wireless world

MAY 1976 35p

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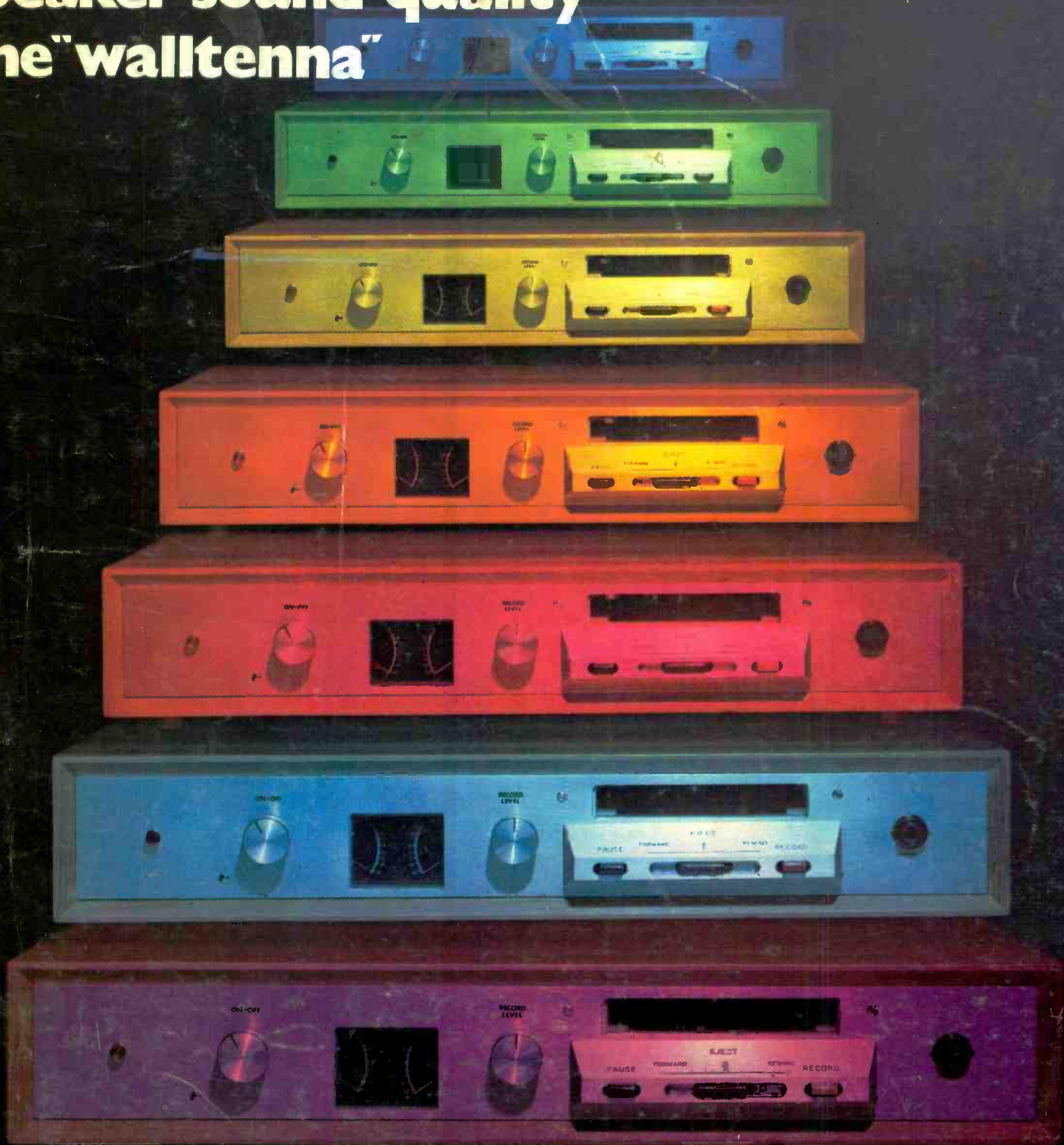
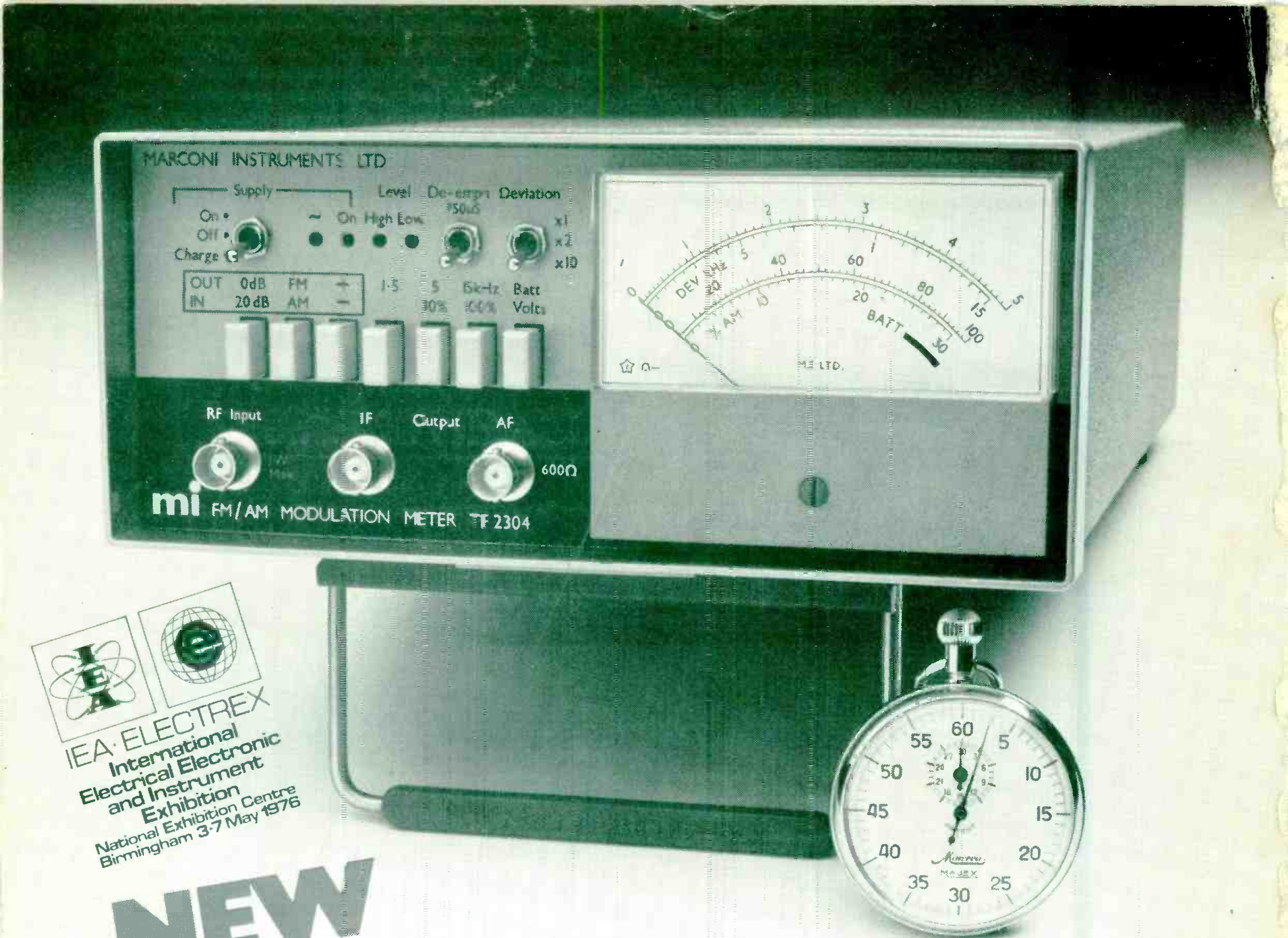
Speaker sound quality

The "walltenna"



Low-noise cassette deck



IEA·ELECTREX
International Electrical Electronic and Instrument Exhibition
National Exhibition Centre Birmingham 3-7 May 1976

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.

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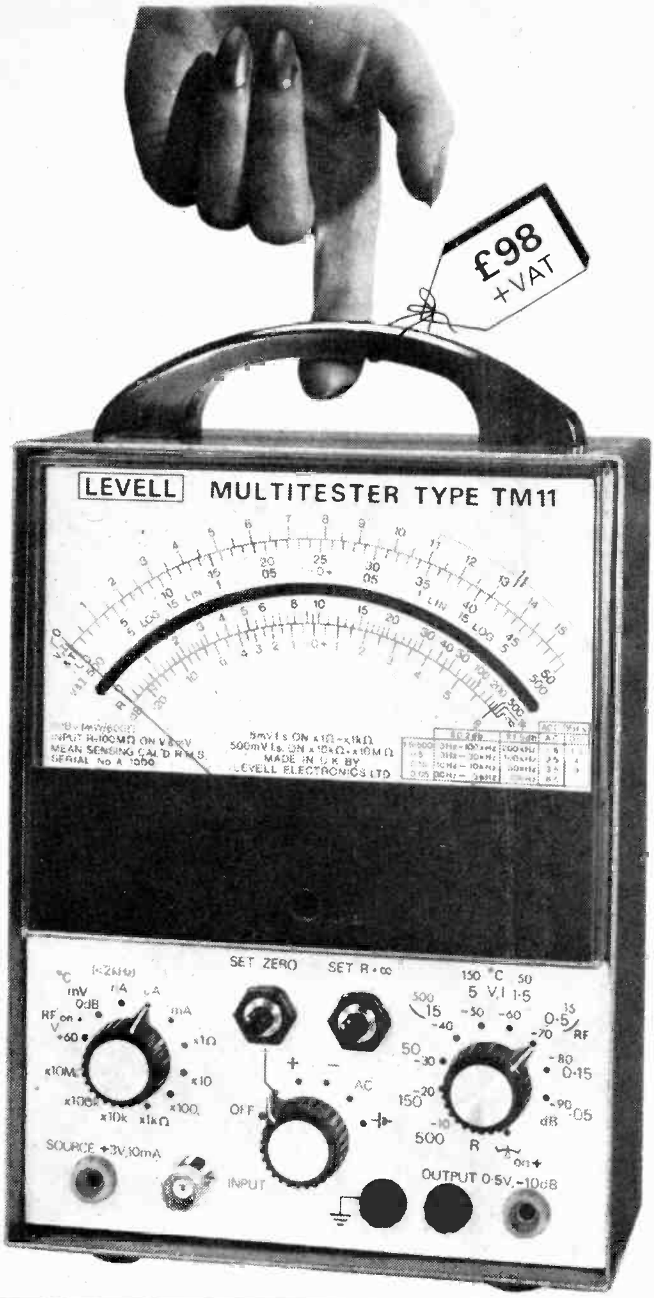
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SET ZERO
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Haltron

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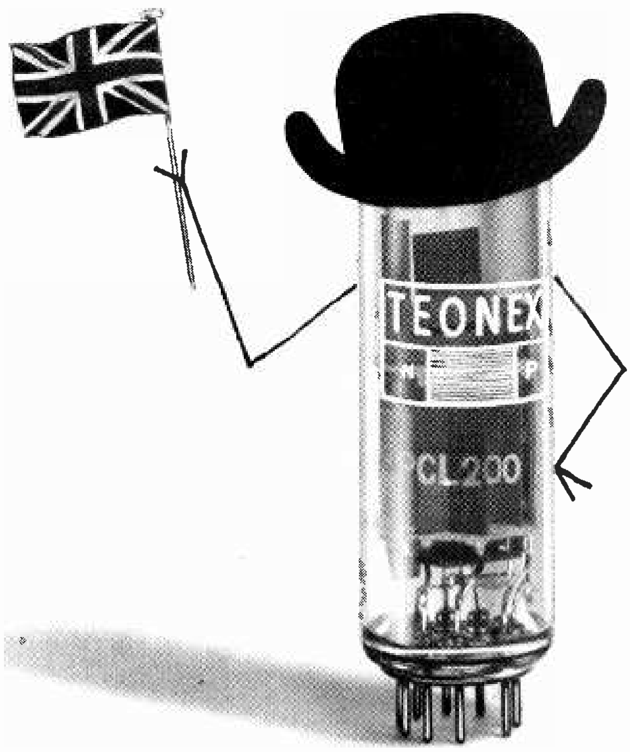

Electronic valves (a really comprehensive range), semi-conductors (a wide variety), integrated circuits.

Teonex offers more than 4,000 devices. They are competitively priced and they are superlative in performance, because the company imposes strict quality control. Teonex concentrates entirely on export and now operates in more than 70 countries, on Government or private contract. All popular types in the Teonex range are nearly always available for immediate delivery. Write now for technical specifications and prices to Teonex Limited, 2a Westbourne Grove Mews, London W11 2RY, England.
Cables: Tosuply London W11. Telex: 262256

REGD TRADE MARK

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ELECTRONIC VALVES + SEMI CONDUCTORS **for Teonexport only**

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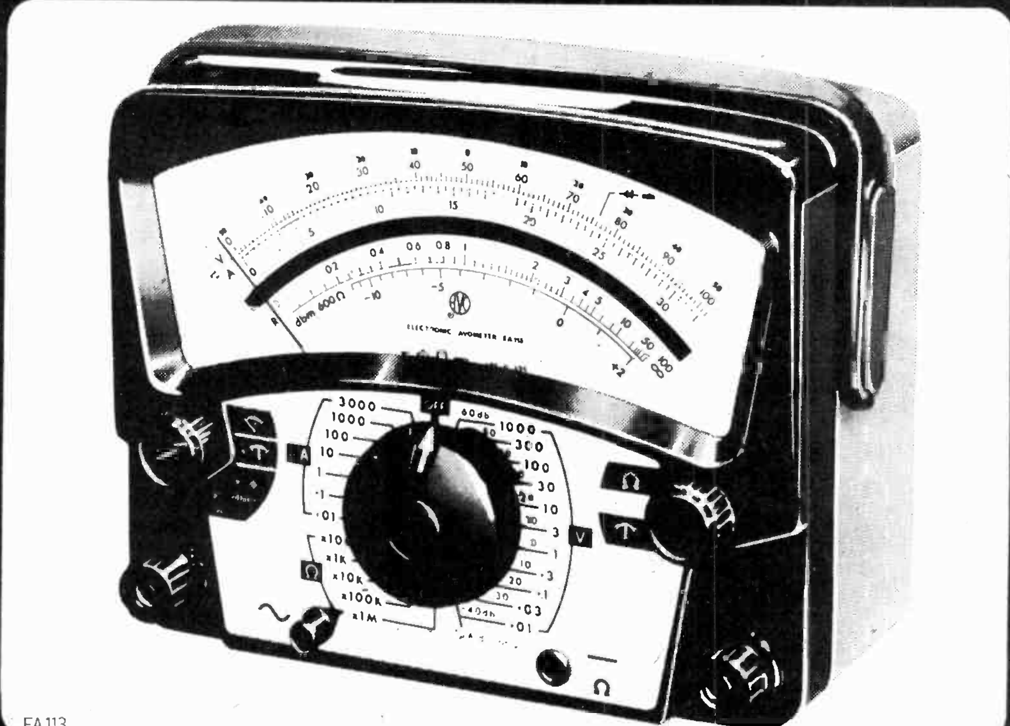
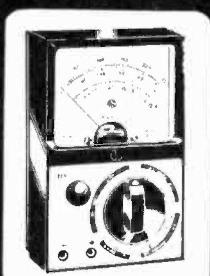
THE PEAK OF VERSATILITY.

The AVO EA113 steps forward from the AVOMETER range to take a well deserved bow

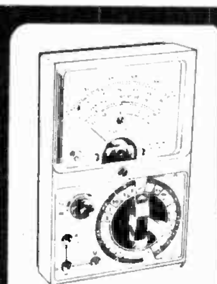


EA113



72

8 Mk 5



EM 272

DA 114

The AVOMETER range for Electronics.

EA113 does everything a major multimeter will do, but it does it with a high input impedance of 1MΩ/V (dc voltage ranges), a 100kHz capability, centre zero facility, single switch range selection, overload protection and other refinements, all for a UK Trade Price of well under £120. EA113 is, of course, an Electronic multimeter.

The range of measurement and accuracy are outstanding too. Voltage from 100μV to 1kV (±1.25%): Current from 0.01μA to 3A (±1.25%): Resitance from 1Ω to 100MΩ.

Yes, digital instruments also have high impedances – Avo offer the DA114 – but when it comes to all-round versatility in the laboratory and maintenance workshop, with many peaking adjustments to make, you can't beat analogue display.

As a final bonus, the EA113 brings you two valuable time-savers. No electrical zero setting, and internal batteries which are rated to run for 10 months of continuous round-the-clock operation.

Choose your next multimeter from the British-built AVOMETER range and ring your Distributor for price and delivery.

Avo Limited,
Dover, Kent, England.
Telephone: Dover
(0304) 202620.

Avo

THORN Thorn Measurement Control and Automation Division

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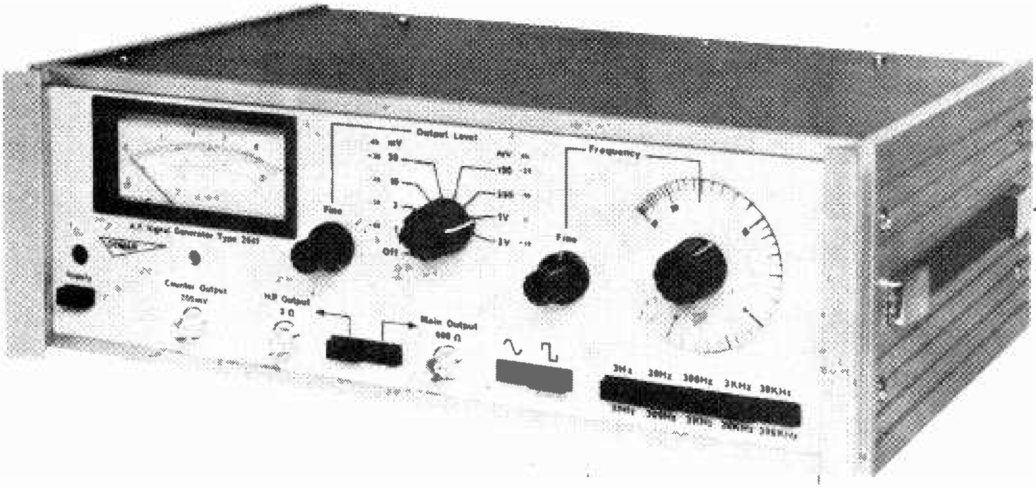
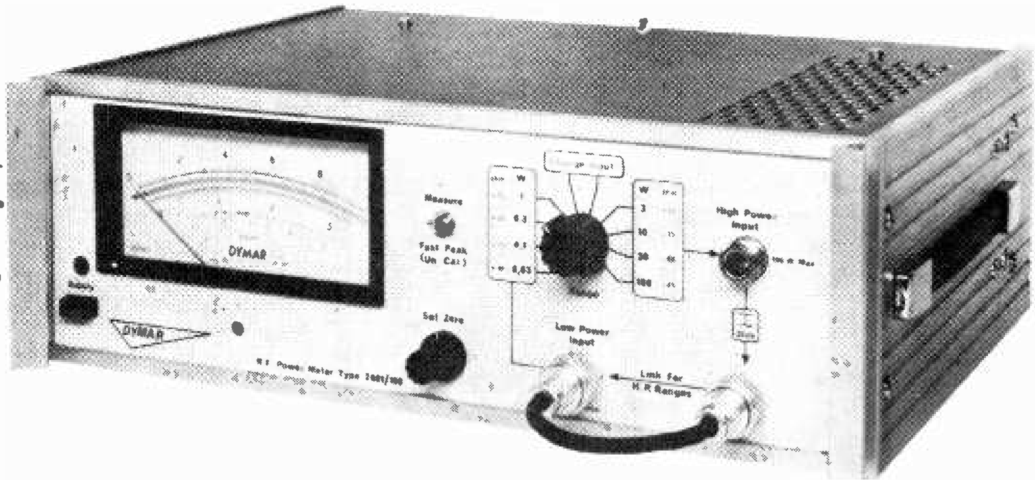
New Faces



Dymar 2041 AF signal generator



Dymar 2081 RF power meters

Born to be stars!

The communications industry has voted top spot to every Dymar instrument since the first in 1965.

Now meet two newcomers.

Type 2041 AF signal generator. Frequency range 3Hz to 300kHz. Maximum output 3W into 3 ohms. A combination to cover the field from audio applications to vibration analysis. Calibrated and stepped 600 ohms attenuator gives adjustable output levels from 1mV to 3V (fsd). Auxiliary output from oscillator for accurate frequency monitoring.

Type 2081 RF power meters. 2081/30 resolves 1mW to 30W 2081/100 covers 2mW to 100W. Bandwidth-DC to beyond 500mHz And that covers most communications transmitters-hand portable, mobile or base-operating in HF, VHF and UHF. Built-in extras. RF sampling and fast response peaking.

Of course, both operate from mains supply or internal rechargeable batteries-conferring the famous Dymar go-anywhere quality.

And both will undoubtedly receive the recognition heard everywhere. 'Check it on the Dymar.'

Ask Dymar for details or use the Reader Reply Service.

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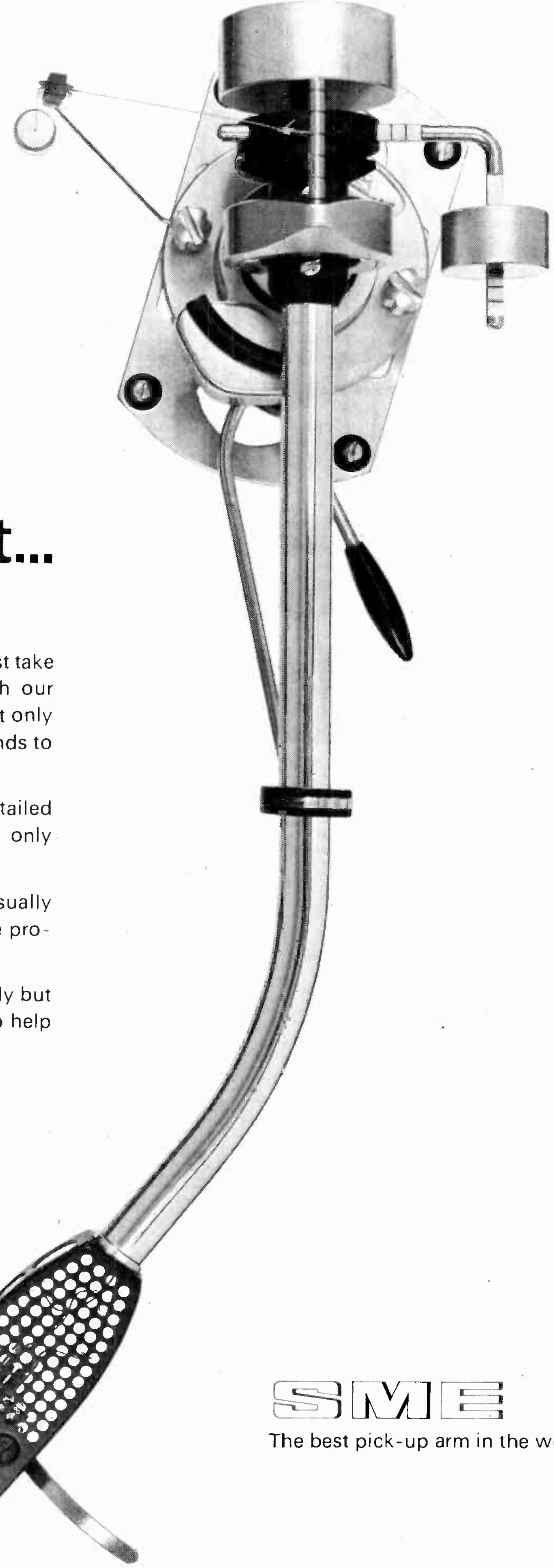

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Design Council Award 1976

QUAD 405

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Once again, the design is all our own work, and we are justifiably proud of it.

For further details of the QUAD 405 current dumping amplifier and other QUAD products write to: Dept. WW
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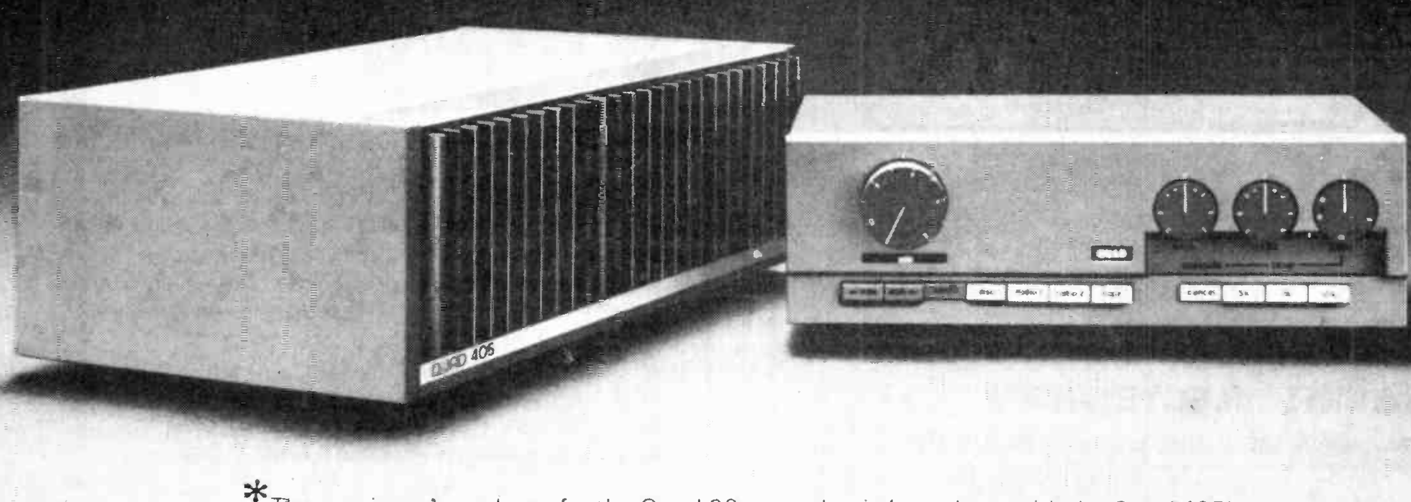

*The previous Award was for the Quad 33 control unit (seen here with the Quad 405) the Quad 303 power amplifier and Quad FM stereo tuner in 1969.


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STETOCLIP LIGHTWEIGHT HEADSET
SENIOR STETOCLIP HEADSET
STETOMIKE BOOM MICROPHONE HEADSET
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2,5 mm and 3,5 mm JACK PLUGS & SOCKETS
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DANASONIC INDUCTION AUDIO LOOP RECEIVER
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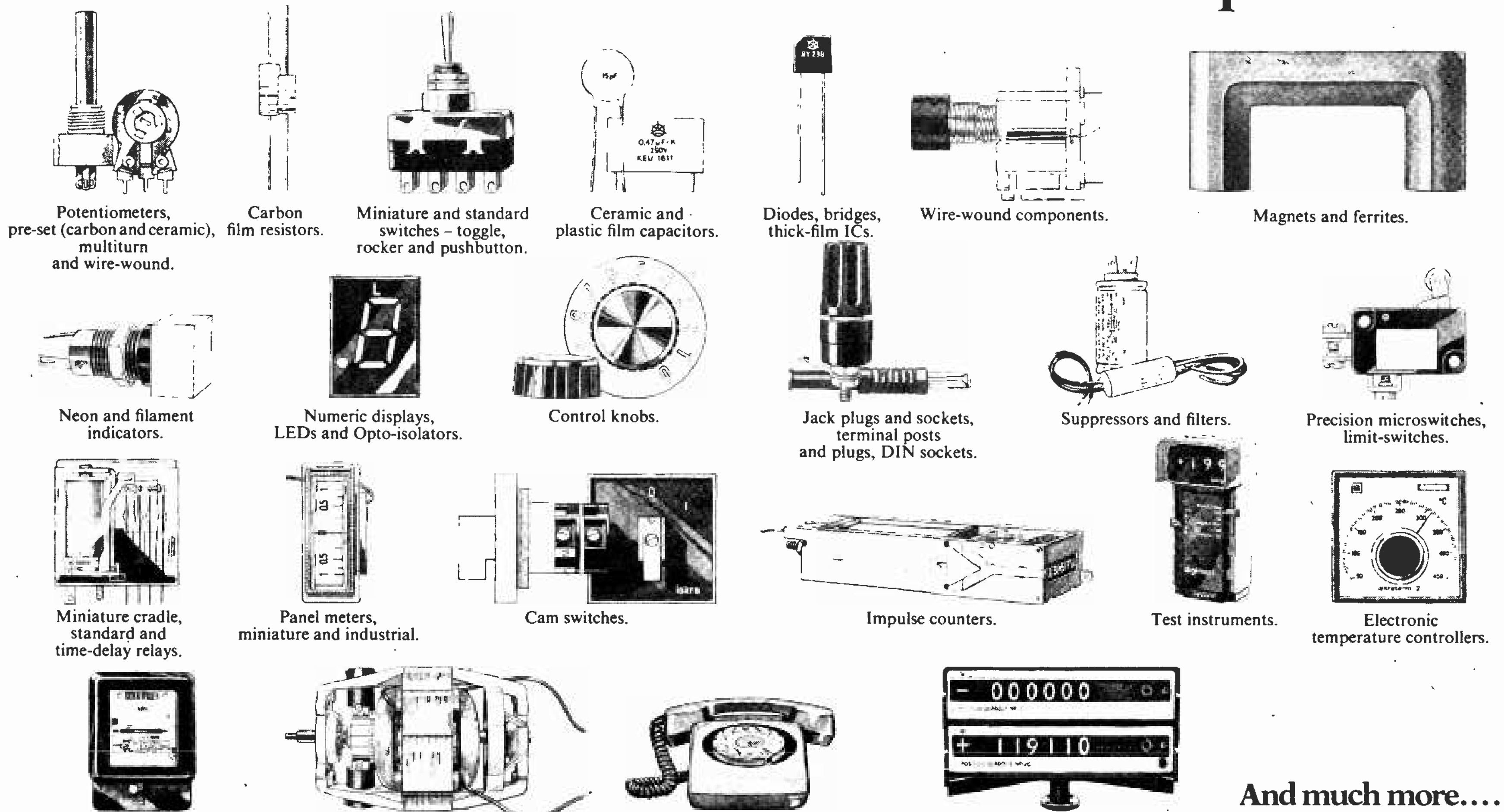

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Miniature and standard switches – toggle, rocker and pushbutton.

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And much more....

You have probably heard of us, but do you know what is behind us? Guest International, a subsidiary of the multinational Iskra organisation, supply an extensive range of components for the electrical, electronic and instrumentation fields throughout the United Kingdom. From resistors and potentiometers to process control and telephonic equipment.

Guest also have a wide supporting range of components from other reliable British and Continental manufacturers. In addition, Iskra manufacturing facilities are available for special products.

In total, Guest International can offer a complete manufacturing and selling capability with a developing and ever-expanding network of franchised distributors so that popular products are available fast and with on-the-spot service.

A copy of the new Short Form Brochure is available on request.

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GUEST

Guest International Limited.
Redlands, Coulsdon, Surrey CR3 2HT. Telephone: 01-668 7141. Telex: 946880

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We at Icon Design can justly claim to have originated many ideas now becoming standard; the single lamp tuning indicator and a moving coil frequency meter for example. We were also one of the first to use push button pre-select with separate manual tuning.

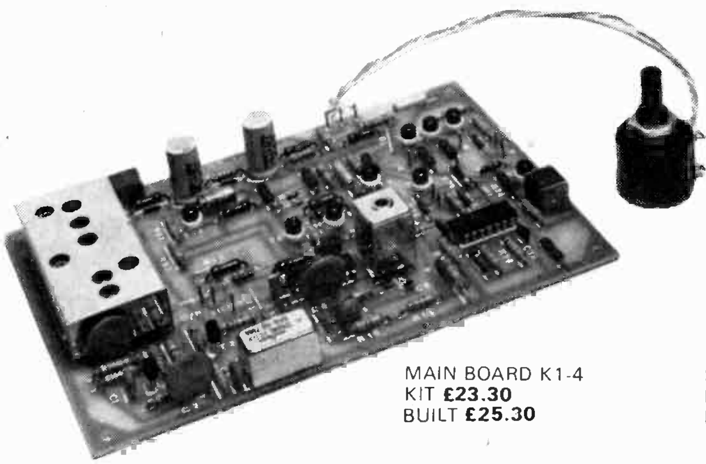
Our quality and service are still second to none.

We are now pleased to announce a

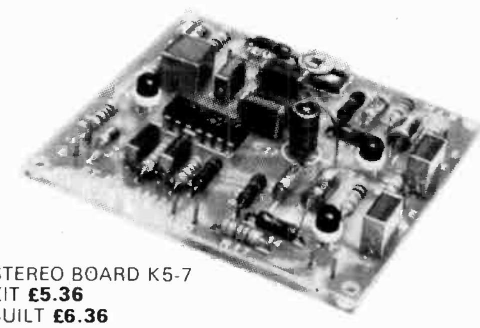
TOUCH TUNE PRE-SELECT UNIT
for our tuner

This is a separate unit, powered from the normal tuner supply, and designed as an alternative to the existing push button unit (K9a). It provides six pre-select channels while maintaining the manual control and frequency meter circuits. The pre-set pots (20 turn cermet types, of course) are accessible from the underside of the tuner without removing the cabinet, being mounted between the chassis and the front panel. The channel selected is indicated by L.E.D. lamps incorporated in the touch buttons, which replace the manual buttons without modification to chassis or front panel.

We regret that a photograph was not available at the time of printing, and invite requests for full details and prices by return of post.



MAIN BOARD K1-4
KIT **£23.30**
BUILT **£25.30**



STEREO BOARD K5-7
KIT **£5.36**
BUILT **£6.36**

KITS

K1	All main board resistors, including tuning pot	**£5.32**
K2	All main board capacitors	**£1.98**
K3	Main board transistors and diodes	**£3.00**
K4	Main P.C.B. i.c.s, filter coil and front end	**£13.00**
K5	Stereo board resistors	**£0.76**
K6	Stereo board capacitors	**£1.05**
K7	Stereo P.C.B. i.c. and transistors	**£3.55**
K8	4 way function switches	**£4.59**
K9a	6 way channel selector, inc. cermet pots, P.C.B.	**£12.75**
K10	Power supply, including transformer and P.C.B.	**£5.50**
K11	Full metalwork set, front panel, cabinet, plugs mains lead, wire, etc.	**£25.60**
K12	Frequency meter and drive components for K9a	**£10.22**

SEPARATE ITEMS (inc. in kits)

P.C.B. for main board	**£1.95**
P.C.B. for stereo	**£0.95**
P.C.B. for selector	**£0.95**
P.C.B. for power supply	**£0.95**
MC1310 or equiv.	**£1.95**
TBA750B	**£1.55**
SL301B	**£1.10**
SL3046	**£0.85**
TBA625C (reg) & heat sk.	**£1.15**
LP1186 front end	**£5.95**
Filter SFG10·7MA	**£1.55**
Coil. (assembled & adjusted)	**£0.50**
Ten turn tuning pot	**£3.00**
Front panel	**£1.75**
Teak cabinet	**£7.75**
Meter (scaled 105 or 108 MHz)	**£8.85**
Scale only (state which)	**£0.30**

All kits guaranteed to work or free repair!

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FULL TUNER KIT £85.00
COMPLETED TUNER £92.50

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We also manufacture Frequency Changers, Power Supplies and Standby Systems, and we are always happy to quote for your special requirements. All prices plus VAT

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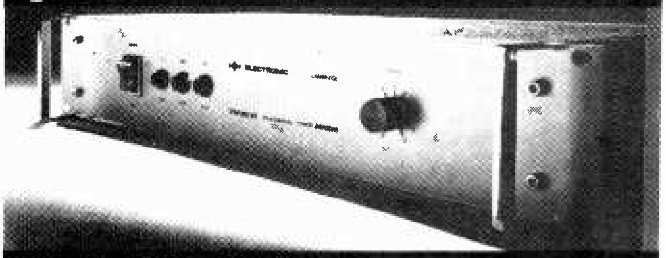
TPA SERIES-D

integrated circuit power amplifier



TPA 50 - D Specification

Power Output	100 watts rms into 4 ohms 65 watts rms into 15 ohms
Freq Response	±0.1dB 20Hz to 20KHz into 15 ohms. -1dB at 150KHz
Total harmonic distortion	Less than 0·04% at all levels up to 50 watts rms into 15 ohms
Input sensitivity	OdBm
Noise	-100dB
Rise time	2 u seconds
Price	£77 plus V.A.T.

100V Line (C.T.) and balanced inputs available.
For full technical information contact:

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TELEPHONE CAMBRIDGE 65945/6/7

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CHOICE. Filament or LED with Polaroid Filter.

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Sensitivity 10mV
Frequency 100 Mhz
PRICE £199.00

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Sensitivity AMP 1.DC-150 Mhz. 10mV
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(8 digit only)
Sensitivity 10mV
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Type DG700F
Sensitivity AMP 1.DC-200 Mhz. 10mV. PRICE £569.00
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Prices exclusive of VAT

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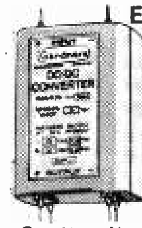

ENCAPSULATED POWER SUPPLIES

DC Input — NV Converter Series

- Fully stabilized
- Input/output isolation
- Short circuit protection
- Fully shielded, low radiation
- Commutation spikes less than 20 mV P-P

Cat. No.	Nominal DC Input Voltage	OUTPUT Volts	OUTPUT Amps	TYPICAL REGULATION (Volts) LINE	LOAD
NV7300	5	2x15	0.25	.006	.006
NV7308	5	180	0.05	2.5	2.5
NV7312	12	5	1.00	.005	.024
NV7314	12	2x 5	1.00	.005	.024
NV7317	12	6	1.00	.009	.021
NV7319	12	2x 6	1.00	.009	.023
NV7323	12	2x12	0.50	.014	.011
NV7328	12	2x15	0.50	.019	.011
NV7336	12	24	0.5	.07	.09
NV7342	24	5	1.00	.004	.024
NV7344	24	2x 5	1.00	.004	.024
NV7349	24	2x 6	1.00	.008	.023
NV7353	24	2x12	0.50	.010	.012
NV7357	24	15	1.00	.024	.021
NV7358	24	2x15	0.50	.015	.012
NV7366	24	24	0.5	.07	.09
NV7368	24	50	0.25	.3	.2
NV7372	50	5	1.00	.002	.024
NV7383	50	2x12	0.50	.007	.011
NV7388	50	2x15	0.50	.010	.012
NV7396	50	24	0.5	.07	.09
NV7398	50	50	0.25	.3	.2

Based on ambient 20°C, 100sq. in heatsink
*modules facilitating polarity changes
Additional designs are fully described in GT.21B.

AC Input — Minimod Series

- P.C. mounting interchangeable with most American types
- Linear stabilization
- Foldback current limiting
- Wide temperature range
- Modules available for U.K. (210-250v), European (200-240v) and American (106-121v) requirements
- Supply Frequency 50-400Hz

Type number	OUTPUT Voltage*	OUTPUT Amps	Short Circuit Current mA (Typical)	% Regulation line & load (Typical)
PU01	5	0.5	370	0.3
PU02	5	1.0	770	0.5
PU03	15-0-15	0.10	37	0.1
PU04	15-0-15	0.20	84	0.1
PU05	12-0-12	0.12	45	0.1
PU06	12-0-12	0.24	120	0.2
PU11	18-0-18	0.15	50	0.1
PU10	15	0.10	37	0.1
PU12	12	0.10	45	0.1
PU13	18	0.065	23	0.1

*Voltage tolerance 5v models ± 0.1v. All other models ± 0.2v.

Nickel-Cadmium Cell Charger Units

Constant current outputs permitting up to 10 cells to be charged in series. DC INPUT - NV7304 AC INPUT - PU07

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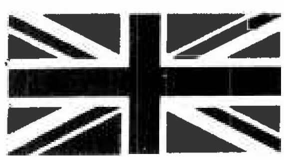

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Approved manufacturers of electronic transformers, modular power supplies, inverters and converters to Defence Standard 05-21

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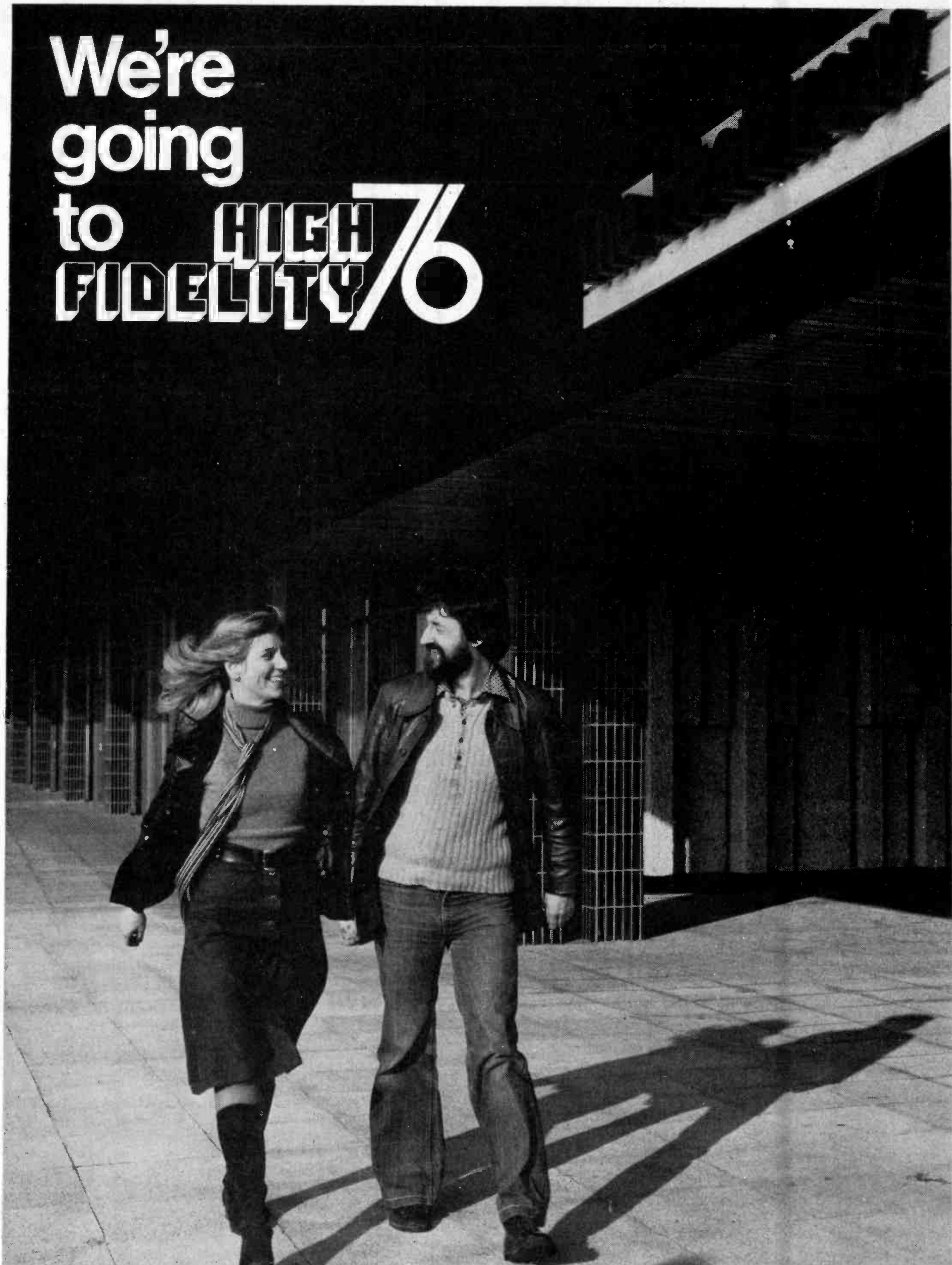
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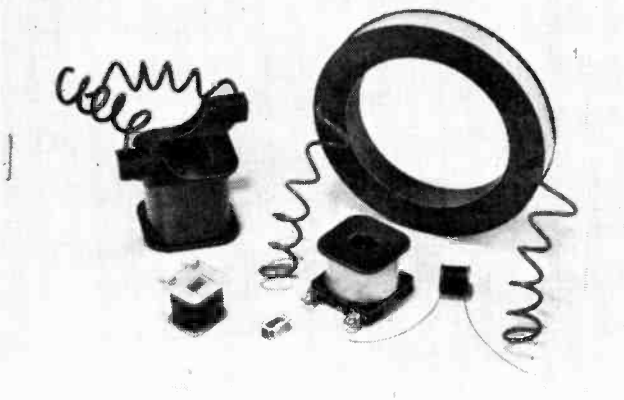
FIDELITY 76

COIL WINDING



Manufacturers of all wound components including transformers, chokes, stators and armatures. Prototype and design service available.

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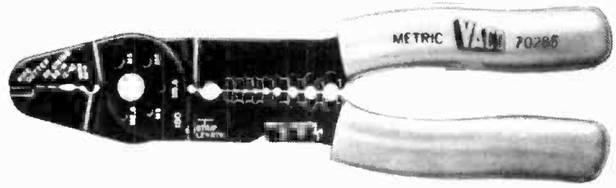

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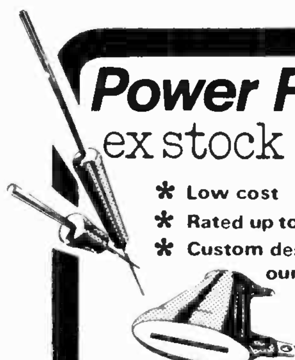

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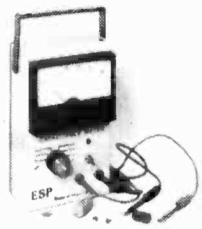

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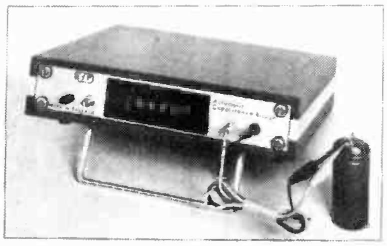

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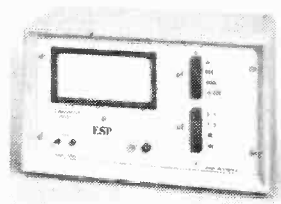

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MAY 1976 Vol 82 No 1485

Contents

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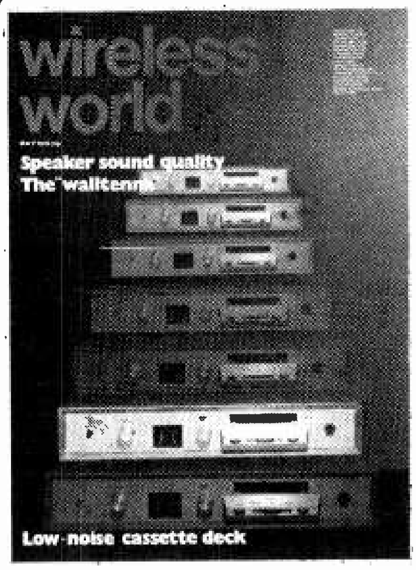

Front cover design is based on a multiple-exposure photograph of the low-noise, low-cost cassette deck described in this issue.

IN OUR NEXT ISSUE

Intelligent beings in other solar systems? If they exist we may be able to communicate with them by radio. An article on the engineering aspects of signalling across stellar distances.

CD-4 demodulator. Design using QSI integrated circuit forms part of QS/SQ/CD-4 decoder unit to be described.

Antiphase or 180° phase shift — what is the difference? A discussion of common misunderstandings.

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Plain words to the word-bound

The English language may not survive. It becomes compressed into a smaller working space with every advance in science, engineering and the arts. Just before it disappears, someone may possibly be heard to mutter "destructive, superfluous augmentation" or perhaps, being the last plain English speaker, "What does it all mean?"

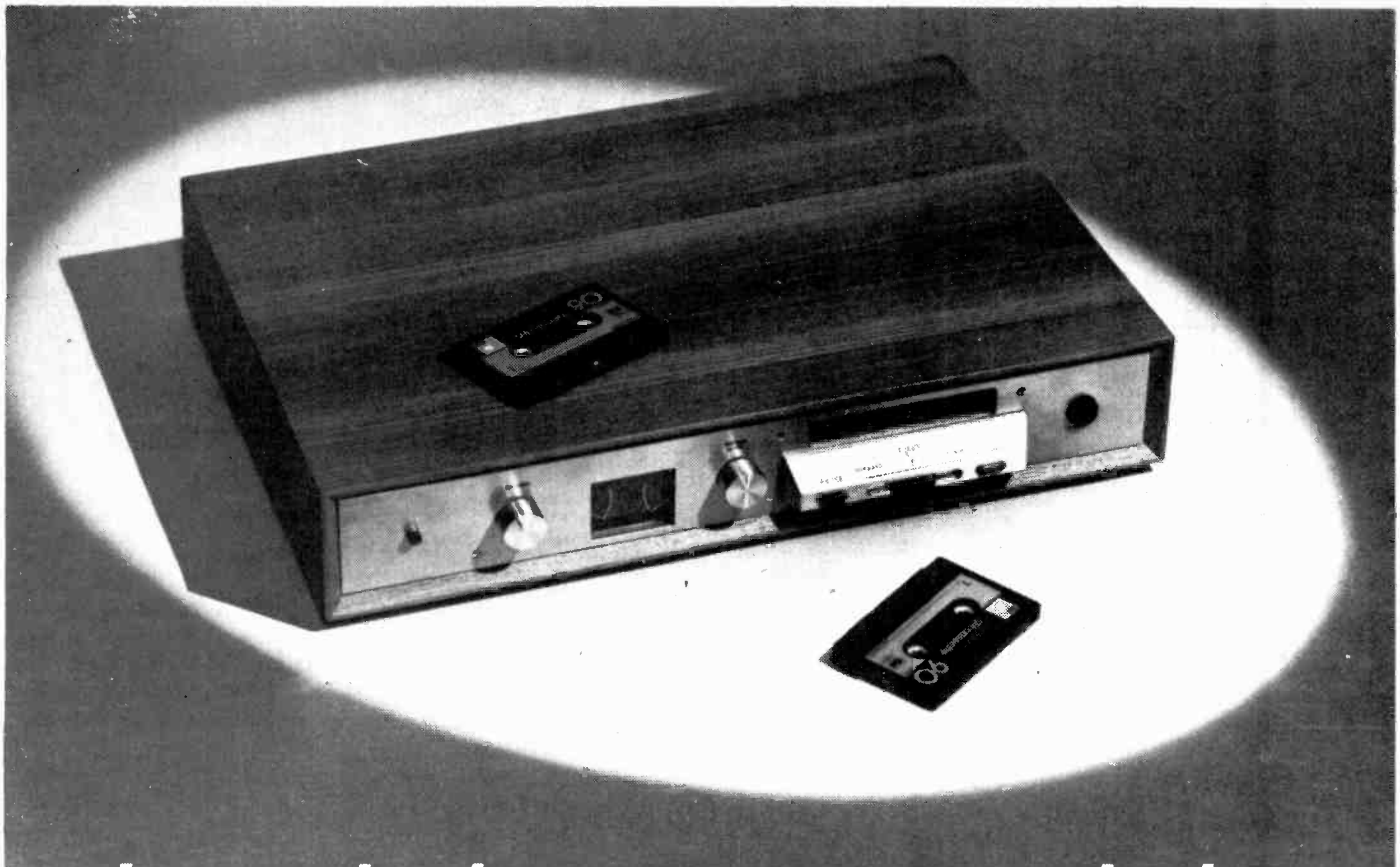
It sometimes appears to technical journalists, exposed as they are to the full force of technical gobbledygook on all sides, that jargon is used in preference to plain words because it sounds more esoteric. It also saves the writer the trouble of finding the ordinary word which would be understood by people who are not, perhaps, familiar with the subject and may be thus admitted to to the circle of cognoscenti. For example, is the instruction "For store access, input 'initiate' command. Interrogation complete will indicate" easier to take in than "To obtain data, push 'start' button. Light will flash when finished"? We think not. Things have now reached the point where public relations firms not only issue "hand-outs" to describe their clients' products, but hand-outs to explain their hand-outs.

It is easy to accuse the Americans of debasing the English language, but the British manage to do that very well themselves. Admittedly, the Americans do come up with some grotesque phrases, such as "as of this point in time . . ." and "It is GO". They have even coined such mutants as "to merchandize" and "to pressure" and many other noun-verbs — but most are understandable, if absurd.

Our main complaint is against the making of new, jargon words from standard ones when the intended meaning is the same. To reference an amplifier output to its input is no different from the ordinary process, in which one refers to it. To input is the same as to put in and to access is no improvement on to take out. It may be said that the words are not misleading, merely unnecessary; but what of "random-access memory", which implies that a read-only memory is not equally accessible in a random way?

Self-importance is not the only spur to "jargonization"; laziness is often responsible for writing that is hard to understand. It is easy to see why someone should write "l.s.i. r.o.m. i.c."; the words would take too long to write and use up too much space. But if this is true perhaps the words ought to be replaced by better ones, or redundant ones left out.

There is no excuse for attempts to confuse the uninitiated readers by special language when plain words can be used (sometimes of course they can't; one would be hard put to it to write "staphylococcal peri-onychial whitlow" in economical standard English). Communication is essential if people are to be educated and jargon is a formidable barrier against this. It is probably too late for this journal to do any more than record its dismay, but if we can persuade a few writers not to talk of decoupling an emitter *to* earth or of a power unit supplying d.c. current, we will have helped a bit.



Low-noise, low-cost cassette deck

High-quality design for mains/battery use

by J. L. Linsley Hood

For some years the author had contemplated the possibilities for the provision of music of reasonable technical quality, by way of headphones, while away from home on camping holidays – which were normally taken in scenically attractive but physically remote parts of the countryside. Of the available alternatives, the use of previously recorded tape cassettes seemed the most satisfactory, but it is unlikely that further action would have been taken on this matter but for the current availability at an attractive price of good-quality cassette mechanisms made under Staar patents by Garrard and Goldring-Lenco.

It must be explained, at the outset, that the intention was not to provide an instrument which would equal or exceed that of expensive and carefully engineered "transcription" cassette recorders, but rather to evolve a straightforward and relatively inexpensive circuit arrangement which would nevertheless provide a standard of performance which would be acceptable in the context of existing, high quality, audio equipment. In the event, the performance of the prototype has substantially exceeded expectations, and has led to a major revision of the author's opinion of the performance obtainable from this medium.

In particular, it would appear that, with good system design and appropriate attention paid to recording and bias levels in a direct recording made from a good quality l.p. disc onto a reasonable quality ferric-oxide cassette tape, the major component of noise on replay is likely to be the surface noise on the original disc. Also, the differences between the source material and the cassette transcript can be sufficiently small that they are not readily apparent, even on A-B comparison.

Basic circuit

The general layout of the system adopted is shown in Fig. 1. The d.c. power supply unit has two outputs – one of about 12-14V at 200-400mA to feed the d.c. drive motor which operates the cassette feed, and which has its own speed control system incorporated by the manufacturers, in the case of the Garrard CT4 used in the prototype – and one having a well-smoothed and electronically stabilized output preset to a nominal 13.5V, which feeds either the replay or record amplifiers. Between these two lines there are two change-over switches, to the centre point of which can be connected a 12-14V d.c. supply, so that the system can also be operated from batteries.

The changeover switch in the amplifier supply line is a small microswitch, not supplied with the cassette mechanism but operated by a protruding tag on the side of the record push button on the mechanism. To make a recording, this is depressed before the cassette is inserted, when a mechanical interlock retains the button in the inward position. When the d.c. supply is connected to the record amplifier panel, it also energises a 12V, three-pole change-over relay connected in parallel with it. This relay transfers the connections from the combined replay-record heads from the input to the replay amplifier to the output of the record amplifier. Under normal replay conditions, neither the relay nor the record amplifier panel are energized. The bias/erase oscillator is mounted at the output end of the record amplifier and is supplied with power when this panel is energized. By using separate record and replay amplifiers some additional component cost is incurred, but the internal switching is greatly simplified.

Replay amplifier

The use of the extremely low tape speed of the Philips cassette design, coupled with the small head gaps necessary for good high frequency response, and the

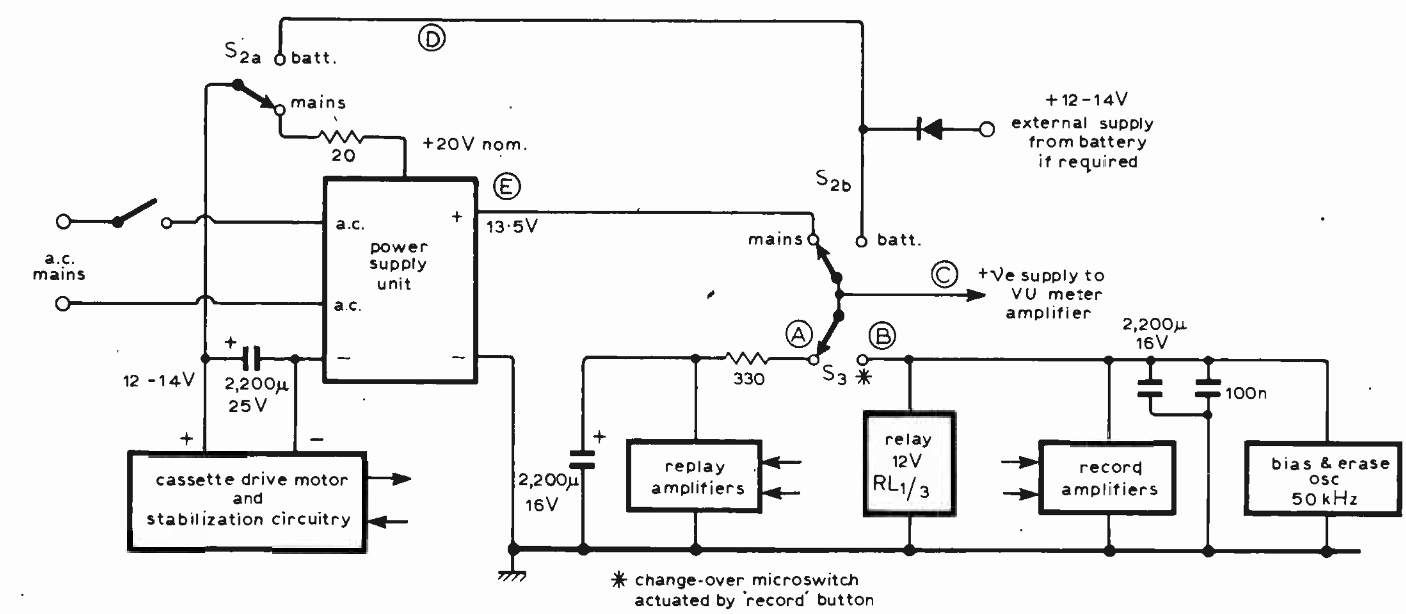


Fig. 1. System diagram showing record/replay switching and battery/mains selection. Motor stabilization circuitry is provided by the makers of the mechanism.

relatively low coil inductance required for adequate recording and bias current, lead to a very low output voltage from the cassette replay heads. In the stereo configuration this means a 0VU (normal maximum record level) output of some 800-1000µV, and actual signal levels down to a few tens of microvolts. Under these circumstances, it is imperative that great care is taken, both in the design of the input amplifier circuit and in the layout of the wiring from the heads to this, to prevent obtrusive noise or hum. The use of a d.c. tape motor greatly reduces hum originating in the motor, but the mains transformer in the power supply should have a low external mains field and should be as far away as possible from the replay amplifier input wiring and replay heads.

In the prototype, as the mains transformer which had been obtained was not very well designed from the point of its external 50Hz field, a home-made Mumetal shroud was fashioned from a surplus c.r.t. screen to enclose it and this completely solved the problem.

The input circuit of the replay amplifier is shown in Fig. 2: the amplifier is optimized for the minimum practicable noise voltage, to which the major contributory factors are Johnson noise, due to thermal agitation in the input circuit and input device base diffusion impedances (minimized by making the input impedance as low as practicable and by the correct choice of input devices – epitaxial-base silicon bipolar transistors are preferred); "Shot" noise, which is proportional to both current and bandwidth; "excess" or "1/f" noise, due to imperfections in the crystal lattice and proportional to device current and root bandwidth and inversely proportional to root frequency; collector-base leakage current noise, which is influenced both by working temperature and collector-base voltage; and finally surface recombination noise in the base region. Where these are approximately calculable, the equations shown below are appropriate.

Johnson (thermal) noise $V=\sqrt{4KTR\Delta f}$

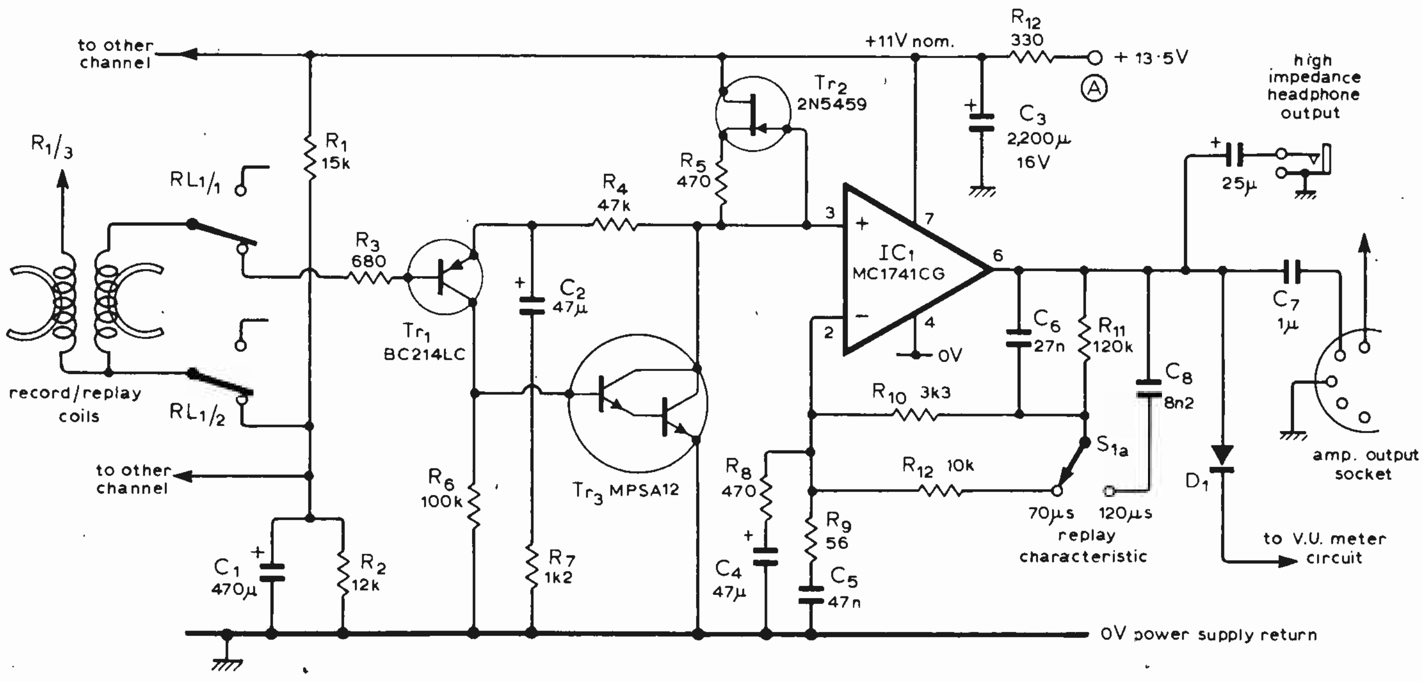
Shot noise $i=\sqrt{2qI_{DC}\Delta f}$

Modulation (1/f) noise $V_m=\sqrt{\frac{\Delta I^2\Delta f}{f}}$

where Δf is the bandwidth (Hz) $K=1.38\times10^{-23}$, T the temperature (K), q the electronic charge (1.59×10^{-19} coulombs), f the frequency and R the input impedance.

In practical terms, this means using a silicon bipolar epitaxial-base transistor as the input device, which should be of p-n-p form to take advantage of the

Fig. 2. Relay amplifier.



better surface recombination noise characteristics of the n-type base material, at an appropriately low collector-to-emitter voltage, say 3 to 4V, with as low a collector current as is permissible and a base circuit impedance giving a suitable compromise between Johnson noise and device noise figure requirements. In the case of the Texas Instruments BC214LC, the optimum collector current and base circuit impedances are 10μA and about 800 ohms. This gave, on the prototypes of this amplifier, a measured noise referred to the input of some 0.2μV which is only slightly above the predicted Johnson noise value for the known input impedance and equalized bandwidth. In practice, the input noise introduced by this stage is sufficiently less than that of the tape background for it to be unimportant as a contribution to the overall system noise figure.

In the second stage of this amplifier, where the replay equalization (frequency/amplitude response shaping) is performed, a good-quality integrated operational amplifier "gain block" is employed, as in all the other gain stages of the system. The unit chosen is the Motorola MC1741CG, which is a fairly standard 741 but in an 8-pin TO39 metal-can encapsulation, and is, in the authors experience with these devices, much to be preferred on grounds of reliability. Two equalizing characteristics are provided, having 70μs and 120μs upper time-constants. Of these, the former is the internationally agreed standard for chrome tape, and the latter is the normal standard for ferric types.

The output from this amplifier, about 0.4volts r.m.s., at 0VU and 660Hz, is taken to the output socket, and the VU meter through an isolating silicon diode. A similar isolating diode on the output of the record amplifier circuit allows the VU meters to be used both on record and replay settings, which is useful for assessing tape output characteristics, and the recording levels of recorded cassettes.

The two replay characteristics are shown in Fig. 3, and are determined by the switched values of $R_{10,\ 12}$ and $C_{6,\ 8}$. Some additional treble lift to compensate for head limitations is given by R_9, C_5 and gives rise to the part of the curve indicated in Fig. 3.

Although the author has some personal reservations about the use of series feedback configurations in the case of magnetic pick-up input equalization arrangements, where at the upper end of the recorded frequency range it is possible to generate relatively large pickup output voltages with consequent risk of distortion due to common-mode failure, in the case of cassette replay heads the likely output voltages are so small in relation to the input device C_{be} voltage that this is a negligible problem. Also, to design for the lowest practicable noise level, series feedback configurations remain the simplest form to implement, although in higher-speed, higher-output recorder systems it could be worthwhile to introduce feedback, around an inverting amplifier, at a low impedance at the earthy end of the playback coils.

To avoid replay head magnetization problems due to switch-on current surges through the replay coil windings on the charging of an input series capacitor, the replay coil is connected between the input reference voltage source and the base of the input transistor, so that the total current flow through this is limited to the base current of this device – about 0.1μA. (Head magnetization is less of a problem on record due to the demagnetizing effect of the fairly large bias voltage applied to it during recording. It is, however, important that the time constant of the record output circuit should be shorter than that of the decay of bias voltage, which is ensured by the use of fairly substantial capacitor values on the record amplifier positive supply line.)

The measured total harmonic distortion of the replay amplifier, input to output, at up to 1V r.m.s. output, is less than 0.01%, and a very high degree of h.t.-line noise and ripple rejection is given by the use of a constant-current-source load (Tr_2) in the first stage.

