method does not necessitate the distinction and, as Mr Scroggie admits, the distinction between the two is another point which causes confusion. I have used the symbol e for voltage across an impedance, whether it be resistance, inductance or capacitance. Everyone uses e for inductance so why not also for resistance and capacitance? They all impede the flow of current in an a.c. circuit. That is consistent, isn't it?

SMALL SHOPS CARE

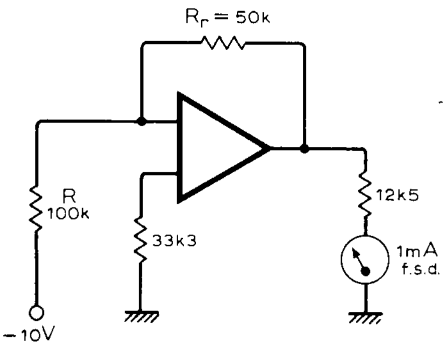
I take exception to certain remarks in your September issue in the article "Electrical safety, standards and the law."

The impression is given that small retailers are a second best, technically dim section of the trading community. This is not so. For technical knowledge, experience and simply caring about what we sell and whether our customers will survive, we are far ahead of the multiples and others. How many

of these selling organisations even keep a Megger at the point of sale, let alone know how to use it? Perhaps a quick check by your readers would turn up some interesting figures on 13-amp plugs sold complete with 13-amp fuses and no enquiry about the appliance to be connected. Small is beautiful.
G. J. Badman,
Watts Radio,
Somerton,
Somerset.

RESISTANCE COMPARATOR

I may be wrong — but! Surely the circuit shown solves the Griffiths-Choi problem (Letters, September issue) even more simply.



It uses a current instead of voltage meter, but as these are the only moving-coil types made it's of no practical concern.
A. Sandman,
London NW3.

SAFETY REGULATIONS

With reference to the article "Electrical safety, standards and the law" in the September issue, I should like to draw your attention to a problem concerning the connection of electronic circuits to the earthed metal cases of instruments.

It is the practice of some manufacturers of electronic test equipment (such as oscilloscopes) to connect the low-potential terminal of the electronic circuit directly to the metal case and to provide a three-core cable to facilitate the earthing of the case. The combined use of a number of such equipments in a test may lead to the induction of a spurious e.m.f. into the loop formed by the low potential signal wire and the mains wiring between the two earthed metal instrument cases. To defeat this difficulty, some people (illegally) cut the earth lead(s) to one or more instruments. Following the test, the earth connection which has been severed is seldom repaired, with the result that the instrument now represents a hazard to the next unsuspecting user.

Having suffered many bad electric shocks from equipment which has been subjected to this illegal practice, I have very strong feelings on this subject.

The difficulty may be eliminated by insulating the low-potential terminal of the electronic circuit from the earthed case. Alternatively a manufacturer may connect a resistor of low value, say 100 ohms, between the low-potential terminal and the mains earth lead in order to reduce the magnitude of current that can flow around any such earth loop. In either case, the temptation to cut an earth wire is thus removed.

Finally, I suggest that the direct connection of the electronic circuit to the earth wire *within the instrument* be forbidden. There is nothing to stop the user from making his own *external* connection if he should so wish.
Roy C. Whitehead,
Sutton,
Surrey.

LAWN MOWER POWERED GENERATOR

It is to be expected that such a simple emergency generator as that described by J. M. Caunter (February issue) would not be free from danger, but something which most of your readers may overlook is the fact that the Electricity Boards expect all persons with their own generators to provide proper two-pole changeover switching. Otherwise, as they point out, it is possible for their workmen to be exposed to risk.

Not, I think, a very likey risk, but it is possible. My own Board started a rather acrimonious correspondence with me even after they had seen the installation but, it appears, failed to appreciate there was the necessary isolating switch. In my case the supply was 240V d.c. from accumulators, which could supply a very high current for a few minutes.

D.c.-to-a.c. converters are usually constructed so that the load is plugged in, so isolation is automatic. Otherwise quite extensive house wiring alterations may be needed to satisfy the Electricity Board.
L. Sreatfield,
Poole,
Dorset.

READ-OUT FOR THE VISUALLY HANDICAPPED

A near-blind physicist is in a good position to stimulate his electronics colleagues to think along the lines suggested by Mr John Osborne in his letter in your July issue and this has been going on here for some years. We should not like to see wasted effort so I am writing to give brief details of current activities.

With financial assistance from the RNIB Mr David Smith has produced an audio-output unit designed for adding on to three current Advance calculators and this is on the verge of commercial manufacture. He is also working on a similar unit for the Hewlett Packard calculators and has built a prototype audio read-out for a computer.

We have also produced a c.c.t.v. reader for the partially sighted which is based upon standard British equipment but which includes a circuit designed by our Mr John Ward which reverses black and white and also enhances contrast. Although similar equipment has been developed in parallel in other countries we believe ours to be better as well as much cheaper.

There are of course many other fields of activity in the application of electronics to helping the visually handicapped. Anyone wanting to find out what is being done should consult the International Register maintained by Dr John Gill of the University of Warwick.
A. J. Croft,
Clarendon Laboratory,
University of Oxford.

BLOWERS ON AMPLIFIERS

Our attention has been drawn to the article in the August issue describing the Chicago Consumer Electronics Show.

In the third column is a report that suggests that, due to the new Federal Trade Commission ruling on amplifiers, Crown amongst others have had to incorporate blowers or fans on their amplifiers.

This is incorrect and your contributor may have been misled into believing this by seeing the M600 Amplifier which does have fan cooling but was designed some 3-4 years before the new ruling was introduced. The DC300A model has no fans incorporated but in America is offered with additional clip-on heatsinks which greatly improve the heat dissipation.
I. M. Marshall,
Macinnes Laboratories Ltd,
Saxmundham,
Suffolk.

The BS1852 resistance code contains the letters F, G, J, K, M which refer, respectively, to $\pm 1\%$, $\pm 2\%$, $\pm 5\%$, $\pm 10\%$, $\pm 20\%$ tolerance. For those who find it difficult to remember the letter sequence reader B. L. Hart suggests the following mnemonic:

FEW GOOD JUDGES KNOW MUCH

Audio Fair preview

New in amplifiers, tuners, tape recorders and turntables

Fighting the current trend against a declining market and ever reducing profits, audio manufacturers seem to be retaliating with an amazing range of technical innovations and new products for this season. It seems that every branch of technology has been drawn upon, from carbon fibres, popularly associated with Rolls Royce turbo-jet fan blades, to the recently developed power f.e.ts. Technique is not the only factor brought to bear upon the public since speakers, tuners and amplifiers all seem to have grown bigger since last year. One new amplifier, for example, weighs 115lb (52kg) and is unusual in that it is fitted with a pair of castors to help in moving it about the floor!

It will be interesting to see how the public reacts to the present sympathy for buying British, since many of the remaining British manufacturers seriously in the hi-fi business are making obvious attempts to fight back against the Japanese invasion, with high quality designs and a degree of innovation. What is disappointing is that so few of these British manufacturers have come to the Audio Fair. Perhaps they should be encouraged by the example of the small Northern company of North East Audio Ltd, which has not only survived since it was opened some years ago, but has actually thrived and is producing a wider range of models than ever before. Certainly, the hi-fi enthusiast is becoming more discriminating in the choice of products and not only demands value for money, but also a very high standard. That NEAL should have been able to meet these criteria in the face of competition from giant manufacturers from overseas is all credit to them.

This review cannot hope to survey the complete range of new products that appears at the 1975 Audio Fair. Instead, a few highlights will be selected from the major product divisions to illustrate some of the technical trends which can be expected in the New Year.

Surround-sound

Developments in surround-sound this year have centred mainly around improved equipment and a gradual increase in the number of records available, notably for the CD-4 system. As far as the quest for system dominance goes, informed opinion is that the early systems were launched too soon — before the theory of surround-sound was properly developed and understood. This premature marketing, resulting in a less than wholehearted commitment by record companies and indifferent demonstrations, taken with the recent economic situation has given the surround-sound industry a slap in the face.

Nonetheless, new equipment continues to be developed. The initial spate of extended-response cartridges has been followed by some improved designs, for example Pickering's XUV/4500Q, JVC's X-1 and Empire's 4000D/111. The X-1 uses a beryllium cantilever, rather than the more usual aluminium or titanium, with lower density, higher sound velocity and higher Young's modulus. A special coating gives protection against possible beryllium poisoning. It uses the recently developed samarium cobalt polymer magnet, its high energy product (BH) allowing a significant reduction of weight in moving magnet systems. The magnetic circuit is improved by a laminated core and smaller gap, reducing dips in the h.f. response.

The Pickering XUV is the first low-tracking-force extended-response pickup (1 ±0.5g). This is achieved using a tiny moving samarium-cobalt magnet (about 0.6 x 1.3mm dia.) giving reduced damping, in addition to mass, with consequent improvement in mid-range tracking. The well-known Pickering slide-in stylus assembly carries a four-surface tip (Shibata has two) called Quadrahedral. Tracking force of the fixed-magnet Empire is also low at 0.75 ±0.5g.

Notable recent demodulators are the Technics SH400, using the QS1 CD-4 chip. Facilities include pre-set controls that push into the front panel to avoid accidental alteration, a "high-blend" switch to reduce the effect of noise on worn recordings, and a facility for use with the Technics semiconductor cartridge. The JVC "professional series" CD4-1000 uses phase-locked loop demodulation with the full two-band a.n.r.s. circuit (earlier demodulators used the one-band version). Increased signal-to-noise ratio, decreased distortion and increased separation are claimed and the carrier-to-baseband time delay is adjustable to allow optimization with different pickups. A switchable 10kHz filter (—6dB) is provided in the carrier-channel circuits.

An extremely useful and under-publicized demodulator is the Denon type UDA-100 (Nippon Columbia). This features demodulation circuitry for both CD-4 and UD-4 systems, as well as having switched positions for the basic SQ and QS matrix systems. An optional expander circuit allows reduction of the carrier channel levels at low signal levels. (If this were used in the CD-4 system, loss of carrier channel would spoil sound localization but with UD-4 loss of carrier would result only in a broadening of directivity.) This decoder/demodulator is the only model on the market that caters for all four marketed surround-sound systems. (From Johnsons of Hendon Ltd.)

At the recording ends both JVC and RCA now use modulator equipment based on phase-locked loop principles. The JVC mark III equipment claims improved dynamic and frequency range and eliminates the need for advance heads on the tape transport (used for carrier level control). Price is around $30,000. The Ortofon 731 cutter head has improved crosstalk — 30dB over the critical range of 10 to 22.5kHz, which range is equivalent to 20 to 45kHz as cutting is done at half speed. Positional feedback at low frequencies controls amplitude response down to 10Hz. Its "T-bar" structure is claimed to provide tight coupling between stylus tip motion and the motional feedback coils.

Though not in public use in the UK the artificial head recording technique is in popular use by broadcasters in Germany, especially for drama. While its limitations are widely recognised — particularly the loss of realhead movement, making front images difficult to place — it has stimulated one company at least to investigate techniques of achieving an out-of-head stereo image with normal recordings (see page 523).

Amplifiers

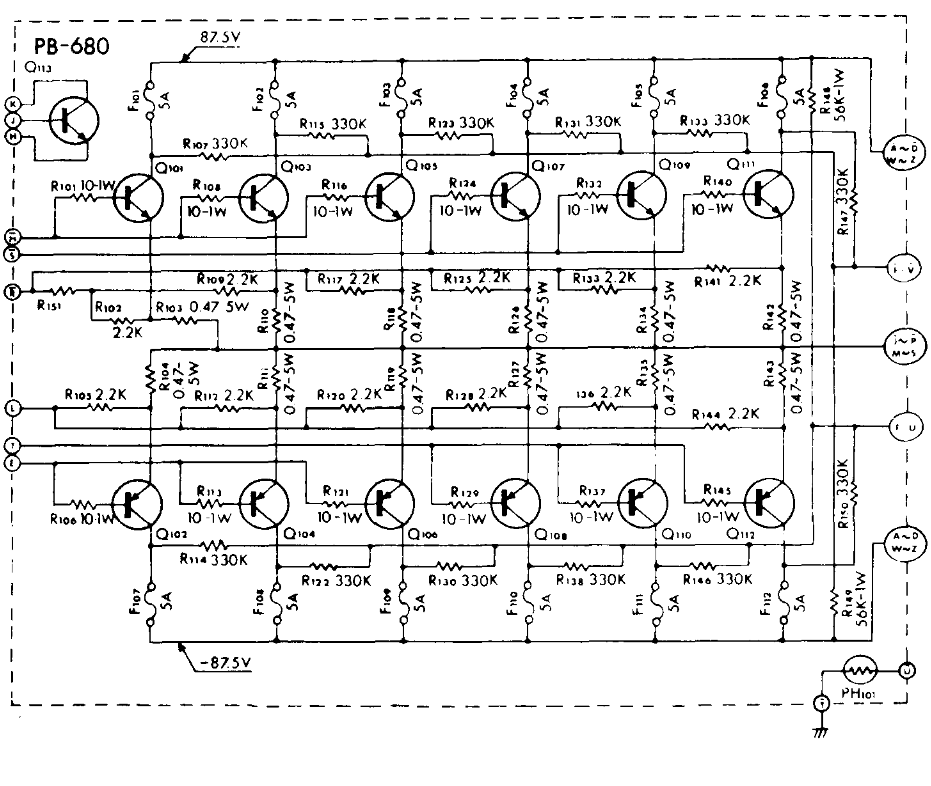
Over the past three or four years, loudspeaker manufacturers have tended to produce loudspeakers with lower and lower efficiency. This, in turn, has brought the reaction of amplifiers with steadily increasing power outputs. This year must surely have seen the ultimate in the race for higher powers from amplifiers, since quite a large number of 200 and 300-watt amplifiers are on show on various manufacturers stands.

The 115lb amplifier with castors mentioned in the introduction, is the Luxman M6000. This is the power amplifier part of a complete system including a preamplifier-control unit in a separate cabinet. The specification suggests a 300-watt continuous power output per channel, into 8 ohm loads, from 20Hz to 20kHz at no more than 0.05% total harmonic distortion. Additionally, the rated intermodulation distortion is suggested as being no more than 0.05% into an 8 ohm load at 300 watts using test signals of 60Hz and 7kHz in an amplitude ratio of 4:1. (Such wealth of detail in a specification is a new trend to be welcomed, but it is questionable whether most consumers will understand what all this means.) The frequency response for the M6000 is said to be ±1dB from 5Hz to 50kHz and the signal-to-noise ratio is better than 100dB, referred to the input voltage required to produce 300 watts output. Just as an added statistic, the power consumption is said to be 150VA with no input signal and 1.3kVA when driving the maximum output into an 8 ohm load.

As if all these statistics are not enough, combined with the weight of the unit mentioned above, the circuitry features 12 transistors arranged in 6 pairs, complementary symmetry for each channel, with each output transistor individually fused and protected (see circuit). The protection circuitry is quite complex, and occupies a remarkably large panel inside the amplifier. The high standard of mechanical engineering is undoubted, with almost every part of the chassis being hand made. This perhaps provides a clue to the sales potential of such an amplifier, and it is suggested that it is more of a prestige product than a practical part of an audio system for the home.

Coming to more practical aspects of amplifiers, of direct interest to many readers of this journal are the Dynaco kit amplifiers being offered by Sound Incorporated (Sutton) Ltd. One integrated amplifier, the SCA 80Q, is offered together with two pre-amplifiers, the PAT 4 and PAT 5 and a choice of up to six power amplifiers ranging in price from £75.95 up to £261.95 plus VAT. At least one of these amplifiers should interest many of our older readers, being the Model Stereo 70.

This is a valve amplifier offering a 70W continuous power output, with both channels driven at 1kHz into 4, 8 or 16 ohms. The harmonic and intermodulation distortion is claimed to be under 1% at the rated output and under 0.05% at 1W. Hum and noise are claimed to be more than 90dB below 35W on each channel, and the frequency response ±0.5dB from 10Hz to 40kHz.



Circuit diagram of the Luxman M-6000 output stage for one channel.

It would seem that valve amplifiers are simply refusing to die!

Tape and cassette recorders

Tandberg deserve special attention for their interesting reel-to-reel tape recorder, the Model 10XD Stereo. This represents a step up in the existing range of machines offered by Tandberg, since the 10XD will accept 10½in NAB centered spools. Capable of tape speeds from 3¾i.p.s. through 7½i.p.s. to 15i.p.s., the recorder uses three motors and a total of four tape heads.

However, all of this seems relatively mundane by modern standards, until it is realised that Dolby B noise reduction is offered at *all* tape speeds. This must make the Tandberg the first reel-to-reel tape recorder to 'officially' record a Dolby B processed signal onto a tape, running at what is normally regarded as a "professional" tape speed. Since the introduction of the Dolby B system there has been a resistance from Dolby to tape recorders being offered with the B system operative at 15 i.p.s.

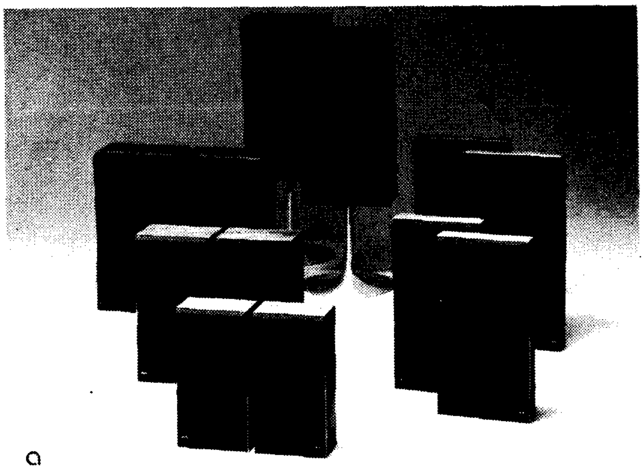
Some time ago Revox planned to offer a model of this type, but were discouraged by Dolby. Obviously Tandberg have been able to persuade Dolby that their fears about the dangers of two systems of noise reduction at this tape speed (Dolby A being the professional system used at 15 i.p.s. and higher speeds) causing confusion were unfounded. Probably we will see a spate of new machines which later will incorporate Dolby B at a tape speed of 15 i.p.s. The 10XD Stereo features many other facilities familiar to the users of the other Tandberg tape recorder models and includes a remote control facility to operate the deck at some distance. Additionally, since electronic servo speed regulation is employed, it has been possible to fit an external control socket which permits the basic tape speed to be varied over a range of values, by a simple add-on accessory.

Among the large numbers of cassette recorders being introduced perhaps the most remarkable is that being offered by Akai, the model GXC325D. This machine is a development of the three-head principle in cassette recorders, but avoids the problem of having to rearrange other components in the tape path in order to accommodate the additional head.

This is achieved by combining the record and replay head into a single moulded block, occupying the normal position for the record/replay head.

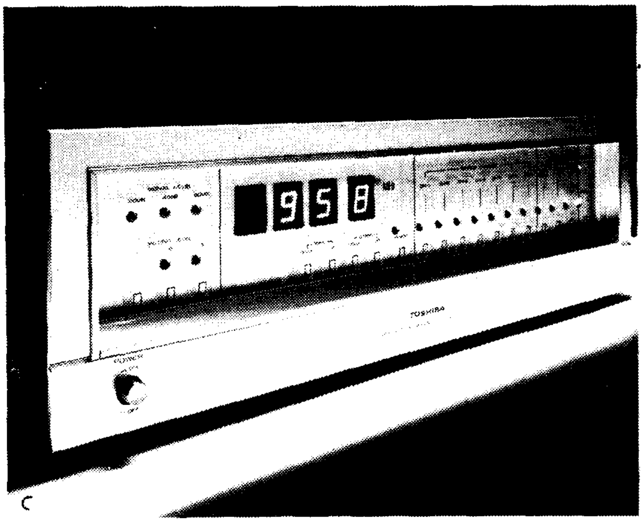
Turntables and arms

Among the many turntables which will be shown for the first time at the Audio Fair will be a piece of innovative engineering from A. R. Sugden. This is the Connoisseur Transcription unit, which represents a considerable advance from their simpler, but very effective, BD1 and BD2 units. The turntable platter is driven by a 9V d.c.



a

b



c

d

(a) B&O Uni-phase loudspeakers. (b) Toshiba digital tuner. (c) Tandberg TR2075 tuner. (d) Strathearn STA4 turntable.

servo-controlled motor, at a choice of one of three speeds, 33⅓, 45 or 78 r.p.m., selected by a control on the front edge of the plinth. The power supply for the system is housed in a separate unit, thus eliminating hum fields, and is convertible for 120 or 230V mains supply.

One of the unusual features of this turntable is its two-part platter, consisting of a continuously revolving flywheel, on the surface of which are a series of rubber studs. Set above this, and separate from the flywheel, is an aluminium platter 11½in in diameter, which carries the record itself. Operating a lever on the left hand side of the plinth raises the large diameter flywheel up until the rubber studs come into contact with the underside of the aluminium plate causing it to revolve.

Further movement of the lever raises the flywheel and platter together, a fraction of an inch, to come into contact with the stylus tip. Thus the arm does not lower to the disc, rather the disc rises under the stylus tip. This means that the vertical movement of the arm is restricted, that instant start and rapid cueing is possible, and the problem of side drift caused by bias compensation on the tonearm during lowering, is avoided.

The tonearm is of unusual design, being of very low effective mass and mounted on a unipivot for horizontal motion and knife-edges for the vertical motion. Magnetic stabilization is used on the unipivot bearings to prevent side-slop. Magnetic bias, which is adjustable, and calibrated for spherical and elliptical styli is available via a large knob set on top of the housing for the tonearm bearings.

The headshell is lightweight and interchangeable, and fits into an aluminium anodized straight cube. As in many other turntables at present on the market, isolation from vibration from the outside world is provided by special rubber feet, while the platter and arm themselves are solidly mounted in the plinth. Clearly, this turntable is aimed directly at the semi-professional and professional market, particularly broadcast studios. The price is between £80 and £90.

Contrasting with the efforts of Sugden, Technics have developed a professional turntable with precisely the same market in mind, but bringing to bear a different technique. This turntable is the SP-10 MkII, utilizing a direct drive motor. Rather than use a clutch system to disengage the motor during run-up periods, the motor has been made to have a very high starting torque, to provide a virtually instant start facility. From standstill, the motor can take the 3kg platter up to 33⅓ r.p.m. in 0.25s or only 25 deg of revolution. Braking the platter is equally as fast, taking only 0.3s or 1/12 of a turn to come to a standstill from the rated speed. Motor control is achieved by a quartz crystal controlled phase-lock loop servo. The main power supply for the system is housed in a separate box in the same manner as the Connoisseur turntable.

Since the torque of the drive motor is so high, the platter has had to be bolted to the motor shaft itself. Again, with the mass of the rotating system and the large torque of the drive motor, a significant problem has been to design a plinth which does not twist during acceleration or braking. In the example to be shown at the Audio Fair, the turntable has been mounted in a plinth consisting of finely ground black granite, compressed in a matrix of plastic. Technics claim that the plinth consists of over 75% granite! The price is estimated to be about £450 plus VAT and the system is expected to sell purely in the professional and semi-professional world.

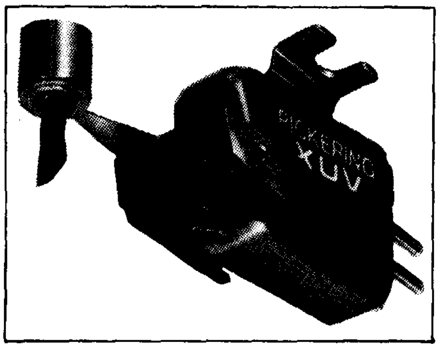
Finally, before leaving the subject of turntables, it is interesting to mention another UK effort at designing advanced record players. This comes from Strathearn, the new Northern Ireland company set up by Government grant. Two turntables will be shown by Strathearn and both use a direct drive motor developed in the UK. One of the two turntables, the STA 4 is remarkably priced at £58.75. This includes a low mass pick-up arm and provides two speed, automatic electronic servo operation.

Loudspeakers

As is customary with the loudspeaker market, the end of the summer usually sees the emergence onto the public market of a new design trend taking us one step nearer the state of "perfection" which audio engineers have the notion that they are approaching. This year's talking-point is "linear phase," several manufacturers having produced designs in which the phase characteristics have been tailored to be linear with respect to frequency, the aim being to reproduce the "ideal" amplitude and phase characteristics of a band-pass filter. It is claimed that benefits in clarity and definition of sound reproduction can be obtained in this manner. Those companies participating at the Audio Fair who are manufacturing linear phase loudspeakers include Bang & Olufsen with their Uni-phase range consisting of six loudspeakers, a selection of wall-, shelf-mounting and free-standing speakers whose power handling capacity ranges from 30W to 70W. Technics are also into linear phase with their SB-700 "Flat Phase" loudspeaker system. This is a three-speaker bass reflex system which produces an SPL of 93dB at 1m for a 1W input. External dimensions are 480 × 845 × 410mm.

Leak have introduced an improved treble unit into their 2000 series of loudspeakers which is claimed to have a smoother response than the previous unit while retaining similar power handling capabilities. The speaker units used in the 2000 system were designed using holographic test methods for spotting and control of unwanted resonances in the cone material.

Improvement of systems by paying extra attention to the drive units themselves has resulted from several developments in test and measurement techniques from the use of holography to the digital analysis of performance characteristics à la KEF (who are not, incidentally, exhibiting at this year's Audio Fair). Design techniques have not improved greatly from the classical work done during the 1950s but improvement of materials and manufacturing techniques have led to refinements hitherto unknown.

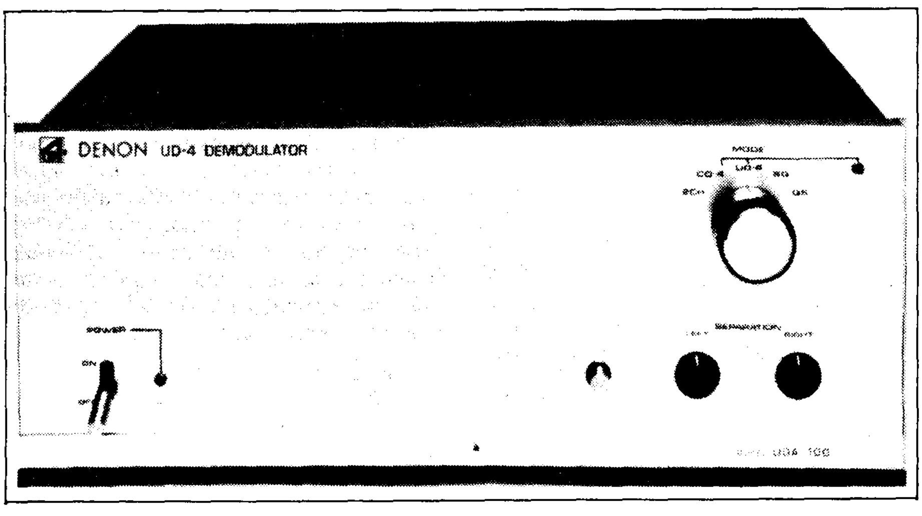

Pickering XUV cartridge.

Bookshelf units are no longer necessarily so relatively inefficient and lacking in bass due to improvement in power handling capacity and reduction in natural resonant frequency of the smaller drive units used in bookshelf units. Reflex techniques also seem to be making a comeback, again advantage being taken of this technique in small cabinet volumes to keep efficiency up at low frequencies and also to extend the bass response.

Tuners

Despite the recent norm in quality f.m. tuner circuits of dual-gate f.e.t.s, voltage-tuned front ends, piezo filters and i.c. demodulators and decoders, there is still a wide variation in specifications. Not so much in sensitivity or distortion — figures of 1 to 2μV for a mono signal-to-noise ratio of 30dB and 0.2 to 0.8% harmonic distortion on stereo being typical — but frequently with selectivity and susceptibility to unwanted signals.

Part of the service area planning process is to minimize the occurrence of difficult reception problems, but planners are much like ordinary mortals in their ability to see into the future. The demands of a full stereo service were unknown when the U.K. mono service was planned in the 1950s; it is now well known that stereo reception is much more susceptible to interference from other stations than mono. But of course, most reception problems are parochial and it would be unfair to expect everyone to pay for refinements intended for a minority.



Denon surround-sound demodulator / decoder features UD-4, CD-4, QS and SQ decoding.

