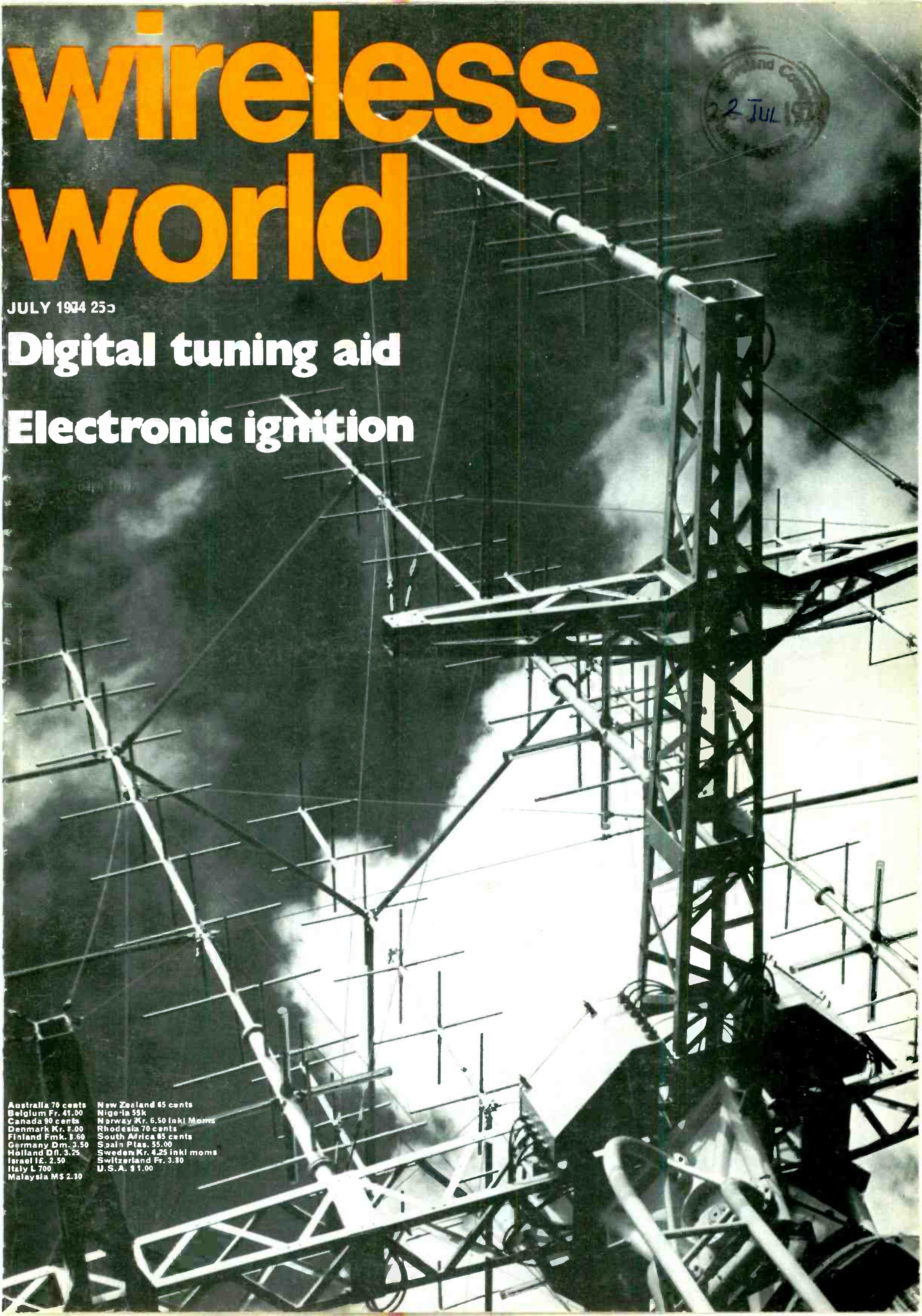
wireless world

JULY 1974 25p

Digital tuning aid

Electronic ignition



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From millions of hours operating experience come four NEW Plumbicon* Camera Tubes.