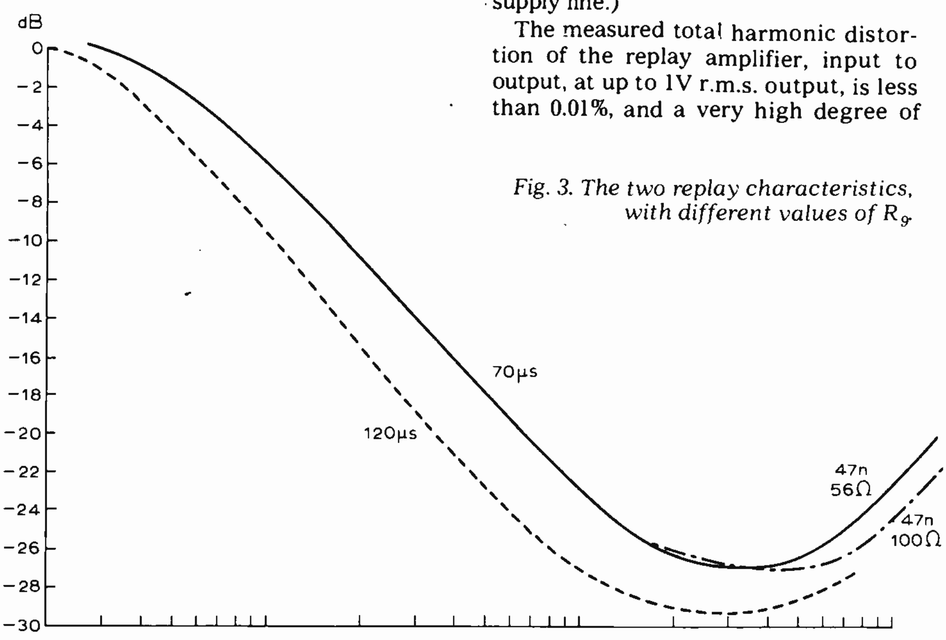


Fig. 3. The two replay characteristics, with different values of R_9.

Measured performance figures of prototype
(Garrard CT4 mechanism)

Frequency response ±1dB 35Hz –12kHz (BASF LH Super C90)
Channel separation 45dB at 1kHz
Erasure better than 50dB
T.h.d. at 0VU (660Hz) 0.75%*
Replay amplifier background noise, CCIR weighted, −56dB.
Zero recorded level background noise, CCIR weighted, −52dB.
Bulk erased tape background level, CCIR weighted, −54dB.
The above figures refer to a 1kHz tone recorded at 0VU on BASF LH Super C90.
Both channels are identical to within 1dB.
Record amplifier t.h.d. at +3VU less than 0.02%
Replay amplifier t.h.d. at +3VU 0.01% (Residual distortion less than background noise at −6VU.)

*This figure should be considered in the context of typical disc replay figures (e.g. 1.2% and 0.6% harmonic distortion for 20cm/s at 1kHz, vertical and lateral modulation respectively) for a good-quality pick-up cartridge in a good-quality arm, rather than in comparison with the less than 0.1% t.h.d. typical of a good-quality audio amplifier.

Record amplifier

Since the design value of input sensitivity for this amplifier is not very high – 50mV r.m.s. input at 1kHz for a 0VU record level – great care to obtain a high signal-to-noise ratio is unnecessary (the difference in recorded noise obtained by replacing the input MC1741CG with a very low noise circuit such as that used in the replay amplifier is only of the order of 0.75dB). A simple amplifier design based on a pair of these operational amplifiers is therefore entirely adequate, and confers a number of minor advantages in addition to those of simplicity and economy of component cost.

To avoid the necessity for winding coils for the generation of the required peaky record characteristic (desirable to offset shortcomings in the head performance, tape and recording characteristics at the upper end of the recording range) an active RC circuit arrangement is employed. This is shown in the circuit diagram of Fig. 4, and consists of the network R_{16}, R_{17}, C_{12}, C_{13} in conjunction with R_{19}/VR_2 and C_{15}. The recording characteristics obtainable from this are shown in Fig. 5, for various component values, which may be of use if it is desired to use different record heads to those supplied with the Garrard CT4. The magnitude of the pre-emphasis hump in the 13-15kHz region is determined by the setting of VR_2 (a preset component on the circuit board), while the basic recording treble

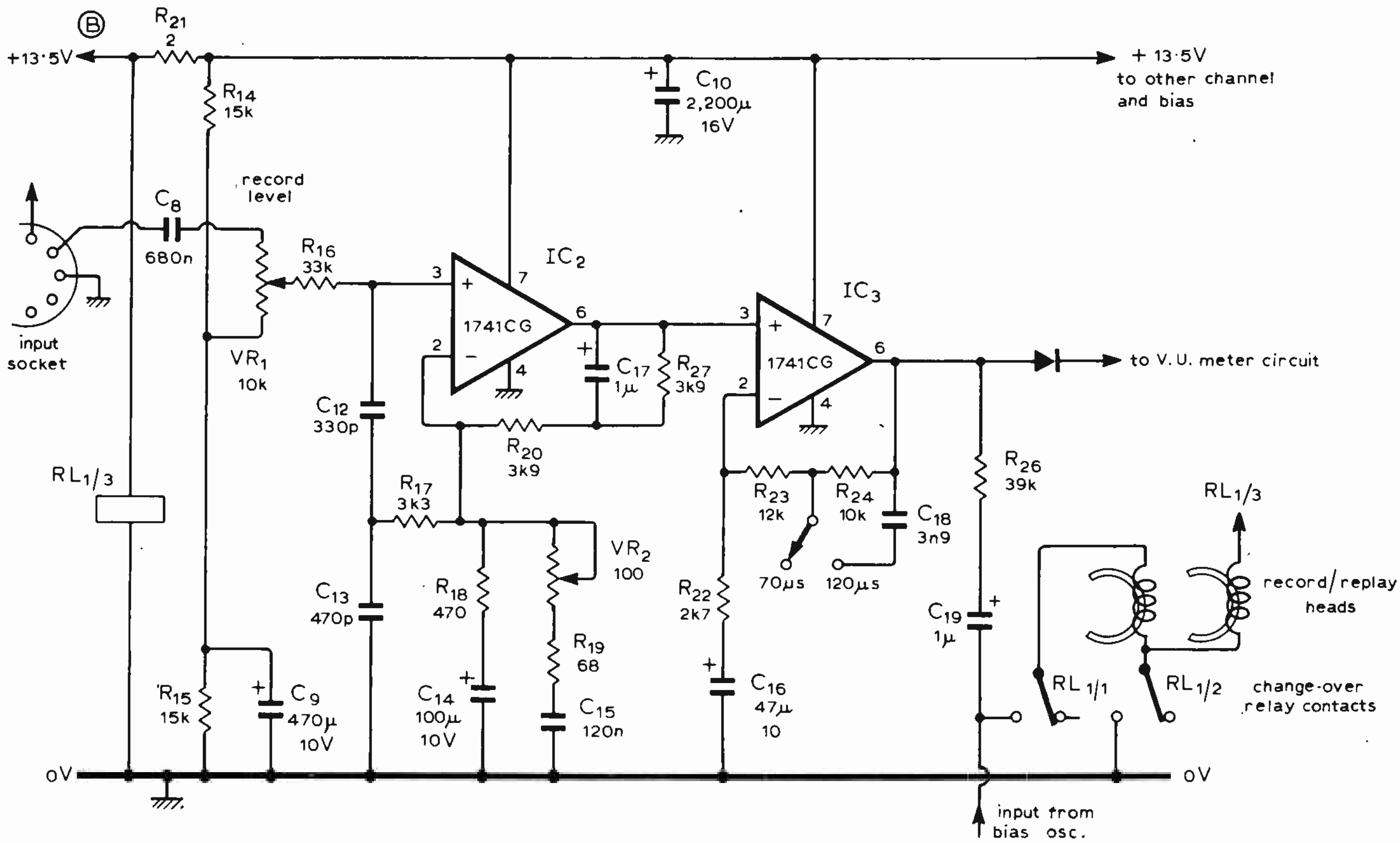


Fig. 4. Recording amplifier.

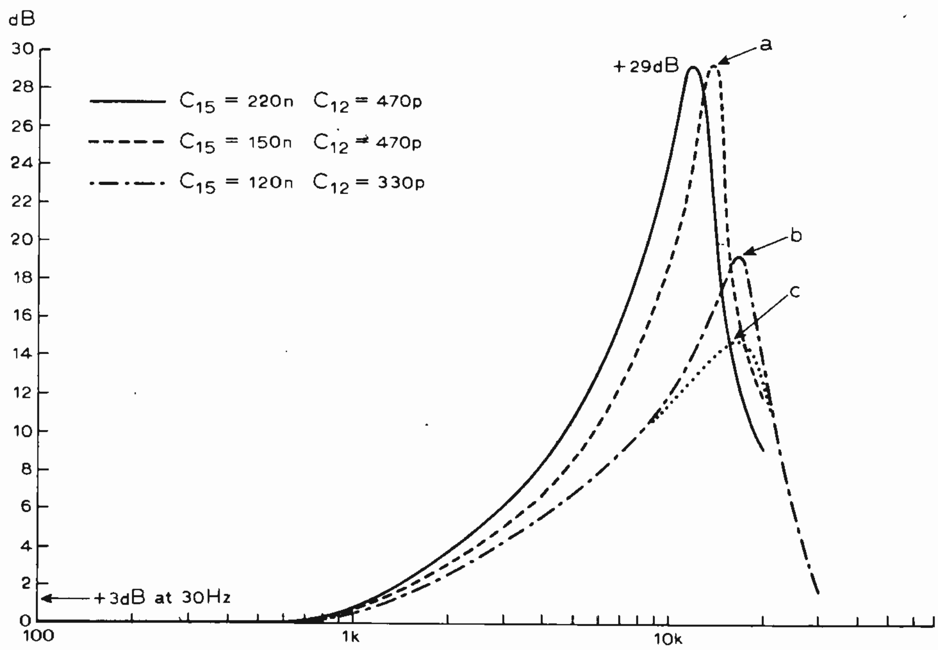
lift time constants are determined by C_{12} and C_{15}.

Changeover from the basic 70μs recording characteristic to the 120μs one is by switching C_{18} into circuit. The new cassette-standard bass pre-emphasis at 3180 μs is provided by C_{17}, R_{27}. A 39kΩ swamping resistor is interposed between the output of the record amplifier and the head, to approximate to a constant-current recording condition. Since the impedance of the head at the upper end of the frequency range of the recorder is less than 10kΩ, the loss of h.f. due to this is small, and readily compensated for in the equalizing circuitry. With this value of output swamp resistor, attenuation of the bias voltage by the low output impedance of the 1741 is sufficient to eliminate the need for any additional bias-trap circuit, while allowing record amplifier circuit outputs of up to +3VU with less than 0.02% t.h.d. at 1kHz.

With the recording heads used in the prototype, a 0VU record level at 660Hz, chosen to avoid regions in which pre-emphasis characteristics would influence the result, corresponded to 2.25Vr.m.s. at the output of the recording amplifier. Since the output magnetic flux characteristics of the heads were not specified, this level was chosen arbitrarily as the one at which a third-harmonic distortion level of approximately 1% was given at 660Hz on a good quality (BASF Super LH C90) ferric tape. This gives a +3VU setting of 3.1V r.m.s., which is below the amplifier clipping level on 13V supply line voltage.

The output of the record amplifier is taken to the VU meter circuit through a silicon diode, but since the record output is higher than that of the replay, an attenuator is included in this circuit to bring the two outputs to equality. The 47kΩ resistor to the zero-volt line serves to provide a forward current to bias the diodes into conduction. Switching between record and replay in the VU meter circuit is automatic since only the circuit in use has an output above the zero-volt level, the other one being disconnected from the supply line. Unwanted signal transfer through this diode feed network is of a very low order magnitude.

Fig. 5. Recording characteristics with variations in C_{15} and C_{12}. The peak heights are adjustable by VR_2, (b) being the compromise adjustment and (c) the setting for optimum square wave reproduction.



VU meter

This is a straightforward precision millivoltmeter of conventional type, in which the meter rectifier bridge is connected in the feedback loop of an operational amplifier as shown in Fig. 6. Although this is a more elaborate arrangement than most conventional VU meter systems, the cost of the operational amplifiers and the associated germanium diode rectifiers is small in comparison with even a modest twin

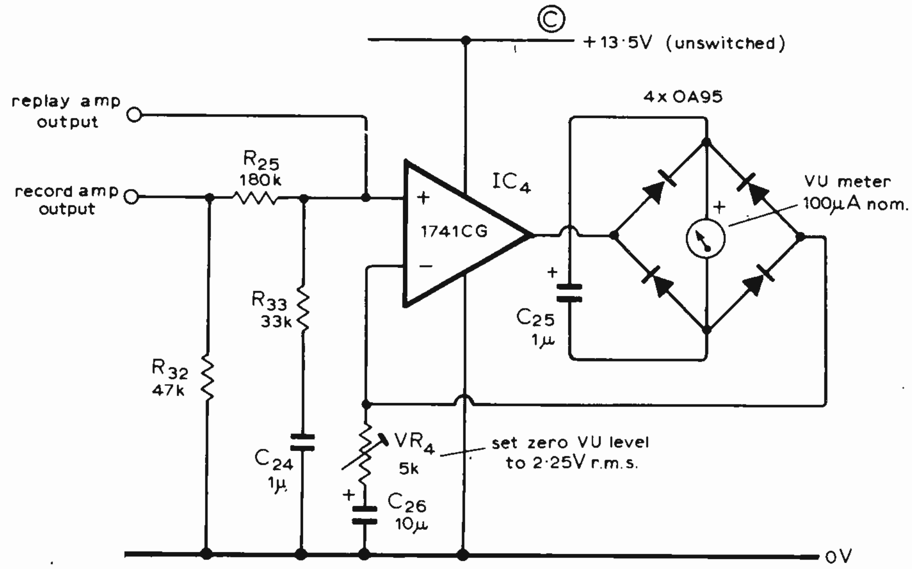


Fig. 6. VU meter circuit.

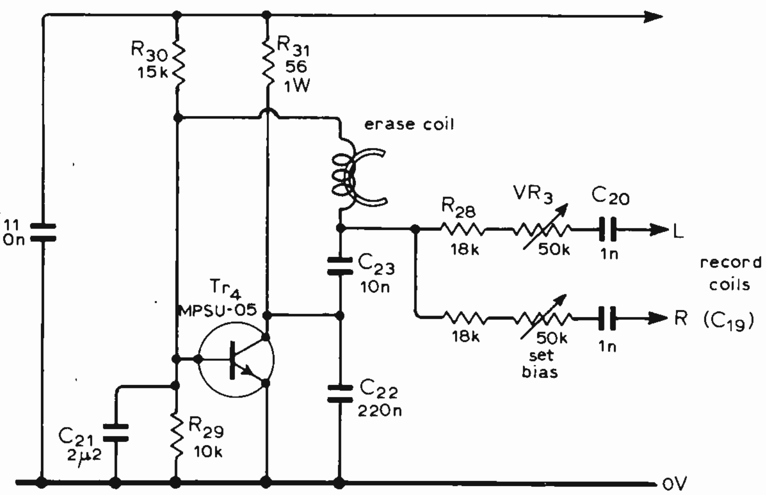


Fig. 7. Erase and bias oscillator, with continuous variation of bias level. Provision is made on the p.c.b. for the level to be switched.

VU meter, and the arrangement has much in its favour in a very linear a.c.-to-d.c. conversion, flat frequency/amplitude response, high input impedance, and short output voltage rise time due to the low output impedance of the amplifier. This latter feature is of particular value in tape recording, where the signal level meter should ideally have zero inertia so that it can follow the modulation of the signal without missing short-duration peak levels.

Bias and erase oscillator

A fairly common and irritating feature of inexpensive cassette recorders is their inability to erase fully an existing programme on a tape, when a further recording is being made on top of this. For satisfactory erasure of ferric and ferrichrome tapes, at least 20V r.m.s. should be supplied to the erase coil, and for chrome tapes a value as high as 25V may be required with typical cassette erase heads. To obtain voltages as high as this with low-voltage lines, it is customary to use a push-pull oscillator driving a step-up transformer, but some care is necessary to avoid harmonic distortion which can impair the recorded signal quality and s/n ratio.

A simpler method, which avoids many complications, is to use the erase head as the coil in a self-oscillating circuit, and employ the Q-multiplication of the tuned circuit around the erase coil both to provide the necessary voltage swing and also to improve the purity of the waveform. The circuit shown in Fig. 7 is a modified Colpitts, and provides an output of 25-33V r.m.s. at the required erase frequency (50kHz), with supply voltages in the range 12-14 volts and with a waveform distortion of less than 1%, even when loaded with the bias circuitry. The current consumption is, however, of the order of 100mA, giving a transistor dissipation of about 0.7W. The Motorola MPS-U05 is particularly suitable, but other high-gain, high-transition-frequency 1W devices are quite suitable since the circuit is not particularly critical of component values or types, except in so far that these may modify the operating frequency, which should be within the range 50kHz ±5%.

The h.f. bias waveform is also derived from the erase coil, by way of a resistor-capacitor chain, VR_3, R_{28}, C_{20}, to each record head output (VR_3 is twin-gang). Since the purity of the bias waveform at the recording head is the design requirement, it is tempting to use a value of series capacitor (C_{20}) which will be series resonant with the record coil at the bias frequency, as is fairly standard commercial practice. However, on reflection, confirmed by measurement, it is better to use a larger value of C_{20}, and take advantage of the integrating characteristics of the series network to attenuate higher order distortion components in the bias waveform, as seen at the head.

The bias voltage required across the record coil is dependent on the tape used but, as a guide, should be in the region 5-7V r.m.s., with the CT4 heads. The signal level, for reference, at this point, is only about 50mV.

(To be continued)

Garrard Engineering Ltd now tell us that production of the CT4 mechanism is to stop in June. As mentioned in the article, however, Goldring Ltd also market a unit made under the Staar patents and this will continue to be available for some years. The type number is CRV and one difference between the two is that the CRV does not incorporate motor speed stabilization. An easy way to overcome this is to use the SGS-Ates TCA910 regulator i.c. on a small p.c.b., the design of which we will publish in the next article.

Wireless World has arranged a supply of stereo glass fibre p.c.bs for this design. The boards measure about 9in × 3¾in and accommodate the changeover relay as well as two pre-set potentiometers per channel for switchable bias settings. One-off price is £4.50 inclusive from M. R. Sagin, 11 Villiers Road, London NW2.

Automation in broadcasting

In addition to the International Broadcasting Convention being held in London, September 20-24, there is to be an international conference on automation in sound and video broadcasting and transmission networks held in Paris, October 19-21. Papers are still being invited and anyone wishing to contribute is asked to contact Mr B. Sewter, IBA Engineering Headquarters, Crawley Court, Winchester, Hampshire (Tel: Winchester 822477).

News of the Month

Traffic broadcasting demonstrated

The BBC has demonstrated the technical feasibility of its proposed m.f. single-frequency road traffic information broadcasting service to UK Government officials, police, motoring and freight organizations and receiver manufacturers. It is a "dedicated" system (separate from the existing sound broadcasting networks) with many low-power m.f. transmitters – one for each local traffic area. Using as it does only one frequency, it avoids mutual interference by time division multiplex working (for principle, see January News, p.36, and May 1973 issue).

The demonstration was based on two 250-watt RCA transmitters working on 593kHz, one at Brookmans Park, Herts, and the other at Tatsfield, Surrey, representing two adjacent local service areas in, say, an 80-station national network. Guests were taken on a trip round the north-west London suburbs in a coach fitted with a special t.r.f. receiver for the service and an ordinary car radio and cassette player. At regular intervals formal announcements (representing real traffic bulletins) from the transmitters were heard on a loudspeaker. At different parts of the route, a switch on the special t.r.f. receiver was operated automatically by signal level so that the passengers heard either the nearest ("local") transmitter or both ("local and adjacent") transmitters. Also, when the car radio or cassette programme was on continuously it was automatically interrupted when a traffic transmission occurred, ensuring that the traffic bulletins were heard. This was done, and the traffic t.r.f. receiver switched on and off, by a burst of tone transmitted before and after each bulletin which operated a decoder in the t.r.f. receiver.

The next step is for the BBC to run a full field trial using real traffic bulletins in a given district. Meanwhile the European Broadcasting Union's working party studying traffic information broadcasting has said that the v.h.f. scheme using existing sound broadcasting stations, operating in W. Germany, Austria and Switzerland (and to be tried in the Netherlands), provides a short-term answer but that a "dedicated" m.f. network as proposed by the BBC would be preferable in the long term.

Programmable record playing

To believe the BSR publicity machine, the ACD Accutrac is not only the greatest thing since sliced bread, it's supposed to rank alongside the invention of the gramophone and claims to be "... the first innovation in record reproduction since the l.p. was introduced over 30 years ago." Despite this classic overstatement, the Accutrac 4000 is certainly a novel machine, with its use of an m.o.s. chip to enable the sequence of playing tracks on an l.p. disc to be programmed at will.

Track identification is achieved with the pickup, a development from ADC's XLM cartridge, which houses an infrared source and detector responding to energy reflected from the smooth surface between bands. Band selection can be determined by a remote control unit which duplicates the push-button functions on the turntable assembly. Functions provided are clear, play, reject, cue and repeat, together with the choice of any sequence of up to 24 selections from the 13 track-selection buttons. The remote unit contains m.o.s. circuitry, whose consumption is so low that the battery is permanently connected, that sends binary-coded ultrasonic pulses at around 40kHz to a receiver which may be positioned remotely from the player.

Two motors are used in the player, a brushless d.c. direct-drive mechanism for the platter and a servo-controlled motor for operating the pickup arm, the drive being disconnected when the stylus plays a groove.

Because the controls are situated outside the lid, it can be closed as soon as a record is placed on the turntable; and the automatic feature means that the pickup arm need never be handled.

BSR, who own ADC, now produce 65% of the world's record players and changers from the U.K. at a rate of 240,000 per week. Bulk of this goes to the U.S.A. and BSR claim they now have over 50% of the Japanese market. BSR aim to produce 5000 Accutrac units per week by September, the U.S.A., Japan and Germany being the main targets. Three models will be in production, the 4000 unit costing around £300, including v.a.t. and excluding power amplifier.

Computer-assisted mixing system

With the rapid growth of multi-track recording — as many as 24 tracks being common these days — it is becoming almost impossible for the sound engineer to remember the steps he is taking during the mixdown process. After years of consultation with broadcasters, film and recording studios around the world, Rupert Neve & Company Ltd have produced NECAM, the first British computer-assisted mixing system.

Curling tongs in use with a new p.t.c. thermistor now available from Mullard. The thermistor is fitted with a high thermal capacity sleeve (inset) and is doubly insulated to make it an effective self regulating heater with no need for a thermostat.

Launched in March, the system eliminates the dull and repetitive tasks associated with multi-track recording equipment while retaining the artistic expression of the sound engineer.

NECAM reduces the real-time problem by enabling the engineer to interrupt a "take", recycle over short segments, or even operate at half tape speed, allowing the computer to "look after the joins". Many take attempts may be stored, recalled, and updated at will. The faders are servo driven and touch sensitive, providing both control and indication. A small keyboard provides fingertip control of all the functions so that segments of many take attempts may be assembled into a new take simply by computer data handling, a display at all times indicating what is happening. Although the decision functions of NECAM are stored as software in the computer memory, a floppy disc store provides a permanent record of all the takes. The system uses the internationally accepted SMPTE edit code for fixing tape transport locations.

Communications at the National Theatre

During the past three years complex audio and visual communication systems have been installed in the first two of the three theatres which form the New National Theatre at The South Bank, London. The two theatres are the 890-seat conventionally shaped Lyttleton Theatre which will concentrate on living writers' productions and the 1,160-seat Olivier Theatre which will be used for classical plays.

Basically the installations consist of a telephone exchange, ring intercom, paging systems (including radio paging), closed circuit and off-air television. Each stage manager's desk has the following facilities: low voltage effects and telephone ringing circuits; cue lights system; talkback; control of show relay and house lights; Post Office and internal telephones; two-channel c.c.t.v. monitor; stop watch, desk and script lights. The desks can be plugged into at least four different positions in each theatre. In addition each theatre has an inductive loop system available for "hearing aid" simultaneous translation. The last-mentioned can also be used in conjunction with the ring intercom system for technicians. The two theatres (the smaller Cottesloe studio theatre will be equipped in time for the official opening in June or July) have a comprehensive c.c.t.v. system providing show relay sound and vision in the many foyer areas, control rooms and offices in the building.

Japanese award for Britain

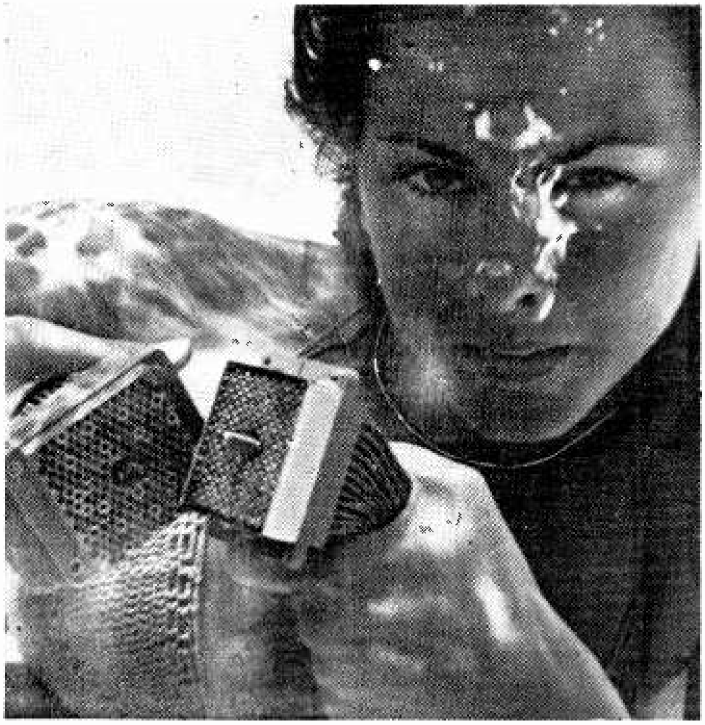
One of Britain's leading hi-fi loudspeaker manufacturers has won the Grand Prix award in the overseas products category of the 5th Japanese Stereo Components Grand Prix Contest. This is considered to be of high prestige value by Celestion who won it, particularly as the award, which is given to only one product in the entire hi-fi field each year, was gained in the face of competition from American, Scandinavian and German products.

A further award for a British product was received by Quad's 405 amplifier. The award is the "Decibel d'Honneur" made by the French audio journal Revue du Son and was presented for "unquestionable excellence of performance". What might be called a relative honour.

Flight warning system proved

A new aircraft safety system, GPWS (Ground Proximity Warning System), which should help to reduce the number of aircraft crashes into high ground and during airfield approaches on landing, was demonstrated during February. The demonstration, on an HS748 from the Royal Aircraft Establishment at Bedford, included a full test of GPWS against the Civil Aviation Authority's operating specifications. (These are curves of flight variables plotted against rate of change of height above terrain for all the varying flight modes.) Analysis of aircraft accident statistics has apparently shown that, of the 743 passenger deaths in 1975, a total of 510 were caused by situations which could have been avoided if GPWS had been in use.

The new device, developed by Plessey Aerospace at Titchfield, Hampshire, gives the pilot a verbal warning by means of a synthesized voice to "pull up" or "climb" when the aircraft is approaching a dangerous situation. Heart of the system is a small computer known as Miproc produced by Plessey Microsystems. This is claimed to have advantages over analogue systems, such as those developed in the USA, including accuracy of control, rapid re-programming capability to meet minor specification changes, and ease of maintenance. Currently, ground proximity warning systems receive information from the radar/radio altimeter, landing gear, flap selectors, ILS glidescope/localiser receivers and the barometric altimeter or air data computer.



This electrical link-up was carried out under water to demonstrate that a new connector now in production at Hughes Microelectronics Ltd's Glenrothes factory really does keep out the moisture, particularly important for airborne electronic equipment where rapid altitude variations are a major cause of seal failure through moisture intrusion.

Package radio stations

Complete national radio networks are now available in standardized modules. In March, Pye TVT Ltd, of Cambridge, launched a range of sound broadcasting units designed for national, regional and local stations. A unit consists of standard buildings fitted with studio furnishings and modular equipment to suit varying requirements. Expansion from one type of station to another is carried out simply and economically by the addition of further standard buildings and equipment. The range includes transportable and mobile stations for isolated areas and outside broadcast networks. Inter Engineering BV of Eindhoven are to handle all civil, architectural and acoustic design in addition to power and supply services. This range of equipment and services is intended, in the main, for the overseas market and it is claimed that everything needed to establish a working network is included.

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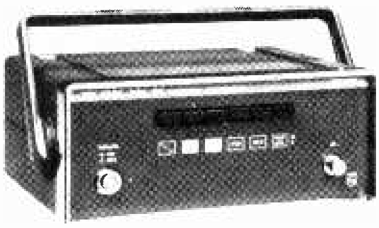

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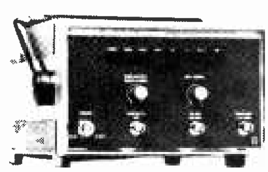

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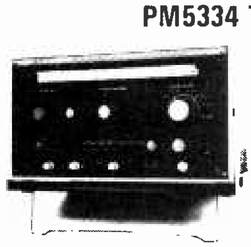

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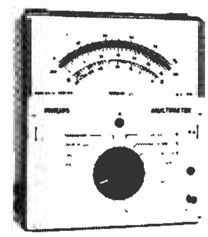

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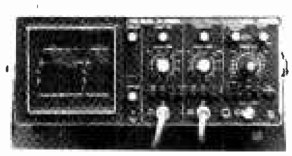

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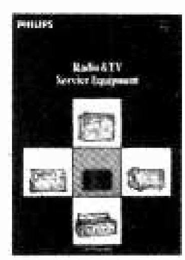

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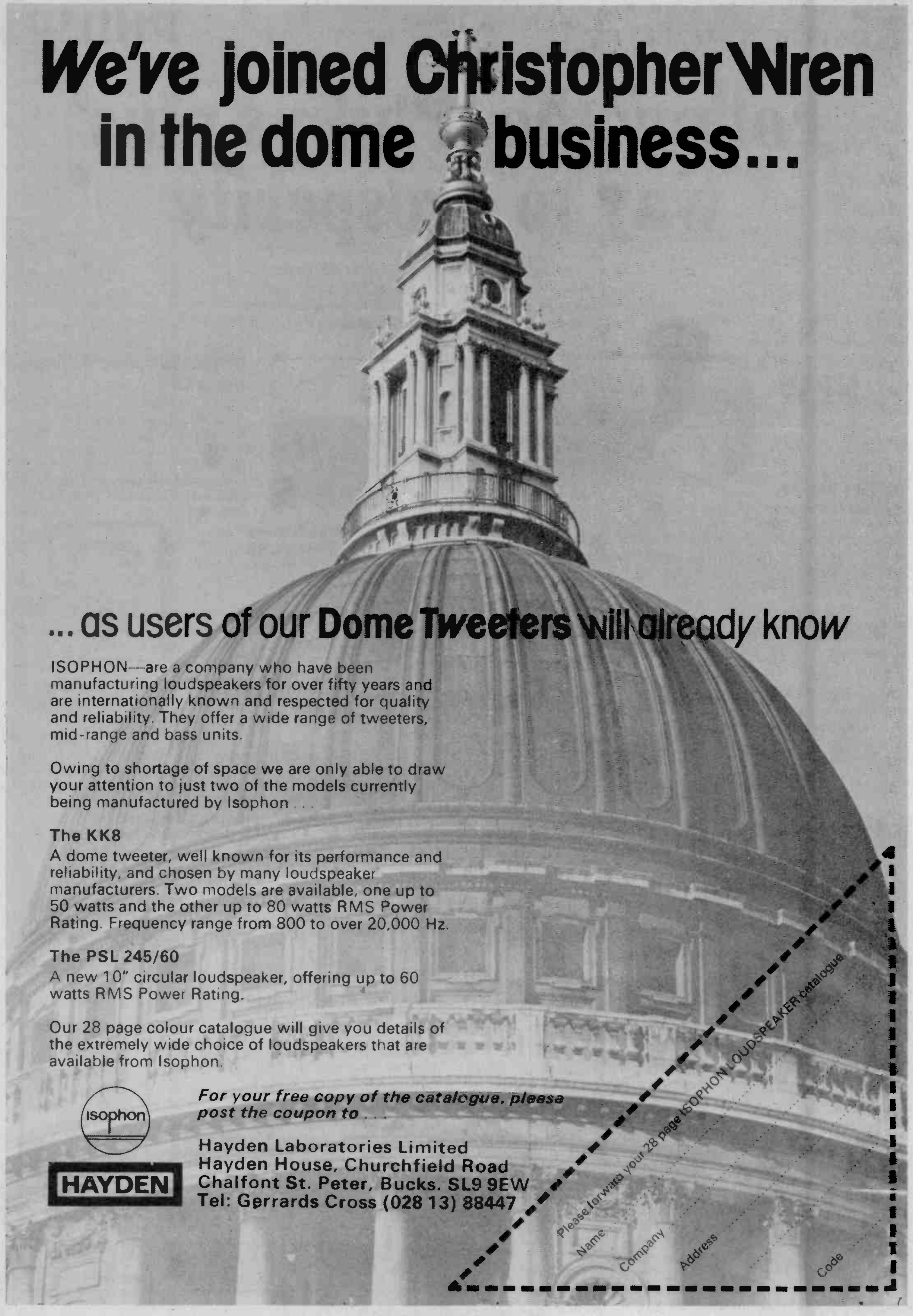
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Some factors in loudspeaker quality

by H. D. Harwood

BBC Research Department

Some of the factors in loudspeaker design have been dealt with in the technical press many times but there are others which have received comparatively little attention, at any rate quantitatively. In this article it is proposed to deal with a few of the latter and to add some subjective data which is new.

In the presentation of this material it is intended to follow the frequency scale, that is to start at the bass and work upwards.

Bass response

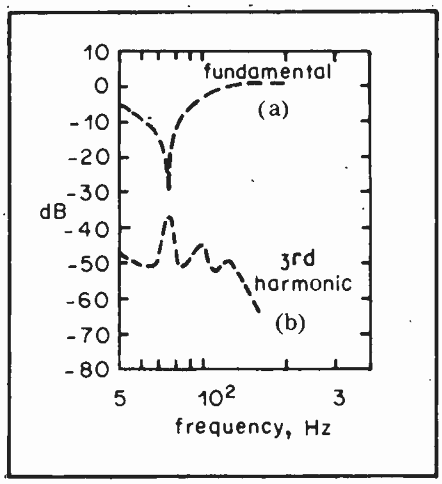
(a) **Effect of surround stiffness.** A loudspeaker is essentially a band pass device and it is well known that in a closed type of cabinet the lower cut-off frequency is set by the resonance frequency of the unit in the cabinet.

In an endeavour to obtain as extended a bass response as possible, various devices have been tried. One such is to increase the mass of the cone, but this carries with it the penalty of reduced output. Another device has been to make the combined stiffness of the spider and surround as low as possible thus allowing the cabinet volume to be the deciding factor in the effective resonance frequency[1]. The argument has been that the air stiffness is more linear than that of the spider/surround combination and that by making it the dominant factor, distortion at high sound levels is reduced [1,2,3]. This can be true at high sound levels but it will be shown here that this form of design can actually lead to increased distortion at low and medium sound levels.

Among the many functions the surround is called upon to fulfil is that of sealing the cone to the cabinet. When the cone moves backwards into the cabinet it creates a back pressure in it and this in turn attempts to drive the surround outwards, i.e. in the opposite direction to the movement of the cone. If the mechanical impedance of the surround has been made low this inverse surround excursion may be quite appreciable. Furthermore, the stiffness of most surrounds is not very linear for finite amplitudes, so that in practice under these conditions they may execute essentially a square wave and so generate a number of the higher harmonics together with the corresponding objectionable intermodulation products. It will immediately be seen that this effect is greatest at low and medium levels; at high levels the cone will drag the surround with it and the effect will be less in proportion. The worst surrounds will be those whose linearity ends abruptly, for example any type containing cloth as a reinforcing material, whereas if the surround is perfectly linear the only effect will be an appreciable loss in effective radiating area.

It will be realised that this effect also takes place in a vented cabinet where, at the vent resonance frequency, the sound pressures acting on the cone and surround will be correspondingly greater than in a closed cabinet. The only way of reducing the effect is to make the mechanical impedance of the surround high and the area low. It would be convenient to have data to show how serious the effect can be in practice but it would be difficult in a closed cabinet to prove that it was not due to the other usual forms of non-linearity, and because of awareness of this defect, this type of unit has always been avoided in the BBC. What can be done is the other extreme, to show that in a unit with a surround of high mechanical impedance the effect can be held within reasonable bounds. To make the illustration clearer a vented cabinet has been chosen so that the effect is local and easily distinguishable. Fig. 1 shows the acoustic output from an 8in unit having a free air resonance frequency of no less than 65Hz, with the microphone near the surround[4]. Curve (a) shows the fundamental together with the expected dip at the vent resonance frequency, whereas curve (b) shows the third harmonic distortion rising to a peak of 10dB at the same frequency i.e. where the excursion of the cone is least but the back pressure is greatest. Because these curves were taken at a fairly low level the distortion at other frequencies is low, and if the *total* output from the unit plus vent is assumed to be uniform at the 200 Hz level, the distortion due to the surround is not greater than about 2%. It should be stressed that this distortion is from a "good" surround – those of lower mechanical impedance would be much worse. Also for a vented cabinet design at high sound levels, the curve of the third harmonic will reverse and show an increase at the adjacent frequencies leading to a dip at the vent resonance frequency.

Fig. 1. Non-linearity distortion produced by loudspeaker unit surround at low sound levels in a vented cabinet: (a) fundamental, (b) 3rd harmonic.



(b) **Effect of total magnetic flux.** The effect of total flux on the sound output will now be considered. It is well known that if the design parameters are adjusted correctly a bass response curve like that shown schematically in Fig. 2 curve (a) is obtained. Now if it becomes necessary to increase the flux by a factor of two, curve (b) is produced. In the mass controlled and stiffness controlled areas, where the motional impedance is low, a rise in output of 6dB is produced for the same input voltage. On the other hand in the region of resonance where the motional impedance predominates, this impedance increases by four times with a corresponding decrease in driving current, and a quarter the current in a field of twice the flux gives a loss of 6dB. There is therefore a relative loss of 12dB and this has to be corrected by equalization.

Now there is another way of arriving at the desired equalization. This is to attach an accelerometer to the voice coil former and connect the output of the accelerometer to a feedback network, and for a closed cabinet this can be made to give the same result. But there is no magic about feedback and it does not change the efficiency of the unit; in essence the same operation as before is being performed, that is, equalization is being applied.

Incidentally although motional feedback is now becoming popular it is salutory to remember that in fact the idea is quite old.[5] The earliest reference known to the author is to a patent taken out by P. Voigt in January 1924. It may surprise many people who thought that negative feedback came in with Black and Nyquist ten years later, to realise that the principles and advantages of feedback were appreciated so long ago, and that they were applied to so intractable a subject as loudspeakers. There have been at least two other patents on motional feedback, one by A. Sykes in 1926 and one by M. Trouton in 1928, before the Black and Nyquist papers.

Now to return to our subject. Another method available to help the bass response is to use a vented cabinet design. This is well-known and the provision of a high acoustic load at the rear of the cone reduces the motional impedance considerably and allows a greater driving current to flow, thus improving the matching. The mechanical circuit diagram is shown in Fig. 3; the series circuit represents the loudspeaker unit and the parallel circuit the vented cabinet. Now a very simple relationship holds provided only that the impedance of the parallel circuit is high enough at resonance to swamp the remainder. Taking the series circuit first, well above resonance the circuit is mass controlled and all of the open circuit force will be applied to the cone mass which will move with a corresponding velocity. On the other hand when the impedance of the parallel circuit is dominant all the open circuit force will appear across it and in particular across the vent mass which again will move with a corresponding velocity. If then the two masses are equal we get the same output at the vent resonance frequency as in the mass controlled region of the cone. If in order to use a smaller cabinet the mass of the vent is made to be twice that of the cone, then the output at the vent resonance will be down by 6dB, and for three times the mass by 10dB. Note that nothing has been said about the two resonance frequencies.

Novak pointed out that for the particular condition where the resonance frequencies of the two circuits are equal, the relative outputs depended on the ratios of the two capacitances. Of course this follows immediately as a special case; the masses are obviously the pertinent factors. The question of ripple in the frequency response must not be overlooked of course, but the relationship is very useful when first estimating values.

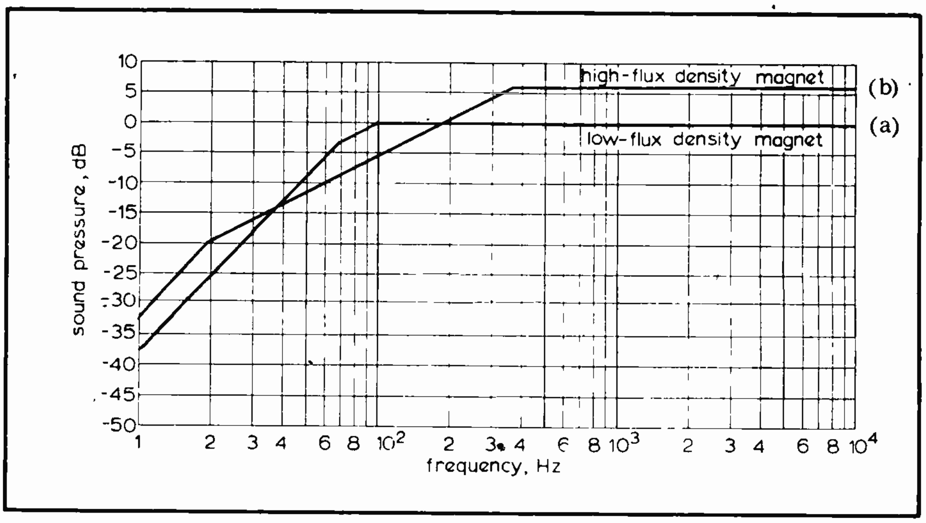


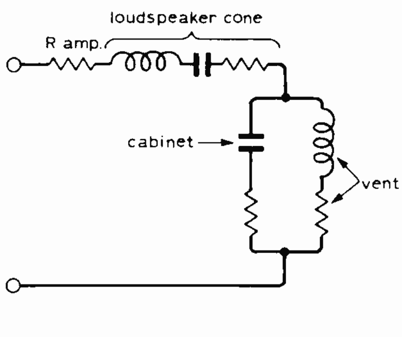
Fig. 2. Schematic curves of effect of flux on axial frequency response of a loudspeaker unit in a closed cabinet: (a) normal flux, (b) twice the flux.

Now the question arises again as to what to do if the output at the vent resonance frequency is below that in mid-band; once again equalisation is necessary.

Well what is wrong with this equalization? The answer is nothing, provided the implication is appreciated. This is that if it is desired to provide uniform sound pressure down to the cut off frequency, where 12dB of equalization was used, then 12dB more power input must be provided with all it implies, or else some distortion will be produced. If therefore it is intended to use a 50-watt amplifier for mid-band purposes then no less than 800W must be available at the bass; in addition the unit has to be capable of accepting this input without damage.

Fortunately if the input is restricted to programme the position is not quite as bad. When a high-quality monitoring loudspeaker was being designed[6] the relationship between peak programme level *overall* and the peak programme level in various octave bands in the middle and bass was examined, having the latter particularly in mind. Programmes known to have a heavy bass section were selected from classical music, pop and organ and it was found that the latter was the most demanding from this aspect. Fig. 4 shows the results of the tests. The one point at 70Hz was a solitary note from a pop group, which on the basis of statistics was ignored. It can be seen that at, say 50Hz the peak output is some way below the rest. Corresponding equalization can therefore be applied without demanding any extra power rating for the amplifier, but for any values of equalization *above* this figure the laws of nature demand a corresponding increase in available power. This aspect appears to have often been overlooked in the past.

Fig. 3. Mechanical circuit diagram of a loudspeaker unit in a vented cabinet.



Mid-band frequencies

Now let us go slightly higher up the frequency scale and consider the mid-band region.

It is well known that units become more directional as frequency increases and that to avoid excessive directional problems at least a two-unit system is normally used. If the axial frequency response curve is equalized to be flat then it is well known that the off axis curves, say, at 60° in the horizontal plane will look like the curve in Fig. 5. The off axis response is by no means uniform and on the basis of subjective tests this is undesirable, and the question arises as to what can be done about it. One simple answer is to use a three unit system, but of course, this is expensive. A cheaper solution was suggested by Chapman and Trier[7] in 1947, that is, of placing a slot over the offending unit. The idea was that sound should radiate from the slot and if the slot axis were vertical then a much better spread of sound would be obtained in the horizontal plane. It looks so simple but in practice there are a number of difficulties.

Firstly the mass of air in the slot is in series with that of the cone and will reduce the efficiency accordingly. Secondly this air mass will resonate with the stiffness of the air behind the slot and in front of the cone, and a local increase in sound output will be produced. Thirdly above this frequency the acoustic circuit will act as a single-section low-pass filter and the output will be severely reduced. The magnitude and frequency of these various effects will depend, among others, on the width of the slot, and successful design depends on achieving an optimum result for any one unit. One rather unexpected result is that in addition to an improvement in the horizontal directivity there is also a small improvement in the vertical plane.

The directivity in the horizontal plane would appear to be a simple function of the slot width but in the process of carrying out various designs the author has found that this is not so. Finally in the design[6] of the BBC LS5/5 loudspeaker it was decided to investigate the problem a little more closely. A 12in bass unit was being used with two possible alternative designs, one with the bass unit crossing over at 400Hz, the other with a crossover at 1500Hz. For the latter it appeared that a slit of 100 mm would give adequate directivity. Now it is a little difficult to estimate just what the radiation pattern from the slit will be. For example is the slit to be regarded as a line source, or as a piston in an infinite plane, or alternatively as a piston in the end of a cylinder, all possibilities for which the radiation pattern is known and for which the radiation, at say 60° relative to that on the axis, can be calculated from formulae of varying degrees of complexity. If all these assumptions are valid it would be expected that the answers would be similar, at least for small ratios of slit width to wavelength, and indeed this is so as shown in Fig. 6. It can be seen that for small values of d/λ the curves (a), (b) and (c) agree quite well, and for the value of d/λ of 0.3 chosen, the 60° response should be within about one to two dB of that on axis. In practice this was by no means obtained; curve(d) shows the measured results and the discrepancy is gross. The question arose as to whether the slit was uniformly "illuminated", and going to an extreme, if all the sound were concentrated at the two edges the radiation pattern would obviously be different, and calculation gives curve (e) which is in better agreement with curve (d). However a quick test with a probe microphone showed that this energy distribution was not followed, in fact the sound pressure at the centre was slightly higher than that at the edges. In desperation the problem was then worked backwards and the apparent width of the source calculated; it turned out to be exactly the width of the cabinet for values of d/λ up to 0.7; the points are plotted as (f). It is now clear what is happening; the slit is indeed working as expected but because of this, sound energy flows along the front of the cabinet until it meets the discontinuity at the edges and is then re-radiated. The obvious moral is, to make the front of the cabinet as narrow as possible. As pointed out elsewhere[8] by the author this solution has other advantages from the aspect of structural resonances in the cabinet walls.

Above the frequency quoted, the slit tends to radiate on its own as shown by curve (d) approaching the calculated curves, but only for a short while, it then becomes more directional again. Neither is this the end. In the loudspeaker design mentioned the same slit width is used over the bass and middle frequency units in, of course, the same width cabinet. It might therefore reasonably be expected that the directivities of the two sources would be the same, but they are not. The radiation from the 8in middle frequency unit has a wider beam than that from the 12in bass unit. Time has not permitted the problem to be investigated further but it is clear that in practice the performance of slits is not as simple as would appear at first sight.

High frequencies

Let us continue this question of directivity but now include the high frequences. It has often been suggested in the literature that the variation of the spherical response with frequency is the most important feature of a loudspeaker. Methods of measuring this include the use of a reverberation chamber, measuring the polar response at various angles and frequencies in a free field room and calculating the result, and finally a method developed at the BBC by Gee[9] which uses an integrating meter to give a direct answer at any frequency or band of frequencies. The first method is limited in that it requires a room much larger than one to ISO standards to ensure adequate diffusion at the bass. The second method is rigorous if sufficient measurements are taken and if the free field room is adequately large[10], by no means always the case. It is however extremely laborious and time consuming, and is rarely used. The third method also relies on an adequate size free field room but is quite rapid. It has moreover the advantage over the first method that it is possible to weight sound coming from differing directions, e.g. sound from the front hemisphere relative to that from the rear.

This raises the whole question of what we are trying to measure and why. In the BBC the spherical response of a number of loudspeakers has been measured and efforts made to correlate it with sound quality in a live room, but with very little result.

When for example we listen in a room of normal reverberation time to a rather directional loudspeaker on its axis, it is common experience that the sound quality does not change drastically when in the near or reverberant sound field. On the other hand if we were really listening simply to the sound pressure at these two points then the direct response and the spherical response would indeed be the determining factors. Furthermore a similar factor must be involved in the fact that with such a loudspeaker in a live room the directional properties are clearly audible even when listening well into the reverberant field.

These experiences indicate clearly that the spherical response is not the predominating factor in determining sound quality under live listening conditions and to check this a formal experiment was carried out at BBC Research Department. A monitoring loudspeaker was taken having three units and representing as omnidirectional a device as was possessed at the time, and for comparison an 8in wide range unit representing as directional a device as was likely to be met. Listening on axis in a free field room and using

Fig. 4. Peak spectrum (octave bands) of middle and bass for various types of programme.

Fig. 5. Schematic frequency response of two unit loudspeaker; on axis and at 60° in horizontal plane.

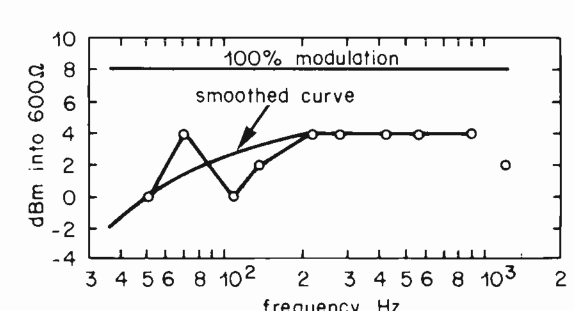


Fig. 4

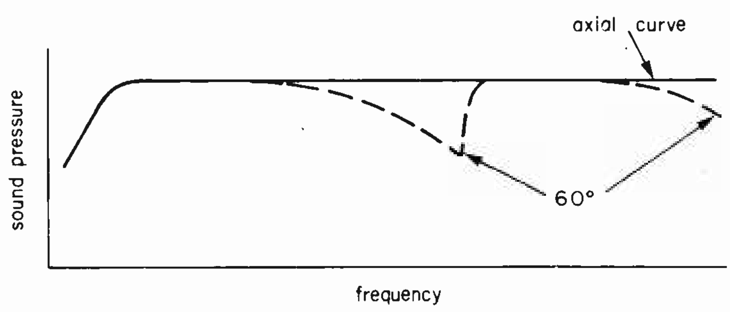


Fig. 5

speech and a team of experienced observers, the two were equalized by ear to sound as closely similar as possible. They were then transferred to a listening room well away from the walls; the room had a reverberation time of about 0.4s, and the loudspeakers were again compared, listening on the axis. The results in the two conditions were almost identical within the experimental error, although a small change towards the known spherical performance could be discerned but not guaranteed. The conclusion therefore was that it is essentially the direct sound which determines the sound quality and not the spherical response. The measurement of frequency response at various angles in a free-field room is therefore a much better indication of performance than the spherical response even when listening in the reverberant field, and this has been confirmed by careful listening tests many times since.

The question still arises however as to what is the optimum delivery and here a look at history is useful.

At one end of the scale, a loudspeaker developed by Harz and Kosters of NWDR[11] in 1957 used a bass unit facing upwards, and a middle and high requency cluster of no less than 32 units mounted on the surface of a sphere. This resulted in a very close approximation to an omnidirectional loudspeaker and gave a pleasant spacious image on orchestra. However, when an announcer spoke it sounded as if his mouth were six feet wide.

This design has been followed by another German design much more modest in outlook in which units are only mounted in the sides and front, none in the rear; in this design even the side facing units can be switched off leaving only the front ones, so it looks as though our experience was that of others too.

In the BBC we have gradually progressed from the opposite direction. The first loudspeakers were single cone wide-range devices which were very directional in the treble, and subsequent multi-unit designs have all tended to increase the angle of radiation at high frequencies and this has been approved by users. Of course over the years stereo has been introduced and this has involved other factors. For the last high quality loudspeaker designed in Research Dept. there were some vague suggestions that the angle of radiation might be too wide for stereo. Fig. 7 shows the axial and off-axis curves for the loudspeaker concerned. (For this discussion the bass cut should be ignored, and is due to the fact that the free interior volume of the cabinet is only 1/6 cu. ft.) It may well be therefore that any loudspeakers more omnidirectional than this will fail to provide first-quality stereo. In this discussion it has been assumed, of course, that a sharp stereo image is regarded as essential; these comments are not applicable where the stereo image is made rather diffuse over the whole seating area.

The next point to be discussed is the question of optimum axial frequency response. This question is not concerned with how wide a frequency range should be covered, but what shape the response curve should be. First of all the underlying assumption must be clearly stated. This is that both the microphone and all associated amplifiers have a uniform frequency response. The usual conclusion is that the loudspeaker should also have a uniform axial frequency response but this is precisely what is being challenged. Not even in stereo reproduction are the sound wave-fronts produced in a listening room similar to those heard in the studio or concert hall and it therefore seems clear that if by "bending" the axial response curve of the loudspeaker a more realistic psychological impression is obtained, then this is entirely justified. Thus, for example, if a uniform output is maintained at all frequencies an orchestra sounds extremely close.

This condition is quite unnatural and a much better sense of perspective is obtained if a slight dip in the 1 to 3kHz region is applied. About 2dB is sufficient to provide the more distant perspective without destroying the sound quality. It may well be that as techniques progress other such tricks will follow. All that is intended at this stage is to get away from the rigid idea that a uniform axial response is necessarily the best.

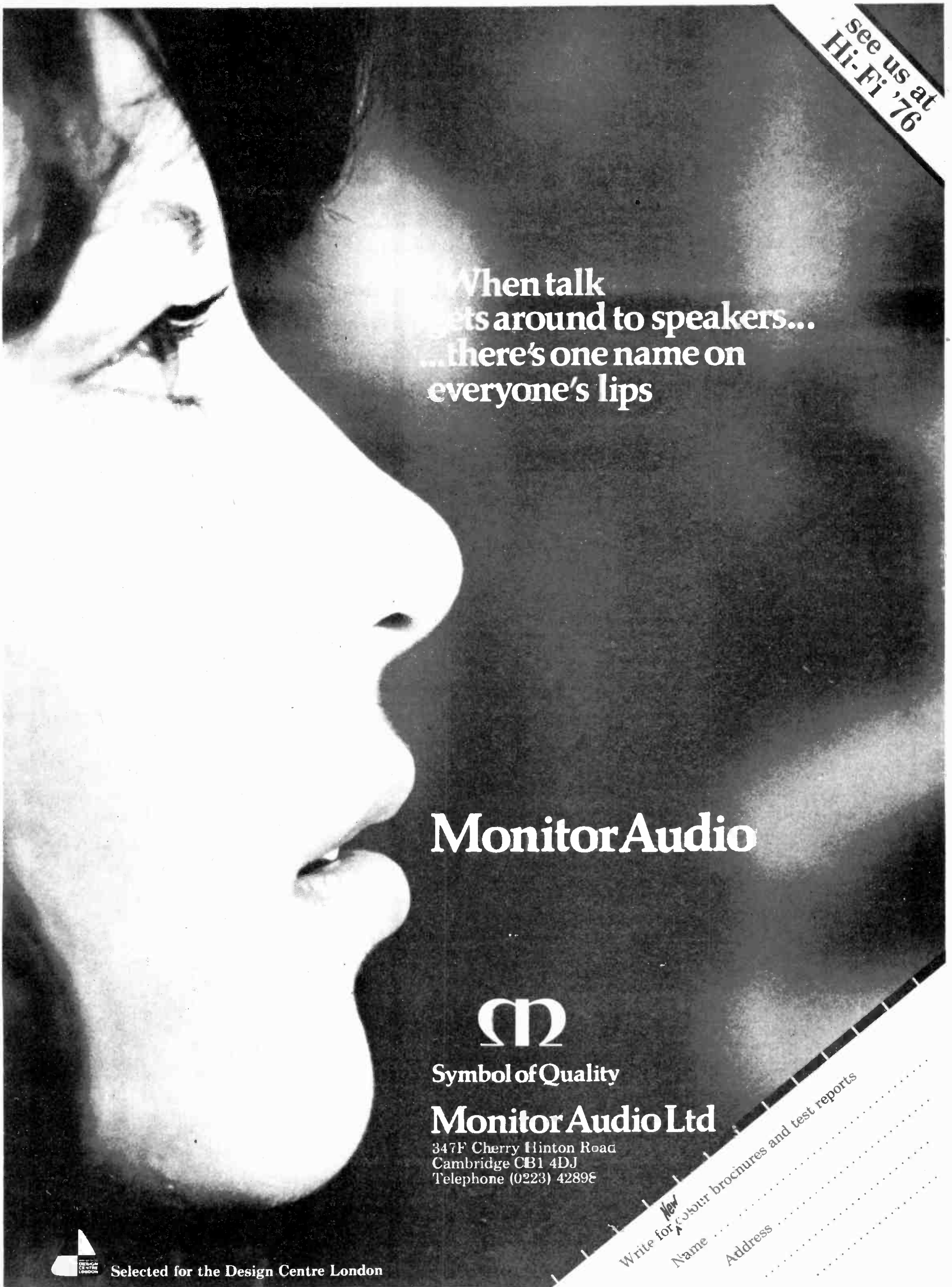
So far general trends have been discussed and it has been assumed that perfect units were available. As all designers know this is far from the truth and the question arises as to how far departures from the ideal can be made without perceptibly degrading the sound quality. This is also important from the aspect of listening in rooms which after all is where most listening is done. It has been shown that it is the direct sound from a loudspeaker that is predominant, but of course if a loudspeaker is close to a wall, then the near images may form part of the "direct" sound and will produce irregularities in response.

The loudspeaker can be regarded for this purpose as a two channel device with the two channels in parallel. To start with let us examine the case where the main channel has a uniform response and the other has a resonant circuit of variable Q (narrower than a critical band) whose output at resonance adds to that of the main channel and whose amplitude relative to it can be varied. The varying degrees of audibility at different frequencies and for differing Q has been established for pink noise in the form of the relative levels for the peak of the resonance and in the main channel. Now for *loudness* the energy in the critical band is summed and it appears as though this relation roughly holds too for degrees of colouration. Only roughly, for the actual law varies with the degree of colouration itself as shown in Fig. 8. It will be seen from this figure that there is a regular variation in the law with the degree of perception. The law for the "just perceptible" condition is close to the power law and the curve marked "definitely perceptible" is at about the limit of perceptibility for *programme* and is therefore the one we are most interested in. Note that the horizontal axis is not Q but reverberation time and that the vertical axis is dilution. This variation in law with perceptibility is in accordance with the findings of Kryter and Pearsons[12] in relation to the noisiness of a tone in noise and they also show that as the ratio of tone increases the noisiness increases faster than the total r.m.s. value of the critical band concerned. The general slope shown in the figure is confirmed in subsequent work by Moulana. The height of the corresponding irregularity in frequency response is shown in Fig. 9 for the "definitely perceptible" condition.

When narrow peaks are subtracted from the main channel, conditions are very different. Whereas for additive peaks the just perceptible condition was approached, as the amplitude was reduced, slowly and rather indefinitely, for the subtractive condition the colouration suddenly disappeared and it was immediately evident that a cancellation was taking place. This effect was, as would be expected, shown up in the standard deviation of the results; in one case the test team even returned the ultimate of zero spread. The implication of this effect is extremely important as it shows clearly that the subjects were in fact listening to the steady state condition; for it is evident that the time function could not be cancelled in this way. This is a very important distinction, as much earlier unpublished work by the author and supported by other unpublished work also at the BBC by Gilford[13] has shown an anomaly, namely that under certain conditions, which are not at all clear, the law of dilution with Q for a given perceptibility can go in precisely the opposite direction, that is the higher the Q the more obvious is the colouration. It seems highly likely that in these latter conditions it is the time function which is being observed.

Fig. 10 shows the height of an irregularity for a subtractive peak for the "definitely perceptible" condition which again closely corresponds with the "just perceptible" condition for programme. The curve is very different from the additive condition and the results are more nearly like the audibility of tone in wide band noise. In both cases given here dilution appears to be the fundamental factor rather

Continued on page 51



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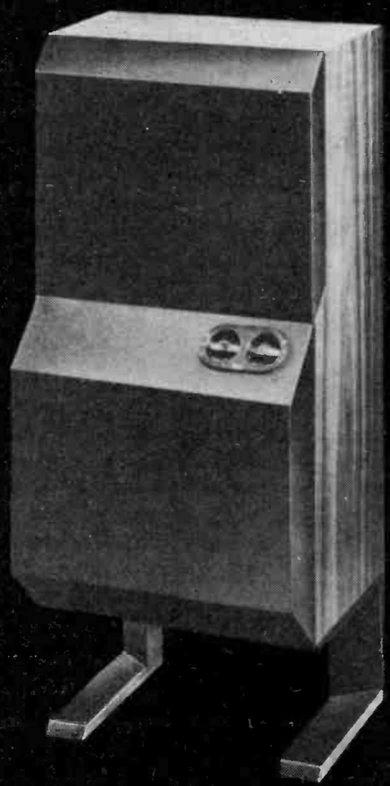

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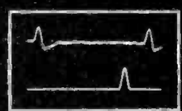

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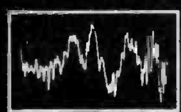
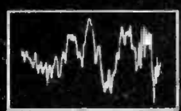


Output from amplifier



Output from measurement microphone 3m from DM6

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than height of irregularity and the unfortunate conclusion is arrived at that even for the steady state condition the audibility of a narrow peak cannot be assessed unless the relative polarity is also known.

Now the question arises as to what happens outside the critical bandwidth. The loudness function is known to be different and this might also apply to colouration. The audibility of a resonant circuit with a Q of about 3, i.e. roughly ⅓ octave wide was examined for various frequencies of resonance using *programme* designed to be critical over the frequency band being tested. The results are given in Fig. 11 which shows the height of the peak for the just perceptible condition. During these tests, after first identifying the frequency of colouration, the subject was permitted to switch the resonance in and out of the circuit and to reduce the height of the peak until it was only just audible. Under these conditions the height of the peak is roughly independent of frequency except at the bass. Here we are, of course, inside the critical bandwidth, but this does not seem to be the essential factor, as experiments with octave bandwidth circuits show a similar shape curve. The standard error for the points in this curve is roughly ½dB.

If two contiguous circuits are used to form a plateau of twice the bandwidth, centred around a mid-band frequency, a "just perceptible height of 2.6dB is obtained and if the bandwidth is doubled again using four contiguous peaks a just perceptible height of 1.8dB is obtained. It is clear that some form of summation is taking place and extrapolation suggests a minimum audible level for wide band signal of about 1dB. However it is equally clear that, from the point of view of sound quality, this summation does not proceed indefinitely as it does with loudness. To take an extreme example if the entire range is raised by 10dB there is a large change in loudness but, by definition, none in sound quality. Furthermore if the entire spectrum except for the lowest ⅓ octave were raised the effect would not be described as an excess in most of the range but as a deficiency in the bass. One point to be noted was that even with the wide pleateau used, i.e. 1⅓ octaves wide, only one frequency of colouration was heard.

It has been seen that some form of summation is taking place over quite a wide frequency band and it is therefore pertinent to enquire how far apart two peaks must be before they are audible as separate entities.

For this test the same resonant peaks with a Q of 3 were used as before. The observer was instructed to increase the height of the peak at the reference frequency until the colouration was *clearly audible*. Successive peaks were then raised and lowered at one third octave intervals, to a height deemed by the observer to give maximum discrimination, until the frequencies of colouration of the two peaks were separately discernible; once again programme was used appropriate to the frequency range being covered. The results were quite astonishing; the mean values for the team of observers are given in Table 1.

Table 1

Ref frequency (Hz)	125	250	500	1k	2k	4k
Minimum distance apart of peaks, in octaves	1.5	1.3	1.3	1.1	1.1	1.0
Standard error of mean, in octaves	0.08	0.11	0.11	0.13	0.08	zero

The variation with frequency is interesting and may be due to the nature of programme spectrum. It will be appreciated that as the frequency increases the detailed structure of the spectrum becomes more and more random until at high frequencies it is not far removed from modulated random noise. The figure of one octave obtained in this part of the spectrum approaches the corresponding value which is obtained using pink noise as a source, instead of programme.

The remarkable result in Table 1 may possibly be the key to a number of previously unexplained phenomena. For example does it indicate why the irregularities in the sound field of a live room are not separately audible?

However, one conclusion is clear; if the loudspeaker contains a number of low Q resonances spaced closer together than one octave and covering the whole frequency range they should be inaudible. When a test was actually made of a series of peaks at intervals of ⅔rd octave at a level of 6dB above the base line, using a critical material such as speech it was found that they were in fact inaudible even on an A/B test. The conclusion is therefore correct, and the frequency response of such a characteristic is shown in Fig. 12.

If however the peaks are increased to a level of say 15dB, the sound becomes extremely coloured and it is evident from the character of the sound that a regular series is being heard. (The comment about irregularities in a room must include, therefore, the proviso that the frequency spacing is also irregular.) It should be noted however that the series being used is a logarithmic one not an arithmetic one and that the bandwidth of each peak is also a logarithmic function; however the ear still detects it as a regular series. The question therefore arises as to what constitutes a regular series, regular on what scale? Examples of series in loudspeakers include mis-terminated horns, a loudspeaker spaced away from one wall, a folded corner horn and a labyrinth.

If a frequency characteristic is listened to which is uniform up to 1kHz followed by the logarithmic series mentioned above, somewhat imitating a horn, the "fundamental" heard is clearly the lowest peak, in spite of the ⅔ octave spacing. It will be noticed however that the upper terms of the series are relatively inaudible and this prompts the question as to how many terms of a series are necessary to give this peculiar sound quality; experiment gives the answer of only three or four terms. If however the low end of the frequency scale has this series starting at 40Hz finishing at 500Hz and of uniform response thereafter, the position is now reversed. The most prominent colouration is at 500Hz and the lower, so to speak "fundamental," frequencies are relatively inaudible. What then constitutes the "fundamental" of the series? Now let us go further, if a complete series starting at 40Hz and finishing at 20kHz is listened to, using pink noise for convenience, it is found that on a high quality loudspeaker the main colouration is in the 600 to 800Hz region, no less than 15 times the "fundamental"!

Now how is a series detected? One obvious answer is by means of a scanning technique, and it would appear from the examples quoted above as if the scanning may work in both directions, from the bass upwards in frequency and from the treble down e.g. a triangular wave form. It follows that if there is a scanning mechanism, there also exists a corresponding time series, and it might be expected that this also would give rise to peculiar effects, and this is found to be correct. To take a well known example; if a person claps his hands under a bridge with the arches, say, 100ft apart, a series of pulses with a repetition frequency of about 10Hz is produced, nearly an octave below the lowest frequency we can hear. But what in fact is heard is a noise like a "twang," with a spectrum centred around, say, 1500Hz; no less than 150 times the fundamental! Nor is this an isolated example. In one studio in the BBC, under certain conditions the sound quality could, before remedial action was taken, become very hard. Reverberation time measurements give no clue to this effect at all. On one occasion however the audience balcony, which was rarely used, was entered, and on clapping, a flutter of less than 10Hz frequency was heard, and the connection was appreciated. That studio was being modelled[14] at the time and measures were taken to remove the flutter in the model. When corresponding modifications were carried out in the real studio the hard quality disappeared.