A new receiver whose specification appears to cover many eventualities is the Tandberg TR-2075, with a sensitivity of 1.8μV for 30dB signal-to-noise ratio (IHF, 300 ohms) and a distortion of 0.3% in stereo (75kHz deviation). The receiver gives low unwanted outputs of pilot tone and subcarrier (−70dB), and has an IHF signal-to-noise ratio of 68dB in stereo and 1mV antenna voltage (61dB DIN). Suppression of unwanted signals is: a.m. 65dB, image frequency 70dB, i.f. 95dB and ½ i.f. 95dB. Selectivity for the alternate channel (±400kHz) is 100dB and 40dB for the adjacent channel. Facilities on this tuner include a 25μs time constant (Dolby f.m.) switch for the American market. (It has many other facilities, such as tape copying, tape input prior to tone controls, peak power meter, that belong to the a.f. section.) Performance of the a.m. section is good too (image rejection 90dB) and it is relatively unusual to see a.m. distortion quoted (0.8% for 30% modulation, 1.5% for 80%). Appearance of the set is distinctive but the scales are of the type fitted to many Japanese made tuners.

Technics, who claim their range of receivers is the only one to include a phase-locked loop circuit in the decoder in all their models, use linearly-phased ceramic filters in three i.f. stages to maintain a flat group delay time. The range includes the ST3050 "budget" tuner, the ST3150 tuner, the SA5150, 5250, 5350 and 5550 receivers, all with very similar circuitry.

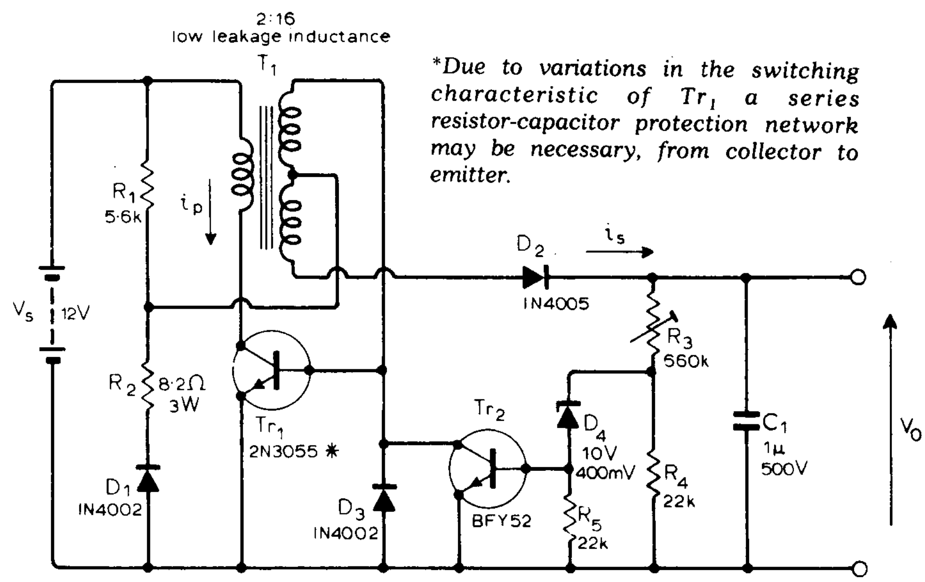
A few receivers are available now equipped with Dolby B processors, such as the NAD 300, but these are made primarily for the American market. Another feature becoming more common is that of a local oscillator frequency synthesized in steps, usually 200kHz (channel spacing). The Toshiba ST-910 goes the whole hog and gives a digital readout of frequency which, with its seven-station sensor panel, gives the tuner a distinctive appearance. Automatic tuning and stepped manual tuning is provided (100kHz or 1MHz steps) together with a memory. Such memories need to be kept supplied with power and in some tuners a battery is provided so that memory is retained for a limited time (48h) in the event of power failure. Three lamps indicate signal strength in 20dB steps the lowest two to indicate sufficient signal for mono and stereo reception, though one would have thought the ear would have been the best test. A useful feature is a three-level muting control.

Circuit Ideas

Variable voltage-ratio transistor converter

Conventional square wave inverter circuits give an output voltage proportional to the d.c. supply. The efficiency of such a system can never exceed 50% due to voltage limiting and component losses. The circuit described can charge a capacitor from zero volts at efficiencies of over 80%. When a conventional series stabilizer is used to drop the voltage of a 9V battery to 5V the average efficiency, taking the end point voltage of the battery as 6V, is only 67%. The use of this inverter extends a battery life in two ways: firstly by the higher efficiency and secondly by allowing the battery to be used to a lower end point voltage.

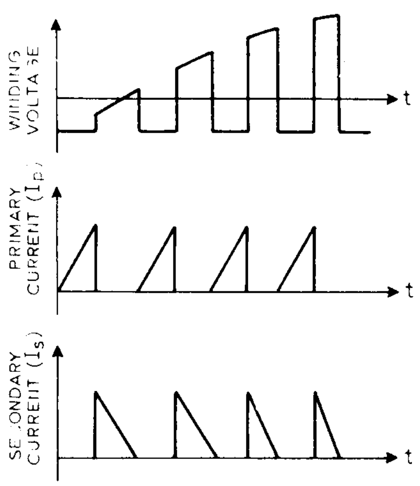
The primary current in T_1 is controlled by Tr_1 and oscillation is started by a low current passing through R_1 and the feedback winding of T_1 to the base of Tr_1. The transistor switches on due to the positive feedback action of the transformer and the main base drive is provided by the feedback winding through R_2 and D_1 While Tr_1 is conducting, D_2 is reverse biased and there is no current in the secondary winding. The collector current is therefore the sum of the referred base drive current and the magnetizing current which rises linearly according to the equation



**Due to variations in the switching characteristic of Tr_1 a series resistor-capacitor protection network may be necessary, from collector to emitter.*

$$\frac{di_p}{dt} = \frac{V_{cc} - V_{ces}}{L_p}$$

where V_{ces} is the transistor saturation voltage, L_p the primary inductance of transformer and i_p the primary current. Thus the collector current rises until the base current is insufficient to saturate T_1, the positive feedback action then causes it to switch off. Reverse voltage on the transformer windings rises until D_2 and D_3 conduct and secondary current passes into the reservoir capacitor C_1. Diode D_1 is then reverse biased. Energy stored in the magnetic field of the transformer is transferred to C_1 and, when the current has dropped to zero, the winding voltages collapse and the oscillation is repeated until C_1 has charged up to a voltage which causes D_4 to conduct through the resistor R_3 and the base of Tr_2. This transistor then diverts the base current from Tr_1 and stops the oscillator until C_1 has discharged through the load circuit. Resistor R_5 carries the leakage current of D_4 and so prevents Tr_2 from conducting before the zener voltage has been reached. Waveforms are shown as C_1 is charged from zero. For fast switching it is essential that the leakage inductance between primary and feedback winding is very low. The leakage inductance between primary and secondary must also be low because the energy stored in the leakage flux cannot be transferred to the secondary when the transistor switches off. Air-gapped cores have been found most successful. There are two types of application where the circuit is of particular interest. For pulse generators where repetitive charging of a capacitor in a pulse-forming network is required or for generating one or more stabilized voltages from a dry battery. The circuit enables voltages above or below the battery voltage to be generated and the efficiency remains high throughout battery life. In the case of capacitor-discharge ignition systems the power conversion efficiency is so high that a heatsink is not required and only one power transistor is needed. The full output voltage is obtainable when the battery voltage is less than half its nominal value which results in an improvement in cold starting.

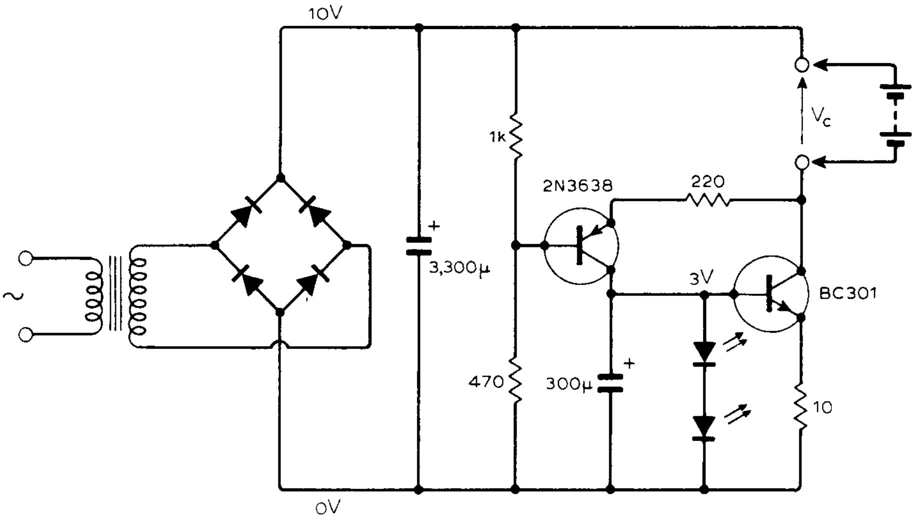


R. M. Carter,
Lincarc Ltd,
Lincoln.

Battery charger

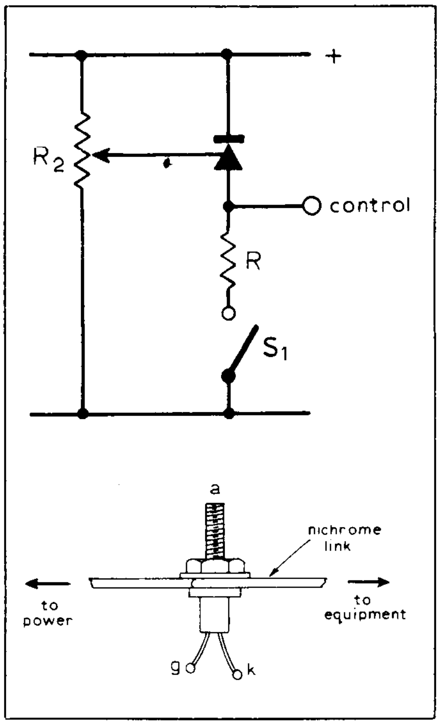
The simple circuit shown is for charging four size D nickel cadmium cells in series at constant current and with automatic voltage limiting. The BC301 acts as a current source, its base voltage being stabilized at about 3V by two l.e.ds, which may also be used to indicate the charge condition. The 2N3638 provides voltage limiting by cutting off the BC301 when V_c approaches the voltage across the 1kΩ branch of the voltage divider. For the component values shown, charge current is 260mA at low V_c, 200mA at V_c of 5V, and decreases to virtually zero at V_c of 6.5V.

N. H. Sabah,
American University,
Beirut.



Thermal overload cut-out

Thyristors provide a simple and economic answer to the older mechanical overload cut-out. Four-layer devices have a trigger threshold that is temperature dependent. By arranging that the gate current is just below the threshold, any increase in temperature will cause triggering. Potentiometer R_2 sets the bias current to the "just untriggered" level. Once triggered the thyristor latches and can only be reset by opening S_1. Circuit control can be via relays and/or transistors.



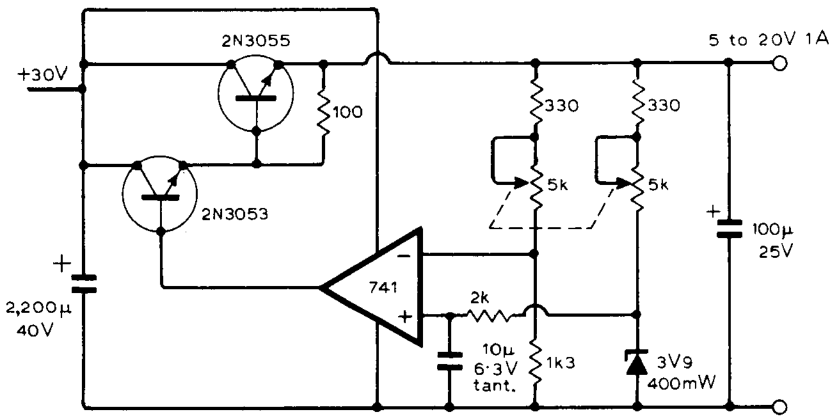
The heating element can be isolated from the thyristor case, or it can be a short resistive link, in the positive line or bolted to a heat sink, and connected to the thyristor anode as shown. In d.c. circuits a 1/25Ω will monitor a 25A circuit with ease. Thyristor packaging and mounting govern the thermal inertia of the system.

C. Woolf,
Swanland,
Yorks.

Variable power supply with zener stabilization

In regulated power supplies it is advantageous to feed the reference zener diode from the stabilized line. This is more difficult with a variable voltage supply; however, a simple solution to the problem is to use a dual linear potentiometer as in the circuit shown.

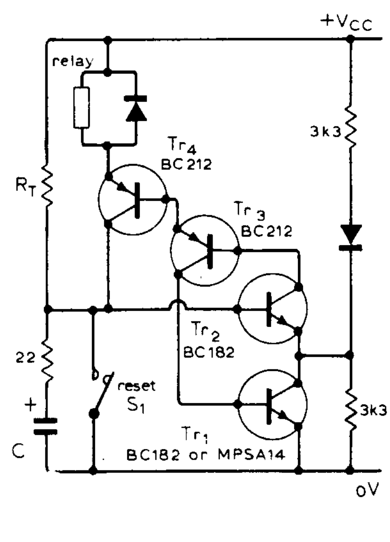
L. J. Baughan,
Charlbury,
Oxon.



One-shot timer circuit

The circuit shown is a four-transistor configuration which is similar in operation to the well-known 555 device but, since the normal state is all transistors on, the circuit has a high degree of impulse noise immunity — thereby avoiding the occurrence of spurious timing cycles which are sometimes troublesome in i.c. timing circuits.

In operation, the voltage on the timing capacitor C rises until Tr_2 begins to conduct which in turn causes Tr_3, Tr_4 and Tr_1 also to switch on. Regeneration in the circuit is caused by the interaction of Tr_2 and Tr_4, and the timing capacitor is discharged to about 0.6V by the operation of Tr_3 and Tr_1. The timing cycle is initiated either by the application of V_{cc} or by the opening of S_1. As in the 555, the timing period is V_{cc} independent as long as it is stable during the timing cycle.



J. L. Linsley Hood,
Taunton,
Somerset.

Contributors to Circuit Ideas are urged to say what is new or improved about their circuit early in the item, preferably in the first sentence.

International Radio and Television Exhibition

Berlin, 29 August — 7 September

Infra-red sound links and m.o.s. l.s.i. in colour receivers

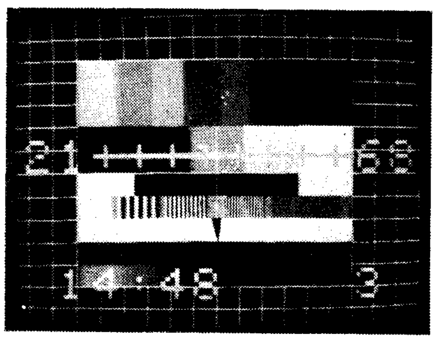
At the time of going to press, attendance figures for the 1975 international radio and television exhibition were not available. But if the 1973 event is anything to go by, it will be over the half-million mark. With 386 manufacturers represented, showing around 800 new products in 23 halls and two pavilions, and in an area of 88,000 square metres, this report of the largest event of its kind cannot possibly be complete. What follows then is a mere sampling of some of the more interesting things seen.

With rising labour costs forcing German manufacturers to increase prices from September this year (colour television set prices had so far remained relatively constant or fallen slightly since colour tv was introduced in 1967), its not surprising that many of the innovations appearing in television sets are designed to reduce labour content and servicing time. Modular construction has enabled 95% of all components to be housed in modules, and 100% of the receiver circuits. Introduction this year of the Philips 20AX self-convergent in-line tubes by Valvo has made setting up simpler and self-diagnostic systems reduce servicing time. At the same time, integrated circuits are used wherever possible, especially thick-film circuits, the latest ideas involving digital m.o.s. i.cs in ultrasonic remote control links and programme selection.

Philips, for instance, are proposing a digital channel-selection technique that would provide up to 16 pre-selections (the numbers game applies to television as well as audio equipment!) replacing two costly pull-out drawers of specially-tested pre-set potentiometers with frequency-synthesis m.o.s. circuits and an m.o.s. memory. The technique is part of a concept to provide circuits for search tuning, remote control, local control and on-screen displays of memorized sound level, brightness, colour setting and tuning, with Valvo m.o.s. l.s.i. circuits that could be available in production quantities next year. A small current drain would be needed to keep the memory "alive", and a nickel-cadium battery would prevent loss during a mains failure.

Remote units have become digitized. The Blaupunkt and Siemens FM100 chassis, the Nordmende Spectra and Prestige sets and the Körting colour chassis 8 incorporates the ITT-Intermetall p.m.o.s. circuit SAA1025 for decoding a maximum of 30 commands. A c.m.o.s. SAA1024 coder in the remote unit, with a 4.43MHz oscillator, accepts control inputs and converts them to a 5-bit code for an adjustable divider. (Types SAA1000 and 1010 provide up to 15 channels). Twelve channel selections, mains on/off, sound on/off, and "up" and "down" movements of colour saturation, brightness and sound level are typically provided by dividing the band into 30 frequencies, 346Hz apart, between 33.945kHz and 43.990kHz, this range lying between the second and third harmonic of the line oscillator frequency.

These frequencies, representing the commands, are received by a wideband pre-amplifier, measured by the 1025 i.c. and converted to 5-bit codes (4-bit for the 1010), and fed to programme selection circuits via a decoder. Signals for the analogue variables are stored and delivered in the form of variable mark-space ratio pulses.



On-screen display of time, channel number and tuning scale in Grundig S9000 chassis.

Three Siemens circuits SAB1000, 1001 and 1002 provided similar functions for 36 channels of control, but these appear to have been superceded. Valvo have produced l.s.i. c.m.o.s. chips, SAB1011 and 1012, with a capability of 32 commands using a carrier pulse-coding system. The latest circuit—used in the Telefunken Supersonic sets — is capable of handling 32 commands using only two frequencies. In the coding circuit, a p.m.o.s. i.c. type SAB2000, the number of cycles from an external oscillator is counted until it agrees with the number allocated to the selected button (varying from 1760 to 7360 cycles at intervals of 160 cycles). After this number, the oscillator is changed to a second frequency, until the button is released, for 480 cycles. After release, the i.c. is disconnected from the supply to reduce consumption from 10mA to 100μA.

In the SAB2010 decoder, commands are identified by counting the number of initial cycles. Commands for any one of 16 programmes result in an output signal having a number of pulses corresponding to the selected programme. Six commands for increasing and decreasing colour, volume and brightness are passed in serial form to an SAB2020 and converted into an analogue voltage. If buttons are depressed for longer than 100ms the selected setting is changed by one out of 32 voltage steps at clocking time of 100ms (it therefore takes 3.2s to change from one extreme to the other).

A facility is provided for bringing the analogue outputs to a mid-position prior to entering commands, as on the ITT i.c., the command button or sensor for this having been dubbed "granny button" or, in more polite circles, Ideal Color (ITT).

With such remote units, the user has no indication of control setting. Some makers provide a display on the set, next to the screen, as in the Nordmende "spectra color TM-3-infra". There are three eight-point scales, illuminated by l.e.d.s, for brightness (coloured yellow), saturation (red) and sound level (green) that light when a sensor key is touched. This remote unit also has a standby position which immediately restores picture and sound when one of the channel selections is made. A timer in the remote unit enables the receiver to be switched on or off at a pre-selected time. (This set also has the facility to transmit sound via infra-red transmission to headphones or tape recorder (see later). And it has a built-in 30-watt amplifier to DIN45,500, with a three-way loudspeaker system. Following Grundig's lead in 1973, this set can accept a Secam decoder for reception of programmes from the Democratic Republic.)

In the case of the Körting circuit the variable mark-space ratio outputs from the SAA1025 i.c. — which ratio is proportional to the value of the three analogue parameters — are used to produce horizontal bars across the bottom 30 lines of picture, the length representing that value. Green is used for brightness, red for saturation and blue for volume. A "band" is switched off a second or so after the control has been activated.

Television receiver statistics

(Germany)

Licenceholders 19 million, estimated penetration: 34% colour, 84% with black and white.

	Millions of units		
	1973	1974	½ 1975
Production: colour	2.1	2.4	1.1
b & w	1.6	1.7	0.66
Sales* colour	2.0	2.4	0.96
b & w	2.0	2.1	0.81
Exports: colour	0.53	0.60	0.30
b & w	0.77	0.90	0.33
Imports: colour	0.13	0.29	0.15
b & w	0.9	0.91	0.44

*Domestic plus export sales.

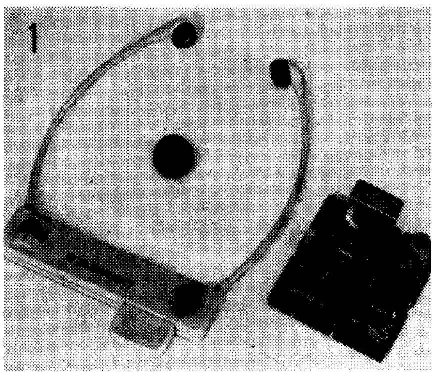
DISPLAY OF TIME and channel number on the screen for a few seconds after command is a feature of one Telefunken variant. After a mains failure, the need to reset the clock is indicated by flashing. Another Telefunken model includes a seven-watt sound i.c., type TCA940, with tone controls and remotely controlled switching for speech or music — giving two different amplitude-frequency responses (18dB boost at 100Hz and 10kHz for music).

Grundig's new colour S9000 set provides high-quality sound to DIN 45,500 from its 15-watt amplifier with tone controls and two-way speaker system. This model, and eight others with various styles of cabinet all using 66m 20AX self-convergent tubes, includes a clock circuit and character generator for on-screen display of time, in addition to showing channel number. Digits are 4-cm high and coloured green. Seconds are indicated by a blinking colour. A tuning scale can also be superposed on the screen (see photograph) to facilitate setting the programme selector. Saba, Blaupunkt and Telefunken colour sets also display time and channel number on the picture.

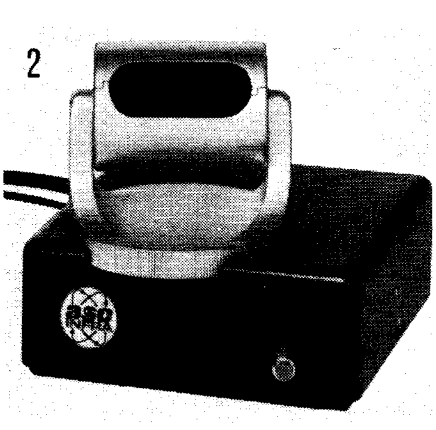
Rather than indicate time on the picture area, ITT models 1789 and 2689, along with Philips model 567, include digital clocks that can be used as timers. In the ITT sets, a stand-by mode enables time to be normally displayed, but control buttons allow switch-on time to be set and memorized. The clock is normally switched off when the set is in operation.

Unlike the Loewe, Saba and Grundig sets, with their plug-in diagnostic aids, ITT, Blaupunkt and Siemens use on-board l.e.d. indicators to speed fault location. Blaupunkt call their concept ISA, using nine l.e.d.s, and ITT (Schaub-Lorenz and Graetz) call theirs Vidom. Using six l.e.ds to signify correct voltages at various points, with another that flashes if the electronic fuse in the switched-mode power unit fails, the Vidom concept also includes board markings to ease component location, signal-path identification and to indicate test points, with voltage readings where appropriate.

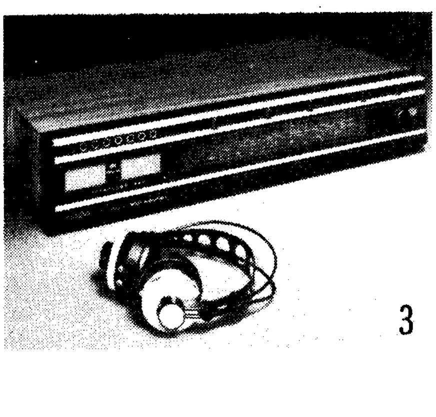
These innovations of l.s.i. in remote controls, built-in clocks and timers, on-screen identification of channel, time and tuning, infra-red sound links, self-convergent in-line tubes, and almost total modular construction are complemented by options for addition of Secam converters and tuners for cable television at a later time. And all the new colour sets have provision for connection with audio and video recorders, often including automatic switching for line synchronization time constant.



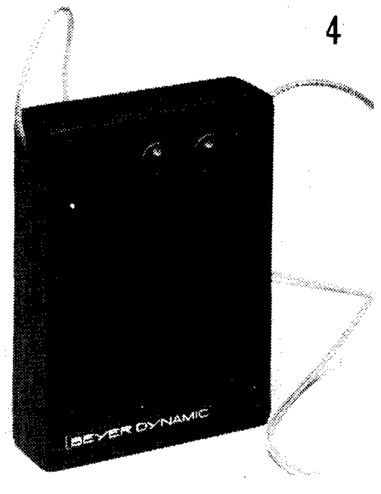
1



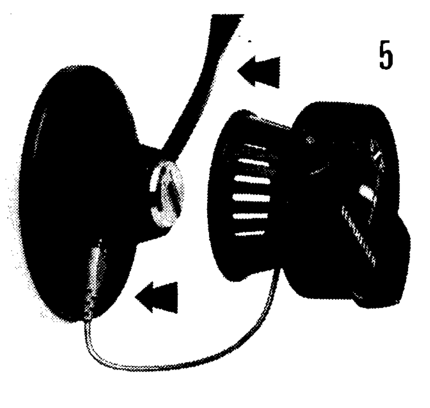
2



3



4



5

New infra-red equipment: 1-Sennheiser receiver and transmitter module; 2-Nordmende receiving adapter; 3-Saba tuner-amplifier with transmitters and AKG phones; 4-Beyer neck-slung receiver; 5-Sennheiser receiver adapter.

Infra-red sound links

Our report of the 1973 Berlin exhibition mentioned the development by Nordmende of an infra-red link between television set and headphones. Now two years later most of the major German television receiver and headphone manufacturers were showing sets equipped with such links and the industry standardized on system details last June. In on the act are Blaupunkt, Grundig, ITT (with the Graetz and Schaub-Lorenz brand names), Loewe-Opta, Metz, Nordmende, Saba and Siemens, together with headphone makers AKG, Beyer and Sennheiser.

Use of a frequency-modulated sub-carrier in the infra-red links is clearly the way to avoid noise problems from a.c. filament lamps and the frequency agreed is 95kHz with a maximum deviation of ±50kHz, although some makers are quoting other figures, e.g. Loewe-Opta with 93.7kHz (presumably to minimize beating with the sixth harmonic of the line frequency), Saba who quote 100kHz with a deviation of ±10kHz, and Beyer who use ±30kHz deviation. Pre- and de-emphasis of 50μs is used and with an a.f. bandwidth of 40Hz to 10kHz and distortion figures being quoted range from 1 to 3%.

The Sennheiser AD416 infra-red headset is a stethoscope-type headphone with transducer, receiver with volume control, and nickel-cadmium battery mounted as shown in the photograph and weighing 70g. Signal-to-noise ratio achieved depends on the transmitter power; distance from transmitter, room size and surface absorption. Measurements taken 4 metres from a transmitter (60mW emitted) in a room 4 × 6 × 3 metres with light walls and a tiled ceiling gave a signal-to-noise ratio of 58dB in daylight (200 lux). This worsens to 40dB when the receiver faces away from the transmitter. The 50mAh receiver battery module contains components for recharging at 1.5mA and one merely plugs it into a mains outlet.

Grundig, Nordmende, Blaupunkt (who also make sets for Siemens) and Metz have adopted the Sennheiser approach in their new ranges of television receivers. An add-on unit for existing sets will be available in February next year. To provide present owners of Sennheiser headphones with the capability to receive i-r transmissions a receiving adapter has been developed that clips on to both earpieces (see photograph).

AKG use Körting's circuitry in their new system. The infra-red transmitter type G-20wl can be connected to the line, loudspeaker or headphone outputs of monophonic equipment and provides 100mW of radiated power at 940nm, over an angle of ±60° in the horizontal plane and ±35° in the vertical plane (±6dB figures). Bandwidth is 30Hz to 12.5kHz. The headphones, a modified version of the K140 model, contain the receiver in one earpiece and an automatic-off manual-on switch. Loss of signal or very poor signal-to-noise ratio causes the circuit to switch off. Sockets on the phones allow them to be used with an ordinary stereo input and an a.f. output is provided for connection to a tape recorder or amplifier. The five-cell battery is charged by connecting to a separate charger unit. A miniature neck-slung receiver E-10sl is available too, for current owners of headphones, providing an output of 1.55V at the 1% distortion level.