Just because over 80% of the world's colour TV cameras use our Plumbicon Camera Tubes, doesn't mean that we can rest on our laurels. At Mullard, experience has taught us to anticipate your needs: to keep that extra step ahead. Hence we now offer you four NEW 25mm Plumbicon Tubes (XQ1083 to 1086); that's in addition to a range already 16 strong. The most advanced 25mm camera tubes available anywhere in the world, they feature the anti-comet-tail gun, enhanced red response, anti-halation discs and low output capacitance producing improved signal to noise performance. They also incorporate a light biassing system for reduced lag.

Behind Mullard's capability

Mullard's background in electron optics is based on a thorough understanding of vacuum and glass technologies. At Mitcham, part of Europe's biggest Electron-optics capability—complete with its own fibre optic drawing plant, we make night vision and low light level TV devices. Years of experience in the design and manufacture of image intensifiers and other electron optical devices has resulted in a capability well geared to today's and tomorrow's requirements. Whether your need is for high volume standard devices, or custom-built specials, Mullard have the experience and the resources to meet it.

For full details about Plumbicon and other camera tubes, contact:

Mullard Limited, Mullard House, Torrington Place, London WC1E 7HD.

*registered trade mark for Television Camera Tubes

Mullard components for communications

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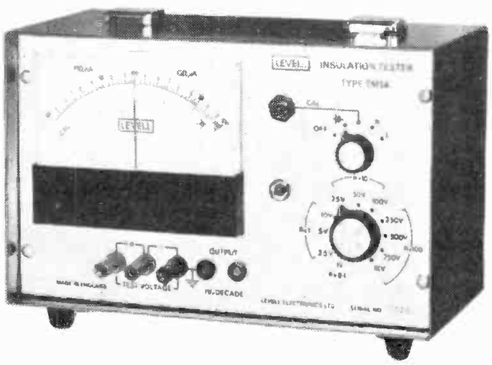
M 82

LOW COST TESTERS

LEVELL

PORTABLE INSTRUMENTS

INSULATION TESTER



A logarithmic scale covering 6 decades is used to display either insulation resistance or leakage current at a fixed stabilised test voltage. The current available is limited to a maximum value of 3mA for safety and capacitors are automatically discharged when the instrument is switched off or to the CAL condition. The instrument operates from a 9V internal battery.

RESISTANCE RANGES

10M Ω to 10T Ω (10^{13} Ω) at 250V, 500V, 750V and 1kV.
1M Ω to 1T Ω at 25V, 50V and 100V.
100k Ω to 100G Ω at 2.5V, 5V and 10V.
10k Ω to 10G Ω at 1V.
Accuracy ±15% +800 Ω on 6 decade logarithmic scale.
Accuracy of test voltages ±3% ±50mV at scale centre.
Fall of test voltages < 2% at 10µA and < 20% at 100µA.
Short circuit current between 500µA and 3mA.

CURRENT RANGE

100pA to 100µA on 6 decade logarithmic scale.
Accuracy of current measurement ±15% of indicated value.
Input voltage drop is approximately 20mV at 100pA, 200mV at 100nA and 400mV at 100µA.
Maximum safe continuous overload is 50mA.

MEASUREMENT TIME

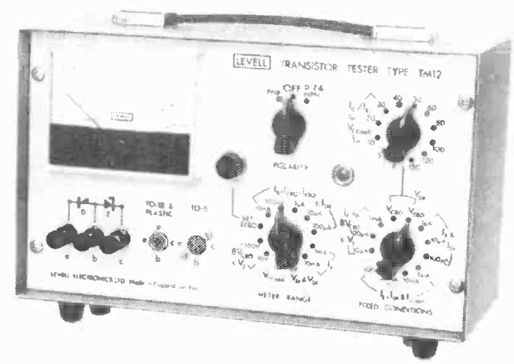
< 3s for resistance on all ranges relative to CAL position.
< 10s for resistance of 10G Ω across 1µF on 50V to 500V.
Discharge time to 1% is 0.1s per µF on CAL position.