As a final example, in a sound control

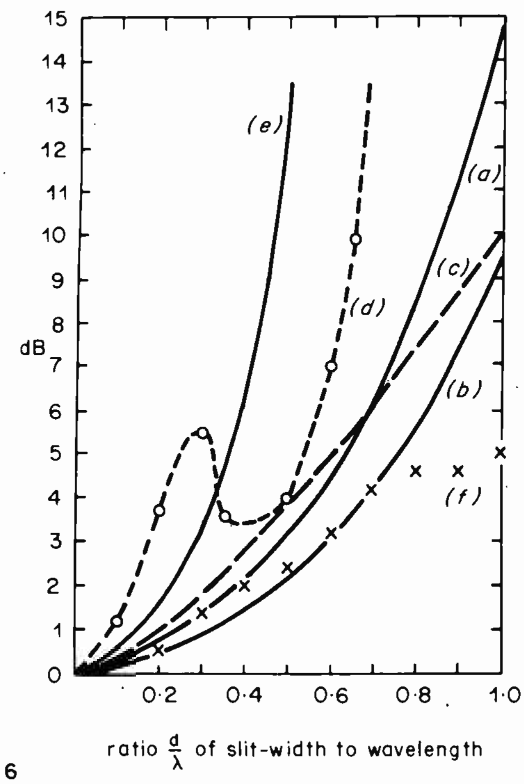

Fig. 6

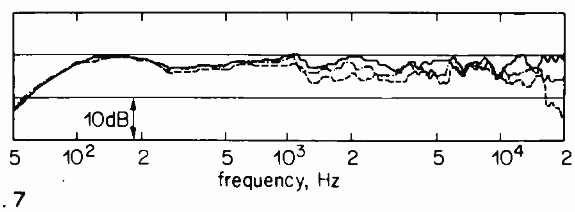

Fig. 7

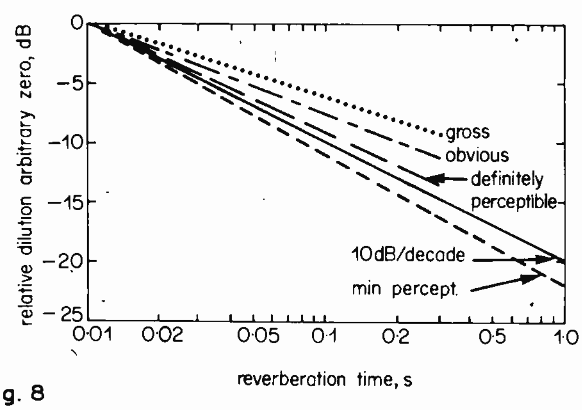

Fig. 8

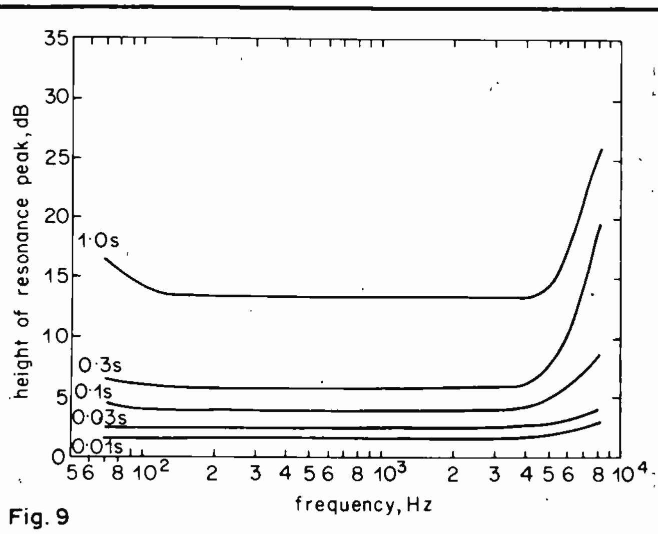

Fig. 9

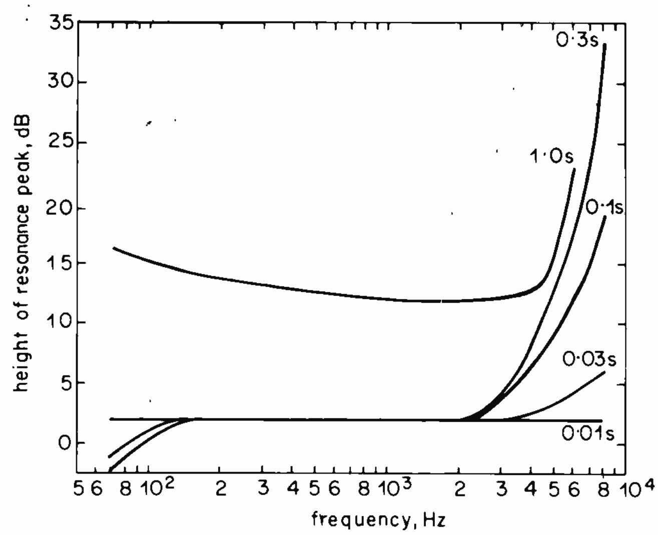

Fig. 10

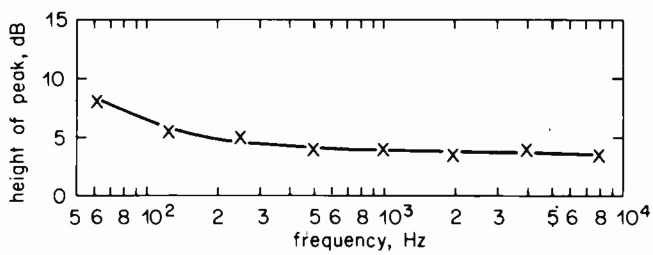

Fig. 11

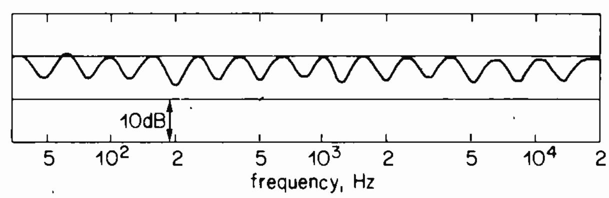

Fig. 12

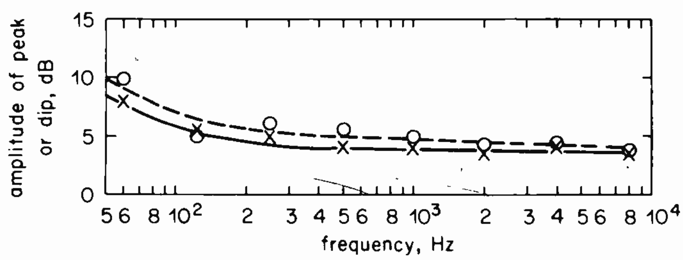

Fig. 13

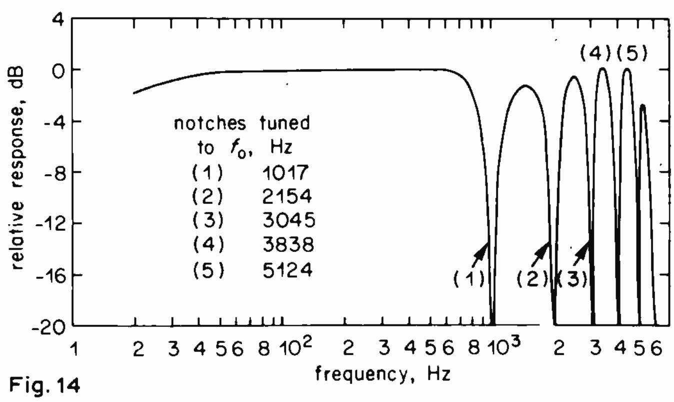

Fig. 14

room attached to one of the television studios a loudspeaker was suspended near a corner, and complaints were made of the sound quality. It was clear from a visit that the quality was indeed very peculiar and "tunnelly"; moreover, it varied considerably throughout the room. To check that it was not caused by the loudspeaker itself, this was lowered to the floor and it was shown that there the sound quality was quite satisfactory. A frequency response curve was taken with the loudspeaker back in place, taking precautions to eliminate as much of the reverberant field as possible. This curve showed definite evidence of a series. The loudspeaker was then lowered 35cm to try and break the series and a further measured curve showed that this had been successful. Under these conditions the sound quality was completely satisfactory and also now reasonably uniform through the room.[15]

To sum up, it is not at all clear how to define a series; it appears that it can be regular in hertz or octaves, but what about mels, and how regular is regular? Clearly however series should be avoided at all costs as there are no means of knowing in what part of the spectrum the subjective effect will occur.

Dips

It is now necessary to consider the effects of dips in the response curve on their own. It would be expected from perturbation theory that unless the hearing system is highly non-linear the magnitudes of dips would be similar to that of peaks, for the just perceptible conditions. Experiments were carried out to determine the just perceptible values for Qs of 3 as for peaks, except that the in/out switch was not used; the reason for this will be discussed later. The results are given in Fig. 13 together with the corresponding values for peaks. It will be seen that the two sets of values are closely similar, such differences as there are being in the direction that general experience would indicate. The depth for two contiguous dips forming a trough in the midband was 3.8dB, and for four contiguous dips was 2.5dB, again both slightly greater values than for the corresponding plateaux.

However, when the experiments with the four continguous dips were being carried out a further effect was noticed which had not been observed before. Particularly when the trough was clearly audible, in addition to the effect of the dip, the high frequency recovery to normal level was also clearly audible. Experiments to determine the narrowest trough for which this effect was noticeable gave a result of 1⅓ octaves exactly the same value as obtained for the minimum distance apart of two peaks for this part of the spectrum. The question arises as to whether this mythical scanning mechanism is again responsible, having the slow decay time we have postulated, a certain bandwidth for the trough being necessary before the fall is great enough to be audible. Furthermore a fast rise time was also suggested and under these conditions it is not surprising that two peaks should give the same separation as a trough.

Now this matter can be taken a little further; if the upper recovery in frequency response of the trough is removed completely so that instead of having a trough there is merely a step, it might be expected that the decay of the scanning mechanism should still register, and it does. Under these conditions the audibility of the spectrum near the step is definitely reduced whilst that somewhat higher in frequency appears to stand out in excess. This latter effect is not a new discovery, it has been known for at least 30 years and was a common feature in early single unit loudspeakers where it was known by the delightfully descriptive name of "disembodied top" as the upper end of the spectrum appeared to be separated from the main body by a gap.

Now narrow crevasses must be examined. It has often been stated that narrow crevasses are inaudible but it depends on the exact frequency of the dip. For example if it falls on the fundamental of a musical instrument the result can be disastrous. However, Professor Hill, formerly of the BBC Research Department, has shown[16] that if the frequency of the crevasse is offset by about a quarter tone from a fundamental, a narrow crevasse can indeed be almost inaudible. Figure 14 shows one extreme example he tested. The high frequency cut off of 6kHz was imposed for other reasons, and the frequencies of the crevasses are not simple multiples of one another. This appalling looking response was tested on subjects using as test material, male speech, piano music and dance music. The subjective mean grading in each case, where one unit represented "slightly worse than the standard" which also had a 6kHz cut off, was 0.6 for speech, 0.8 for music and an *improvement* of 0.3 for dance music; obviously the overall effect was quite small.

A/B testing

Now the alarming fact is that A/B testing may under certain circumstances give rise to completely wrong results when comparing the sound quality of two loudspeakers. If pink noise is used as a convenient source, and a deep narrow crevasse produced in it, it has been shown that the effect will be almost inaudible. If this is listened to for, say, half a minute as if programme were being used to judge a loudspeaker, and then the crevasse is switched out so that a uniform spectrum is produced, the ear will hear a strong colouration at the frequency of the crevasse. It seems that there are two mechanisms at work; the conscious one ignores the crevasse but the subconscious one detects it clearly. When the uniform condition is suddenly heard the subconscious mechanism comes forward and points out that there is now a considerable amount more sound energy at the frequency of the crevasse, and as that condition had been accepted as satisfactory the only conclusion to be reached is that there is now an excess in this region and that the sound must now be highly coloured. Transferring this to loudspeakers it is implied that if one with a crevasse is first listened to then it will probably appear that one with a uniform response is coloured.

Conclusions

There is a real danger of making loudspeaker unit surrounds too compliant as this can give rise to non-linearity distortion of high orders at quite low levels.

Equalization at the bass under whatever name it is called must be applied with full regard for associated power requirements or distortion may occur.

To obtain uniform response at various angles in the mid-band region a narrow-fronted cabinet is called for. Slits can be very useful but their action is obviously considerably more complex than appears at first sight.

The sound quality of a loudspeaker is determined much more by the direct response at any given angle than by the spherical integrated response, and at any rate for stereophonic purposes there may well be a degree of omnidirectionality beyond which it is inadvisable to go.

Fig. 6. Directivity of a slit; response at 60° relative to that on axis.
Fig. 7. Frequency response of a miniature loudspeaker at various angles to axis.
Fig. 8. Variation of law of addition with subjective degree of colouration.
Fig. 9. Height of irregularities due to additive peaks for a definitely perceptible condition, using pink noise.
Fig. 10. Height of irregularities due to substractive peaks for definitely perceptible condition, using pink noise.
Fig. 11. Height of irregularities due to additive peaks having a Q of 3 when listened to one at a time; for just audible condition, using critical programme.
Fig. 12. Response curve showing nature of inaudible irregularities when listened to together.
Fig. 13. Height of irregularities due to dips in response for a Q of 3 when listened to one at a time, for just audible condition, using critical programme; curve of Fig. 11 added for comparison.
Fig. 14. Frequency response of transmission chain used by Prof. Hill.

A plea is made for non-uniform axial frequency response insofar as it assists greatest realism overall.

Additive narrow peaks in response appear to add up on a roughly r.m.s. basis but subtractive ones appear to obey a different law. Dilution of the peaks relative to the main channel appears to be the fundamental factor rather than height of irregularity. Wider peaks of the same relative polarity add upon a rather different basis and the frequency discrimination for colourations is astonishingly poor.

Series are not yet fully understood, but the indications are that they should be avoided at all costs.

Dips in response appear to have little or no effect on contiguous peaks either inside the critical band or outside it.

Isolated dips obey similar laws to peaks, and narrow crevasses can be inaudible if they avoid fundamentals.

A/B tests of sound quality are found to have pitfalls and appropriate measures should be taken where necessary as have been indicated.

In a number of these phenomena there is a suggestion that a scanning mechanism may be at work and that it may operate in both directions, i.e. from the bass up and from the treble zone. This could also account for the fact that if a step in the response curve is produced the corner of the step is always audible whether the step is up or down. This suggestion immediately raises the questions of what is the scanning repetition rate, is the scanning linear and if so on what scale, hertz, octaves or mels, and what are the rise and decay times?

Finally it should be appreciated that only a few of the effects which go to make up sound quality have been mentioned but all these effects appear to be used simultaneously.

The views expressed here are based on experience within the BBC. Some of the conclusions are drawn from limited evidence and not all engineers within the BBC would necessarily agree with all of them. It spite of all that has been said, in the final decision, a good loudspeaker remains a matter of personal choice. However, experiment and analysis help us to make this choice.

Thanks to my colleagues for bearing so patiently in the experiments and to the Director of Engineering of the BBC for permission to publish.

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The following list of manufacturers and their addresses is not a definitive guide to producers of high quality loudspeakers but is provided by *Wireless World* as a help to readers.

Manufacturers

Acoustical Manufacturing Co. Ltd, St. Peter's Road, Huntingdon, PE18 7DB.
Acoustic Research International, High St., Houghton Regis, Beds. LL15 5QJ.
Altec Sound Products Ltd, 17 Park Place, Stevenage, Herts.
Bang & Olufsen (UK) Ltd, Eastbrook Road, Gloucester GL4 7DE.
Bose (UK) Ltd, Milton Regis, Sittingbourne, Kent.
B & W Electronics, Meadow Road, Worthing, Sussex, BN13 1QA.
Cambridge Audio Ltd, Lamb House, Church Street, London W4 2PB.
Cerwin Vega (UK), 281 Balmoral Drive, Hayes, Middx.
Celestion, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP.
Chartwell Electro Acoustics Ltd, Alric Avenue, London N.W.10.
Eagle International, Heather Park Drive, Wembley, Middlesex HA0 1SU.
Gale Electronics & Design Ltd, 39 Upper Brook Street, London W1Y 1PE.
Goodmans Loudspeakers Ltd, Downley Road, Havant, Hampshire PO9 2NL.
Griffin, H. K. & Co. (Electronics), Siddons Factory Estate, Howard Street, West Bromwich, Staffs.
Gulton Europe Ltd, The Hyde, Brighton, Sussex BN2 4JU.
Hayden Laboratories Ltd, Hayden House, 17 Chesham Road, Amersham, Bucks HP6 5AG.
Hitachi Sales (UK) Ltd, Hitachi House, Station Road, Hayes, Middx. UB3 4DR.
IMF Electronics Ltd, Westbourne Street, High Wycombe, Bucks.
Jordan-Watts Ltd, Benlow Works, Silverdale Road, Hayes, Middlesex UB3 3BW.
KEF Electronics Ltd, Tovil, Maidstone, Kent ME15 6QP.
Lansing, James B., C. E. Hammond & Co. Ltd, Lamb House, Church Street, London W4 2PB.
Leak, Rank Radio International Ltd, P.O. Box 596, Power Road, Chiswick, London W4 5PW.
Lecson Audio Ltd, Burrel Road, St. Ives, Hunts PE17 4LE.
Lowther Acoustics Ltd, St. Mark's Road, Bromley, Kent BR2 9HQ.
Macinnes Laboratories Ltd, Stonnam, Stowmarket, Suffolk, IP14 5LB.
Marantz, Pyser Ltd, Fircroft Way, Edenbridge, Kent TN8 6HA.
Millbank Electronics Group, Bellbrook Estate, Uckfield, Sussex, TN22 1PS.
Monitor Audio, 347 Cherry Hinton Road, Cambridge CB1 4DJ.
Mordaunt-Short Ltd, Durford Mill, Petersfield, Hampshire, GU31 5BB.
Nordmende, H. Vesshof & Co. Ltd, Unit 4, Blackwater Way, Ash Road, Aldershot, Hants GU12 4DL.
Omal Group Ltd, Omal House, North Circular Road, London NW10 7UF.
Philips Electrical Ltd, Century House, Shaftesbury Av., London WC2H 8AS.
Photax (London) Ltd, Hampden Park, Eastbourne, Sussex.
Pioneer, Shriro (UK) Ltd, Shriro House, The Ridgeway, Iver, Bucks SL0 9JL.
Quad, Acoustical Manufacturing Co. Ltd, St. Peter's Road, Huntingdon, PE18 7DB.
Quasar, Quasar Division, Precision Centre, Heather Park Drive, Wembley, HA0 1SU.
Radford Audio Ltd, Ashton Vale Road, Bristol, BS3 2HZ.
Rank Audio Products Ltd, P.O. Box 70, Brentford, Middx.
Regent Acoustics, Carrington House, 130 Regent Street, London W1R 6BR.
Sansui, Vernitron Ltd, Thornhill, Southampton SO9 5QF.
SMC, Monitor Distribution Co. Ltd, 76 Bedford Road, Kempston, Beds, MK42 8BB.
Sonab Ltd, P.O. Box 4, Oldfield Road, Hampton, Middlesex, TW12 2HN.
Spendor Audio Systems Ltd, Unit 12, Station Road Industrial Estate, Hailsham, Sussex.
Stereostage, Nucleus, 22 Hyde Green, Marlow, Bucks.
Studio Craft, Acoustico Enterprises Ltd, Unit 7, Space Waye, North Feltham Trading Estate, Feltham, Middlesex, TW14 0TZ.
Tannoy Products Ltd, Norwood Road, West Norwood, London SE27 9AB.
Telefunken, AEG Telefunken (UK) Ltd, Bath Road, Slough, Bucks.
Yamaha, Natural Sound Systems Ltd, Strathcona Road, North Wembley, HA9 8QL.

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For more details write or telephone Natural Sound Systems Ltd, Strathcona Road, Wembley, Middx. 01-904 0141.

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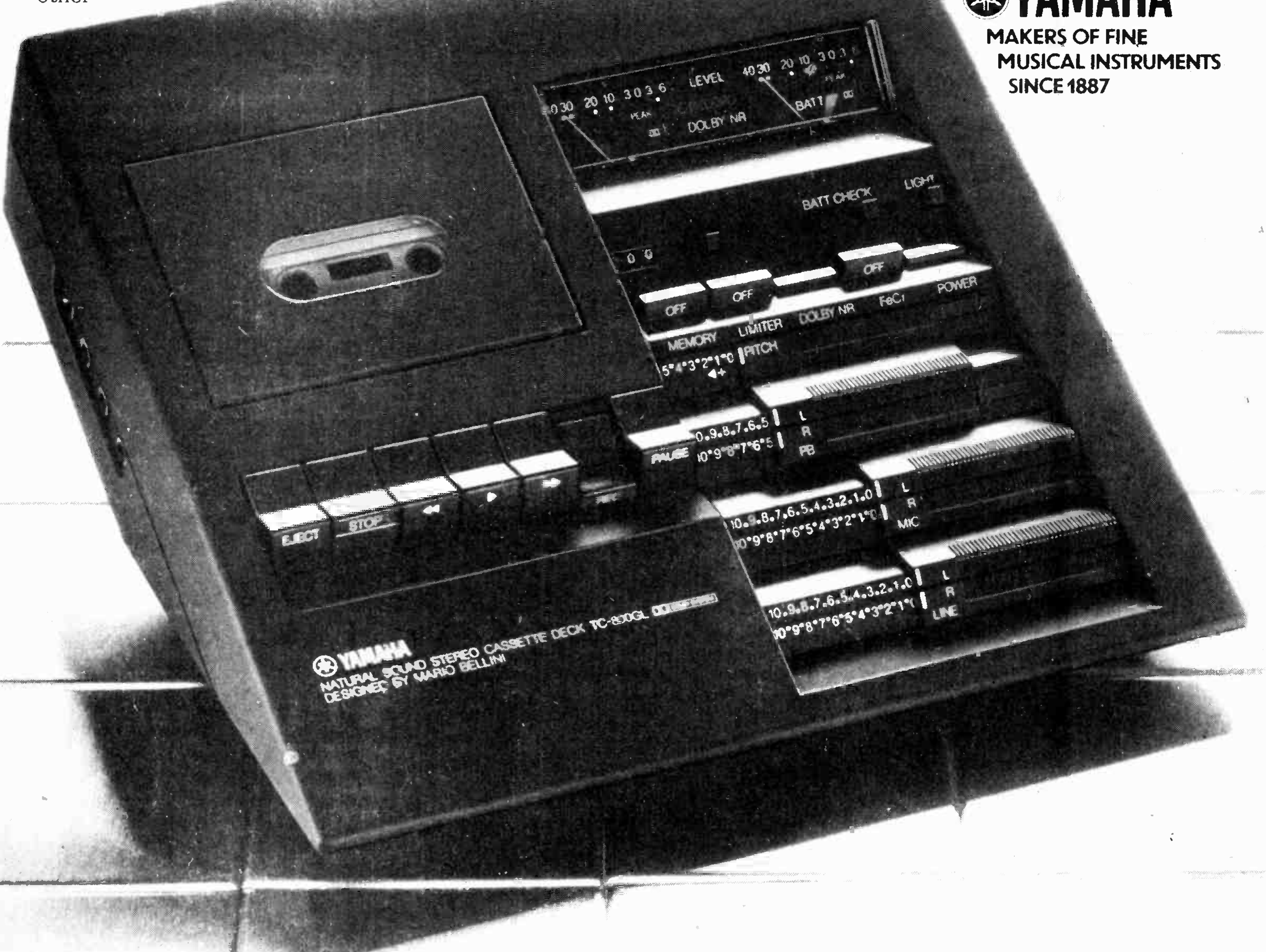

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The "walltenna"

Foil antenna array hidden by wallpaper

by Ray Schemel and Dennis Brown

For f.m. stereo, long-distance TV, or improving reception in marginal areas, one's first temptation is to install the largest and most elaborate fishbones, wire mesh reflectors, and other pieces of aluminium-mongery at the highest and most eye-offending part of a house. It is odd, but more time, effort, and money is expended on extracting the last decibel of gain from an antenna than almost any other part of the receiver chain. After six months' exposure to the weather, those precious decibels may well have been lost and the extra signal level might better have been obtained, for example, by paying attention to the antenna matching. In fact an excellent location for an antenna could well be in the same room as the receiver — it goes without saying that the room should have walls of paper and be in the attic! The antenna structure is not exposed to the elements, water cannot enter the feeder, feeder losses are minimized, and the appearance of our towns and villages would be much improved.

The "walltenna" was conceived as a method of receiving the Wrotham and Norwich f.m. transmitters at a location near the coast of Holland at distances of 180 and 135 miles respectively. At this range the transmitters are well below the normal horizon, but a weak signal is almost always present. Signals from the "walltenna" fluctuate over a wide range, and in good weather conditions, presumably when sufficient refraction or ducting takes place, stereo reception is perfectly possible. Estimates of quality tend to be very subjective, but the signal is well above a significant degree of quieting for a high proportion of the time, although not necessarily of entertainment value because of the rapid fading. The estimates are quoted, not because this article is about f.m. reception, but to give some idea about the pick-up properties of the finished antenna.

The basic principle behind the antenna is simple. Why not make a large array essentially two dimensional, and then hide this behind wallpaper or some other decorative medium? The large size of the array would compensate for the losses of the walls, and the bother of mounting antennas on the roof would be avoided. Various alternative schemes were considered, including multi-element Yagi and rhombic arrays on the ceilings and floors, but the arrangement described here was found to be the most suitable because it was not overly directional in the horizontal plane.

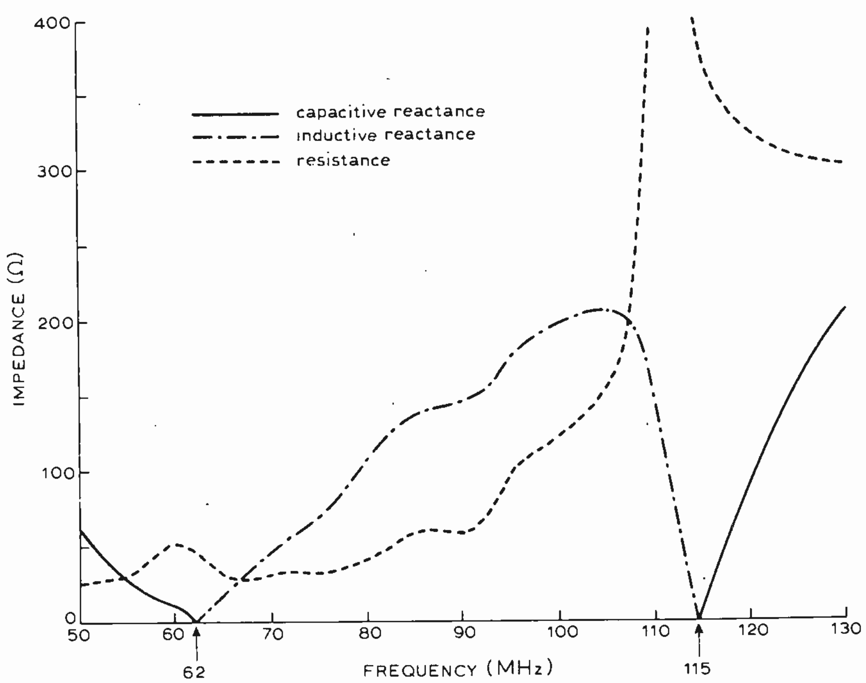
It consists of a vertical array of dipoles mounted broadside to the direction of propagation; the greater the number of dipoles, the greater the signal pick up. It is often overlooked that the signal power extracted from a given field strength is broadly independent of the wavelength, being only a function of the area of the antenna. An elaborate 20-element beam used for u.h.f. TV probably picks up less power than a piece of wire connected to a medium-wave radio. To increase the power available one has no real alternative but to use the largest capture area practicable.

A dipole in free space is resonant when it is almost one half wavelength long. It then has a gain of about 2.2dB relative to isotropic. As the length is increased, the familiar figure-of-8 polar diagram narrows, and when the dipole is a full wavelength long and is centre fed, the gain increases by a further 1.8dB. Of more importance is that the antenna is inherently a good radiator (or receiver) as the length increases beyond a half wavelength.

Four such dipoles, suitably phased, could give a gain of up to 10dB, and if one were fortunate enough to be able to place a plane wire mesh reflector behind the dipoles, the gain could go as high as 16dB, not allowing for mutual coupling losses. A reflector is scarcely possible in a living room, but even so, a gain of up to 10dB is quite promising. Four dipoles fit nicely into an average height of living room, and so this particular design was adopted. In practice the gain will depend on the wall characteristics.

The situation when dipoles are placed adjacent to a lossy wall is complicated in that the impedance and the resonant frequencies are markedly altered. The resonant frequency is always decreased, and the radiation resistance is also altered for a given electrical length. In addition, radio waves must penetrate what amounts to a lossy dielectric. Reflection and refraction occur at each wall-air interface and attenuation occurs in passing through the brickwork. Complicated conduction and displacement currents are set up in the wall. In spite of this, the signal pick up properties of the antenna are not necessarily degraded provided that full account is taken of the changed impedance of the dipole. Fig. 1 shows the impedance of a 1½-metre dipole mounted on an 18-in thick breeze block and

Fig. 1. Series impedance of 1.5 metre dipole mounted on a wall (measured values).



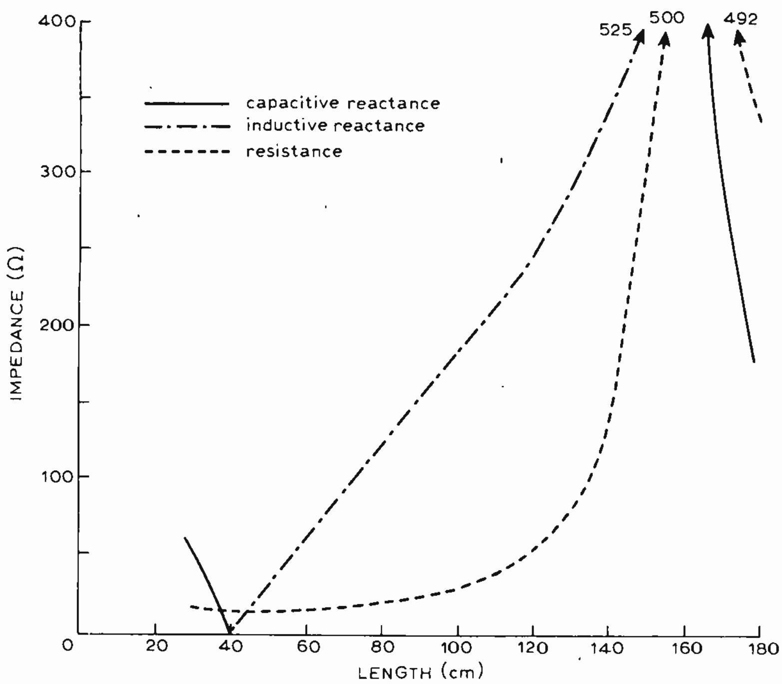


Fig. 2. Series impedance of a dipole mounted on a wall at 92MHz (measured values).

brick wall. The antenna was made of 1½-in wide aluminium foil taken from a capacitor, and would normally be resonant at about 97MHz in free space. Notice that the half-wave resonance has shifted to 62MHz and the full-wave resonance occurs at 115MHz. An alternative measurement is shown in Fig. 2, where the frequency is held constant at 92MHz and the length of the dipole is varied. In this case the dipole was placed along an 18-in thick reinforced concrete beam; notice again the length at which the half and full-wave resonances occur.

Most *Wireless World* readers will not have the facilities for measuring antenna impedances, which in any case vary in a complex manner with frequency and with the type of wall. Fortunately, it is not necessary. An antenna does not have to be resonant, and neither does it have to be any particular length. Provided that it is long electrically, i.e., greater than, say, one half wavelength, and that some suitable impedance matching to the receiver is performed, it will exhibit reasonable pick up properties. A good rule of thumb is to make an antenna a full wave-length long. It then yields useful gain and is not too directional or large in size. For average brick walls this corresponds to it being about one half wavelength long in free space.

Constructional details

The configuration of four vertically-stacked dipoles referred to earlier will be found the most convenient for an average eight-foot living room. Details of this are shown in Fig. 3(a), and its construction is largely self-explanatory except for the feeders. Figs. 3(b) & (c) show other arrangements which may be found more suitable, and in these cases the general rules for combining any number of elements are as follows:

— When $n/2$ wavelengths of feeder are terminated in an impedance Z_r, the input impedance of the feeder is also Z_r. The signal is shifted in phase by $180n$ degrees. Usually $n = 1$.

— Balanced feeders can always be reversed to give a fixed phase shift of 180 degrees.

— When $(n/2 + 1/4)$ wavelengths of feeder are terminated in an impedance Z_r, the input impedance of the feeder is Z^2_o/Z_r, where Z_o is the characteristic impedance. Usually $n = 0$.

— When dipole elements are not mounted above one another, there is a relative phase shift caused by the difference in time of arrival of the received signal. The phase difference is $360D\sin\theta$, where D is the antenna spacing in wavelengths and θ is the angle of arrival relative to the line joining the elements.

— The phase difference of two groups of dipole elements may be compensated for by using unequal feeder lengths, provided that the sum length of both feeders is $n/2$ wavelengths.

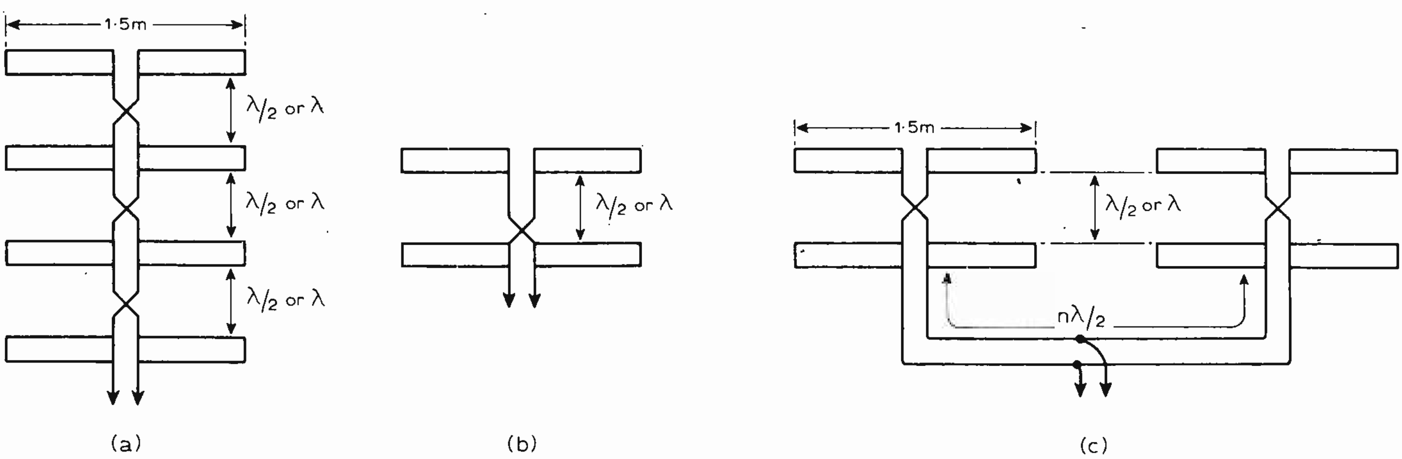
— The electrical length of feeders is longer than their physical length. Because of this, the phase shift is $360/v$ degrees per wavelength of feeder, where v is the velocity factor.

— Dipoles should be spaced no closer than a quarter of a free-space wavelength apart, otherwise mutual coupling effects reduce the potential signal pick up.

An excellent material for the antenna is the foil from large paper or electrolytic condensers. Aluminium baking foil or one of the proprietary aluminium-backed wallpapers can also be used. The width is not critical, but to make the antenna reasonably wide band, it should be 2in or more. After cutting the foil it may be pasted directly onto the wall, leaving a small amount free at the centre for making connection to the feeders.

Feeders present a small problem if they are to be invisible. A surprisingly

Fig. 3. Four vertically-stacked dipoles (a) most convenient for average living rooms; alternatives are (b) and (c). Electrical lengths of feeders shown.



low-loss feeder suitable for the purpose of v.h.f. can be made from aluminium foil and ordinary newspaper. Lay a long strip of aluminium foil on a flat surface and tape down the ends. Then paste a similar width of newspaper onto the foil. When it is dry, lay two lengths of thin wire, say 36 to 40 s.w.g., along the middle of the newspaper about 0.25in apart, and tape down the ends. Finally, paste a second strip of newspaper on top to hold the wires in position. Alternatively, those who are a little more adventurous could try dispensing with the top layer of newspaper and instead building up the feeder directly on the wall.

A feeder made in this way had a velocity factor of 0.5 and an impedance of 170 ohms, but these figures will be dependent on the dielectric constant of the paper used. For short runs of feeder, say up to one wavelength, the approximations involved are not likely to give significant effects, but to remove the uncertainty connected with the velocity factor it is hoped that a manufacturer will be found to produce a standard type of strip line. There are other alternatives: ordinary screened balanced 75-ohm feeder can be channelled into the wall, or unscreened twin feeder can be placed in plastic conduit.

Connect feeders to the antennas by bending over the aluminium foil, pressing down firmly over the join and then folding a second time at 45° to the first, and finally placing adhesive tape over the join to hold the foil in position.

The special feeder described above is only required down to the skirting board, and for convenience it should be made an integral number of quarter wavelengths long if possible. At the skirting board it should be matched into ordinary coaxial cable or a balanced feeder.

The impedance matching makes use of a pi network and a balun as shown in Fig. 4 (the balun is not required if the receiver has a balanced input). To obtain the maximum range of adjustment, inductance L_1 should be wound on a former that accepts brass and ferrite slugs. Also, some obstinate antennas may still need additional encouragement to match, in which case an extra quarter wavelength of feeder can be inserted on the receiver side to give a further impedance transformation. The pi network could, with advantage, be placed on the unbalanced side of the balun as it makes the two adjustable capacitors earthy on one side. However, 3-30pF trimmers are easy to obtain whereas ones four times this value are not, and the balun always works at the correct impedance level.

Baluns are available but you may wish to make your own. A satisfactory balun can be made by winding 10 turns of bifilar wire onto a coil former, about ¼in diameter with a ferrite slug. The two windings are then placed in series as shown in Fig. 4.

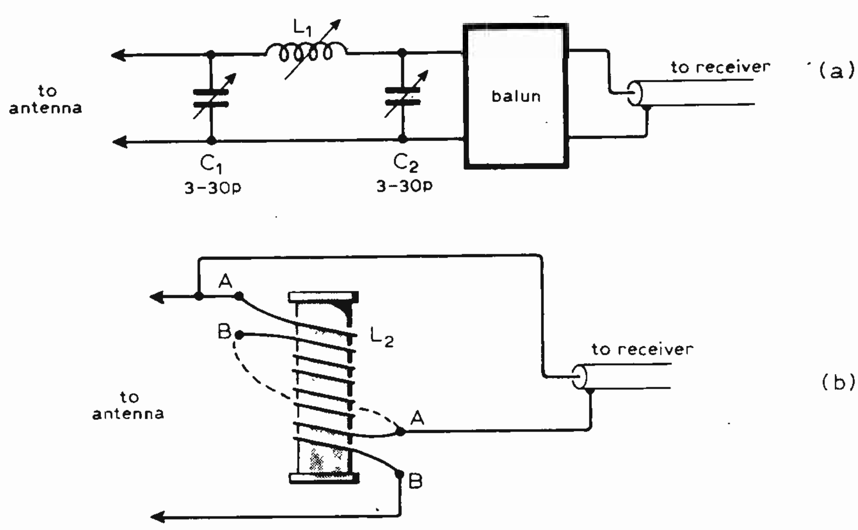


Fig. 4. Impedance matching unit (a) requires a balun (b) for receivers with unbalanced input circuits. L_1 is 5 to 10 turns on a 0.25in dia. former about 0.3in long. L_2 is 10 turns of close-wound bifilar wire on 0.25in dia. former wire gauge can be around 28-30 s.w.g.

Measurements and setting up

Before constructing the "walltenna", make a folded dipole as shown in Fig. 5, remembering to include a balun. This is most important, as unscreened twin feeders can pick up appreciable amounts of signal which may upset measurements. If the receiver normally operates with a balanced input it is well worth using a twin screened feeder to overcome the pick up problem, or even considering the use of two baluns and ordinary coaxial cable. The temporary antenna should be moved to different points on the wall to find the best positions, and these should be used for the finished dipole elements.

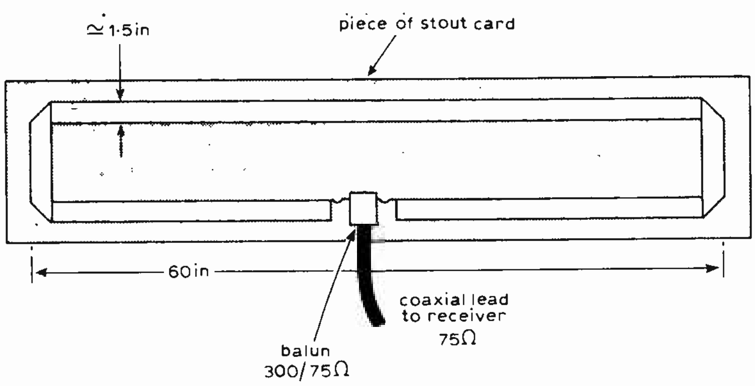
After the antenna is finished, the pi network will require adjusting for maximum signal transfer. To do this a meter is really required, perhaps placed on the a.g.c. line of the receiver, but an acceptable alternative is to use a weaker station and to tune for minimum noise on stereo. First adjust C_2, then L_1, and finally C_1. Remember that C_2 and C_1 are live as far as the signal is concerned and must not be touched, as opposed to adjusting, when measuring.

If the antenna of Fig. 3(c) is being used, the tapping point along the feeder must first be optimized. This can be done by calculation; the displacement from the centre point *away* from the dipole nearest the transmitter is $\frac{1}{2}D v \sin\theta$ as per the points made earlier. Alternatively, a temporary sliding connection can be made along the feeder and then this is adjusted together with the pi network.

Follow the above procedure before wallpapering, because, in spite of its simplicity, difficulties which cannot be rectified afterwards may occur. In principle, every element added to those existing should increase the total signal, after an impedance adjustment has been carried out. In practice it may be found that adding further elements gives no increase or even a decrease in signal, and better results are obtained by reversing the feeder connections. Such effects need not be unexpected. They result from differences in the pick up capabilities of each array element and the variable impedance of the wall. In these cases it is simply a question of cut and try methods, and if all else fails, of experimenting with fresh positions.

The "walltenna" principle is applicable to a wide variety of antennas and it is hoped to be able to give constructional details for u.h.f. TV at a later date.

Fig. 5. Temporary antenna is used to find best position on wall.



Letters to the Editor

CITIZENS' BAND IN THE UK?

Recent discussion in your correspondence columns over the merits of a Citizens' Band in the UK are, I fear, of mere academic interest. I am prepared to bet anyone that the chance of the introduction of Citizens' Band facilities in this country have about as much hope as a snowflake in hell.

Why, it may be asked, do I take such a gloomy view of its chances? Well, the cards are well stacked against it because there are too many vested interests that oppose it – and will oppose it vigorously, using all the spurious technical arguments that can be dreamed up. Let me take just two. Contrary to any opinions otherwise, in the UK the airspace is owned by the Government and its agencies – and for a start, I cannot see the PO agreeing to anything that would take away its monopoly of communications. The radio amateurs will oppose it violently, since they will see it as a threat to them, taking away "their" precious rights to a share of the airspace. For my part – and there must be many others, the usefulness of a Citizens' Band is beyond question; and it could be a valuable fillip to the radio industry in this country, who could gear themselves to meet the inevitable heavy demand for equipment to a tightly controlled specification – which indeed, it would have to be.

But alas, it will never be. The only area for *vox populi* to have any effect is through one's parliamentary representative. I failed in my particular search for a champion for the cause. He never ever understood the arguments I gave him and took as gospel the bland technical arguments fed back to him by the Home Office. Still, some technically minded M.P. may read this and do something about it – but don't put your money down yet.

Reg Williamson,
Norwich.

I have noted with interest the recent correspondence regarding the possibilities of a Citizens' Band in the UK. I wholeheartedly agree with Mr Webber's comments, and wish to add that if, as the gentlemen from the Home Office frequently say "any form of CB in the UK would soon get out of hand and lead to chaos, regarding the infringing of the conditions of ones licence, including the allowed power, the gain of the antenna, etc.," it would be relatively easy and not too costly to detect infringements, summon, and finally revoke an operator's licence, so clearing the band of any bootleg operators.

Finally, to answer the Home Office's probable remark regarding the above opinion, it most definitely is not costly to track an illegal operator down, as costs are awarded in court in the majority of cases; this is drawn from rather unfortunate past experiences.

I would very much like to contact anyone interested in forming a CB Association whose responsibility it would be to look into all the possibilities of the setting up of licenced CB in the UK. Please write, enclosing an s.a.e.

P. Jenkins,
30 Gainsborough Road,
North Finchley,
London N12 8AG.

News of the Month in the March issue makes mention of the Home Office's reluctance to license Citizens' Band radio in the UK. It should not take the Home Secretary more than five minutes to make up his mind.

If a schoolboy can pay £1 and then blaze away for five years on 27MHz at his toy aeroplane, on the edge of an airfield or a city playground, with a black-box transmitter made in Hong Kong and bought by his auntie in a toyshop, why cannot remotely sited citizens be given facilities to call assistance when in dire need?

The farmhouse in which I live is connected to civilisation by a mile-long farm road at 1400ft altitude and two thin telephone wires, on poles, over the fields and hills for miles. Most winters we are snowed in for days and weeks, then come the floods. Even if the doctor, ambulanceman or vet could not get through, at least we could, with radio, get advice, or neighbour's help. (Try feeding 200 beasts and digging sheep out, with one's helpmate ill in bed.) This story could be repeated right through the South-West, Wales, Yorkshire and the North.

The Home Secretary need not worry about television interference with neighbours over the horizon and, as for his frequency allocation worry, I could set my communication receiver on any one of a hundred channels and not hear more than static from one year to the next.

All we would need is a frequency modified trawler-band transmitter-receiver. The depressed radio industry would like that.

R. J. Leeves,
Simonsbath,
Somerset.

I have followed, with increasing anxiety, the correspondence in your columns concerning the possible opening of 27MHz as a Citizens' Band.

Whilst I am not against a Citizens' Band in principle, it would be the height of folly to put it on 27MHz. This band is already occupied, and very busily too, by radio-control model enthusiasts. Even though CB equipment is illegal in this country, there is enough of it in use to cause considerable aggravation to the modelling fraternity. I have lost at least one model, representing several months' hard work, not to mention a fair bit of hard cash because of this kind of interference. Even aside from the financial side of it, the dangers must be apparent to all. A model aeroplane sent out of control in this manner would be bad enough, but of recent years radio control helicopters have become practical propositions.

The thought of a model 'copter weighing some 11 lb, powered by a 1½ h.p. motor, rotor diameter 5ft, tip speed of rotors 250 m.p.h. chasing me round my local flying site in response to "smokey bear" messages is almost enough to make me give it up! Normally this sort of model can be operated in complete safety because (a) modern digital R-C gear is virtually 100% reliable, and (b) 27MHz is a very clear frequency. CB on 27MHz would end all that!

Countries that operate CB on 27MHz appear to appreciate this difficulty, and move model control elsewhere, usually around 72MHz, but tentative enquiries have shown that this is not possible in England. However if the CB was put on some frequency other than 27MHz this could have considerable benefits for our domestic manufacturers. The Japanese would be unable to swamp the market with their enormous stocks of 27MHz gear. Who knows, they might even decide that such a small market is not worth retooling for, and leave the field open for our own manufacturers. How about using one of the Band 1 or Band 3 television channels for CB when 405 line television finally dies?

P. Christy,
South Harrow,
Middlesex.

In New Zealand, CB radio is restricted to seven channels and an output power of one watt maximum. When I left New Zealand there were somewhere near forty thousand people on the bands, and the only time it does get a bit confusing is when the "skip" season is on during the summer months. We have a calling channel which we call 4, and when the contact is made we shift to another channel. If there is any trouble the local radio inspector locates and jumps on whoever is causing it. Every operator pays a licence fee and is issued with a callsign which he or she retains until cancelled.

I use my CB sets car-mobile, hand-held, and back-pack mobile, and there are also a few people who use CB as a marine mobile. We have sports clubs and small businesses also on the band. The reason that I take a set back-pack mobile is because it is a fully mobile unit, especially in a part of the world which is prone to earthquakes, etc. I can be on the road with the civil defence organisation.

CB is really an ideal system for the average man in the street who cannot afford to go into the world of amateur radio.

P. H. Inwood,
Hungerford,
Berks.

I have noted the comments in your journal and the current wave of speculation about Citizens' Band in the UK. As one of the many thousands of licensed users of 27MHz equipment whose interests would most certainly be threatened by CB operation, I would appreciate the opportunity to register a protest and to comment on the situation.

First, it is estimated that there are between 70 and 80,000 users of 27 MHz equipment in the UK; admittedly they are not all licensed but at least the equipment itself is legitimate. In round figures this total accounts for about £9,000,000 worth of gear in regular use. The bulk of the equipment is not compatible with the operation of CB systems; in fact there would be a direct conflict on the 27MHz band.

Any proposal to establish CB on, or adjacent to, this band shows a total and blatant disregard for existing, legitimate users and their investment in equipment. Even in these days of selfish commercialism the proposals show an appalling lack of sensibility.

It is the same thoughtlessness, coupled with a disregard for discipline, that has made CB operators the menace they are in other countries. They have brought upon themselves the present round of threats, restrictions and, in one case, a clamp-down on operation. This situation, along with the now reported saturation of the Japanese home market, gives an additional incentive to the establishment of a CB in this country. The current market "stimulation" exercise (for that's what in truth it is) together with the pressure on the Home Office for a Citizens' Band looks very like an attempt to open up the UK as a dump for more foreign-made equipment; or a remarkable coincidence of events.

So far the Home Office had tended to resist the current exhortions. May its officials continue to show their wisdom. They have noted for themselves the reasons for the clamp-down on CB operations in Holland.

They will not have been as impressed as Mr J. R. Brinkley (March issue, p61/62) with its progress in the States either. Let me quote from the report: "F.C.C. says that the violation of CB rules is rampant and the band is chaotic. In 1975 it received 31,000 complaints, 55% about radio interference from CB operators."

The Home Office is obviously hard pressed now to execute its statutory duties. To think it had a cat-in-hell's chance of containing a CB on any frequency in the UK is just being totally naive.

Sir, it has already been sufficiently demonstrated in several countries that Citizens' Band brings little but conflict and trouble. At the best it is an abused public toy – my advice is that we keep this cancer out of the radio frequency spectrum in the UK.

D. L. Martin,
Newthorpe,
Nottingham.

PHASE AND SOUND QUALITY

James Moir tossed off a few words at the end of his most informative article about phase and sound quality (March issue) by saying that phase was of considerable importance in a two-channel system, and I would venture to suggest any multi-channel system.

To have shown, as he did, gross differences in a waveform as between points a few inches apart, is also to show that two sounds from two speakers, while deriving from electrically identical inputs, will as like as not have two grossly different sound waveforms at the listening point. This poses the very interesting question as yet unanswered — how do the ears' work and what is the real value of stereo?

But one ought to look back further and consider whether the two channels of a stereo system can even provide electrically identical signals. Does not practical equipment contain large numbers of components with 20% tolerances and many sources of phase shift including deliberately introduced tone controls? Thus by Mr Moir's comment one may wonder if there are many equipments capable of producing theoretically correct audio outputs at the speaker cone, i.e. before the room adds its distortion of the waveform.

Since more reproduction stems from records one may even consider – it seems to be rarely if ever tested – whether records and pickups do reproduce each channel in correct phase relationships. In fact I suspect there is evidence to show that they do not. As Mr Moir points out, varying phase shifts can produce peak amplitude changes, and in fact there is nothing surprising about this or the thought that the process applies to the interaction of the two channels of a stereo record when the outputs of a stereo pickup are electricaly combined and applied to a single channel amplifier. My comment is that some stereo records suffer, when so reproduced, from intermittent low frequency effects which are not rumble and are not in my experience to be found on mono records.

It would be interesting if somebody could unravel the further significance of phase in multi-channel reproduction before we are again taken for a ride on the bandwaggon of alleged technical obsolescence. In view of the enormous quantity of recorded material at present available it would surely be of enormous public benefit to show how this can be reproduced to yield the most pleasing results. Even the makers of mono records and stereo equipment combine in saying two loudspeakers sound better than one – rather odd in view of the modern doubts about the effect of phase!

C. Streatfield,
Poole,
Dorset.

In the never-ceasing game called Higher Fidelity, we are now about to be deluged with facts and not-so-audible figures about linear phase equipment.

John Bowers, in his letter (February issue) declares that his company has spent two and a half years and some £75,000 developing a linear-phase loudspeaker. We may safely presume that part of this sum was for sophisticated measuring equipment. And may we also presume that these lengthy tests were made in the usual anechoic chamber? The point seems to be that unless you have a very good pair of ears (worth at least £75,000) plus digitally encoded material, a linear-phase amplifier and linear-phase speakers you can't be expected to hear the difference. Michael Gerzon (letters, March issue) goes even further — phase distortions can't be appreciated until you get yourself sophisticated electronics—including microphones. Just imagine the horrors that the BBC have been perpetrating with their mixer desks, their seedy Post Office lines and even their transmitters! They've been pulling the wool over our ears for years — and nobody suspected it!

It was fortunate that the March edition of your journal contained some realism. We have, rightly, been increasingly aware of greater fidelity to the original sound source, and this includes "surround sound" and ambisonics in addition to the four channel gang — because we do not hear direct sounds only, but reflected sounds as well. The concert hall is a mass of direct sounds *and* indirect sounds; nobody has yet complained of sitting in an out of phase seat to my knowledge. As J. Moir stated in his paper "Phase and sound quality": "Sounds arrive at every point in an auditorium by direct transmission . . . and also by a magnitude of indirect paths that include multiple reflections (and so) arrive delayed in time, and in consequence, with their phases radically changed."

Again, in that same issue, P. L. Taylor states, with some conviction in his letter: "the consensus of opinion among my colleagues is that the tonal quality of sound depends solely on the amplitudes of the harmonic components *and not on the phases.*" I hope my name may be added to that list, because, although I do not listen to my stereo in concert hall acoustics, neither do I listen in an anechoic chamber. I have listened to "conventional" speakers and linear phase (including B & W DM6s) and I believe I'm still happy with what I have already. I may be out of phase with the boffins – but I'm still solvent!

J. C. Nuttall,
Worthing,
Sussex.

During the second world war a popular wireless magazine (not *Wireless World*) published a reader's letter describing a circuit claimed to slow down the reception of broadcast news bulletins, enabling the text to be taken down at dictation speed. Having regarded the original letter as a leg-pull, I recall observing with increasing incredulity the ensuing correspondence from readers reporting success with the circuit, and in some cases claiming improved performance resulting from their own modifications to it. The series ended with a sheepish editorial note closing the correspondence and I was left to reflect on the ability of the human ear to detect what it is predisposed to hear.

I find myself with similar feelings after reading some recent contributions on the audibility of phase non-linearity in loudspeaker systems – not least that of Mr Michael Gerzon, whose letter claims a detectable difference on reversing the phase of a monaural signal in a high-quality system. Mr H. D. Harwood's temperate reply to this letter is a model of the polite patience demanded from an employee of a state organisation addressing a member of the public! The audible effect of a phase response having various forms of non-linearity with frequency is certainly a debatable topic, but the audibility of a total phase reversal is surely ludicrous. To be charitable to Mr Gerzon, if he is not attempting to pull the editorial leg, one might assume that his phase reversal experiment introduced an associated effect resulting in a detectable change of quality; otherwise I am back to reflecting on the ability of the ear to detect what it is predisposed to hear.

More seriously, the published experimental evidence suggests the postulate that the human auditory system responds to the energy content of each frequency component of a complex recurrent waveform. Amplitude changes of any component (which affect the waveshape) are thus readily detectable, while phase-angle changes of any component (which also affect the waveshape) have no effect. It would be interesting to have the comment of a specialist in the physiology of human hearing on this suggestion.

If that were so it would resolve the issue for recurrent waveforms, but still leave open the question of audible effects of phase non-linearity on the true transient, that is a single impulse or the leading edge or trailing edge of a wave-train, as distinct from the recurrent edges of a 1kHz square-wave as used for demonstration by Mr James Moir. It is

significant that Mr Moir quotes reports indicating phase non-linearity to be audibly more perceptible with speech material than with music. Speech contains far more discontinuities and explosive consonant sounds than does a typical music programme and would thus be more susceptible to leading-edge and trailing-edge degradation. With music the audible effects would be confined to the attack and decay of individually-sounded notes or percussion — effects which might well combine to degrade the reproduction of certain classes of programme material more than others.
J. H. Haslett,
Haywards Heath,
Sussex.

HIGH-QUALITY F.M. TUNER

Having relied upon Dr K. R. Sturley's excellent design of an f.m. receiver, which was published as an *Electronic Engineering* monograph as far back as 1942, I am somewhat disillusioned with the performance of the high-quality f.m. tuner described by Mr J. B. Dance in the March issue of *Wireless World*. I wonder how many readers have encountered difficulties.

In the first place, I would question the design of the power supply, in particular the value of the reservoir capacity. The ripple on the output of the TBA625B regulator is about 1.5 mV r.m.s. and this gives rise to an audible hum at 100Hz. I found that the performance of the regulator followed expectations based on the information in the SGS data sheet. The device's supply voltage regulation, that is the ratio of the input/output ripple, is typically 46dB. I increased the value of C_{13} from 250 μF to 1250μF and reduced the output ripple to 125 μV r.m.s., whereupon the hum disappeared.

Turning to the Signetics NE563 phase-locked demodulator, I have to admit that I had instability with the first lay-out that I attempted, but soon overcame this difficulty by constructing the circuit to the p.c.b. lay-out which the manufacturer very kindly supplied. I decided not to use the printed wiring, but arranged the physical disposition of the components on a piece of Vero board so that they were in identical positions to those on the p.c.b. The signal from the i.c. is taken from the mono output and fed directly into the pre-amplifier of a mono reproducer.

I have two observations to make regarding the performance of the NE563. Firstly, judged subjectively the distortion is slightly more perceptible than with Dr Sturley's receiver and secondly, the hiss, or white noise, is noticeably worse. For example, with the volume set at concert level the quiet passages of "Nimrod" in Elgar's Enigma Variations are comparable with the hiss power. With the valve receiver the hiss is imperceptible. Signetics make no claim for the signal-plus-noise to noise ratio on their otherwise very comprehensive specification for the NE563. They did advise me, however, of possible cross-over distortion in the phase-detector and suggested a remedial procedure, but I have had no cause to implement this advice.

To sum up, I believe that the performance of Mr Dance's receiver would probably satisfy a large number of readers. For other than orchestral music, which has a large dynamic range, the residual noise would remain un-noticed, but for the ultimate in s/n ratio, paradoxically, my twenty-year old valve receiver still remains supreme. It only goes to show that a good job Dr Sturley made of his design.
J. M. Reid,
Shepperton.

Mr Dance replies:
I understand that there is a mis-print in the TBA625B data sheet; it seems that the typical ripple rejection should be quoted as 54dB. I measured the ripple on my receiver positive line as 630μV r.m.s. with a digital meter when using a capacitor for C_{13} with a marked value of 250μF. If, as Mr Reid states, an increase in the value of this capacitor by a factor of five results in a decrease in the 100Hz ripple by a factor of twelve, this suggests his 250μF capacitor is low in value or his 1250μF high. Variations in the regulator ripple rejection and actual capacitor values can give variations in the ripple level of up to about 20dB. This is no real problem, since if audible hum occurs due to ripple on the Varicap line, one merely increases the value of C_{13}.

I have heard from two readers who have experienced instability in the receiver owing to the use of circuit boards with copper strips. Clearly the use of parallel strips of copper is inappropriate with a high gain device at the frequencies concerned even if the strips are quite short. I employed a "Lektrokit" board of the type into which one inserts metal pins; a miniature co-axial lead was used to pass the signal from the front-end to the 563 and no instability was found. Although this type of construction is not the neatest, it has the advantages that stray capacitance is minimised and one can easily add extra components.

Mr Reid is not correct in his implication that Signetics have not published (s + n)/n data for the 563. In the preliminary data sheet a nominal value of 70dB was quoted. The subsequent data sheet presents the (s + n)/n data graphically, the value being 65dB for input levels above about 800μV r.m.s. if a low-pass filter is used at the output (such as the de-emphasis filter in the monaural output). As stated in the "Letters" column of the July 1975 issue, the bandwidth and noise can be reduced somewhat by reducing the value of R_6 of Fig. 1, but the 65dB figure reported by Signetics was obtained with the wide-band, 22kΩ value.

Unfortunately it is not possible to determine the origin of the noise from the information given by Mr Reid. If Dr Sturley's receiver was designed in 1942 before stereo was available, it may have had a relatively narrow i.f. bandwidth and this would reduce the effect of any noise coming from the aerial or from the front-end. If the signal provided by the aerial is inadequate, a wide-band i.f. unit for stereo reception may produce more noise at its output than an earlier type of valve receiver. It would be interesting to take an i.f. signal from Mr Reid's valve receiver and feed it to the 563 before blaming the noise level on the 563 circuit. The noise at the output of the 563 varies somewhat from one device to another, whilst one might expect that noise and distortion could be greatly increased by any significant amount of spurious coupling.

The 563 device has been temporarily withdrawn from the Signetics/Philips product list as from December 1975, but it is understood that some retailers still have the device in stock. The manufacturers intend to re-introduce it again when they have made some changes in their production processes. In my view, it is no mean achievement to produce a complex chip which provides f.m. detection of broadcast quality without the use of any inductors.
Brian Dance,
Alcester,
Warwickshire.

THERMISTOR AND THERMOCOUPLE ACTION

Mr Budd, in his article on thermistors and thermocouples, seems to have solved a problem which has faced engineers for many years – that of having to run thermocouple leads in expensive compensating cable. Closer examination of his circuit, Figure 10, reveals, however, that he has all three junctions at the same temperature, which he shows quite correctly in Figure 8, will give an output of zero.

Perhaps Mr Budd is a little out of touch with the industrial use of thermocouples as I cannot agree that they have been neglected in favour of thermistors. I believe that the thermocouple is still by far the most widely used temperature measuring element and it certainly lends itself much more readily to fail-safe type circuits than do any of the resistive devices.
M. McAlevey,
King's Lynn,
Norfolk.

Mr Budd replies:
The point that Mr McAlevey makes is quite correct and I apologise for the error. Of course, as he says, the situation of Fig. 10 reduces to that of Fig. 8 if the "additional" junctions are at the same temperature as the main sensing junction and the output will then be zero.

Regarding the question of whether or not the thermocouple has been neglected in favour of the thermistor; judging from his letter Mr McAlevey has had far more industrial experience than myself and so I would not presume to argue with what he says. Nonetheless, I feel that, from the constructor's point of view, the thermocouple could be used much more widely and with advantage.
C. Budd,
21 Rushes road,
Petersfield,
Hants, GU32 3BW.

OUR DAILY BREAD

Your citing, in your March leader, of a contemporary's designation of degrees in technology as "passports to poverty" raises the even wider issue of the cost of being a professional of any kind. As a teacher and research unit leader in a polytechnic, I have in recent years seen this trend for the better technician/technologist to acquire some of that magic (?) aura of the teacher that has put the latter in his present situation as a man who is blandly told by his paymasters: "But you *enjoy* your work, so you shouldn't expect to be paid highly".

Twice, recently, we have had to advertise, in your columns and elsewhere, for an electronics engineer to work in my own unit; the second advert was necessitated by the first appointee's emigrating after a two/three-year stint with us, which he greatly regretted terminating, and for purely financial reasons.

In both cases, our advertisements contained offers of design opportunities, not because we were seeking to get better men than we were paying for, but because I and my colleagues believe that a job without such opportunities has no real appeal. Both appointees welcomed this aspect, both were aware of being in a sense exploited thereby, but both accepted that to work as a colleague *in* a team and not as a serviceman *for* a team is worth some financial sacrifice, as long as it can be afforded.

I am not sure where our world goes from here. Research is, of course, an expensive mistress for all those involved in her upkeep, and when it is in an academic institution where funds are low and cost-benefit relationship may be hard to demonstrate, one has to be thankful for whatever crumbs of finance can be garnered to gain her favours with. Maybe the *cachet* of "white-collared intellectual" by which you designate us, *has* to be paid for in this way. Maybe we should be glad of the chance to go on serving man instead of Mammon, as so many sections of society now do!

W. B. Broughton,
The Athenaeum,
London, S.W.1

ELECTRODYNAMICALLY INDUCED e.m.f.

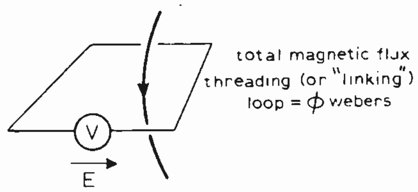
The question posed by Messrs Taylor and Todd in the July letters column asked "Can an induced e.m.f. be measured in a loop moving through a constant flux density if parts of the loop (e.g. the meter leads) are screened with a high permeability material?"

The basic circuit for an unscreened loop is as Fig. 1. If, by any mechanism, the quantity of flux threading the loop is changing, then a high impedence voltmeter would measure an e.m.f. E volts numerically equal to $d\Phi/dt$ (Φ is in webers). If the loop moves through a constant flux density B, then $E = 0$ since $d\Phi/dt = 0$. (The movement assumed is translational not rotational.)

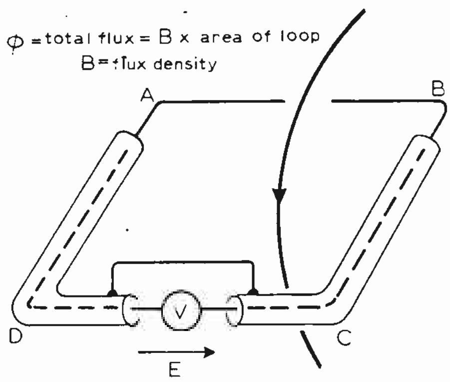
If we now screen the leads of the meter (Fig 2) but otherwise keep the loop dimensions the same, the same total flux Φ links the wire/meter leads loop ABCD, and if this flux changes, $E = d\Phi dt$ as for Fig. 1. The metal screen (whether high permeability or not) does not affect the flux linking the loop and hence has no effect on the circuit voltages. Therefore a system such as Fig. 2 moving *en bloc* through a constant flux density will give no measured e.m.f. (and no circuit currents either), irrespective of the presence of screening since $d\Phi/dt$ for the loop is zero.

This example illustrates the use of the "flux linking" concept, which is more basic and more valuable than the concept of "flux cutting". If "flux cutting" were invoked one might argue that in Fig. 2 A-B sees an e.m.f. generated by movement through a region of flux density B, but C-D is screened. The fallacy in this argument is not difficult to unravel if it is appreciated that flux cutting is a special case of flux linking and implies assumptions about the remainder of the circuit. Flux linking is the more fundamental and should be used in all "difficult" problems, and will generally yield the correct answer.

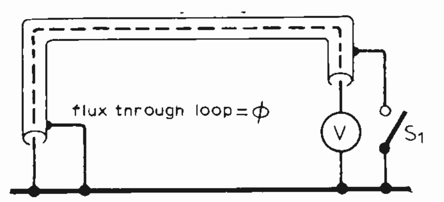
A small point about the effectiveness of screening is worth stating. The screening provided by braided copper, solid copper and aluminium tube, or solid high permeability tube, does not differ in principle, only in relative effectiveness. The screening is a function of conductivity, permeability and thickness of the material; hence for most purposes (particularly r.f.) the high conductivity of Cu and Al makes for effective screening, although μ_r for both metals is only 1.



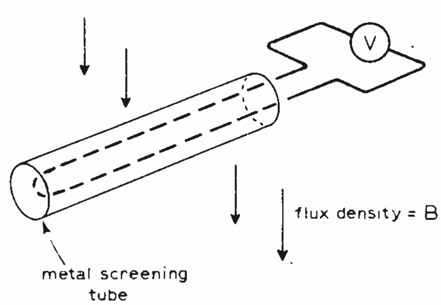
Basic unscreened loop.



Similar loop with screened leads.