Beyer Dynamic make a transmitter IS76, using ten diodes and operating with ±30kHz deviation at 1.5% distortion, a receiver IE76 for existing headphones (neck slung and about the size of a cigarette packet), a DT444 "infraphone" with 9-V rechargeable battery, and a charger.

Most transmitter circuits use a TBA120S limiter/demodulator whose input is the 5.5MHz sound signal. In the Loewe-Opta circuit the audio output modulates a 95kHz multivibrator, whereas in the Nordmende circuit there is no audio stage, the 95kHz signal being generated by mixing the 5.5MHz signal with the output of a 5.595MHz oscillator. Another difference in the Nordmende circuit is the use of a single 60mW infra-red diode, SLH8, transformer coupled to a BF457 output transistor. Most manufacturers fit ten CQY38 diodes (Telefunken) or eight LD241 diodes (Siemens) in series, rather than use high-power Valvo or Texas emitters, on cost grounds. The Sennheiser transmitter circuit is the simplest, the Intersil 8038 circuit providing a pulse frequency modulated output (see Fig.1.). Constant-width pulses can be transmitted as an alternative to reduce dissipation in the emitting diodes.

Receiver circuits use the Siemens BPW34 p-i-n photodiode, reversed biased to give better linearity and low capacitances. Despite its large area 3 × 3 mm² its capacitance is only around 15-33pF. This is followed by either an f.e.t. preamplifier and Siemens SO41P f.m. limiter/detector, as in the Körting circuit, or a three-stage bipolar preamplifier and SO41P, as in the Loewe circuit. Another variant, used in the Nordmende "infra-adapter", has a three-stage bipolar amplifier following an f.e.t., providing a signal voltage that is rectified and used to switch off the TBA120S i.c. when signal level drops below a certain threshold.

The infra-red transmission approach can of course be applied to stereo amplifiers and receivers by using two subcarrier frequencies. Though there is no agreement yet on frequencies and deviation, 200kHz and 280kHz have been used with a deviation of ±20kHz. Page 522 has a photograph of a Saba receiver fitted with two infra-red transmitters — model 8101 "audiomatic".

Pot-pourri

The interest which the dummy-head stereo demonstrations created at the 1973 exhibition abounds: there were many demonstrations of the technique, especially by the broadcasting interests. One of the results of the artificial-head work, evidently, has been to stimulate interest in obtaining out-of-head images with headphones. Engineers from Matsushita were showing the results of their work in the form of a prototype "ambience phone" system. They have conducted experiments which led them to believe that out-of-head localization is possible by synthesizing a proper proportion of indirect to direct sound energy. These experiments showed that perception of out-of-head images depends not only on the amount of indirect sound present in recordings, but also to the decay time of the first reflected sound and to the decay envelope. A Matsushita "bucket-brigade" analogue delay device is used to obtain a simulation of indirect sounds. In addition some modification is made to amplitude-frequency response in cross-feeding left and right signals to simulate the effect of the head on high-frequency perception.

Full details are not available yet, but results of their preliminary work has shown that consistent in-head localizations are obtained when the ratio is zero, that out-of-head images obtain in 80% or more auditions when the ratio is about 0.5 or more, and that for a ratio of 0.12, localizations are 50:50 in or out. Initial tests used two loudspeakers, with narrow and wide directivity, which, together with sound absorbers and an anechoic room, enabled five values of energy density ratio to be investigated.*

*Additionally, the sound source direction was moved through 180° at 30° intervals, with the interesting result that the occurrence of out-of-head images depended on source direction, maximizing around 80-130°, and in particular for the case of zero reflected energy it reached 50% of auditions at 120°.

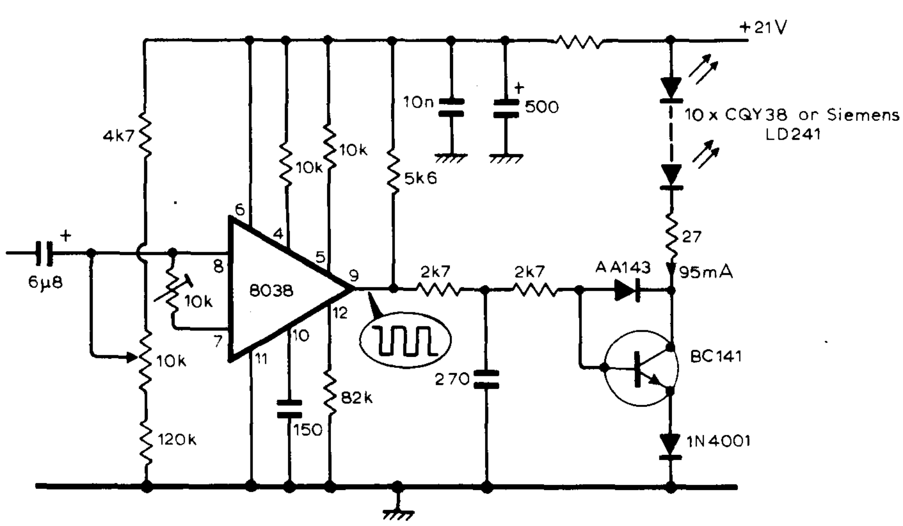


Fig.1. Sennheiser's suggested circuit for mono transmitter.

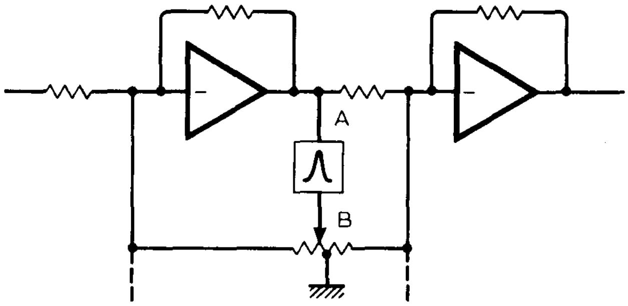
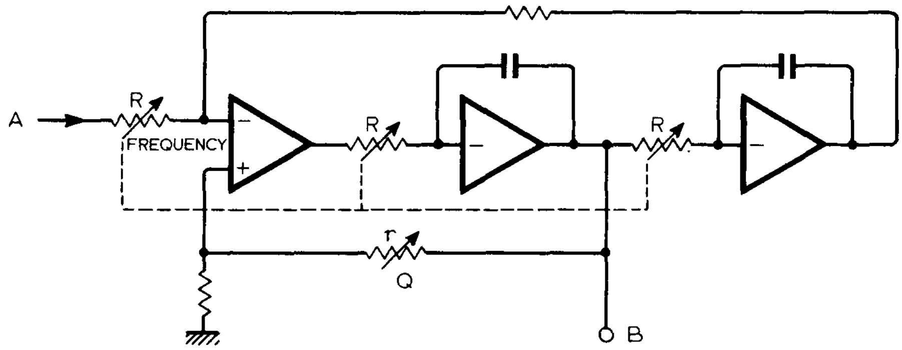


Fig.2. Two-integrator loop used in Technics equalizer permits independent control of Q and centre frequency (using three-gauged control).



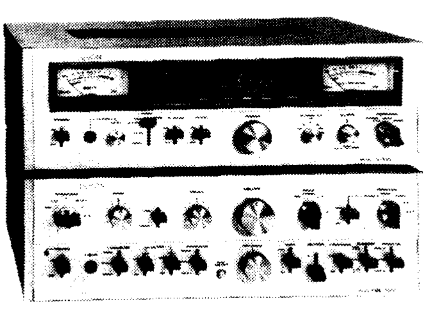
Later experiments used two separate recording rooms, one anechoic and one reverberant with speaker facing away from the dummy head, signals from the two being mixed after electronically delaying the reverberant signals. (A corrective filter was included in the two combined stereo channels to take account of the coloration produced by transmission down, effectively, two auditory canals.) This time the percentage of in and out-of-head localizations of the listeners and subjective distance were investigated as a function of energy density ratio, with delay time and reverberation time as parameters. Results showed that out-of-head localizations could be achieved in anechoic conditions even for centre front sources some of the time and that perception depended not only on the energy density ratio but also on delay time and decay envelope. (For an r.t. of 0.25s a 98% score of outer localizations was possible with a ratio of unity — whether delay was 5 or 20ms — while for 0.15 s.r.t., ratio had to be 3 to produce the same effect.) T. Goto, manager of Matsushita's acoustics research lab., tells us that their further work on the correlation of these various parameters will be reported shortly.

An interesting product from Matsushita is the Technics equalizer, SH-9090. Interesting because it appears to be the first equalizer with independent control of centre frequency, level and Q. It achieves this using 12 two-integrator loop RC active filters, with triple-ganged variable resistors for centre frequency (see Fig.2.). Each of the 12 octave-band sections is adjustable in centre frequency by ± one octave, and Q is variable between 0.7 and 7.0. A wide range of curves can be synthesized with this unit by virtue of the ability to overlap three curves. Filter characteristics from one octave above and below a selected frequency can be moved to coincide at that frequency. The equipment is mono, and harmonic distortion is below 0.05%. Phase response curves are given in the operating instructions.

Receivers and tuners

Two frequency synthesis tuners were shown for the first time in Europe, having been announced at the Chicago CES. Unlike the Kenwood/Trio tuner with its synthesized local oscillator frequencies and conventional analogue scale, mentioned in our report in the August issue, the Scott RD1000 receiver has digital readout and a frequency input keyboard. It adopts the same technique used in their five-year-old digital tuner but with the addition of a memory section. Up to ten frequencies may be stored and called up on command. To keep the memory "alive" a constant drain of 1.5mA is incurred provided by a nickel-cadmium cell in the event of short-term mains failure. Scanning, at 5 channels per second, can be on a stereo-only or all-station basis. Four l.e.d.s indicate signal strength; de-emphasis is switchable between 25, 50 and 75μs; tuning accuracy is 0.001%!

Denon tuner has fixed pointer, moving tuning scale, and separate headphone level control. Meters can be used for external measurement.



Three further tuners and receivers stood out. BASF introduced receiver with four audio channels in two versions, model 8440 with 40 watts output and 8425 with 25 watts output. Its outstanding feature is a slot that accepts plug-in modules for the Philips dynamic noise limiter, Dolby B processor unit, SQ decoder, CD-4 demodulator and a UD-4 demodulator (under development), making it an extremely versatile receiver. BASF are believed to be the first European company to plan a facility for the Nippon Columbia UD-4 surround-sound system. The new Thorens AT410 receiver has a very fresh appearance. With five preset f.m. channels and, unusually, two a.m. channels, its field strength meter also functions as a tuning scale for the preset controls. Two filters, one at 9kHz and one at 6.5kHz can be switched in simultaneously to give a 14dB/octave slope with a cut-off frequency of 4.8kHz for use with a.m. radio. The Denon tuner was shown by Bolex, together with the studio-quality amplifier PMA700Z. The tuner features a null balancing arrangement, a meter attenuator to enable the two level meters to be used with external signals (meters double as signal level and null balance indicators) and the all too rare facility of separate headphone level adjustment is provided. The tuning scale, with fixed pointer and moving scale, is a welcome change from most Japanese scales.

More motional feedback loudspeakers

Rather than use the motional feedback system to reduce distortion in normal-sized loudspeaker enclosures, Philips chose to reduce enclosure size (at the expense of weight) in their RH532 system. They have now taken this a step further with an even smaller system (eight litres) using two instead of three drive units. Model RH541 measures 23 × 29 × 17cm and weighs half of the RG532 (6.5kg). Amplifier power is 20 watts at 0.1% distortion and 30 watts at 1%. A new version of the 532 is also available finished in black (RH544).

Jamo of Denmark are producing a motional feedback system using the Philips bass drive unit in a box 46 × 28 × 24cm. Upper crossover frequency is 4.5kHz rather than the 3kHz of the RH544 and adjustable level controls are provided for the three speakers. The low-frequency amplifier provides 40 watts at 0.1% distortion and the lower half-power frequency is 30Hz.

Bolex were showing a speaker from 3a in France, that uses an apparently similar technique to the Servosound system. A bridge circuit is used to cancel out the static properties of the voice coil, leaving the dynamic effects to be used in a feedback arrangement (see, for example, *WW* 1947, pp.401/2).

Continued on page 539

Television tuner and design — 2

Gives quality sound as well as vision signals

by D. C. Read, B.Sc.

Using a varicap u.h.f. front-end, this tuner design provides quality sound and vision outputs for connection to a separate sound reproduction system and to a monitor-type receiver. It provides a group-delay corrected signal and proper black-level registration. Sound information is removed prior to the video demodulator, overcoming the problem of sound and colour subcarrier interference. Modifications, to be described subsequently, enable it to be used with a vaned-capacitor u.h.f. tuner, a domestic-type receiver — using an opto-coupler — and as a simplified sound-only unit.

The expected tuner performance up to the MC1330 demodulator input is illustrated by the frequency sweep photographs in Figs. 3 to 7. Fig. 3 was obtained by feeding the sweep signal to the base of Tr_1, with the soldered link disconnected and using the oscilloscope to inspect the signal appearing at the test points provided across C_{22} (i.e. at the demodulator input). For this measurement, C_{23} and the L_{19}/L_{20} circuit were also disconnected and L_{21} was shorted. The response shown in Fig. 3 is therefore simply that of the second i.f. pass-band shaping circuit.

For Fig. 4, the sound trap/take-off circuit was reconnected and the resulting deep notch at 33.5MHz caused by phase cancellation is clearly shown both here and in the magnified version of the response in this region given in Fig. 7.

Comparison of Fig. 3 with Fig. 4 reveals an unfortunate but not disastrous side effect caused by action in this circuit. Because the injected signal phase becomes additive on either side of the notch, there is an increase in signal level in the range 30 to 33MHz which includes the adjacent-channel vision-carrier frequency. Fortunately, transmitter siting and frequency allocation in the U.K. has been carefully arranged so that adjacent-channel interference is rarely a serious problem under normal reception conditions. Thus, the conventional 31.5MHz trap at the input to Tr_1 reduces the overall response in this region by a sufficient amount (about 15dB, see Fig. 6) despite the unwanted increase given here.

A more helpful result of the sound-trap/take-off circuit operation is that the video i.f. pass-band response cut-off between 33 and 34MHz is made steeper as is also shown by comparison of Figs. 3 and 4.

With the input link to Tr_1 replaced and the adjacent sound and vision trap circuits disconnected, or tuned out-of-band, a sweep injected at the ECL1043 test point gives the basic overall i.f. response, shown in Fig. 5. Re-connection of the traps then gives the final

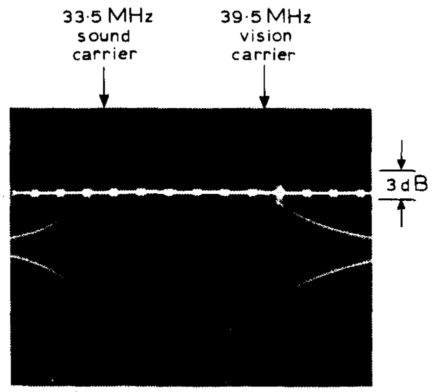


Fig. 3. Sweep response of second band-pass filter (L_4/L_6) feeding demodulator (sound trap/take-off circuit disconnected).

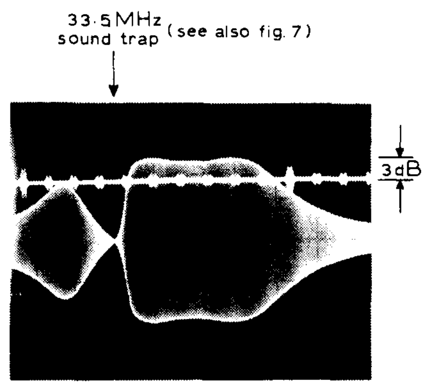


Fig. 4. As for Fig. 3 but with sound trap/take-off circuit connected.

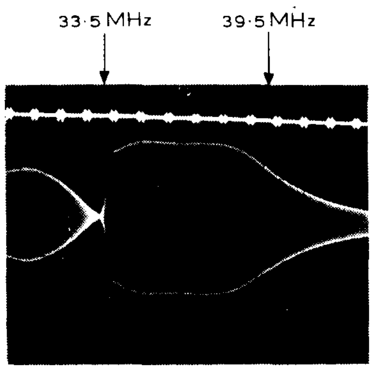


Fig. 5. Sweep response of i.f. chain (first and second band-pass filters); adjacent-channel traps (L_1, L_3) disconnected

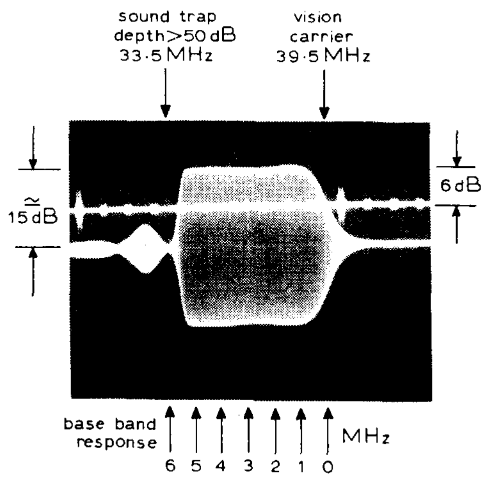


Fig. 6. As for Fig. 5 but with adjacent-channel traps connected. This is the complete response of the video i.f. chain.

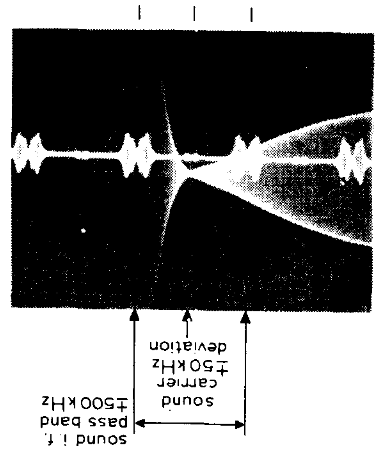


Fig. 7. Magnified response sweep showing phase cancellation of sound carrier giving >50 dB notch in vision response.

complete pass-band shape as in Fig. 6. An approximate scale indicating the eventual baseband signal frequencies has been added here to show that the shape obtained is a good approximation to the ideal receiver response (Fig. 8). In particular, the adjacent-vision trap has modified the response cut-off at the vestigial side band end so that the correct rate of fall is obtained with the vision carrier frequency positioned at the 6dB-down point.

The MC1330 video demodulator is connected in a standard manner with L_7 and C_{26} supplying the two necessary unmodulated carrier feeds in phase opposition; and Fig. 9 explains the essential circuit action in this type of synchronous demodulator.

Two other points regarding this circuit deserve comment. Because the following video circuits are directly coupled (allowing true blanking-level measurement and control) it is important that the demodulated output at pin 4 of the i.c. carries the correct d.c. component. Normally, the 200-300 ohm value of R_{18} plus R_{19} will provide for this, but as there is some spread in the MC1330 operating characteristics, it will be necessary to set R_{19} so that the required clipping action occurs at Tr_{13} emitter.

The dotted components including the 'line-linearity' variable, R_{17}, form an optional extra circuit which provides the means to adjust for accurate balance of the demodulator internal circuit. In practice, the degree of improvement possible is usually quite small and, in any event, can only be obtained by accurate measurement. Therefore, this part of the circuit should be omitted unless suitable high-grade test equipment is available.

Following the demodulator, two trap circuits L_8/C_{28}, L_9/C_{29} create notches in the video response at the sound carrier offset of 6MHz and 8.86MHz (twice colour subcarrier), as shown in the oscillogram of Fig. 10. Separate traps are used instead of a 5.5MHz low-pass network because it is an easier way to arrange the required baseband cut-off, and also reject the two out-of-band components likely to cause interference in subsequent circuits.

In view of the almost total removal of sound carrier by phase cancellation at the take-off point, it may seem that the 6MHz trap is an unnecessary extravagance; for most of the time that the tuner is operating this is true. Exceptionally, however, such as when first switching on in a cold room and before a.f.c. has become fully effective, there may be an appreciable frequency shift of the phase-cancellation point. As the 'expanded' sweep photograph of the sound take-off circuit response (Fig. 7) shows, a relatively small shift would result in a considerably increased 6MHz component in the tuner output and hence, in the absence of any other precaution, a large amount of interference on the picture.

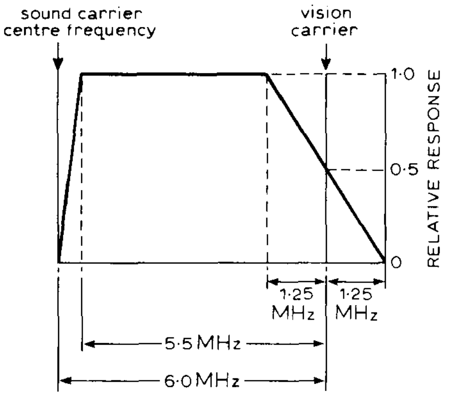


Fig. 8. Ideal receiver vision-channel response (taken from BBC/ITA publication: "Specification of television standards for 625-line system I transmissions". — 1971).

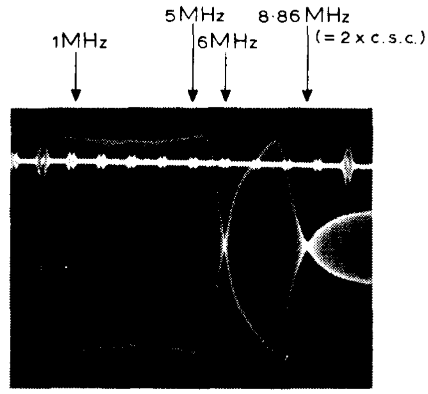


Fig. 10. Sweep response showing effect of 6MHz and 8.86MHz trap circuits.

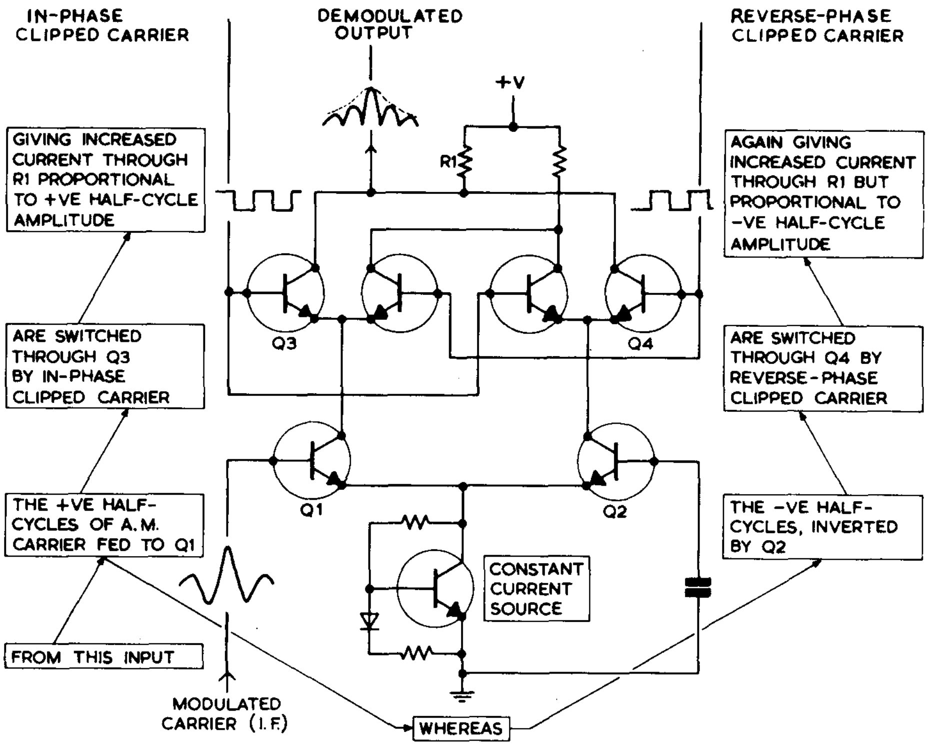


Fig. 9. Circuit action and waveforms of synchronous demodulator.

An even more important benefit obtained by having this 6MHz notch circuit is that its action is helpful during initial tuner line-up; various adjustments – particularly of the sound take-off circuit itself – would be more difficult without it, again because of high-level unwanted output-signal components.

The complementary-pair amplifier, Tr_4, Tr_5 has three main functions. It provides about 7dB gain; it presents the correct terminating impedance for the notch circuits and feeding impedance for the group-delay equaliser; it produces an additional feed of video with the required amount of d.c. shift for the direct-coupled Tr_{13} to Tr_{18} circuits which measures blanking level and generates the a.g.c. voltage.

The group-delay corrector has two resonant sections each acting over a different part of the video band such that their combined effect changes the basic delay characteristic (lower curve in Fig. 11b) to the fully corrected (upper) curve. No attempt has been made to correct the sudden change in delay beyond 5MHz because the incoming video signal contains little information above this frequency. In fact, there is some compensation for delay variation at these higher frequencies given as a by-product of modifications to the PAL decoder to be discussed in a later article.

Fig. 11a has been included for reference. It shows the approximate spectral energy response curves relating to two important components of the insertion test signal (i.t.s.) radiated as part of the television signal by U.K. transmitters. The two components are known as the 2*T* luminance and 10*T* composite pulses which, as explained in the line-up procedure, are most useful when adjusting the four inductors in the group-delay equaliser.

The final stage of the video signal circuit is a complementary-pair ampli-

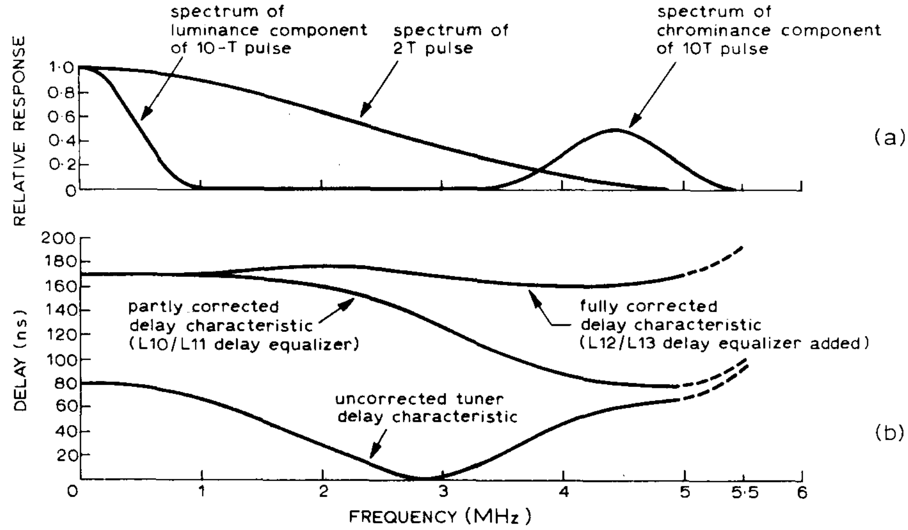


Fig. 11. (a) Spectral response of Insertion Test Signal pulses. (b) Curves showing result of two-stage delay correction.

fier which can provide up to three 75-ohm outputs or, if constructed as shown in the circuit diagram, gives one 75-ohm output for coax distribution and one medium-impedance output for direct connection to the monitor decoder (in the same box).

Fig. 12 illustrates the overall performance of the tuner using a line-repetitive frequency sweep test signal injected at the aerial input. The top trace shows the d.c. to 6MHz response up to the terminated tuner output; the lower trace displays the same signal in its i.f. carrier form before demodulation as observed at the C_{23} test terminals (see Fig. 2). To avoid adding confusing stray impedances here, a Hewlett-Packard 'twin-legged' oscilloscope probe attachment was connected in place of C_{23} to obtain this oscillogram; a photograph of this attachment together with possible home-constructed alternatives will be included in the line-up instructions.

Sound and a.f.c. circuit

The 33.5MHz sound carrier from the take-off point is fed first to an impedance-matching common-base stage, Tr_8, and thence to the 'top-C' over-coupled band-pass pair comprising L_{14} and L_{15} which gives a double-humped response with a band-width of about 1MHz. The tuning of the 'secondary' coil, L_{15}, is offset to give a lop-sided overall characteristic which counteracts the response tilt in the video band-shaping (i.f.) circuits. An asymmetrical response here is particularly important so that the resulting a.f.c. action is equally effective on either side of the correct tuning point.

Most of the sound i.f. amplification is provided by the cascode pair, Tr_9, Tr_{10}. In this stage, part of the load is formed by a resonant circuit which is tuned to 33.5MHz so that it fills in the dip in the L_{14}/L_{15} response.