RECORDER OUTPUT

1V per decade ±2% with zero output at scale centre.
Maximum output ±3V. Output resistance 1k Ω.

type TM14 **£77**

TRANSISTOR TESTER



Tests bipolar transistors, diodes and zener diodes. Measures leakage down to 0.5 nA at 2V to 150V. Current gains are checked from 1µA to 100mA. Breakdown voltages up to 100V are measured at 10µA, 100µA and 1mA. Collector to emitter saturation voltage is measured at 1mA, 10mA, 30mA and 100mA for I_C/I_B ratios of 10, 20, 30. The instrument is powered by a 9V battery.

TRANSISTOR RANGES (PNP OR NPN)

I_{CBO} & I_{EBO}:	10nA, 100nA, 1µA, 10µA and 100µA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10µA with fall at 100µA < 5%+250mV.
BV_{CBO}:	10V or 100V f.s.d. acc ±2% f.s.d. ±1% at currents of 10µA, 100µA and 1mA ±20%.
I_B:	10nA, 100nA, 1µA . . . 10mA f.s.d. acc. ±2% f.s.d. ±1% at fixed I_E of 1µA, 10µA, 100µA, 1mA, 10mA, 30mA, and 100mA acc. ±1%.
h_{FE}:	3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert I_B into h_{FE} readings.
V_{BE}:	1V f.s.d. acc. ±20mV measured at conditions on h_{FE} test.
$V_{CE(sat)}$:	1V f.s.d. acc. ±20mV at collector currents of 1mA, 10mA, 30mA and 100mA with I_C/I_B selected at 10, 20 or 30 acc. ±20%.

DIODE & ZENER DIODE RANGES

I_{DR}:	As I_{EBO} transistor ranges.
V_Z:	Breakdown ranges as BV_{CBO} for transistors.
V_{DF}:	1V f.s.d. acc. ±20mV at I_{DF} of 1µA, 10µA, 100µA, 1mA, 10mA, 30mA and 100mA.

type TM12 **£77**

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WW—005 FOR FURTHER DETAILS

The one you can't ignore!

Our picture illustrates some of the U-type JVC VCR features. They are not the only ones that matter.

For instance. You can use any colour or monochrome receiver or monitor to view your recordings. Automatically repeat or return to a scene of interest. And the picture is always locked in colour before it is displayed.

Such excellent features, in fact, that you ought not to buy a video cassette recorder until you've seen the complete specification of the JVC machine. **And it is available now.**

In addition to the CR 6000E $\frac{3}{4}$" U-type recorder/player there is the CR 5000E for playback only. CR 6000E, price from £749 ; CR 5000E, from £664 (prices exclude VAT).

We'd like to tell you more. Telephone Bell & Howell's Video Systems Division on 01-902 8812 or write to Bell & Howell A-V Ltd., Freepost, Wembley, Middlesex, HA0 1BR (no stamp required).

BELL & HOWELL **JVC U VCR**

WW—008 FOR FURTHER DETAILS

WW—009 FOR FURTHER DETAILS

The Greenwood guide to professional soldering.

Greenwood Electronics offer a range of highly advanced products specifically for professional soldering applications.
For more detailed information about the comprehensive Greenwood range, contact the address below.

1. The Iso-Tip. A safe, high-power iron which works anywhere without a mains lead. The breakthrough? Nickel Cadmium cells that are re-chargeable. (A charging stand is included for 240v or 115v A.C.) Each charge gives at least 60 soldering joints. Weight? Only 6 oz. Price: £10.95 & VAT.