V will only be zero when Φ attempts to change if S_1 is closed, thus allowing the screen to carry a circulating current which opposes the change in Φ and so reduces the $d\Phi/dt$.



V will be small for fast B changes for an unbonded screening tube since skin effect prevents currents and flux penetrating the tube, hence within the tube $d\Phi/dt \rightarrow 0$.

Interesting practical demonstrations of many of the problems of flux linking and induced voltages have been obtained in the course of a research programme being undertaken at the UKAEA Culham Laboratory. The research programme is concerned with the effects of lightning on aircraft, one aspect of which is the problem of lightning currents causing voltage transients on internal wiring in the aircraft. The mechanisms of induced voltage generation are being investigated theoretically, computationally and experimentally and good agreement between theoretical prediction and experimental measured results has been achieved. Among other experimental investigations, the usefulness of screening has been investigated and some simple generalisations may be stated: For screening to be at all effective in preventing voltages due to magnetic flux changes either (a) the screen must be able to carry net current longitudinally, or (b) both wires of the loop must be inside the screen. These points are illustrated in Figs. 3 and 4.

The importance of effective screening stems from aircraft design trends. These trends are: (a) the use of solid-state avionics systems which could be more susceptible to transients, and (b) the increased transparency to magnetic flux of the aircraft wings and fuselage owing to the use of non-conducting materials (glass fibre etc.).

The loop e.m.f. effects described above do not say however that electric fields are not produced by motion at a speed $\bar{V}$ through a magnetic field $\bar{B}$ ($\bar{V}$ and $\bar{B}$ are vectors). In fact an electric field E is produced equal to the vectorial cross product of $\bar{V}$ and $\bar{B}$. Magnetic deflection of electron beams (as in a c.r.t.) relies on this effect; the motion of the electron in the magnetic field produces a transverse electric field ($\bar{V} \times \bar{B}$) and the electric field acts on the electron to deflect it.

B. J. C. Burrows,
Culham Laboratory,
Oxfordshire.

Objections in principle are invited on a proposed airborne ground-speed indicator based on $E' = v \times B$. If B is the field of magnetised rocks on a flat earth surface, then v is the unambiguous speed of the aircraft relative to those rocks. This would be a useful adjunct to the air-speed indicator, which needs correction for wind.

However, if the magnetised rocks are in layers under the curved surface of a spinning earth, each layer has a different linear component of velocity relative to the aircraft.

Some trials of the suggested rotating dipole have been made. (G. S. Watt "A Phase-locked Loop Amplifier System," Diploma Thesis, Electronic Engineering Department, University of Hull.) The dipole has an active conductor with amplifier input connected to the centre through slip rings; the tips of the dipole are loaded by capacitor plates, which project along the axis of rotation at the side opposite to the slip rings.

Responses are detected to movement of the apparatus in the non-uniform magnetic field of a laboratory. But an objection to this version is that the active conductor and the asymmetrical capacitor form a loop, which confers sensitivity to $d\Phi/dt$.

A new attack on the problem might have a non-rotating active conductor, which transfers charge into the rotating capacitor plates by making brief central contact.

D. Midgley,
University of Hull.

Wireless World Teletext decoder

7 — Construction and interfacing with the television receiver

by J. F. Daniels

Construction techniques

Many different methods of construction are possible because the circuit is fairly non-critical in terms of i.c. layout. High-frequency decoupling should be used on the power supply rails, and about one 0.047μF capacitor for every ten i.cs should be adequate. Extra decoupling should be employed close to the two clock oscillators and also on the plus and minus five volt rails close to IC_{81}, the dual difference amplifier.

For those constructors who intend to use the p.c. boards available from Catronics Ltd, the following hints on construction may be useful. The first thing to do is to make up the through connection holes using tinned copper wire. As there are a great many of these to do, the following method will probably be found to be the quickest. Support the board, component side down, about ¼in above a flat surface. Take a long length of suitable tinned-copper wire and push it through a hole that requires connecting through until it rests on the surface under the board. Solder it on the upper surface of the board and cut off with side cutters. Continue by soldering all the wires on the same side of the board, and then turn it over and solder the other side. The underside of the board is done first because it is easier to differentiate between connecting holes and i.c. holes on this side. Holes for capacitors and resistors are distinguished by the fact that they have larger "roundels".

After the connecting process has been carried out on the two digital boards, the i.c.s. may be mounted, and care should be taken here to ensure that no pins are left unsoldered. Only some pins require soldering on the upper surface of the boards and these are indicated by roundels. Where space permits these roundels have extra tabs to increase the soldering area. Great care should be taken when soldering the m.o.s. random-access memories on board one, and similarly the read-only memory on board two. Although all the inputs are protected to a certain extent against static charges, care should be taken to ensure that the soldering iron tip is adequately earthed. The printed-circuit boards have been designed in such a way that i.c. holders may be used for the m.o.s. devices to avoid soldering on the top surface of the board and this is probably the safest, if slightly more expensive solution.

Capacitors, resistors and preset potentiometers can then be added. Some of these components may require soldering on both sides of the board and the best rule to follow is: wherever there is a roundel, solder it!

When both of the digital boards have been completed they should be joined together by wire links along the rear edge of the boards. These links are best made from lengths of insulated stranded wire, each one being about two inches long. This enables the boards to be "opened out" if access is required to the i.cs on the lower board. At this stage the four power supply leads may be connected to the lower board. (Note that the two leads for the −5 and −12 volt supplies only go to the lower board, and no links are used to the upper digital board at this point.)

The analogue board may now be constructed. This is only a single sided board and a number of wire links are required as shown on the layout diagram. The analogue board is intended to be mounted above the upper digital board at the right hand end. Three wire links are needed at the upper (short) edge to the lower digital board, for the plus 5, minus 5 and 0 volt rails, and five more links at the top end of the right hand edge are connected to adjacent pads on the uppermost digital board. These links to the analogue board should be long enough to allow removal of this board, to allow "unfolding" of the two digital boards.

Connections to all the decoder function switches are made to the right-hand edge of the lower digital board and this board projects further than the other boards at this end to facilitate connection of the leads. The suggested method of connecting the function switches as shown in Fig. 5 (April).

If lower-case characters are being included in the decoder the extra board should be made up in a similar way to the two larger boards. The extra board is intended to be mounted above the upper digital board at the left-hand end, opposite the analogue board. Wires should then be connected from this board to the underside of the lower digital board. It is advisable, however, to get the decoder working and lined up before adding the lower case board, as any faults will be located more easily if the lower case board is not present.

Video switching and interface

This board is mounted in the TV receiver and must be capable of switching the red, green and blue outputs of the Teletext decoder into the receiver in place of the TV picture. Before describing some typical receiver and video switching circuits, it would be as well to examine the problems which will arise, and describe ways of overcoming them.

Let us assume that we have an "ideal" receiver which we wish to modify. This receiver will have three identical video amplifiers for the red, green and blue signals and the amplifiers will have capacitor-coupled inputs, i.e., the amplifier will be internally biased and clamping of the three signals will take place at the c.r.t. cathode. The amplifiers will require an input of about 4V pk-pk and have a flat amplitude frequency response up to at least 5.5MHz.

If a receiver with this type of amplifier were being modified, a simple method would be to use a three-pole changeover relay to disconnect the amplifier inputs from the red, green and blue picture information and connect the outputs of the Teletext decoder. Although this method would produce a perfectly acceptable Teletext display, it would have the disadvantage that newsflashes and subtitles could not be shown in boxes, as intended.

In order to display boxed information, the video switches must operate very rapidly, preferably with a switching time of less than about 300ns. This, however, is not the complete answer, because if switching is attempted between the decoder output and capacitor-coupled or "floating" picture information, the background brightness and colour of the display box will change, depending upon the average level of each of the three picture waveforms. This can be overcome fairly easily by clamping the three TV waveforms and the three Teletext output waveforms to the same potential prior to switching. The output of the video switches can then be capacitor-coupled into the output amplifiers as before.

Figure 1 shows a basic video switching circuit, and this will be described initially. Alterations to the basic circuit will then be considered in conjunction with different TV receiver designs. The actual switching elements are contained in $IC_{1,2}$, and these are c.m.o.s. CD4016 analogue switches, each with its own control input. When the control input is at the 0 level, the input and output terminals are effectively open circuited, and when at a 1 level, the input and output terminals represent a resistance of approximately 300 ohms. The device will pass frequencies up to about 10MHz, which is ideal for our purpose, and as long as a fairly high supply voltage is used, it is quite linear in operation. The slight disadvantage is that, being an m.o.s. device, the switch time is not particularly fast, and this can cause slightly coloured edges on the inserted box. However the advantages of simplicity and cheapness outweigh this slight disadvantage.

The typical switch arrangement shown in Fig. 1 uses two CD4016 i.cs. The control inputs are fed from the outputs of two high-voltage open-collector t.t.l. gates, because correct operation of the switches requires that the control-input voltage must approach the supply voltage. The input from the decoder function switches is normally held at 0 by a 470Ω resistor, ensuring that the switches are left in the TV position if the decoder is not connected to the switch board. Resistors $R_{4,5,6}$ are chosen to reduce the amplitude of the Teletext signals to the same as that of the TV signals, and capacitors $C_{4,5,6}$ may be added to boost the h.f. response if this is found to be necessary. (Because of the high frequency components contained in the verticals of the alphanumeric characters, some commercial receivers may not have a sufficiently good h.f. response to display them adequately. Later in this article a simple modification to the Teletext circuit will be described which reduces the h.f. requirement of the video amplifiers by effectively increasing the width of character verticals.)

The three capacitor-coupled video signals are clamped to the potential which is set by R_1, VR_1 and R_3. Similar, the Teletext signals are clamped to a voltage set by R_7, R_8 and VR_2. In this particular arrangement the actual clamp voltage is arbitrary but would probably be best set to about 3V. Two separate potentiometers are used so that the black level of the Teletext signals can be varied independently of the picture brightness, and thus the background brightness of the inserted box may be adjusted. The reason for not clamping to 0 volts is that the c.m.o.s. switches are not particularly linear when the input signal approaches the extremities of the supply voltage, and raising the potential of the signals ensures linear operation of the switches. After the video switches, capacitors C_1, $_{2,3}$ remove the d.c. component of the waveforms before they are fed into the receiver video output amplifiers. (It

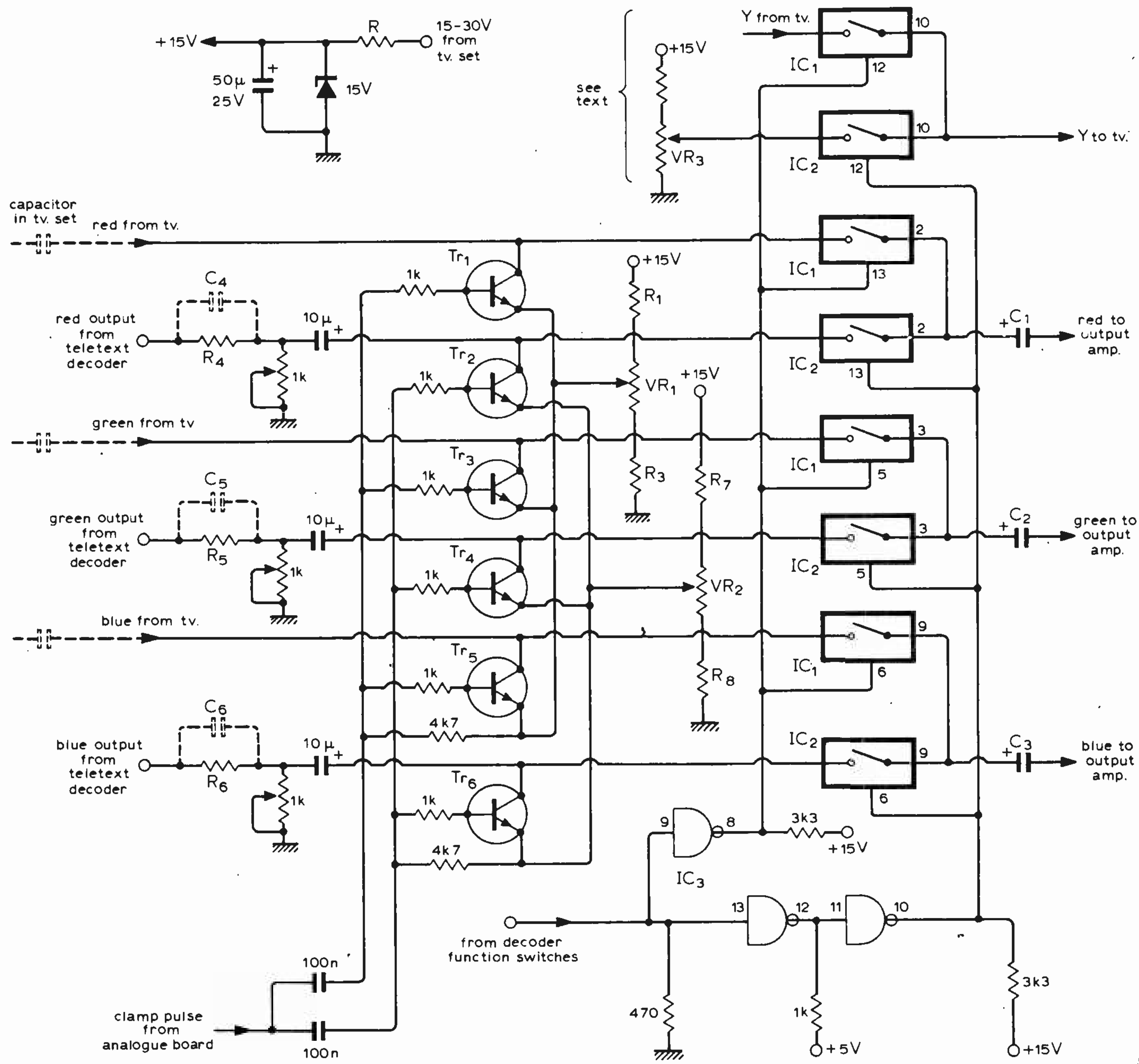


Fig. 1 The basic video switching circuit.

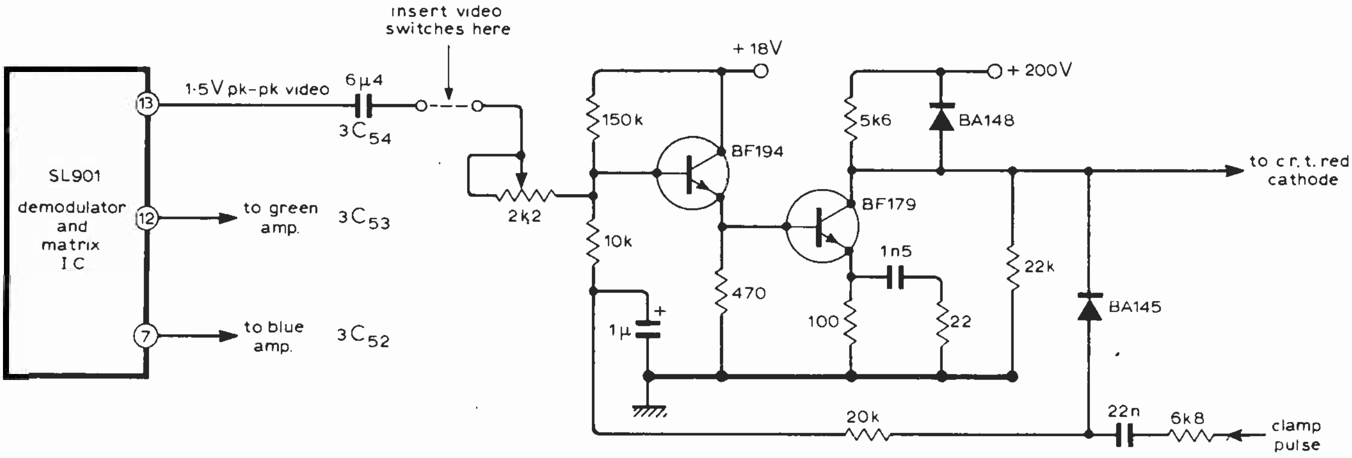
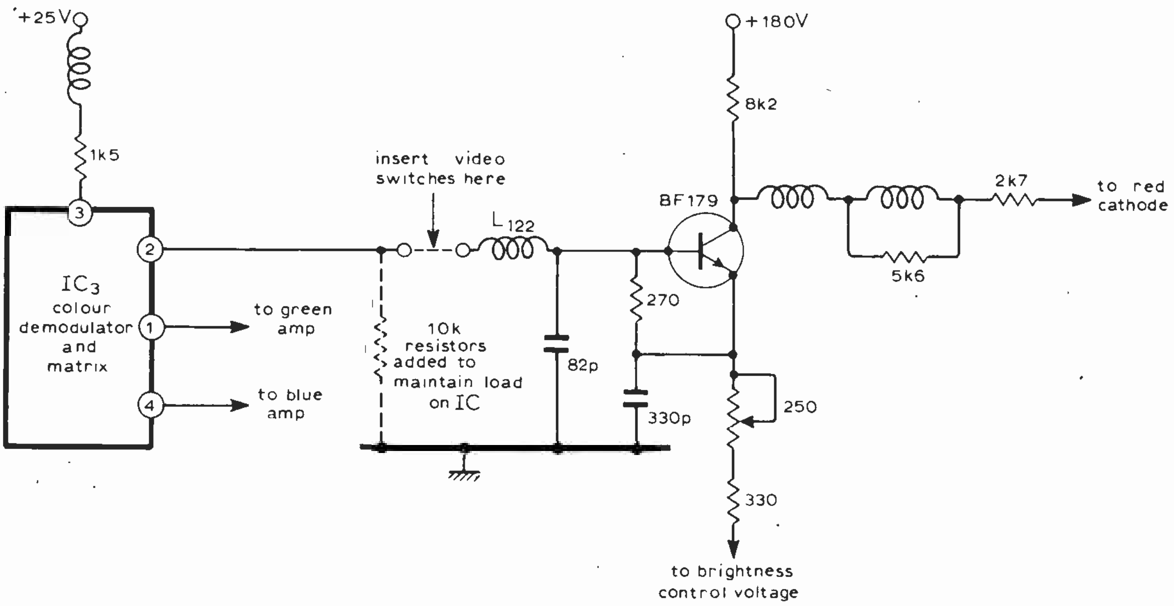


Fig. 2 Video output circuitry of the Bush CTV182S, CTV184S and CTV187CS.



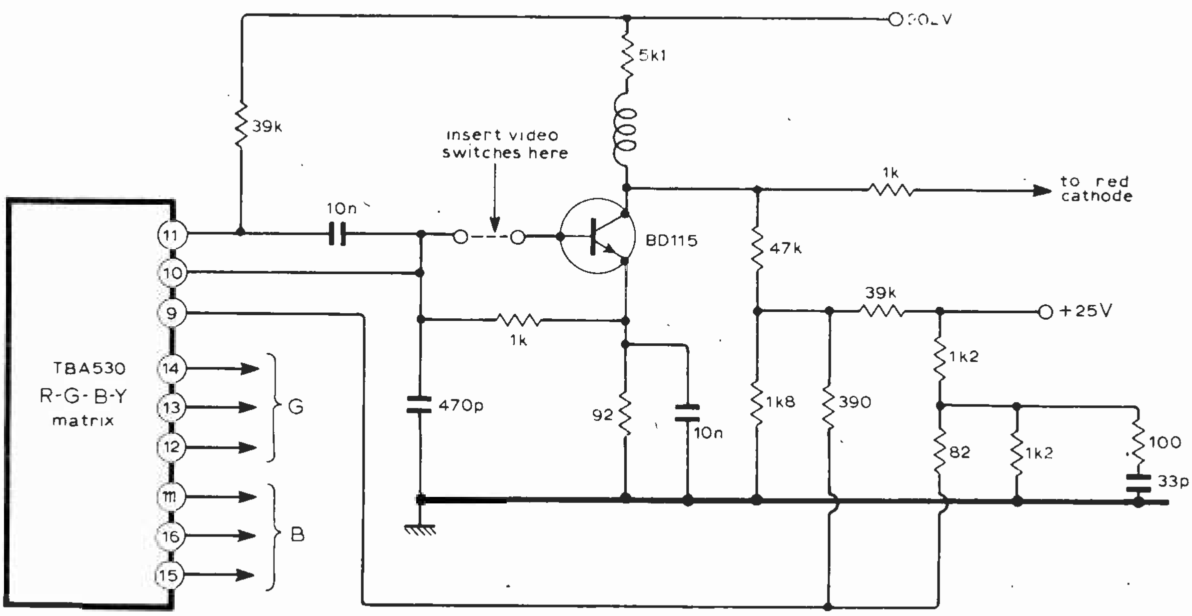


Fig. 3 The BRC 8000 shown above, while below is the Philips G8 video output.

should be noted that the polarity of these and the input electrolytics will depend on the individual receiver design and may not be as shown.) Figure 1 shows a fourth pair of switches which are not required when modifying a receiver of the type described. They are useful, however, when modifying a set which has colour-difference amplifiers (R-Y, G-Y and B-Y), as they can be used to switch off the luminance signal, which would otherwise be present while watching the Teletext display.

Figure 2 shows the circuit of one of three identical output amplifiers used in Bush models CTV182S, 184S, 187S, 192, 194, 196, 197C, 199 and 1026. For sets which have output amplifiers of this type, i.e., capacitor-coupled, positive-going R, G and B video inputs of less than about 5 volts peak to peak, the circuit just described will be adequate. Other receivers using similar amplifiers are: Murphy CV1916S, 1917, 2211S, 2212, 2213, 2610, 2611 and CT2516CS; Alba CS1919; Decca CS1910, 2211, 2213, 2611; ITT/KB CK600, CK500, CK701, CK822, CVC5, Colourscope 20 and Studio 100, and probably quite a few others.

Next will look at some receivers which differ from those just described by virtue of the fact that the output amplifiers are directly-coupled. The amplifiers still carry the R, G and B signals, but instead of being clamped at the tube cathodes, the signals are clamped earlier in the circuit and directly-coupled from this point through to the tube cathodes. Two circuits are shown in Figure 3; the first is a type used in the BRC8000 chassis, which is used by a number of different manufacturers, and the second is a circuit using Mullard i.cs used in the Philips G8 chassis, which is also quite widely used.

Because these sets have directly-coupled amplifiers, the easiest course of action is to remove the capacitor coupling in the original video switch circuit (remove $C_{1, 2, 3}$) and this means that in the TV mode the only change in operating conditions will be the addition of the effective resistance of the c.m.o.s. switch, about 300Ω, which will almost certainly be negligible. Since the TV signal is effectively clamped at this point in the circuit, we no longer require Tr_1, Tr_3 and Tr_5. The Teletext input circuitry can remain unchanged and VR_2 should be adjusted to make the Teletext signal black level about the same as that of the TV signal at this point. VR_2 effectively forms a Teletext brightness control.

It should be noticed that three 10kΩ resistors are required on the output pins of the matrix i.c. in the BRC8000 circuit. These resistors form the emitter load for the output transistors in the i.c. when Teletext is selected, to prevent the signal voltage at this point rising towards the positive supply rail and upsetting the operation of the c.m.o.s. switches. (The input signals to the c.m.o.s. switches must not be allowed to go outside the limits of the supply voltage to the i.c., as incorrect operation will result, with possible breakthrough on switches which are supposed to be in the off condition.)

Other receivers using the BRC8000 chassis are the Ferguson 3712, Alba 8000 and Marconiphone 4712 to name a few. Similar output stages are also used in Decca models CS2030, 2230, 2630 and 2631.

The three types of output stage just described cover the majority of the more modern British-made sets. However, there are still many older types of receiver giving good service and it was the tendency until fairly recently to drive the grids of the TV tube with colour-difference, valve video output stages. (All the circuits so far described feed the cathodes of the tube with the red, green and blue signals.)

This older type of circuit had three identical valve output stages, each one usually consisting of a triode-pentode valve of the PCL84 type. The pentode section was used to drive the tube grids with either the R-Y, G-Y or B-Y signals, and the triode section was used to clamp this signal at the tube base. The cathodes of the tube were effectively joined (sometimes potentiometers were used to vary the amount of drive to each cathode), and fed with the luminance output signal from a separate pentode valve.

A typical circuit used in the Pye CT70 series chassis is in Fig. 4. All three output stages are identical, and they are fed from three transistors, two of which are used as R-Y and B-Y amplifiers, the third being used to derive a a G-Y signal from the other two. Although it might be possible to drive the basis of these transistors, the three circuits are not identical at this point and trouble might be experienced with the green channel. The best place to feed the signal in is almost certainly at the grid of the pentode valve as shown in the diagram. The only disadvantage of feeding in here is that the Teletext signal must be negative-going at this point to produce the correct display.

There is no reason why the Teletext signals should not simply be inverted, using three ordinary t.t.l. inverters, prior to the attenuating resistors R_4, R_5 and R_6. The six capacitor-coupled signals can then be clamped using Tr_{1-6} as before, but the clamp potentials should be greater than before, at about 6V, as the signals are now negative-going at this point. Capacitors C_1, C_2 and C_3 should be used to couple the switch outputs as before, and these capacitors can be considerably smaller than before as they are feeding valve grids. The Teletext tisplay will now appear on the screen, but it will be superimposed on a black and white TV picture because the luminance signal is still connected to the tube cathodes. Some means must be found of switching off the luminance signal and for this purpose we can use the two remaining c.m.o.s. switches. By connecting them as shown in Figure 1 it is possible to insert the switch in series with the luminance chain at some suitable low-voltage point. VR_3 may be used to adjust the d.c. conditions during switching to keep the black-level correct.

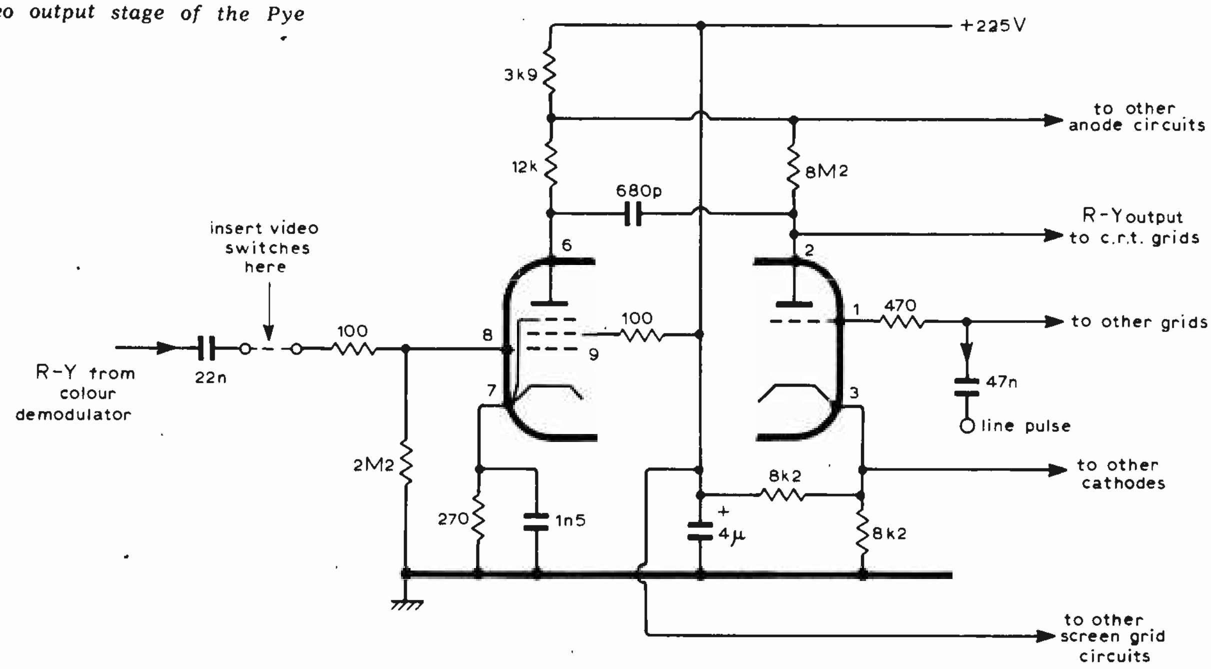
Other sets using this type of output stage are as follows: Bush CTV25 and CTV167; Murphy CV2510 and CV2511; Baird 700 series and 710 series; Decca CTV25; Pye CT79, CT152 and CT153; Dynatron CTV1, CTV1CH and CTV2; Ekco CT102 and CT104; Ferranti CT1166 and 1167; Invicta CT7050; GEC 2040, 2041, 2073, 2100, 2103 and 2107.

Before leaving the subject of modifying TV receivers, the BRC2000-3000 series of receivers, which do not really fall into any of the previous categories, should be examined. Figure 5 shows a video amplifier used in the earlier 2000-series chassis, but the later 3000- and 3500-series used a configuration very similar to this and for our purposes can be considered the same. The three video amplifiers are basically identical, with one important difference. The R-Y and B-Y circuits are both as shown in the diagram, but the input capacitor of the G-Y amplifier is connected to the +30V rail, effectively earthing this point to a.c. and turning the first transistor into a common-base stage. The emitter of this transistor is fed with different amounts of R-Y and B-Y signals to form the G-Y signal.

The best approach to modifying this type of receiver is to treat the three amplifiers as identical capacitor-coupled amplifiers and put the three video switches in the base circuit of the input transistors. Extra capacitors should be used in series with the inputs to the video switches, since the colour-difference signals are close to the 30V rail at this point and outside the range of the 15V supply rail permissible for the c.m.o.s. switches. The luminance chain must also be broken before it feeds the bases of the output transistors and this can most easily be done at the input to the luminance emitter follower (not shown in the diagram). As it stands, this circuit will then produce reasonably acceptable results although, because a certain proportion of the red and blue signal is still being fed into the G-Y amplifier, the green Teletext display appears rather too bright in relation to the red and blue signals. The solution to this problem is to use two extra c.m.o.s. switches, one in the R-Y feed to the G-Y amplifier and the other in the B-Y feed to this amplifier. These switches should be wired so that they are in the open-circuit condition during the Teletext mode of operation. Resistors $R_{4, 5, 6}$ on the switching board will need to be about 10kΩ for this type of receiver, and $C_{4, 5, 6}$ about 10–15pF.

The 12–15 volts required for the c.m.o.s. switches can easily be obtained from the video amplifier power rail in

Fig. 4 Video output stage of the Pye CT70/71.



the TV set, using a simple zener diode stabiliser if the rail is higher than 15V. Most sets have a supply of between 12V and 30V and the current drawn by the switching circuit is minimal.

This concludes the description of colour-receiver output stage modifications, but there remains the problem of obtaining a suitable video signal from the set to feed into the Teletext decoder.

There should be no serious problems here, but since the signal that is fed into the decoder will determine whether or not it operates correctly, it is rather important to get this bit right. The signal into the decoder should be a positive-going video signal of between about 1V and 5V peak to peak, not limited in frequency by chrominance, or other filters. The signal should preferably be taken from a low-impedance point in the circuit, to reduce any losses in the coaxial cable feeding the signal to the decoder. A large number of modern receivers employ i.c. synchronous demodulators of the MC1330 type; these are ideal, providing around 2V of positive-going video output signal. Some older sets such as the BRC 3000 series employ separate luminance and chrominance detectors and in this type of receiver the luminance detector output should be used. This is not normally restricted in bandwith sufficiently to upset the operation of the decoder. If a suitable positive-going video signal does not exist, then a small transistor invertor may be needed.

To round off the series of articles, the final part will include a description of setting-up the decoder and a suggestion for reducing the effects of restricted bandwidth in the television receiver. We also hope, at a later date, to publish a modification to allow a new, combined upper- and lower-case character generator to be used. In addition, we will try to include information on modification to the circuit to enable it to be used with the Post Office Viewdata service.

Lack of space will prevent the publication of printed-circuit board layout and component disposition, but we have them at this office and will send copies to anyone who cares to write and ask for them. Please send a large, stamped and addressed envelope.

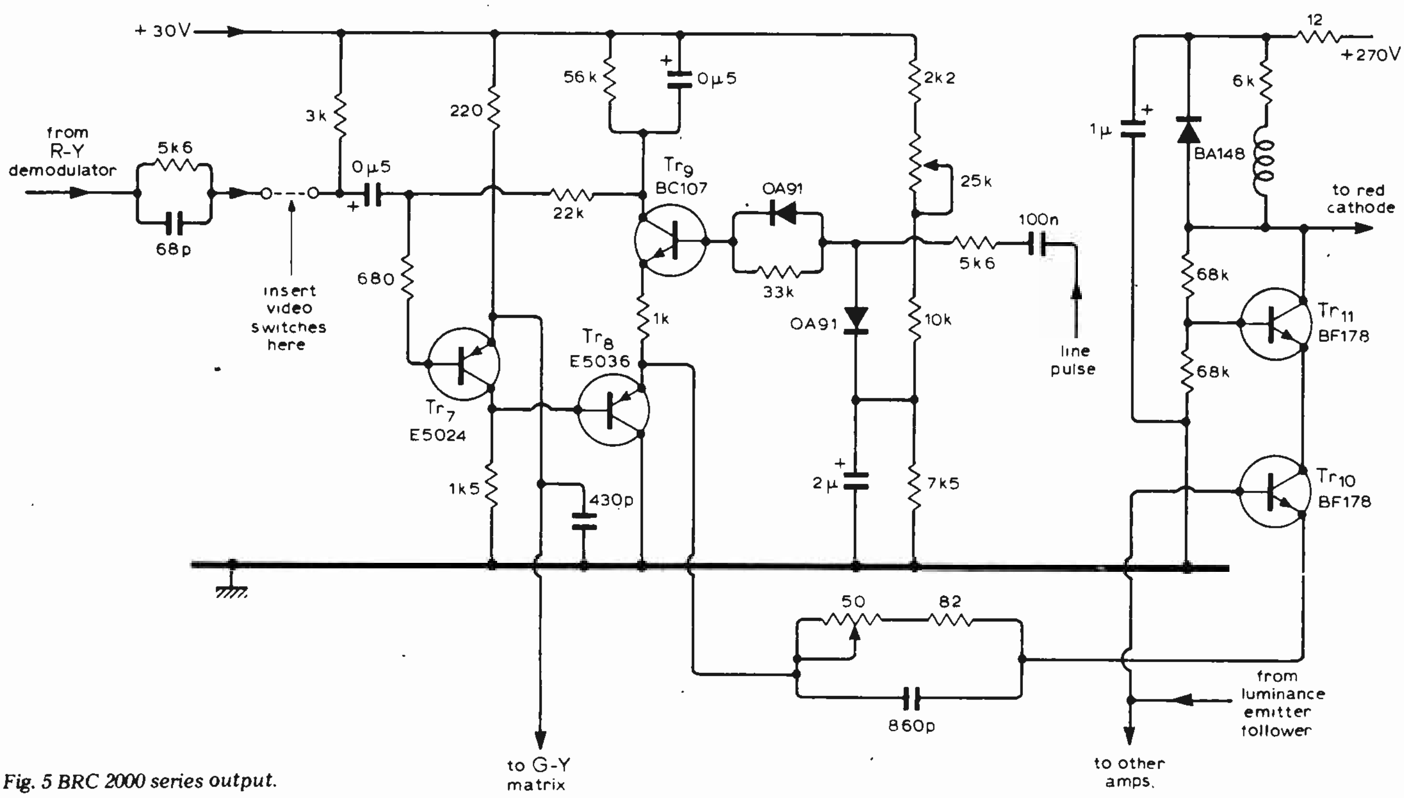


Fig. 5 BRC 2000 series output.

E.h.t. staircase generator for colour receivers

New line-output transformer needs no h.v. capacitors

by A. W. Lee, M.I.E.E.

General Instrument (UK), Ltd.

In the 1930's Blumlein pioneered the flyback transformer with its energy-recovery circuit, since which time the continuous pressure on television set designers to reduce costs and improve performance have resulted in only a few major changes. Ferrite cores have been introduced, as have winding techniques to make harmonic tuning possible, and transistors capable of withstanding reverse collector-emitter pulses of more than 1000 volts are obtainable.

With the coming of mass colour-television reception, came the need to increase the display-tube anode voltage and beam current. In Europe, voltage multipliers, fed with a comparatively low pulse voltage obtained from the line output transformer, became accepted as the normal way to obtain a d.c. output of 25kV from the 6-7kV pulse voltage.

In the second half of 1975 a new component from both European and Japanese component suppliers started to reach set-makers. This is a line output transformer which not only generates the horizontal deflection current, but also the direct voltages required by the display tube focus and anode electrodes without using any additional high-voltage capacitors.

There is very little new in the techniques used in the assembly of this component. It is a combined line output transformer and a voltage multiplier. It uses, as already stated, no additional high-voltage capacitors, but it does have diodes which are connected between its secondary windings, as shown in Fig. 1. These secondaries start at the same side, are wound in the same direction around the same core on top of each other and have the same number of turns. The flyback pulse voltage generated per turn depends on the magnetic flux changes which occur in the core and is, therefore, the same for all turns. Thus, the pulse voltage generated in a turn of an upper secondary is the same as that in a turn of the lower secondary upon which it sits. The pulse voltages generated between such turns, and therefore along the whole width of the paired secondaries, are virtually zero.

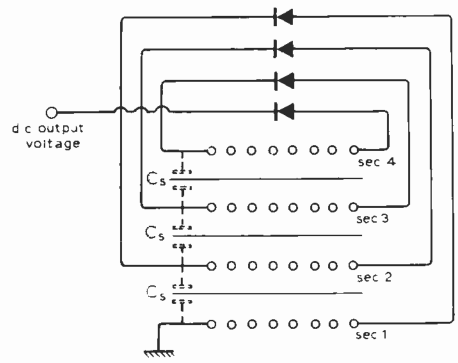
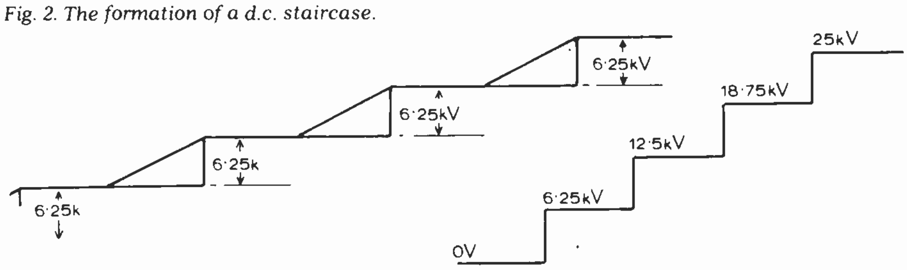


Fig. 1. Connexions of secondary coils and diodes.

The use of wide, single-layer, windings keeps the self capacitance between each pair of secondaries high. By connecting the finish of a lower secondary to the start of the secondary immediately above it, via a diode, the lower coil charges the self capacitance C_s, which exists between the two windings, to the peak flyback voltage of the lower secondary. The upper secondary, therefore, sits on a direct voltage level set by the peak voltage generated in the lower secondary. Figure 2 shows that a voltage staircase is built up, the number of steps being set by the number of secondaries and diodes. This technique means that a direct output voltage can be obtained, which is a multiple of any one secondary winding peak pulse voltage. If there are only four secondaries and diodes, each with a peak flyback voltage of between 6 and 7kV, an output voltage of 25kV can be obtained.

The reliability of the new components is yet to be determined. Set makers are currently evaluating samples, with particular reference to faults which could be caused by encapsulation and the handling of fine wire. The diodes are internal and cannot be changed.

Fig. 2. The formation of a d.c. staircase.



Books Received

TV Sound Operations by Glyn Alkin. This book is concerned with the art and practice of television sound operation, and is intended for the guidance of people involved in all types of audi-visual systems. The text is divided into sections covering a general introduction to the sound medium, types of microphone, methods of applying microphones in various circumstances, hardware following the microphone, methods of tackling speech and music, and, finally, peripheral equipment. Price £2.25. Pp.176. Focal Press Ltd, 31 Fitzroy Square, London W1.

The Story of Radio by W. M. Dalton. This story is divided into three books, called How radio began, Everyone an amateur, and The world starts to listen. The first volume deals with the history of radio up to the first War. The second volume is devoted to the pioneers of radio. These amateurs, many of them ex-servicemen, compelled governments to provide public broadcasting services and developed the long distance, low-power short wave communication as we know it today. The final volume continues with the development of radio in an era when people started to listen to BBC transmissions, and the quality of sound broadcasts was being improved. Price £4.50 per volume. Pp.160, 168 and 168. Adam Hilger Ltd, Rank Precision Industries, 29 King Street, London WC2E 8JH.

Instruments, Electronics and Automation

IEA exhibition at the new National Exhibition Centre

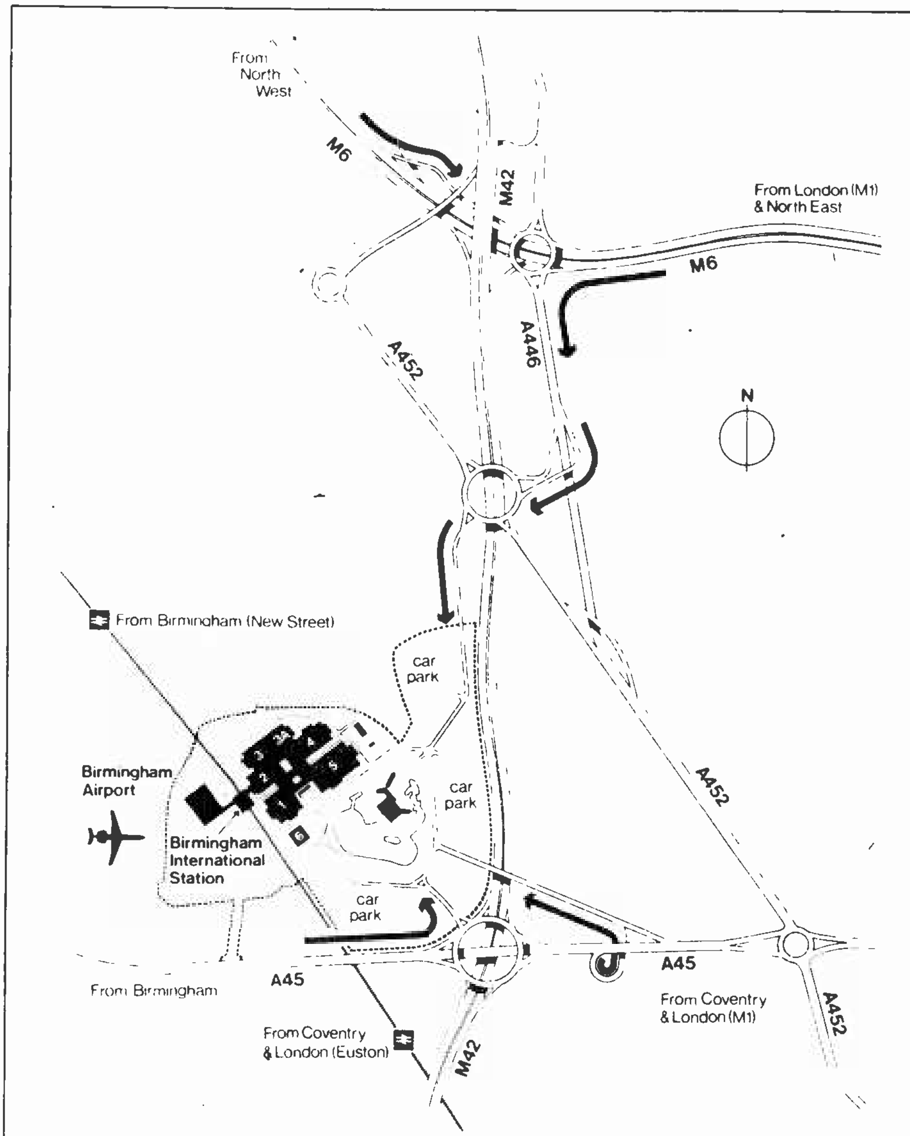
Aerial view of the National Exhibition Centre and its environs. On the left is the adjacent specially built railway station.

For the first time the IEA Exhibition is to be held at the new National Exhibition Centre, Birmingham, and as it is the first time, this preview contains details of how to get there and what to expect. The show will take place from May 3 to 7, 1976, opening times being 10.00 to 18.00. On display will be a vast range of electronic equipment, systems and basic components. The length of the exhibitors' list on page 72 gives an indication of company participation in the show, many firms coming from overseas. Entrance price to the 11th IEA exhibition (which also includes admittance to Electrex '76, the 18th International Electrical Exhibition, combined this year with the IEA show) is £1.00.

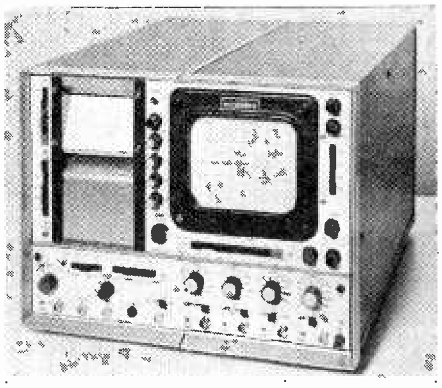
The accompanying road map and list of train times should provide visitors with a guide to the travel services available for reaching the exhibition centre.

Viewdata and Teletext

A special demonstration at the show will be on the *Wireless World* stand which is shared with *Electronics Weekly*. This is a demonstration of Teletext, and, possibly, the Post Office's Viewdata system of transmitting pages of written information for reception on a domestic TV set. Teletext information is broadcast along with the normal television programme signal whereas Viewdata is transmitted over the existing domestic telephone line (see "Viewdata on trial soon", November 1975, p.532). A full public service of Viewdata could start in 1978-9, say the Post Office, if present trials show that it is a commercially viable system.



Map of access by road, rail and air to the exhibition centre.



Four-channel recording oscilloscope, the FOR-4 produced by Medelec, can be used as a strip chart recorder, an X-Y plotter or as an alternative to a conventional oscilloscope. A modified version to be shown for the first time includes an automatic repriming circuit which operates in the single shot mode to allow the recording of random transients.

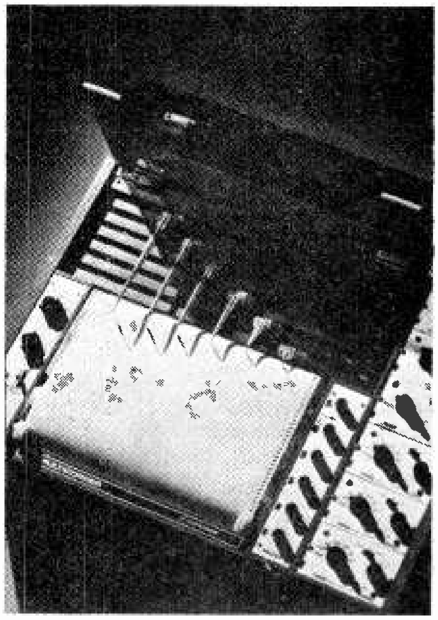
New Products at the show

Gould Advance instruments on show include new products in the oscilloscope, digital multimeter, signal generator, timer-counter and chart recorder ranges produced by the company. Oscilloscopes include the recently launched OS4000 digital storage 'scope which combines a conventional 10MHz performance with a digital memory system capable of storing signals up to 450kHz, together with the new 4001 "hard-copy" output module.

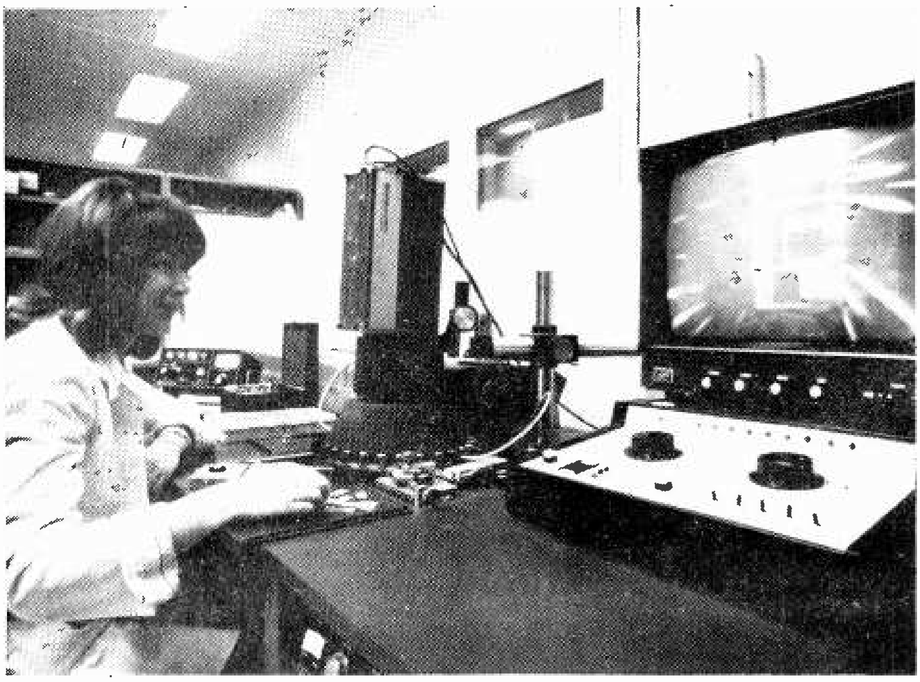
First showing will be made of Avel-Lindberg's system 520 static no-break power supply system which can provide up to 45kVA of emergency power if the mains supply fails. The equipment automatically senses an a.c. mains failure and by means of a solid-state static switch changes over the supply source instantaneously and draws power from a d.c. battery bank.

The Computer and Instrumentation Division of Westinghouse will be displaying the following new items: the Veritrak 75 range of process control instrumentation; the model 215 Oxygen Sentinel; model 2570 process control computer packages; and the New World computer numerical control systems, together with the series 100 solid-state numerical control units which are for sequencing and motion control of a range of machine tools.

Hinchley Engineering double bobbin transformers now include ratings from 1VA to 150VA – which has enabled them to provide class II designs meeting the requirements of the Consumer Protection Act. Portable transformers of "all-insulated" construction (up to 1500VA) are being shown for the first time. These will be available with a range of socket outlets to BS196, BS4343 and also BS1363.



Included in the range of Watanabe recorders are: the new Microservo single pen recorder; the improved Mk III Linearcorder and Miniwriter, 1 to 12-pen, fast response recorders; the A3 size X-Y recorder, supplementing the A4 size high speed recorders which have a writing speed up to 100cm/s; the model WX625 digital drum plotter and WX511 digital flat bed plotter, both designed for use with computers to produce fast recordings of graphs, designs, maps, etc; also the standard range of Multicorder and Servocorder multi-pen potentiometric recorders.



Custom designed resistor networks may be either laser or air abrasive trimmed. The picture on the left shows RIFA equipment for laser trimming.

List of exhibitors

A.R.O. Machinery Co.
Adcola Products
AEI Semiconductors
AGA Infrared Systems
Aktiebolaget Rifa
Alcon Instruments
Allotrope
Alma Components
Ampex GB
Amphenol
Anacon (Instruments)
Analysis Automation
Analytical Devl. Co.
Anderman & Ryder
Anglo Weld Equip.
Anopoint
Appliance Components
Arca Controls
Arcolectric Switches
ARI Industries
Arkon Instruments
Arrow-Hart (Europe)
Astralux Dynamics
Aughton Automation
Austen, Charles, Pumps
Automated Quality Lathe Parts
Automatic Oil Tools
Avdel
Avel-Lindberg
Avery, W. & T.
Avo

B.H.S. Electronics (Sales)
Bafco
Bahco Tools
Bailey Stamp & Sons
Barr & Stroud
Batley Valve Co.
Bauch, F.W.O.
Belix Co.
Bell & Howell
Berger Lahr
B & K Laboratories
Blakeborough, J., & Sons
(Bopla) Bundaplast
Bowthorpe
Bristol Automation
British Brown-Boveri
British Central Electrical Co.
British Physical Laboratories
Buchanan Electrical Products
Budenberg Gauge Co.
Burgess Micro Switch Co.
Burr-Brown International

Calex Electronics
Cambion Electronic Products
Carlo Gavazzi (UK)
Cassinelli & Co.
Cetronic
Chemical & Thermal Controls
Chessell
Chinaglia UK
Circuit Automation
Clare, C.P. Electronics
Clarke-Hess Communications
Colstar
Com Dev
Consolidated Products
Continental Disc Corporation
Controls and Automations
Coutant Electronics
CRC Equipment
Critchley Brothers
Crump, A.E. Spectronics
CSM (Engineering)
Custom Component Switches
Custom Synthetics

D.G. Controls
Data General
Data I/O UK
Data Technology Corp
Datron Electronics
Daturr
Datwyler AG
DB Products Inc.
Delta Controls
Derby Automation Consultants
Digital Equipment Corporation
Digitron
Dowty Hydraulic Units
Dunegan-Endevco

Dynamco (AOT)
Dyson Diecastings

E.L.D.R.E.
E & D Manufacturing
Educational Measurements
Electrical Contracts
Electro-Craft Corporation
Electrohome
Elektromodul
Electronic Flo-Meters
Electronic Instruments
Electronic Services & Products
Elgenco
Emerson & Cuming (UK)
Endevco
Endress & Hauser (UK)
English Glass Co.
Engineering Suppliers Associates
Environmental Equipments
Erma
ESPA
Evans, F.W.
Evershed & Vignoles

F.W. Components
Fabrique Nationale de Ressorts
Farnell Instruments
Feedback Instruments
Ferranti
Ferrograph
Filhol, S.J.
Foreign Trade Company Metronex
Formby, John & Co.
Foster Cambridge
Foster Transformers
Fothergill & Harvey
Foxall, T. & Sons
Foxboro-Yoxall
Frequency Devices
Frost, N.T.
Furnace Instruments
Eduard Fussinger
Future Film Developments

Gain Rad
Gauges-Bourdon (GB)
Gay-Misuratori Elettronici
GEC
General Automation
General Radio Co. (UK)
Goldring
Gore, W.L. & Associates
Gresham Lion
Grundig (GB)
Guest International
Guildline Instruments

H.I.D.B.
Handy & Harman Tube Co.
Hartmann and Braun (UK)
Hawnt Electronics
Healey Meters
Heat Trace
Hellermann Electric
Hengstler G.B.
Hepworth Electronics
Hepworth Group
Herga Electric
HES Electronics
Hinchley Engineering Co.
Hitachi Electronic Components (UK)
Hoke International
Howaldtswerke Deutsche Werft AG
Hunter Equipment Sales
Hutson Industries
Hybrid (Component) Systems UK
Hymatic Industrial Controls

I.E.R.C.
Imhof-Bedco
IMO Precision Controls
Industrial Pyrometer Co.
Inovan-Stroebe KG
Insa Divison, Sen Electronique
Instem
Institut Dr. Ing Reinhard Straumann
Instrument Links
Insuloid Manufacturing
Interelectric
Interlevel Control
International Instruments
International Rectifier
Intrel

ITT Controls
ITT Instrument Services
Ivo Counters

Kager
KDG Instruments
Keighley Instruments
Kelor
Kempston Electrical Co.
Kent, George
Kerry Ultrasonics
Keyswitch Relays
Kirsten, G. & A.
Klaus Schaefer
Klippon Electricals
Kogyo, Rikadenki, Co.
Kovo Foreign Trade Corp.
Krohn Hite Corp

Laaser U. Co. Nachf
Landis & Gyr
Lan-Electronics
Lectromec Controls
Leeds and Northrup
Lee Engineering
Lemosa S.A.
Lemo (UK)
Licon Electronics
Lindstore, F.E.
Litre Meter
Littex
Lloyd, J.J. Instruments
LNR Communications
Londex
London Instrument Repair Centre
Lucas Electrical
Lyons, Claude

Magnetic Polymers
Marconi
Markem
Markovits, I.
McMurdo Instrument Co.
Measurement Technology
Medelec
Meko Instrument
Mentor Electronic
Mentor Inc.
Metronic AG
Meyer, Wm. A.
Micanite & Insulators Co.
Micro Computer Systems
Micro Consultants
Mid-West Instrument
Millivac Instruments
Mine Safety Appliances Co.
Miteq
Mitsui Machinery Sales (UK)
Monroe Calculator Co.
Mullard
Multi-Contacts

N.V. CRC Chemicals Europe
National-Standard Co.
Neff Instrument Corp.
Negretti & Zambra
Newport Instruments
NF Circuit Block Co.
NH Research
Non Linear Filters
Nova Electric Manufacturing Co.
NRDC
Nuclear Chicago Division

Ormiston, P. & Sons
Osram (GEC)

P.S.I.
Parmeko
Parsonage, W.F. & Co.
Pearl, A.B. Mikrofonlaboratorium
Pepperl & Fuchs (GB)
Perkins, E. & Co.
Phenix Electronics
Plasmoulds
Platon, F.A.
Portescap (UK)
Precision Relays
Prefag
Printed Motors
Proper Equipment
Pye of Cambridge

Racal Instruments
Radio Resistor
Ralcon EMC
Ramseyer
Record Electrical Co.
Redpoint Associates
Rendar Instruments
Rhodes, B. & Son
Riam S.A.
RKB Precision Products
Rojon Technical Services
Rosemount Engineering Co.
Rothwell (AOT)
Rothwell Valve Company (AOT)
Roxburgh Electronics
Ryaland Pumps

S.E.B.S.
S.E.C.M.E.
Saft (UK)
Sangamo Weston Controls
Schroff KG
Scopex Instruments
Semiconductor Specialists UK
Sensors and Systems
Sescom
Shackleton Systems Drives
Siegert Widerstandsbau KG
Sifam
Sigma Instruments
Signal-Anlagen Peter Brockskes K.G.
SIMA
Sirco Controls
Smith, A.O., Meter Systems UK
Sonicstore
Souriau
Stafford King (Engraving)
Stanley Palmer, G.A.
Steatite Insulations
Sturge Automation
Sullivan, H.W.
Superior Electric B.V.
Swiss Instruments & Components
Symonds, R.H.
Symot
Syntest Corporation
Synton

T.E.C.O.
T.E.M. Sales
Taylor Electrical Instruments
TCS Eurotherm
TEC
Tektronix UK
Telefonbau und normalzeit
Teradyne Components
Thermo Electric International
Thomson-CSF
Thorn
Topper Cases
Transmission Lines
Transmitton
Treston OY
Trident Engineering
Trimm
Triskelion
Trump-Ross Industrial Controls

Unicell
Unimatic Engineers
Unit Controls

Varta (GB)
Vectron Laboratories
Vero Electronics
Volkseigner Aussenhandelsbetrieb

W. Controls
Walsall Electrical Co.
Wandel & Goltermann
Watson's Anodising
Wayne Kerr Co.
Weller Electric
West Hyde Developments
Westinghouse Electric
Weyfringe
Whiteley Electrical Radio Co.
Widney Dorlec
Wika Pressure Gauges (UK)
Wilmott Breeden Electronics
Wireless World

Zettler UK Division
Zorn KG

Communication theory

2—Redundancy and the exchange rate

by D. A. Bell,

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In the April issue we considered the finite nature of selective information, moved on to an entropy measure of information in the presence of uncertainty and cited Shannon's formula for the communication capacity of a noisy channel. But we omitted any mention of **redundancy,** which is perhaps the most difficult concept in communication theory. The dictionary account of "redundant" is

> "Superfluous (freq. of workers in industry), excessive, pleonastic; copious, luxuriant, full."

In a single, more colloquial phrase it means "More than the minimum necessary to do the job." But first one must ask what job is to be done in what conditions. Secondly although one may regard something superfluous or excessive as wasteful, one may sometimes feel inclined to pay a little extra for something which is copious, luxuriant or full; so has redundancy anything positive to offer in communication theory?

In answer to the first question, the job is to communicate information in the presence of noise. If the information is originally in discrete form, such as numbers or written characters, the minimum number of digits which will represent it unambiguously can be obtained from formula (7) in the April issue and if more digits or characters are employed than this the extra ones are redundant. For example, we think of an average English word as being made up of 5 letters from a 26 letter alphabet. Applying the formula we get $5\times \log_2 26 = 23.5$ bits. But it seemed in part 1 that an average English word could also be identified by 4 decimal digits plus one binary symbol, giving $I = 4 \log_2 10 + 1 = 14.3$ bits. Finally we said that by repeated binary division of the dictionary any word could be represented by not more than 16 binary digits. Any form other than the direct use of binary decisions thus requires more bits, in other words it introduces some redundancy.

But before condemning redundancy as wasteful, consider the possible effects of noise. If due to noise a signal transmitted as 509 R 4 (in our dictionary code April issue) were received as 508 R 4 the end result would be the world "gemmule" instead of "generation", which would make the phrase meaningless. On the other hand the result of changing one letter in "generation" say to "generption" would probably appear as a mis-spelling for which the recipient could guess the appropriate substitution. The redundancy in the spelling of English words has then served a useful purpose in making it possible to correct errors. If we are handling a passage in English language, as distinct from isolated English words, the context also helps. Experiments have shown* that in a passage in English about half the letters can be deleted before it becomes impossible to guess what the words were.

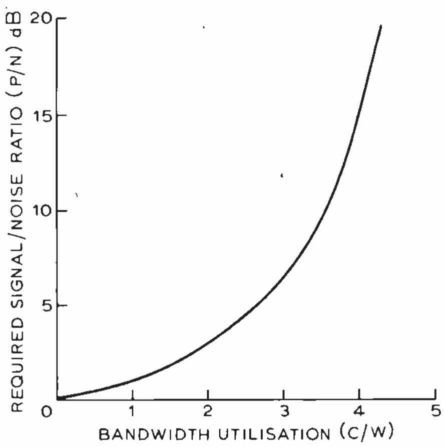


Fig. 1. Required signal/noise ratio, P/N, as a function of bandwidth utilisation: C/W = bits/s per hertz of bandwidth.

Words have to be pronounceable, which eliminates a large number of combinations. As a simple example, there are $26^3 = 17{,}576$ different combinations of three letters; but if we require one of the three to be a vowel the number comes down to $5 \times 26^2 = 3{,}800$ and we should have to include some combinations of four letters to cover as many as 17,576 words. Thus the exclusion of some combinations leads to an increase in average length of words which we recognize as redundancy. If conditions for spoken communication are very bad one may need to add further redundancy by spelling on a basis such as "A for apple, B for baker . . ." Years ago, when telephone lines were not always good, a telephone directory contained a list of such alphabet words headed "Aids to clarity of speech." What was meant, of course, was "aids to overcoming lack of clarity in speech."

So we see that redundancy has value in making it possible to detect or correct errors which may be caused by noise in the communication of information. The redundancy in English words is spread in rather an irregular way, so that it does not give the greatest possible error-protection in return for the extra length of signal involved. Over the last couple of decades a great deal of effort has been put into the design of codes for binary signals to allow the detection or correction of errors automatically. The redundancy of English words is normally utilised by a human operator at the receiving end of the channel, who mentally compares the received "word" with what he "knows to be right." A computer replacing the human operator would have to search the dictionary every time to find the nearest match of what it had received to an English word, and this would be a very slow and cumbersome business. The simplest error-detecting code for mechanised telegraphic use is the Van Duuren code, which represents each letter by a combination of seven binary digits instead of five. With the two extra digits providing redundancy one uses only the 35 combinations of the seven digits (out of a possible 128) which contain 3 mark and 4 space digits. Any single error (and in fact any odd number of errors) will upset the count of 3 mark digits and so will be detected, as will some combinations of multiple errors.

* C. E. Shannon, "Prediction and Entropy of Printed English." *Bell Syst. Tech. Journ.* vol. 30 (1951), p.50.

Among the more complicated and powerful codes are the Hamming codes for correcting single errors, the BCH codes which can be designed for correcting any number of errors and various others which have special properties for special purposes. The common feature of all of them, however, is that they employ more digits than would be necessary if one did not need error-protection. The increased number of digits is usually described as increasing the length of the signal, but this can be taken in two ways. If the bandwidth of the channel, and therefore the digit rate, is left unchanged, the larger number of digits will occupy a longer time; but if the digits are sent at a faster rate, so that the longer string of digits is sent in the same time, the channel will have to be increased in bandwidth. Either way the product TW will have been increased by the redundancy. One has to be careful, since increasing the bandwidth usually increases the noise; and unless the signalling power is increased in proportion, the capacity of the channel will be reduced through the P/N factor. It is simplest to assume that the signalling power is increased with the bandwidth to keep P/N constant. The signalling *energy* (power × time) is then increased in exactly the same ratio whether one allows T or W to increase to accommodate the redundancy.

When dealing with analogue signals there is no obvious datum from which to measure redundancy. One can only say that an increase in TW (or in P/N) for the communication of nominally the same information must represent an increase in redundancy. It is implied that if TW is to be increased then P/N is to be kept constant, or vice versa. Indeed one of the major consequences of Shannon's mathematical theory of communication is that signal-to-noise ratio can be traded against bandwidth, though in practice the terms of trade are rather one-sided. The channel-capacity formula

$$C \leqslant W \log_2(1+P/N) \text{ bits/s} \qquad (1)$$

tells us that for a given communication rate C we can vary W and P/N to any extent we like provided we keep the product of W and log $(1+P/N)$ constant. It is now seen to be untrue that the minimum bandwidth of a channel is fixed by the highest Fourier component at the input to the system: W can be made arbitrarily small provided we are willing to pay the price in increased P/N, but the price many be high. On transforming (1) to give a direct expression for P/N, instead of the logarithm of $1+P/N$, we find

$$P/N \geqslant 2^{C/W}-1 \qquad (9)$$

Now C/W is the communication rate in bits per second divided by the bandwidth in hertz, which is the number of bits per cycle. It could therefore be called the specific communication rate in bits/second per unit bandwidth.

Fig. 1 is a graph of P/N against C/W and shows that if we want to communicate at a rate of more than about two bits per cycle the signal-to-noise ratio required increases rapidly. It might be asked whether we should not plot P/N in decibels, whereupon the graph would approximate to a straight line for large values and the values of P/N in a range up to 13dB do not seem particularly high. In answer to the second point, it must be remembered that this graph represents the maximum performance which could be achieved with ideal coding, and any fairly simple practical system may need as much as 20dB better signal-to-noise ratio. The best reply to the first point is the comment of a radio engineer that decibels improvement in signal-to-noise ratio which are obtained by increasing transmitter power are "gold-plated decibels." An improvement of 10dB or 20dB may not sound impossible from the point of view of a receiver, but increasing the power of a radio transmitter from 1kW to 10kW or 100kW is not to be undertaken lightly. In some cable communication systems it is even more difficult to increase the input signalling power because of such limits as the insulation strength of the cable or the power-handling capacity of repeaters using solid-state devices.

However, Fig. 1 does not tell the whole story. In most systems the noise power increases in proportion to the bandwidth but Fig. 1 relates overall signal-to-noise ratio to channel utilisation in bits per hertz. A different picture results from relating signalling power to bandwidth at constant communication rate, and it is this which is relevant to considering bandwidth expansion or contraction schemes. The modified formula is derived in the Appendix and Fig. 2 is a graph showing change of

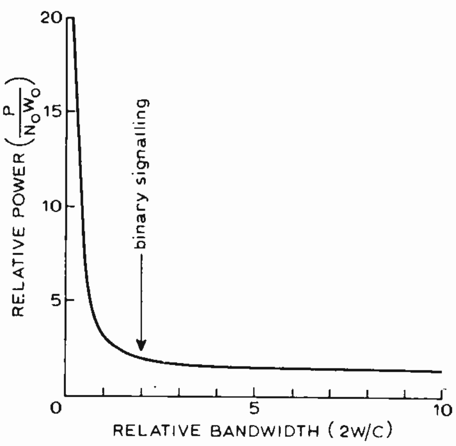


Fig. 2. Actual noise power is usually proportional to bandwidth. N_0= noise power per hertz; W_0= bandwidth needed for communicating C bits/s by binary signalling. With bandwidth W and rate C the relative bandwidth is represented by 2W/C.

necessary signalling power with change of bandwidth relative to binary signalling. This is, of course, considering only random channel noise and ignoring any effects such as quantizing noise which may be involved in any coding of signals for change in bandwidth.