The amplfied signal is then fed to the long-tailed-pair limiter circuit of Tr_{11} and Tr_{12}. Only one stage of limiting is needed because a.g.c. action on the tuner r.f. and video i.f. circuits maintains the level of the extracted sound carrier at a nearly constant value. (There is, of course, a specified fixed difference of 5 to 6dB between the sound and vision carriers leaving the transmitter.) The back-to-back diodes D_5 and D_6 are included to by-pass high-level signals which may exceptionally appear at the limiter input; e.g. such as might occur if the vision carrier level is drastically reduced at the transmitter because of a fault. Normal limiting takes place for signals in excess of about 0.2 volts peak-to-peak; the diodes clip signals of about 1.4 volts peak-to-peak.

The circuit including L_{17}, L_{18} and diodes D_7, D_8 forms a discriminator of the Foster-Seeley type. 'Top-C' coupling between the two tuned circuits is provided by C_{53} to feed an in-phase 33.5MHz carrier component to the diodes; the quadrature component is injected via C_{50} to the secondary 'centre-tap' formed by C_{51} and C_{52}. Resistors R_{52} and R_{53} act as the diode loads, and the demodulated a.f. signal appearing across C_{54} is de-emphasized by R_{54} with parallel resistances and C_{56}.

There are two further points which need mention in respect of this circuit. One is purely practical and concerns the series inductors (not numbered) shown on either side of D_7 and D_8. These are constructed by winding the diode leads in small-diameter coils using, for instance, a piece of 10-gauge wire as a temporary former. The inductance of a few turns here – as near to the diode body as possible – will help to prevent radiation of the sound-carrier harmonics which are generated as a result of diode non-linearity and which could cause interference in the r.f. circuits.

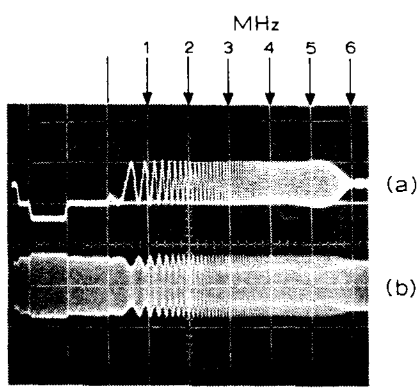


Fig. 12. (a) Tuner overall response (video terminated output) with line-repetitive sweep d.c. to 6MHz. (b) i.f. vision carrier envelope at input to MC1330 for the same signal as in (a).

The second point is more important and relates to another function of this circuit: that of producing the a.f.c. voltage and combining it with the switched tuning-control voltage developed in a subsidiary circuit. Fig. 2 shows that the discriminator secondary circuit has no direct connection to earth. Therefore, in addition to the audio signal across C_{54}, the discriminator output contains a d.c. component varying by up to ±10 volts from the mean value in proportion to the difference between the incoming sound i.f. (ideally, at 33.5MHz) and the frequency corresponding to the discriminator conversion curve centre (also set at 33.5MHz). When the a.f.c. inhibit switch is on, a reduced-voltage feed of this varying d.c. is taken via R_{62} and other resistors to the high-impedance input of zero-gain amplifier IC_{2b} where it is mixed with the switched tuning-control voltage which, for tuners operated in the London area, will have a value between 3.7 and 8.3 volts according to the station selected. The combined tuning and frequency control voltages are filtered by R_{64} and C_{60} to remove a.f. modulation before being fed to the u.h.f. module.

Diodes, D_{15} and D_{16}, are included to restrict the a.f.c. range and so prevent the tuner capturing the wrong carrier when re-selection takes place. Figures quoted for the ECL1043 module indicate that a tuning-voltage change of ±0.5 volts, i.e. the total available from the a.f.c. circuit without the catching diodes, would cause a frequency change of about ±10MHz. In practice, a maximum frequency change of ±2MHz is sufficient and this is the extent of control allowed by D_{15} and D_{16} which together with dividing resistors R_{61}, R_{62} and R_{101} restrict the applied a.f.c. voltage excursion to about ±0.1 volt. An inset drawing in Fig. 2 shows the alternative circuit which is necessary if a mechanically-controlled u.h.f. tuner is installed instead of the varicap one. In such an instance, a.f.c. sensitivity is much less, perhaps ±2MHz for ±4V, and for the same amount of control a larger voltage swing can be tolerated; the catching diodes used are the 3.3-volt zeners connected in series as shown.

Amplifier IC_{2a}, connected as shown in Fig. 2, has a gain of 6dB and produces the unit audio output at about 0.5 volt r.m.s. from a low-impedance source. The gain of this stage can be set to suit a particular installation by changing the ratio of R_{63} to R_{59}.

A.G.C. circuit

A feed of positive-going composite video at 4 volts pk-pk is taken from Tr_5 in the main circuit, filtered by R_{27} and C_{62}, giving a 6dB/octave reduction for frequencies above 1MHz, and then applied to emitter-follower Tr_{13}. When properly set, the output from Tr_{13} has its blanking level at about +15 volts d.c. Clipping action at Tr_{13} emitter, controlled either by D_9 or by simple potential division from R_{67}/R_{73} according to the circuit fitted, causes this waveform to be sliced at a nominal 16 volts so that the remaining signal comprises negative-going mixed-sync pulses together with a volt or so of the picture component. The clipped signal then follows two paths; one goes directly to the f.e.t. sample switch, Tr_{16}, and the other to Tr_{14} which, acting as a sync-tip detector/amplifier, produces an output of 4-volt positive pulses labelled, logic-fashion, $\overline{MS}$.

The blanking-level sampling pulse is generated as follows. During each sync-pulse period, C_{64} charges to the full pulse amplitude taking current through Tr_{14} and the base-emitter junction of Tr_{15}. At the end of the pulse, this transistor is momentarily cut off as C_{64} discharges through R_{72} and the base potential of Tr_{15} then rises from about −3.5 volts to the on value of +0.7 volt; this takes about 3μs.

While Tr_{15} is conducting, its collector holds the gate of Tr_{16} near to 0 volts. As Tr_{16} source is fed with the clipped video at an average potential of about +15 volts, the gate voltage is well below that required for pinch-off in this type of f.e.t. But, during the 3μs period that Tr_{15} is cut off, the gate voltage rises above this inhibiting value so that the f.e.t. conducts, and charges storage capacitor C_{65} to the Tr_{13} emitter blanking-level voltage present at that time.

Emitter bias of Tr_{17} is arranged so that conduction occurs for a base potential somewhere in the range +15 to +18 volts, the precise value being pre-set by adjustment of R_{78}. Having fixed the bias conditions in this way, conduction in this transistor then depends on the blanking-level samples stored in C_{65}. Suppose, for instance, the blanking-sample voltage moves negatively; the 'sense' of the MC1330 transfer characteristic is such that this indicates an increase in r.f. signal level. As a result, Tr_{17} begins to draw more current, the a.g.c. voltage fed from the junction of R_{80} and R_{81} to Tr_2 in the main circuit rises, and the i.f. gain is reduced. Hence, the signal level re-established at the MC1330 input is that pre-determined to give the required unit output; thus, R_{78} acts as a 'set output level' control.

Although the black-level sample-and-hold a.g.c. system requires some extra circuitry, it does offer at least two worthwhile advantages compared with the more usual methods. One is that it gives equal 'attack' and 'recovery' times for either sense of gain change, and therefore follows fast and repeated variations in incoming r.f. signal level (e.g. aircraft flutter) more faithfully. Second, it does not depend on the maintenance of a constant picture/sync ratio in the detected video signal.

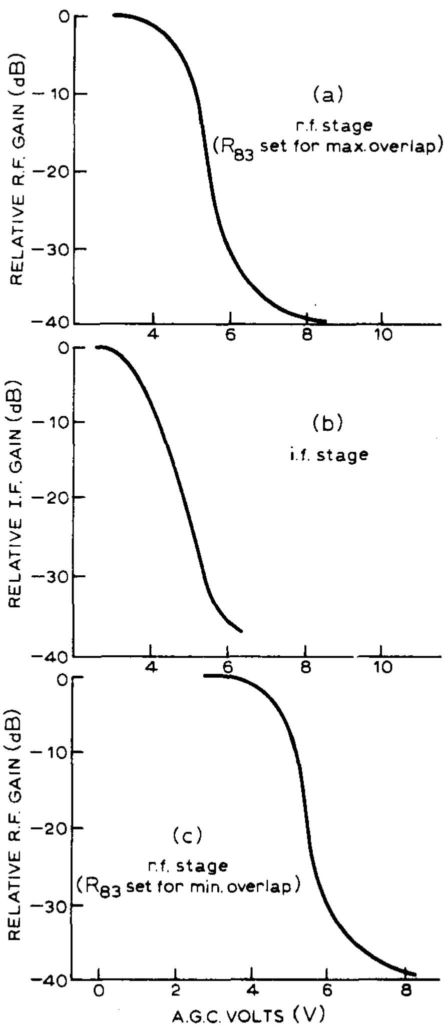


Fig. 13. Tuner a.g.c. characteristics (arranged to show the effect of crossover adjustment).

The i.f. a.g.c. voltage produced as shown is also fed to the common-base stage Tr_{18} which is biased by the divider chain R_{82} to R_{84} so that a 'delayed' version of the control voltage is derived for application to the u.h.f. module. The amount of delay obtained depends on the setting of R_{83} which determines the positive value of emitter voltage required (i.e. the point on the i.f. gain-control range) necessary to cause conduction in Tr_{18}. For a continuing rise in this voltage, the current drawn by Tr_{18} then increases the p.d. across R_{86} which reduces the tuner r.f. gain.

Obviously, the overall tuner a.g.c. characteristic is governed by the degree of overlap between the i.f. and r.f. control ranges and hence depends largely on the setting of R_{83}. In practice, the crossover point is chosen to obtain the best compromise between conflicting requirements according to local reception conditions.

Figs. 13(a) and (b) illustrate the r.f. and i.f. a.g.c. characteristics separately. Comparison between these two curves shows the relationship of their actions on the appropriate stage gain with R_{83} at its least positive setting i.e. for maximum overlap. Here, Tr_{18} is bottomed so that the two a.g.c. voltages are equal, tracking together and taking proportionate shares in the control of the overall gain. In this condition, the r.f. circuits tend to operate at relatively low gain and the noise they and the mixer produce is amplified by the i.f. circuits working at high gain so that the picture is thereby degraded.

The alternative limit condition, which obtains with R_{83} at its most positive setting for minimum overlap, is illustrated by comparing Fig. 13(b) with Fig. 13(c). The last-mentioned is simply the r.f. a.g.c. characteristic from (a) redrawn with a displaced horizontal (voltage) scale. Transistor Tr_{18} is now biased off until the i.f. a.g.c. reaches about 5.7 volts, i.e. reduction of r.f. gain is 'delayed' by this amount as indicated by the scale displacement. Over the same range of incoming signal levels as before, the r.f. circuits are at full gain and there is accordingly less i.f. amplification of r.f. stage and mixer noise. But the larger-voltage signals now acting in the r.f. stages may cause capacitance change in the varicap diodes, such changes being, of course, in sympathy with the a.m. vision carrier envelope. The resulting phase modulation of the outgoing i.f. signal has no effect on the video component, but the sound discriminator detects it as frequency modulation and hence produces a 'buzz' on the sound output. A secondary result of having excessive r.f. signal level is that there is then a danger of overloading the u.h.f. mixer stage with consequent intermodulation effects.

The choices open when setting up this section of the tuner can now be clearly seen. In those locations where all the stations which may be required for selection are received at low and constant level, the user will probably opt for high r.f. gain and so obtain the best possible noise performance. If, however, there is wide disparity in the received signal strength from different stations, or the signal from any one station is subject to large changes in level, then the alternative approach – that of keeping the r.f. gain as low as possible to prevent sound-carrier phase modulation occurring when the incoming level is high – may be preferable.

Printed circuit boards. *Wireless World has arranged a supply of printed circuit boards for the tuner design. The board, which measures approximately 25 × 13cm, is a double-sided glass-fibre type and is supplied roller tinned and drilled with test points marked. One off price is £6 inclusive; make cheques or postal orders payable to M. R. Sagin at 11 Villiers Road, London NW2.*

A kit of parts, including board, will be available from Magnum Electronics, 25 The Rise, Elstree, Herts, details of which will be given in part three of the article.

Crossover networks and phase response

A problem solved in loudspeaker design

by S. K. Pramanik

Bang & Olufsen, Denmark

Linearity of phase response has long been an aim of audio equipment designers, although its benefits to listening quality is a much debated subject. Whatever the *pros* and *cons* of the argument, it will be realised that to reproduce exactly through a speaker system (at least the direct sound) the wave form as received at the microphone, the two major influencing factors are the frequency and phase response of the chain. For example, to reproduce the steep wave front of a transient sound, not only must the harmonics be present in the same ratio as in the original sound, but their phase relationship must be equally correct. Other factors, such as harmonic distortion, etc., have a smaller visible effect when wave shapes are compared on an oscilloscope. This does not imply that there is any direct proportionality between the audible effect of any factor and its effect on visible wave shape. Phase distortion may therefore be regarded as wave shape distortion. Equally, it may be regarded as a frequency dependent delay in arrival times of different parts of the sound spectrum.

Square waves have long been used to give a quick and meaningful check on audio equipment, where by custom it is linked with transient performance. In fact it is a combined amplitude/frequency and phase/frequency response test, and gives little indication of harmonic or intermodulation distortion, or any of the other parameters considered relevant to audio equipment. It has, however, never been used to test speaker systems, as the reproduced wave has always been so far from the original that no conclusions have been possible. Generally it has been assumed that it was impossible to reproduce square waves on speaker systems, and, since the best designs sounded so good, that it was obviously unnecessary.

Ashley[1] showed that the problem of phase response lay more in the design of crossover networks than in the units themselves. In all multiway systems it is assumed that the sound from all the units is integrated in the air, by the time it reaches the listener. Therefore, provided the vector sum of the sounds from each unit is, at all times, equal to the input to the speaker system, the wave form from the system will be the same as the input. The stress here is on the vector sum and therefore includes phase, rather than the amplitude sum and therefore amplitude/frequency response. Provided the units respond perfectly to the signal input applied to them with respect to both frequency and phase, the wave shape of the sound from the speaker system will be an exact replica of the wave shape of the input signal.

In practice, speaker units have a perfectly acceptable frequency and phase response over a limited bandwidth, usually of the order of four octaves. Also, technology exists today for units to be designed to cover a bandwidth of this order anywhere in the frequency spectrum. The problem therefore, is to ensure that the vector sum of the signals from the crossover network to the units exactly equals the input. Additionally, a sufficient number of units must be used to cover the audio spectrum, with adequate attentuation outside the useable bandwidth of each unit, for the quality level and the power handling capacity required.

Equal input-output crossover networks

The simplest form of crossover network is the first order filter, which operates at 6 dB/octave. Limiting the argument to two-way systems only (the mathematics is less straightforward but can be extended to multiway systems) for the sake of simplicity, the voltages received by the bass and treble units for unity voltage input to the crossover network* are

$$V_{bass}=\frac{1}{s+1} \qquad V_{treble}=\frac{s}{s+1}$$

The attenuation curves for these functions are shown in Fig. 1. The vector sum of voltages to each unit is therefore

$$V_{output}=\frac{1}{s+1}+\frac{s}{s+1}=1$$

showing that the output is identical to the input in amplitude and phase. A speaker system therefore can be made to have linear phase response using crossovers of 6 dB/oct., with correct choice of crossover components. However, this will not solve any of the other problems associated with first order filters, such as the large overlap of four octaves for just 12 dB attentuation. These problems are so well known that they need not be restated. In fact first order filters are used today, almost exclusively for less expensive systems, designed for modest power handling applications.

Higher order crossover networks

For second and higher order crossover networks, the vector sum of the voltages will not be identical with the input. For example, for a second (12 dB/oct) order network, the voltages received by the bass and treble units for unity voltage input in the crossover network are

$$V_{bass}=\frac{1}{s^2+\sqrt{2}s+1}$$

$$V_{treble}=\frac{s^2}{s^2+\sqrt{2}s+1}$$

If the two units are connected in phase, the vector sum is

$$V_{output}=\frac{1+s^2}{s^2+\sqrt{2}s+1} \qquad (1)$$

This gives attentuation curves for each unit and total amplitude/frequency characteristic shown in Fig. 2. It can be seen that the suckout at the crossover frequency will give audibly poor results, and to get around this most designers connect the two units in opposed phase. This gives the same attenuation char-

* For the mathematical models, voltage transfer functions are used, which include both amplitude and phase information. They are simplified by using the normalised frequency variable $s_n=s/\omega_0$, ω_0 being the nominal crossover frequency. In the text, however, "s_n" is replaced by "s" for the sake of clarity. The equations given are based on "maximally flat Butterworth filters", but the mathematics and results are valid for any other filter.

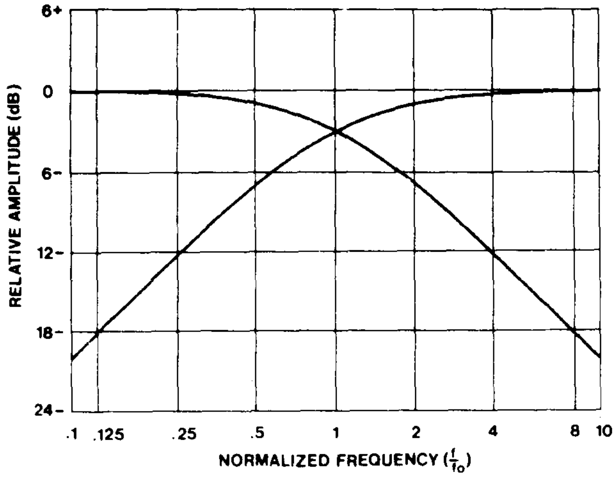


Fig. 1. Simple 6dB/octave crossover.

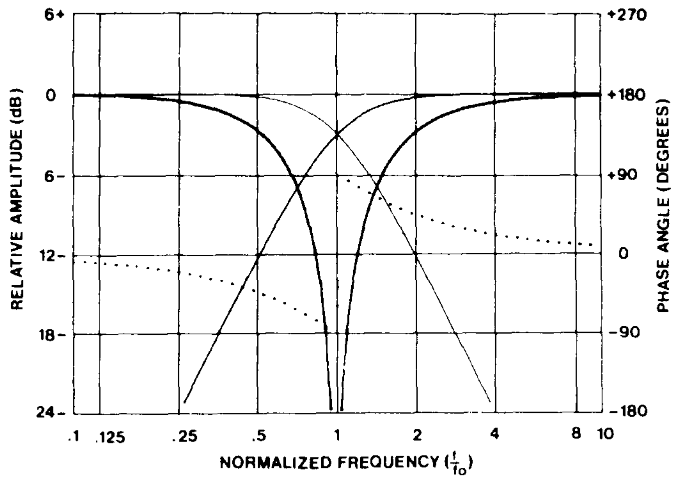


Fig. 2. Second order crossover network.

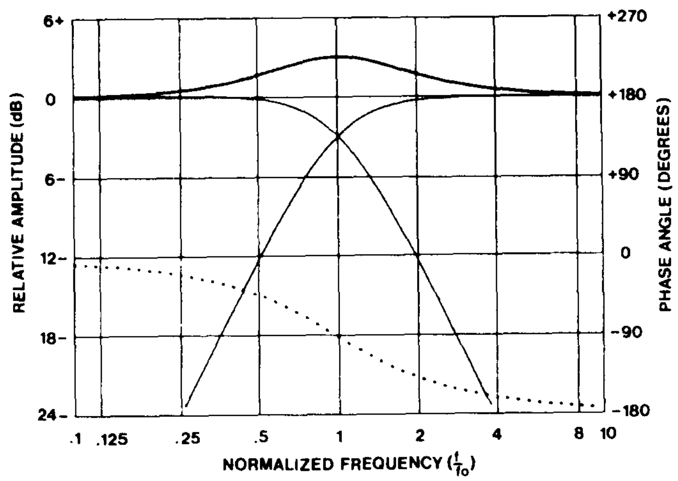


Fig. 3. As Fig. 2, but with tweeter phase reversed.

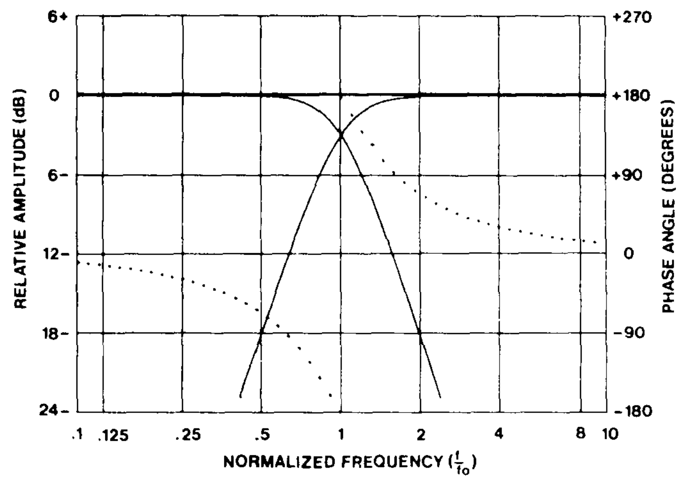


Fig. 4. Third-order crossover network.

acteristics for each unit, but the curve for the total amplitude/frequency characteristic (Fig. 3) shows a 3 dB rise at the crossover frequency. The vector sum of the voltages:

$$V_{\text{output}} = \frac{1+s^2}{s^2+\sqrt{2}s+1}$$

The dotted line in Figs. 2 and 3 shows the phase characteristics in the two cases, and it can be seen that in both cases a phase shift of 180° occurs in the crossover region. While the frequency response cam be improved slightly by juggling with crossover components, the phase shift is an inherent property of the filters and cannot be altered.

In the case of a third order network (18 dB/oct) one gets a perfectly flat amplitude/frequency characteristic (Fig. 4). Phase, however, shifts 360° over a broad band centred on the crossover frequency, the vector sum being given by the expression

$$V_{\text{output}} = \frac{1+s^3}{1+2s+2s^2+s^3}$$

As a third order crossover network has a large number of components it is basically expensive, but even more than this, components have to be matched to close tolerances, for the system to function as designed. Its application has therefore been limited to speaker systems in the highest price bracket and even then generally limited to two-way systems.

Active crossover systems

To achieve linear phase response through the crossover network, Ashley[1] proposed a mathematical solution, which was later modified by Ashley and Kaminsky[2] and Small[3]. The basic idea behind these solutions is the same, together with their advantages and disadvantages. If we go back to the equation (1) for the second order filter, we find that the vector sum

$$V_{\text{output}} = \frac{1+s^2}{1+\sqrt{2}s+s^2}$$

This expression can be made unity, i.e. identical with the input, by adding the term $\sqrt{2}s$ to the numerator. In a practical case this term can be added to either the bass unit, the treble unit, or split between the two. For example, one could design a crossover network so that the voltages received by the bass and treble units were

$$V_{\text{bass}} = \frac{1+\sqrt{2}s}{1+\sqrt{2}s+s^2}$$

$$V_{\text{treble}} = \frac{s^2}{1+\sqrt{2}s+s^2}$$

This would give the attenuation characteristics shown in Fig. 5, and since their vector sum is unity, would result in flat amplitude/frequency and phase characteristics. This principle can be extended to higher order filters and an example of a proposed third order network by Small[3] is shown in Fig. 6.

Systems such as these characteristically show a peak in the voltage to one or both units (depending on whether the crossover is designed to be assymmetric or symmetric), at a frequency near the crossover point. In passive crossover networks, power supplied by the amplifier will be referred to this peak and the required characteristic can only be obtained by dissipating power at all other frequencies in the crossover network. For a peak of 3 dB anywhere in the amplitude/frequency characteristics of either unit, therefore, virtually half the power supplied by the amplifier is dissipated before it reaches the units, rather than converted to acoustic energy.

The only practical answer for using this principle is to use a high impedance crossover network and individual amplifiers for each unit, the system being sometimes known as an active loudspeaker system. Even so, although

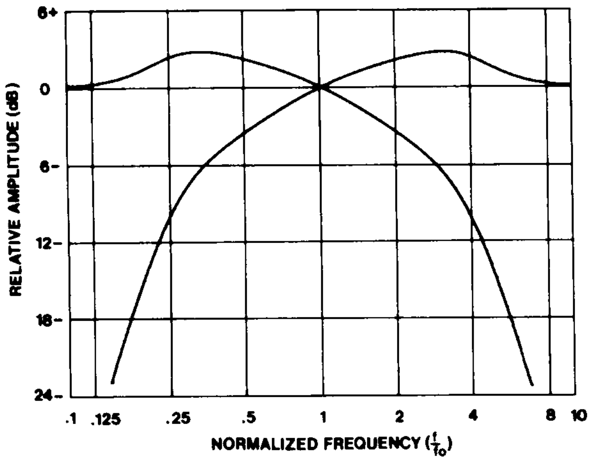


Fig. 5. Second order active crossover.

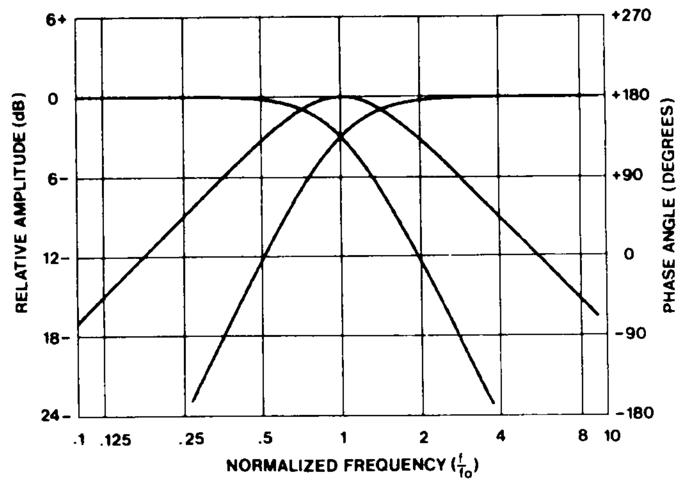


Fig. 7. Three-unit filler driver 2nd order system..

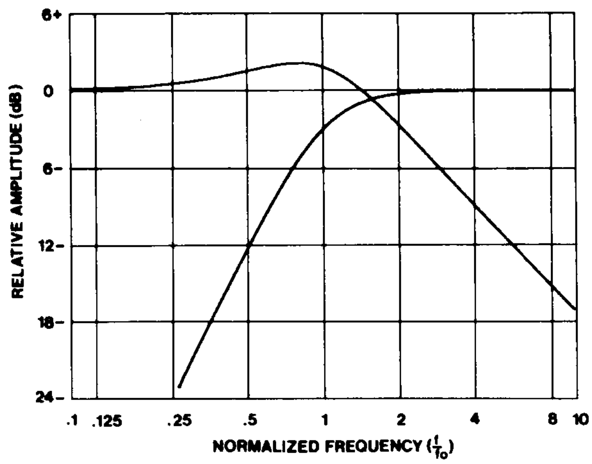


Fig. 6. Third order active network after Small.

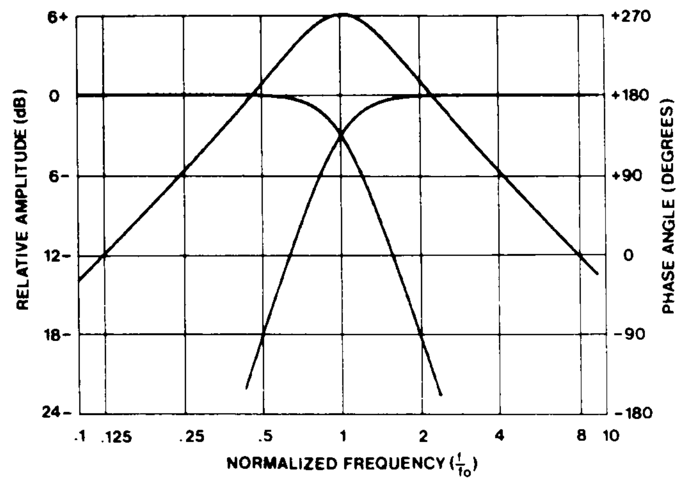


Fig. 8. Third-order filler driver system.

power is no longer dissipated in the crossover, amplifiers must be designed to supply power for the peak in the amplitude/frequency characteristic of each driver, although it is generally used at much lower levels for most of the frequency range.

Finally, perhaps the most significant drawback is that overlap at crossover frequency between the two units is appreciably increased. While the normal 2nd order network gives an overlap of two octaves for 12 dB attenuation, the modified network of Fig. 5 gives over 3.5 octaves. The third order network of Fig. 6 gives an even larger overlap of almost 4.5 octaves for the same attenuation. Compared to the 4 octaves of a first order network, which can also be designed to give a linear phase response, the performance gain is marginal for an enormous increase in cost.