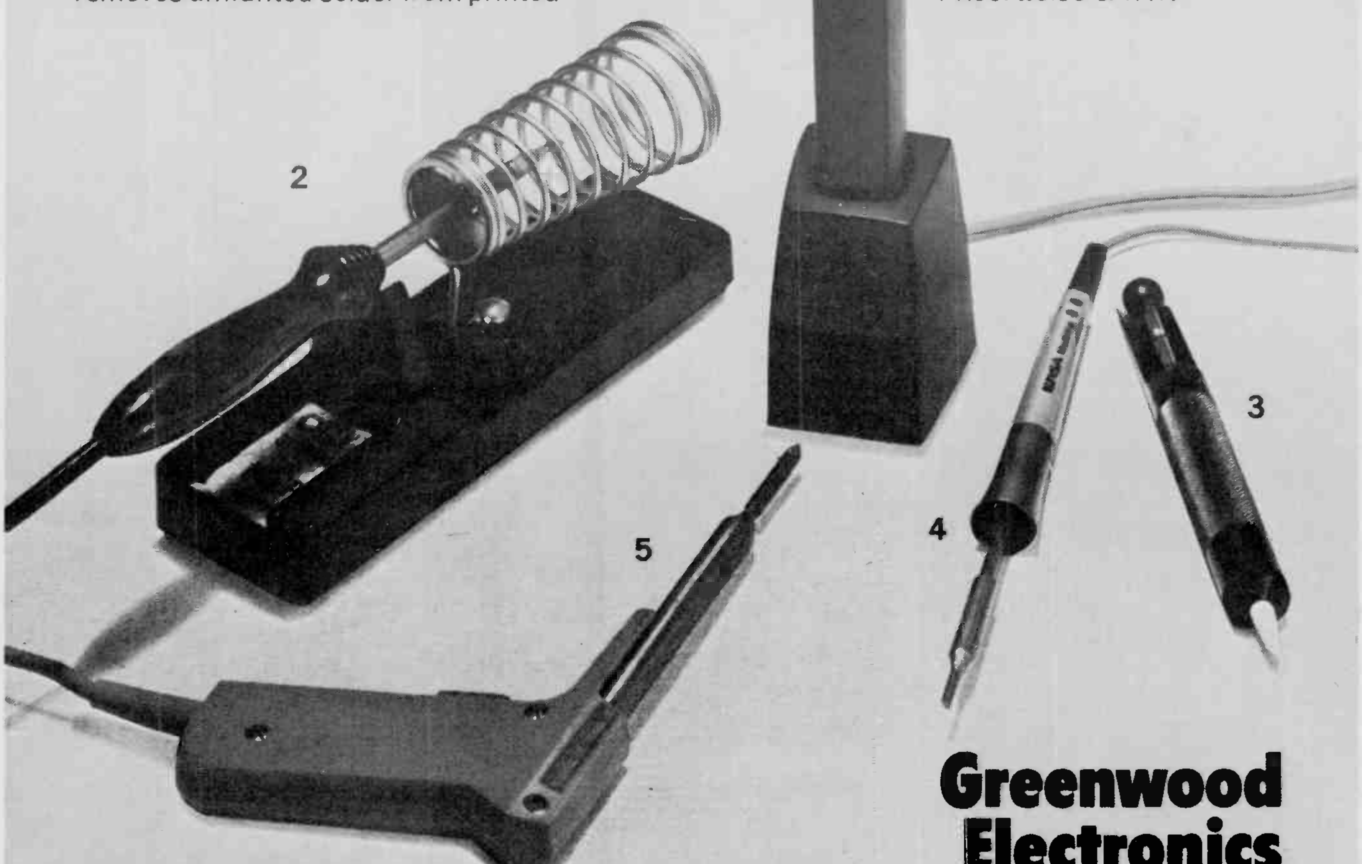
2. The Oryx 50. A temperature controlled mains soldering iron. (Temperature control within ± 2%). Adjustment (200° - 400°C) can be made whilst iron is operating, using the same tip. Light, compact, and easy to handle. A large 50W element loading gives rapid heating and high performance with constant tip temperature.
Price: £5.90 & VAT. Also available: Oryx safety stand: £2.10 & VAT.

3. Oryx SR3A desoldering tool. Ideal where components are tightly grouped. Instantly removes unwanted solder from printed circuits etc. Accurate, reliable, speedy, and safe. Price: £4.50 & VAT.