It is clear from Fig. 2 why systems involving bandwidth expansion (for example f.m.) have been popular but there has been little genuine use of bandwidth compression. There was an early attempt to use f.m. with a very narrow frequency swing, with the mistaken idea that the bandwidth occupied would be limited to the narrow swing, regardless of the modulating frequencies. This was shown mathematically to be incorrect, as can easily be deduced in a non-rigorous way as follows. Any practically realisable† waveform which repeats at regular intervals can be represented by a Fourier series consisting of a fundamental frequency corresponding to the repetition rate and harmonics of that frequency. A wave modulated in frequency by a modulating frequency of n hertz repeats every $1/n$ seconds (neglecting the minor effect of carrier phase if the carrier frequency is not an exact harmonic of n); therefore all Fourier components must be multiples of n and the first sidebands must be distant from the carrier by amount n. The *minimum* bandwidth occupied is thus determined by the modulating frequency, and the actual bandwidth may be more if other sidebands are present in appreciable magnitude. We know, in fact, that the amplitudes of carrier and 1st, 2nd . . . sidebands are proportional to Bessel functions $J_0(x)$, $J_1(x)$, $J_2(x)$ . . . where x is the ratio of frequency swing to modulating frequency. Thus the first idea of using f.m., for reduction of bandwidth, was erroneous.

Then Armstrong introduced wide-band f.m. as a means of improving the received signal-to-noise ratio, but again on a fallacious argument, namely that noise consisted of changes in amplitude and could therefore be rejected by a limiter in a system using phase or frequency modulation. In fact the combination of a noise voltage with a signal voltage will change the phase as well as the amplitude in the resultant and the phase change due to the noise cannot be removed by a limiter. The explanation of the noise advantage of f.m. which is usually given is that its demodulation is a non-linear process; and this accounts correctly for all the facets of f.m. performance. It is, however, legitimate to point out that f.m. provides a form of redundancy, in that modulation by a single tone may produce several significant pairs of

†Functions which cannot be Fourier-analysed are mathematical monstrosities such as those having an infinite number of discontinuities or an unbounded range of variation which could not be realised in practice.

sidebands, whereas a.m. would produce only one pair. Since it also produces an increase in bandwidth for the same rate of communication (however the latter may be defined in the case of speech or music), it represents a move to the right on the graph of Fig. 2 so that the expansion in bandwidth should make it possible to reduce transmitter power.

Another aspect of redundancy, and one much nearer to the everyday use of the word, comes into play when one asks whether all the detail of a message is really necessary. Phoneticians reckon that there are only 38 distinct speech sounds or phonemes in European languages. The codes for the phonemes could be transmitted through a much narrower band than the full range of voice frequencies and a device for transmitting speech on this narrow-band basis is called a vocoder. It has the disadvantage that the reconstructed speech is very flat and impersonal and therefore it has never been put to much use. But it does raise the question whether in speech communication one wants only intelligibility of words or also shades of meaning conveyed by intonation and the details of voice sounds which are individual to each speaker**. This is a case for the customer, not the engineer, to decide what is redundant; and the customer's view is that nothing is redundant in a telephone conversation.

However, there are times when the engineer makes compromises which reduce the transmission of information without the customer being aware of it; and television naturally has the best examples of this sleight of hand. First of all there is interlaced scanning. The eye notices changes in the brightness of large areas as flicker if the changes occur at 25 per second, yet it cannot take in picture details in less than 1/25th second. So if the picture were scanned at 50 times per second half the information would not be taken in by the eye and to that extent would be redundant.

The scanning frequency is also related to the reproduction of motion in the picture, and a closer look at the structure of the video signal provides half the explanation of the miracle of colour television. (I call it a miracle, because if there were no redundancy in the system the transmission of the information needed to construct a colour picture of the same definition as a monochrome picture would need three times the bandwidth – yet colour pictures are being transmitted in the same bandwidth as monochrome.) A picture devoid of motion would produce a periodically repeating waveform consisting of harmonics of the picture frequency, though there is usually so little difference between odd and even

In some military radiotelephone systems it is considered essential to provide enough bandwidth for a speaker to be immediately recognized as a particular person (e.g. Captain Smith or Lieutenant Brown). – Ed.

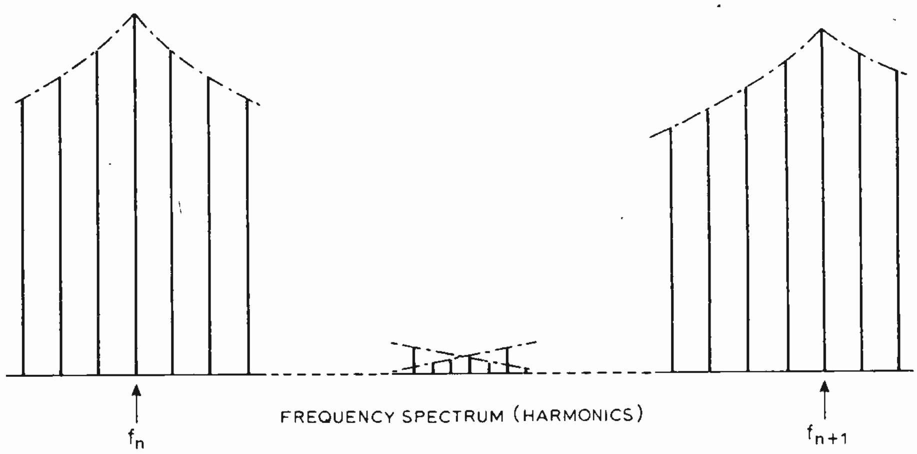


Fig. 3. Part of the spectrum of a typical television signal, showing the n^{th} and $(n+1)^{th}$ harmonics of line frequency. Each of these is accompanied by "sidebands" corresponding to field frequency and these overlap halfway between line harmonics.

lines that only harmonics of the field frequency are significant; and the separation of lines by synchronising pulses means that the harmonics which coincide with harmonics of the line frequency are much stronger. In fact it appears as though the spectrum consisted of line harmonics, each accompanied by its own sidebands spaced at field frequency. As shown in Fig. 3, these sidebands decrease in amplitude with distance from the line harmonic; and although the separation within each group is the field frequency, the groups associated with neighbouring line harmonics interleave, showing that all harmonics of the picture frequency are present. If, as commonly happens, movement affects only a minor part of the picture, the intensity of the spectral components between the lines is small. But if a spectrum consists only of narrow lines most of it is empty and it is very tempting to try to put something in between.

The second criticism of the television spectrum, from the point of view of communication theory, is that it is not flat across the bandwidth occupied. Taken on the average for any reasonable waveforms, the amplitudes of the Fourier components are inversely proportional to their harmonic order, so that the video spectrum of a television signal almost always has an approximately inverse-frequency shape. This is obviously inefficient, because it means that if the signal-to-noise ratio is just sufficient at the top end of the band it will be much greater than necessary at the bottom. In the days of monochrome television this seemed to call for a top boost before transmission and a corresponding cut in the receiver, but this was never done. I believe the difficulty is that while theory can say "Taken on the average for any reasonable waveforms . . ." the television engineer must be prepared to handle the exceptional waveforms which produce strong high-frequency components, even though they occupy only a minute fraction of the programme time. Experience with the very modest amount of top boost which is normally employed in f.m. sound broadcasting (pre-emphasis) has shown that it very readily brings the danger of over-modulation.

However, this weakness of the monochrome spectrum has also been exploited in the transmission of colour pictures, since the colour information is placed near the top of the video band and with a subcarrier placed exactly half-way between line harmonics. The use of a subcarrier which is doubly modulated (with I and Q components) is an ineresting variant on the Nyquist-Gabor theorem that one can transmit two independent signal elements per unit of time-bandwidth. If one identifies sine waves of different frequencies by counting cycles over a time T the number of possible different frequencies within a band W is WT. But it is possible to distinguish between sine and cosine waves; so, when using both, the number of distinguishable signals is $2WT$. If you think about superimposing sine and cosine carriers, both independently amplitude-modulated, you will see that it comes to the same thing as modulating a single carrier simultaneously in both amplitude and phase, which is what one first thinks of as double modulation of a single carrier.

The rest of the trick of colour television depends on the engineer deciding that some of the colour information is redundant because the eye would not respond to it. The eye has maximum acuity for changes in brightness but less for changes in colour, so the high frequencies in the colour signal are redundant. The brightness or luminance signal must therefore be transmitted with full bandwidth, exactly as for a monochrome picture; while the colour information is transmitted with reduced bandwidth which confines it to that part of the spectrum which is left comparatively empty in the monochrome signal.

There is also a great deal of redundancy in television signals due to correlation between different areas of the picture. This has been known for many years, but it has not been practicable to make use of it until the recent developments in digital techniques which look like revolutionising all forms of communication. But that is the subject for a future article.

To summarise, an absolute measure of redundancy can only be obtained by comparing the communication rate which is actually achieved with the channel capacity which is calculated as a function of T, W and P/N. But more often a change in relative redundancy is thought of as a change in the TW product for a given amount of information, with P/N as an independent variable. It is in this sense that an increase in redundancy can be used to give protection against noise, as in the use of error-correcting codes in digital transmission or wideband f.m. for analogue transmission.

Appendix

If W is changed by a factor x, then N is also changed by a factor x and both can be expressed in terms of their standard or normalised values and x. It is usual to normalise N to noise per unit bandwidth, so that $N = W N_0$. Remembering that we want to work in terms of a constant communication rate it is convenient to take W_0, the normalised value of bandwidth, as that bandwidth which would accommodate C by binary signalling at the Nyquist rate. The noise power in this band, which is $N_0 W_0$, is taken as the reference value for signal power. We now re-write formula (9) as

$$\frac{P}{N_0 W} \geq 2^{C/W} - 1 \qquad \text{(i)}$$

Next put $W = x W_0$ and $W_0 = C/2$ so that $C/W = 2/x$.

Formula (i) then becomes

$$\frac{P}{N_0 W} \geq x(2^{2/x} - 1) \qquad \text{(ii)}$$

In this formula x is the factor of bandwidth expansion or contraction relative to binary signalling and with the equality sign this is plotted in Fig. 2.

(Next article: the digital revolution)

Addendum

Part 1 of "Communication theory" in the April issue should have included a footnote on p.44, middle column, referring to the quotation from Francis Bacon. The footnote should read: This was brought to the author's attention by a letter in *Computer Bulletin*, March 1968, by M. G. Farringdon.

Festival of sound

Seen and heard at the Festival International du Son, Paris, March 8-14

The most striking impression received from the Festival du Son was that the French audio market is far from being in a state of depression — if one judged from the attendance during the first two days and the remarkable range of new products on display. The Festival du Son is not really a show of equipment, although this does form a major part. The core of this six-day event was sound, not just reproduced sound but real, live sound, and this very strong influence made itself felt even in some of the demonstrations arranged by some equipment manufacturers.

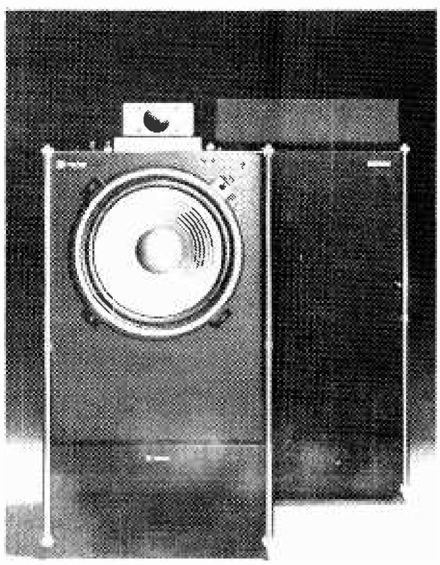
This year, the Festival was held in the impressive exhibition, hotel and shopping complex of the Centre International de Paris at Porte Maillot in the 17th arrondissement. This modern, purpose-built structure consists of a three-floor exhibition area, divided into a number of rooms of varying size, coupled to a large hotel at the rear and an indoor shopping precinct in several levels of basement beneath. If one can resist the temptation of sightseeing in Paris, there is therefore no necessity to leave the area during the entire visit to the show!

Loudspeakers. With the topic of "linear phase" loudspeakers still current in the pages of this journal, it may be apposite to remark that models with staggered front baffles were to be seen everywhere in the exhibition. The French firm Elipson, who were well known for their curious spherical design of loudspeaker, have added several rather more conventional cabinets to their range, all of which have a staggering of the units, presumably to correct for the time delay effects accompanying the normal arrangements of drive units in a loudspeaker. Technics showed additions to their range of loudspeakers with two systems labelled "linear phase", the models SB3000 and SB5000. The last-mentioned is illustrated, and consists of a bass reflex cabinet in which is mounted a 25cm woofer, surmounted by a 6cm dome tweeter loaded by a separate infinite baffle enclosure.

A particularly interesting extension to the principle of the motional feedback loudspeaker was demonstrated by KM Servo Sound. Two models were on show, the KM30, which contained two drive units and an integral 30W amplifier, and the KM50, also having two drive units but with an amplifier rated at 50W. The real novelty of these designs lay in the application of the motional feedback loop to a passive piston, which loaded the port of the bass cabinet, as well as to the bass radiator itself. The manufacturers claimed that up to 20 times normal efficiency was obtained between 35Hz and 60Hz in the former enclosure, with a similar improvement obtained between 30Hz and 60Hz in the larger KM50. The KM50 was accompanied by an extra unit which, to quote the manufacturers, "... from the gathered stereophonic signals, supplies the information on the acoustical reflection characteristics of the listening room." It would seem the KM Processor PR5/6 is a device which enhances the ambience information contained in the original recording.

One particular demonstration was noted as a real return to what the subject of high fidelity is all about. It was found in the Esart room, where that (French) company had arranged for a

Technics type SB5000 loudspeaker system.



jazz quartet to play a selection of musical items live, in conjunction with a recorded version reproduced by a bank of their loudspeakers. This difficult exercise was made more impressive by certain solo passages being taken up by the loudspeakers and counterpointed by the live instrument. The results must have gone a long way to convincing the audience that Esart were producing extremely realistic sounds from their loudspeakers.

Akai type GXC-570D stereo cassette deck.

Electronic equipment. Impressive though the new loudspeakers were, they were somewhat overshadowed by the electronic equipment appearing at the Festival. In some instances, such as the KM loudspeakers, there was an inseparable interface, and this was also to be seen in a curious piece of modern art called "les structures lumineuses" originating from a company called Cyberson. This consisted of large metal and plastic panels concealing a loudspeaker and variable-colour light sources. Used in conjunction with a level and frequency sensitive switching circuit, the displays showed pulsating light patterns related to the composition of the sound signal being reproduced by the loudspeaker. The principles are well known and are frequently used in disc-jockey shows. The novelty appeared to be in the incorporation of the ideas into a single display which could be mounted on a wall as an item of *art décoratif*.

Several amplifiers using valves were noted, and there were others with numerical indication of mean output signal power on liquid crystal and l.e.d. displays. Observing the trend towards higher output powers in amplifiers (e.g. up to 400W per channel), the Festival organizers commented, memorably, "La course aux watts continue".

Also on show was the new Thorens TD126 turntable, featuring a semi-automatic pickup arm (automatic stop and lift) and a choice of 33⅓, 45 or 78 r.p.m. speeds. The suspension of the platter and arm is a completely new design, as is the arm itself.

Bang & Olufsen showed yet another example of brilliant cabinet styling in their new Beomaster 1900 tuner-amplifier. The f.m. tuner offers a choice of five pre-set stations, selected by touch sensitive pads, or continuous tuning by a concealed control under a plate on the top panel. Touch sensitive controls are used to raise or lower the volume level and also to switch to the various alternative inputs. The power output rating of the tuner-amplifier was specified as 30W into 4Ω.

On show were two of the latest products from Nakamichi. These were the model 600 cassette deck, a high quality machine based on an inclined plane front panel design, and the model 610 mixing console. The last-mentioned has similar dimensions to the cassette deck and is obviously intended to be used in conjunction with it. Three stereo inputs, "line", "phono" and "micro" (for moving coil cartridges) are offered, together with two outputs to "line" and to cassette recorder.

The cassette recorder is designed to be used in conjunction with two types of tape, the controls being labelled with the mysterious letters SX and EX. Since the specified frequency response is 40Hz to 18kHz, ±3dB, some explanation regarding the tapes seemed to be necessary. In a separate announcement, Nakamichi explained the basis of the new tapes and, although not directly stated, it would appear that the EX tape corresponds to Maxell UD-XL and the SX tape to the TDK Super-Avilyn. Both of these tapes utilise cobalt in one form or another and were introduced in the UK during the past year.

Headphones on show included the Koss Phase 2+2, which provide four transducers, for stereo and quadraphonic reproduction, together with a pocket-calculator type of keyboard for selecting different combinations of these and of phase relationships between them. Altogether 127 modes of listening are claimed to be available.

One thing that can be said in conclusion is that the French seem to have arrived at exactly the right formula for attracting the public. If this is due in large part to the co-operation of the broadcasting organisations and the musicians, who were present in strength, then this can only be a lesson for the organisers of our own audio shows. B.L.

Toshiba a.m./f.m. tuner, type ST220

Circuit Ideas

High-speed picoammeter

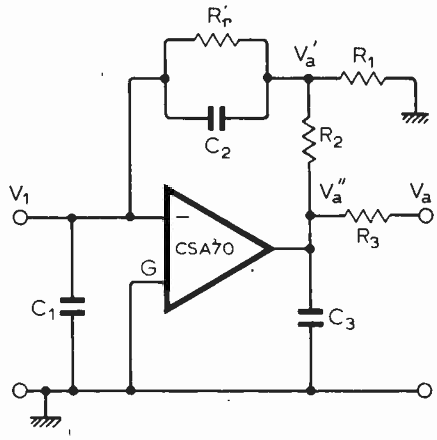
This highly stable picoammeter takes advantage of a chopper-stabilized operational amplifier, the Valvo CSA 70, and enables accurate measurements to be made which are stable over a wide time period. The requirement for an extremely high feedback resistance is accomplished by the voltage divider R_1, R_2 incorporated in the feedback loop. For the circuit shown;

$$V_a = -I \frac{AR_r}{1+R_2/R_1+A}\left[1-\exp\frac{-t}{\tau}\right]$$

where the amplifier gain A is $-V_a/V_1$, and the time-constant, τ, is given by

$$\frac{R_r(C_1+C_2)}{1+R_2/R_1+A}$$

Under the assumption that R_r, C_1 and C_2 are of the same order, it is approximately $1/A$. Components values for the circuit are: $R_r' = 1M\Omega$, $R_2 = 1M\Omega$, $R_1 = 10\Omega$ thus $R_r = 10^{11}\Omega$, $C_1 = C_2 = C_3 = 0.1\mu F$.



Kamil Kraus,
Rokycany,
Czechoslovakia.

Digital sample and hold

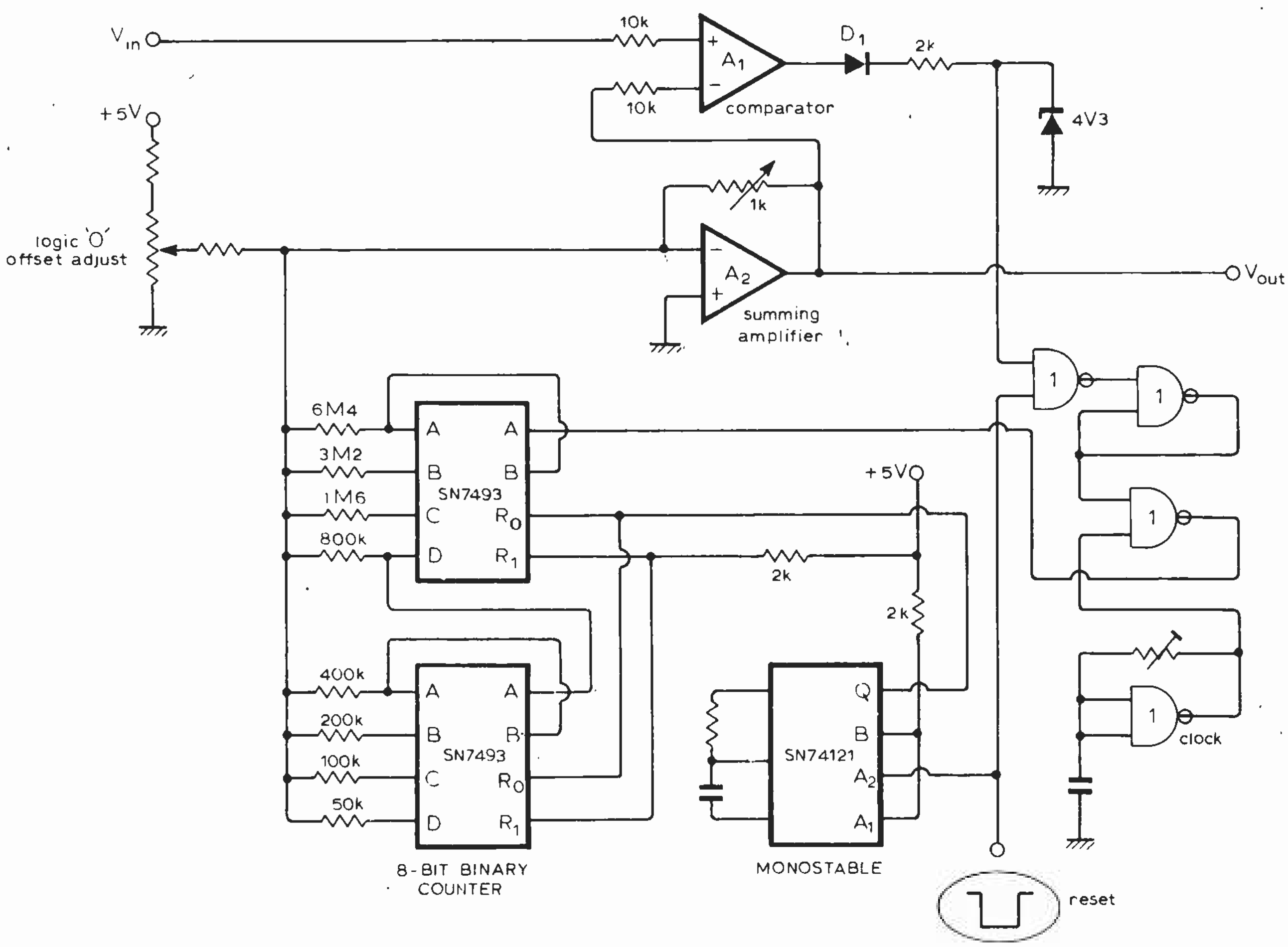
To hold a sampled voltage for long periods, a process of digital approximation provides negligible drift. This circuit is t.t.l.-compatible and provides an analogue-to-digital conversion facility.

The basic element is an 8-bit binary counter using two cascaded 7493s. This provides 256 discrete voltage levels from the op-amp A_2. The input voltage provides a varying reference voltage to comparator A_1.

Applying a 0 at the reset input clears the counter for a period determined by the monostable. The counter now provides a staircase waveform, via A_2, to A_1. When the staircase is equal or greater than V_{in} the comparator goes high and disables the counter clock. The count is held and a sample voltage appears at the output. The reset state has to have a period greater than the sum of the monostable period and 256 clock periods. The speed of the clock is limited by the response of the op amps.

Greater accuracy may be obtained by cascading more counters, but at the risk of increasing the period between voltage transitions at the output. Digital conversion is available directly at the outputs of the counters.

N. Macdonald,
Northampton.

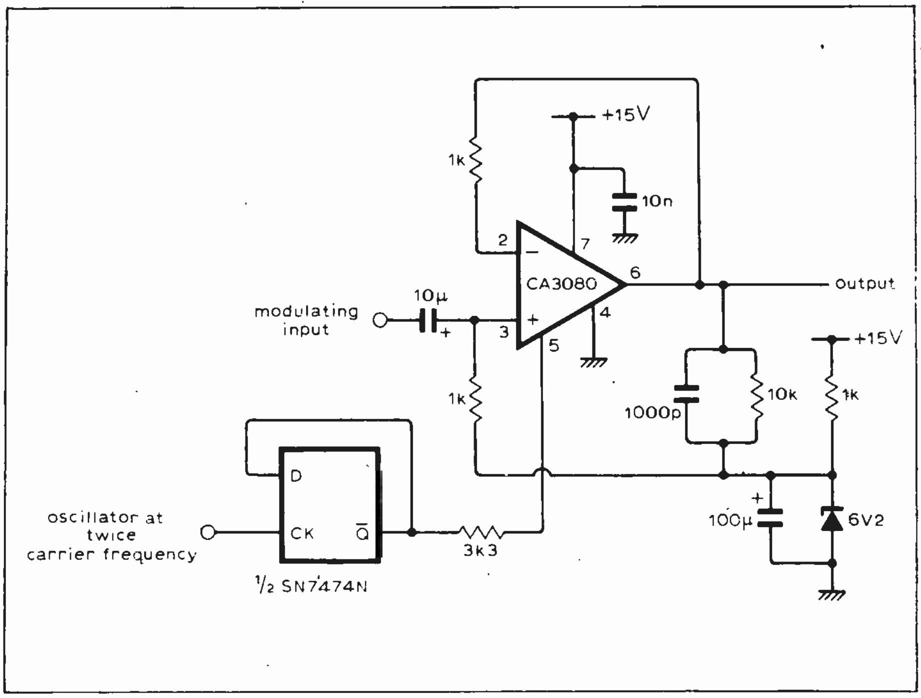


Single balanced mixer

Most i.cs that can be used as balanced mixers have poorly defined conversion gains and are prone to carrier balance variations caused by drift. The CA3080 transconductance amplifier can be used as a precise low frequency single balanced mixer with inherent carrier balance and with an accurately defined conversion gain.

In the circuit shown the oscillator frequency is halved by the binary divider to give a carrier waveform with an accurate mark/space ratio of unity. This is used to switch the amplifier on, as a unity gain voltage follower, and off. The output capacitor provides frequency compensation but limits the frequency at which the carrier can switch the mixer without degrading the performance. The conversion loss is 4dB.

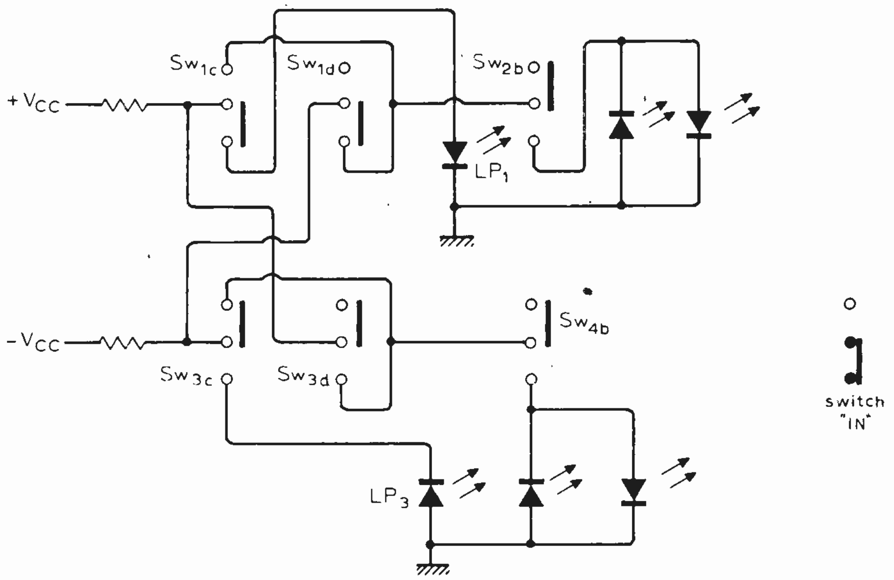
R. J. Harris, G30TK,
Binegar,
Bath.

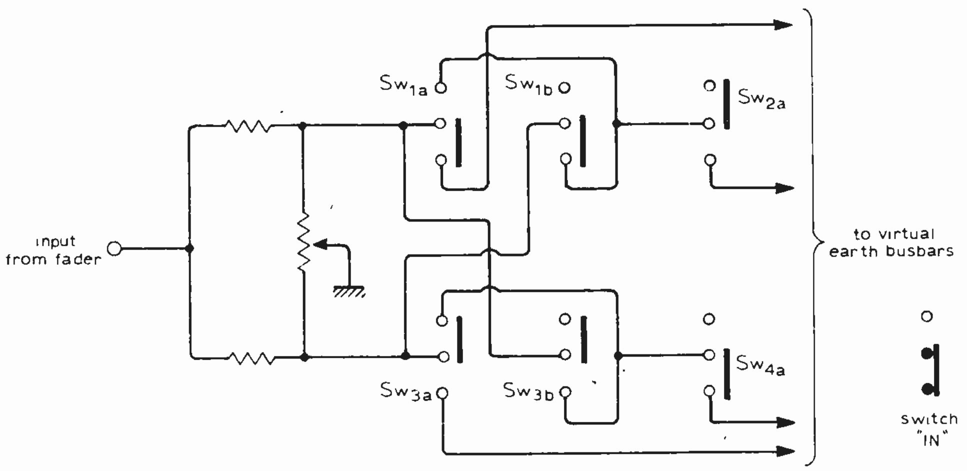


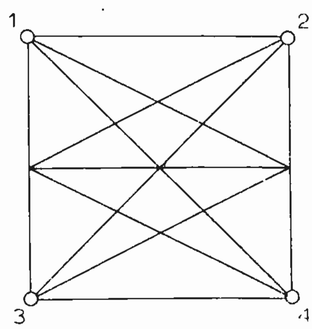
Pan-routing switch

This routing switch was designed to facilitate panning between any two output groups on a multichannel four-output group audio mixer. By pressing any two switches in a square formation a graphical indication is produced of the six panning combinations. By pressing three, or even four, a further five combinations can be obtained. To give visual indication of these pan-paths the circuit can be duplicated to switch suitable l.e.ds as shown. This eliminates the need for joystick controls used in quadraphonic mixdown. It should be remembered that for normal routing the balance should be set to normal.

Q. A. Rice,
Mitcham,
Surrey.

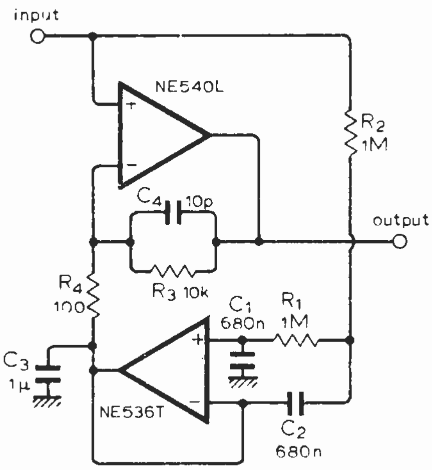






Low frequency a.c. amplifier

This circuit is designed to amplify a.c. down to low frequencies in the presence of large d.c. input offsets. The main amplifier has a gain of 101 while the NE536T has a d.c. gain of unity and forms part of a low-pass Sallen & Key network. This applies the d.c. input offset as a common-mode voltage to the inverting input of the main amplifier.

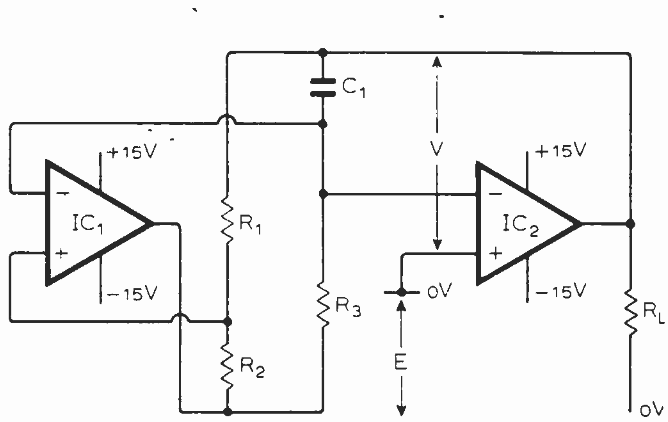


For direct currents the 540L has unity gain, and for alternating currents the gain rises to $1 + R_3/R_4$. The corner frequency is defined as $1/(2\pi\sqrt{R_1R_2C_1C_2})$ so with $R_1 = R_2 = 1M\Omega$, $C_1 = C_2 = 0.68\mu F$ it is about 250kHz. Because of these high resistors the main amplifier should have a f.e.t. input to reduce input-offset current effects. This amplifier should also be provided with zero offset compensation as its output will be amplified 100 times. Capacitor C_3 is sometimes needed to ensure high frequency stability.
A. Royston,
Durham.

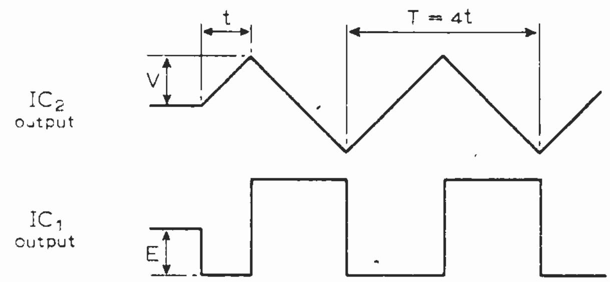
Low-frequency triangle wave generator

A simple low-frequency triangle wave generator may be designed around a pair of operational amplifiers. The passive components form a bridge; IC_2 is the active element in the integrator C_1 R_3, and IC_1 is a level detector with positive feedback, its output switching between positive and negative limits as the bridge passes through the balanced condition. Resistors R_1 and R_2 define peak output voltage as a function of amplifier IC_1 output.

In practice, the amplifier output has not been symmetrical. For more precise applications the output of IC_1 may be clamped by two, back-to-back zener diodes either via a limiting resistor or by making use of the amplifier's constant-current output characteristic. The upper frequency limit may be set by the slewing rate of IC_1, and its effect on the linearity of the generated triangle. For an output voltage linearity of better than ±5% an upper frequency of about 3kHz is suggested, and for linearity of ±1%, an upper limit of 600 Hz.
A. Bishop,
London NW8.

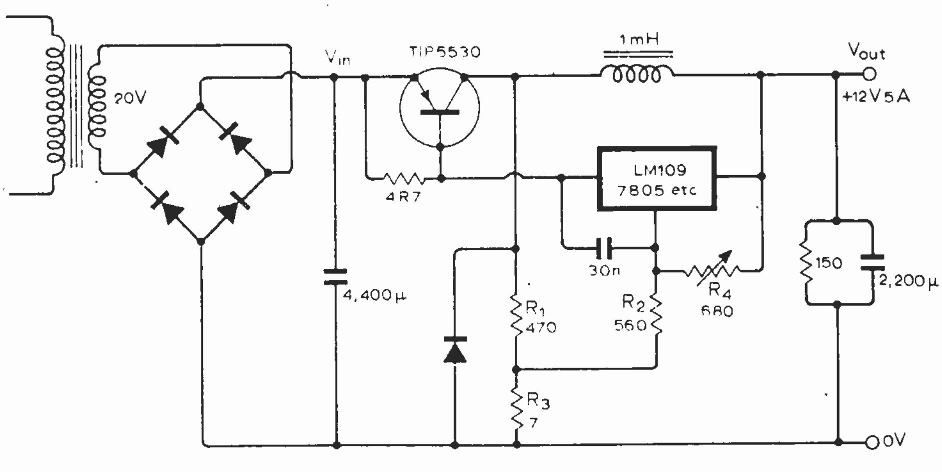


recommended limit values :— $R_1 \leqslant 0{\cdot}8\ R_2$
$R_2/R_3 \geqslant 10k$
$R_3 \leqslant 30k$



Adjustable voltage-switching regulator

Voltage regulators such as the LM109 and 7805 may be arranged in a simple circuit to provide an output voltage higher than the rated output of the i.c. The circuit shows an arrangement for combining two circuits to provide an adjustable voltage-switching regulator. A voltage pedestal is developed across R_2 and R_3 which is added to the normal regulated output voltage of the i.c. The new output is adjusted by varying the ratio of R_4 to $R_2 + R_3$. Positive feedback is also provided through the potential divider R_1 and R_3 into the regulators' pedestal circuit. This feedback allows switching of the i.c. and transistor.
V. R. Krause,
Johannesburg,
South Africa.



Diode model of the m.o.s.f.e.t — 2

Conclusion of an insight into device operation

By B. L. Hart

North East London Polytechnic

Considering a horizontal section taken along a plane defined by the line AA′ in Fig. 9, at a level down the side-walls of the S and D diffusion well removed from the region where a channel can exist, shows that this part (at least) of the structure constitutes a lateral n.p.n. b.j.t. Its symmetrical nature is indicated, here, by two arrows on the otherwise conventional b.j.t. symbol. Irrespective of any field-effect action at the substrate surface, normal b.j.t. action is possible, viz, the injection of *minority* carriers from S into the substrate and their collection at D (or vice-versa), but the length of the base region in comparison with the diffusion length means that the coupling between the emitter-base and collector-base diodes is very small. In most applications this n.p.n. transistor is regarded as a nuisance – a parasitic element – and the effects of its existence are minimized by ensuring that it is always cut-off. ($V_{BS}>0$, $V_{BG}>0$). Because of its long basewidth the transistor can then be represented as two diodes in series opposition, as mentioned earlier in the section on m.o.s.f.e.t. operation, and minority carriers play no significant role in normal unipolar device operation.

A point to bear in mind, when arranging for the lateral n.p.n. to be cut-off, is that V_T is somewhat dependent on V_{BS}. This is because of modulation in width of the induced p.n. junction depletion layer. The details need not concern us here. Suffice it to say that for $|V_{BS}|>0.8$V,

$$V_T \approx V_{TO} + K\sqrt{|V_{BS}|} \qquad (6)$$

where V_{TO} is that V_T for which $V_{BS}=0$, and K (typically about 0.5) is constant for a given device type. In passing, it is worth noting that by arranging for $V_{BS}<0$, b.j.t. action can be exploited (in signal mixing circuits) though the common-emitter d.c. current gain of the laterial device is less than unity, normally, because of the comparatively large values of L used in m.o.s.f.e.t. design: this hybrid-mode operation of the m.o.s.f.e.t. is dealt with elsewhere[6].

The bulk resistances of the S and D diffusions can be allowed for by including resistances r_{Sx}, r_{Dx}, in our final d.c.

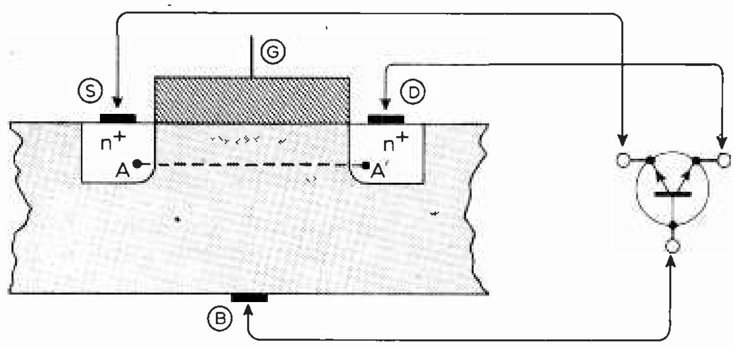


Fig. 9. Showing the existence of an inherent lateral n.p.n. transistor

model (Fig. 9), which has been used in computer-aided design[7]. It would be a very unusual circuit problem which required the use of the complete model. A reduced form is usually sufficient in any given problem. Thus r_{Sx}, r_{Dx} can nearly always be ignored because they are usually some two orders of magnitude less than the resistance offered by the intrinsic active device in any of its operating modes.

Determining model parameters

Ignoring r_{Sx}, r_{Dx}, the model is completely defined once the conductance coefficient λ, and the threshold voltage, V_T, are determined. Reference to Fig. 8 will show that strapping G and D together automatically guarantees $V_{DG}>0$ with the result that $I_R=0$, operation is in the pinch-off mode, and $I_{DS}=\lambda[V_{GS}-V_T]^2$.

Thus a useful practical arrangement for parameter evaluation is shown in Fig. 10. When the switch, Sw, is at 'A' the digital voltmeter monitors V_{GS} for values of R_S and V suitable for the current level desired: at 'B' the p.d. across current-monitoring resistor R_D (conveniently 1kΩ, or 10kΩ, etc) gives the actual operating I_{DS}. A plot of $\sqrt{I_{DS}}$ against V_{GS} yields a straight line of slope $\sqrt{\lambda}$ and the extrapolated intercept on the V_{GS} axis gives the value of V_T to be used in our model. (This is *not* the Threshold Voltage given by manufacturers. The latter, for measurement convenience, specify V_T as that V_{GS} for which I_{DS} is a low value, typically 10μA.)

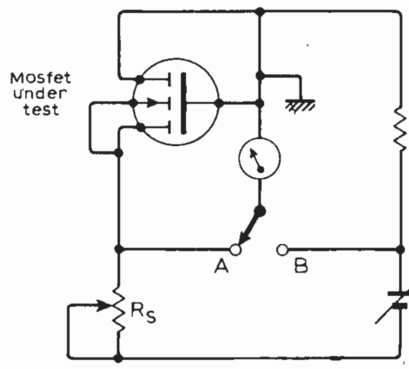


Fig. 10. Test circuit for determination of model parameters

Fig. 11 shows such a plot for one n-channel device of a CD4007 array to which later photographs and measurements refer. For testing a large number of devices repeated plotting can be a laborious process and an automatic display technique such as that described by Storm[8] is preferable. It permits a rapid assessment of the effect of substrate bias and temperature variation. Basically, increased temperature, T, implies: decreased electron mobility leading to a decrease in λ with T; a change in V_T of a few mV/°C due, mainly, to contact potential changes.

One implication of the model shows up well with a swept display – the electrical symmetry. Fig 12(a), obtained by double exposure of the curve tracer film, shows a plot of I_{DS} against V_{GS} for

$V_{DG}=0$ for the device in the forward connection and inverted connection (S and D interchanged), the potential difference between the substrate and the region functioning as source being maintained at zero in both cases.

The basically similar shape and location of the two curves reflects the symmetrical geometrical design of the device. Such small differences as are apparent can be explained by slight differences between the substrate doping levels in the vicinity of S and D. (It must be remembered that the measurements refer to points well in the pinch-off region not at the edge of pinch-off). Further observations showed the I_{DS}, V_{DS} curves to be identical over the major part of the pre-pinch-off region.

Fig. 12(b) shows the effect of non-zero V_{BS} on the transfer characteristic and permits the estimate of K in equation (5).

Summary and conclusions

This article has attempted to clear up some of the difficulties encountered in an initial study of m.o.s.f.e.ts, and to introduce the Gibson-Wedlock square-law diode model which gives more insight into device d.c. operation than the usual purely mathematical description. The model is most accurate when the channel stretches the whole way from source to drain; this mode of operation encompasses a large number of applications.

Two final points: by the addition of appropriate capacitances the model can be adapted to cope with dynamic behaviour; an n-channel enhancement mode m.o.s.f.e.t. has been considered throughout but the model can also handle other device types. Thus, reversing the battery in the gate lead of Fig. 7 (c) gives the model of an n-channel depletion-mode device.

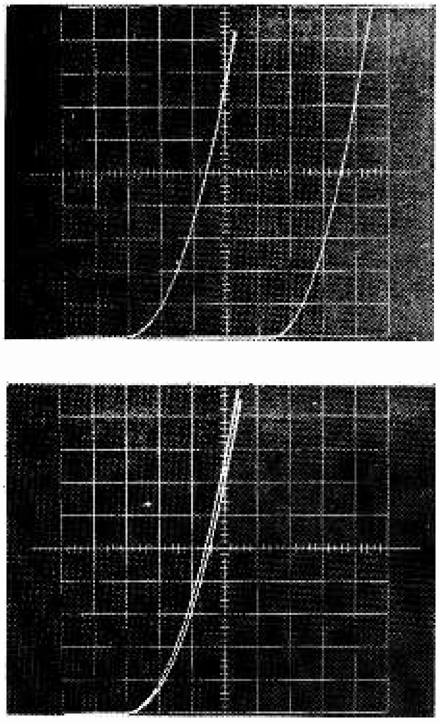


Fig. 12. (a) Superimposed transconductance traces for: (i) $V_{DG}=0$; $V_{BS}=0$; (ii) $V_{GS}=0$, $V_{BG}=0$ (b) Device in forward connection with $V_{BS}=0$ (left) and $V_{BS}=-12V$ (right) Scales for both photographs: vertical 0.2mA/cm, horizontal 1V/cm

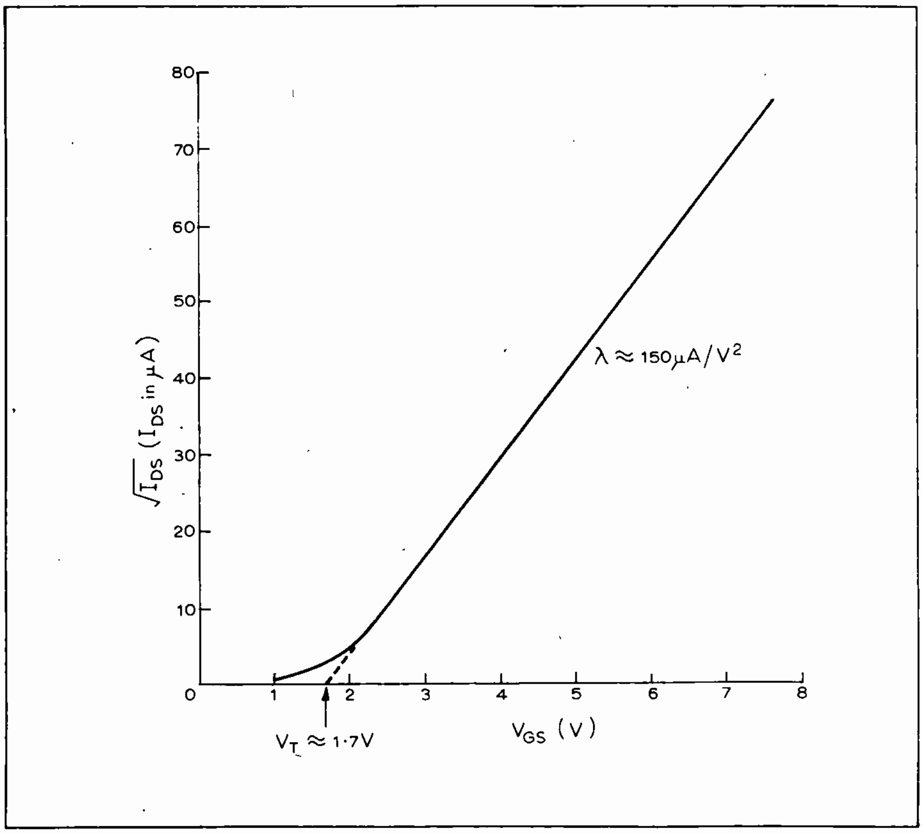


Fig. 11. Measured characteristics of an n-channel m.o.s.f.e.t. on CD4007A (RCA) c.o.s.m.o.s. chip: $V_{BS}=0$

Appendix

Simple derivation of basic m.o.s.f.e.t. d.c. equation. For drift-controlled carrier transport the current density $J(x)$ is the product of carrier density, $\sigma(x)$, and carrier velocity $v(x)$,

Thus, $J(x) = \sigma(x)v(x) = I(x)/W$ (A1)

where, $I(x)$ = channel current

Now, from equation (1) of the text,

$$\sigma(x) = -C_0 \left\{ V_{GS}-V_T-V(x) \right\} \quad (A2)$$

Also for electron transport,

$$v(x) = -\mu_e E(x) = \mu_e \left\{ dV(x)/dx \right\} \quad (A3)$$

where, $E(x)$ = x-directed field in the channel

Combining (A1), (A2) and (A3),

$$I(x) = \mu_e[-C_0 \left\{ V_{GS}-V_T-V(x) \right\}] [dV(x)/dx] \quad (A4)$$

or $$\int_0^L I(x)dx = -\mu_e C_0 \int_0^{V_{DS}} \left\{ V_{GS}-V_T-V(x) \right\} dV(x) \quad (A5)$$

By virtue of current continuity, $-I(x)$ = constant = I_{DS} = (conventional) current flow into D.

Hence, integrating each side of (A5) and substituting the basic parallel plate capacitor relationship for C_0 i.e. $C_0 = (\epsilon\epsilon_{ox}/t_{ox})$ gives,

$$I_{DS} = [\mu_e\epsilon\epsilon_{ox}/2Lt_{ox}] [2V_{DS}(V_{GS}-V_T)-V_{DS}^2] \quad (A6)$$

Equation (A6) contains equations (2) and (3) of the text.

References

6. Hart, B. L. and Barker R. W. J., "First-order theory of MOSFET hybrid mode operation" (Awaiting publication; *International Journal of Electronics)*.
7. Hamilton A. W., "A new model of the insulated gate field effect transistor for use in computer-aided design" Proc. 15th Mid-west symposium on Circuit Theory, U.S.A., 1973.
8. Storm, H. F., "MOS-FET Analyzer" *IEEE Transactions on Instrumentation and Measurement*, Feb. 1970, pp 2-5.

Control and Instrumentation goes regional

The organizers of the Control and Instrumentation series of exhibitions held in London every other year since 1971 announce details of a long-term exhibition programme in which low-cost regional events will alternate with the London show. The first regional event, Control and Instrumentation — North East 1976, will be held at the Newcastle Centre Hotel, Newcastle upon Tyne, on October 13 and 14, 1976. Further information may be obtained from Holdsworth Smith Ltd. 39 Victoria Street, London SW1.

High performance voltage regulator

A new simple and practical technique

by K. W. Mitchell, B.Sc.

The Royal Victoria Infirmary

Design criteria for linear voltage regulators and the factors affecting the performance of these circuits are discussed. A relatively simple and cheap circuit is given which uses only three transistors and a reference element. It features improved performance over that achieved by monolithic i.c. regulators and comparable performance to the latest combined discrete and monolithic circuits.

In conventional transistor voltage regulators (Fig. 1) a reference voltage, which is obtained from an unregulated, smoothed input, is compared with a feedback signal derived from the regulated output. The error signal produced is amplified and drives a bipolar transistor which in turn feeds the power-pass transistor. Such designs have inherent limitations in that a.c. ripple is imposed upon the reference voltage and is fed-through to the regulated output; and also fluctuations in supply current to the reference element, due to transformer regulation and line variations, cause variations in the magnitude of the reference, usually tens of millivolts, which are fed through to the output.

In order to minimize these quantities the reference element must be driven from the regulated output voltage. This solution in itself poses a significant problem, i.e. with reference and feedback elements being driven by the output voltage provision must be made to initially start the regulator after switch on, or the output voltage will not rise.

In Fig. 2 a general design of feedback controlled regulator is shown. This has improved performance over the first design, but resistor R is necessary to start the regulator and also feed Tr_1 and Tr_2. Some ripple feedthrough from the input through R will be present, and line variations will vary the current passing through Tr_2. The performance is limited therefore by the necessary inclusion of R. This should be replaced ideally by a constant current source, to reduce the above effects, but this means at least two extra active devices, thus increasing cost and complexity.

In Fig. 3 a further improvement is shown. Transistor Tr_1 is changed to a p.n.p. device. This now introduces extra gain into the circuit with appropriate inversion of the reference and feedback voltages to the output. Line and load current regulation is improved but once again a resistor, R, must be included to provide the necessary current drive to Tr_2 and thus facilitate "starting". This circuit is representative of present techniques and has one possible drawback in that IC_1 must be able to operate from a single supply rail. Care must also be taken in the choice of the zener reference potential V_z, in that this must lie within the common mode voltage input range of the operational amplifier for the circuit to function satisfactorily.

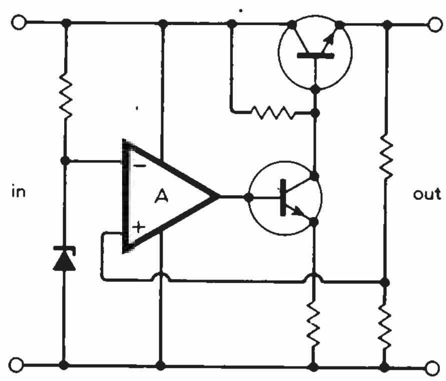


Fig. 1. Conventional transistor voltage regulator.

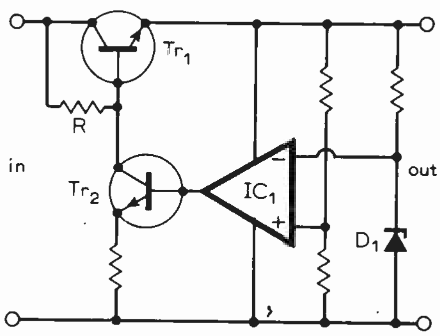


Fig. 2. General design of a feedback controlled regulator.

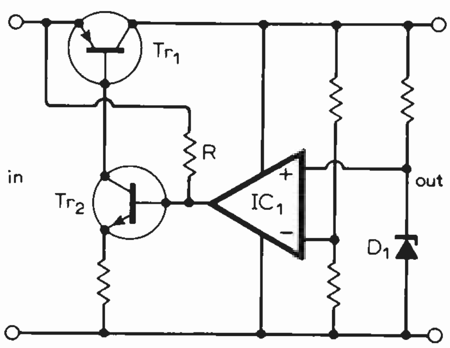


Fig. 3. Further improvement to introduce extra gain and improve line and load current regulation.

A circuit having similar performance to that shown in Fig. 3 but which is much cheaper to build is shown in Fig. 4. The circuit is completely feedback controlled and the output voltage given by.

$$V_{out} = V_{zD} + V_{BE}$$

Any load connected to the output tends to make it fall, and this drop is transmitted to the base of common emitter amplifier Tr_1. Thus the collector of Tr_1 will rise, Tr_2 will conduct harder and the current drive to Tr_3 will increase. The result of this is that the collector of the series transistor Tr_3 will tend to rise and the circuit regulates. Capacitor C_1 is included to reduce r.f. noise on the output and also to prevent high frequency oscillations under load. If very high gain transistors are used, oscillation may still occur, but this can be prevented by decoupling the collector of Tr_1 with a capacitor value of 0.1μF. This will limit the high frequency response of the regulator and the value of the capacitor should be selected as that required just to prevent oscillation under maximum load.

When the regulator is switched on Tr_2 is driven hard via R_1 and a large pulse current of approximately 50mA is driven through the emitter-base diode of Tr_3, transistor Tr_2 and R_2. This only occurs at switch on and ceases as soon as D conducts, hence driving Tr_1 and stabilizing the feedback loop.

A practical design is shown in Fig. 5. This circuit can supply 1A at 5V. It uses two low cost, high gain transistors, type BC109, and a plastic series transistor, TIP 32A, although many types have been tried with the circuit still working satisfactorily. Extra ripple rejection is achieved by the inclusion of C_2 (100μF) which introduces more a.c. feedback into the loop. Foldback short-circuit protection is included by introducing Tr_4 and associated drive resistors. Foldback occurs at a value of current given by

$$I_{max} \approx 0.6/R$$

When I_{max} is reached, Tr_4 begins to conduct thus making Tr_1 conduct harder. The drive to Tr_2 reduces, and hence Tr_3 begins to switch off. The output begins to fall, and this drives Tr_4 harder through the 15kΩ feedback resistor. When Tr_1 is saturated, Tr_2 and Tr_3 are switched "off" and hence output voltage and current will be virtually zero. The foldback characteristic is programmable depending on the magnitude of the feedback resistor.

The performance of the circuit is as follows:

Load regulation	0.01%
Line regulation	0.05%
Ripple rejection	0.1%
Output ripple and noise	1mV
Speed (i.e. time to respond to a 500mA pulse)	10μs
$V_{in}-V_{out}$(at 1A load)	0.5V

It can be seen from the above table that the regulator will work with a very small input-output differential voltage. This obviously improves the efficiency of the unit and reduces the effect of transformer regulation. It also means that Tr_3 does not dissipate much power, and therefore it can be mounted on a small heat sink capable of dissipating two to three watts.

The temperature coefficient of output voltage drift can also be minimized by selecting a suitable zener reference current so that the temperature drift of zener voltage is compensated by the V_{BE} temperature drift of Tr_1. (These two devices should be mounted in close thermal contact if optimum performance is desired.)

It is suggested that if the regulator is driving a logic circuit and is separated from it by a long lead length, remote sensing should be adopted ie. points X and Y should be directly attached to the load via separate wires.

I have found the design to be very flexible and have constructed various circuits to give up to 2A at 40V, all circuits being equally satisfactory. However, if currents in excess of 2A are required Tr_3 should be replaced by a Darlington pair in the usual series pass mode to give extra current gain.

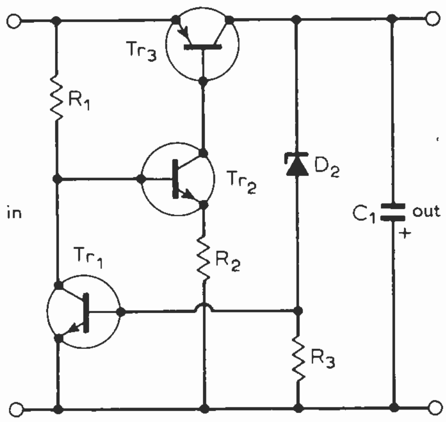


Fig. 4. Similar circuit to that in Fig. 3, but cheaper to build.

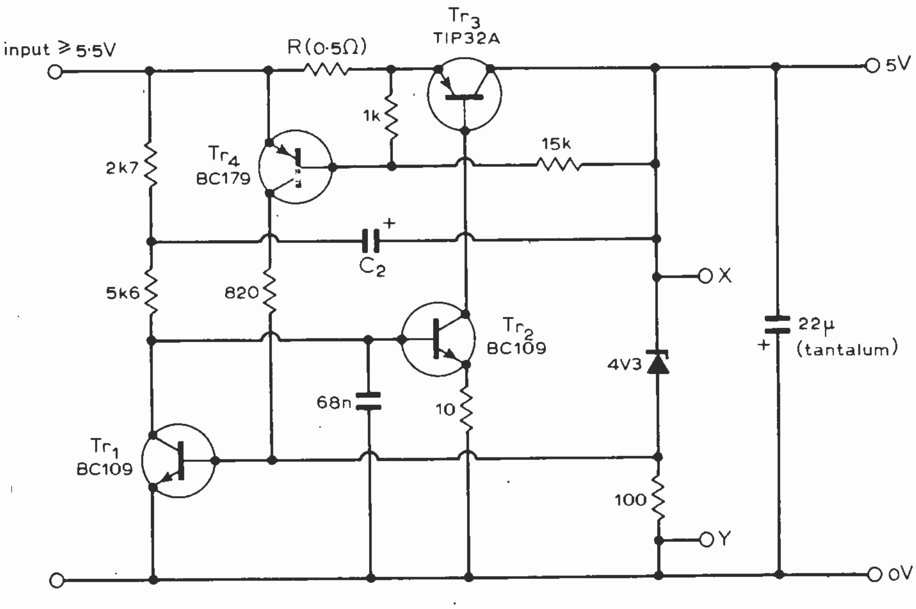


Fig. 5. Practical design of the regulator circuit.

Announcements

General Radio Company (UK) Ltd has changed its name to **GenRad Ltd,** Bourne End, Bucks. The change, which reflects similar changes by all GR companies throughout the world, has been brought about to avoid future possible misinterpretation of their role in the international electronics industry.

Intersil Inc. have appointed the London based microprocessor and memory specialist distributors Rapid Recall Ltd, 9 Betterton Street, Drury Lane, London WC2H 9BS as their franchised distributors.

Redifon Telecommunications Ltd. Broomhill road, Wandsworth, London SW18 4JQ, has secured a £200,000 contract with the Ministry of Defence, Malaysia, for the supply and installation of their solid-state 643/CJP naval communication stations on board warships of the Royal Malaysian Navy.

Hoeschst U.K. have appointed Kent Insulations Ltd as main UK distrbutor for their Hostaphan **polyester film,** which is used by the electrical industry in the manufacture of transformers, electric motors and cables.

Impectron Ltd, 23-31 King Street, London W3 9LH, a member of the Barlow Group, have been appointed by Fairchild Semiconductor Ltd as sales representative for the UK consumer market.

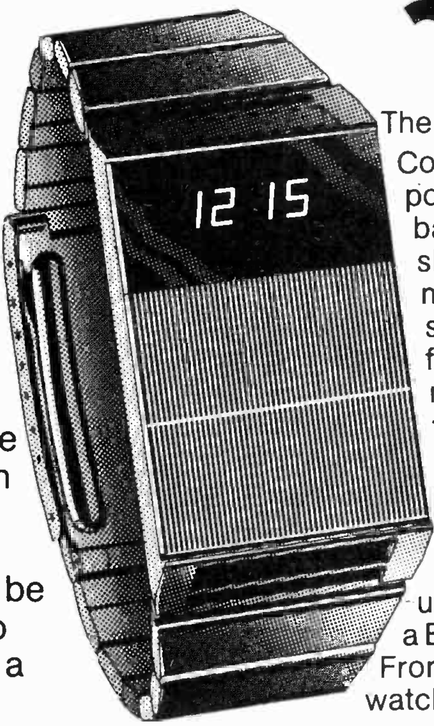
AMI Microsystems Ltd have appointed Apex Components Ltd, 396 Bath Road, Slough, Berkshire, as distributor for the AMI range of m.o.s./l.s.i. digital integrated circuits.

Sixty Years Ago

The battles of electronics today are well known. We refer to the actions and counter-actions taking place in the design of defence and espionage electronics. Missiles are confused by anti-missile devices, which in turn are counteracted by jamming devices. Telephone systems are bugged, and in turn bugging devices are jammed. The story continues. From an article in the issue of *Wireless World* May 1916 we can see that this has been a long and lingering battle:

"Wireless plays an important part in every operation at sea, and this fact recently received a most striking illustration on the occasion of the battle between the Alcantara and the Greif. It will be remembered that the Alcantara was a converted liner taken over from the Royal Mail Steam Packet Co. and fitted out as an auxiliary cruiser. Her wireless apparatus, unless it had been replaced by fresh fittings since her conversion, was only of that power which was settled by the Berne Convention as not to be exceeded by merchant vessels. German ships notoriously evade these regulations, and it is quite plain that the apparatus employed on the Greif was of a far more powerful nature than that of the English vessel. As soon as the concealed enemy disclosed her true character and started to jam the signals of the Alcantara, she cut the latter's wave-length with remarkable readiness, so that a stub-born action was fought between the wireless rooms as well as between the guns. With regard to the latter, the weight of metal appears to have been on the side of the Germans, but the superiority in gunnery combined with more skilful seamanship, enabled the British to outclass and overcome the enemy."

The Black Watch kit £14.95!



★ **Practical**–easily built by anyone in an evening's straightforward assembly.

★ **Complete**–right down to strap and batteries.

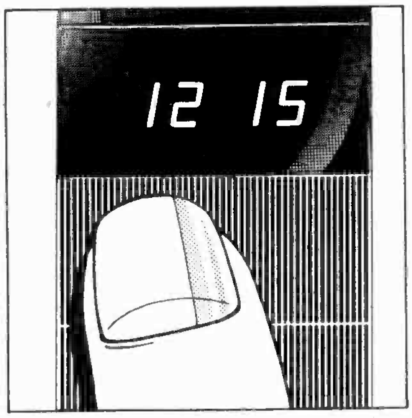
★ **Guaranteed.** A correctly-assembled watch is guaranteed for a year. It works as soon as you put the batteries in. On a built watch we guarantee an accuracy within a second a day–but building it yourself you may be able to adjust the trimmer to achieve an accuracy within a second a week.

The Black Watch by Sinclair is unique. Controlled by a quartz crystal, and powered by two hearing aid batteries, it uses bright red LEDs to show hours and minutes, and minutes and seconds. And it's styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

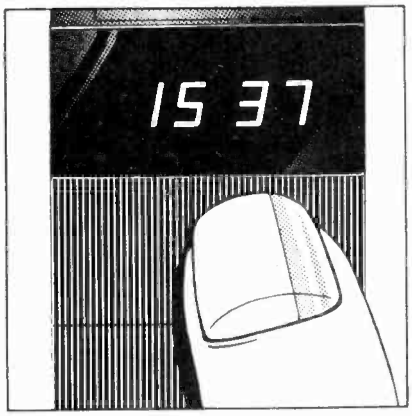
The Black Watch kit is unique, too. It's rational – Sinclair have reduced the separate components to just four–and it's simple: anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

Touch and tell

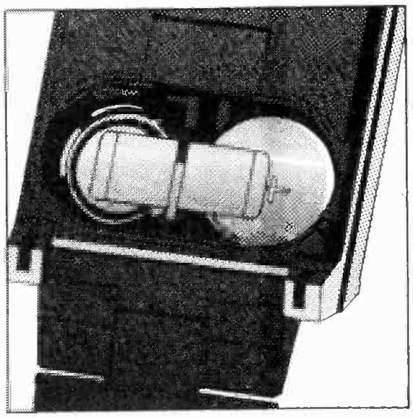
Press here for hours and minutes...



here for minutes and seconds.



Batteries easily replaced at home.



The specialist features of the Black Watch

Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra–see order form.)

Large, bright, red display–easily read at night. Touch-and-see case–no unprofessional buttons.

Runs on two hearing-aid batteries (supplied). Easily re-set using special button–no expensive jeweller's service.

The Black Watch – using the unique Sinclair-designed state-of-the-art IC.

The chip...

The heart of the Black Watch is a unique IC designed by Sinclair and custom-built for them using state-of-the-art technology – integrated injection logic.

This chip of silicon measures only 3 mm x 3 mm and contains over 2000 transistors. The circuit includes

a) reference oscillator
b) divider chain
c) decoder circuits
d) display inhibit circuits
e) display driving circuits.

The chip is totally designed and manufactured in the UK, and is the first design to incorporate *all* circuitry for a digital watch on a single chip.

...and how it works

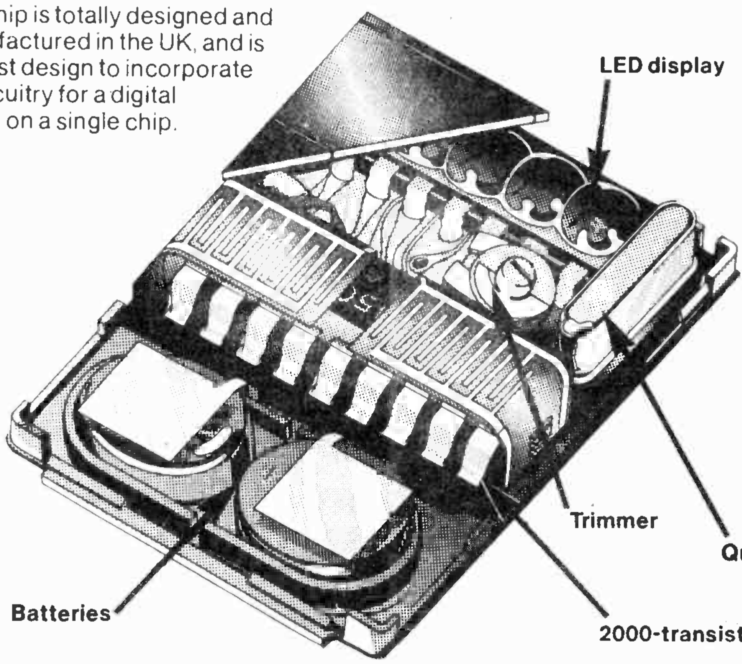
A crystal-controlled reference is used to drive a chain of 15 binary dividers which reduce the frequency from 32,768 Hz to 1 Hz. This accurate signal is then counted into units of seconds, minutes, and hours, and on request the stored information is processed by the decoders and display drivers to feed the four 7-segment LED displays. When the display is not in operation, special power-saving circuits on the chip reduce current consumption to only a few microamps.

Complete kit £14.95!

The kit contains

1. printed circuit board
2. unique Sinclair-designed IC
3. encapsulated quartz crystal
4. trimmer
5. capacitor
6. LED display
7. 2-part case with window in position
8. batteries
9. battery-clip
10. black strap (black stainless-steel bracelet optional extra – see order form)
11. full instructions for building and use.

All the tools you need are a fine soldering iron and a pair of cutters. If you've any queries or problems in building, ring or write to Sinclair service department for help.



Take advantage of this no-risks, money-back offer today!

The Sinclair Black Watch is fully guaranteed. Return your kit in original condition within 10 days and we'll refund your money without question. All parts are tested and checked before despatch - and correctly-assembled watches are guaranteed for one year. Simply fill in the FREEPOST order form and post it - today!