The filler driver solution

Baekgaard[4] suggested that the missing term in the numerator of equations (1) could be added as an extra, completely separate unit, instead of attempting to alter the attenuation curves for the existing units. This unit, which he called a filler driver, has the advantage that there is no alteration in the attenuation characteristics of the normal bass and treble units, and therefore overlap is unaltered.

The calculated amplitude/frequency characteristic of the three units in what is still nominally a two-way system is shown in Fig. 7, for a second order (12 dB/oct) crossover network. The characteristics of the filler driver show a peak at the crossover frequency, with an attenuation of 6 dB/oct on both sides. It is therefore asked to handle only limited quantities of power, in a limited bandwidth centred on the crossover frequency.

The mathematical expressions for the attenuation characteristics are now

$$V_{\text{bass}} = \frac{1}{s^2 + \sqrt{2}s + 1}$$

$$V_{\text{filler}} = \frac{\sqrt{2}s}{s^2 + \sqrt{2}s + 1}$$

$$V_{\text{treble}} = \frac{s^2}{s^2 + \sqrt{2}s + 1}$$

The vector sum is unity, showing that both the frequency and phase responses are linear, and therefore the input and output wave shapes are identical.

A similar solution can be used for third order (18 dB/oct) filters, the attenuation characteristics being as shown in Fig. 8. It will be noticed that the efficiency of the filler driver must be twice that of the basic units, a solution most easily realised by an active circuit. In passive crossover methods a special unit would have to be used, to obtain the required efficiency.

Listening for phase distortion

Whether phase distortion can be heard is a much debated subject, and the author does not wish to contribute to that debate in this article. A word of warning about the methods used may, however, be in order.

It is well known that no two speaker systems are identical, even when made under laboratory conditions using identical units and crossover networks. It is therefore imperative that the same cabinet and units are used for comparative tests.

Phase shift may be introduced electronically by coupling a phase shifting circuit at a high impedance stage in the amplifier. A circuit may be made up to give an unaltered amplitude/frequency characteristic, but with frequency dependent phase shift corresponding to the relevant crossover network. A circuit published by Russel[5] corresponds to the phase shift of a third order filter. Such a test will, of course, be relevant only if the basic speaker system has no more than modest phase shift over most of the audio spectrum.

Another test would be to start with a speaker system using a third order crossover network, which has a flat amplitude/frequency characteristic. The addition of a filler driver to such a system gives it, in addition, a flat phase characteristic. Provided switching the extra unit has no effect on the amplifier characteristics, or on the function of the crossover network, the effect of phase distortion can be estimated. This can again be done by using a high impedance "electronic" crossover network.

Testing with microphones in normal living rooms is largely irrelevant, because reflected sound has a very large influence on measurements. The ear, on the other hand, finds it very easy to distinguish between direct and reflected sound. If therefore in comparative tests, the ear is able to distinguish between loudspeakers having undistorted and distorted phase response, even on a few signals, the value of correctly designed loudspeaker systems will have been proved. We will then have to wait for signal sources with undistorted phase response from the software manufacturers, before the benefits of loudspeaker systems with linear phase response become fully apparent.

References

1. Ashley, J. Robert, On the transient response of ideal crossover networks, *J.A.E.S.*, July 1962.
2. Ashley, J. Robert & Kaminsky, Allan L. Active and passive filters as loudspeaker crossover networks, *J.A.E.S.*, June 1971.
3. Small, Richard H. Constant-voltage crossover network design, *J.A.E.S.*, January 1971.
4. Loudspeakers — the missing link. Paper of the 50th Convention of the A.E.S., London 1975.
5. Russel, Howard T. Design active filters with less effort, *Electronic Design*, January 1971.

The above article is based on a paper presented by Mr Pramanik at the Wireless World private conference on "linear phase" loudspeakers (see note in October 1975 issue, p. 482).

Electronic circuit calculations simplified. We regret that it has been necessary to postpone publication of Part 6 of this series, on LC circuits.

We also apologise that an error appeared in Part 4 on RC combinations in the September issue. The diagrams above the captions Fig. 6 (p.424) and Fig. 8 (p.425) should be transposed.

Viewdata on trial soon

In January 1976 the Post Office starts limited trials of Viewdata, its television-screen information service. Like Teletext (see first article in this issue), Viewdata presents "pages" of printed information on the home television set — but there are two differences. First, the information is not broadcast but sent into the home by data transmission over the existing domestic line. It comes from a central "data base" — a digital computer with magnetic disc storage. Secondly, Viewdata is "interactive" in that the subscriber, by pressing buttons on a keypad, can interrogate the data base to obtain increasingly detailed information. This is arranged on a "tree" selection basis. For example, starting from the general item "eating out" on the index page, the subscriber can obtain successively: classes of restaurants (e.g. Italian, Greek); names, addresses and telephone numbers of restaurants in a particular class; and finally menus.

Viewdata is intended to be complementary to Teletext and technically compatible with it, so that the same domestic television sets and decoders can be used for both services. The page and character formats (960 characters per page, 7 colours, characters on a 7 x 5 dot matrix) are identical. The Post Office has already had discussions with BREMA, the set makers' organization, to ensure that suitable domestic equipment can be provided.

A demonstration of how the system will work was given at a recent computer conference, Eurocomp, at the Heathrow Hotel in London. Standard commerical Teletext receivers made by GEC were used, and to these keypads were connected for selecting pages and interrogating the data base. Information in ASCII telegraph code was transmitted to and from the sets via modems by the standard Post Office Datel 600 data transmission service — at a rate of 1200 bits/second for incoming information to the sets and 75 bits/second for outgoing information. The Datel 600 signals passed via the ordinary public telephone lines and exchanges to and from a data base consisting of a GEC type 4080 digital computer at the old Post Office Research Station at Dollis Hill, London. This machine has a magnetic disc cartridge store (capacity 2.4 megabytes) on which the pages are held in binary code. It is estimated that the computer system will give an enquiry response time of less than 2 seconds to 200 subscribers using it simultaneously. The machine will be moved to the new Post Office Research Station at Martlesham, Suffolk, for the start of the Viewdata trials, when initially it will be serving 20 to 50 home terminals.

Information for the service will be provided by outside organizations, and about 40 potential sources have already been approached by the Post Office. Classified advertisements might be accepted.

Design for a purpose-made Viewdata terminal for business users. Home terminals will be domestic television sets.

A full public service could start in 1978-9, say the Post Office, if the trials show that Viewdata is commercially viable. Assessments have yet to be made of the range of information to be provided, the likely demand and the charges to be made for the service. A typical domestic installation would consist of an "interface" or adaptor unit, to which would be connected the telephone line, the telephone handset, the television set (with built-in decoder) and the controlling keypad. Cost of a home installation might be in the region £50-£100. In addition to the facilities mentioned above, it might be possible for subscribers to contact by telephone the providers of displayed information and to send their own messages — "electronic telegrams" — through the system.

Big demand for electronic watches

Production of electronic watch modules and the assembly of modules into cases will contribute over 30% of Hughes Microelectronics' turnover in 1976. This prediction was made by Dr Guy Barnes, the company's managing director who said that it was originally intended to develop production to 2,000 modules per month by August. This figure was rapidly lifted to 4,000 per month and the latest target is 6,000 modules per month. Plans are now advanced to include a two-button, five-function men's watch module and a ladies' module, and delivery will start later this year.

Optical sensor ignition system

Electronic switch replaces contact-breaker

by H. Maidment

This design combines the Marston capacitive discharge circuit with an optoelectronic switch to produce an ignition system which does not suffer from the timing drift or points-wear associated with a mechanical type.

A capacitive discharge (c.d.) system overcomes most of the problems inherent in the traditional Kettering system, and retains the option of reversion. The case for combining c.d. with a contactless timing source has been argued by J. R. Watkinson (*WW* July 74 and *WW* Annual 76), preferably with ignition advance determined by non-mechanical means. Although the last mentioned is desirable, it has not yet been proved to have superior reliability.

Having personally experienced timing drift, due to heel wear, with a contact-driven c.d. system and the longer term effects of cam-profile and distributor-shaft play on engine performance. I considered that a reliable contactless system, insensitive to the effects of shaft play, would be a worthwhile objective, provided that a roadside reversion was still possible.

With the availability of relatively cheap point-source l.e.ds and high-sensitivity planar phototransistors of matched spectral characteristics, an optical sensor was developed for use with the basic R. M. Marston c.d. ignition system (*WW* Jan 1970). The aim was to achieve a compact sensor head small enough to fit most distributors without disturbing the existing circuit-breaker assembly, and a design relatively immune to interference without the use of screened leads.

As shown in Fig. 1. the c.d. circuit follows the Marston design with the addition of C_1, to overcome a tendency for false triggering, and the deletion of the bounce-suppression circuit. The last mentioned may be left in if existing units are being adapted, and C_1 need only be added if the complete unit self triggers while the light path is interrupted. The trigger circuit operates in the following manner; l.e.d. D_{10} is energized from D_9 via R_{19}. Transistor Tr_6 provides a low impedance load for

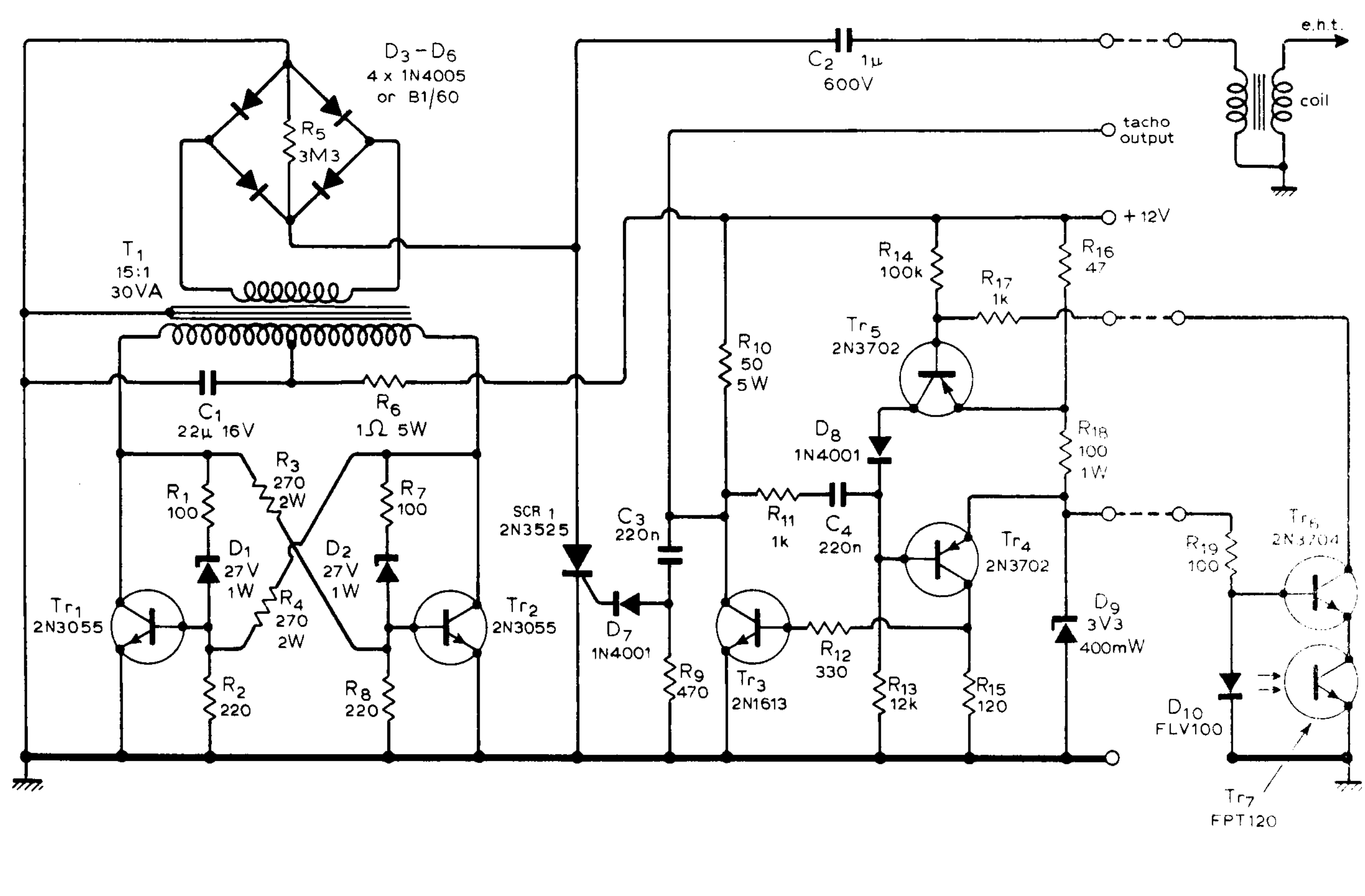


Fig. 1. Complete circuit diagram showing remote sensing head which is connected to the main circuit by unscreened leads.

phototransistor Tr_7. These items form the remote sensing head in the distributor, connected by unscreened leads to the main unit. With an interrupted light path, $Tr_{5,6}$ and $_7$ are cut off and Tr_3 and $_4$ saturated. When light falls on Tr_7 and the voltage across R_{14} exceeds about 3V, a regenerative action follows, with Tr_5 conducting and Tr_4 being cut off, which causes the voltage across D_9 to rise by 0.5V, increasing the current in D_{10}. This ensures positive switching down to zero rev/min.

Transistors Tr_3 and Tr_4 are connected to form a complementary monostable which provides an output suitable for triggering $\overline{SCR_1}$, to provide an average voltage proportional to engine speed, and an automatic engine speed limiter. It also provides a measure of false-trigger immunity. The time constants have been chosen for four cylinder engines to limit the speed to about 6,500; C_4 should be reduced to 0.15μF for six cylinder engines.

A double sided p.c.b. design is shown in Fig. 2. The earth or negative return area on the circuit side, and the heat-sink areas on the component side were covered with Fablon. The rest of the circuit was inked in with a resist pen before etching. The clearance areas in the heat sinks were made after etching by lightly countersinking with a 3mm drill. If desired, a more compact assembly may be obtained by cutting the board at XX and mounting back to back as shown in Fig. 7. Readers wishing to adapt the trigger circuit for use with an existing Marston c.d. unit, may prepare a single-sided board as shown below the line YY, omitting D_7, R_9, C_3 and R_{10}. Note that $R_{3,4,6,10}$ and $_{18}$ are mounted clear of the board for better heat dissipation, and that C_2 is not mounted on the p.c.b.

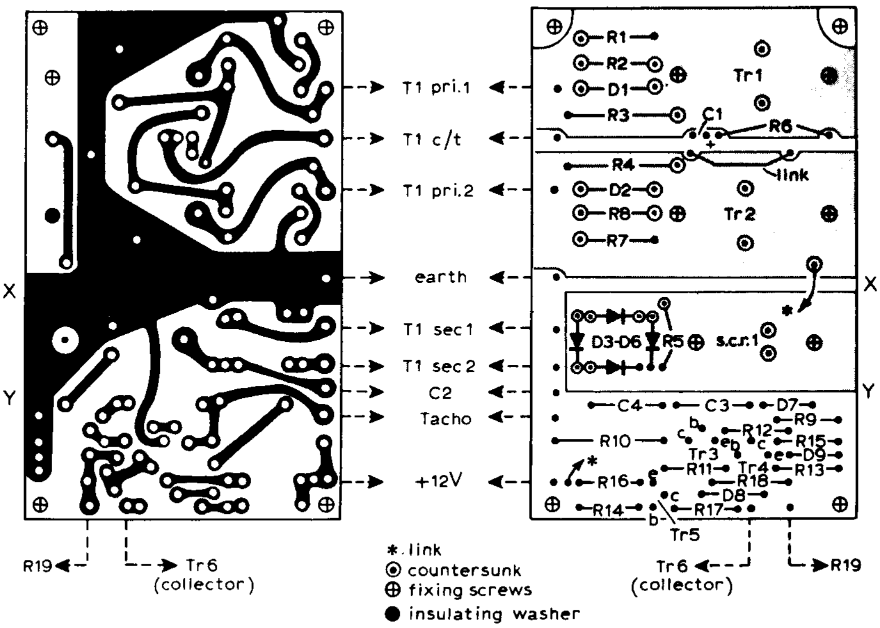
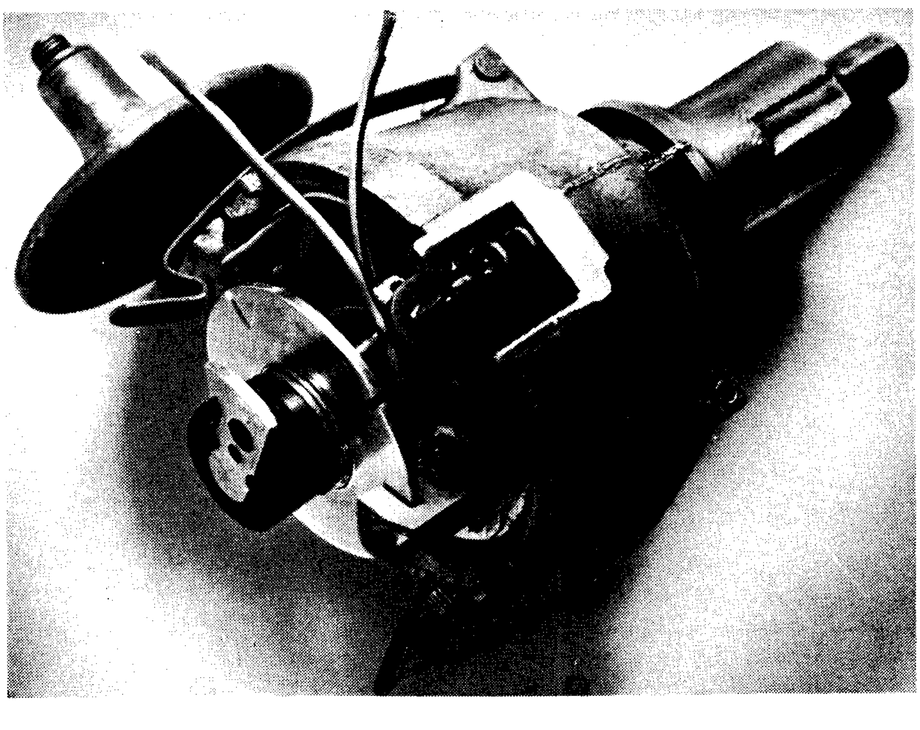


Fig. 2. Double sided p.c.b. layout measuring 2½ × 4 in. This board can be cut across XX and the two halves mounted back to back. Alternatively, if the trigger circuit is to be used with an existing Marston c.d. unit the board below YY may be used.

Fig. 3. Vertical sensing head and shutter assembly mounted on a Lucas distributor.



Sensing-head design

The detail design of the shutter, sensing head and mounting bracket will depend on the type of distributor. Shown in Fig. 3 is a prototype assembly mounted on a Lucas distributor, with the optical axis vertical. This is the easier to construct, but to avoid the possibility of excessive dust on the phototransistor lens a horizontal optical axis is to be preferred. This type was used by the author on a Saab 99 employing a Delco-Remy distributor—Fig. 8.

The two types of shutter are shown in Figs. 4(a) and 4(b). The disc version can be fabricated from 18- or 20-gauge dural sheet, first scribing two lines accurately at right-angles for 4 cylinder engines, or three at 60° for 6 cylinder versions, and circles of radii to suit the distributor. The slots are only critical with respect to their leading edges, which should be filed accurately to the scribed lines and bevelled slightly on the underside, particularly the trailing edge. The bevelling eliminates stray reflections which can cause timing scatter.

An alternative approach, where facilities are available, is to black anodize the disc before attachment. The cylindrical type of shutter follows much the same principle except that it is more easily machined from dural stock in a lathe. To obtain the desired clearance between the lower edge of the shutter and the contact breaker, it is necessary to turn a shoulder on the rotor arm against which the inner diameter of the shutter locates. It is possible to hand file the slots to within 0.1mm of the scribed line using a suitable ward file. This represents about 0.5 crankshaft degrees error at 25mm radius, and compares well with the allowable cam lobe error, normally ±2°. The width of slot is uncritical but less than 1mm will result in a loss of light and more than 3mm will increase the non-linearity of the tachometer output at low engine speed.

The two forms of sensing head are shown in Figs. 5(a) and 5(b). Both can be constructed from 6mm dural plate, although slightly thicker material would be an advantage when drilling the 5mm hole. This should be eased with a half round file and emery paper for a snug fit. The outer edges of each hole are rebated on one side to clear the device wires, which are bent at right-angles to align with the p.c.b. The height of the sensing head and form of

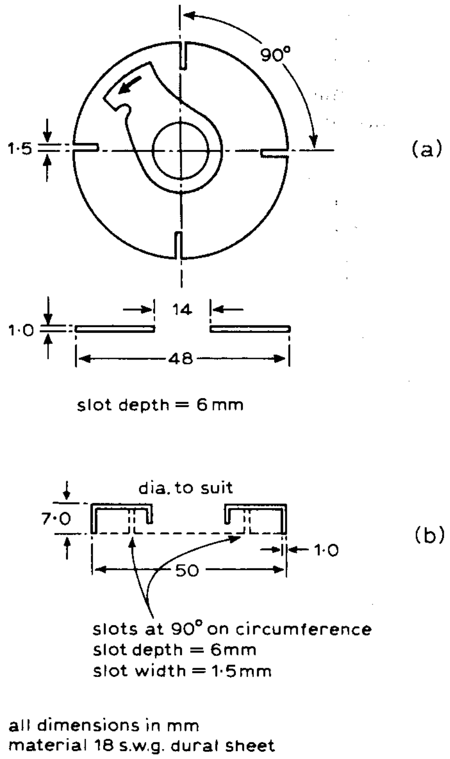


Fig. 4. Shutter design for vertical axis (a) and horizontal axis (b).

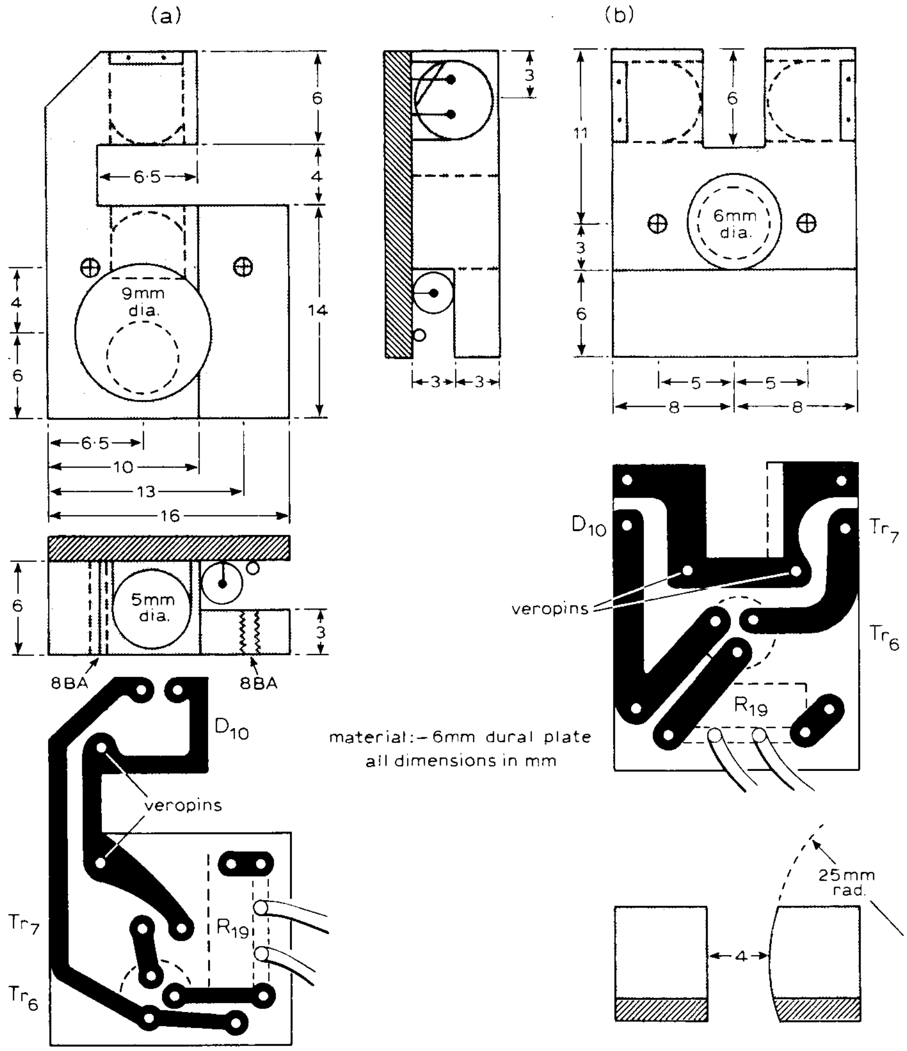


Fig. 5. Vertical and horizontal sensing-head details. The two Veropins in both types earth the circuit and act as locating dowels.

the mounting bracket will depend on the type of distributor used, but the arrangement shown using two 8 BA screws for attachment to a suitable mounting bracket should suffice for most types. The single sided p.c.b. was prepared and etched in the normal manner. In the case of the horizontal-axis sensor, the p.c.b. was first clamped to the body of the sensor after ensuring correct alignment, and two 1.0mm holes drilled, as indicated in Fig. 5, to receive a pair of 0.04in Veropins which serve to earth the circuit and act as locating dowels. At the same time the inner face of the slot is gently radiused to match the shutter curvature. A similar dowelling technique may be used for vertical sensors.

Before final assembly, Tr_6 R_{19} and two fly leads are soldered in place. The fly leads should be thin instrument wires which are doubled back through clearance holes for mechanical strength. Diode D_{10} and Tr_7 are positioned with their lenses 0.5mm behind the slot faces. Tr_7 occupies the inner or lower position with its base wire cut off flush. The p.c.b. is then aligned and soldered to the dowels, which have been force fitted to the block. The completed assembly is given a coat of polyurethane varnish which anchors the devices in place and

Components

Resistors

R_1	100
R_2	220
R_3	270, 2W
R_4	270, 2W
R_5	3.3M
R_6	1.0, 5W
R_7	100
R_8	220
R_9	470
R_{10}	50, 5W
R_{11}	1k
R_{12}	330
R_{13}	12k
R_{14}	100k
R_{15}	120
R_{16}	47
R_{17}	1k
R_{18}	100, 1W
R_{19}	100

All resistors ½W unless otherwise stated

Capacitors

C_1	22μ, 16V
C_2	1.0μ, 600V
C_3, C_4	0.22μ, 250V (polyester)

Semiconductors

Tr_1	2N3055
Tr_2	2N3055
Tr_3	2N1613, 2N3053 or BFY52
Tr_4	2N3702, BC212 or ZTX500
Tr_5	2N3702, BC212 or ZTX500
Tr_6	2N3704, BC182(3), or ZTX300
Tr_7	FPT120 (Fairchild)*
SCR_1	2N3525
D_1	27V, 1W zener
D_2	27V, 1W zener
D_{3-6}	1N4005
D_7, D_8	1N4001
D_9	3.3V, 400mW zener
D_{10}	FLV100 l.e.d. (Fairchild)*

T_1 15:1 centre-tapped transformer rated at 30VA, A l.t. or battery charger 240:16V type can be used. For details of modifying a transformer refer to *WW* Jan 70.

* Obtainable from Ambit International Ltd, 37a High Street, Brentwood, Essex CM14 4RH.

provides moisture protection. Care should be taken not to damage the lenses or contaminate them with varnish during construction.

Mounting

A suitable mounting bracket for the type of Lucas distributor shown in Fig. 3 is detailed in Fig. 6. This bracket is fitted in place of the capacitor whose original fixing screw provides a means for synchronizing the optical system to the contact breaker. Oversize holes in the vertical bracket and suitable washers behind the 8 BA screw heads holding the sensor permit adjustment of the shutter running-clearances. Brass was used as this allows the vertical bracket to be soldered in position on its base plate. Similar constructional methods may be adapted to suit most distributors.

The position of the sensor with respect to the rotor arm is uncritical except in the case of the vertical axis version, when it should not be in line at the triggering points. The orientation of the shutter with respect to the contact-breaker opening point, with the sensor bracket mid way in the angular range of adjustment, should be determined before Aralditing to the rotor arm. The disc shutter increases the height of the rotor arm; this should be checked by removing the brush from the distributor cap, and placing a knob of plasticine on top of the rotor arm before seating the distributor cap. If the clearance is less than 0.5mm, the base of the rotor arm should be carefully filed to suit. To maintain concentricity between the disc type shutter and rotor arm whilst Aralditing, a short length of split tube should be located through the shutter into the rotor arm and removed before the Araldite is fully cured.