4. The Ersa Multitip. A top-quality iron that's ultra-light offering reliability so necessary to achieve constant production flow. A range of different shaped tips simply push onto the stem of the iron. It has the unique advantage that you can change the element in seconds.
Price: £3.52 & VAT.

5. The Ersa Sprint. Unique – it heats up to maximum temperature in only 10 seconds, and is the lightest gun on the UK market. Ideal for the service-man. With its light weight (only 7 oz.) and compact construction, it can be manoeuvred in even the most awkward areas.
Price: £6.55 & VAT.

1



Greenwood Electronics

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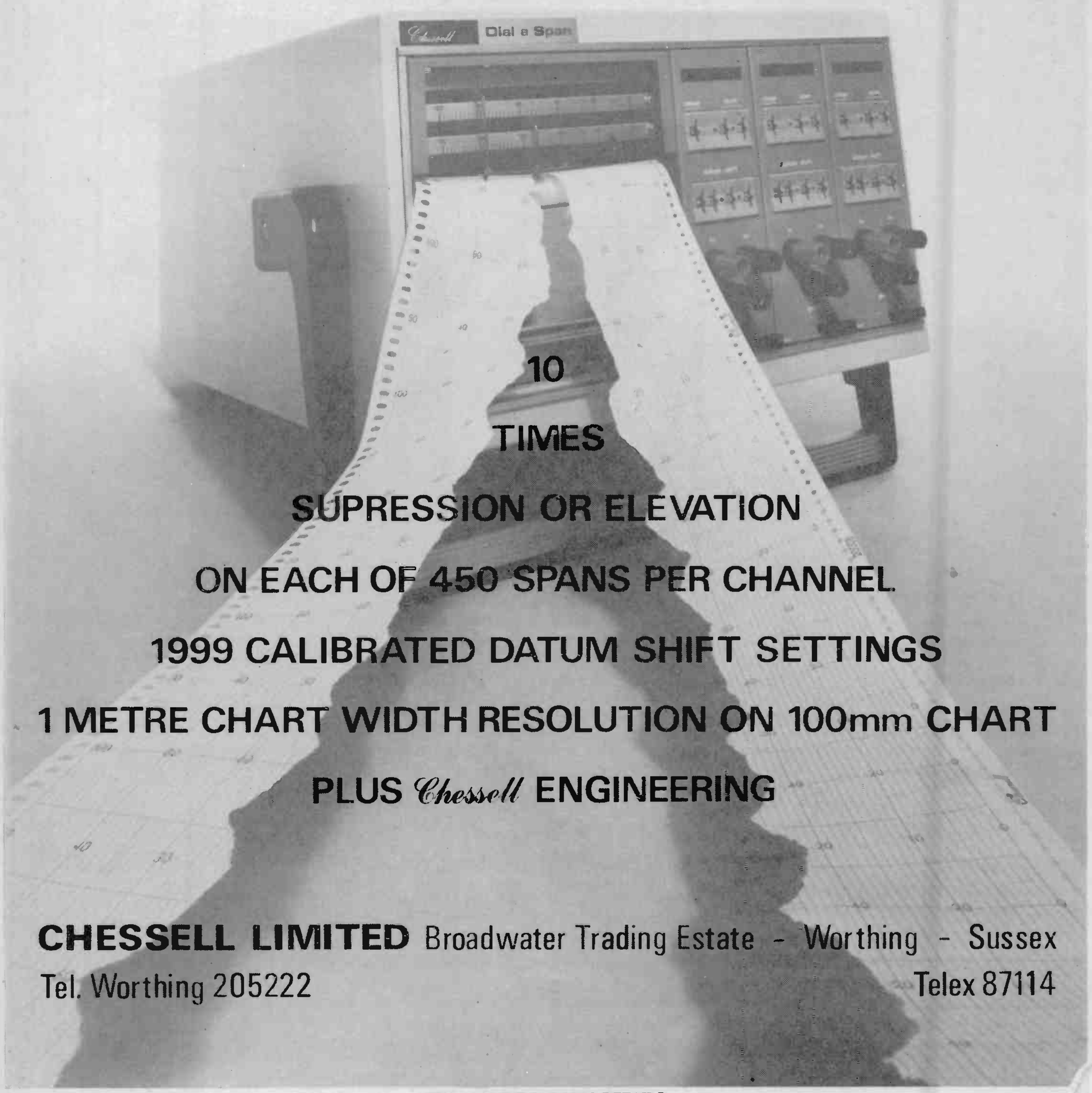
WW—010 FOR FURTHER DETAILS