Price in kit form: £14.95 (inc. black strap, VAT, p & p).

Price in built form: £24.95 (inc. black strap, VAT, p&p).

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London Road, St Ives,
Huntingdon, Cambs., PE17 4HJ.
Tel: St Ives (0480) 64646.
Reg. no: 699483 England. VAT Reg. no: 213 8170 88.

To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.

Please send me Total £

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.... (qty) black stainless-steel bracelet(s) at £2.00 (inc. VAT, p&p). ....

* I enclose cheque for £........................ made out to Sinclair Radionics Ltd and crossed.

* Please debit my *Barclaycard/Access/American Express account number

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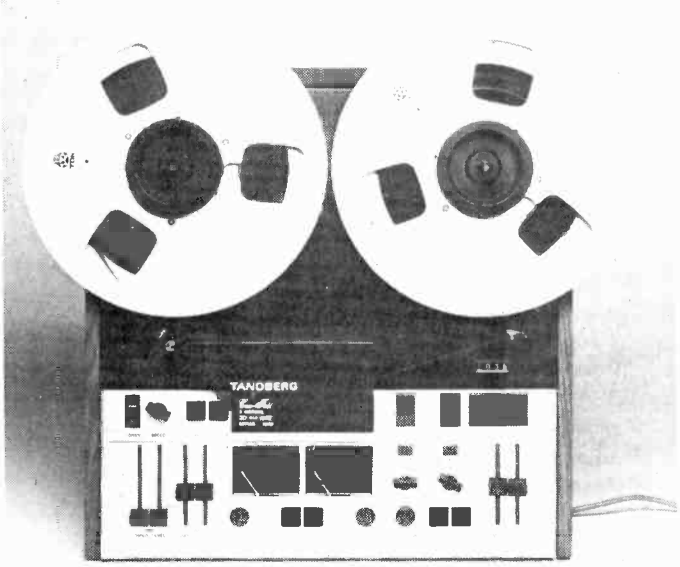

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Audio in Zürich

Brief notes from the 53rd Audio Engineering Society Convention, March 2-5

Each year, the European and British Sections of the Audio Engineering Society hold a convention in one of the European cities. This year the event was held at Zurich and consisted of an exhibition, commercial demonstrations and a papers session.

The Acoustic Research demonstration was of particular interest, though of indeterminate value. It arose from an interest in recreating the original concert hall ambience and consisted of a 16-channel delay line in which the delay for each channel was independently programmable. The output of the delay lines fed 16 power amplifiers and 16 loudspeakers. The loudspeakers were disposed around the walls of the room, in a carefully spaced array that included height as well. Thus each vertical array of three loudspeakers was arranged on a series of separating columns with the lowest speaker near the floor, the next at about ear height and the top one at about ten feet. The chain was driven from a stereo signal which also fed the main stereo pair of loudspeakers in the front.

From computer analysed data, obtained from recording the impulse response of some famous halls, it was possible to programme the delay lines to simulate the pattern of early reflections existing in that concert hall. It was stated that the experimental apparatus was at an early stage in its development and perhaps that explained the unconvincing results heard.

The exhibition contained a number of new products, among them a digital frequency analyser from Bruel and Kjaer, offering actave or ⅓ octave real-time analysis, together with an independent memory to store a second spectrum for comparison. Studer showed the long-awaited Unisette broadcast cassette recorder. Using a special cassette loaded with ¼-in tape, this offers a source for inserts of up to 30 minutes of programme, together with an extremely fast rewind time.

A particularly interesting paper was presented by Fritz Winckel entitled 'A quick test method for the diagnosis of speakers' and singers' voices under stress'.

Dr Winckel noted that with an increasing number of untrained voices appearing professionally in pop-groups, there had also been an increase in the number of cases of lost voices. It was felt that voice training must offer some way of increasing the efficiency of the sound producing process and so research was commenced using highly trained voices and also including an analysis of the listening process. Tests were concentrated at first around the value of the singing formant which, at about 3kHz, appears to coincide with an outer ear canal resonance occurring at about 2.8kHz. Tests made at the 1975 Berlin Funkausstellung using several thousand visitors as test subjects showed that the piercing or penetrating power of the voice appeared to reside in the 3kHz region and the more energy concentrated there, the better the voice appeared to carry.

Vibrato, which is well-developed in professional singers, also seemed to be a method used to raise the efficiency of sound production and further tests confirmed this thought. The author concluded by describing a simple metering device which could quickly analyse an artist's voice and give an immediate indication of the degree of efficiency and thus, presumably, the likelihood of serious strain occurring.

Two papers, one from Matti Otala, the other from T. Jelsing of Bang & Olufsen, summarised different aspects of transient intermodulation distortion in amplifiers. Otala's paper was largely concerned with discussing the various forms of test signal which might be suitable for obtaining a quantitative analysis of t.i.d. whilst Jelsing's paper discussed the design criteria which ensured its elimination.

Jelsing demonstrated mathematically that the origin of t.i.d. was non-linear limiting in early stages of power amplifier – before the final stage has run into a limiting situation itself. The simple design rule was thus to ensure that the output stage limited before any other stage of the amplifier. He also demonstrated that an amplifier which suffered from t.i.d. could be improved by the simple addition of a band-pass filter designed to limit the frequency range of the input signals. Jelsing pointed out the futility of trying to measure the value of t.i.d. when it was so easy to eliminate, and proposed instead a simple method of testing to establish an amplifier's freedom from t.i.d.

If the test proved negative, it unfortunately did not automatically prove that t.i.d. was present – just that it was likely. The test was conducted as follows: a low-frequency sine wave is fed to the amplifier input and the amplitude increased to a level just below output stage limiting. With no other change being made, the signal frequency is swept over the full bandwidth of the amplifier, while plotting the harmonic distortion in the output.

An amplifier can be regarded as being free from t.i.d. if there is no sharp increase in distortion at frequencies up to the −3dB point of the amplifier. Jelsing added that the sine wave signal used was quite satisfactory for testing the amplifier's response to a step input, since if limiting did not occur for the sine wave, it equally could not occur for the step signal input.

A paper sought a solution to the well-known problem with the conventional four-corner array of loudspeakers for "quadraphonic" reproduction, that it is impossible to obtain a satisfactory phantom image immediately to the left or right of the listener when using pair-wise mixed material.

The authors, Theile and Plenge, sought a loudspeaker arrangement that solved this problem. Extensive experiments left them with only one solution, and that was to use six loudspeakers, the extra set being located at the sides. These loudspeakers were to be fed with a signal derived from an additional matrix decoding of the left side and right side signals.

Ted Trendell of EMI Research Laboratories dealt with the problems of tracing distortion correction. He argued that the origins of this form of distortion lay in the inability of the replay stylus to accurately follow the modulations cut in the record groove by a chisel shaped stylus.

The paper demonstrated that the distortions arising from this error on playback could be precisely calculated and then compensated for by introducing an opposing distortion in the recorded signal. He pointed out that the success of the original experiments had been encouraging, but that the correction was based on a single type of replay stylus shape and that as yet it was still not known how much deterioration would occur as a result of using other forms of stylus shape.

Another paper was concerned with the design of modern, low inertia pickup arms, and was presented by Peter Rother of Thorens. This must stand as a definitive explanation of the criteria of good tone arm design and is a model of clarity. One of the main features of the introductory paragraphs is a plea to cartridge manufacturers to consider more carefully the relationships between stylus compliance, cartridge mass and the practicable values of effective mass for the modern pickup arm.

He suggested that effective masses for modern arms can now be realised in the region of 5gm, but even with this very low mass, a consideration of the compliance and masses of several popular high quality cartridges showed that an ideal low-frequency resonance of 10Hz for the pickup arm and cartridge combination was impossible to realise with at least two of the examples selected.

P. J. Bloom of University College, Cardiff, investigated the phenomena associated with localization in height. Prior work had indicated that a principal factor was the spectral modification found in the pinna. Bloom's work led him to discover that there is a distinct interaction between the pinna and the incident signal, resulting in marked filtering effects above 4kHz. The effect was to produce a "suck-out" in the frequency response of the perception thresholds of the ear.

From this Bloom produced a hypothesis "That a signal produced from a stationary source and having only its spectrum altered in accordance with data ... carried sufficient information to elicit the impressions of diverse source elevations. Furthermore these impressions should correlate with each subject's own pinna transformations." An experiment was set up to determine a quantitative relationship between the phantom elevation of a signal presented on a level with one or other ear and the location of the notch frequency which evoked it. The noise band, with notch, was fed to a loudspeaker located in an anechoic chamber and the subject seated to one side of the loudspeaker in darkness. A second transducer could be located at any angle between −6° and +45° in a vertical plane at the side of the listener. The frequency of the notch in the noise signal could be adjusted to move the phantom source to a location similar to that of the real source. Results of the test showed a close correlation between the frequency of the notch and the vertical elevation of the phantom signal.

Bloom concluded that it was possible to produce the sensation of elevation in a noise signal simply by the introduction of a notch in the spectrum of the signal. The auditory system decoded that signal as if the shaping of the signal had occured naturally. An effective demonstration of such a phantom signal was given in the lecture theatre, with about 75% of the audience experiencing the sensation of a phantom signal moving up and down.

A surprising paper, at least to this author, was presented by J. J. Geluk of Radio Nederland who discussed the advantages of enhancing the diffusivity of the sound field in the living room. He argued that the previous circuits adopted for this purpose, notably the Hafler and Gerzon types, suffered from the disadvantage of direct connection with existing stereo equipment, a possible reduction in frontal localization, and that the overall effect is seldom accompanied by an improvement in acoustic quality.

Dr Geluk's proposal is to pick up the output of the front two loudspeakers with microphones, add electrical delay and, if desired, some reverberation and feed this to two rear loudspeakers to be radiated at equal power to the front pair, but toward the ceiling.

Two papers dealing with loudspeakers are selected. The first, by S. K. Pramanik of Bang & Olufsen, was a proposal for describing the terminal characteristics of the loudspeaker-amplifier interface. In essence, the suggestion is to describe amplifier outputs, not in terms of watts, but in volts across a specific minimum load. It would then be a simple matter to express the load characteristics in terms of the maximum voltage required to drive the load, together with the minimum resistance over the operating bandwidth. This would suggest a 20V, 4Ω amplifier, say, being suitable to drive a loudspeaker requiring 20V and having a minimum resistance of 4Ω over its operating range.

The other paper, originated from the Victor Company of Japan, represented a repeat and extension of a paper previously read at the 52nd Convention entitled "A technique for observing loudspeaker wavefront propagation." A loudspeaker drive unit was fed with a series of pulses and the acoustic output measured by a microphone at various points on an imaginary plane in front of the drive units. The results are stored and on completion of the test, the pattern of instantaneous sound pressure distribution displayed on an oscilloscope at a speed which makes the progression of sound field easily observed. The tests had been extended to demonstrate the sound pressure field from two drive units, coupled with either minimum phase or non-minimum phase networks, and showed the rapid reconstitution of the original signal in the case of the former example. BL.

Railways use p.c.m.

A commercial 30-channel pulse-code modulation system to go into service with British Rail has been handed over by GEC Telecommunications Ltd. The system connects New Street Station in Birmingham with Birmingham International, the new main-line station built at the National Exhibition Centre (see IEA preview, this issue). The system operates in the proximity of the 250kV overhead electrification, so engineers have had to overcome the interference problems created by this environment. The equipment suppliers will also be training British Rail staff in digital transmission techniques. The 30-channel p.c.m. railway contracts also include a system between Didcot and Reading in the Western Region — part of a re-signalling scheme associated with the new 125 m.p.h. high speed trains — and a system for the East Coast re-signalling scheme in the Scottish Region. This last-mentioned (to connect Edinburgh with Drem, Dunbar, Grantshouse and Tweedsmouth) will include a standby line system which will be switched in automatically if the working line system fails. The equipment enables 30 high-quality speech channels carrying telephony and data signals to be put on two pairs in an ordinary telephone cable which would normally carry only two circuits. In the New Street to Birmingham International system, special units have been designed and supplied to British Rail to enable remote subscribers to operate over the p.c.m. system directly into a central automatic exchange.

Literature Received

The second edition of a book on memories, published by Intel, is now available. It is entitled "Memory Design Handbook" and its three sections are concerned with the background to memory devices, memory components of various types, system design data, and interface and refresher circuit design. Intel Corporation (UK) Ltd. Broadfield House, 4 Between Towns Road, Cowley, Oxford OX4 3NB. W.W. 405

Packaged amplifiers and systems are fully described in Burr-Brown's new catalogue, which lists devices for data acquisition, conversion, isolation and instrumentation, operational amplifiers and linear devices for multiplication, division, etc. Burr-Brown International Ltd, Permanent House, 17 Exchange Road, Watford WD1 7EB. WW411

Earth-leakage circuit breakers with a trip sensitivity of 30mA are made by Groveland Electronics and a leaflet is available. Load contacts have a short-circuit capability of 1500A and the unit cannot be held on in a fault condition. The firm is at 5/6 Hale Wharf, Ferry Lane, Tottenham, London N17. .... WW412

Introducing non-linear circuits

Logarithmic, power and r.m.s. laws

by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams

Paisley College of Technology

A growing need for a variety of mathematical function generations has led to a variety of circuit solutions. The problems range from the use of resolvers in servo systems in which sine/cosine function generation is needed, to the measurement of the true r.m.s. value of non-sinusoidal waveforms.

If we restrict ourselves to one or two variables, then Fig. 1 shows a sample of the functions that might occur in practical systems – either because the output of a system is required in some particular form such as a decibel representation of a voltage gain, or to correct for some non-linear property of a transducer. Few of these functions can be obtained directly from existing devices and circuits unless limited accuracy is acceptable. For example, the field-effect transistor has a square-law term in its I_D/V_{GS} characteristic and this has been exploited to provide such functions as X_2 and XY.

However, the circuits have been fairly complex, have resulted in significant departure from the ideal law or have drifted badly with change in temperature and/or supply.

Some of these functions can be obtained by indirect means such as the parametric techniques of Hall-effect devices or varactor diodes. Others can be obtained via modulation processes as in the multiplier/divider circuits of Circards Set 29. The most valuable tool available to the designer in this area is the transistor, not because of its amplifying properties, but because the I_C/V_{be} characteristic follows a particular non-linear law precisely and over a wide range of currents.

In its simplest form that law can be written as: $I_C = k \exp V_{be}$. This hides a number of inconvenient factors such as its dependence on temperature, but is an accurate representation of the shape of the characteristic. As indicated in the previous article this is the basis of logarithmic amplifiers in which the output voltage is a logarithmic function of the input voltage.

From the basic properties of logarithms various power-law operations can be implemented.

one variable	two variables
X^2	XY
$\sqrt{X}$	$\frac{X}{Y}$
$1/X$	$\frac{X^2}{Y}$
aX^2+bX+c	$\sqrt{X^2+Y^2}$
$\log_e X$	$\sqrt{X^2\ Y^2}$
e^x	
$\cos X$	
$\sin X$	
$\sqrt{X^2}$	

Fig. 1. Common functions that can be obtained by passing X, Y through circuits with corresponding transfer functions.

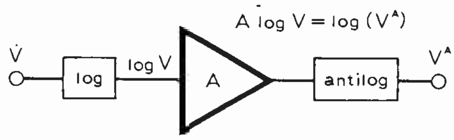


Fig. 2. Logarithmic circuits are based on natural logarithms rather than $\log_{10}$ because of the way diode/transistor characteristics are expressed.

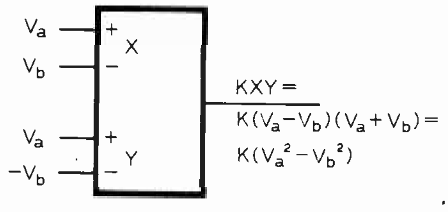


Fig. 3. Circuit produces an output that, after filtering and passing through a square-rooting circuit, would give the vector difference between two input variables. More elegant solutions are available using feedback/feedforward.

Let $V_a = K \log_e V_1$ and $V_b = K \log_e V_2$.

Then $V_a + V_b = K \log_e (V_1 V_2)$ 1

$V_a - V_b = K \log_e (V_1/V_2)$ 2

$nV_a = nK \log_e V_1 = K \log_e (V_1{}^n)$ 3

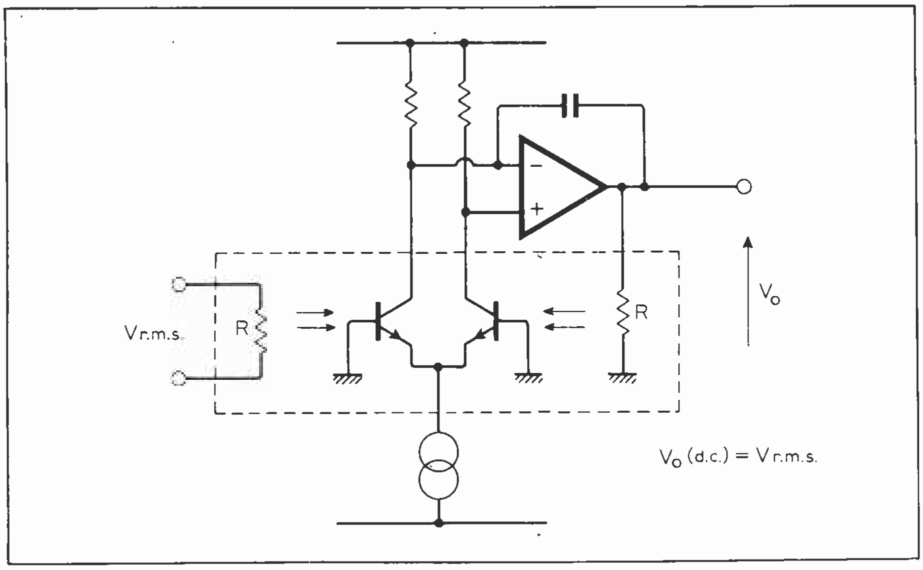
Thus adding, subtracting or amplifying the input variables all of which are within the scope of normal linear circuit design, result in outputs that involve the product, ratio or powers of those variables. The remaining problem is that the output is still a logarithmic function; if it is succeeded by an antilog circuit then the process is completed. A typical configuration is shown in Fig. 2.

A second family of circuits makes use of existing functional blocks such as the multiplier *(XY)* or the multiplier/divider *(XY/Z)*. Using various feedback and feedforward configurations, a number of the other functions such as square, square root and division can be performed. As an example, consider the circuit of Fig. 3. It illustrates how complex functions can be built up piecemeal. With care and ingenuity elegant and efficient solutions to such problems can be found using various interconnections to remove the need for additional functional blocks.

A group of four transistors in which the base-emitter voltages have a relationship of the form $V_1 + V_2 = V_3 + V_4$ must result in a corresponding collector current relationship $I_1 I_2 = I_3 I_4$ once the log characteristics are taken account of (see previous article). This leads directly to the implementation of a multiplier by making, say, I_2 constant and forcing I_3, I_4 to be proportional to the two input variables. Other interconnections of these transistors can yield functions such as square, vector sum, and division.

Some novel solutions demand devices not readily available to the average user – devices developed by manufacturers for use in their own instruments.

One such that shows an old idea brought very firmly up-to-date is given in Fig. 4. It uses what is effectively a balanced bridge to determine the true r.m.s. value of an input voltage. If two identical transistors are separately heated by equal resistors then they will remain in balance only if the flow of



heat to each is equal. Any unbalance is amplified by the operational amplifier forcing the direct output voltage to deliver the same power to the right-hand resistor as the input delivers to the other. Hence the r.m.s. values of the two voltages are equal. A neat idea, though one that requires a very carefully constructed chip if the sensing transistors are each to respond to only one of the heat sources.

A severe problem in many of these ideas is that of identifying and neutralizing the error sources. Because of the non-linear equations involved, the relative errors are different at all parts of the range. Manufacturers of modules and i.cs directed at these applications devote a great deal of effort to this topic, and readers would be well-advised to consult them if high-precision functions are needed.

Circuits based on these principles are described in Set 30 of Circards, under the following headings:
Root-law array
Voltage divider circuit
Ramp-sinewave converter
R.m.s.-d.c. converter
Delta-sigma converter
Cube-law generator
Logarithmic amplifier
Resolvers
Applications of is multipliers
Computation of $(x^2+y^2)^{1/2}$

How to get Circards

Order a subscription by sending £18 for a series of ten sets to:
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IPC Electrical-Electronic Press Ltd
General Sales Department, Room 11
Dorset House
Stamford Street
London SE1 9LU

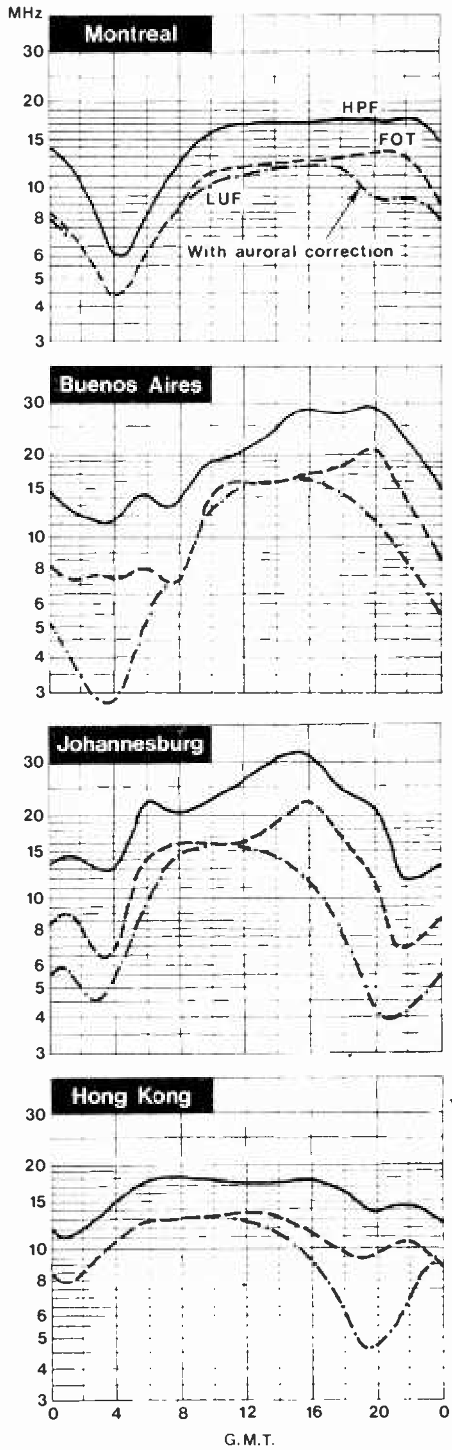
Specify which set your order should start with, if not the current one. One set costs £2.00, postage included (all countries). Make cheques payable to IPC Business Press Ltd.

Fig. 4. Two identical transistors are heated separately by resistors supplied from an unknown input voltage and the output of an op-amp. High gain forces the transistors into balance by increasing V_0 until the power it supplies matches that delivered by $V_{r.m.s.}$

Topics covered so far in Circards are:
1 active filters
2 switching circuits (comparator and Schmitt circuits)
3 waveform generators
4 a.c. measurement
5 audio circuits (equalizers, etc.)
6 constant-current circuits
7 power amplifiers (classes A, B, C, D).
8 astable multivibrator circuits
9 optoelectronics: devices and uses
10 micropower circuits
11 basic logic gates
12 wideband amplifiers
13 alarm circuits
14 digital counters
15 pulse modulators
16 current-differencing amplifiers—signal processing
17 c.d.as — signal generation
18 c.d.as — measurement and detection
19 monostable circuits
20 transistor pairs
21 voltage to frequency converters
22 amplitude modulators
23 reference circuits
24 voltage regulators
25 RC oscillators-1
26 RC oscillators-2
27 Linear c.m.o.s.-1
28 Linear c.m.o.s.-2
29 Analogue multipliers
30 Non-linear circuits

HF predictions

H.F. predictions have two basic sources of error. First, that arising from the associated forecast of solar activity and secondly that arising from the methods used to determine monthly median values of HPF, FOT and LUF for a given level of solar activity. Measurement of these parameters would constitute in statistical terms a single trial with a fairly small sample, so there will inevitably be some deviation from predicted values. Additional trials to determine prediction accuracy could only be made in the same month of following years, by which time solar activity may have changed considerably. The problems are therefore treated statistically, with the outcome in simple terms that prediction error is unlikely to be greater than ±5% when the effects of solar and magnetic disturbance are removed.



Maritime satellite to aid shipping

The world's first commercial maritime communications satellite, designed to provide instant ship-to-shore communications for merchant vessels and American naval forces was launched by NASA from Cape Canaveral, Florida on February 19. The satellite, called Marisat, is the first in a new series of synchronous orbit communication satellites designed to relay high quality voice, telex, facsimile and other data over the Atlantic and Pacific oceans for the international maritime industry. A second Marisat, scheduled for launch in May, will be stationed over the Pacific.

Ship-to-shore communications serving vessels over thousands of square miles of ocean have until now relied primarily on h.f. radio transmissions, which are subject to fading and atmospheric interference, while delays of 4 to 24 hours in the delivery of messages are common. The new satellite is designed to operate in three frequency bands. These are u.h.f. for the US Navy, L-band for merchant vessels and offshore platforms and C-band between shore stations and the satellite. (An earlier maritime satellite navigation system, using the Transit non-synchronous satellites, was described in our February 1975 issue, pp. 52-57).

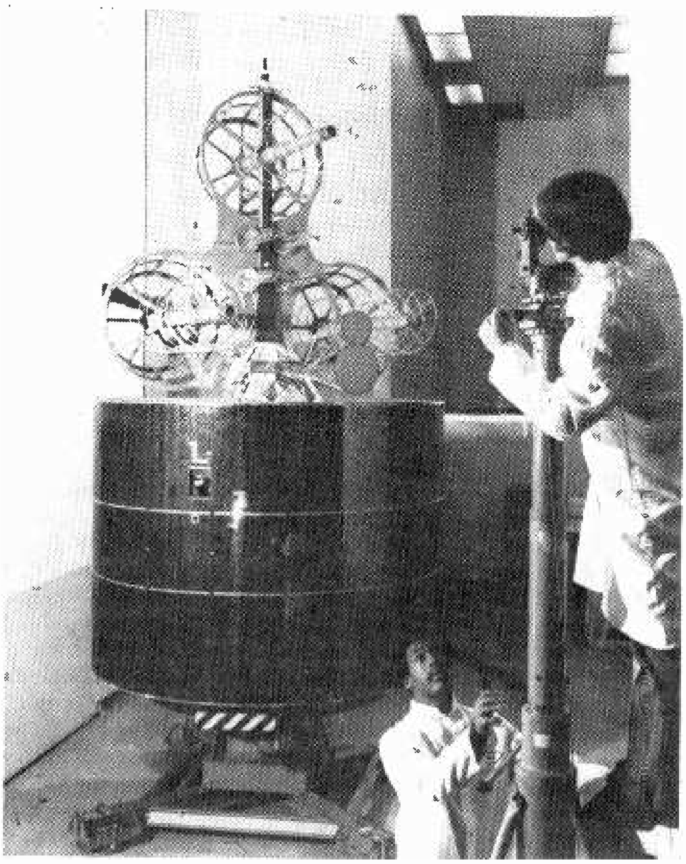
UK researchers celebrate

Ten years of research at the Mullard Space Science Laboratory were celebrated during March by a retrospective exhibition at University College, London. The research group, which today makes up a UCL laboratory at Holmbury St. Mary, Surrey, grew up under Professor R. L. F. Boyd at University College over the ten years 1956 to 1966 before its move to the MSSL in 1966. Its growth became rapid with the start of the collaborative US/UK Ariel 1 satellite project in 1960, and work on this historic undertaking opened the way to participation in a large number of space projects being planned then by the US National Aeronautics and Space Administration and somewhat later by the European Space Organisation, now the European Space Agency.

Attention of the laboratory has recently turned to studies of the magnetosphere and of magnetospheric-ionospheric interactions.

With three X-ray astronomy instruments in orbit, data can be expected to flow to the laboratory for at least another eighteen months, but the analysis and exploitation of the results will go on even longer. In 1977, two new satellite projects on which the laboratory is currently expending much effort, the ESA geo-stationary satellite Geos and the UK X-ray astronomy satellite UK-6 will mature. Geos will supply data on low-energy particle fluxes taken on a field line intersecting the Kiruna rocket range, related low-altitude measurements being made from rockets as part of a high latitude rocket campaign there. UK-6 will permit study of chosen X-ray sources at lower energies than before, using detectors with windows of a material so thin that gas systems have to be provided to replace the constant diffusive loss of counter gas.

Two further major projects now in hand will result in satellite launches in subsequent years. The NASA "solar maximum mission" will carry two instruments, built jointly by Lockheed's Palo Alto Laboratories, the astrophysics research division of the Appleton Laboratory and the MSSL, for making X-ray measurements of the solar corona that meet the demanding requirements of spatial, spectral and time resolution. The ESA Exosat spacecraft will carry two X-ray observing systems for which MSSL will provide the detectors, one being a position-sensitive detector. This provides positional information so that an X-ray image created by the newly-available focusing X-ray optical systems can be realized electronically and transmitted from satellite or rocket to ground station. A similar system, but which uses a larger X-ray reflector than hitherto, will be flown jointly by the Lockheed and MSSL groups on an Aries rocket. This payload will be one metre in diameter, as compared with the 40cm Skylark payload diameter, and will represent the kind of instrument package that in the 1980s will be carried into orbit by the Shuttle vehicle. Shuttle and the use of Spacelab will gradually become very important in the work programme of the MSSL over the next ten years.



Marisat, built by Hughes Aircraft Company in California (see news item). Technicians are adjusting a theodolite to determine horizontal and vertical alignment.

World of Amateur Radio

Vanishing ionosphere?

The recent public debate on the possible effects of aerosols containing fluorocarbons on the protective ozone content of the upper atmosphere has caused William W. Lamb, W8BJ, to speculate whether, long before we may be affected as human beings, we could conceivably suffer loss of h.f. long-distance transmissions. Another amateur has suggested that one solution might be to go back to "ozone creating" spark transmission!

During the remarkable Sporadic-E opening of June 1, 1975 the amateur station 9H1CD on Malta was able to contact OZ10F in Denmark, a distance of 2400km, and just failed to contact a station in Finland. Both paths represent exceptional distances for Sporadic E propagation, although transatlantic contacts on 28MHz seem to indicate that double-hop Sporadic-E contacts are occasionally possible.

Modes and band-plans

For several years there have been efforts to persuade the Home Office that the amateur licence should include facilities for fascimile transmissions using the A4 and F4 modes. It has now been announced that such transmissions can be made by licensed amateurs in the 3.5, 7, 14, 21, 28 and 144 MHz bands provided that the bandwidth does not exceed 6kHz. No special application need be made.

The RSGB Repeater Working Group has proposed channel frequencies in the 432MHz band as a basis for orderly, planned n.b.f.m. operation, and it is hoped that equipment suppliers and crystal retailers will co-operate in developing this band-plan. Channel RB2, 433.05MHz output and 434.65MHz input repeaters; Channel RB4, 433.10MHz output and 434.70MHz input repeaters; Channel RB6, 433.15MHz output and 434.75MHz input repeaters; Channel SU8, 433.20MHz simplex channel; Channel RB10, 433.25MHz output and 434.85MHz input repeaters; Channel SU12, 433.30MHz simplex channel; Channel RB14, 433.35MHz output and 434.95MHz input repeaters; Channel SU16, 433.40MHz simplex channel; Channel SU18, 433.45MHz simplex channel; Channel SU20, 433.50MHz calling channel.

The Raynet amateur emergency network, in agreement with other RSGB committees, has proposed that 144.8, 144.825, 144.850 and 144.875MHz should be classified as emergency channels and is appealing to other amateurs not to use these channels for normal contacts.

Under a reciprocal licence agreement with the Republic of Cyprus, holders of Class A licences can now obtain examination-free licences in Cyprus. Those with Class B licences have to take a 12 w.p.m. Morse test.

Frank Hennig presents...

Frank Hennig, G3GSW, a well-known freelance broadcaster (for some years he recorded the weekly gardening chats with the late Fred Streeter), has become the presenter of the BBC's "World Radio Club" where he joins Henry Hatch, G2CBB. During the war, Frank Hennig was a member of Royal Signals and during 1944-45 commanded a No. 10 microwave equipment signals unit in Normandy, Belgium and Holland, and later occasionally operated the club station VS1BU in Singapore. He is currently active on h.f. with a transceiver and four-band ground-plane aerial.

Listeners in the USA, Central and South America will benefit from the opening shortly of the joint BBC-Deutschewelle Carribean relay station on Antigua equipped with four 250kW transmitters. Programmes will be relayed from Europe either by direct re-broadcast, by special s.s.b. point-to-point link, or via ocean cable circuits. The associated receiving station is equipped with two rhombic aerials but is not expected to employ diversity techniques.

Here and there

The next reunion of the Radio Amateur Old Timers' Association will be held on Saturday, May 1 (not May 8 as originally announced) at the Cora Hotel, Upper Woburn Place, London WC1. Membership details of RAOTA, open to amateurs who have held their licences for 25 years, are available from Miss May Gadsden, 79 New River Crescent, London N13 5RQ.

The Southampton University Radio Club (G3KMI) celebrates its 21st anniversary in September and the present committee is planning a special reunion. Former members of the club are invited to contact the Secretary, Southampton University Radio Club, Students Union, The University, Highfield, Southampton SO9 5NH, for further details.

Lord Wallace of Coslany who while a Member of Parliament took considerable interest in amateur radio licence matters and whose son is an active amateur is to be RSGB president 1977.

"At the present time the only countries where amateur radio is completely prohibited are those associated with China — and even there, I understand, there is some hope of a change in the not too distant future" — Dr John Allaway, RSGB president, said recently.

The RAF Gibraltar Amateur Radio Society (ZB2A) is celebrating its 30th anniversary by a special burst of on-air activity from May 25 to June 1 when it is hoped to contact many of those who have served on The Rock.

In the first six months of its current financial year, the RSGB had a financial deficit of about £7,000. It is currently considering buying an IBM32 mini-computer to improve handling of the membership records. The Society recently received a legacy of over £4,000 from the estate of Mrs Sherley-Price, widow of the former G8SP.

The problems underlining enforcement of Citizen Band regulations in the United States are indicated in a recent report of the US General Accounting Office. This supports FCC suggestions that additional legislation is needed to assess fines against unlicensed operators and to make it a crime to "kill, assault or intimidate" FCC personnel making station checks. FCC has reported that its enforcement agents are increasingly being subjected to vocal and physical abuse but that at present when violence occurs the only recourse is through local and state courts. There have been instances of Post Office inspectors investigating "pirate operation" in the UK being threatened with physical violence.

In brief

Membership of the G-QRP-Club, devoted to low power radio communication, has increased to 195 members (George Dobbs, G3RJV, 8 Redgates Court, Calverton, Nottingham, NG14 6LR for details) . . . Following the earthquake in Guatamala on February 4 an amateur radio emergency link was quickly established through TR9LW and TG9GF to the United States on 14,325kHz and provided communications for the stricken area for several weeks, winning Red Cross praise . . . A survey made by J. H. Brazzill, G3WP, a sub-manager of the RSGB QSL Bureau showed that of 3055 QSL cards received by him recently, only 1696 were collected by amateurs . . . An American amateur is reported to have copied Morse code at 80 w.p.m. . . . The satellite OSCAR 6 is now available for use during descending orbits on Saturday mornings.

PAT HAWKER, G3VA

New Products

Phase-controlled soldering iron

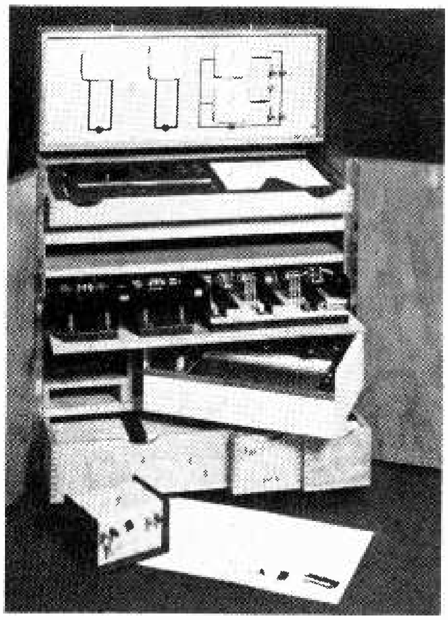
The ORYX super 30 iron is a general purpose tool which offers phase control circuitry incorporated in the handle. This circuit limits the power and therefore the temperature of the iron, which in turn extends the life of the element. The handle also has a mains neon. A range of ten bit sizes is available for the iron which is rated at 27W and has a tip operating temperature of 365°C. The unit is priced at £2.95 + v.a.t. and is available from Greenwood Electronics, Portman Road, Reading, RG3 1NE.

WW 301 for further details

Instructional electromagnetics set

A system known as LoSAID includes magnets, coils, slip rings and commutators which can be rotated slowly to produce outputs for a three channel pen recorder which is also in the set. Using this system, low frequency electromagnetics can be studied, from a simple moving coil meter to motors, attenuators, generators, 3 phase supplies, synchronous motors and positional servo systems. The complete set is housed in a wooden cabinet and is available from Educational Measurements Ltd, Brook Avenue, Warsash, Southampton, SO3 6HP.

WW 302 for further details



WW 302 for further details

Thin film strain gauge

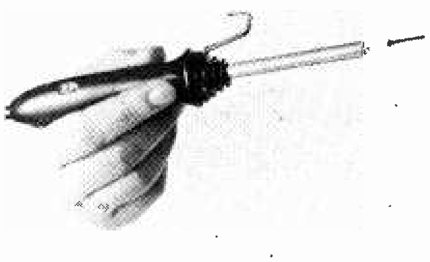
The series C cantileverstrain gauge has a thin film device deposited onto the cantilever surface using a radio frequency sputtering technique. This is claimed to provide a strong bond without using adhesives. The sensing element comprises a Wheatstone bridge circuit in which two of the elements are active. Alma Components Ltd, Park Road, Diss, Norfolk IP22 3AY.

WW 303 for further details

Power dividers

A series of four-way power dividers which are claimed to be capable of withstanding rigorous environments has been introduced by Merrimac Industries. The PDF-4E series of power dividers provides broadband coverage over the frequency range of 50kHz to 500MHz. These "flat pack" devices were designed for mounting on stripline and printed circuit boards, particularly in situations where high-density packaging is required. The model PDF-4E-50 is representative of the series and covers the 2 to 100MHz range, with −6dB coupling and 30dB isolation. Other characteristics of this model include: amplitude balance 0.2dB, phase balance 1°, insertion loss 1dB, impedance 50Ω, v.s.w.r. 1.3:1, and power 1W with matched loads. Merrimac Industries, Inc., 41 Fairfield Place, West Caldwell, N.J.07006, U.S.A.

WW 304 for further details



WW 301 for further details

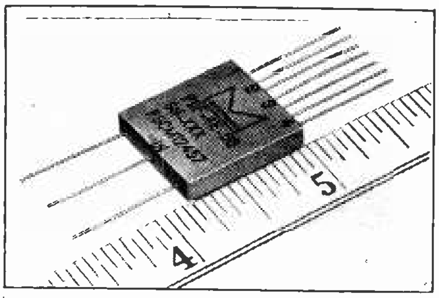
Frequency counter

A 1.2GHz frequency counter has been added by R.C.S. to their range of instruments for laboratory use. The instrument uses a silicon-on-sapphire thin-film hybrid input amplifier and has a sensitivity better than 10mV over its range from 4Hz to 1.2GHz. An automatic decimal point facility is provided. The R.C.S. 1001 counter has a short-term stability of 5 parts in 10^{10}. The directly-gated range of this instrument is 4Hz to 80MHz at an input impedance of 1MΩ in parallel with 20pF. Two scaler inputs are provided, 80-150MHz and 120MHz-1.2GHz with an input impedance of 50Ω. R.C.S. Electronics, National Works, Bath Road, Hounslow, Middlesex TW4 7EE.

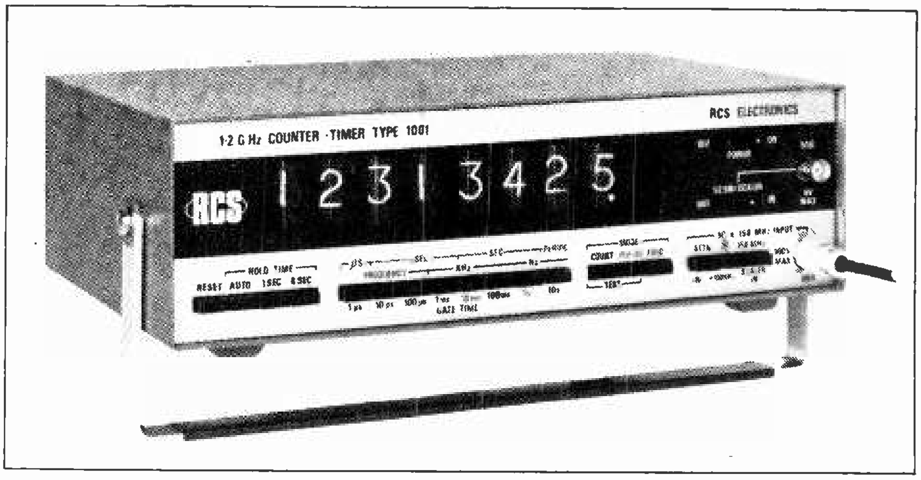
WW 305 for further details

Plotting system

The Gould Plotmaster, designed to run in conjunction with an IBM 360/370 computer, is available from Nanotek Ltd. The system, which has a high-speed electrostatic printer/plotter, can generate alphanumeric information at speeds of up to 3000 lines per minute as well as displaying engineering, scienti-



WW 304 for further details



WW 305 for further details

fic or business information in graphical form.

A feature of the Plotmaster system is its intended ease of use in business applications where it can be incorporated into existing systems. A business graphics package known as DISPLAY is used to generate line, bar and pie charts. Because DISPLAY has the ability to recover from input coding errors and produce an acceptable chart, reprogramming is minimized. A PLOT graphics package can generate background grids, variable line weights, automatic stripping, text annotation and erasure of previously programmed line segments. Gould Advance Ltd, Raynham Road, Bishop's Stortford, Hertfordshire.

WW 306 for further details

Wire bundle mount

Panduit Ltd has announced an inexpensive aluminium mounting base for harnessing cable ties. The mount, which is available with or without adhesive backing, can be screw mounted if necessary and measures 1.0 × 0.5in providing an effective means for securing bundles to flat metal or non-porous surfaces. Panuit Ltd, Sittingbourne Industrial Park, Unit 22a, Crown Quay Lane, Sittingbourne, Kent.

WW 307 for further details

Chip inductors

Aladdin Components have announced a family of chip inductors for use in the hybrid and thick film circuits. Series FC fixed-value inductors are shielded and have welded internal connexions capable of withstanding reflow solder temperatures. Moulded in a case 3.05 × 3.18 × 3.81mm, the inductors are suitable for resonant circuits and decoupling and are available in the range 0.01μH to 1mH. Type VC tunable inductors also incorporate internally-grounded gold-plated brass tuning adjusters and are available in the range 0.1μH to 1mH. Both the FC and VC types have gold contact pads. Aladdin Components, Aladdin Building, Western Avenue, Greenford, Middlesex UB6 8UJ.

WW 308 for further details

Inductance meter

The model 62A 1MHz inductance meter has full scale ranges from 1μH to 3mH with an accuracy of 5%. A digital version, the model 62AD, has programmable range functions or an autoranging capability. Analogue and b.c.d. outputs are provided for driving peripheral equipment and the unit is said to be suitable for systems applications. Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1 1YE.

WW 309 for further details

Automatic distortion meter

The model DM-153A distortion meters offers automatic fine frequency-tuning and balance adjustment over the frequency range 6Hz to 600kHz, and distortion ranges from 100% to 0.1% f.s.d. Fundamental and harmonic outputs are also available for the display of Lissajous figures. The instrument is priced at £540 + v.a.t. and is available from Lyons Instruments Ltd, Hoddesdon, Herts.

WW 310 for further details

Resistance deviation bridge

Nine resistance ranges on the model 506 deviation bridge from Electro Scientific Industries Inc allow measurements from 0.1Ω to 50MΩ with 5½ decades per range for setting nominal resistance value and percentage. Deviation can be measured in p.p.m. and up to 200% respectively. The basic accuracy of the model 506 is 50 p.p.m. Facilities include thermal e.m.f. cancellation, automatic compensation for lead resistance and measurement of resistors in closed-loop and buried-node circuit configurations. Primarily designed as a production tool, the unit can be used in conjunction with a sorting fixture and/or comparator for rapid sorting or checking. Tranchant Electronics (UK) Ltd, Tranchant House, 100a High Street, Hampton, Middlesex.

WW 311 for further details

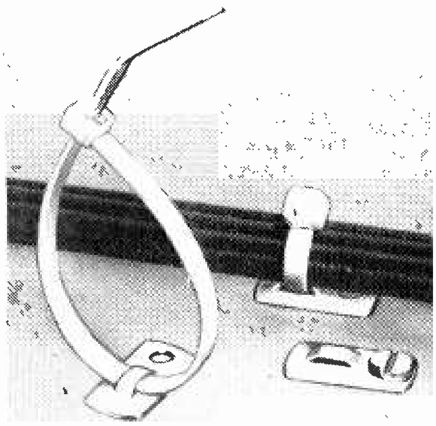
Circuit breakers

A range of miniature circuit breakers from Belling & Lee covers load current ratings from 300mA to 15A in two series. Devices in the L5400 series are thermally operated for use where a time lag is required. The L5500 series employs a thermal-magnetic trip mechanism which provides a faster action. The units are reset by a push button, and an additional set of change over contacts can be included for remote signalling. Belling & Lee Ltd, Great Cambridge Road, Enfield, Middlesex EN1 3RY.

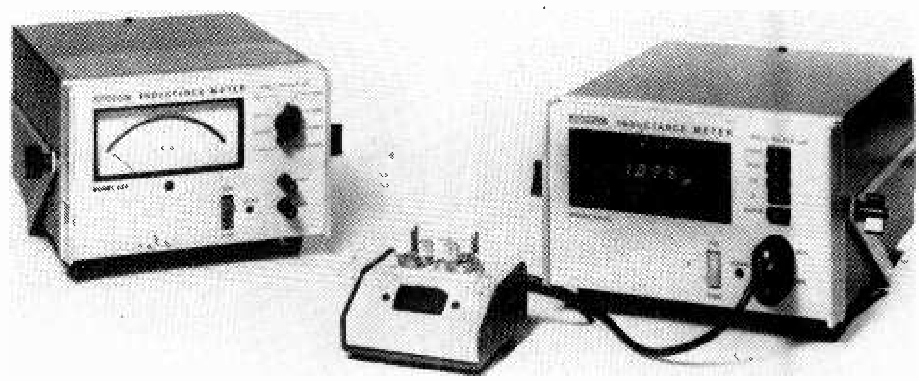
WW 312 for further details

Ultrastable Gunn oscillators

Series 6901-1200 Gunn oscillators developed by Trak Microwave Corporation are claimed to be virtually unaffected by voltage, v.s.w.r. and temperature shifts. The oscillators are mechanically tunable over ±0.5% of a centre frequency, selectable between 8GHz and 16GHz, for a thermal stability of ±0.05% from −54°C to +71°C. Radio frequency output is between 13dBm and 19dBm.



WW 307 for further details



WW 309 for further details

Harmonics are greater than 50dB down with non-harmonic spurs measured at greater than 80dB down. REL Equipment and Components Ltd, Croft House, Bancroft, Hitchin, Herts, SG5 1BU.
WW 313 for further details

Microwave signal generator

The model 399/X is a solid-state signal generator variable between 8.2 and 12.5GHz. The instrument uses a high Q broadband coaxial cavity with a plug in Gunn diode. Operating frequency and relative power level are displayed on digital displays. Internal pulse and square wave modulations are applied via a pi.n. modulator in the r.f. output circuit, while internal sawtooth modulation is applied directly to the Gunn diode supply.

Other models in the series provide coverage from 7.5 to 18GHz in overlapping bands. Flann Microwave Instruments Ltd, Dunmere Road, Bodmin, Cornwall, PL31 2QL.
WW 314 for further details

Synchro/digital display

The synchro/digital display type RDD100 is supplied with synchro, hybrid synchro-to-digital converter, 0.6in character display, b.c.d. output and connecting cable. Available as a three or four decade display with standard readings, 0-360, 0-360.0 ± 179 or ± 179.9 degrees. Custom scale factors can also be supplied, e.g. 0-1000. Total system accuracy is 1 part in 1000. Incremental systems with counts up to 5000 per revolution are also available. Moore Reed and Company Ltd, Walworth Industrial Estate, Andover, Hampshire.

WW 315 for further details

Voltage controlled oscillator

A voltage controlled crystal oscillator, type QC1308D, has an operating frequency of 2048kHz which can be divided to produce the discrete frequencies for communications systems. The device is compatible with t.t.l. circuitry and requires a 5V supply. Frequency adjustment is by varactor diodes and a control voltage between 0 and 8.5V. Once the required frequency has been selected the oscillator stability is around ± 2 p.p.m. over the first year. Salford Electrical Instruments Ltd, Times Mill, Heywood, Lancs.
WW 316 for further details

Tunable L-band magnetrons

The MCV1352 and MCV1353 tunable L-band magnetrons from Thomson-CSF deliver a minimum peak output power of 2.2MW and together cover the 1270-1370MHz band. Both magnetrons are suitable for air-search radars, and in particular moving target indicator systems which require stable radio frequency pulses. The magnetrons are cooled by simple tap water circulating systems. Thomson-CSF Electronic Tubes Ltd, Ringway House, Bell Road, Daneshill, Basingstoke, Hants RG24 0QG.
WW 317 for further details

Linear displacement transducers

A range of d.c./d.c. linear displacement transducers with stroke lengths up to 150mm has been introduced by Jackson Brothers (London) Ltd. Standard models are available in three stroke lengths of 50, 100 and 150mm and an output sensitivity of up to 100mV per mm is available. The devices can be custom built to meet individual requirements. Jackson Brothers (London) Ltd, Kingsway, Waddon, Croydon.
WW 318 for further details

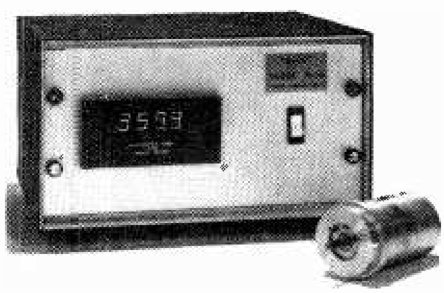
Low noise toroid transformer

Avel-Lindberg have designed a toroid transformer for use in data-processing video monitors. The toroid construction has no air gap, and is shielded by the windings which go completely around the core. This, say the makers, keeps unwanted magnetic radiation to a minimum. The transformer has a 0-110-120V primary winding and 17-0-17V, 8.5-0-8.5V secondary windings rated at 1A and 3A per side respectively. Dimensions of the toroid are 115mm outside diameter by 52mm high. Avel-Lindberg Ltd, South Ockendon, Essex RM15 5TD.
WW 319 for further details

Relay for amusements

A relay designed specifically for vending machine and amusement equipment applications has been introduced by Magnetic Devices Ltd. Designated series 270C, a push-button, press-to-operate key provides a quick means of checking correct operation without removing the relay from the circuitry under test. Mechanical life is better than ten million operations and electrical life is 100,000 operations at full load. The series 270C is available in two- and four-pole, same polarity switching versions with coils rated at 1.4VA, 50V a.c., or 0.9W, 24V d.c. Ambient operating temperature is up to +55°C and insulation between coil and contact is proof voltage tested to earth at 1,500V r.m.s, 50Hz. Magnetic Devices Ltd, Exning Road, Newmarket, Suffolk CB8 0AX.
WW 320 for further details

WW 314 for further details



WW 315 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.

Power transistors

The BUX46-47-48 switching power transistors are triple diffused devices rated at 850V, $V_{ce\,sat}$ at less than 1.5V for up to 9A collector current and a typical fall time of 0.3µs. High voltage power transistors are also available: BU142-3-4, intended primarily for 110° precision-in-line tube applications; BU126 for switching mode power supplies; BU207-8-9 for very high voltage horizontal deflection circuits in colour TV applications. Voltage ratings are up to 1700V, $V_{ce\,sat}$, current ratings are up to 12A and a typical fall time is less than 1µs at up to 8A collector current. The BUX37 power Darlington transistor is designed specifically for high voltage electronic ignition applications.

Thomson CSF

WW 321 for further details

Limiter diodes

Limiter diodes claimed to handle pulses of up to 4kW peak power and reduce leakage power to as little as 10mW have been announced by Alpha Industries, Inc. for protecting sensitive receivers. CLA3131, CLA3132 and CLA3133 series are p-i-n silicon diodes providing passive receiver protection over a range of frequencies from 100MHz to beyond 20GHz. Peak input power range (for a pulse of 1µs maximum duration) is 50 to 66 dBm. The diodes are supplied in basic chip form or encased in a variety of glass or ceramic packages.

Impectron

WW 322 for further details

Memory for v.d.u.

A 512-line, 512 elements-per-line video image can be stored by the in-477 4k r.a.m., announced by Intel. The memory is intended to replace the usual shift register, allowing both sequential and random access at 20M bits/sec. A single 4k memory, contained on one 15in square board, will suffice for a monochrome, alphanumeric or graphic display of any size or shape, while coloured or tonal images will require several memories in parallel. Board selection is built in. The memories require +5V, −5V and +12V, dissipate less than 25W, and are t.t.l.-compatible. An 18-bit address code is used and the standard time for access to the data is 600ns, which can be reduced by arrangement with the makers.

Intel

WW 323 for further details

High voltage rectifiers

A range of rectifiers from Amex have voltage ratings from 3kV to 50kV and power ratings up to 1W. The devices are housed in moulded cases or standard epoxy packages.

Amex

WW 324 for further details

Timekeeping circuits

The TA6779 and TA6930 are 4.194MHz c.m.o.s. clock circuits designed for operation at low voltages (1.1 to 2.2V for the TA6779 and 1.2 to 2.2V for the TA6930). The circuits, developed by RCA, can be driven by standard quartz crystals and are suitable for use in both clocks and watches. For a drive voltage of 1.6V the maximum operating current is 100µA for no load. The TA6779 has a 32Hz output (50% duty cycle) and a frequency stability of 1 in 10^6 per 0.1V change in drive voltage, while the TA6930 has a 1Hz motor output and a stability of 0.2 in 10^6 per 0.1V change.

RCA

WW 325 for further details

Multi-decade counters

An integrated circuit, the MM74C925, from National Semiconductor combines a four-digit counter, data latches and a seven-segment multiplexed output capable of directly driving a four-digit l.e.d. display. The multiplexing circuit has its own free-running oscillator and requires no external clock. Several other versions of the counter are available with different options. The MM74C926, for example, is similar to the 925 but has a carry-out connexion that is employed for cascading counters in systems with more than four digits, and a display select line that allows either the data in the latch or the data in the counter to be displayed.

National

WW 326 for further details

Power Darlington transistors

Six power Darlington transistors in n-p-n and p-n-p types rated at 100W, 150W and 225W at a V_{ceo} of 100V have been introduced by Lambda Electronics. Peak current ratings for the three power levels are 16A, 20A and 40A respectively. Power de-rating is effective above case temperatures of 50°C: h_{FE} minimum is 1,000 at 4A, 6A and 10A respectively and continuous ratings are 8A, 12A and 20A. Designated PMD-10K-100, 11K, 12K, 13K, 16K, and 17K, these devices are 100% tested for leakage current stability at 200°C junction temperature and are temperature cycled from −65° to +200°C. Each device is tested for secondary breakdown current and they are hermetically sealed in TO-3 packages.

Lambda

WW 327 for further details

Microwave power transistor

Characteristics specified for the Motorola MRF 835 at 870MHz using a 12.5V d.c. supply are output power 15W, minimum gain 7dB and efficiency 50%. A gold metallization system has been used instead of aluminium so that current migration within the device is reduced and the mean time between failures if increased 1,000 to 10,000 times.

Motorola

WW 328 for further details

Instrumentation amplifiers

Two i.c. amplifiers, claimed to be suitable for thermocouple, strain gauge, bridge, and other low-level transducer applications, have been introduced by Burr-Brown. The 3662JP is continuously rated at 96dB and has a maximum gain non-linearity of 0.1% with a drift of less than 6µV/°C at a gain of 1000. The 3662KP, rated at 104dB, has a maximum non-linearity of 0.05% and a drift of less than 2.5µV/°C at a gain of 1000. Both amplifiers have typical common-mode impedances of $2 \times 10^{10}\Omega$ in parallel with 3pF and require an input bias current of less than 300nA. The 14-pin d.i.l. packages include all network resistors, with the exception of the gain setting resistor.

Burr-Brown

WW 329 for further details

Suppliers

Thomson-CSF UK Ltd, Ringway House, Bell Road, Daneshill, Basingstoke, Hants RG24 0QG.

Impectron Ltd, 23 King Street, London W3 9IH.

Intel Corporation UK Ltd, Broadfield House, 4 Between Towns Road, Cowley, Oxford OX4 3NB.

Motorola Semiconductor Products Ltd, York House, Empire Way, Wembley, Middx.

National Semiconductor UK Ltd, 19 Goldington Road, Bedford MK40 3LF.

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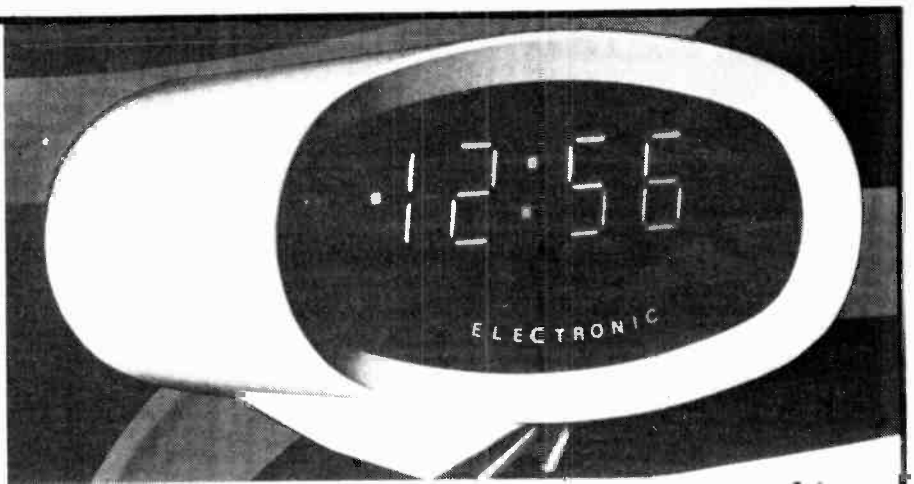

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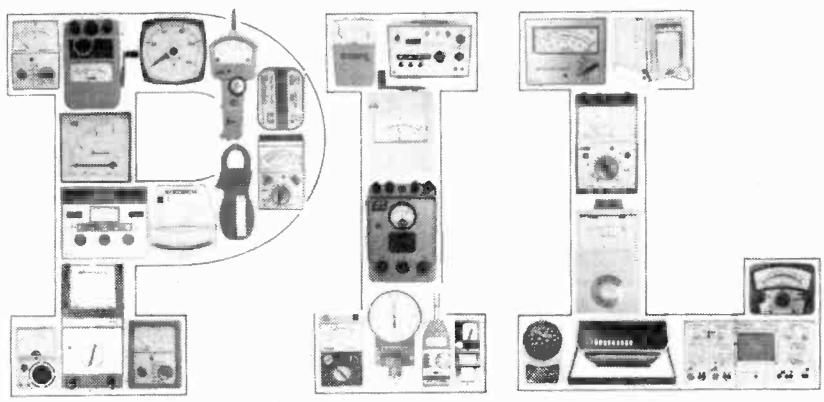

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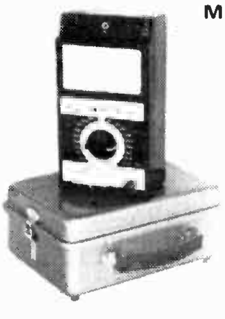

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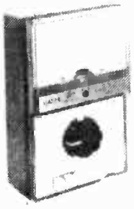

U4324: 33 ranges 0.06mA — 3A D.C., 0.3mA — 3A A.C., 0.6-1200v D.C., 3-900v A.C., 0.5-500kΩ; Sensitivity 20,000Ω/v D.C., 4000Ω/v A.C. Accuracy 2.5% D.C., 4% A.C. Re-chargeable cadmium cell operation. £10.85.