In some distributors, significant angular backlash exists between the rotor arm and the shaft. This should be eliminated by shimming the clearance

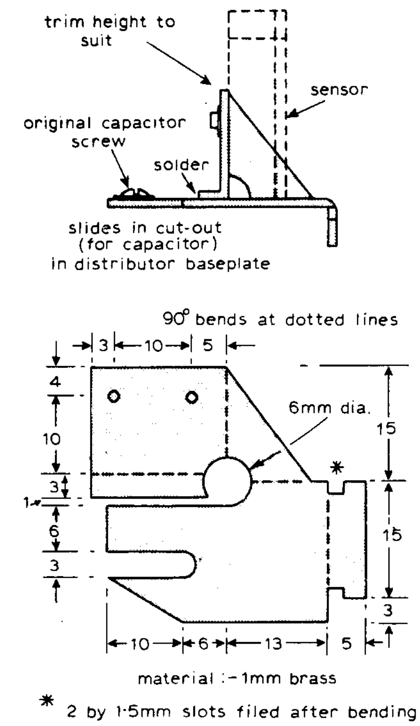


Fig. 6. Mounting bracket for use with a vertical sensing head in a Lucas distributor.

between the leading edge of the slot in the shaft and the key in the rotor arm. This may be achieved by forming a shim steel or beryllium copper strip in the shape of a question mark, the circular section fashioned to fit the hollow section of the shaft, and the tail bowed slightly, cut to suit the depth of the keyway, and located against the leading edge; thus taking up the backlash when the rotor arm is fitted. An alternative method is to oil the shaft spigot and coat the sides of the rotor arm with Araldite

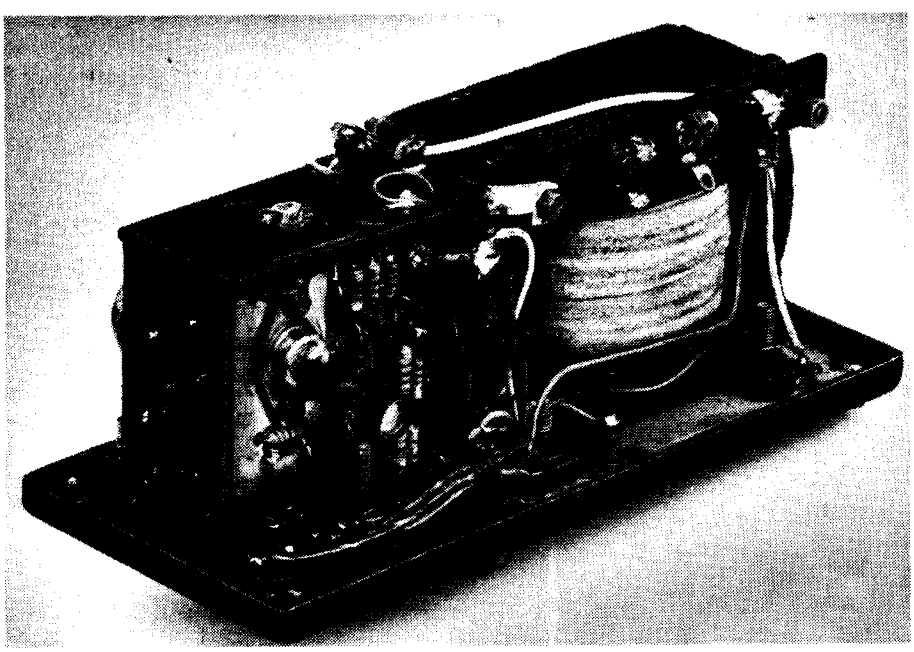


Fig. 7. Main electronic unit showing the double sided p.c.b. cut in half and mounted back to back.

before locating on the shaft. The rotor should be gently eased off the shaft before the Araldite is fully cured.

The construction of the main unit is left to the reader, following the general advice given by Marston. The optical trigger amplifier and sensor should be checked on the bench as follows. When the light path is uninterrupted; Tr_3 collector should be cut off, the current in R_{19} about 22.5mA and the current in R_{17} between 100 and 200μA. When the light path is interrupted; Tr_3 collector should not exceed 1V, the current in R_{19} should drop to about 17.5mA, and in R_{17} it should be less than 1μA provided that there is no background illumination. The circuit should change state cleanly when the current in R_{17} exceeds about 30μA.

Installation

When installing the sensor and shutter, the mechanical clearances over the full rotation (taking account of distributor bearing play) should be carefully checked. Between the shutter edge and the base of the slot in the sensor there should be between 0.25 and 0.75mm clearance, and from 1.0 to 1.5mm on the sides. The fly leads should be wound into a four-turn helix around a 3mm drill shank and either taken through a grommet in the base of the distributor, or to a pair of feed through bushes; the fly leads must not foul or be strained over the range of vacuum advance travel. The capacitor from the distributor should be mounted alongside the coil and connected to the redundant contact breaker lead from which a lead may be taken to the c.b. connection of the coil as a "get you home" expedient. The contacts should be kept open with a slip of Tufnol to hold the heel clear of the cam when using the optical system.

The complete system should be monitored with a voltmeter at the tachometer output with the engine at tick-over — there should be no voltage kicks indicative of false triggering. If this is not the case, the supply line impedance may be the most likely cause, as in the case of the basic c.d. system (*WW* January 1970). Similar checks should be made when selecting each of the electrical services in turn. The most probable source of interference will be horns operated directly from the button; however, the horn is infrequently used and the effect on the engine is only slight.

Some problems were experienced from relay transients during the circuit development, and better noise immunity was achieved by adopting a 3V threshold for Tr_5 and transferring Tr_6 from the main unit to the sensing head. The timing delay introduced by the optical system was measured in a test rig where a second l.e.d., driven from the tachometer output (with C_4 disconnected) was mounted behind the shutter, 180° away from the sensor. The shutter, comprising two 0.5mm slots

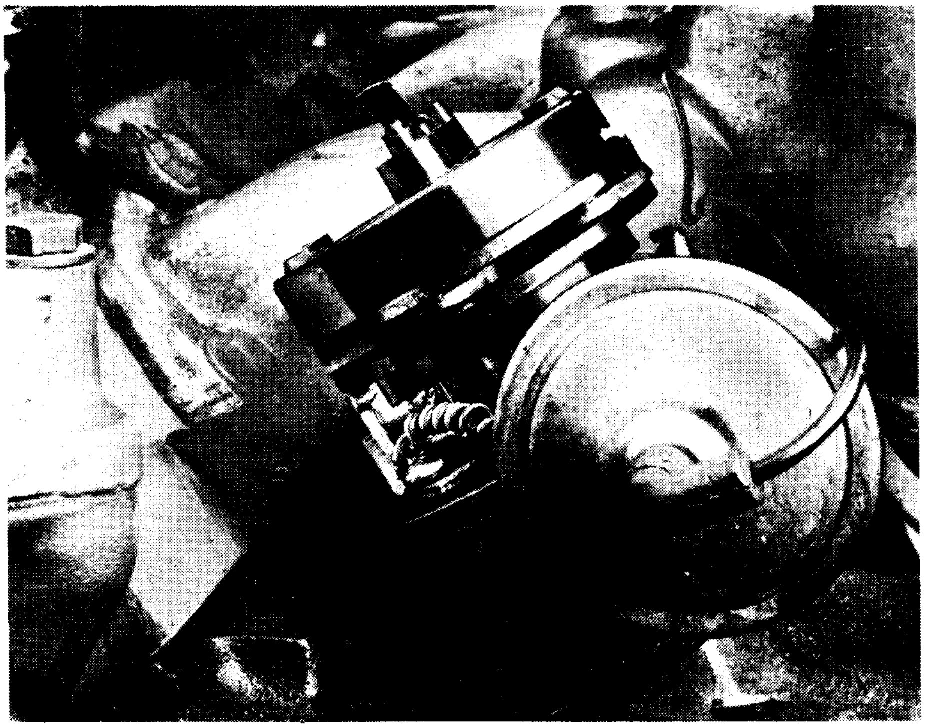


Fig. 8. Horizontal-axis sensor head mounted in a Delco Remy distributor on a Saab motor car.

diametrically opposed, was run at 3,000 r.p.m. (i.e. 6,000 crank r.p.m.) and the angular movement of the l.e.d. needed to restore full brilliance when viewed through the slot was less than 30 μs. The low voltage start performance was also simulated in powering the ignition from 6 V, and good starts from cold were achieved. This is a stringent test because under realistic conditions low voltages are only severe during the starter motor transient from rest.

The system described has operated with complete reliability and no timing drift for over 18 months in the author's car, as well as six months in a Singer Vogue. In the last-mentioned case, the electrical system used a positive earth, so a three-wire sensor was used with the main circuit wired upside down. Readers wishing to instal a permanent tachometer may use any suitable moving coil movement up to about 2mA f.s.d. The meter should be mechanically zeroed to offset the standing voltage present with the ignition on and the engine stationary. The desired f.s.d. may be set with an appropriate preset resistor. The linearity is good between 1,500 and 6,000 r.p.m., but will require calibration at a known roadspeed equivalent. As a guide, 9V is approximately equivalent to 5,000 r.p.m. on a four-cylinder engine. Although the trigger amplifier was specifically designed for use with the Marston c.d. unit, it should be readily adaptable to suit other designs in existence.

Literature Received

Four publications from Willsher and Quick describe their cases, racks and card frames now available. The 19-in Eurorac, Camac 19-in racks and the AEC-NIM range of crates and modules are described. Willsher & Quick Ltd, Walrow, Highbridge, Somerset TA9 4AQ WW401

A catalogue, detailing transformer assemblies for use in 5-1500VA applications, has been sent to us by Custom Transformers Ltd. Only the mechanical parts are offered. Custom Transformers Ltd, Bristol Road, Malmesbury, Wilts SN16 0DU WW402

The Ensign range of high-voltage, high-stability power supplies is described in a new leaflet sent to us by Brandenburg Ltd, High-voltage Engineering Division, 939 London Road, Thornton Heath, Surrey CR4 6JE WW403

We have received a leaflet from Hipotronics, which gives details of a range of dielectric and insulation testers, working at potentials up to 10kV a.c. and 25kV d.c. Leaflet HP7107 is obtainable from Hipotronics, Inc., Brewster, N.Y.10509, U.S.A. WW404

A new leaflet from BHS gives full constructional and technical data on the 2500VDC series of h.v. capacitors, which are epoxy-encapsulated and of polypropylene construction. The leaflet is available from BHS Electronics (Sales) Ltd, Bercourt House, York Road, Brentford, Middlesex WW405

Digital panel meters, with 200mV or 2V full-scale sensitivities, and 3½-digit l.e.d. displays, are described in publication D.1 from Farnell Instruments Ltd, Sandbeck Way, Wetherby, West Yorkshire LS22 4DH WW406

A pulse measuring system, counter and digital multimeter are combined in the Field Datameter DTM1000, described by Weir in a new leaflet. The instrument is for use with t.t.l. and m.o.s. logic and, in addition to voltage and resistance measurements, display of transition times, pulse width, duty cycle, time interval and pulse overlap is provided for. Weir instrumentation Ltd, Durban Road, Bognor Regis, Sussex WW407

The range of optoelectronic devices from Hewlett-Packard is fully covered in a new Designers Catalogue, which includes data on l.e.ds, l.e.d. displays, isolators and detectors. The catalogue is obtainable free from GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks WW408

Details of ITT power supplies, d.c.-to-d.c. converters and transformers, together with a number of reprinted articles, are published in a new catalogue from ITT Components Group Europe, Electrical Product Division, Edinburgh Way, Harlow, Essex WW409

Two brochues from Du Pont describe a range of conductive silver compositions, for use with various methods of application to the substrate and curing temperatures. The brochures can be obtained from Du Pont Electronic Materials Division, Maylands Avenue, Hemel Hempstead, Herts WW410

We have received from Ferranti a 40-page catalogue of application information and data on T/R cells and duplexers. Ferranti Ltd, Professional Components Department, Dunsinane Avenue, Dundee DD2 3PN WW411

A brochure describing a buffered magnetic tape transport for minicomputer use is obtainable from Pertec International, Peripheral Equipment Division, 10 Portman Road, Reading, Berks. The system includes the buffered tape formatter and one of several transports, providing auto read and write for tape/buffer transfers, at up to 79kHz................................ WW412

The 360-page Marconi Instruments catalogue for 1975/6 is now available, covering a wide range of measuring instruments for the communications and electronics industry. The catalogue is obtainable from Marconi Instruments Ltd, Longacres, St Albans, Herts.

Equipment for vacuum handling of small components and a range of de-soldering instruments is described in leaflets produced by Air-Vac Engineering of Connecticut, U.S.A. The leaflets can be obtained from Tony Chapman Electronics Ltd, 80a High Street, Epping, Essex CM16 4AE WW413

A leaflet describing the Mini-Therm range of temperature controllers is published by Solid State Controls. The units are either plug-in or panel-mounting types and can cover temperature ranges between −100°C to +1600°C, using either thermocouples or resistance bulbs. The leaflet can be obtained from the company at Brunel Road, Acton, London W.3..................... WW414

The Ariel group of companies have sent us a range of catalogues, describing electrical connectors, lampholders, fans, audio leads, tools and gauges. Available from Ariel Group of Companies Ltd, Wollaton Road, Beeston, Notts WW417

Research Notes

Black holes to solve the energy crisis?

Atom-sized black holes could spell the end of man's frantic search for energy, according to American physicist George Chapline of California University. Just before a black hole swallows matter, a pulse of radiation is emitted. This fact, coupled with the notion that there may be quite sizeable numbers of these minute black holes about the universe (10^{23} in our galaxy), prompted the suggestion that a captive hole could provide our energy needs for all time. As an added bonus its insatiable appetite for matter would neatly solve the problem of rubbish disposal. But where do you find a black hole, and perhaps more difficult still, how do you contain it when you've got it? One possibility would be to give it a charge and then suspend it in an electric field. Then simply add garbage (any old junk will do) and wait for a pulse of energy to emerge. So easy, but, maybe we'd better stick to nice safe plutonium reactors after all. Black holes, if they exist, are supposed to have a rather nasty habit of turning into white holes and then . . .

Come back, Geller, all is forgiven?

If the idea of generating power from black holes seems just a little on the dangerous side, then there may be a perfectly safe alternative. Indian research shows that when a metal rod is broken, electric and magnetic fields are produced around the fracture. In the experiment a test rod was placed near a small copper "aerial" connected to an oscilloscope and then stretched to the point of breaking. Although the effect only lasts for a few tenths of a second, a rod made from magnetic material does acquire a degree of permanent magnetism.

Just a second . . .

If you've built one of the recent designs for crystal-controlled digital clocks, you're probably congratulating yourself on how few seconds it gains or loses in a year. And indeed time and frequency are the most accurately measurable of all physical quantities. But oddly enough it appears that, even using atomic frequency generators, a perfectly standard second is a rather elusive commodity.

You probably recall an experiment a few years ago in which atomic clocks were synchronised and then flown around the world in opposite directions. The result, predicted by Special Relativity, was a discrepancy of several microseconds. This is the so-called Time Dilation Effect, and so paradoxically standard time must stand still!

Gravity is another factor affecting time, and indeed all the world's standard clocks are corrected according to their height above sea level. But even with this sort of precaution, standards labs still have to issue correction factors to bring themselves into line, and, until recently, for no obvious reason.

The solution, according to two Canadian physicists, may lie in the suggestion that we've all overlooked yet another aspect of relativity. Maybe the rotational acceleration of the earth needs to be taken into account, making time different in different latitudes. Curiously enough when the latitude correction was applied to data from all the world's time standards there was complete agreement, with however one exception — the Royal Greenwich Observatory. So maybe British Standard Time is quite unique after all!

Bat sonar is best

Bats can be trained to distinguish between targets which look the same on ordinary man-made sonars. Research in St Louis, Missouri, USA, used plastic objects of nearly identical size and shape. The only difference was that shallow depressions in the objects (square slabs of Perspex) differed in depth. The bats (rewarded by food when they responded to the correct target) learned to discriminate effectively between holes 7mm and 8mm in depth.

Sound waves to hold liquids in space lab?

One of the most striking demonstrations of standing waves is the generation of Chladni's figures. A vibrator, such as a square piece of metal sheet, suspended at its centre is set in harmonic motion by applying acoustic energy. Fine powder — traditionally lycopodium spores — sprinkled on the surface moves to the points of minimum amplitude. The result is a visual standing wave display.

A three-dimensional acoustic standing wave in the air would show similar properties if gravity were absent. Solids or liquids placed in the sound field would be pushed to the points of minimum amplitude and held there.

It is proposed to use this effect in several crystal-growing experiments on board Spacelab, where ultrasonic standing waves will prevent alloys such as gold-germanium from coming in contact with any container. In this way it will be possible to achieve hitherto impossible standards of purity.

Meteorites: poor man's intelsat?

Those who can remember the good old days when wavelengths below 100m were "relegated" to amateurs will take pleasure in the belated arrival of the professional in yet another erstwhile amateur province; in this case meteor-scatter. Scientists at Lahore University in Pakistan are now exploring the possibility of using the ionisation trails left by meteors as a sort of cheap substitute for the communications satellite. Full of eastern promise you might think, but the snag, of course, is the unpredictability of the meteor trails. Undeterred by this the Pakistani scientists plan to record digital data and then fire it off at high speed whenever conditions are ripe. Quite obviously the wise men of old who followed the star in the east never guessed the habit would be catching!

Sixty Years Ago

The contents of our November 1915 issue must have been frustrating in the extreme for the thousands of amateurs who were forbidden even to possess "wireless" parts, be they for transmission or reception. The journal was full of the activities of military and marine operators, but the war had put paid to any participation by unofficial listeners or operators. The most tantalizing article was on the exposure of German neutrality violation at their station at Sayville in the USA. Apparently the Germans were using innocent-sounding commercial messages to convey military information from the US to German submarines, and an American experimenter, C. E. Apgar, had recorded the messages on wax cylinders. Sayville was promptly taken over by the US authorities.

The editorial of this issue contained what may have been one of the first references to a "black box." The writer of the editorial was promising a bumper Christmas issue and said "A notable feature will consist of a brightly written story covering the twenty years (more or less) which have elapsed since Senatore Marconi landed with his little black box on the shores of England."

More from the Berlin show

An improved model of the three-year-old Philips VCR video cassette recorder was introduced, model N1500 having sold an estimated 90,000 units. As well as the obvious areas of improvement, such as greater integration of components and re-styled appearance, stability has been improved, a "stop-motion" facility added and a greater bandwidth achieved — 3.1MHz for the luminance channel instead of 2.7MHz. Model N1460 also features the stop-motion and wider bandwidth, but is a playback-only unit. The new models sell for DM2750 (DM2450 for the N1500) and DM1980.

Sony gave the first European demonstration of their 305cm colour projection system, VPK1200E, using a specially-developed Trinitron tube. Sony's president, Akio Morita, said at a press conference that with tape recorders and colour television being the company's two main technologies, Sony saw their future in combining the two. He told *Wireless World* that in future colour tv sets would have a cassette system built in, especially as the choice of television broadcasts was small and receivers were in use for only a limited time. Units incorporating a 48cm colour receiver and Sony's new 1.3cm Betamax cassette system are being prepared for marketing in the US for $2,295. The outstanding feature of the Betamax system is its very low tape consumption — lower in fact that BASF's LVR proposal. It achieves this by reversing colour phase polarity on alternate tracks, thus allowing guard bands between diagonal video tracks to be eliminated. A comb filter technique is used to deal with remaining crosstalk.

Because of the greater penetration of colour television receivers, and the joint venture with MCA, Philips plan to market their VLP video disc system first in the USA during the latter part of 1976. Marketing in Europe is planned for 1977, with "software" probably being mostly supplied by Polymedia, a 50:50 Philips and Siemens venture. There are hopes that the potentially competitive systems under investigation by Zenith and Thomson-CSF, will produce compatible discs — Zenith have now chosen an optical system and have demonstrated compatibility on a Philips player, and Thomson are reported to be thinking in terms of a reflective disc.

Since our last report on VLP players (pages 541/2, 1973), a further servo-controlled mirror has been added. The single pivoted mirror behind the objective lens and its control system allowed for radial tracking corrections due to eccentricity of the track. Though eccentricity of the hole and player combined is less than 50μm a longitudinal correction is needed to avoid timing errors, provided by a second orthogonal mirror and servo system. Other improvements have enabled a full composite video signal to be recorded with a 5MHz bandwidth, instead of translating the colour subcarrier downward and limiting luminance bandwidth to 3MHz.

The Rabe MDR magnetic video disc recorder appears now to operate at 33 rev/min — when we first reported this development, speed was 156 rev/min (p.542, 1973), but the unit wasn't available at the time of our visit. The unit is expected to be avilable at the end of the year for DM2,000-2,300. The most likely problem this will meet is that due to dust on the disc surface — good head to disc contact being important to prevent dropout. Then there is the duplicating problem to be tackled.

Transcription units

A host of new cassette decks have the Dolby B system fitted (many being front-loading decks) — Akai, Braun, Elac, Grundig, ITT, Kenwood/Trio, NAD, Pioneer, Saba, Sanyo, Sharp, Tandberg, Telefunken, Uher and Wega (now owned by Sony). Some have both Dolby B and the Philips d.n.l. built in, such as the Braun TGC450, Elac CD520 and Philips N2520, while the Grundig CN700, Sanyo RD4050 and Saba CR833 have d.n.l. only. A new trend is the use of Dolby circuits in music centres, and according to Dolby Laboratories there are now 10 such models. There is still a lack of quality cassette machines with built-in power amplifiers.

Automatic arm lift-off is provided in the new Thorens TD145 turntable unit whilst leaving the pickup arm completely free of any mechanical attachment. A ferrite magnet is attached to a vertical spindle at the pickup arm centre of rotation, and a sensing coil energized by an h.f. oscillator is situated close to it. When the acceleration of the pickup arm in the run-out part of the disc groove is sensed the motor is switched off and the pickup arm lifted using the cueing lift.

The astonishing Technics SP-10 Mk2 professional direct-drive turntable was given its first European showing. Speed drift is held to within ±0.002% by a quartz-controlled oscillator, giving a playing time repeatable to within ±0.036s for a 30 minute l.p. disc! It is insensitive to drag load, lkg not causing any change in speed. Full speed is achieved in 25 degrees of revolution (at 33 rev/min) and the 3kg platter can be stopped in 30 degrees. Speed change time from 33 to 45 rev/min is 0.1s. Needless to say wow and flutter are imperceptible. It includes a 78 rev/min speed, and the only slight disadvantage we could possibly pick out is the lack of a 16⅔ rev/min speed which can sometimes be useful for pickup cartridge testing. But this is no loss for broadcasters, for whom the unit was intended.
GBS.

Books Received

Principles and calculations for radio mechanics part 2 by R. A. Braney and A. P. Gilbert. This publication deals with subjects relative to the City & Guilds Radio Mechanics course 222 and is also suitable for courses 231 and 221. Price £1.90. Pp. 166. Newnes-Butterworth, Borough Green, Sevenoaks, Kent TN15 8PH.

Electronics Theoretical & Experimental is published monthly and contains a collection of papers by specialists in the electronics field. Most of the papers are theoretical with a full mathematical analysis making them suitable for knowledgeable engineers. Price (annual subscription) £50. Taylor & Francis Ltd, 10-14 Macklin Street, London WC2B 5NF.

SCR applications handbook edited by Dr Richard G. Haft is a very useful paperback devoted to thyristors and triacs. Thirteen chapters cover most aspects of s.c.rs including series/parallel operation, a.c. phase control, and choppers, with the final sections dealing with protection, cooling, and testing of devices. Numerous circuits are given together with the waveforms produced for different modes of operation. Price £1.50. Pp536, International Rectifier, Hurst Green, Oxted, Surrey.

Directional Broadcast Antennas by Jack Layton. This book deals with the practical aspects of installing, adjusting, and maintaining antennas using minimal theory and mathematics for explanation. Price $12.95, pp.209. Tab Books, Blue Ridge Summit, Pa.17214, U.S.A.

The Use of Microphones by Alec Nisbett. This is a useful handbook for those wanting a working knowledge of microphones and recording techniques. The first chapter provides a crash course in sound and acoustics, with subsequent chapters covering speech, music balance, sound with picture techniques and the electronic control of sound. Price £1.75 (paperback), pp.168. Focal Press Ltd, 31 Fitzroy Square, London, W1.

International Handbook of Liquid Crystal Displays 1975-76 by Martin Tobias. At last! was the cry as I flicked through the pages, a book that will sort out one corner of the confused display market. After a general description of l.c. devices the chemistry of materials is discussed followed by the manufacture of displays. Subsequent chapters cover visual, optical and electro-optic characteristics of the devices with final sections describing drive systems, and lifetimes of l.cs. The book also contains an international directory of the l.c. industry together with manufacturers of associated components. Ovum Ltd, 14 Penn Road, London N7 9RD.

Integrated Circuits vol. 1 analogue circuits, vol. 2 digital circuits, published by A. E. Kluwer. These two data books list details and characteristics of i.cs sold with a PRO Electron classification. Price £6 and £7.50 respectively, available from The Technical Press Ltd, Freeland, Oxford OX7 2AP.

World of Amateur Radio

What goes wrong?

For several years the New Zealand Association of Radio Transmitters (NZART) has encouraged its branch groups to provide constructional kits for a variety of projects. For example, in 1970 the Otaga branch provided 120 kits of parts for an s.s.b. exciter. P. W. Johnson, ZL4LV, who designed the equipment, has kept careful record of the problems that have arisen during the construction of 30 of these kits, amounting to some 70 faults. Of these, 15 were due to dry joints in soldering; there were 9 wrong parts used; 7 were errors in reading resistor colour codes; 11 parts had been omitted during construction; 2 diodes had been connected the wrong way round; but the most frequent faults, amounting to 20, arose in the winding and connection of the various inductors, in particular a trifilar-wound wide-band toroid output transformer, even though a special diagram had been provided to help constructors with this component. Of the actual components, only 4 were found to be faulty, less than 0.08 per cent of the total supplied.

From Australia comes the suggestion that cigarette smoking by amateurs may not only be a personal health hazard but can account for a significant number of equipment faults. Ron Fisher, VK3OM, claims that "having looked at dozens of receivers, transceivers and transmitters over the years, there is no doubt that a smoking amateur will have more trouble with his gear that his non-smoking compatriots. The by-product of cigarette smoke will firstly discolour the front panel, fog up the dial and meter faces, and finally work their way into valve sockets, relay contacts and even into the bearings of v.f.o. tuning capacitors. It forms a sticky coating over valves and, in conjunction with dust, forms a substance that will reduce the efficiency of a final stage to a marked extent."

Inflated awards?

A strong attack on the rapidly rising cost of amateur operating awards has been made by Jock White, ZL2GX, contest manager of the New Zealand society. He suggests that amateurs are now being asked for excessive fees for some awards in what are "blatant money-making exercises" and believes that "the birth of the 'dollar per award'," derived from the "horrendous dollar per QSL" practice which grew rapidly about the time that specially mounted "DX-peditions" became popular.

Jock White accepts that return postage charges for QSL cards have risen alarmingly but considers these could be reduced by appointing accredited amateurs to check cards locally. He is particularly concerned at the recent imposition of the US$10 charge for new applications for the DXCC (DX Century Club) and US$20 for the five-band DXCC since these awards have become internationally accepted and recognised yardsticks of amateur radio operation.

But the cost of awards and certificates is only one aspect of the many problems that inflation and high postal rates are presenting to organised amateur radio operation. The R.S.G.B. has recently forecast "the worst financial result the Society has ever had in its history" which suggests that the deficit must be in the region of five figures. B.A.T.C. though still in surplus is urgently seeking ways of increasing revenue; many local societies are reducing the number of newsletters and other postal communications with members.

A. O. Milne, G2MI, who for over 30 years has been QSL Manager for the R.S.G.B., has urged amateurs to forget the old saying "the ultimate courtesy of a contact is a QSL card" pointing out that of the 1¼ million cards he receives each year some 600,000 are never claimed and have to be destroyed.

On the bands

After the summer doldrums, maximum usable frequencies for the h.f. bands rose steeply on September 5-6, bringing good long-distance openings back to 21 and 28 MHz. On September 5, the 21 MHz band remained open to the United States to beyond 2230 G.M.T. In view of recent suggestions that there may be a link between sunspot activity and earthquakes it may perhaps be significant that these high m.u.f.'s occurred at roughly the same time as the serious earthquakes in Turkey.