TWO WAY STRETCH *by Chessell*

DIAL-A-SPAN PROVIDES THE BREAKTHROUGH IN THREE-CHANNEL PEN RECORDER FLEXIBILITY



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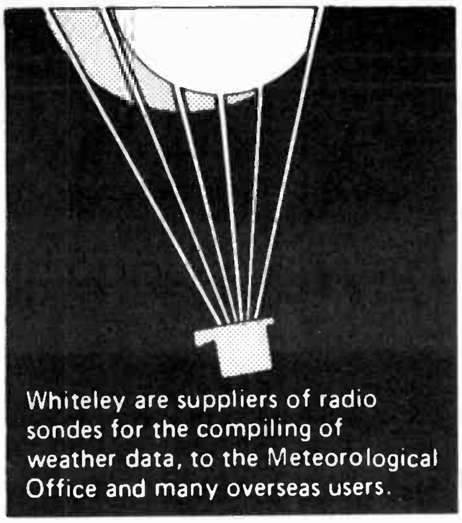

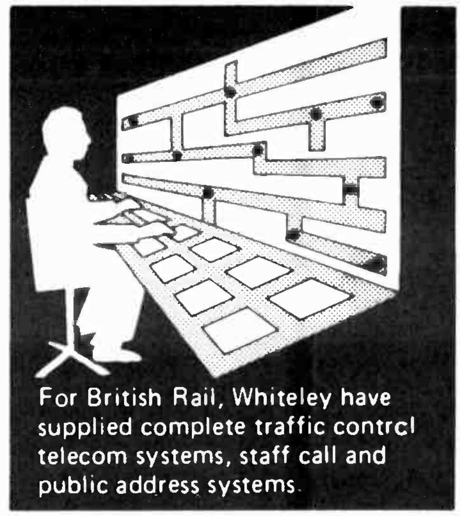

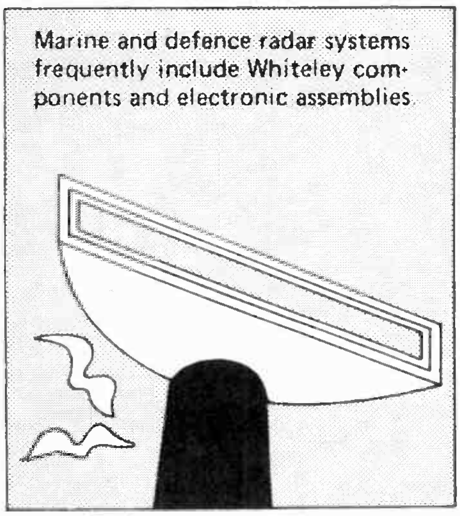

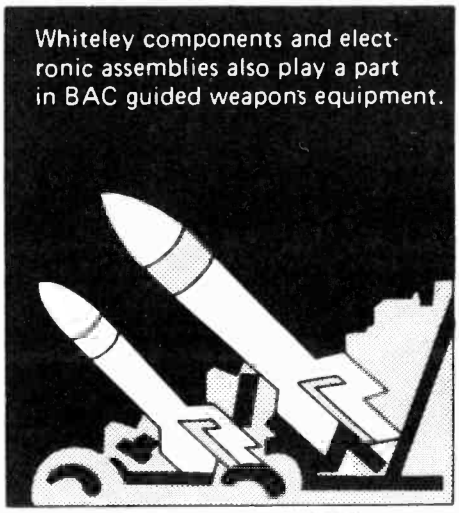

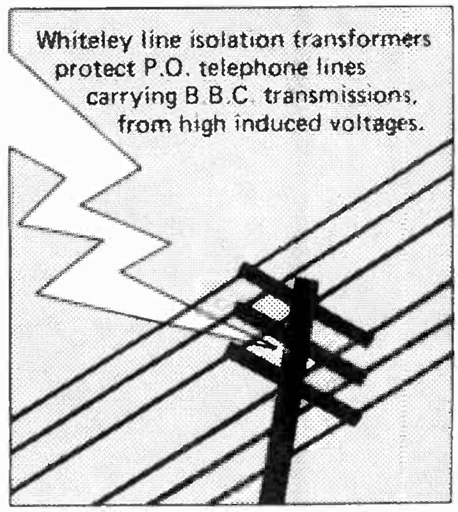

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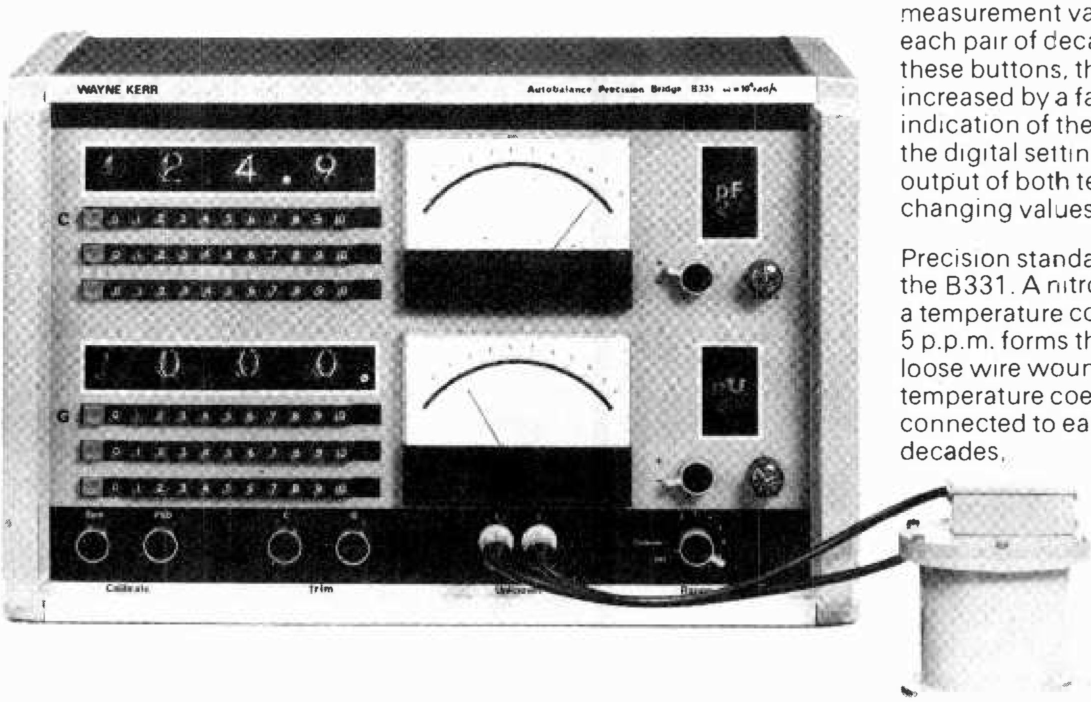
WW—015 FOR FURTHER DETAILS

Six figures in six seconds

A precision bridge that balances itself

the Wayne Kerr B331



This bridge was designed for use in Standards Laboratories, but ease of operation combined with an in-line readout giving up to 6 figure discrimination has enabled many other applications to be covered.

The B331 measures directly a wide range of capacitance and conductance values to 0·01% accuracy. The three terminal facility enables small values of capacitance and high values of resistance to be measured at the end of long cables.

Automatic compensation for the series impedance of the measurement leads is given by an advanced design of Kelvin clip, and a low impedance range directly calibrated in resistance and inductance permits four terminal measurements to be made.