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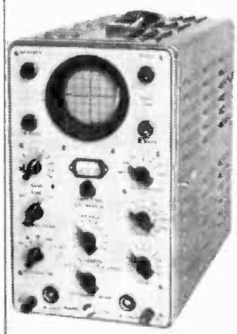

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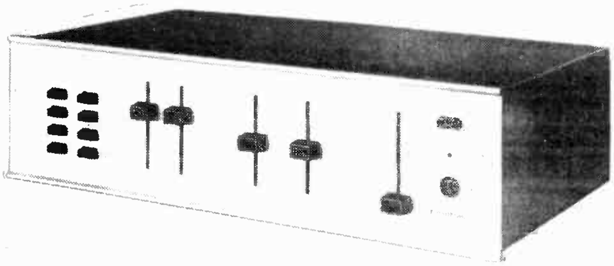

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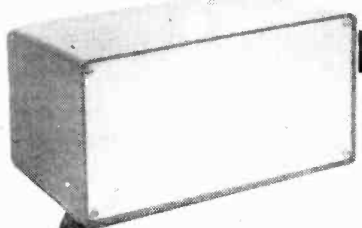

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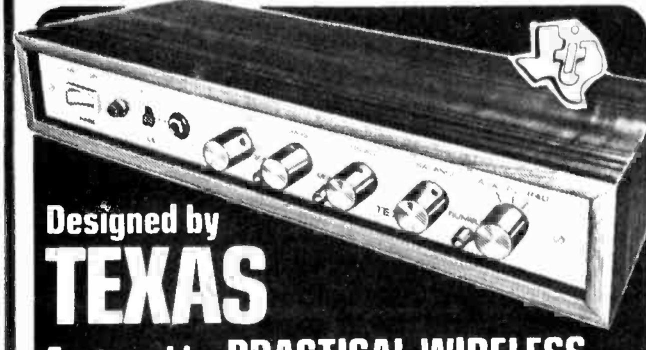

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203	500, 500	0-15-27, 0-15-27	3.15	72
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CD4017	0.88	LM748		SN7412	0.22	SN7494	0.75	SN76033N	2.92
CD4018	0.88	8DIL	0.44	SN7413	0.28	SN7495	0.68	TAA263	1.20
CD4019	0.52	14DIL	0.41	SN7416	0.28	SN7496	0.68	TAA300	1.84
CD4020	0.98	LM3900	0.61	SN7417	0.28	SN74100	1.10	TAA350A	2.10
CD4021	0.88	LM7805	1.88	SN7420	0.16	SN74107	0.30	TAA550	0.32
CD4022	0.85	LM7812	1.99	SN7423	0.23	SN74118	0.85	TAA611C	2.18
CD4023	0.18	LM7815	1.99	SN7425	0.23	SN74119	1.75	TAA621	2.03
CD4024	0.72	LM7824	1.99	SN7427	0.23	SN74121	0.32	TAA661B	1.03
CD4025	0.19	MC1303L	1.50	SN7430	0.15	SN74122	0.42	TBA641B	2.25
CD4027	0.43	MC1310P	2.50	SN7432	0.22	SN74123	0.65	TBA651	1.69
CD4028	[illegible]83	MC1330P	0.90	SN7437	0.28	SN74141	0.75	TBA800	0.89
CD4029	1.06	MC1351P	0.80	SN7438	0.28	SN74145	0.72	TBA810	0.98
CD4030	0.52	MC1466L	3.50	SN7440	0.16	SN74150	1.20	TBA820	0.80
CD4031	0.98	MC1469R	2.75	SN7441AN	0.68	SN74151	0.68	TBA920	1.79
CD4037	0.88	MC14553	4.07	SN7442	0.65	SN74153	0.68	14DILSKT	0.17
CD4041	0.70	NE555V	0.70	SN7445	0.78	SN74154	1.20	16DILSKT	0.13
CD4042	1.83	NE556	1.30	SN7446	0.84	SN74155	0.78		
CD4049	0.45	NE560	4.48	SN7447	0.80	SN74157	0.76		

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2N697	0.16	2N4037	0.42	AF239	0.85	BD140	0.87	OC28	1.48
2N698	0.82	2N4036	0.67	AF240	0.90	BF115	0.29	OC35	1.16
2N699	0.59	2N4058	0.18	AF279	0.70	BF117	0.55	OC42	0.50
2N706	0.14	2N4062	0.15	AF280	0.79	BF154	0.20	OC45	0.32
2N708	0.17	2N4289	0.34	AL102	1.00	BF159	0.27	TIP29A	0.49
2N916	0.28	2N4920	1.10	BC107	0.14	BF180	0.35	TIP30A	0.80
2N918	0.32	2N4921	0.83	BC108	0.14	BF181	0.36	TIP31A	0.62
2N1302	0.185	2N4923	1.00	BC109	0.14	BF184	0.30	TIP32A	0.74
2N1304	0.26	2N5245	0.29	BC147B	0.10	BF194	0.12	TIP33A	1.01
2N1306	0.31	2N5294	0.48	BC148B	0.09	BF195	0.12	TIP34A	1.51
2N1308	0.47	2N5296	0.48	BC149B	0.11	BF196	0.13	TIP35A	2.90
2N1711	0.27	2N5457	0.29	BC157A	0.16	BF197	0.15	TIP36A	3.70
2N2102	0.60	2N5458	0.26	BC158A	0.16	BF198	0.18	TIP41A	0.79
2N2147	0.78	2N5459	0.29	BC167B	0.15	BF244	0.21	TIP42A	0.90
2N2148	0.94	2N6027	0.45	BC168B	0.15	BF257	0.47	TIP2955	0.98
2N2218A	0.47	3N128	0.73	BC169B	0.15	BF258	0.53	TIP3055	0.50
2N2219A	0.52	3N140	1.00	BC182	0.12	BF259	0.55	TIS43	0.28
2N2220	0.25	3N141	0.81	BC182L	0.12	BFS61	0.27	ZTX300	0.13
2N2221	0.18	3N200	2.49	BC183	0.12	BFS98	0.25	ZTX301	0.13
2N2222	0.20	40361	0.40	BC183L	0.13	BFR39	0.24	ZTX500	0.15
2N2369	0.20	40362	0.45	BC184	0.13	BFR79	0.24	ZTX501	0.13
2N2646	0.55	40406	0.44	BC184L	0.13	BFX29	0.32	ZTX502	0.18
2N2904	0.40	40407	0.35	BC212A	0.16	BFX30	0.34	1N914	0.35
2N2905	0.47	40408	0.50	BC212LA	0.16	BFX84	0.30	1N3754	0.15
2N2906	0.33	40409	0.52	BC213LA	0.15	BFX85	0.30	1N4007	0.10
2N2907	0.22	40410	0.52	BC214LB	0.18	BFX88	0.30	1N4148	0.04
2N2924	0.20	40411	2.00	BC237B	0.16	BFY50	0.30	1N4504	0.22
2N2926G	0.12	40594	0.74	BC238C	0.15	BFY51	0.28	1N5408	0.30
2N3053	0.25	40595	0.84	BC239C	0.15	BFY52	0.205	AA119	0.08
2N3054	0.60	40636	1.10	BC257A	0.16	BRY39	0.48	BA102	0.25
2N3055	0.65	40673	0.73	BC258B	0.16	ME0402	0.20	BA145	0.18
2N3391	0.28	AC126	0.20	BC259B	0.17	ME0412	0.18	BA154	0.12
2N3392	0.15	AC127	0.46	BC301	0.34	ME4102	0.11	BA155	0.12
2N3393	0.15	AC128	0.35	BC307B	0.17	MJ480	0.95	BB103B	0.23
2N3440	0.59	AC151	0.27	BC308A	0.15	MJ481	1.20	BB104B	0.45
2N3442	1.40	AC152	0.49	BC309C	0.20	MJ490	1.05	BY126	0.17
2N3638	0.15	AC153	0.35	BC327	0.23	MJ491	1.45	BY127	0.15
2N3702	0.12	AC176	0.41	BC328	0.22	MJ2955	1.00	BYZ11	0.51
2N3703	0.13	AC187K	0.35	BCY70	0.17	MJE340	0.48	BYZ12	0.51
2N3704	0.15	AC188K	0.40	BCY71	0.22	MJE370	0.65	OA47	0.06
2N3706	0.15	AD143	0.68	BCY72	0.18	MJE371	0.75	OA81	0.18
2N3708	0.14	AD161	0.69	BD121	1.00	MJE520	0.60	OA90	0.06
2N3714	1.38	AD162	0.69	BD123	0.82	MJE521	0.70	OA91	0.08
2N3716	1.80	AF106	0.40	BD124	0.67	MJE2955	1.20	OA200	0.08
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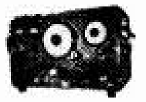

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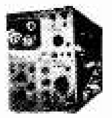

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CV131, CV132, CV133, CV135, CV136, CV137, CV138, CV140, CV144, CV160, CV173, CV187, CV188, CV190, CV220, CV261, CV273, CV284, CV286, CV287, CV315, CV329, CV337, CV342, CV345, CV354, CV359, CV360, CV371, CV372, CV378, CV391, CV395, CV397, CV428, CV434, CV447, CV449, CV466, CV469, CV488, CV491, CV492, CV493, CV717, CV808, CV1072, CV1076, CV1092, CV1219, CV1343, CV1475, CV1476, CV1477, CV1478, CV1794, CV1480, CV1481, CV1482, CV1787, CV1832, CV1833, CV1835, CV1994, CV2000, CV2131, CV2154, CV2155, CV2160, CV2179, CV2235, CV2237, CV2238, CV2253, CV2289, CV2520, CV2522, CV2721, CV2901, CV3523, CV3629

CV3986, CV3988, CV3991, CV3998, CV4001, CV4002, CV4003, CV4004, CV4005, CV4006, CV4007, CV4008, CV4009, CV4010, CV4011, CV4012, CV4013, CV4014, CV4015, CV4016, CV4017, CV4018, CV4019, CV4020, CV4022, CV4023, CV4024, CV4025, CV4028, CV4033, CV4035, CV4038, CV4039, CV4040, CV4056, CV4059, CV4060, CV4062, CV4063, CV4064, CV4079, CV4501, CV4502, CV4503, CV4504, CV4507, CV4508, CV5060, CV6004, CV6008, CV6045, DA30, DA41, DA42, DA100, DET22, E55L, E80CC, E80FC, E80F, E80L, E80T, E81CC, E81L, E82CC, E83CC, E83F, E88CC, E90CC, E90L, E91H, E92CC, E180CC, EA50, EA52, EA76, ECC35, ECF804, EF50

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AD149 0.50
AD161 0.44
AD162 0.44
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AF116 0.25
AF117 0.24
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ASY28 0.25
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BC107 0.14
BC108 0.13
BC109 0.14
BC113 0.15
BC117 0.21
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OC25 0.40
OC28 1.00
OC35 0.55
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OC45 0.20
OC71 0.25
OC72 0.28
OC76 0.30
OC77 0.54
OC81 0.29
OC81D 0.28
OC81Z 0.45
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OC140 0.14
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ZTX503 0.15
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1N914 0.06
1N4001 0.06
1N4002 0.7
1N4003 0.8
1N4004 0.8
1N4005 0.10
1N4006 0.12
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1N4148 0.06
IS131 0.13
IS921 0.07
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IS2051A 0.20
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2N697 0.16
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2N1131 0.25
2N1132 0.24
2N1302 0.18
2N1303 0.18
2N1304 0.28
2N1305 0.22
2N1306 0.28
2N1307 0.28
2N1308 0.28
2N1309 0.30
2N1613 0.21
2N1614 0.45
2N2147 0.78
2N2160 0.78
2N2369A 0.16
2N2646 0.50
2N2904 0.20
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2N2905 0.32
2N2905A 0.25
2N2906 0.20
2N2926 0.12
2N3053 0.18
2N3055 0.45
2N3525 0.91
2N3614 0.65
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2N3820 0.50
2N3823 0.50
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2N3905 0.25
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2N4058 0.15
2N4059 0.10
2N4060 0.13
2N4061 0.13
2N4062 0.14

2N4289 0.30
3N141 0.81
40360 0.40
40361 0.45
40362 0.40
40430 0.85
SN7400 0.16
SN7401 0.16
SN7402 0.16
SN7403 0.16
SN7404 0.26
SN7405 0.22
SN7406 0.42
SN7407 0.42
SN7408 0.28
SN7409 0.28
SN7410 0.16
SN7411 0.25
SN7412 0.30
SN7413 0.36
SN7416 0.36
SN7417 0.36
SN7420 0.16
SN7422 0.75
SN7423 0.37
SN7425 0.37
SN7427 0.37
SN7428 0.40
SN7430 0.16
SN7432 0.37
SN7433 0.37
SN7437 0.37
SN7438 0.37
SN7440 0.22
SN7441AN 0.92
SN7442 0.79
SN7450 0.16
SN7451 0.16
SN7453 0.16
SN7454 0.16
SN7460 0.16
SN7470 0.36
SN7472 0.38
SN7473 0.41
SN7474 0.42
SN7475 0.59

SN7476 0.45
SN7480 0.60
SN7482 0.87
SN7483 1.10
SN7484 1.00
SN7486 0.47
SN7490 0.55
SN7491AN 1.00
SN7492 0.70
SN7493 0.70
SN7494 0.80
SN7495 0.80
SN7496 0.95
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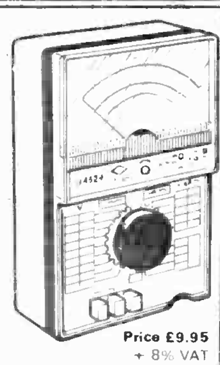

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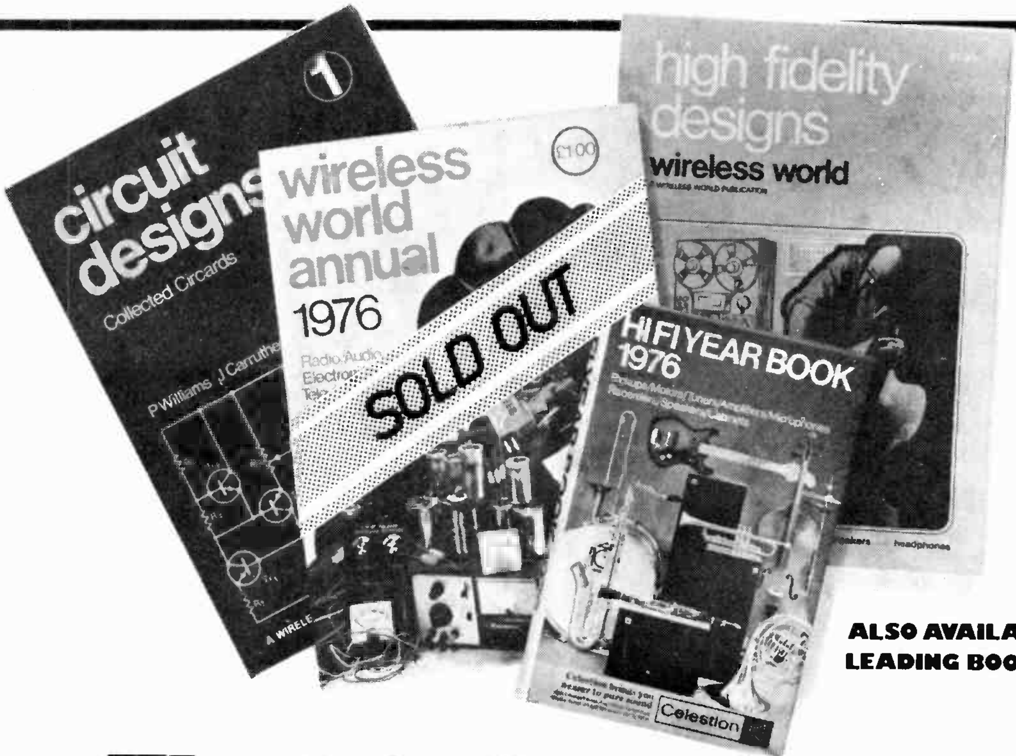

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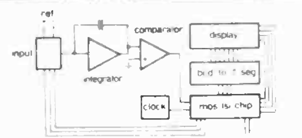

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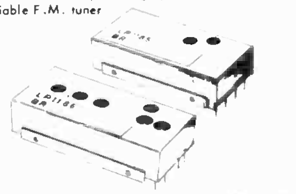

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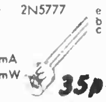

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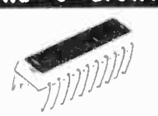

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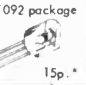

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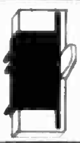

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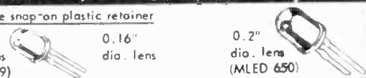

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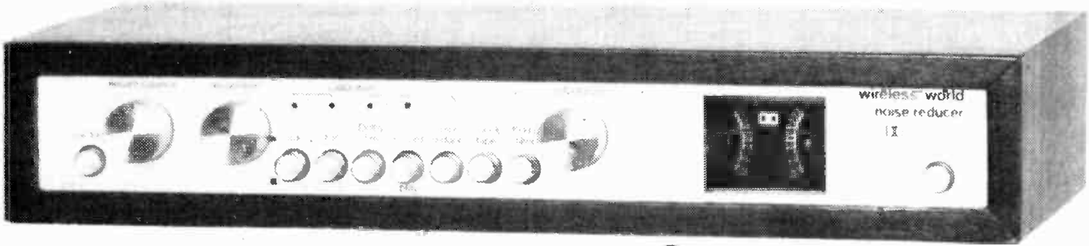

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30mV sensitivity.

PRICE: £34.40+VAT

Calibration tapes are available for open-reel use and for cassette (specify which) .... **Price £1.80**+VAT*

Single channel plug-in Dolby(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components .... **Price £6.50**+VAT

Single channel board with selected fet .... **Price £2.00**+VAT

Gold plated edge connector .... **Price £1.27**+VAT*

Selected FET's **54p** each+VAT, **96p**+VAT for two, **£1.76**+VAT for four

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We guarantee full after sales technical and servicing facilities on all our kits

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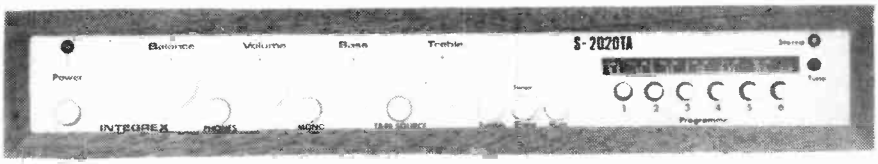
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET

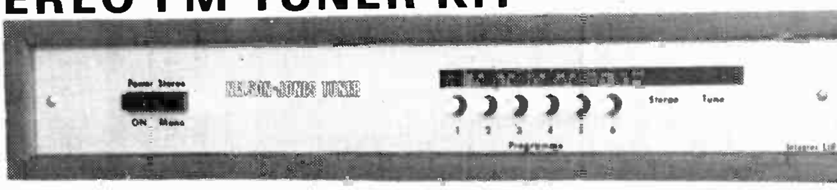


A high-quality push-button FM Varicap Stereo Tuner combined with a 20W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc), THD less than 0.1% at 20W into 8 ohms. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.8µV.THD typ. 0.4%

PRICE: £48.95+VAT

NELSON-JONES STEREO FM TUNER KIT



A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75µV. Image rejection — 70dB. IF rejection—85dB. THD typically 0.4%
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price

Mono £26.31+VAT
With ICPL Decoder £30.58+VAT
With Portus-Haywood Decoder £32.81+VAT

STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC

Sens. 30dB S/N mono @ 1.8µV
THD typically 0.4%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Mono £25.55+VAT
Stereo £28.65+VAT

S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Typ. Spec. 20+20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £30.94+VAT

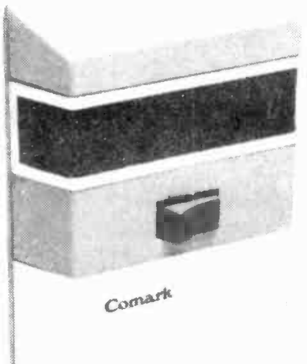
ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT	£13.13+VAT
BASIC MODULE TUNER KIT (Mono)	£13.25+VAT
BASIC MODULE TUNER KIT (stereo)	£15.25+VAT
PHASE-LOCKED IC DECODER KIT	£4.47+VAT
PUSH-BUTTON UNIT	£3.50+VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT	£7.93+VAT

WW—042 FOR FURTHER DETAILS

The 3001 pocket thermometer.

(Just a little more less for your money.)



Big thermometer capability in a diminutive, take it anywhere, 300gms package. That is what's so special about the 3001.

- Accuracy at better than 2°C over the range −50°C to +800 C.
- Bright-green, 8.2mm display.
- Simple front panel thumb switch selection of either continuous or flash display.
- Designed for use with thermocouples.
- Operates up to 7 hours with either dry batteries or rechargeable cells.

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5196

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orchard electronics

TRANSISTORS

	p		p		p		p		p		p		p
AC125	20	ASY26	30	BC132'	11	BC178B	18	BC261A	16	BC559'	9	BF166	38
AC126	20	ASY27	34	BC135'	12	BC179B	19	BC262A	15	BCY70	15	BF167	21
AC127	20	ASY28	30	BC136'	16	BC182B'	10	BC266A	18	BCY71	18	BF173	20
AC128	20	ASY29	34	BC137'	16	BC182L'	11	BC267A	14	BCY72	14	BF178	24
AC132	35	ASY67	70	BC138	15	BC183B'	10	BC268B	13	BD115	60	BF179	25
AC141	20	BA145'	15	BC139	35	BC183L'	10	BC269	13	BD121	90	BF180	30
AC142	17	BA154	10	BC142	22	BC184B'	12	BC287	20	BD123	90	BF181	30
AC151	24	BA155	12	BC143	24	BC184L'	11	BC300	27	BD124	68	BF183	34
AC153	27	BAX12	10	BC147A'	9	BC186	25	BC301	26	BD131	38	BF184	25
AC176	20	BAX13	4	BC147B'	10	BC187	28	BC302	24	BD132	38	BF185	28
AC188	20	BAX16	6	BC148'	9	BC204A'	16	BC303	30	BD133	65	BF194'	10
AD161	42	BC107	11	BC148B'	10	BC205A'	15	BC304	27	BD135'	37	BF195'	10
AD162	42	BC107A	12	BC149B'	11	BC206A'	15	BC307A'	16	BD136'	39	BF196'	12
AF114	24	BC108	10	BC149C'	11	BC207A'	11	BC308A'	14	BD137'	44	BF197'	12
AF115	24	BC108B	11	BC153'	18	BC208A'	11	BC309B'	16	BD138'	47	BF200	38
AF116	24	BC109	11	BC154'	18	BC209B'	13	BC317A'	12	BD139'	54	BF257	30
AF117	24	BC109B	12	BC157B'	12	BC212A'	13	BC319B'	12	BD155'	75	BF258	50
AF118	47	BC109C	13	BC158A'	12	BC212L'	15	BC322B'	15	BD165'	34	BF259	52
AF124	30	BC115'	15	BC159A'	12	BC213B'	12	BC327'	20	BD232'	70	BF271	50
AF125	30	BC116'	15	BC167A'	11	BC213L'	14	BC328'	18	BDY20	80	BF336	28
AF126	28	BC117'	18	BC168B'	14	BC214'	15	BC337'	18	BF115	22	BF337	30
AF139	34	BC118'	10	BC171A'	14	BC214L'	17	BC338'	16	BF154'	20	BF338	34
AF186	50	BC119	28	BC172A'	15	BC237A'	16	BC461	35	BF158'	20	BFW10	68
AF239	37	BC125'	14	BC173B'	16	BC238A'	15	BC557'	9	BF159'	26	BFW11	68
				BC177	17	BC2395'	15	BC558'	9	BF160'	20	BFX13	55

SILICON RECTIFIERS

50V 3A	13p
100V 3A	15p
200V 3A	18p

THYRISTORS

60V1A	20p
100V 1A	30p
200V 1A	40p
600V 1A	60p
BT106	120p

RESISTORS (E 12) 1½p ★
½W 1Ω – 10mΩ

Diodes

OA 47	5p
OA202	7p
1N 914	5p
1N4001	5p
4002	6p
4006	10p
4148	5p

I.C.s	TTL Dig
7400	18p
7401	20p
7402	18p
7403	18p
7404	23p
7405	23p
7406	40p
7407	40p
7408	24p
7409	23p
7410	18p

BRIDGE REC

100V 1A	24p
200V 1A	25p
400V 1A	26p
200V 2A	78p
600V 2A	97p

DIL SOCKETS

8 pin	13p
14 pin	15p
16 pin	17p

C MOS, CAPACITORS POTS & PRESETS
POTS PRESETS, PLUGS & SOCKETS

I.C.s LINEAR

709 (8 PIN DIL)	.40p★
741 (8 PIN DIL)	.33p★
LM 380	1.29★
NE 555	.60p★
SN76013N	1.57p★
SN76023N	1.57p★
TBA 800	1.35p★
ZN 414	1.35p★

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4V3 4V7 5V1
5V6 6V2 6V5
7V5 8V2 9V1
10V 12V 13V
15V 18V 30v
All at **12p'** each

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(TO3)

5V ½A	1.35
12V ½A	1.35
15V ½A	1.35
5V 1A	175p
12V 1A	175p
15V 1A	175p

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125 Red (like TIL)	20p
125 Grn (209 0 125")	27p
TIL 200 Red	25p
TIL 200 Grn	29p
125R Red	20p
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TELETYPE BRPE 110 cps Synchronous Punch 5 7 8 channel. Self-contained mains-operated unit consisting of punch unit base motor and tape supply spool. Price **£145.00**. Sound reducing cabinet available at **£25.00**.

FACIT 4060 rack-mounting heavy-duty punch. 5 8 channel maximum operating speed 150 cps. Complete with supply and take-up spools, tape low/out sensor and large built-in chad box. **£595.00**. Control unit also available.

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TALLY 420 Rack-mounting perforator. Asynchronous operation up to 60 cps. Integral supply and take-up spools. Complete with Model 5088 transistorised drive package. **£495.00**.

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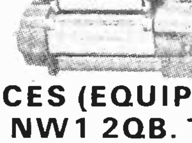
DIGITAL PRINTING MECHANISM TYPE EP 101

Capacity 21 columns. 16 print positions (0-9 + - · $). Parallel data entry. Column spacing 3 5mm. Line spacing 5 1mm. Character dimensions 1 8mm wide × 2 9mm high. Power requirements 15V DC. Current 150mA non-printing up to 410mA maximum printing load. Very compact unit measuring 6 × 5 × 4. **OUR BARGAIN PRICE £49.00** (P&P £1). Input Output connector also available price **£2.00**.



New Economy 80 Column Hand Punch

Completely redesigned with many important new features — send for brochure
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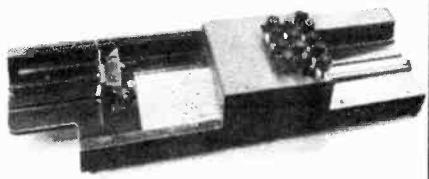

NEW STOCK JUST RECEIVED:

16-Key Japanese Keyboard. BRAND NEW SURPLUS! Magnetically operated read relay switches mounted on PCB 9 white keys 4 black, 2 yellow, 1 red. Dimensions 3½" × 3" × ½". Price £3.50 (P&P 30p).

Keyboards

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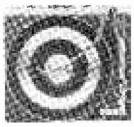
STEREO AND MONO



Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in with STEREO and MONO CARTRIDGE **£10.95** Post 75p

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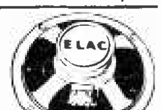
8in. or 10 x 6in.



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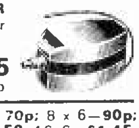

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All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer Input 200/240V a c Output voltages available, 6 or 7 5 or 9 or 12V d c. up to 100mA or less Size 3 x 2½ x 1½ in Please state voltage required. **£2.95** Post 45p

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Ideal for Mike, Tape, P U, Guitar, etc Can be used with Battery 9-12V or H T line 200-300V d c. operation. Size 1¾ x 1¼ x ¾in Response 25 c/s to 25 kc/s 26 dB gain. For use with valve or transistor equipment. Full instructions supplied Details S.A.E. **£1.45** Post 30p

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This kit is suitable for record players, guitars, tape playback, electronic instruments or small P A systems Two versions available Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel, input 100mV; size 9½ x 3 x 2in approx S.A E. details. Full instructions supplied. AC mains powered

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ALL POST 50p

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8 ohm 10W Large ceramic magnet Special Rubber cone surround Frequency response, 30-8000 c/s. Ideal HI-FI Enclosure Systems **£6.75**

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8/350V	28p	100+100/275V	65p	32+32/250V	20p
16/350V	35p	150+200/275V	70p	32+32/450V	80p
32/500V	60p	8+8/350V	50p	350+50/325V	85p
25/25V	15p	8+16/350V	50p	100+50+50/350V	85p
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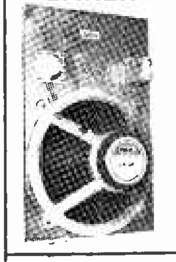
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 50V **57p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **85p;** 50V **95p.**

SHORT WAVE 100pF air spaced gangable tuner, **95p.**
TRIMMERS 10pF 30pF, 50pF **5p.** 100pF 150pF **15p.**
CERAMIC, 1pF to 0 01mF **5p.** Silver Mica 2 to 5000pF. **5p.**
PAPER 350V-0 1 **7p;** 0 5 **13p;** 1mF 150V **15p;** 2mF 150V **15p;** 500V-0 001 to 0 05 **5p;** 0 1 **10p;** 0 25 **13p;** 0 47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 0-0' 208pF + 176pF **£2.00;** 500pF standard **75p;** 365 + 365 + 25 + 25pF. Slow motion drive **50p.** 120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V AC/DC. Amber or red. **30p.**
RESISTORS. ¼W ½W. 1W 20% **2p;** 2W. **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg . **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg . **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt, 10 ohms to 100K **12p** each
TAPE OSCILLATOR COIL Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**

BAKER MAJOR 12" £11.50



30-14,500 c/s, 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s Rated 25W. NOTE. 3 or 8 or 15 ohms must be stated

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions. **£14.50** Post 60p each
Please state 3 or 8 or 15 ohms.

BAKER "BIG-SOUND" SPEAKERS. Post 50p each

'Group 25'	'Group 35'	'Group 50/15'
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3 or 8 or 15 ohm	3 or 8 or 15 ohm	8 or 15 ohm

NEW MODEL **BAKER LOUDSPEAKER,** 12-inch 60 WATT. GROUP 50/12, 8 OR 15 OHM HIGH POWER, FULL RANGE PROFESSIONAL QUALITY. 30-16,000 CPS MASSIVE CERAMIC MAGNET ALUMINIUM PRESENCE CENTRE DOME **£14.50** Post 80p

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in. or 10in speaker 20x13x12in **£12.50** Post 95p
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LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls Suits all speakers This professional quality amplifier chassis is suitable for all groups, disco, P A, where high quality power is required 5 speaker outputs. A/C mains operated Slave output Produced by demand for a quality **valve** amplifier
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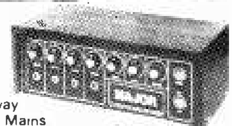
De Luxe Horn Tweeters 2-18kc/s, 15W, 15 ohm, **£4.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHMS. 7x4in **£1.50;** 6½in, **£1.80;** 8x5in., **£1.90;** 8in., **£1.95.**
SPECIAL OFFER: 80 ohm, 2¼in, 2¾in., 35 ohm, 2in., 3in, 25 ohm, 2½in dia, 3in dia., 5in dia, 8 ohm, 2½in, 3in, 3½in, 15 ohm, 3¼in dia, 6x4in, 7x4in, 8x5in, 3 ohm., 2½in, 2⅝in., 3½in, 5in. dia. **£1.25 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, ceramic magnet **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS 8in diameter 4W **£2.50.** 10in diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state
VALVE OUTPUT TRANS. 40p; MIKE TRANS. 50 1, **40p.** Mike trans. mu metal 100 1 **£1.25.**

Loudspeaker Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting. ¼in. spindle. **65p**

BAKER 100 WATT ALL PURPOSE AMPLIFIER



All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing Output 8/15 ohm, a c. Mains Separate treble and bass controls. Guaranteed Details S.A E. **£65** Carr £1.00 each
NEW MODEL MAJOR—50 watt, 4 input, 2 vol Treble and bass. Ideal disco amplifier. **£49.95**

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Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. 9V. **£5.20**
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BALANCED TWIN RIBBON FEEDER 300 ohms. 7p yd.
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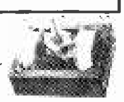
JACK PLUGS Std. Chrome 30p; 3.5mm Chrome 15p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS, 10p.

R.C.S. SOUND TO LIGHT KIT
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. **£12.50.** Post 35p
Easy to build Full instructions supplied, cabinet **£3.**
As featured in December Practical Wireless

E.M.I. TAPE MOTORS. 240V a c 1,200 r p m 4 pole 185mA Spindle 0 187x0 75in Size 3¼ x 2½ x 2¼in **£2.** Post 40p
120V Model, £1



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7447	75p	74164	120p		
7448	70p	74166	126p		
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7451	16p	74175	85p		
7453	16p	74176	120p		
7454	16p	74177	100p		
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TEXAS 75 SERIES

75107	160p
75450	120p
75451	72p
75452	72p
75453	72p
75454	72p

OP. AMPS

1458	Dual Op. Amp. Int. Comp.	8 pin DIL	70p
301A	Ext. Comp.	8 pin DIL	36p
3130	COSMOS/Bi-Polar MosFet	8 pin DIL	100p
3900	Quad. Op. Amp.	14 pin DIL	70p
536T	FET Op. Amp.	TO-99	275p
709	Ext. Comp.	8/14 pin DIL	30p
741	Int. Comp.	8/14 pin DIL	22p
747	Dual 741	14 pin DIL	70p
748	Ext. Comp.	8/14 pin DIL	36p
776	Programmable Op. Amp.	TO-5	140p

LINEAR I.C.s

*CA3028A	Diff. Cascade Amp	T05	90p
ICA3046	5 Transistor Array	14 pin DIL	50p
*CA3048	Quad. Low Noise Amp	16 pin DIL	200p
*CA3053	Diff. Cascade Amp	T05	45p
*CA3089E	FM IF System	16 pin DIL	200p
*CA3090AQ	FM Stereo Multi. Dec.	16 pin DIL	400p
ICL8038BC	VCO Fun. Gen	14 pin DIL	550p
ICL8038CC	VCO Fun. Gen	14 pin DIL	275p
*LM380	2W Audio Amp	14 pin DIL	90p
*LM381	Stereo Preamp	14 pin DIL	160p
*M2S2	Rhythm Generator	16 pin DIL	800p
*MC1310P	FM Stereo Dec.	14 pin DIL	175p
MC1495	Multiplier	16 pin DIL	300p
*MC1496L	Bal. Mod./Demod	14 pin DIL	100p
*MFC4000B	1/4W Audio Amp	PCB	70p
MFC6040	Electronic Attenuator	PCB	140p
NE555	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod	16 pin DIL	325p
NE562	PLL with VCO	16 pin DIL	325p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun. Gen	8 pin DIL	150p
NE567	PLL Tone Dec	8 pin DIL	200p
2567	Dual 567	16 pin DIL	370p
SN72710	Diff. Comparator	14 pin DIL	50p
*SN72733	Video Amp	14 pin DIL	120p
*SN76013N	Pwr Aud Amp with int HS		140p
*SN76023N	Pwr Aud Amp with int HS		140p
*TAA661B	FM IF Amp-Limiter/Det	QIL	120p
*TBA641B	Audio Amp	QIL	250p
*TBA800	5W Audio Amp	QIL	90p
*TBA810	7W Audio Amp	QIL	100p
*TBA820	2W Audio Amp	QIL	80p
*TDA2020	20W Audio Amp	QIL	325p
XR2240	Prog. Timer/Counter	16 pin DIL	370p
*ZN414	TRF Radio Receiver	TO-18	110p

Basic data sheets on above at **10p** each + S.A.E.

TRANSISTORS

AC125	16p	BFY52	16p	2N3442	140p
AC126	12p	BRY39	34p	*2N3702	11p
AC127	12p	BSX19	18p	*2N3703	11p
AC128	11p	BSX20	20p	*2N3704	11p
AC141	18p	*BU105	140p	*2N3705	11p
AC142	18p	BU108	250p	*2N3706	10p
AC176	11p	*MJE340	45p	*2N3707	11p
AC187	13p	MJ2955	75p	*2N3708	9p
AC188	12p	MJE2955	99p	*2N3709	9p
AD149	43p	MJE3055	65p	2N3773	220p
AD161	36p	*MPS6534	18p	2N3866	90p
AD162	36p	*MPSA06	30p	*2N3903	18p
AF114	18p	*MPSA12	50p	*2N3904	16p
AF115	18p	*MPSA56	32p	*2N3905	18p
AF116	18p	*MPSU06	62p	*2N3906	16p
AF117	18p	*MPSU56	78p	*2N4058	15p
AF139	33p	OC28	65p	*2N4059	10p
AF239	45p	OC35	55p	*2N4060	13p
BC107	9p	OC36	60p	*2N4123	18p
BC108	9p	*OC71	20p	*2N4124	18p
BC109	10p	*TIP29A	40p	*2N4125	18p
BC109C	12p	*TIP29C	55p	*2N4126	18p
*BC117	22p	*TIP30A	48p	*2N4289	20p
*BC147	7p	*TIP30C	60p	2N4347	130p
*BC148	7p	TIP31A	52p	2N4348	160p
*BC149C	8p	TIP31C	70p	*2N4401	27p
*BC157	11p	TIP32A	58p	*2N4403	27p
*BC158	10p	TIP32C	82p	*2N5089	27p
*BC159	11p	TIP33A	90p	*2N5401	50p
*BC169C	12p	TIP33C	115p	40360	40p
BC177	18p	TIP34A	115p	40361	38p
BC178	17p	TIP34C	160p	40362	40p
BC179	18p	TIP35A	225p	40364	120p
*BC182	10p	TIP35C	290p	40409	55p
*BC183	10p	TIP36A	270p	40410	55p
*BC184	11p	TIP36C	340p	40411	225p
BC187	30p	TIP41A	65p	40594	75p
*BC212	11p	TIP41C	75p	40595	85p
*BC213	10p	TIP42A	70p		
*BC214	14p	TIP42C	82p		
BC478	30p	TIP2955	70p		
BCY70	18p	*ZTX108	10p	**FETs**	
BCY71	22p	*ZTX300	13p		
BD124	65p	*ZTX500	15p	*BF244	25p
BD131	36p	*ZTX502	18p	*MPF102	30p
BD132	40p	2N697	13p	*MPF103	30p
*BD135	43p	2N698	30p	*MPF104	30p
*BD139	63p	2N706	16p	*MPF105	30p
*BD140	70p	2N708	18p	*2N3819	22p
BF115	22p	2N918	40p	*2N3820	57p
BF167	23p	2N930	18p	2N3823	50p
BF170	23p	2N1131	18p	*2N5457	30p
BF173	25p	2N1132	18p	*2N5458	30p
BF177	26p	2N1304	32p	*2N5459	30p
BF178	28p	2N1305	32p		
BF179	33p	2N1306	36p		
BF180	33p	2N1307	36p	**MOSFETs**	
BF184	22p	2N1308	36p	3N128	85p
*BF194	10p	2N1309	36p	3N140	85p
*BF195	9p	2N1613	20p	3N141	85p
*BF196	14p	2N1711	20p	3N187	180p
*BF197	15p	2N1893	30p	3N202	120p
BF200	32p	2N2219	20p	40603	58p
BF257	32p	2N2222	20p	40673	58p
BF258	36p	2N2369	14p		
*BFR39	30p	2N2484	30p		
*BFR40	30p	2N2904	20p		
*BFR79	30p	2N2905	20p	**UJTs**	
*BFR80	30p	2N2906	20p	*TIS43	27p
*BFR88	30p	*2N2926R	7p	2N2160	80p
BFX30	30p	*2N2926B	7p	2N2646	38p
BFX84	26p	*2N2926O	8p	*2N4871	30p
BFX85	25p	*2N2926Y	9p		
BFX86	25p	*2N2926G	9p		
BFX87	20p	2N3053	18p	**PUJT**	
BFX88	24p	2N3054	45p	*2N6027	48p
BFY50	16p	2N3055	50p		
BFY51	15p	2N3439	67p		

DIODES

SIGNAL*

OA47	7p
OA70	9p
OA81	8p
OA85	10p
OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN916	9p
IN4148	4p

RECTIFIER

*BY100	25p
*BY126	12p
*BY127	12p
IN4001	5p
IN4002	5p
IN4004	6p
IN4005	6p
IN4007	7p

ZENER
2.7V to 33V*
*400mW 9p
*1W 18p

TUNNEL
AEY11 70p

VARICAP
*BB105 25p

NOISE
*Z5J 110p

BRIDGE RECTIFIERS

*25A100V	20p
*1A 50V	20p
*1A 100V	22p
*1A 200V	24p
*1A 400V	25p
*1A 600V	30p
*2A 50V	30p
*2A 100V	35p
*2A 200V	40p
*2A 400V	45p
*4A 100V	60p
6A 50V	65p
6A 100V	72p
6A 200V	78p
6A 400V	84p

TRIACS

Amp	Volts	
3	400	120p
6	400	150p
6	500	180p
10	400	185p
10	500	195p
15	400	210p
15	500	250p
40430		99p
40486		99p
40669		95p

DIAC
BR100 25p

MEMORIES

2602B 1024 bit RAM	£2.50
2513(UC) Character Generator	£8.50
2513(LC) Character Generator	£8.50

MULLARD MODULE

LP1186 Varicap FM Tuner £6.75

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin **13p**, 14 pin **14p**, 16 pin **15p**, 24 pin **50p**. 40 pin **75p**.

INSULATORS Mica + 2 Bushes for TO3 & TO66 **5p**

VOLTAGE REGULATORS

FIXED — Plastic 3 Terminals

1 Amp Positive			1 Amp Negative		
5V	7805	140p	5V	7905	200p
12V	7812	140p	12V	7912	200p
15V	7815	140p	15V	7915	200p
18V	7818	140p	18V	7918	200p
24V	7824	140p	24V	7924	200p

LM309K 1 Amp 5V TO3 **140p**

DUAL VOLTAGE REGULATOR
1468 ±15V 100mA 16 pin DIL **300p**. (Adjustable by resistors from ± 8V min. to ± 20V max.)

VARIABLE VOLTAGE REGULATOR
723 2V to 37V 150mA 14 pin DIL **45p**
LM305H 4.5V to 30V 20mA TO5 **120p**
Basic Data Sheets on Vol. Regs. at 10p each + SAE

OPTO-ELECTRONICS

Phototransistors		L.D.Rs.	
OCP70	30p	ORP12	50p
OCP71	120p	ORP60	75p
2N5777	40p	ORP61	75p

LEDS 0.2"

TIL209 Red	14p	Red	16p
TIL211 Green	30p	Green	28p
TIL32 Infrared	75p	Yellow	30p

SEVEN SEGMENT DISPLAYS

3015F	Minitron 0.3 in.	120p
DL704	Com. Cathode 0.3 in.	140p
DL707	Com. Anode 0.3 in.	140p
DL747	Com. Anode 0.6 in.	225p

OPTO-ISOLATORS

Phototransistor TIL 112 (IL 12) 6 pin DIL **140p**
Photodarlington ILCA-55 6 pin DIL **250p**

DRIVERS

75491 Quad. Segment Driver 14 pin DIL **72p**
75492 Hex Digit Driver 14 pin DL **90p**

SCR-THYRISTORS

1A 50V	TO5	40p	BT106 1A/700V	Stud	140p
1A100V	TO5	42p	C106D 4A/400V	Plastic	55p
1A400V	TO5	45p	*MCR101 0.5A/15V	TO-92	25p
1A600V	TO5	70p	2N3525		
3A100V	Stud	49p	5A/400V	TO-66	90p
3A400V	Stud	75p	2N4444		
7A100V	TO5+HS	84p	8A/600V	Plastic	185p
7A400V	TO5+HS	90p	*2N5060		
8A 50V	Plastic	130p	0.8A/30V	TO-92	34p
12A400V	Plastic	160p	*2N5062		
16A100V	Plastic	160p	0.8A/100V	TO-92	37p
16A400V	Plastic	180p	*2N5064		
16A600V	Plastic	220p	0.8A/200V	TO-92	40p

SEMICONDUCTOR KITS

1) Teletext Decoder
U.C. £47.00 inc. VAT and P & P
L.C. £11.00 inc. VAT and P & P

2) Time-Code Receiver Clock
£26 inc. VAT and P & P
(extra £6 includes 45 DIL sockets.

Please send S.A.E. for details

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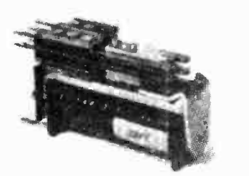


Wilkinsons RELAYS

POST OFFICE TYPE 3000 AND 600 BUILT TO YOUR OWN SPECIFICATIONS AND REQUIREMENTS. THE BEST KNOWN OF ALL RELAYS WITH A LARGE VARIETY OF CONTACT ARRANGEMENTS. KNOWN THROUGHOUT THE WORLD. COMPLETE BANKS OF CONTACTS MADE TO ORDER AND COMPONENT PARTS SUPPLIED. HIGHEST QUALITY AT COMPETITIVE PRICES WITH A QUICK DELIVERY SERVICE. QUOTATIONS BY RETURN HOME AND OVERSEAS. WE ARE SPECIALISTS IN EXPORT ORDERS.

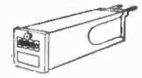
Exclusive offer of a large number of relay sets and selector units with a variety of 3000 type relays and associated components mounted in cases with cover used primarily in BPO 2000 and 4000-type telephone exchange equipments and industrial control systems. Prices on request

Five-Digit Meters BPO type 150A 500 ohms operating current 35mA **£3** ea.

Single and Double Pole High Speed relays available, various resistances

We have a very extensive range of electronic goods to be sold at very low prices, for example Meters, Switches, Rectifiers, Resistors, Blower Motors, etc. Start up your own business. Why not come and see us

HIGH SPEED COUNTERS £1.75 each
3½in × 1in. 10 counts per second with 4 figures. The following D.C. voltages are available: 6 v., 12 v., 24 v., 50 v., or 110 v. Auxiliary contacts, normally open, **40p** extra



TUNING FORKS 125 Hz for 45/50 band teleprinter speeds. **£2.50** each

L. WILKINSON (CROYDON) LTD., LONGLEY HOUSE
LONGLEY ROAD, CROYDON, CR0 3LH - Phone 01-684 0236 - Grams: WILCO CROYDON

All prices shown are carriage paid U.K. only but subject to VAT at the standard rate

WW—100 FOR FURTHER DETAILS

PDP 8L, 4K, with TTY, Software	**£1,150**
DF32, 32K Disc Unit	**£275.00**
Texas 960A with 12K x 16 store, Remex 5-speed Reader/Punch, TTY interface, extended arithmetic option, ROM loader option	**£1695**
Honeywell 120 with 16K	**£140**
G.E. Printing Card Punches, Model P112, all codes, from	**£60**
Facit 4001, 1,000 cps Tape Reader	**£390**
Honeywell 9-track Tape Units from	**£100**

COMPUTER APPRECIATION

CASTLE STREET, BLETCHINGLEY, SURREY RH1 4NX

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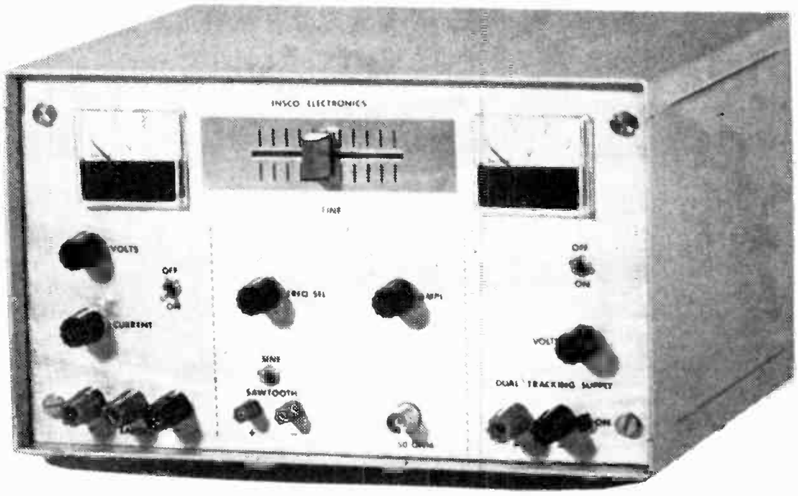
INSCO ELECTRONICS SCOLAB

POWER SUPPLY & TEST EQUIPMENT MANUFACTURERS

**78 WHITECRAIGS ROAD
WHITEHILL IND. ESTATE
GLENROTHES, FIFE**

TELE (0592) 771959



SCOLAB-100 series to provide designers with a complete laboratory capability in one instrument.

0-30V 1A Adjustable Current Limit
±0-30V 0.5A Dual Tracking (Fixed Current Limit 0.5A/Output).

Sine/Triangular/Pulse Waveform Generator adjustable between 10Hz and 1MHz. THD 2.5% Output 0-10V.

Pulse output variable from 200 N Sec Via 50 OHM B.N.C. connector
Sine/Triangular continuously variable via 600 OHM. terminals £148.00

SCOLAB-200 as above but also contains a digital 16 bit serial word generator. The word selectable from front panel controls and can be supplied internally by a 10MHz clock or by an external clock £194.00

WW 110 FOR FURTHER DETAILS

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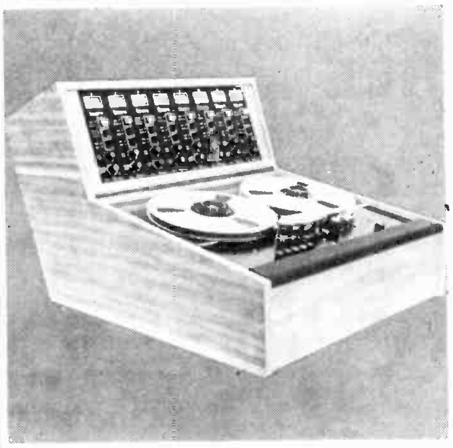
itam

ITAM 805 (8TRACK) MASTER RECORDER



Fully modular electronics using plug-in PCB's throughout. Separate sync and replay amps give identical levels. Switchable VU's with slow decay. Individual oscillator for each channel. Dolby A switching facility. Comprehensive facilities include sync on all channels, servo controlled capstan, modular electronics, variable speed (optional), relay-solenoid operation. Compact presentation for easy portability.

£1790 + VAT Full console optional extra.

Compatible 8-output Mixer available

£1260 + VAT

OTARI

OTARI DP-4050 CASSETTE COPIER

Ideal for one copy or ten thousand. Eight times copy speed, foolproof operation for non-skilled personnel, modular construction, servo-controlled direct capstan drive.

Immediate delivery

THESE ITEMS ARE INDUSTRIAL PRODUCTS AND SUBJECT TO 8% VAT

Industrial Tape Applications ITA

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Telephone: 01-485 6162. Telex: 21879**

WW—103 FOR FURTHER DETAILS

Bahrain Singapore Thailand Iceland Brazil Sweden Germany Iran Jamaica St. Kitts Tunisia

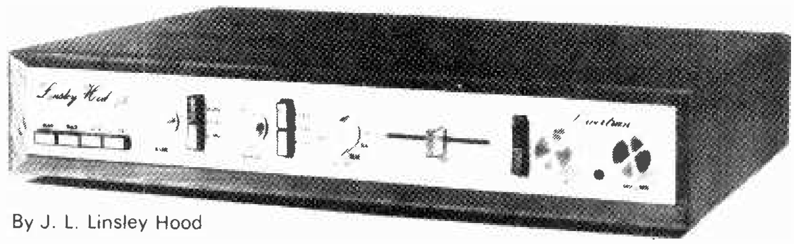
Switzerland S Angola Cyprus Eire Hungary Muscat & Oman Norway United States Guernsey South West Africa Turkey Ghana Zambia Yugoslavia

POWERTRAN ELECTRONICS

INCORPORATING

AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972-February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system namely the equalization stage and tone control stage positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Pack	Price
1. Fibreglass printed-circuit board for power amp	£0.85
2. Set of resistors, capacitors, pre-sets for power amp	£1.70
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£0.80
5. Fibreglass printed-circuit board for pre-amp	£1.30
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£2.70
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£2.05
9. Set of 4 push-button switches, rotary mode switch	£3.70
10. Toroidal transformer complete with magnetic screen/housing primary: 0 117-234 V: secondaries: 33-0-33 V, 25-0-25 V	£9.15
11. Fibreglass printed-circuit board for power supply	£0.65
12. Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£3.50
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£4.25
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £72.25

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£62.40**

WIRELESS WORLD FM TUNER

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout.

Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.80
3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£6.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.80
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£3.45
8. Set of components for channel selector switch, module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc.	£8.30
9. Function switch, 10 turn tuning potentiometer, knobs	£5.30
10. Frequency meter, meter drive components, fibreglass printed circuit board	£8.60
11. Toroidal transformer with electrostatic screen. Primary: 0–117V–234V	£4.45
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
14. Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£6.50
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £76.85

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£66.75**

Wireless World Amplifier Design

Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Linsley Hood designs, together with an efficient regulated power supply of our own design. Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board, for the stereo version of it features 6 inputs, scratch and rumble filters and wide range tone controls which may be either rotary or slider operating.

For those intending to get the best out of their speakers, we also offer an active filter system described by D. C. Read which splits the output of each channel from the pre-amplifier into three channels each of which is fed to the appropriate speaker by its own power amplifier. The Read/Texas 20W or any of our other kits are suitable for these. For tape systems a set of three PCBs have been prepared for the integrated circuit based, high performance stereo Stuart design. Details of component packs are in our free list.

30W Bailey Amplifier	
BAIL Pk 1 F/Glass PCB	£1.00
BAIL Pk 2 Resistors, Capacitors, Potentiometer set	£2.35
BAIL Pk 3 Semiconductor set	£4.70
20W Linsley Hood Class AB	
LHAB Pk 1 F/Glass PCB	£1.05
LHAB Pk 2 Resistor, Capacitor, Potentiometer set	£3.20
LHAB Pk 3 Semiconductor set	£3.35
Regulated Power Supply	
60VS Pk 1 F/Glass PCB	£0.85
60VS Pk 2 Resistor Capacitor set	£1.95
60VS Pk 3 Semiconductor set	£3.10
60VS Pk 6A Toroidal transformer (for use with Bailey)	£7.95
60VS Pk 6B Toroidal transformer (for use with 20W LH)	£7.25
Bailey Burrows Stereo Pre-Amp	
BBPA Pk 1 F/Glass PCB	£2.35
BBPA Pk 2 Resistor, capacitor semiconductor set	£6.10
BBPA Pk 3R Rotary Potentiometer set	£2.40
BBPA Pk 3S Slider Potentiometer set with knobs	£2.70
Active Filter	
FILT Pk 1 F/Glass PCB	£1.05
FILT Pk 2 Resistor Capacitor set (metal oxide 2%, polystyrene 2½%)	£4.20
FILT Pk 3 Semiconductor set	£2.65
2 off Pks 1 2 3 rqd for stereo active filter system	
Read/Texas 20W Amp	
READ Pk 1 F/Glass PCB	£0.70
READ Pk 2 Resistor Capacitor set	£1.10
READ Pk 3 Semiconductor set	£2.40
6 off pks 1, 2 3 required for stereo active filter system	
Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F/Glass PCB	£1.10
TRRC Pk 1 Record Amp F/Glass PCB	£1.70
TROS Pk 1 Bias/Erase/Stabilizer F/Glass PCB	£1.20

PRICE STABILITY!

Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement for two months from issue date provided that this advertisement is quoted with your order. E&OE VAT rate changes excluded.

All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

U.K. Orders Subject to 25% Surcharge for VAT. Carriage free MAIL ORDER ONLY ('or at current rate if changed).

Securicor Delivery For this optional service (Mainland only) add £2.50 VAT inc per kit.

Overseas Orders No VAT. Postage charged at actual cost plus 50p packing and handling.

Further details of above and additional packs given in our FREE LIST

DEPT. WW 05

POWERTRAN ELECTRONICS

PORTWAY INDUSTRIAL ESTATE
ANDOVER, HANTS SP10 3NN

Portugal Mozambique Belgium Sumatra

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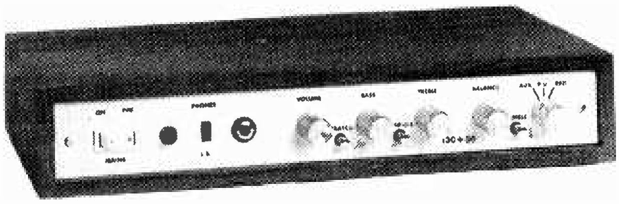
AUDIO KIT SUPPLIERS TO THE WORLD

T20+20 and our new T30+30 20W, 30W AMPLIFIERS



Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20 + 20 delivers 20W per channel of true Hi-Fi at exceptionally low cost The design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and head phones socket. In a follow up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30 + 30 These include RF interference filters and a tape monitor facility Power output of this new model is 30W per channel

Pack	T20	T30	Pack	T20	T30
1 Set of low noise resistors	0.95	1.05	8. Toroidal transformer – 240V prim. e.s. screen	4.95	6.80
2. Set of small capacitors	1.50	2.10	9. Fibreglass PCB	2.50	2.90
3. Set of power supply capacitors	1.40	2.05	10. Set of metalwork, fixing parts	4.20	4.80
4. Set of miscellaneous parts	1.90	1.90	11. Set of cables, mains lead	0.40	0.40
5. Set of slide, mains, P.B. switches	1.20	1.20	12. Handbook (free with complete kit)	0.25	0.25
6. Set of pots, selector switch	2.00	2.00	13 Teak cabinet 15.4" x 6.7" x 2.8"	4.50	4.50
7. Set of semiconductors, ICs, skts.	7.25	7.75			

FREE TEAK CASE WITH FULL KITS

T20+20 KIT PRICE only **£28.25**

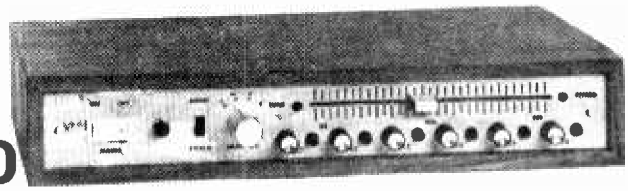
T30+30 KIT PRICE only **£32.95**

2 NEW TUNERS!

WW SFMT II

Following the success of our Wireless World FM Tuner kit we are now pleased to introduce our new cost reduced model, designed to complement the T20 and T30 amplifiers The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this new kit offers most exceptional value for money Facilities included are switchable afc, adjustable, switchable muting, channel selection by slider or readily adjustable pre-set push-button controls and LED tuning indication Individual pack prices in our free list

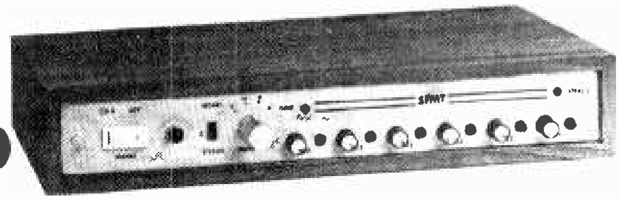
KIT PRICE **£47.40**



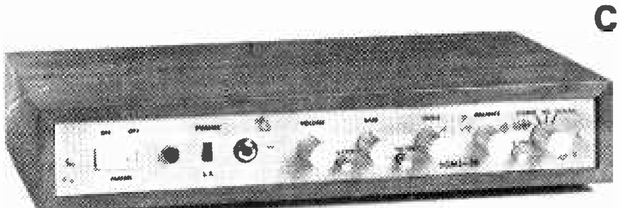
POWERTRAN SFMT

This easy to construct tuner using our own circuit design includes a pre-aligned front end module, PLL stereo decoder, adjustable switchable muting switchable afc and push-button channel selection As with all our full kits, all components down to the last nut and bolt are supplied together with full constructional details

KIT PRICE **£32.60**



CONVERT NOW TO QUADRAPHONICS

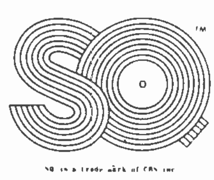


KIT PRICE **£37.15**

With 100s of titles now available no longer is there any problem over suitable software No problems with hardware either. Our new unit the SQM1-30 simply plugs into the tape monitor socket of your existing amplifier and drives two additional speakers at 30W per channel. A full complement of controls including volume, bass, treble and balance are provided as are comprehensive switching facilities enabling the unit to be used for either front or rear channels, by-passing the decoder for stereo-only use and exchanging left and right channels The SQ matrix decoder is based upon a single integrated circuit and was designed by CBS whilst the power and tone control sections are identical to those used in our T30 + 30 amplifier which the SQM1-30 matches perfectly Kit price includes CBS licence fee

Special offer to T20 + 20 and Texan owners!

Owners of T20 + 20 and Texan amplifiers, which have no tape monitor outlet, purchasing an SQM1-30 will be supplied, on request, a free conversion kit to fit a tape monitoring facility to the existing amplifier This makes simple the connection to the highly adaptable SQM1-30 quadraphonic decoder/rear channel amplifier

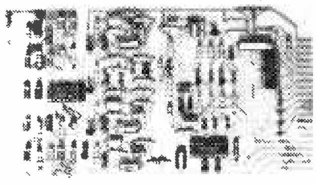


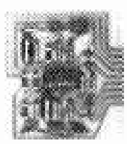
SEMICONDUCTORS

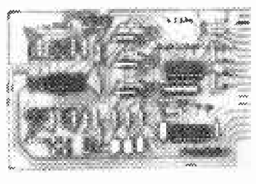
as used in our range of quality audio equipment.

2N699	£0.20	BC212K	£0.12	MPSA65	£0.35
2N1613	£0.20	BC182L	£0.10	MPSA66	£0.40
2N1711	£0.25	BC184L	£0.11	MPSU05	£0.60
2N2926G	£0.10	BC212L	£0.12	MPSU55	£0.70
2N3055	£0.45	BC214L	£0.14	SBA750A	£2.50
2N3442	£1.20	BCY72	£0.13	SL301	£1.30
2N3711	£0.09	BD529	£0.85	SL3045	£1.60
2N3904	£0.17	BD530	£0.85	SN72741P	£0.40
2N3906	£0.20	BDY56	£1.60	SN72748P	£0.40
2N4062	£0.11	BF257	£0.40	TIL209	£0.30
2N4302	£0.60	BF259	£0.47	TIP29A	£0.50
2N5087	£0.42	BFR39	£0.25	TIP30A	£0.60
2N5210	£0.54	BFR79	£0.25	TIP29C	£0.71
2N5457	£0.45	BFY51	£0.20	TIP30C	£0.78
2N5459	£0.45	BFY52	£0.20	TIP41A	£0.74
2N5461	£0.50	CA3046	£0.70	TIP42A	£0.90
2N5830	£0.35	LP1186	£5.50	TIP41B	£0.82
40361	£0.40	MC1310	£2.90	TIP42B	£0.98
40362	£0.45	MC1351	£1.05	1N914	£0.07
BC107	£0.10	MFC4010	£0.95	1N916	£0.07
BC108	£0.10	MJ481	£1.20	1S920	£0.10
BC109	£0.10	MJ491	£1.30	5805	£1.20
BC109C	£0.12	MJE521	£0.60		
BC125	£0.15	MPSA05	£0.25	**FILTERS**	
BC126	£0.15	MPSA12	£0.55	FM4	£0.80
BC162	£0.10	MPSA14	£0.35	SFG1D 7MA	£2.80
BC212	£0.12	MPSA55	£0.25		
BC182K	£0.10				

SQ QUADRAPHONIC DECODERS







Feed 2 channels (200-1000mV as obtainable from most pre-amplifiers or amplifier tape monitor outlets) into any one of our 3 decoders and take 4 channels out with no overall signal level reduction On the logic enhanced decoders Volume Front-Back, LF-RF balance LB-RB balance and Dimension controls can all be implemented by simple single gang potentiometers

These state-of-the-art circuits used under licence from CBS are offered in kits of superior quality with close tolerance capacitors metal oxide resistors and fibre-glass PCBs designed for edge connector insertion All kit prices include CBS licence fee

M1 Basic matrix decoder with fixed 10-40 blend All components, PCB **£5.90**

L1 Full logic controlled decoder with 'wave matching and front back logic for enhanced channel separation All components PCB **£17.20**

L2A. More advanced full logic decoder with 'variable blend extended frequency response increased front back separation All components, PCB **£24.60**

EXPORT NO PROBLEM

Our Export Department will be pleased to advise on postal costs to any country in the world. Some of the countries to which we sent kits in 1975 are shown surrounding this advertisement.

Kenya France St. Martin, Java New Zealand Borneo South Africa Denmark Nigeria Anguilla Finland

MORE THAN JUST A CATALOGUE!

Really good value for money at just 40p.

132 pages!

READY MADE ALARM CLOCK MODULE!

*CAN CONTROL A RADIO, TOO!

Just add transformer and switches!

- BRIGHT 4 DIGIT 0.5 INCH DISPLAY
- FLASHING COLON (1Hz)
- SWITCH FOR DISPLAY SECONDS
- ALARM SET INDICATOR
- P.M. INDICATOR
- POWER FAILURE INDICATION
- SLEEP TIMER
- SNOOZE TIMER
- AUTOMATIC DISPLAY BRIGHTNESS (NEEDS CdS CELL)
- TIME CAN BE SET ACCURATELY TO WITHIN ONE SECOND
- LEADING ZERO BLANKING

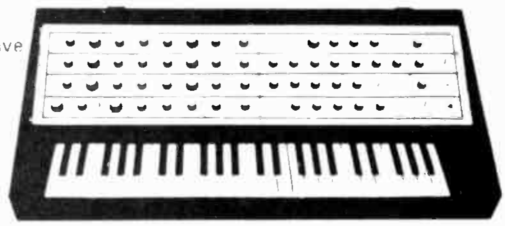
Please note Details not in catalogue

This is a fully constructed and tested electronic clock module as illustrated. Data sheet supplied with module shows how simple it is to connect an audible alarm, and your battery or mains radio. A smart case will be available shortly. Data sheet available separately. Please send s.a.e.

ONLY £8·60 INC. V.A.T. & P/P

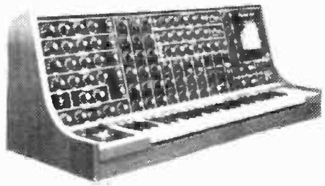
The 3600 SYNTHESISER

The 3600 synthesiser includes the most popular features of the 4600 model, but is simpler. Faster to operate, it has a switch patching system rather than the matrix patchboard of the larger unit and is particularly suitable for live performance and portable use.



S.A.E. please for price list

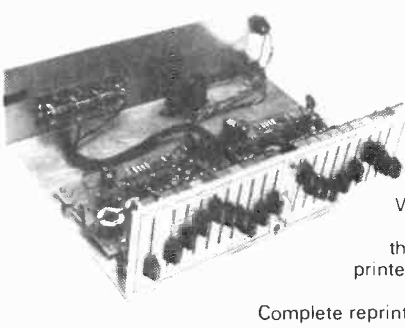
The 4600 SYNTHESISER



We stock all the parts for this brilliantly designed synthesiser, including all the PCBs, metalwork and a drilled and printed front panel, giving a superb professional finish.

Opinions of authority agree the ETI International Synthesiser is technically superior to most of today's models. Complete construction details available now in our booklet price £1.50, or S.A.E. please for specification.

GRAPHIC EQUALIZER



A really superior high quality stereo graphic equaliser as described in Jan. 1975 issue of ETI. We stock all parts (except woodwork) including all the metal work drilled and printed as required to suit our components and PCBs.

Complete reprint of article — price 15p.

ELECTRONIC ORGAN

Build yourself an exciting Electronic Organ. Our leaflet MES51, price 15p, deals with the basic theory of electronic organs and describes the construction of a simple 49-note instrument with a single keyboard and a limited number of stops. Leaflet MES52, price 15p, describes the extension of the organ to two keyboards each with five voices and the extension by an octave of the organ's range.