New Zealand amateurs believe they established a new world distance record for the 3.3 GHz band last February with a contact between Murray Willis, ZL2THW on Mount Murchison, 50 miles south of Nelson and Frances Brown-Douglas, ZL2TSM, on Mount Ruapehu, a distance of 238 miles. Height of the northern station was 5,650 ft. This follows an early 144-mile contact made with the same equipment (CV237 feeding a 3-ft dish aerial at both ends) to establish a Commonwealth record.

A recent "World Radio Club" visit to an RAF radio training centre near Doncaster emphasised the continued importance (and problems) of h.f. radio and c.w. operation under difficult conditions. The 0815 G.M.T. transmission of this BBC World Service programme on Sunday mornings can now be heard on 1088 kHz medium-waves from the new external services transmitters in Suffolk.

Television topics

John L. Wood, G6AHT/T, in *CQ-TV* lists the following British amateur television stations as regularly active: G6ALT/T, Newcastle-upon-Tyne; G6ACK/T and G6AGC/T, Scarborough; G6AHW/T, Sheffield; G6AEP/T, Rotherham; G6MUR/T, Leicester; G6AHJ/T, Rugby; G6MXW/T, Warley; G6KQJ/T, Wolverhampton; G6ACH/T, Huntingdom; and also F6BQH/T, Calais, France.

Not all television and slow-scan television amateurs are happy with the latest IARU Region 1 band plans for 144 MHz and 432 MHz. M. T. Crampton, G6AHJ/T (G8DLX), urges that SSTV should use 144.23 MHz rather than the proposed 144.5 MHz which is not covered by a number of popular s.s.b. transceivers and which is used on Sundays for the R.S.G.B. news bulletins. B.A.T.C. is concerned that the proposed vision carrier frequency of 439.25 MHz is too close to the British band edge to permit use of 625-line vestigial-sideband transmissions to the System I used in the U.K. and appears to have been based on System G used in most of Europe.

In brief

The recent boom in the sale of Citizen's Band equipment in the United States may not be unconnected with a belief that many long-distance lorry-drivers and motorists are using the facilities to pass along thinly-disguised warnings of police speed traps. Recent F.C.C. decisions mean that CB radio can now legally be used "as a hobby or diversion", permit inter-state contacts, reduces the "silent period" between conversations and establishes Channel 11 as a national calling frequency. The demand for CB equipment has caused some manufacturers and distributors to reduce the amount of amateur radio equipment. . . . The Amateur Radio Retailers Association is holding its 4th amateur radio exhibition at the Granby Halls, Leicester, on October 30, 31 and November 1. . . . An R.S.G.B. evening symposium on "Amateur Radio Satellites" will be opened by Pat Gowen, G3IOR, and members of AMSAT-UK (IEE, Savoy Place, London WC2 at 6.30 pm. on November 4). . . . NZART are planning a Golden Jubilee conference in Auckland, New Zealand, from June 4 to 12, 1976 and have arranged group bookings with Air New Zealand.

PAT HAWKER, G3VA

Transmitter power amplifier design — 3

Practical considerations for a two-metre f.m. design using microstrip transmission line impedance matching

by W. P. O'Reilly, M.Sc., M.I.E.E.

The Plessey Company Ltd

The three stage amplifier to be described, which is intended for mobile use in the 144-146MHz amateur band, operates from a nominal 12-volt supply and provides an output of 20W for 150mW input. In order that the matching networks shall not be critically dependent upon capacitor tolerances, two section networks have been selected for all interstage matching and for the final output network. The resulting bandwidth of the amplifier is somewhat wider than the minimum required. If greater miniaturisation is required higher Q single section networks could be used, but unless close tolerance capacitors are available trimmers would be necessary and these are both expensive and lossy at v.h.f.

The power transistors used are BLY34, 2N5990, and 2N5991 having output power and gain capabilities of 2.5W, 12dB; 10W, 7dB; and 25W, 4dB respectively when operated in Class C at 144MHz with a 12.5-volt supply. In this design the input stage is operated in Class AB which provides a gain increase of about 2dB over Class C operation and provides a smoother increase in output power as the drive to the amplifier is increased.

From equation (1) in part 2 the output transistor requires a load resistance of 2.5Ω. The 50-ohms load is transformed to 2.5Ω by a two section matching network having an intermediate impedance of 12.5Ω. The parallel equivalent output capacitance of the 2N5991, which is typically 150pF and corresponds to a reactance of −7.5Ω at 144MHz, is tuned to resonance by a stripline collector choke.

The Smith chart of Fig. 1 illustrates the steps in designing the final stage output matching network: determine (e.g. from Fig. 5 in part 2) how many sections are required to achieve the required impedance ratio and bandwidth with an acceptable v.s.w.r. (note that more sections provide a lower loaded Q factor and hence smaller v.s.w.r., lower loss and less sensitivity to component tolerances). For this amplifier a two section network has been chosen.

Calculate intermediate impedance points at approximately equal geometric spacing. In this case 12.5Ω is selected as near to the geometric mean of 2.5 and 50.

Determine the stripline impedance to be used for the first section of the matching network. For maximum bandwidth the optimum impedance of

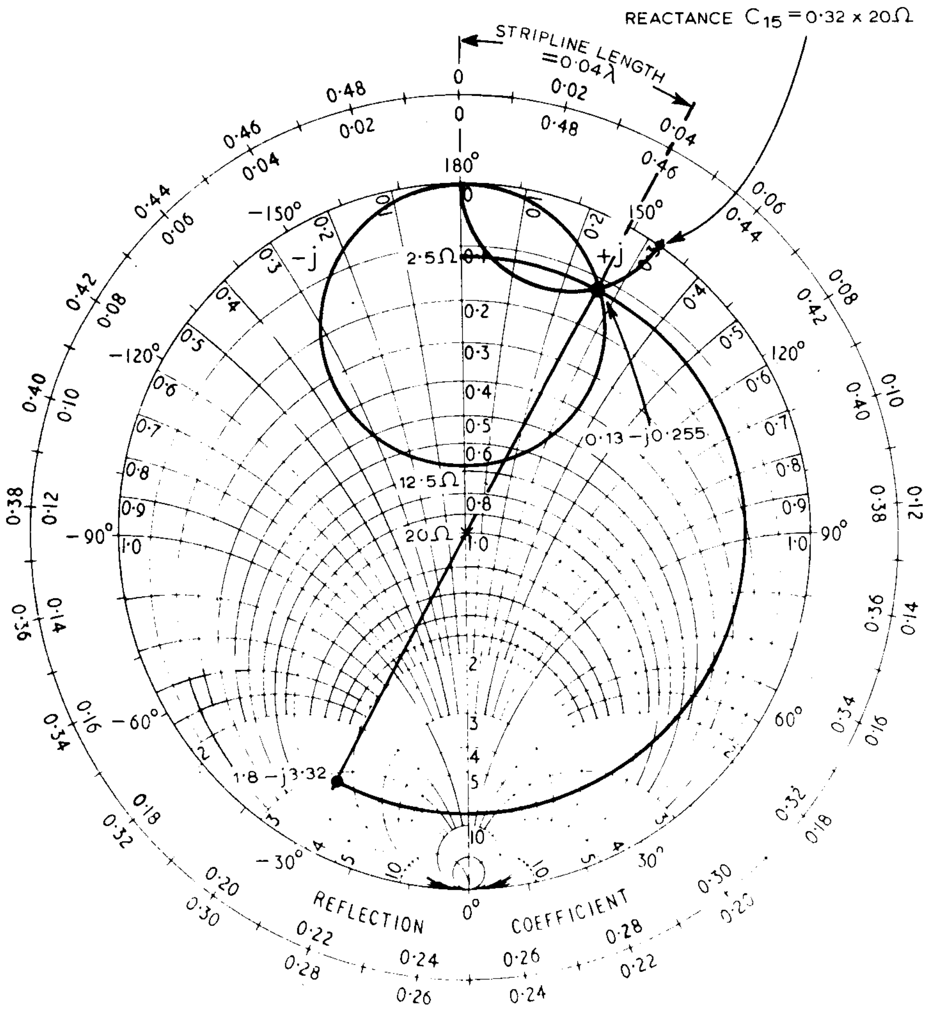


Fig. 1. Output matching network design using a Smith chart.

A member of the *Wireless World* staff has made available a printed circuit board for the strip line r.f. power amplifier. The board, which measures approximately 23 × 11cm, is a double sided glass fibre type and is supplied roller-tinned and drilled. The one-off price if £4.50 inclusive. All cheques and postal orders should be made payable to M. R. Sagin and sent to 11 Villiers Road, London N.W.2.

A component layout diagram will be supplied with the board but will also be published in the final part of this series,

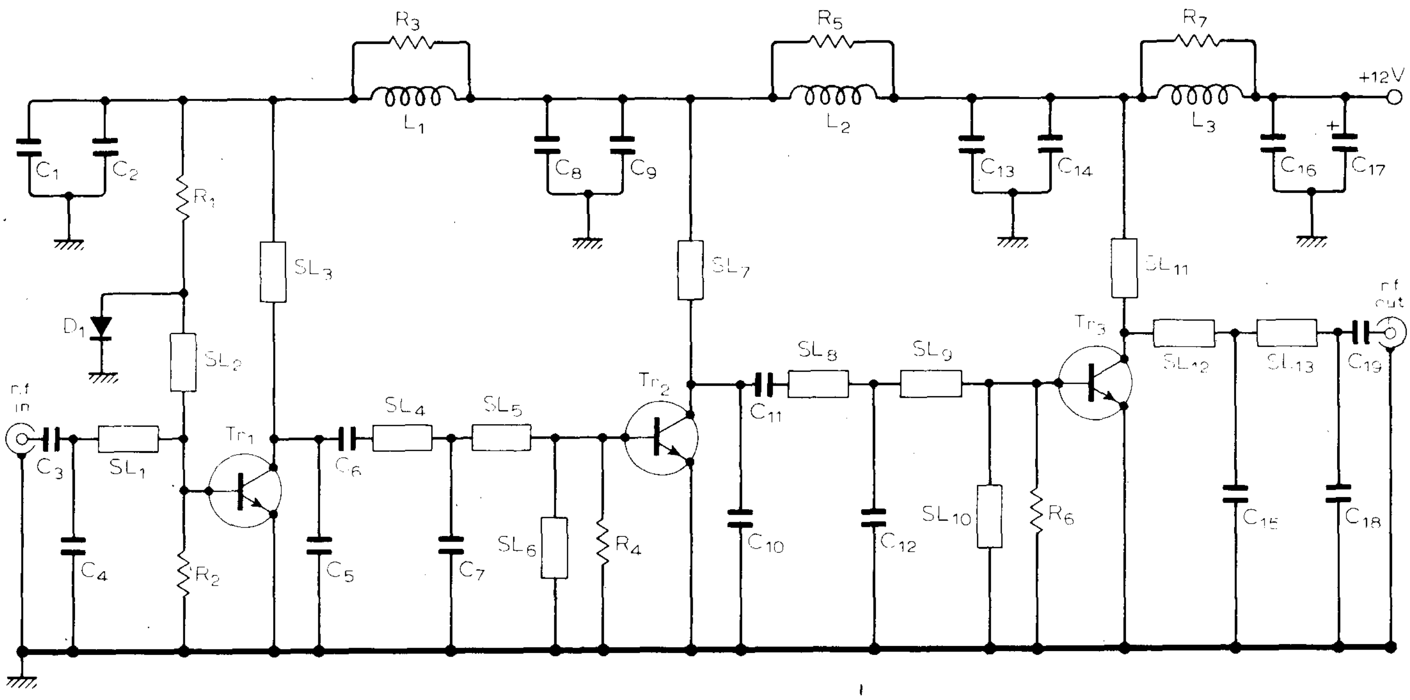


Fig. 2. Circuit diagram of the 20W v.h.f. power amplifier.

the line is $\sqrt{Z_1 . Z_2}$, where Z_1 and Z_2 are the start and end impedances of the section, in which case a line length of $\lambda/4$ would be required. When a smaller bandwidth is acceptable a higher loaded Q factor is obtained using a shorter length of higher impedance line. In the present case a 20-ohm line is used giving a loaded Q of two. Use of a higher impedance line would result in further miniaturization but efficiency would be reduced and closer toleran·e capacitors would be necessary.

On the Smith chart draw a circle with centre at $1+j0$ – i.e. the centre of the chart – passing through the point $0.125+j0$ corresponding to the required 2.5-ohm load resistance. At all points on the circumference of this circle the modulus of the voltage reflection coefficient, (ρ), is 0.78. Traversing the circumference clockwise from the point $0.125+j0$ corresponds to the change in impedance when moving along the stripline from the 2.5-ohm point towards the load.

Draw a second circle centred on the R_σ (ρ)=−1 line and passing through $0+j0$ and $0.5+j0$. The intersection between the two circles at the point $0.13+j0.255$ corresponds to the junction of the stripline and the first shunt capacitor.

Draw a straight line from the centre of the chart passing through the point $0.13+j0.255$. The required length of stripline is now read off from the calibrated scale around the chart. In this case a length of 0.04λ is indicated.

Calculate λ, the wavelength corresponding to 144MHz on the 20-ohm stripline. Due to the permeability of the dielectric, the wave travels at less than its free space velocity, and the guided wavelength is thus less than the free space wavelength λ_0. From Fig. 8 in part 2, $\lambda/\lambda_0=0.5$ for 20-ohm microstrip in a medium of $\epsilon_r=5$, and the free space wavelength is $\lambda_0 = 3 \times 10^8$/frequency = 2.08m Thus $\lambda=0.5\times2.08=1.04$m. The required length of line is thus 0.04λ = 4.16 cm.

In this amplifier the output capacitance of each of the transistors is tuned to resonance by a stripline collector supply choke. When maximum bandwidth is required the output capacitance and input inductance of the transistors can often be used as components of the matching network. The value of the base return chokes is not very critical but a low unloaded Q factor is required. In this design stripline chokes have been used and the Q factor is lowered by means of shunt resistors.

To ensure that any r.f. power on the supply line does not reach the early stages of the amplifier at a sufficient level to cause instability, very low Q factor inductors are used for supply line decoupling. The inductors are constructed by winding enamelled copper wire around the body of a metal oxide or carbon resistor and terminating the inductor so formed to either end of the resistor. Collector feed networks of this type ensure that the transistors operate into their correct impedances at the required working frequency and into near resistive low impedances at lower frequencies where, due to the increased internal gain of the transistors, the probability of destructive oscillations is much greater.

Printed circuit board

The striplines of the amplifier printed circuit board have been meandered to reduce the space which they occupy. A minimum meander spacing of twice the conductor width is necessary to ensure that the characteristic impedance is not altered significantly. It is important to avoid running lines parallel to one another over distances approaching $\lambda/4$ since under these conditions quite strong coupling between the lines can occur. (This effect is made use of in directional couplers which will be discussed in the next article in this series.) Where a stripline abruptly changes direction a chamfer is used to reduce reflections caused by the discontinuity on the line. The p.c. board uses ordinary 1/16in epoxy-glass board with copper cladding of 1oz/sq. ft. on either side. It is essential to retain the copper on the reverse side of the board as this acts as an earth plane without which the striplines will not function correctly.

Components

Microstrip amplifiers contain only a minimum of discrete components. In this design apart from the power transistors the only unusual components are the capacitors used in the matching networks. Because of the very low impedances involved in v.h.f. solid state power amplifiers it is essential to use capacitors having very low internal inductance (e.g. at 144MHz only about 1nH inductance is required to create a 1-ohm reactance). Unencapsulated n-p 0 ceramic chip capacitors are ideal. Also suitable, but more expensive, are porcelain chips and uncased mica capacitors. To achieve reactances of 20 ohms or above, ceramic or mica capacitors with very short leads may be used, but it is advisable to connect several low value capacitors in parallel to achieve the required total capacitance.

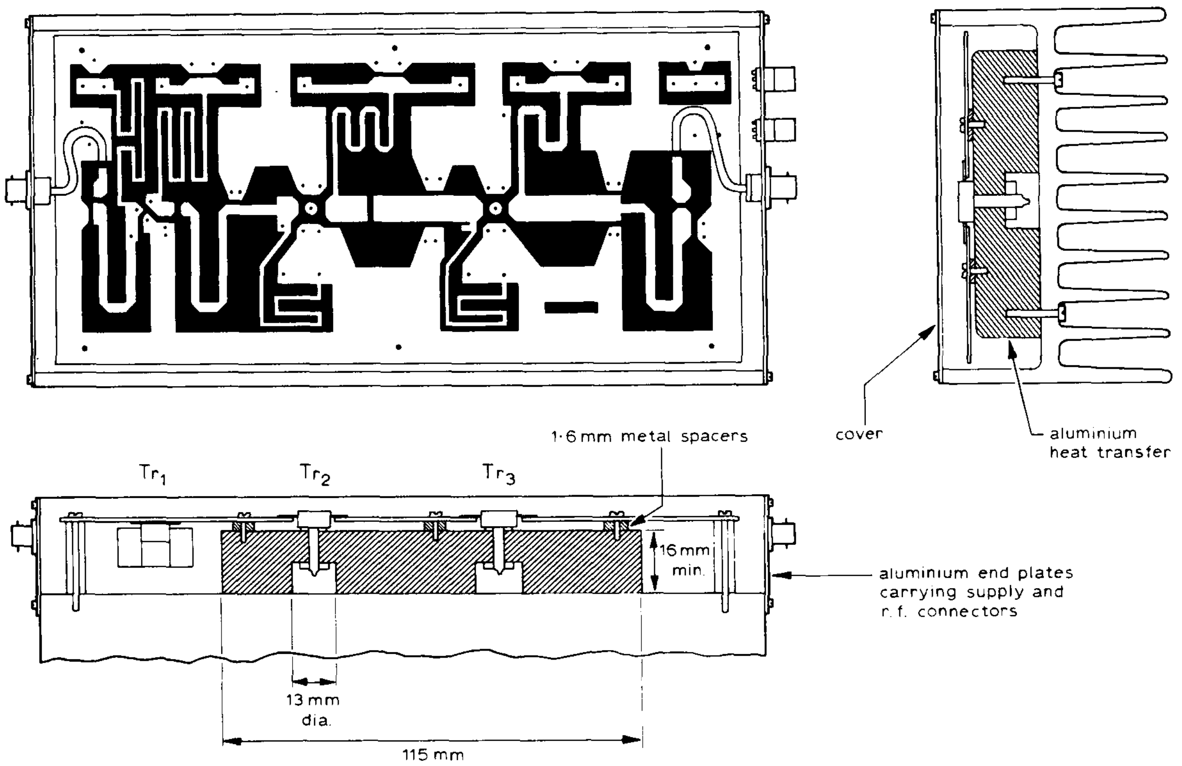


Fig. 3. Assembly of the power amplifier.

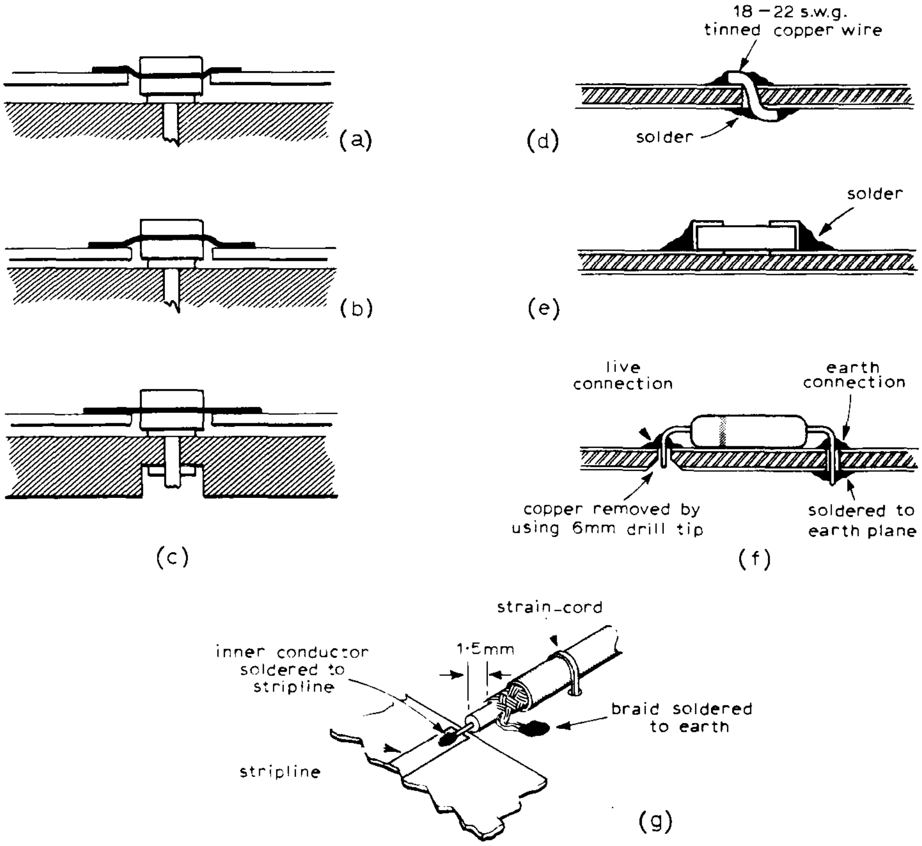


Fig. 4. Component mounting. In (a) and (b) spacers used in mounting a power transistor are not of the correct length, straining stripline leads and possibly causing fracture of package wall. In (c) the spacer is of the correct length. (d) through connection (e) chip capacitor mounting (f) typical resistor mounting (g) how low v.s.w.r. coaxial to stripline transition is made.

Construction

Fig. 3 shows a suggested method of constructing the power amplifier and the following notes should help in assembly.

- Select a heatsink having a thermal resistance to free air of $<1°C/watt$. This will permit safe continuous operation at ambient temperatures up to at least 50°C. If only intermittent operation is envisaged a less effective heatsink may be used, but the maximum duration of transmission must be restricted to avoid damaging the transistors.
- The input stage requires a $<$ 40°C/watt heatsink and since the collector is connected to the case of Tr_1 an insulated heatsink of the clip-on type having low capacitance to ground is most suitable.
- Fig. 4 shows the method of connecting the components and coaxial cables to the microstrip lines. The power transistors must be bolted to the heatsink prior to soldering. The recommended stud torque for transistors of this type if 3.5 to 6.5lb-in; excessive torque will result in damage to the threads of the copper stud. The surface of the heatsink should be smooth and flat with no burrs around the transistor mounting holes.
- If available, a smear of high thermal conductivity silicone compound such as Midland Silicones MS2623 should be used to improve the thermal contact between the transistors and their heatsink.

● **Caution.** Most stripline r.f. power transistors contain a layer of beryllium oxide between the silicon and the metal stud to provide high thermal conductivity and electrical insulation for the collector. This hard white material is extremely toxic and dust particles which result from fracturing the material must not be inhaled or allowed to enter the body via a cut or wound. Do not attempt to examine the interior of this type of transistor. In the event of damage faulty units should be returned to the manufacturer for disposal.

Testing

When a new power amplifier has been assembled there is always the possibility of a faulty component, badly soldered joints or an accidental short circuit and so it is essential that a careful initial testing procedure be carried out if the chance of an unexplained and expensive device failure is to be minimized. The following precautions, which are recommended for initial testing of the 2-metre mobile power amplifier, are generally applicable to the initial testing of solid state r.f. power amplifiers.

● Check that all components are correctly connected giving special attention to the orientation of stripline transistors. Ensure that the assembly is free from solder splashes and other foreign material.

● With the output of the amplifier correctly terminated, preferably via a wattmeter, and the input drive set to a very low level, monitor the supply current as the supply voltage is gradually increased to about 70% of nominal. The quiescent current for this amplifier should be less than 20mA at 8V supply. A power supply with a variable electronic current limit is ideal for initial testing. A heavy quiescent current is indicative of a faulty connection or component.

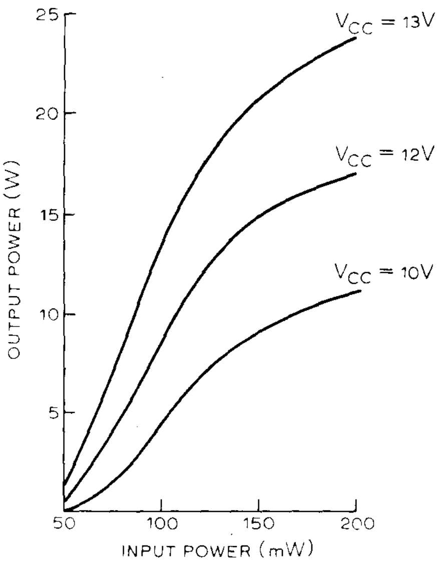


Fig. 5. Input/output characteristic of the amplifier over the 144-146MHz band.

● At the midband frequency gradually increase the drive to the amplifier. The output power and supply current should increase together. If they do not the current to each stage should be checked to determine the location of the fault. Any discontinuity in either output power or current consumption as drive is increased is an indication of instability and should be investigated and corrected before proceeding to test at full supply voltage when low frequency instability could result in destruction of the transistors.

● A spectrum analyser is extremely useful when the first prototype of a new design is being evaluated. The harmonic content of the output signal and any tendency for spurious or sub-harmonic instabilities under conditions of varying supply voltage, drive level or load mismatch may be monitored.

Matching network components

	Microstrip line					Capacitor	
	Circuit Ref.	Z_o (ohms)	Width (mm)	Fraction of wave-length	Length (mm)	Circuit Reference	Value (pF)
Input to Tr_1							
Single section							
50 ohms to (12.5+j1) ohms	SL_1	50	2.5	.073	79	C_4	33.4
Interstage Tr_1 to Tr_2							
1st section							
50 ohms to 12.5 ohms	SL_4	50	2.5	.073	79	C_5	33.4
2nd section							
12.5 ohms to (3+j1) ohms	SL_5	50	2.5	.014	15	C_7	100
Interstage Tr_2 to Tr_3							
1st Section							
10 ohms to 3 ohms	SL_8	20	8	.037	38.5	C_{10}	152
2nd Section							
3 ohms to (1_j0.5) ohms	SL_9	20	8	.015	15.6	C_{12}	525
Tr_3 to Load							
1st Section							
2.5 ohms to 12.5 ohms	SL_{12}	20	8	.04	35.4	C_{15}	172
2nd Section							
12.5 ohms to 50 ohms	SL_{13}	50	2.5	.073	79	C_{18}	33.4

Components

Tr_1	BLY33	Motorola, Ferranti
Tr_2	2N5990	Motorola
Tr_3	2N5991	Motorola

R_1	1.5k
R_2	82Ω
R_3	15Ω
R_4	2 x 15Ω
R_5	15Ω
R_6	2 x 15Ω
R_7	15Ω

All resistors are ½W 10% carbon or metal oxide

L_1	18-22 turns 30 s.w.g. wound on R_3
L_2	18-22 turns 30 s.w.g. wound on R_5
L_3	10-15 turns 26 s.w.g. wound on R_7

C_1, C_8, C_{13}, C_{16}	10nF±20%, 50V unencapsulated ceramic chip
C_2, C_9, C_{14}	1000pF±20%
C_3, C_6, C_{11}, C_{19}	
C_4, C_5, C_{18}	33pF±5%, 50V
C_{10}	150pF±5%, 50V
C_{12}	2 x 150pF and 2 x 120pF each ±5%, 50V n.p.o.
C_7	100pF±5%, 50V n.p.o.
C_{15}	100pF and 82pF n.p.o. each ±5%, 50V
C_{17}	22µF 15V electrolytic

Capacitors 2, 9, 14, 3, 6, 11, 19, 4, 5, 18, 10, 7, and 15 are all 50V n-p 0 unencapsulated ceramic chip.

D_1	BAX12 or similar high conductance silicon diode

In this design, stability is ensured by careful supply line filter design and the use of low Q base return chokes. This ensures that a low source impedance is presented to the transistors at frequencies well below the operating band where the gain is much higher. Due to the inherent inductance of the low value resistors R_4 and R_6 very little gain at v.h.f. is sacrificed.

Fig 5 shows the input/output characteristic of the amplifier over the 144-146MHz band. A saturated output power approaching 25W is obtained for a total current consumption of 3.3A at 13.6V. This corresponds to an overall efficiency in excess of 50%. The collector efficiency of the output stage is over 75% when operating into a matched load.