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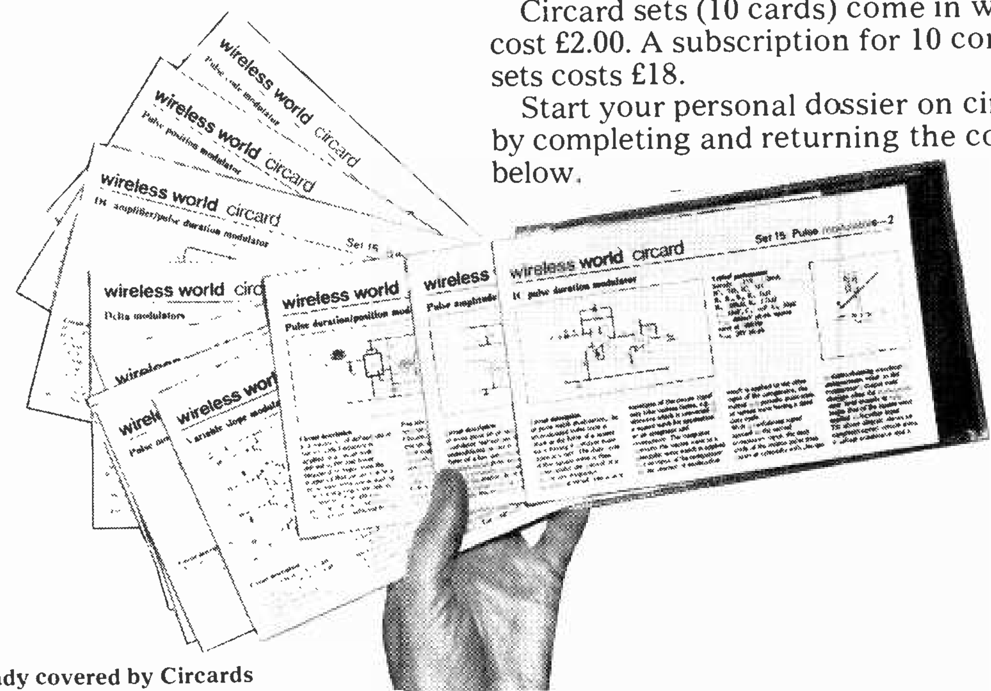

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ACY29	*0.36	BD123	*0.67	OC26	*0.30	2N2905	*0.21
ACY30	*0.29	BD124	*0.70	OC28	*0.51	2N2905A	*0.21
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AD162	*0.36	BD179	*0.71	OC77	*0.26	2N3011	*0.15
AD161 &		BD180	*0.71	OC81	*0.16	2N3053	*0.18
AD162(MP)		BD185	*0.67	OC81D	*0.16	2N3054	*0.47
	*0.69	BD186	*0.67	OC82	*0.16	2N3055	*0.42
ADT140	*0.51	BD187	*0.71	OC82D	*0.16	2N3319	0.15
AF114	*0.25	BD188	*0.71	OC83	*0.20	2N3391A	0.17
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AF181	*0.51	BDY20	*1.02	OCP71	*0.44	2N3525	*0.77
AF186	*0.51	BF115	*0.25	ORP12	*0.60	2N3614	*0.69
AF239	*0.38	BF117	*0.46	ORP60	*0.60	2N3615	*0.76
AL102	*0.68	BF118	*0.71	ORP61	*0.60	2N3616	*0.76
AL103	*0.68	BF119	*0.71	P20	*0.60	2N3646	0.09
ASY26	*0.26	BF121	0.46	P346A	*0.20	2N3702	0.12
ASY27	*0.31	BF123	0.51	P397	*0.43	2N3703	0.12
ASY28	*0.26	BF125	0.46	ST140	*0.13	2N3704	0.13
ASY29	*0.26	BF127	0.51	ST141	*0.18	2N3705	0.12
ASY50	*0.26	BF152	0.56	TIP29	0.44	2N3706	0.12
ASY51	*0.26	BF153	0.46	TIP30	0.52	2N3707	0.13
ASY52	*0.26	BF154	0.46	TIP31A	*0.56	2N3708	0.08
ASY54	*0.26	BF155	*0.71	TIP32A	*0.68	2N3709	0.09
ASY55	*0.26	BF156	*0.49	TIP41A	*0.68	2N3710	0.09
ASY56	*0.26	BF157	*0.56	TIP42A	*0.68	2N3711	0.09
ASY57	*0.26	BF158	0.56	TIS43	*0.31	2N3819	*0.29
ASY58	*0.26	BF159	0.61	UT46	*0.28	2N3820	*0.51
ASY73	*0.26	BF160	0.41	ZN414	*1.11	2N3821	*0.60
ASZ21	*0.41	BF162	0.41	2G301	*0.19	2N3823	*0.29
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BC117	0.19	BF178	*0.31	2G339A	0.17	2N4061	0.12
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7403	0.14	0.13	0.12	7491	1.02	0.97	0.93
7404	0.14	0.13	0.12	7492	0.69	0.66	0.59
7405	0.14	0.13	0.12	7493	0.69	0.66	0.59
7406	0.36	0.31	0.29	7494	0.79	0.76	0.69
7407	0.36	0.31	0.29	7495	0.79	0.76	0.69
7408	0.23	0.22	0.21	7596	0.89	0.86	0.80
7409	0.23	0.22	0.21	74100	1.39	1.34	1.30
7410	0.14	0.13	0.12	74104	0.56	0.54	0.51
7411	0.23	0.22	0.21	74105	0.56	0.54	0.51
7412	0.26	0.25	0.24	74107	0.41	0.39	0.37
7413	0.30	0.29	0.28	74110	0.56	0.51	0.46
7416	0.28	0.27	0.26	74111	0.83	0.81	0.78
7417	0.28	0.27	0.26	74118	0.93	0.88	0.83
7420	0.14	0.13	0.12	74119	1.39	1.30	1.20
7422	0.28	0.27	0.26	74121	0.46	0.44	0.41
7423	0.37	0.36	0.35	74122	0.65	0.63	0.60
7425	0.37	0.36	0.35	74123	0.69	0.68	0.65
7426	0.37	0.35	0.33	74141	0.79	0.76	0.73
7427	0.37	0.35	0.33	74145	1.20	1.16	1.11
7428	0.42	0.39	0.37	74150	1.39	1.30	1.20
7430	0.14	0.13	0.12	74151	1.02	0.97	0.93
7432	0.37	0.35	0.33	74153	0.93	0.88	0.83
7433	0.39	0.37	0.35	74154	1.57	1.43	1.48
7437	0.32	0.30	0.28	74155	1.11	1.06	1.02
7438	0.32	0.30	0.28	74156	1.11	1.06	1.02
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7441	0.69	0.66	0.59	74160	1.30	1.25	1.20
7442	0.69	0.66	0.59	74161	1.30	1.25	1.20
7443	1.11	1.06	1.02	74162	1.30	1.25	1.20
7444	1.11	1.06	1.02	74163	1.30	1.25	1.20
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7448	1.02	0.99	0.97	74174	1.48	1.44	1.39
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7453	0.14	0.13	0.12	74177	1.16	1.11	1.06
7454	0.14	0.13	0.12	74180	1.16	1.11	1.06
7460	0.14	0.13	0.12	74181	3.66	3.56	3.47
7470	0.30	0.27	0.25	74182	1.16	1.11	1.06
7472	0.30	0.27	0.25	74184	1.67	1.62	1.55
7473	0.38	0.36	0.32	74190	1.81	1.76	1.71
7474	0.38	0.36	0.32	74191	1.81	1.76	1.71
7475	0.56	0.54	0.52	74192	1.81	1.76	1.71
7476	0.41	0.40	0.39	74193	1.81	1.76	1.71
7480	0.56	0.54	0.51	74194	1.20	1.16	1.11
7481	1.02	0.97	0.93	74195	1.02	0.97	0.93
7482	0.83	0.79	0.74	74196	1.11	1.06	1.02
74197	1.11	1.06	1.02	7483	1.11	1.06	0.97
74198	2.55	2.50	2.45	7484	0.93	0.90	0.88
74199	2.31	2.21	2.11	7485	1.48	1.44	1.39

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BP933	0.15	0.14	0.13	BP962	0.14	0.13	0.12
BP935	0.15	0.14	0.13	BP9093	0.42	0.40	0.38
BP936	0.15	0.14	0.13	BP9094	0.42	0.40	0.38
BP944	0.15	0.14	0.13	BP9097	0.42	0.40	0.38
BP945	0.28	0.26	0.23	BP9099	0.21	0.40	0.38
BP946	0.14	0.13	0.12				

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20	0.15	0.18	—	—	—	—	—	—	—	—
30	0.19	0.22	—	—	—	—	—	—	—	—
50	0.22	0.28	0.20	0.25	0.36	0.36	0.48	0.51	0.54	1.18
100	0.25	0.30	0.25	0.25	0.48	0.48	0.51	0.57	0.58	1.43
150	0.31	0.38	—	—	—	—	—	—	—	—
200	0.38	0.44	0.25	0.30	0.50	0.50	0.57	0.62	0.62	1.63
400	—	—	0.30	0.39	0.55	0.57	0.62	0.71	0.77	1.79
600	—	—	0.39	0.48	0.69	0.69	0.78	0.99	0.90	—
800	—	—	0.58	0.65	0.81	0.81	0.92	1.22	1.39	4.07

LINEAR I.C.s

Type	Quantities 1	25	100+	Type	Quantities 1	25	100+
72702	0.46	0.44	0.42	TAA350A	1.71	1.67	1.57
72709	0.23	0.21	0.19	uA703C	0.26	0.24	0.22
72709P	0.19	0.18	0.17	uA709C	0.19	0.18	0.17
72710	0.32	0.31	0.28	uA711C	0.32	0.31	0.28
72741	0.28	0.27	0.26	uA712C	0.32	0.31	0.28
72741C	0.26	0.25	0.24	uA723C	0.45	0.43	0.40
72741P	0.28	0.27	0.26	76003	1.39	1.34	1.30
72747	0.79	0.74	0.61	76023	1.39	1.34	1.30
72748P	0.35	0.33	0.31	76660	0.88	0.86	0.83
SL201C	0.46	0.42	0.37	LM380	0.93	0.90	0.88
SL701C	0.46	0.42	0.37	*NE555	0.45	0.43	0.40
SL702C	0.46	0.42	0.37	*NE556	0.88	0.86	0.83
TAA263	0.74	0.65	0.56	TBA800	1.39	1.34	1.30
TAA293	0.93	0.88	0.83	ZN414	1.11	—	—

* SILICON RECTIFIERS

PIV	(DO7)	750mA (SO16)	Plastic		(SO16)	(SO10)	(SO10)	30A (TO48)
50	0.05	0.06	IN4001	0.05	0.07	0.14	*0.19	*0.56
100	0.05	0.07	IN4002	0.06	0.09	0.16	*0.21	*0.69
200	0.06	0.09	IN4003	0.07	0.12	0.20	*0.23	*0.93
400	0.07	0.14	IN4004	0.08	0.14	0.28	*0.35	*0.25
600	0.08	0.16	IN4005	0.09	0.16	0.33	*0.42	*1.76
800	0.11	0.18	IN4006	0.10	0.18	0.35	*0.51	*1.94
1000	0.13	0.28	IN4007	0.11	0.23	0.44	*0.60	*2.31
1200	—	0.32	IN4007		0.28	0.54	*0.69	*2.88

*TRIACS

	Case	100V	200V	400V
2 Amp	TO5	0.31	0.51	0.71
6 Amp	TO66	0.51	0.61	0.77
10 Amp	TO48	0.77	0.92	1.12

DIACS

BR100	*0.23
D32	*0.23

(These two diacs are recommended for use with triacs)

SUPER UNTESTED PAKS

Pak No.		Description	Price
U1	120	Glass Sub min G P Germ diodes	0.60
U2	50	Mixed Germanium transistors AF RF	*0.60
U3	75	Germ. gold bonded sub min like OA47	0.60
U4	30	Germ transistors like OC81, AC128	*0.60
U5	60	200mA sub-min silicon diodes	0.60
U6	30	Sil trans. NPN like BSY95A, 2N706	*0.60
U7	16	Sil rect 750mA up to 1000	0.60
U8	50	Sil. diodes DO-7 250mA like OA200/202	0.60
U9	20	Mixed voltages, 1 Watt Zener Diodes	*0.60
U10	20	BAY50 charge storage diodes DO-7	0.60
U11	20	PNP Sil trans, TO-5 like 2N1132, 2N2904	*0.60
U13	30	PNP-NPN Sil trans OC200 & 2S104	*0.60
U14	150	Mixed silicon and Germ. diodes	0.60
U15	20	NPN Sil trans TO-5 like 2N696	*0.60
U16	10	3Amp Sil. rect. stud up to 1000 PIV	*0.60
U17	30	Germ PNP AF trans. TO-5 like ACY17-22	*0.60
U18	8	6Amp sil rect BYZ13 up to 600 PIV	*0.60
U19	20	Silicon NPN trans. like BC108	*0.60
U20	12	1.5 Amp sil rect. top hat up to 1000 PIV	0.60
U21	30	AF Germ. trans. 2G300 series & OC71	*0.60
U23	25	MADT's like MHz series PNP series	*0.60
U24	20	Germ 1 Amp rect. GJM up to 300 PIV	0.60
U25	25	300MHZ NPN sil trans 2N708, BSY27	*0.60
U26	30	Fast switching sil. diodes like IN914	0.60
U29	10	1 Amp SCRs TO-5 up to 600 PIV	*1.20
U32	25	Zener diodes 400mW DO-7 3-33 volts mixed	0.60
U33	15	Plastic 1 Amp sil rect IN4000 series	0.60
U34	30	Sil PNP trans. TO-5 BCY26, 2S302/4	*0.60
U35	25	Sil trans PNP TO-18 2N2906	*0.60
U36	20	Sil NPN trans TO-5 BFY50/51/52	*0.60
U37	30	Sil trans SO-2 PNP OC200, WS322	*0.60
U38	30	Fast switch sil trans NPN 400MHz	*0.60
U39	30	RF Germ PNP trans 2N1301 5 TO-5	*0.60
U40	10	Dual trans 6 lead TO-5 2N2060	*0.60
U43	25	Sil trans. plastic TO 18 BC113 114	0.60
U44	20	Sil. trans plastic TO-5 BC115	0.60
U45	7	3A SCR TO66 up to 600 PIV	*1.20
U46	20	Unijunction trans similar to TIS43	*0.60
U47	10	TO220AB plastic triacs 50V 6A	*1.20
U48	9	NPN sil power trans like 2N3055	*1.20
U49	12	NPN sil plastic power 60W like 2N5294	*1.20

Code Nos mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked

UNTESTED TTL PAKS*

Pak No.		Contents	Price	Pak No.		Contents	Price
UIC00	=	12x7400	0.60	UIC70	=	8x7470	0.60
UIC01	=	12x7401	0.60	UIC72	=	8x7472	0.60
UIC02	=	12x7402	0.60	UIC73	=	8x7473	0.60
UIC03	=	12x7403	0.60	UIC74	=	8x7474	0.60
UIC04	=	12x7404	0.60	UIC75	=	8x7475	0.60
UIC05	=	12x7405	0.60	UIC76	=	8x7476	0.60
UIC06	=	8x7406	0.60	UIC80	=	5x7480	0.60
UIC07	=	8x7407	0.60	UIC81	=	5x7481	0.60
UIC10	=	12x7410	0.60	UIC82	=	5x7482	0.60
UIC13	=	8x7413	0.60	UIC83	=	5x7483	0.60
UIC20	=	12x7420	0.60	UIC86	=	5x7486	0.60
UIC30	=	12x7430	0.60	UIC90	=	5x7490	0.60
UIC40	=	12x7440	0.60	UIC91	=	5x7491	0.60
UIC41	=	5x7441	0.60	UIC92	=	5x7492	0.60
UIC42	=	5x7442	0.60	UIC93	=	5x7493	0.60
UIC43	=	5x7743	0.60	UIC94	=	5x7494	0.60
UIC44	=	5x7744	0.60	UIC95	=	5x7495	0.60
UIC45	=	5x7745	0.60	UIC96	=	5x7496	0.60
UIC46	=	5x7746	0.60	UIC100	=	5x74100	0.60
UIC47	=	5x7747	0.60	UIC121	=	5x74121	0.60
UIC48	=	5x7748	0.60	UIC141	=	5x74141	0.60
UIC50	=	12x7450	0.60	UIC151	=	5x74151	0.60
UIC51	=	12x7451	0.60	UIC154	=	5x74154	0.60
UIC53	=	12x7453	0.60	UIC193	=	5x74193	0.60
UIC54	=	12x7454	0.60	UIC199	=	5x74199	0.60
UIC60	=	12x7460	0.60	UIC XI	–	25 assorted 74s	1.50

V.A.T.

All prices EXCLUDE V.A.T.

Please add 8% to all prices marked *

Remainder add 25%

AVDEL BOND

SOLVE THOSE STICKY PROBLEMS!

with

CYANOACRYLATE C2 ADHESIVE

The wonder bond which works in seconds — bonds plastic rubber transistors components permanently immediately!

OUR PRICE ONLY 70p *

for 2gm phial

VOLTAGE REGULATORS

TO3 Plastic Encapsulation

uA 7805/L129	5V (equiv. to MVR5V)	1.25
uA.7812/L130	12V (Equiv. to MVR12V)	1.25
uA.7815/L131	15V (Equiv to MVR15V)	1.25
uA 7818	18V (Equiv to MVR18V)	1.25

D.I.L. SOCKETS

	1	25	100+
TS24 24 pin type	0.69	0.64	0.62
BPS8 8pin type (low cost)	0.14	0.12	0.10
BPS14 14 pin type (low cost)	0.15	0.13	0.11
BPS16 16 pin type (low cost)	0.16	0.14	0.12

* DIODES

AA119	0.08	BYZ16	0.41
AA120	0.08	BYZ17	0.36
AA129	0.08	BYZ18	0.36
AAY30	0.09	BYZ19	0.28
AAZ13	0.10	CG62	
BA100	0.10	(OA91 Eq)	0.06
BA116	0.21	CG651	
BA126	0.22	(OA70-OA79)	0.07
BA148	0.15	OA5 Short	
BA154	0.12	Leads	0.21
BA155	0.15	OA10	0.14
BA165	0.14	OA47	0.07
BA173	0.15	OA70	0.07
BB104	0.15	OA79	0.07
BY100	0.16	OA81	0.07
BY101	0.12	OA85	0.09
BY105	0.18	OA90	0.07
BY114	0.12	OA91	0.07
BY124	0.12	OA95	0.07
BY126	0.15	OA200	0.07
BY127	0.16	OA202	0.07
BY128	0.16	SD10	0.06
BY130	0.17	SD19	0.06
BY133	0.21	IN34	0.07
FY164	0.51	IN34A	0.07
BYX38 30	0.43	IN914	0.06
BYZ10	0.36	IN916	0.06
BYZ11	0.31	IN4148	0.06
BYZ12	0.31	IS021	0.10
BYZ13	0.26	IS951	0.07

* SIL G.P. DIODES

300 mW 40 PIV (min) SUB-MIN FULLY TESTED

Ideal for Organ builders

30 for 50p, 100 for £1.50, 500 for 5 1,000 for £9

G.P. SWITCHING TRANS*

TO18 SIM. TO 2N706/8 BSY27/28/95A. All usable devices. No open and shorts. ALSO AVAILABLE IN PNP similar to 2N2906, BCY70.

20 for 50p, 50 for £1, 100 for £1.80, 500 for £8, £1,000 for £14.

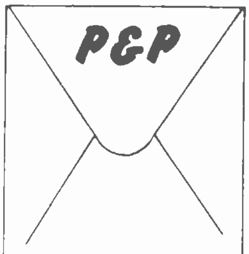
When ordering please state NPN or PNP

GP 300

115 WATT SILICON TO3 METAL CASE

Vcbo 100V, Vceo 60V, IC 15A. Hfe 20-100 suitable replacement for 2N3055, BDY11 or BDY20.

1-24	25-99	100+
50p	48p	46p



Postage and packing add 25p. Overseas add extra for airmail. Minimum order £1

BI-PAK

PO BOX 6, WARE, HERTS

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

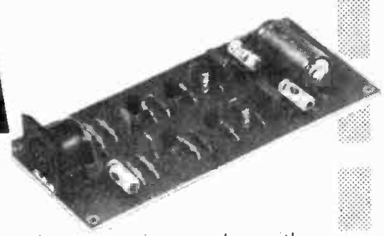
OUR PRICE ONLY **£19.95** Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** card be used if no suitable supply is available, together with the Transformer **T461**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied. **£2.65**

VAT ADD 25%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER PA 100

OUR PRICE **£13.50**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

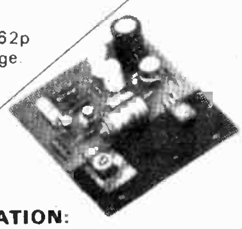
Frequency Response + 1dB 20Hz 20KHz Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz
Supply — 20-35V at 20mA
Dimensions — 299mm x 89mm x 35mm

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £27.55.** plus 62p postage.

TEAK 60 AUDIO KIT: Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £9.20** plus 62p postage.

AL10-20-30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV.RMS**

AL10 3w R.M.S. £2.30 — AL20 5w R.M.S. £2.65 — AL30 10w R.M.S. £2.95

STEREO 30

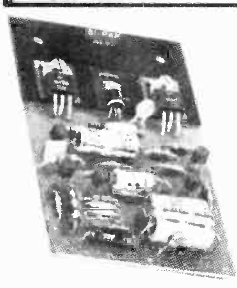
COMPLETE AUDIO CHASSIS
7+7 WATTS R.M.S.

P & P 45p **£15.75**

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £3.65 plus 62p p & p.

AL 60 25 Watts (RMS)



★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast. **£3.95**

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL10/20/30 Amplifier Modules. Features include on/off volume. Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm. **£6.50**

PS12

Power supply for **AL10/20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30 **OUR PRICE £1.20**

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80**, the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80 £2.60 + 62p postage **£3.00**

BI-PAK
P.O. BOX 6, WARE, HERTS.

NEW PRODUCTS

PROTO BOARDS
Build & test circuits as fast as you think!

PB100	10 IC cap breadboard kit. 4 5 x 6 0 x 1 3"	£17.45
PB101	10 14-DIP cap. 5-way post. 940 solderless tie points. 5.8 x 4.5"	£26.15
PB102	12 14-DIP cap. like PB101 with 1 240 tie points. 7 0 x 4 5"	£34.90
PB103	24 14-DIP cap. 4 5-way posts. 2 250 tie points. 6.0 x 9.0"	£52.35
PB104	32 14-DIP cap. 3.060 solderless tie points. 8.0 x 9.76"	£69.80

LOGIC MONITOR
Simultaneously displays static and dynamic logic states of DTL TTL HTL or CMOS DIP ICs Pocket size
LM-1 **£59.95**

PROTO-CLIP
For power on/hands off signal tracing Bring IC leads up from PC board surface for fast trouble shooting
PC14 14-pin **£3.25**
PC16 16-pin **£3.40**

SOCKETS & BUS STRIPS
Plug-in wire test modify or expand without patch cords or solder Snap together to form breadboard needed

PN/Description		Hole-to-Hole	Term'ls	Price
QT59S Socket	6 5"	6 2"	118	£10.90
QT59B Bus	6 5"	6 2"	20	£2.20
QT47S Socket	5 3"	5 0"	94	£8.75
QT4/B Bus	5 3"	5 0"	16	£2.00
QT35S Socket	4 1"	3.8"	70	£7.45
QT35B Bus	4 1"	3.8"	12	£1.75
QT18S Socket	2 4"	2 1"	36	£4.15
QT12S Socket	1.8"	1 5"	24	£3.30
QT8S Socket	1.4"	1 1"	16	£2.85
QT7S Socket	1 3"	1 0"	14	£2.65

740 Series TTL

	1	25	100+		1	25	100+
SN7400	0.14	0.13	0.12	SN7494	0.48	0.45	0.40
SN7401	0.14	0.13	0.12	SN7495	0.60	0.56	0.50
SN7402	0.14	0.13	0.12	SN7496	0.70	0.67	0.60
SN7403	0.14	0.13	0.12	SN7497	0.70	0.69	0.68
SN7404	0.15	0.14	0.13	SN74100	1.35	1.30	1.25
SN7405	0.15	0.14	0.13	SN74104	0.31	0.29	0.26
SN7406	0.30	0.29	0.28	SN74105	0.31	0.29	0.26
SN7407	0.30	0.29	0.28	SN74107	0.31	0.29	0.26
SN7408	0.15	0.13	0.12	SN74109	1.00	0.97	0.95
SN7409	0.15	0.13	0.12	SN74110	0.55	0.50	0.45
SN7410	0.14	0.13	0.12	SN74111	0.81	0.80	0.76
SN7411	0.23	0.22	0.21	SN74114	1.00	0.97	0.95
SN7412	0.19	0.18	0.17	SN74115	1.00	0.97	0.95
SN7413	0.30	0.29	0.28	SN74118	1.00	0.95	0.90
SN7414	0.71	0.70	0.69	SN74121	0.31	0.29	0.25
SN7415	0.30	0.29	0.27	SN74122	0.44	0.41	0.37
SN7416	0.28	0.27	0.26	SN74123	0.62	0.58	0.50
SN7417	0.28	0.27	0.26	SN74125	0.70	0.65	0.60
SN7420	0.14	0.13	0.12	SN74126	0.75	0.70	0.65
SN7421	0.95	0.94	0.93	SN74128	1.40	1.35	1.30
SN7422	0.25	0.24	0.23	SN74132	2.10	2.05	2.00
SN7423	0.26	0.25	0.22	SN74136	0.95	0.90	0.85
SN7425	0.26	0.25	0.22	SN74140	2.50	2.45	2.40
SN7426	0.26	0.25	0.22	SN74141	0.75	0.70	0.62
SN7427	0.26	0.25	0.22	SN74145	1.15	1.10	1.05
SN7428	0.39	0.38	0.37	SN74147	2.95	2.90	2.85
SN7430	0.14	0.13	0.12	SN74148	2.30	2.25	2.20
SN7432	0.25	0.24	0.22	SN74150	1.35	1.30	1.25
SN7433	0.36	0.35	0.34	SN74151	0.68	0.62	0.55
SN7437	0.27	0.26	0.22	SN74152	1.55	1.50	1.45
SN7438	0.27	0.26	0.22	SN74153	0.68	0.62	0.55
SN7439	1.10	1.08	1.06	SN74154	1.55	1.50	1.45
SN7440	0.14	0.13	0.12	SN74155	0.68	0.62	0.55
SN7441	0.70	0.69	0.66	SN74156	0.68	0.62	0.55
SN7422	0.63	0.60	0.53	SN74157	0.90	0.85	0.80
SN7443	1.00	0.99	0.90	SN74158	1.50	1.45	1.40
SN7444	1.08	1.07	1.05	SN74160	0.95	0.90	0.80
SN7445	0.85	0.83	0.70	SN74161	0.95	0.90	0.80
SN7446	1.03	1.00	0.85	SN74162	0.95	0.90	0.80
SN7447	1.03	1.00	0.85	SN74163	0.95	0.90	0.80
SN7448	0.85	0.83	0.70	SN74164	1.60	1.55	1.50
SN7450	0.14	0.13	0.12	SN74165	1.60	1.55	1.50
SN7451	0.14	0.13	0.12	SN74166	1.40	1.30	1.15
SN7453	0.14	0.13	0.12	SN74170	2.40	2.30	2.20
SN7454	0.14	0.13	0.12	SN74173	1.65	1.60	1.55
SN7455	0.40	0.39	0.38	SN74174	1.15	1.10	1.00
SN7460	0.14	0.13	0.12	SN74175	0.97	0.90	0.80
SN7462	0.45	0.44	0.42	SN74176	1.10	1.05	1.00
SN7464	0.45	0.44	0.42	SN74177	1.10	1.05	1.00
SN7465	0.45	0.44	0.42	SN74180	1.10	1.05	1.00
SN7470	0.30	0.27	0.25	SN74181	3.50	3.45	3.35
SN7471	0.60	0.59	0.58	SN74182	1.10	1.05	1.00
SN7472	0.25	0.24	0.21	SN74184	1.60	1.55	1.50
SN7473	0.30	0.27	0.26	SN74185	2.30	2.25	2.20
SN7474	0.31	0.29	0.26	SN74188	4.90	4.85	4.80
SN7475	0.40	0.39	0.38	SN74190	1.75	1.70	1.65
SN7476	0.31	0.29	0.26	SN74191	1.70	1.65	1.60
SN7478	0.65	0.63	0.61	SN74192	1.25	1.05	1.00
SN7480	0.43	0.41	0.36	SN74193	1.25	1.05	1.00
SN7481	1.00	0.95	0.90	SN74194	1.10	1.05	1.00
SN7482	0.75	0.70	0.62	SN74195	0.90	0.85	0.80
SN7483	0.81	0.80	0.68	SN74196	1.05	1.00	0.95
SN7484	0.90	0.86	0.85	SN74197	1.05	1.00	0.95
SN7485	1.25	1.15	1.00	SN74198	2.05	2.00	1.70
SN7486	0.31	0.28	0.25	SN74199	2.05	2.00	1.70
SN7489	3.50	3.20	3.00	SN74200	6.00	5.95	5.80
SN7490	0.45	0.42	0.35	SN74221	1.80	1.75	1.70
SN7491	1.00	0.95	0.90	SN74251	1.80	1.75	1.70
SN7492	0.45	0.42	0.35	SN74278	3.00	2.90	2.80
SN7493	0.45	0.42	0.35	SN74279	1.20	1.15	1.10
				SN74293	1.00	0.95	0.90
				SN74298	2.60	2.55	2.50

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SN74H01	0.34	0.33	0.30	SN74H52	0.36	0.35	0.33
SN74H04	0.38	0.37	0.30	SN74H53	0.36	0.35	0.33
SN74H05	0.37	0.36	0.33	SN74H54	0.36	0.35	0.33
SN74H08	0.40	0.39	0.37	SN74H55	0.36	0.35	0.33
SN74H10	0.36	0.35	0.33	SN74H60	0.36	0.35	0.33
SN74H11	0.36	0.35	0.33	SN74H61	0.36	0.35	0.33
SN74H20	0.36	0.35	0.33	SN74H62	0.36	0.35	0.33
SN74H21	0.36	0.35	0.33	SN74H71	0.80	0.78	0.75
SN74H22	0.36	0.35	0.33	SN74H72	0.74	0.73	0.70
SN74H30	0.36	0.35	0.33	SN74H73	0.90	0.88	0.85
SN74H40	0.36	0.35	0.33	SN74H74	0.87	0.85	0.81
SN74H50	0.36	0.35	0.33	SN74H76	0.90	0.88	0.85
				SN74H101	0.80	0.78	0.75
				SN74H102	0.80	0.78	0.75
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10	100
12	90
15	70
18	50
20	35
22	25
24	15

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4002AE	0.17	0.14	0.12	4035AE	0.97	0.78	0.64
4004AE	1.93	1.55	1.29	4040AE	0.88	0.71	0.58
4006AE	0.97	0.78	0.64	4041AE	0.69	0.56	0.46
4007AE	0.17	0.14	0.12	4042AE	0.69	0.56	0.46
4008AE	0.79	0.64	0.53	4043AE	0.83	0.67	0.55
4009AE	0.46	0.37	0.31	4044AE	0.77	0.62	0.51
4010AE	0.46	0.37	0.31	4047AE	0.74	0.60	0.50
4011AE	0.17	0.14	0.12	4048AE	0.46	0.37	0.31
4012AE	0.17	0.14	0.12	4049AE	0.46	0.37	0.31
4013AE	0.46	0.37	0.31	4050AE	0.46	0.37	0.31
4014AE	0.83	0.67	0.55	4051AE	0.77	0.62	0.51
4015AE	0.83	0.67	0.55	4052AE	0.77	0.62	0.51
4016AE	0.46	0.37	0.31	4053AE	0.77	0.62	0.51
4017AE	0.83	0.67	0.55	4055AE	1.08	0.87	0.72
4018AE	0.83	0.67	0.55	4056AE	1.08	0.87	0.72
4019AE	0.46	0.37	0.31	4060AE	0.92	0.74	0.61
4020AE	0.92	0.74	0.61	4066AE	0.58	0.47	0.39
4021AE	0.83	0.67	0.55	4069AE	0.18	0.15	0.12
4022AE	0.79	0.64	0.53	4071AE	0.18	0.15	0.12
4023AE	0.17	0.14	0.12	4076AE	1.27	1.02	0.85
4024AE	0.64	0.52	0.43	4081AE	0.18	0.15	0.12
4025AE	0.17	0.14	0.12	4510AE	1.27	1.02	0.85
4026AE	1.42	1.14	0.94	4516AE	1.27	1.02	0.85
4027AE	0.46	0.37	0.31	4518AE	1.82	1.46	1.21
4028AE	0.74	0.59	0.49	4520AE	1.82	1.46	1.21
4029AE	0.94	0.76	0.63	4901AE	0.35	0.32	0.30
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APS28-0 8	28	0.8	
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APS12-4	12	4	
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APS28 2	28	2	
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APS12-7	12	7	
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APS28-4	28	4	
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APS6-22	6	22	
APS12-17	12	17	
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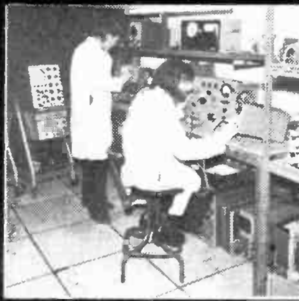

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5326B Univ. Timer/Counter/D.V.M.
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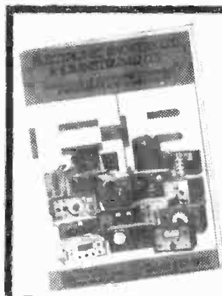

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Hifi International Exhibition and Festival – Dusseldorf – September 24-29, 1976. 2 nights at the first class Quality Inn Hotel. – Ratingen (8 km from the Fair Ground). Fully inclusive price – £99.90. ☐

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185	8–12	6 M	65p*	1250	18–36	2 c/o	65p*
230	9–18	2 c/oHD	75p*	2500	36–45	6 M	65p*
430	15–24	4 c/o	85p*	2500	31–43	2 c/oHD	65p*
600	10-20	6M	85p	15k	85–110	6 M	65p
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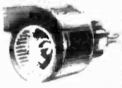

Mfg by Smiths Industries Miniature model Series SF/200 Size 95mm x 82mm x 82mm Aperture 38mm x 31mm 12 c.f.m **£2.75.** Post 50p

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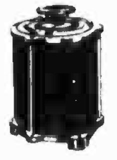

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4ft. 40 watt £6.00 (callers only) **2ft. 20 watt £4.60.** Post 60p (For use in standard bi-pin fittings). MINI **12in. 8 watt £1.75.** Post 25p. **9in. 6 watt £1.40.** Post 25p. Complete ballast unit and holders for either 9" or 12" tube **£1.70.** Post 30p (9" x 12" measures approx.).

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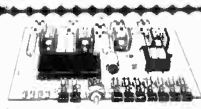

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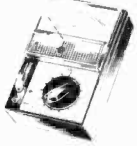

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115 lb. ins. 110 volt. 50Hz. 2.8 amp., single phase, split capacitor motor. Emense power. Continuously rated. Totally enclosed. Fan cooled. In-line gear box. Length 250mm. Dia. 135mm. Spindle Dia. 15.5mm. Length 145mm. ex-equipment **£14.00.** Post £1.50. Suitable transformer 230/240 volt tested **£8.00.** Post 75p

15 R.P.M.

Type SD48 15 r.p.m. 80 lb. ins. Input 100/120 volt A.C. Length incl. gearbox 270mm. Height 135mm. Width 150mm. Shaft drive 16mm. Weight 8.5 Kilos. BRAND NEW Price **£10.00,** carr. £1.00. Suitable transformer for use on 220/240 volt A.C. **£3.85.** Post 50p

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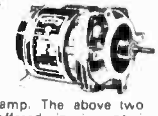
220/240 volt A.C. Small, powerful, continuously rated motor. Mfg. BERGER (Germany). Size 80mm x 65mm x 65mm. Spindle dia. 6mm. Length 15mm. Weight 725 grams. **£6.50.** Post 50p

BODINE TYPE N.C.I. GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle .38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in. **Reversible** 1/80th h.p. 50 cycle .28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v **A.C.** Supplied complete with transformer for **230/240v A.C. input.**
Price, either type **£6.25.** Post 75p or less transformer **£3.75.** Post 65p
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc. etc.

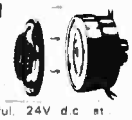
20 r.p.m. GEARED MOTOR

230/240 volt 20 r.p.m. motor. **£1.00.** Post 20p.

REVERSIBLE MOTOR 230V A.C.

General Electric. 230v A.C. 1,600 r.p.m. 0.25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia 20mm long. Ex-equipment tested **£3.00.** Post 50p

BENDIX MAGNETIC CLUTCH



A superb example of Electro-mechanics! The main body is in two sections. The coil section is fixed and has a ⅜in. sleeve. The drive section rotating on the outer perimeters. The uniting plate has ⅜in. ID bearing concentric with main section and 18-tooth cog wheel.
When energized transmission is extremely powerful. 24V d.c. at 240MA. OUR PRICE JUST **£3.50.** Post 45p

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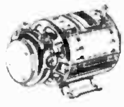
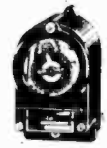


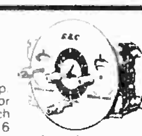
Carbon vane, oil-less. 100/115V A.C. 1/12 h.p. motor. 50/60 cycle. 2875/3450 r.p.m. 20" vacuum. 1.25 c.f.m. 10 p.s.i. (approx. figures). New unused surplus stock, with elect. connection data. Fraction of maker's price **£12.00.** Post £1.00. Suitable transformer **£3.50.** Post 50p

TIME SWITCH



'Horstmann' Type V Mk II Time Switch. 200/250 volt A.C. Two on/two off every 24 hours, at any manually pre-set time. 30 amp contacts. 36-hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case, with glass observation window. Built to highest Electricity Board spec. individually tested. Price **£7.75.** Post 50p. (Total inc. VAT £8.91.)

A.C. MAINS TIMER UNIT



Based on an electric clock, with 25 amp single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs., then switch off. An additional 60 min. audible timer is also incorporated. Idea for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm x 130 mm x 60 mm. Price **£2.25.** Post 40p. (Total inc. VAT & Post **£2.87.**)

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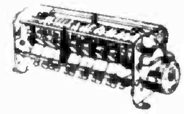
PROGRAMME TIMERS



50 volt A.C. operation. Each cam operates a c/o micro switch. Ideal for lighting effects displays, etc. Ex equip. tested similar to illustration. 6 cam model 20 r.p.m. **£3.50.** Post 60p. 12 cam model 15 r.p.m. **£5.00.** Post 60p. Suit. transformer 230v operation **£1.50.**

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LL8	10	20	10	9	£15.00
LL9	17	21	17	14	£15.00
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- ★ Ampex FR600. 4 speeds. 14 tracks 1"
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- ★ EMI BTR1. 1 speed. 1 track ¼"
- ★ EMI R301G. 2 speeds. stereo ¼"
- ★ Mincom CMP-100. 6 speeds. 7 tracks ¼, ½, 1"
- ★ Leevers Rich DA-2P. 2 speeds. 2 tracks ½"
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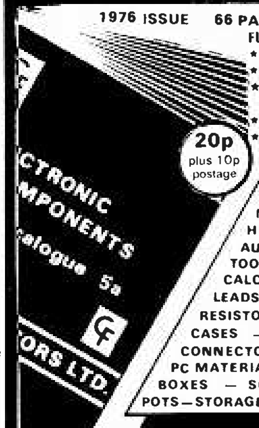

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SPECIAL RESISTOR KITS (CARBON FILM 5%)
(Prices include post & packing)
10E12 ⅛W or ¼W KIT 10 of each E12 value 22ohms—1M a total or 570 **£5.29** net
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SPECIAL CAPACITOR KITS

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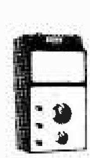
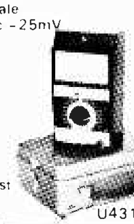
B.H. COMPONENT FACTORS LTD.

MULTIMETER U4341



27 Ranges plus Transistor Tester
16 700Ω Volt
Vdc—0 3—900V in 8 ranges
Vac —1 5—750V in 6 ranges
Idc —0 06 —600mA in 5 ranges
Iac —0 3 300mA in 4 ranges
Resistance—2K Ω—2M Ω in 4 ranges
Accuracy—dc—2½%
ac —4% of F S D
hfe —10—350 in 2 ranges
Size 115 x 215 x 90mm
Complete with steel carrying case, test leads and battery PRICE **£12.10** net P&P 75p
U4341

MULTIMETER U4313



33 ranges Knife edge with mirror scale
20 000Ω Volt High accuracy mVdc —25mV
Vdc —1 5 —600V in 9 ranges
Vac 1 5 600V in 9 ranges
Idc 60—120 microamps in 2
Idc —0 6—1500mA in 6 ranges
Iac—0 6—1500mA in 6 ranges
Resistance 1KΩ 1MΩ in 4 ranges
db scale—10 to + 12db
Accuracy —dc—1½ ac —2½
Size —115 x 215 x 90mm
Complete with steel carrying case test leads and battery
PRICE **£16.09** net P&P 75p
U4313

MULTIMETER U4323

22 Ranges plus AF IF Oscillator
20 000Ω Volt
Vdc 0 5 —1000V in 7 ranges
Vac—2 5—1000V in 6 ranges
Idc—0 05—500mA in 5 ranges
Resistance—5Ω—1M Ω in 4 ranges
Accuracy 5% of F S D
OSCILLATOR —1 KHz and 465 KHz (A M) at approx 1 Volt Size —160 x 97 x 40mm
Supplied complete with carrying case test leads and battery
PRICE **£9.95** net P&P 75p
U4323

MULTIMETER U4324

34 Ranges High sensitivity
20 000Ω Volt
Vdc—0 6—1200V in 9 ranges
Vac —3—900V in 8 ranges
Idc —0 06 —3A in 6 ranges
Iac —0 3 —3A in 5 ranges
Resistance—25Ω —5MΩ in 5 ranges
Accuracy—dc and R—2½% of F S D
ac and db 4% of F S D
Size—167 x 98 x 63mm
Supplied complete with storage case test leads, spare diode and battery
PRICE **£11.72** net P&P 75p
U4324

(WW), LEIGHTON ELECTRONICS CENTRE, 59 NORTH STREET, LEIGHTON BUZZARD, LU7 7EG.
Tel Leighton Buzzard 2316 (Std code 05253)

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THE firm for speakers!

Baker Group 25, 3, 8, or 15 ohm	**£8.64**
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All Radford, Gauss, Castle, Jordan Watts, Eagle, Lowther, Peerless Tannoy units in stock

Prices correct at 1.4 76

INCLUDING VAT AT 25% ON HI-FI
8% ON PRO & P.A.

Cabinets for PA AND HiFi, wadding, Vynair, etc
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Dept. WW

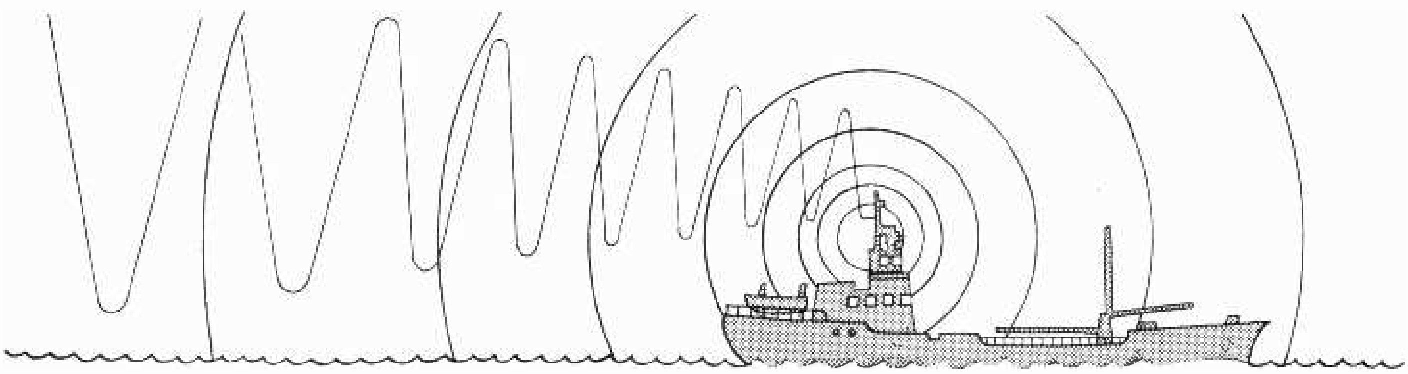
Loudspeakers & Export Dept: Swan Works, Bank Square, Wilmslow, Cheshire SK9 1HF. Discount HiFi, PA etc: 10 Swan Street, Wilmslow. Radio, Hi Fi, TV: Swift of Wilmslow, 5 Swan Street, Wilmslow. Tel. (Loudspeakers) Wilmslow 29599, (HiFi, etc.) Wilmslow 26213.

WW—018 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Monday, May 3, for the June issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £6.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1 per line, minimum three lines.
BOX NUMBERS: 45p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.).
PHONE: Owen Bailey on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have vacancies at some of our coastal radio stations, so if you're 19 or over, write to: ETE Maritime Radio Services Division (L687), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

93

MEDICAL RESEARCH COUNCIL
CYCLOTRON UNIT
WESTERN GENERAL HOSPITAL, EDINBURGH

The following posts are offered for work on a Nuclear Accelerator in a new Cancer Therapy Unit

OPERATOR to be responsible for routine operation and maintenance of accelerator and ancillary plant and some development work Several years experience in installation and maintenance of electrical plant necessary and an HNC in relevant subject Permanent appointment to Technician grade age 23 26 salary £2511-£2790 (scale to £3738)

ELECTRONICS TECHNICIAN to be responsible for maintenance and development of wide range of equipment associated with accelerator and ancillary plant also providing a service to scientists concerned with the physical aspects of the beam Several years practical experience in an electronics laboratory essential Permanent appointment to Technician grade age 23-28 HNC in relevant subject required Salary according to age and experience £2511-£2988 (scale to £3738)

Apply with personal details to
Admin. Officer, MRC Cyclotron Unit, Hammersmith Hospital
Ducane Road, London, W12 0HS

(5712)

INSTALLATION MANAGER

Television and Security Systems

Due to rapid expansion we have an immediate requirement for a qualified experienced and highly competent Installation Manager In addition to his technical skills he will need to be an excellent administrator, flexible in his approach to solving problems and good at handling a team of hard-pressed engineers

The Company which is situated near London is designing and installing many complex systems both in the UK and abroad we are a leader in the field of advanced security technology and expect our systems to be installed to the highest standards possible Thereafter we maintain them providing a fast and efficient service to our customers

A pleasant disposition and efficient manner coupled with a good sense of humour will be essential attributes The Company will pay an excellent salary provide a car and the usual fringe benefits to the successful candidate This is a long term career prospect and the opportunity to become a member of a young and enthusiastic team

5352

TEST GEAR ENGINEERS

Rediffusion, a major British company in television manufacture, is developing a new, state of the art receiver at its Chessington laboratories. To support this project we require additional Test Equipment Design and Development Engineers at senior and intermediate levels to help produce our sophisticated production test equipment. Rediffusion test equipment leads the industry and uses both analogue and digital techniques along with an up-to-date approach to jigging.

Applications are invited from well qualified and experienced test equipment engineers, who will be offered the opportunity to join a young and energetic team. Our work is usually demanding, often under pressure but always stimulating, using new ideas to speed production testing whilst reducing the demands on our test operators.

Salaries, which will depend on experience, are excellent and assistance with relocation will be given where appropriate. Some travelling to our production factories in Co. Durham will be necessary from time to time to assist in the installation and commissioning of new equipment since our design engineers are expected to be responsible for all aspects of their project.

If you are a high calibre engineer and wish to have your ability recognised and rewarded, come and join us.

Write or 'phone to:

A. J. Litteck,
Test Equipment Group Leader,
Rediffusion Consumer Electronics Ltd.,
Fullers Way South,
Chessington, Surrey.
Phone 01-397-5411

REDIFFUSION

(5347)

UNIVERSITY OF EDINBURGH

ELECTRONICS TECHNICIAN

Required for the DEPT. OF RESTORATIVE DENTISTRY. The work is mainly concerned with medical electronics and electromyography. The successful candidate will be concerned with maintenance and modification of a wide range of medical, electronic and allied equipment, and with research and development in electronics as related to dentistry. The post offers challenging and rewarding work in a new and expanding field. Applicants should hold HNC or equivalent in appropriate subjects. Salary will be on scale £2751-£3207 p.a. Assistance with relocation expenses is available if necessary

Applications, quoting post reference no. A171, and giving full details of age and qualifications, together with the names and addresses of two referees, should be submitted by 30th April, 1976, to the Personnel Officer, University of Edinburgh, 63 South Bridge, Edinburgh EH1 1LS. Telephone 031-667 1011, ext. 4510-3.

Opportunities in the

ELECTRONICS FIELD

People with analogue or digital qualifications / experience seeking higher paid posts in TEST - SERVICE - DESIGN - SALES.

Phone Mike Gernat, Ref. W.W.

NEWMAN APPOINTMENTS
360 Oxford Street, W.1.
01-629 0501

(94)

AUDIO - TAPE - HI-FI
Service Engineer

Able to work on own initiative. Full range of test gear. Good remuneration, excellent conditions, interesting and permanent post. Regular hours

JOHN KING
71 East Street, Brighton
Telephone 25918/27674

(5311)

C.C.T.V. VIDEO SYSTEMS

We think we are the most successful company in our field and are seeking people of the right calibre to maintain and increase our market share build-up over the last 10 years.

To supplement our existing team engaged in installations in U.K., Turkey, Saudi Arabia and Nigeria, we require exceptional Video Sales Engineers, capable of selling at a high level and supervising installations from conception to commissioning. We need ambitious men, of proved technical ability and unafraid of hard work. The rewards are high and this is a genuine, once in a lifetime opportunity for the right people

Please contact in full confidence

Ian Crammond, Managing Director
TELETAPE VIDEO
76 Brewer Street
Tel. 01-439 6336/7/8

(5342)

Systems Test Engineer

Crosfield Electronics Ltd are leaders in the field of sophisticated electronic equipment for the printing industry. We need engineers to work on the final testing of systems using analogue and digital circuitry with a degree of photographic and optical involvement.

The right people will be aged 20 to 32 and either up to HNC standard with three to five years relevant experience or with a service background. Knowledge and experience of computer software and hardware would be an important advantage.

Starting salary depending on experience will be attractive and benefits are commensurate with those expected of a member of an international group of companies.

For an application form please contact Linda Geers, Crosfield Electronics Ltd, 766 Holloway Road, London N19 3JG. Telephone 01-272 7766.

CROSFIELD ELECTRONICS

MALLA TECHNICAL STAFF

334 Euston Road
London NW1 3BG
01-387 1043

ELECTRONICS AND COMPUTER PERSONNEL. QUALIFIED AND EXPERIENCED ALL SPECIALITIES, ALL AREAS.

(5243)

University of Edinburgh

ELECTRONICS TECHNICIAN

A qualified electronics technician, experienced in servicing and design modification of sophisticated instrumentation, is required by the DEPT OF CHEMISTRY to take charge of a workshop and four qualified staff from 1st August, 1976. The successful applicant will be expected to advise staff on design and data collection problems and give technical information on new equipment. HNC or equivalent qualification required. Salary on scale £3156-£3762 p.a.

Applications, quoting post reference no. A175, should be addressed to the Personnel Officer, University of Edinburgh, 63 South Bridge, Edinburgh EH1 1LS. Telephone 031-667 1011, ext. 4510-3.

(5346)

mi

Careers in Professional Electronics

Your experience could open the door to a range of interesting and rewarding opportunities in the Design, Production or Service departments of a Company whose products complement the most advanced modern electronic techniques.

For more information apply in confidence to :– John Prodger,

MARCONI INSTRUMENTS LIMITED

Longacres, St. Albans, Herts. Tel : St. Albans 59292

A GEC-Marconi Electronics Company

(5208)

FEATURES EDITOR — ELECTRON

ELECTRON, leading fortnightly journal for engineers and management in electronics, requires a Features Editor. Essential requirements are journalistic experience, a good working knowledge of the electronics industry, and knowledge of the latest technological developments in electronic components, equipment and design techniques. Principal functions will include the commissioning of feature articles from specialist experts in industry, and the writing of technical feature articles for an engineering audience. As part of a closely knit team, the Features Editor will also be required to cover press conferences and press visits from time to time. An important function of the position is journal production which involves close adherence to schedule copy dates, and progress of copy through manuscript, galley and page-proof stages.

Salary will be in accordance with NUJ/IPC Business Press Ltd. Grade 5 agreement.

Apply to: W. S. E. Mitchell, Editor, Electron, IPC Electrical-Electronic Press Ltd., Dorset House, Stamford Street, London SE1 9LU.

(5315)

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Dhofar Region Television Service

- Very Good Salary
- Free Family Passage
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- Special End of Contract Bonus
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- Hard work is necessary

We are recruiting on renewable one-year contract and have a vacancy for

SOUND SUPERVISOR

FOR TELEVISION STUDIOS

INCLUDING O.B.s

Let us discuss with you your abilities for this interesting and important position

Phone: Tony Owers, 01-573 8333 for more information

PERSONNEL & ELECTRONICS LTD.

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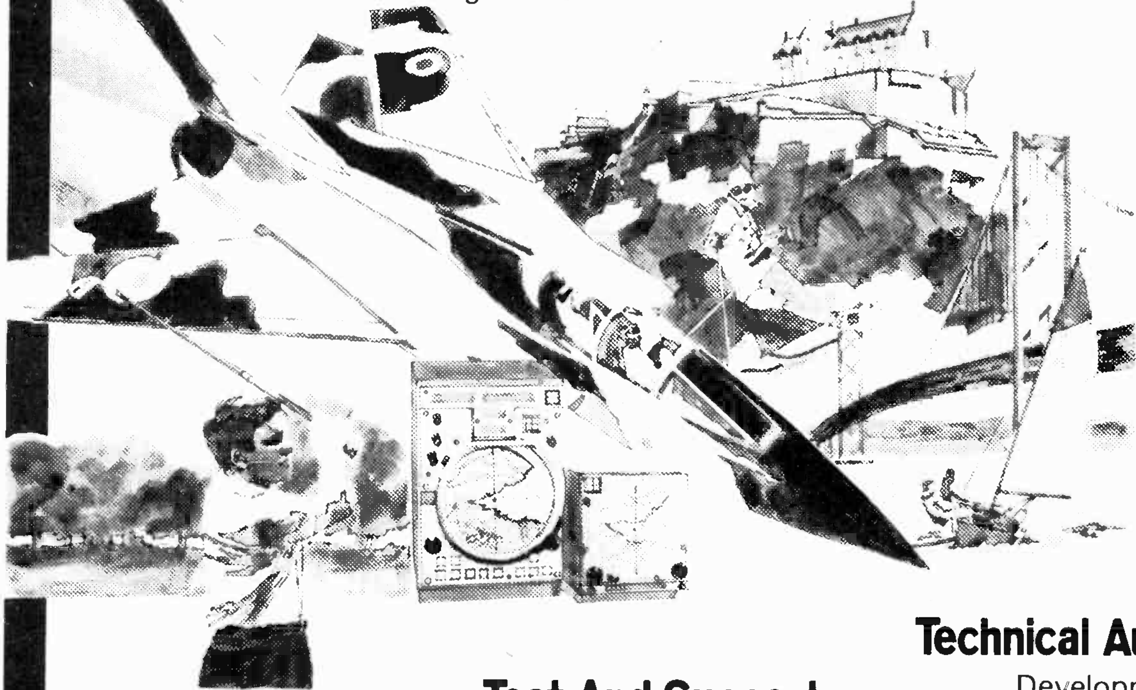
With contracts for a variety of advanced avionic projects in the Tornado (MRCA), Sea Harrier, Nimrod Mk2, Mitsubishi FS-T2, Jaguar and the naval Lynx helicopter, Ferranti in Edinburgh are in a position to offer career conscious engineers a wealth of technological experience. Planned expansion through this year and next now requires the appointment of engineers with experience in the following areas:



Design/Development

Opportunities exist for electronic and mechanical engineers with qualifications ranging from HND to Honours degree to join our design teams involved in airborne radars, laser range finding and target seeking equipments, inertial navigation systems and their associated test gear.

Test And Support

To support our design teams we need engineers with qualifications from C & G to HNC, preferably with Test and Quality Assurance experience.

They will become involved in a range of work covering automatic test equipment, fault diagnosis and building special-to-type test equipment.

Technical Authors

Development across all our projects requires parallel expansion in our Technical Publications Group.

Experienced technical authors will find the close association with project design particularly stimulating and for engineers keen to embark on such a career this is an opportunity to train in one of the most authoritative technical writing teams in the country.

Salaries are negotiable. The Company operates a contributory pension and life assurance scheme and incoming employees will qualify for housing under the Scottish Special Housing Association scheme.

Apply in writing, quoting reference WW/1, with particulars of qualifications and experience to:

Staff Appointments Officer,
Ferranti Limited, Ferry Road,
Edinburgh EH5 2XS.

FERRANTI

ELECTRONIC TECHNICIAN II

Required for the District Works Department based at St. Mary's Hospital, Eastbourne

Qualifications — HNC Electronics or equivalent

Salary Scale — £3,558 to £4,581 p.a.

This is a newly established post offering an exceptional opportunity for the establishment of a section responsible for the maintenance of Electronic and Bio-medical Equipment within this Health District The holder of the post will be responsible to the District Engineer

Candidates should possess broad experience of electronics together with an understanding of the safety aspects of equipment in relation to both the patient and user

In addition to a sound technical background, applicants should possess the managerial qualities required to organise and supervise, both subordinate staff and contracted work and be capable of developing and maintaining successful working relationships with all levels and disciplines of hospital staff

As well as providing a day to day maintenance of equipment, the successful applicant will be required to introduce and operate a Planned Preventive Maintenance Scheme

For job description and application form, write to The District Personnel Officer, Eastbourne Health District, Avenue House, The Avenue, Eastbourne Telephone 0323 37121, ext. 21

Further details obtainable by contacting the District Works Officer, St. Mary's Hospital, Eastbourne. Telephone: 0323 20662.

Closing date: 26th April 1976.

Eastbourne HEALTH DISTRICT EAST SUSSEX AREA HEALTH AUTHORITY (5333)

Test Engineers H.F. Communications

Housing available in Berkshire

The continuing expansion of Racal Communications Equipment Limited has created vacancies for Test Engineers and Test Technicians at our Bracknell Factory.

The positions will involve the testing and auditing of a wide range of sophisticated H.F. Communication equipment, including the assessment of new products.

The Company will be prepared to sponsor eligible candidates for housing with the Bracknell Development Corporation.

We offer excellent terms and conditions, generous holiday entitlement, pension scheme and sick pay entitlement.

If you are interested then:

Communicate with Racal

Please write or telephone for an application form to:

Mr. A. J. Franklin, Personnel Manager,
Racal Communications Equipment Limited,
Western Road, Bracknell, Berkshire RG12 1RG
Telephone: Bracknell 3244 Ext. 44

(5301)

RACAL The Electronics Group

Opportunities for Electronics Engineers

To change to wider fields of electronics – join the EMI Service Team at Hayes.

Vacancies exist on repair and calibration of a wide range of electronic test gear including oscilloscopes, DVMs, pulse generators, power supplies etc

Also

Servicing and commissioning closed circuit television equipment including cameras, VTRs. Monitors etc

Applicants should have at least 5 years practical experience

These positions offer varied and interesting work Attractive starting salaries, subsidised lunches, 4 weeks holiday and excellent sick pay and pension schemes

For further details telephone or write to M Ford 01 573 3888 Ext 2167. EMI Service, 254 Blyth Road, Hayes, Middlesex

EMI

The international music, electronics and leisure Group (5320)

North Midland Co-operative Society Ltd.

require

SENIOR AUDIO ENGINEER

A grand opportunity for a suitable, capable engineer to co-ordinate the activities of our Audio service department, which undertake the wide service aspect across the consumer spectrum.

The person appointed will be directly responsible to the Group Service Manager, and would not normally be expected to work on television or other equipment, but will be capable of dealing with customer inquiries and complaints.

The initial wage rate is £58 per week, and accommodation may be available on rental.

We are situated at the county border of Staffordshire, Cheshire and Derbyshire, which is a very attractive residential environment.

If you desire a change with opportunities, and wish to join an organisation with sales in excess of £34 million per year, apply in the first instance giving details of career to date by letter to the:

Personnel Officer
10 Newcastle Street
Burslem
Stoke-on-Trent
ST6 3QG

COMMUNICATIONS TECHNICIAN

£4005-£4275 (inclusive) Reigate

For the Surrey Fire Brigade. To be responsible for Planning, Repair and Maintenance and general administration of the Brigade's Communications Systems comprising VHF/UHF Radio Scheme, Electronic Visual data Transmission System, Call-out Systems at Fire Stations, telephone and teleprinter networks, pocket radio alerter system for part-time Retained Firemen.

Will undertake the maintenance and repair of radio equipment and therefore must be an experienced practical engineer. 36½-hour, 5-day week.

Application form and Job Description from the Brigade Personnel Officer, Surrey Fire Brigade Headquarters, St. David's, 70 Wray Park Road, Reigate, Surrey RH2 0EJ. Closing date: 12 April, 1976.

SURREY COUNTY COUNCIL

(5340)

T.V. ENGINEERS FOR NEW ZEALAND

Due to the rapid development of colour T.V. and the introduction of a second channel, we are in need of experienced T.V. servicemen. Who are we? N.Z.'s largest T.V. service company with over 30 branches and a staff of approximately 350.

Single Men: 2 Year Contract — Return Fares Guaranteed.

Married Men: Subsidy provided to cover major part of air fares.

Interested? Then write now enclosing a recent photograph, details of past experience and any qualifications to the Technical Staff Supervisor, Tisco Ltd., Private Bag, Royal Oak, Auckland, NEW ZEALAND.

(5263)

POWER SEMICONDUCTOR SALES OPPORTUNITIES

International Rectifier is a market-leader in power semiconductors, and need two people for their sales organisation, who match these job specifications.

1. TECHNICAL SALES ASSISTANT/ JUNIOR INTERNAL SALES ENGINEER

A young person (20-25 years) with experience in a technical selling position (ideally in an electrical or electronics company) is required who can liaise with our customers both by telephone and written quotation, and generally assist our internal sales staff in promoting our product range. A technical qualification would be a distinct advantage and promotion to Product Sales Engineer or Field Sales Engineer should be the ultimate aim of the successful applicant.

2. PRODUCT SALES ENGINEER

TRANSISTORS/CONSUMER PRODUCTS

A qualified engineer (HNC electrical/electronics) aged about 25-35 years, with a commercial bias is required to be responsible to our Product Sales Manager, specifically for technical sales of high voltage TV diodes and other consumer products, and possibly for power and Darlington transistors. Experience in design and/or sales of these particular products is naturally preferred. Customer visits throughout U.K. (and possibly into Europe) will be involved.

If you feel you may fit into our organisation, and can convince us, write to or telephone our Personnel Manager — Ron Sutton — or Doug Daniel — General Sales Manager.

(5349)

INTERNATIONAL RECTIFIER IOR

Hurst Green, Oxted, Surrey. Tel: Oxted 3215

YOUNG ELECTRONICS LTD.

We are a manufacturer of lighting control systems and signal detection equipment, and are looking for a

WIREMAN-TESTER

(male or female) for the construction, testing and servicing of the equipment at our works in N.W.1. Very varied work. Qualifications ONC or C&G or ex-apprentice (electronics or mechanical) or similar desirable. A wide practical experience is essential involving both electronics and mechanical work. We are a small expanding company and will offer a good salary to the right person.

Please write for an application form to—Young Electronics Ltd. 184 Royal College St. London NW1 9NN

(5238)

UNIVERSITY OF SUSSEX SCHOOL OF MOLECULAR SCIENCES

ELECTRONICS SENIOR TECHNICIAN

(Male/Female)

Grade 5 Senior Technician required, from 1st May for four years on a grant supported by the Medical Research Council for construction maintenance and operation of advanced electronics equipment used by the MRC for research on metalloenzymes.

HNC or equivalent required together with at least five years experience.

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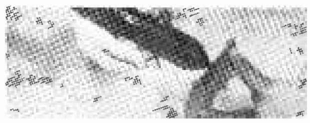

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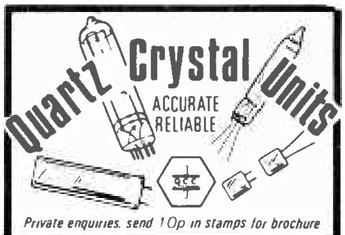

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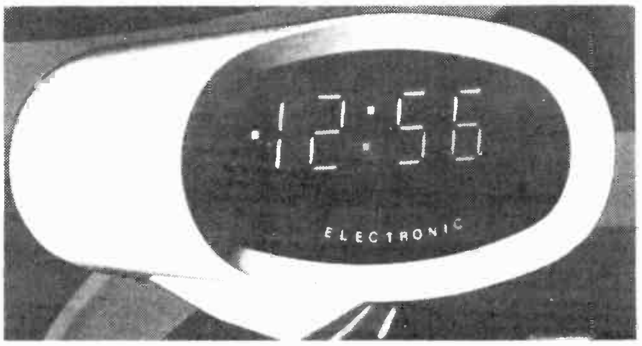

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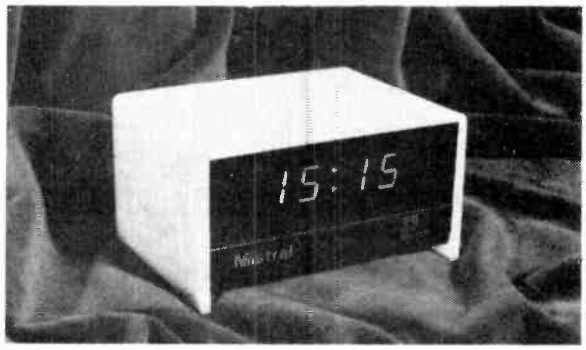

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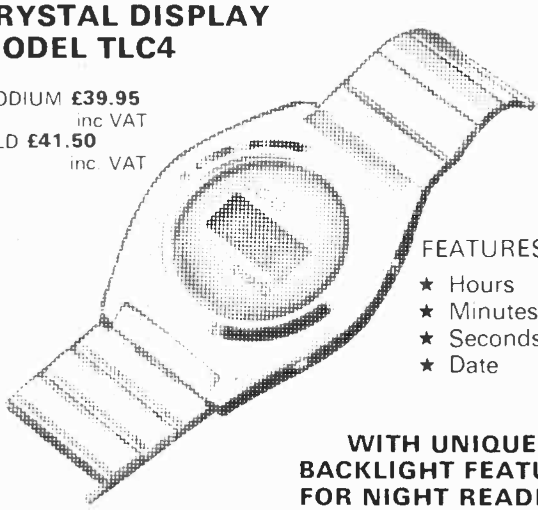

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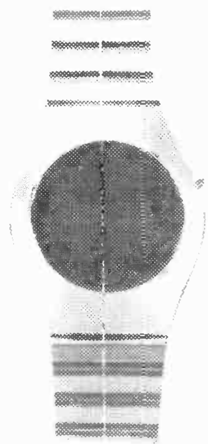

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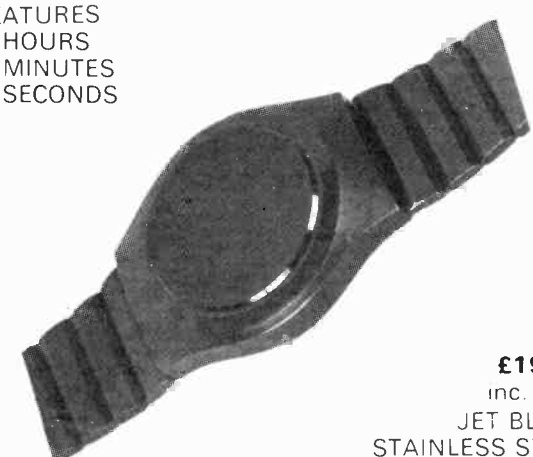

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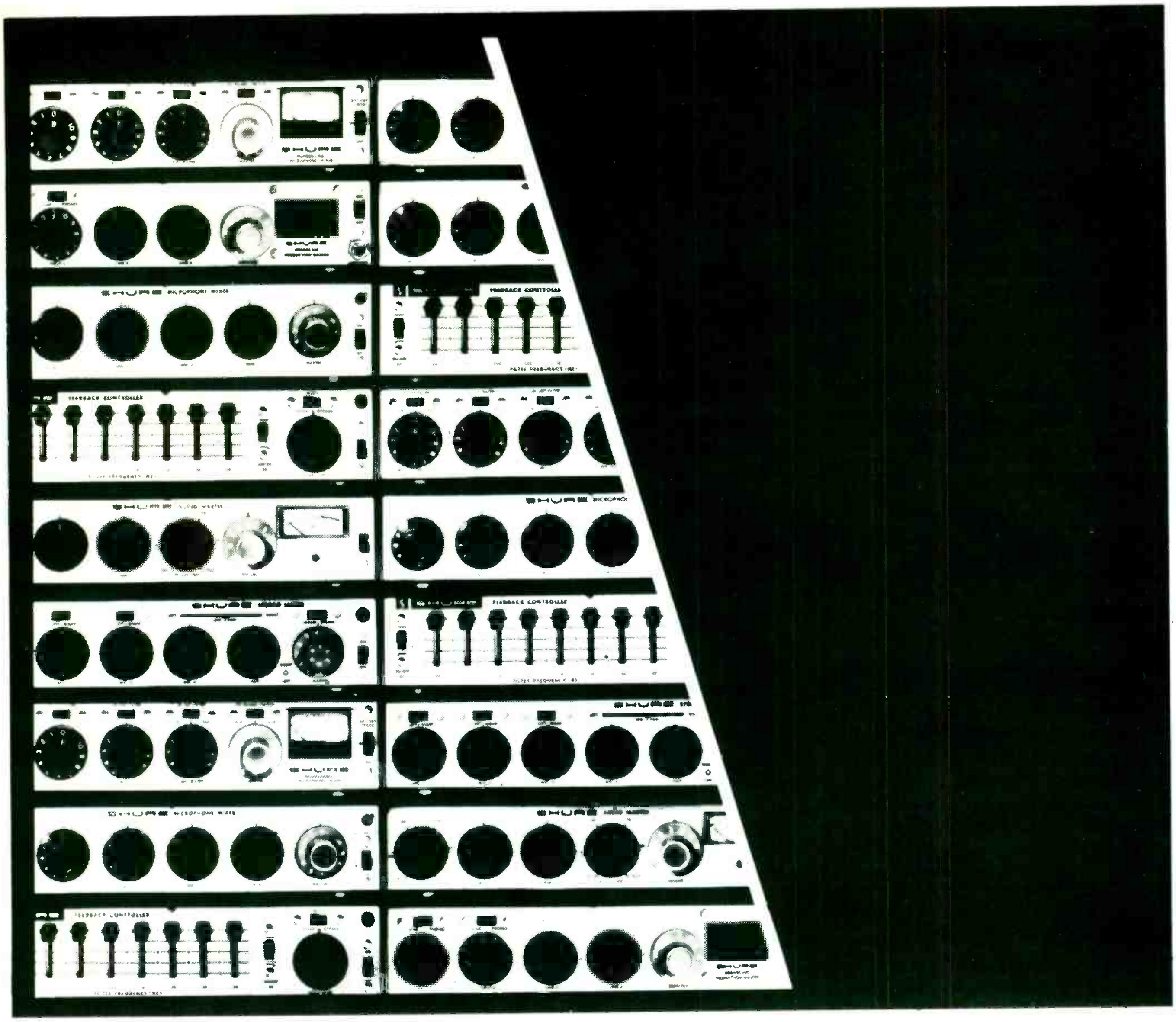

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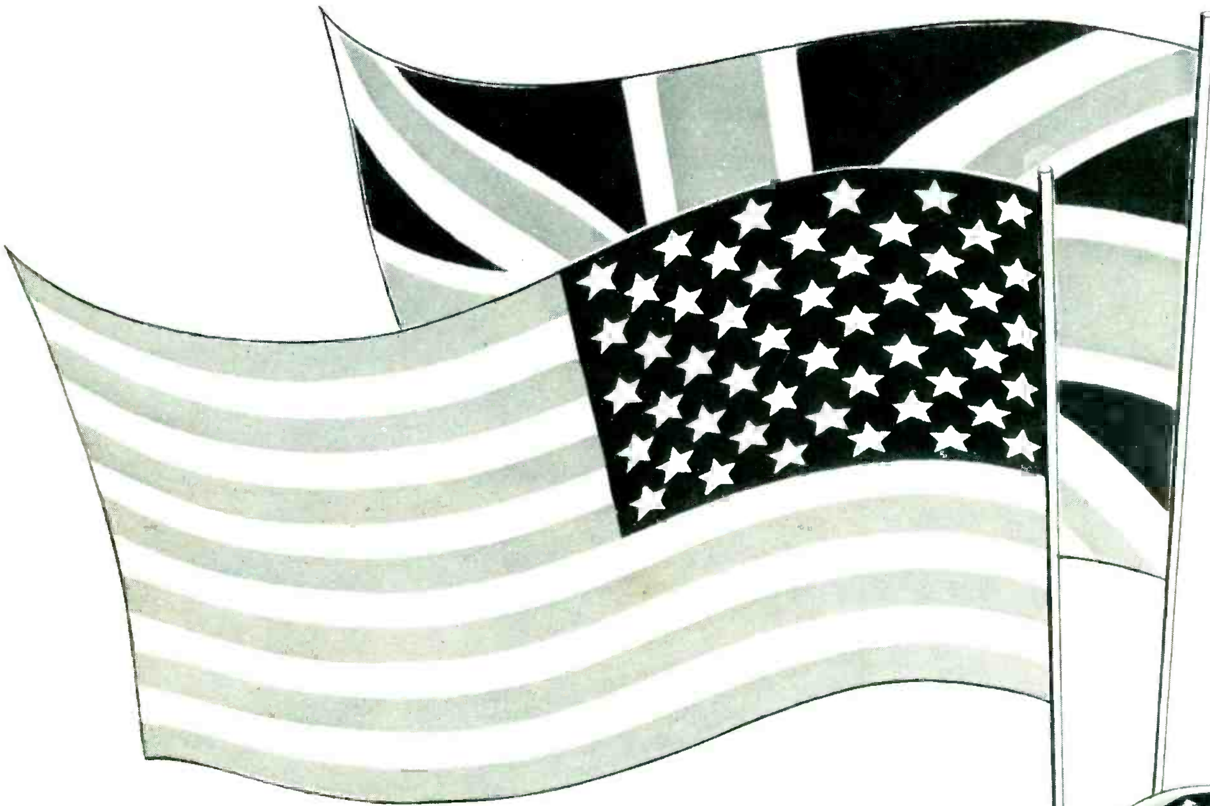

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