(To be continued)

References

1. Jessop, G. R., A compact bandpass filter for 144MHz, *Radio Communication*, June 1971, Vol. 7, No. 6, p.390.

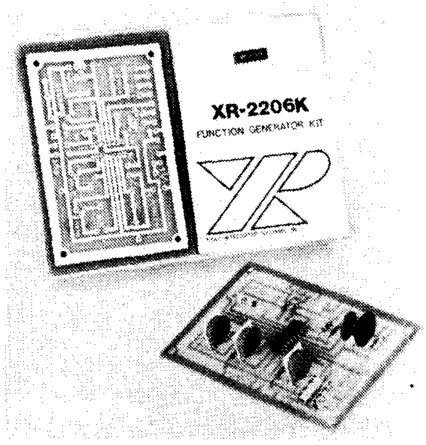
2. Matthaei, G. L., Young, L. and Jones, E. M. T., Microwave filters impedance matching networks and coupling structures, McGraw Hill, 1969.

New Products

Function generator kit

Two function generator kits based on the XR-2206 i.c. are now available from Rastra Electronics. Designated the XR-2206KA and KB both kits comprise a p.c.b., function generator i.c. and instruction manual but the last mentioned also contains the external components necessary for a complete circuit. The complete generator offers sine, triangle and square wave outputs with four overlapping frequency ranges which give an overall range from 1Hz to 100kHz. Total harmonic distortion of the sine wave is typically 0.5%, and the sine/triangle output can be varied from 0 to 6V peak-to-peak from a 600Ω source. The square wave is available at a sync output terminal for oscilloscope synchronizing or driving logic circuits. The circuit also has a.m. and f.m. capabilities. Rastra Electronics Ltd, 275-281 King Street, Hammersmith, London W6 9NF.

WW 301 for further details



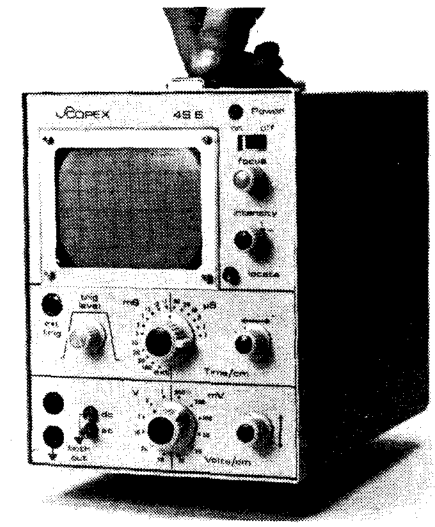
WW 301 for further details

Video tape printer

This is a half-inch video cartridge copier comprising two separate units, a master tape recorder and a tape "printer." The tape recorder will accept inputs from a variety of media, including colour or black and white television cameras, monitor receiver, record player or microphone and produces a ½in master tape. The tape so produced can then be loaded into the duplicator and up to 1,000 copies printed off.

Copying is at 10 times normal speed and operation is fully automatic. National Panasonic (UK) Ltd, Whitby Road, Slough, Bucks.

WW 302 for further details



WW 303 for further details

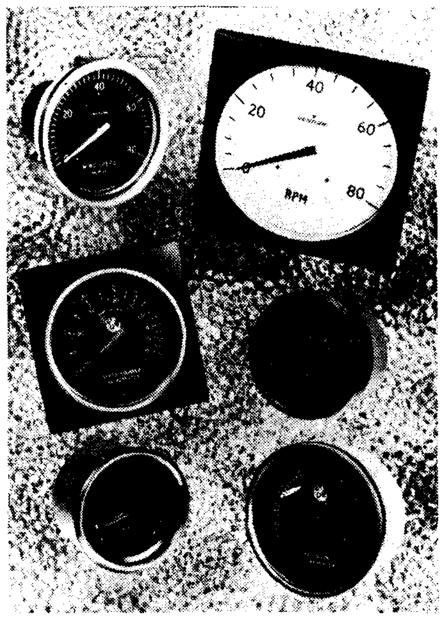
Low cost scope

Scopex have added the model 4S-6 oscilloscope to their range of instruments. This is a low-cost single-beam unit intended for educational and servicing applications. The instrument has a 6 × 8cm screen and offers a bandwidth of 0 to 6MHz, a sensitivity from 10mV to 50V/cm, a maximum sweep speed of 1μs/cm, and a maximum measurement error of 5%. The 4S-6 is priced at £88 and is available from Scopex Instruments Ltd, Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts SG6 1JJ.

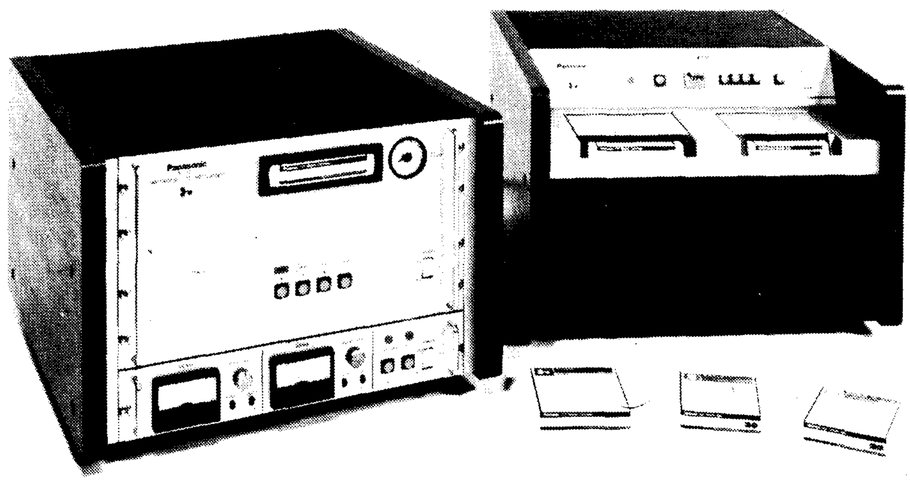
WW 303 for further details

Moving coil meters

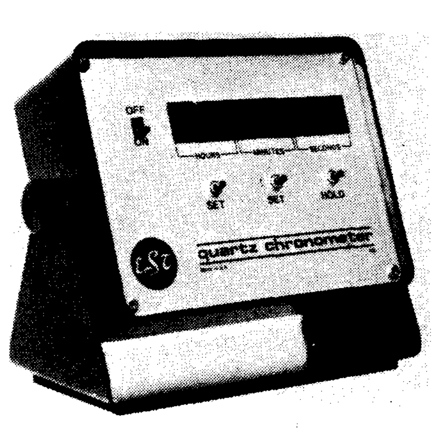
A range of 240° moving coil meters called Linicators will measure any parameter that can be represented by a change in direct current or voltage. The makers claim that these meters have a completely linear, or exactly repeatable non-linear, scale with an accuracy to within 1% which is achieved by a patented self-compensating design. A range of cases with diameters from 52 to 250mm is available and movements with sensitivities of greater than 1mA



WW 304 for further details



WW 302 for further details



WW 306 for further details

f.s.d. Smiths Industries Ltd, Industrial Division, Waterloo Road, Cricklewood, London NW2 7UR.

WW 304 for further details

Power supply

Three types of laboratory bench power supply units are being offered by Gresham Lion. All have a maximum output voltage of 30V and two are dual output types. The GBS 30/25 is a single output, 0-2A, 0-30V unit; the GBS 30/1D is a dual output 0-30V, 0-1A unit and the GBS 30/2D is a dual output 0-30V, 0-2A unit.

Each of the units is fitted with a voltmeter and an ammeter, and has coarse and fine output voltage and current controls. Gresham Lion Electronics Ltd, Gresham House, Twickenham Rd, Feltham, Middx TW13 6HA.

WW 305 for further details

Quartz chronometer

The model 401 is a solid state chronometer which uses a 3MHz crystal to achieve an accuracy to within one second per month at room temperature. The unit is powered from either the mains supply of a 12/24V external battery, with an optional self-contained nicke-cadmium battery.

Seven-segment l.e.d. displays are used in the chronometer which has four versions available either as ready built units or as kits. Electro Systems and Timing Co, 48 Robinson Road, Loudwater, High Wycombe, Bucks HP13 7BJ.

WW 306 for further details

Push button tuner

The CT9 is a novel, patented push-button selector system, coupled to a car radio tuner. Being extremely slim, the design can be combined with a car cassette player mechanism and still be mounted in the normal dash aperture. Autonnic Ltd, Tollesbury, Essex.

WW 307 for further details

Push-button switch

The DSR1066 is an addition to the Bulgin DS1000 series of push-button switches. Requiring only a simple push-fit to a panel, it can be illuminated if required, carry messages and is a push-on, push-off action.

The contacts are twin s.p.c.o. rated at 5A, 250V with the low voltage illumination being isolated from the switches. Available with five lens colours, the components can be assembled with other items from the DS1000 series, to extend the choice of panel presentation and switching configurations. Bulgin & Co. Ltd, Bye-pass Road, Barking, Essex IG11 0AZ.

WW 308 for further details

X-Y recorder

A potentiometric X-Y recorder, suitable for use with A4 standard size graph paper, has been introduced by S.E. Labs (EMI) Ltd. Known as the SM225 Mk II, it features electrostatic chart retention, a zero point which can be set in any position and a 'zero check' switch for instant zero indenting. Chart location is achieved using two points of light as a reference.

Two versions are available, either with 14 steps of sensitivity from 0.5mV/cm to 10V/cm with an interposed vernier adjustment, or with 16 steps between 0.05mV/cm to 5V/cm.

Additional options include a fixed range input for single function operation and a chart feed and winding adaptor for 180mm wide roll-chart application. SE Labs (EMI) Ltd, North Feltham Trading Estate, Feltham, Middlesex.

WW 309 for further details

Digital multimeter

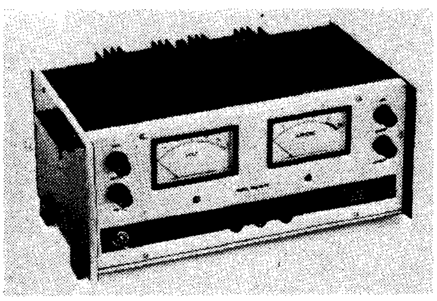
The TR-6656 is a digital multimeter with a d.c. voltage measurement accuracy of 0.01% of reading and a resistance accuracy of 0.015% of reading.

In addition to measuring a.c. and d.c. voltage, direct current, and resistance the unit also measures frequency, period, time interval and incorporates auto-ranging, start and stop inputs together with other separate inputs for the measurement of current, resistance and voltage. REL Equipment and Components Ltd, Croft House, Bancroft, Hitchin, Herts SG5 1BU.

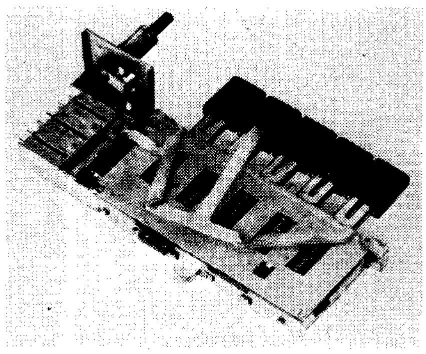
WW 310 for further details

Instrument cases

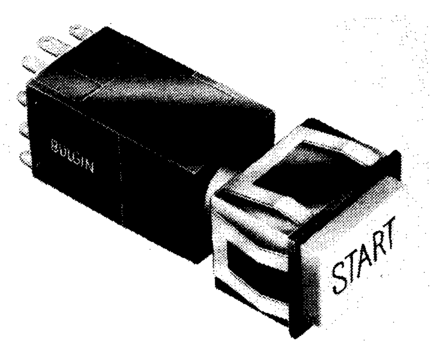
A range of p.v.c.-clad Colorcoat steel cases is being introduced by Vero and is to be called Veropak. Five sizes are



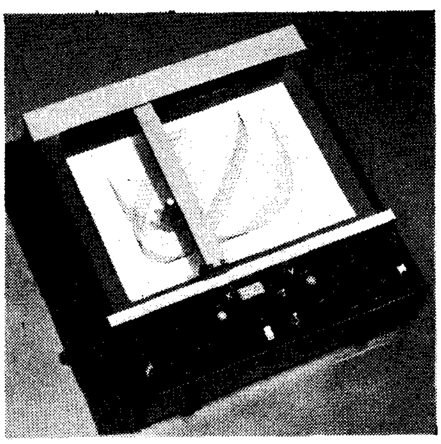
WW 305 for further details



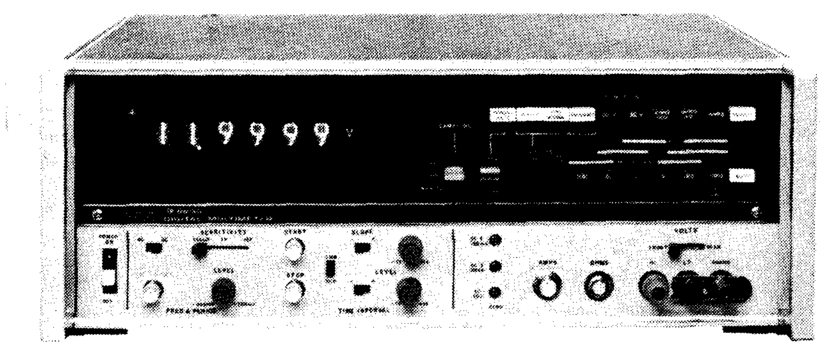
WW 307 for further details



WW 308 for further details



WW 309 for further details

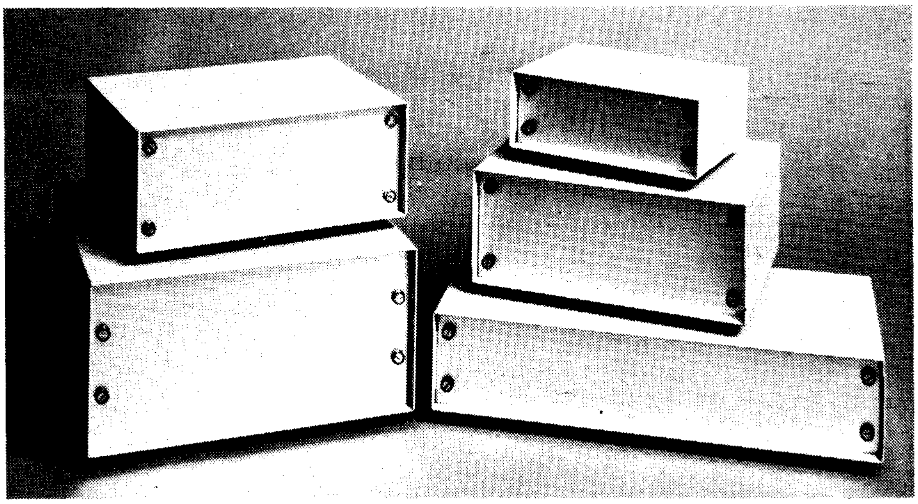


WW 310 for further details

offered with a fixed height of 158mm and depth of 220mm, these being in widths of 278mm, 316mm and 405mm. The 316mm wide case is also available in a 308mm high version and the 405mm case in an additional 114mm height.

Ventilation louvres are cut in the rear and base panels and the front panels are anodised. Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Eastleigh, Hants.

WW 311 for further details



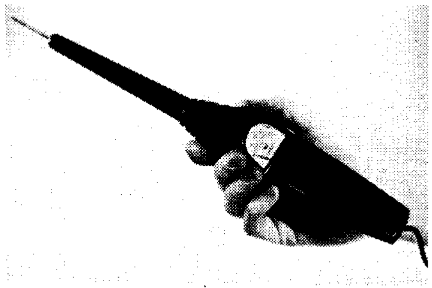
WW 311 for further details

H.v. probe

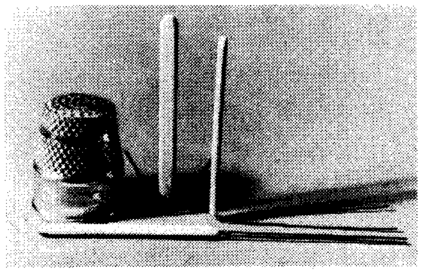
A high-voltage probe with a meter mounted in the handle is being marketed by Precision Instrument Laboratories. The scale has an accuracy of 2% at 25kV and an f.s.d. of 40kV.

The probe tip is 13in long and capable of reading under the corona caps of most TV tubes. Price £22.00 plus VAT. Precision Instrument Laboratories, Instrument House, 212 Ilderton Rd, London SE15 1NT.

WW 312 for further details



WW 312 for further details



WW 315 for further details

D.i.y. potentiometers

The MOD POT components are designed to permit design engineers to assemble prototype potentiometers in a wide variety of configurations. They consist of parts for the Allen-Bradley Series 70, ⅝in square potentiometers and can be offered in either hot-moulded carbon or cermet resistance elements and in single, dual, triple and quad control versions. In addition a variety of switch, drive, shaft, bushing lug and terminal arrangements are possible. Allen-Bradley Electronics Ltd, Pilgrimsway, Bede Industrial Estate, Jarrow, Tyne and Wear NE32 3EN.

WW 313 for further details

Tool cases

Topper are adding to their existing range of carrying and tool cases by offering specialist cases in sizes up to 30 × 15 × 7in. Suitable for use with audio-visual equipment, telecopiers and portable electronic units, they are designed to protect against a wide range of environmental hazards. Topper Cases Ltd, St. Peter's Hill, Huntingdon PE18 7ET.

WW 314 for further details

WW 314 for further details

Resistance element

Suitable for measuring temperature on plane and slightly curved surfaces, the WF 60 resistance element can be used in the temperature range −250°C to +600°C. Designed to withstand vibration and display long term stability with a high response rate. Degussa Public Relations Department, D6000 Frankfurt am Main 1, Postfach 2644, Germany.

WW 315 for further details

P.c. connectors

A range of printed-circuit connectors are now available from Dieter Assmann Electronics, suitable for p.c.bs of thicknesses from 1.4mm to 2.54mm and having single or double sided contacts.

From six to 146 contacts per connector can be provided in the standard range or by using the modular connectors, series A2—MS or A3—MS a virtually unlimited number of contacts can be obtained.

Using appropriate end flanges, the connectors can be adapted for horizontal or vertical mounting, or used unmounted. Contacts are of gold or nickel plated phosphor bronze and can be supplied for 3A or 5A loads. Dieter Assmann Electronics Ltd, Victoria Works, Water Lane, Watford, Herts.

WW 316 for further details

Multi-turn trimmers

An addition to the capacitance range of p.t.f.e.-dialectric Tetfer trimmers has been announced by Jackson Brothers. It is called the 8mm, 20pF Tetfer Trimmer, Cat.No.6030 and is mounted on an 8mm diameter ceramic base. Tolerance at maximum 20pF is -0%, +30% in a temperature range from -55°C to +125°C.

The temperature coefficient is zero within ±100ppm/°C, the power factor better than 0.001 at 1MHz and the tuning resolution, 18 turns from minimum settings to maximum. Jackson Brothers (London) Ltd, Kingsway, Waddon, Croydon, Surrey.

WW 317 for further details

Radiocom system

The SC905 is an addition to the SC900 series radio communications systems from Sonab. It consists of a simplex central processing unit, a u.h.f. transmitter operating on one channel in the 420-470MHz range and the option of a v.h.f. receiver providing duplex operation. Controlled by dial telephone, the c.p.u. converts the dial impulses to tones used to call the mobile stations.

These consist of pocket units, 53.5 × 126 × 19mm, containing a receiver, an f.m. transmitter operating in the 160MHz band and a decoder for selective calling. The range of the base unit is claimed to be 5 miles. Sonab Communications Division, Sonab Ltd, P.O. Box No. 4, Oldfield Road, Hampton, Middx TW12 2HN.

WW 318 for further details

Laboratory power supply

Powerlab is a novel design of power supply from ITT. Unlike most of its competitors, it provides no panel meter. Selection of voltages is by push button.

A choice of three voltages, 5V, 10V or 15V, is offered from two isolated outputs, or a further three, 10V, 25V or 30V by connecting the outputs in series by pushbutton. The output voltage is variable by slide control over a range of ±10% but can be reset, on the 5V range, to within 20mV without reference to an external digital voltmeter.

An l.e.d. indicates constant current limiting, which is adjustable from 10% to 110% of full load current, which is 2A on the twin 5V range and the 10V series range and 1A on the remaining twin and series ranges. This can be doubled by selecting parallel arrangement of the outputs. ITT Components group Europe, STC Ltd, Edinburgh Way, Harlow, Essex.

WW 319 for further details

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Transient spike suppressor

Two "transtectors" designed for protecting circuit assemblies from transients and noise can be used in parallel with standard scr "crowbar" units for fast acting (5ns) protection. They operate by clamping input and output lines to a specified voltage. Types V26 and V216 offer instantaneous clamping at 6.5V d.c. at 1A, and 16.5V d.c. at 400mA ±5% and peak pulse currents of 120A and 67A within an operating temperature range of —55°C to +100°C.

WW 320 for further details **Coutant**

Video amplifier

The SL514 has an open loop gain of 70dB, temperature stable, giving a closed loop gain achievable using standard operational techniques. Slew rate is 175V/μs and a setling time of 50ns to 1%. The bandwidth is 0 to 100MHz at 20dB and the device is encapsulated in a 10-lead T0-5 package.

WW 321 for further details **Plessey**

C.m.o.s. phase-locked loop

The MC14046 contains two phase comparators, a v.c.o. and a zener diode regulated internal supply line. The v.c.o. operates at frequencies up to 1.4MHz with a supply voltage of 10V d.c. Power dissipation is of the order of microwatts.

WW 322 for further details **Motorola**

Dual transistor

The 2N5902 series of monolithic j.f.e.ts have a diode-isolated substrate designed to reduce leakage current to 0.1pA over input voltage swings up to 30V. Common mode rejection is typically better than 120dB and the transistors can be matched to within 5mV and drift to within 5μV/°C. The devices are offered in 8-pin, TO-99 cans.

National Semiconductor

WW 323 for further details

R.a.m.

The S1103X, is a dynamic 1024-bit r.a.m. with a data access time of 120ns. It has a read-write cycle time of 270ns and is available in an 18-pin d.i.p.

WW 324 for further details **AMI**

D.c. — d.c. converter

A thick-film d.c.—d.c. converter, model TG311 has been designed to handle input voltages of 0.8 to 1.6V and to give up to 15V d.c. output. The efficiency is claimed to be 50% or greater over the operating temperature range and the circuit occupies approximately one cubic centimetre.

WW 325 for further details **Redac**

Schottky clock

The CO-238 is a 14-pin, d.i.p. crystal oscillator available at frequencies up to 1000MHz to drive Schottky t.t.l. Power supply is 5V d.c. and the oscillator will fan out into 10 loads. Stability is claimed as ±0.0025% over the range 0-70°C.

WW 326 for further details **Lyons**

Suppliers

Coutant Electronics Ltd, 3 Trafford Rd, Reading RG1 8JR.

Plessey Semiconductors, Cheney Manor, Swindon, Wiltshire SN2 2QW.

Motorola Inc, Semiconductor Products Division, York House, Empire Way, Wembley, Middx.

National Semiconductor UK Ltd, The Precinct, Broxbourne, Herts EN10 7HY.

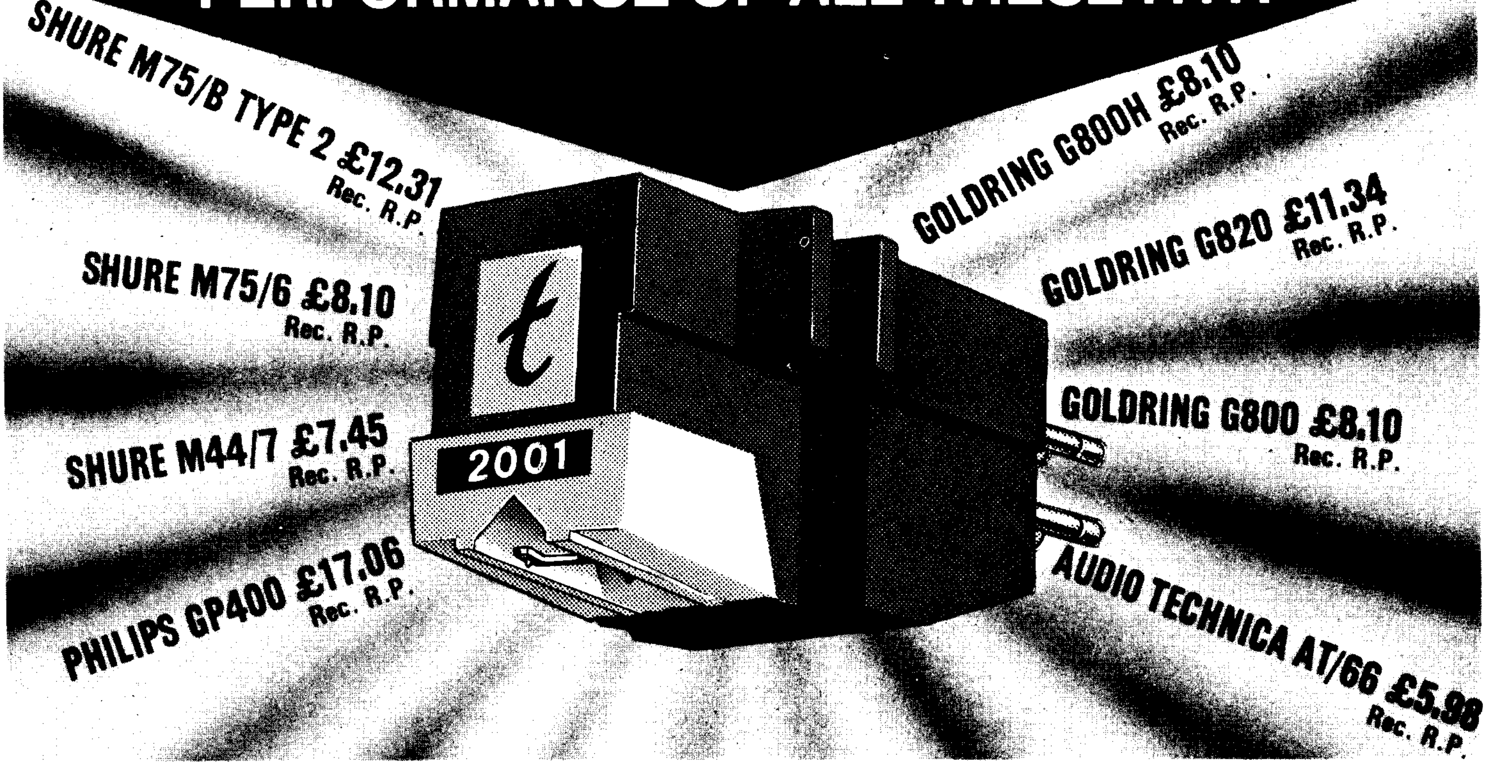
AMI Microsystems Ltd, 108A Commercial Rd, Swindon, Wilts.

Redac Software Ltd, Newtown, Tewkesbury, Gloucestershire GL20 8HE.

Lyons Instruments Ltd, Hoddesdon, Herts.

T2001

THIS CARTRIDGE CAN EQUAL THE PERFORMANCE OF ALL THESE .....



THE NEW tenorel

STEREO 'MAGNEDUCT' CARTRIDGE

TECHNICAL SPECIFICATIONS:

Separation	More than 25db at 1000 Hz
Frequency Response	15 to 25000 Hz
Compliance	20 x 10^{-6} CM/DYNE
Output	5.5 mV at 1000 Hz – 5cm/sec
Playing weight	1½ – 3 grammes
Channel Balance	2db at 1 KHz-dB
Tip Mass	1 mg
Stylus Radius	.0006-15u (colour white)
Load	47K ohms
Weight	7 grammes
Inductance	550 mH
DC Resistance	520 ohms
Measuring Records	DECCA SXL 2057 B + K QR 2009

a cartridge of tomorrow...TODAY!

£5.45

EXCL. VAT
Recommended Retail Price
MADE IN HOLLAND

2 YEAR Guarantee

COME AND SEE US ON STAND No. D15
AT THE AUDIO FESTIVAL AND FAIR
20th - 26th OCTOBER, OLYMPIA

DISTRIBUTORS REQUIRED IN ALL COUNTRIES. FOR FURTHER DETAILS CONTACT: TENOREL LAMBOSTRAAT, 2 BUSSUM, HOLLAND.

Condor
The fastest bird in the business

CONDOR ELECTRONICS LIMITED, 100 COOMBE LANE, LONDON SW20 0AY.
TELEPHONE: 01-946 0033 (4 LINES). TELEX: 928502.

Distributors of cartridges, styli, record cleaners, condenser microphones, headphones, and adaptors etc. Guaranteed 24 hour despatch service.