Up to four significant figures can be set on each measurement term with push buttons.

The bridge automatically balances itself, the meters indicating the remainder of the measurement value on linear scales. As each pair of decades is introduced with these buttons, the meter sensitivity is increased by a factor of 10 giving an indication of the next figures required in the digital setting sequence. Analog output of both terms permit recording of changing values.

Precision standards are incorporated in the B331. A nitrogen filled capacitor with a temperature coefficient of less than 5 p.p.m. forms the reactive standard and loose wire wound resistors with temperature coefficients of 5 p.p.m. are connected to each set of conductance decades.

SPECIFICATION

Range (for 0·01% accuracy)	1pF to 10μF 10n℧ to 100m℧
derived reciprocal values	1mH to 10kH 10Ω to 100MΩ
Low Impedance Range	100μΩ to 10Ω 10nH to 1mH
derived reciprocal values	10μF to 1F
Frequency	(internal) 1591·55 Hz ±0·5 Hz (1000.00 Hz to special order) (external) 200Hz to 20kHz

For more information, either Telephone Bognor Regis (02433) 25811 or write to the address below:

WAYNE KERR

Durban Road, Bognor Regis, Sussex PO22 9RL.
Telex:36120.

A member of the Wilmot Breeden group

WW—016 FOR FURTHER DETAILS

From Goldring. New support for the belief that what goes into a record ought to come out of it.

The Theory is perfectly simple.

A good cartridge should take from a record all the subtle shades of original sound that are stored there, and re-create them for your enjoyment.

The Practice is a little more difficult.

Now Goldring bring the ideal closer with the new 820 series.

A brand new family of cartridges that builds on the advances already achieved by the Goldring 800 series. Providing cartridges that are not only capable of making the most of all that good recording can offer now, but have the capacity to keep pace with new developments in the art of quality recordings.

The 820 series retains the true transparency of sound and the true transduction techniques of earlier designs.

It brings advances in every aspect of design.

The small low-mass diamond point which is mounted on a new type of specially polished lightweight aluminium tube, combined with the new visco-elastic material used for the pivot pad, makes for greater tracking ability.

A special 'tie wire' minimises fore and aft stylus movement, reducing non-linear distortion to a minimum.

The total effect is a cartridge that, other equipment being equal, can narrow almost to vanishing point the difference between the original recording and the sound that comes out of your speakers.

There are three models in the range. The 820 with spherical stylus. The 820E and 820 Super E, both with bi-radial styli. Write for details and full specifications.

And satisfy yourself that 'what goes in comes out'.

The 820 – one of the models in the new range.
Performance characteristics:
Sensitivity @ 5 cm/sec-1 Khz:5mV.
Separation @ 1 Khz:20dB.
Recommended playing wt. 2 grammes.
Stylus point radius: ·0006" 15μ.
Frequency range: 20hz-20Khz.

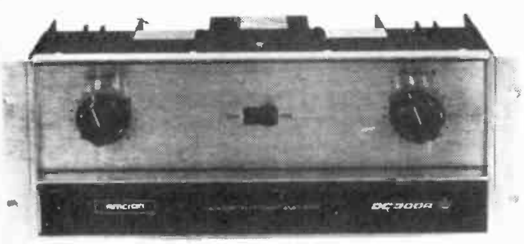
The new 820 series

The expert's cartridge by **Goldring**

Goldring Limited, 10 Bayford Street, Hackney, London E8 3SE. Tel: 01-985 1152

WW—017 FOR FURTHER DETAILS

HIGH POWER DC-COUPLED AMPLIFIER



- ★ UP TO 500 WATTS RMS FROM ONE CHANNEL
- ★ DC-COUPLED THROUGHOUT
- ★ OPERATES INTO LOADS AS LOW AS 1 OHM
- ★ FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.
- ★ 3 YEAR WARRANTY ON PARTS AND LABOUR

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz. The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

Power Bandwidth	DC-20kHz @ 150 watts + 1db. – 0db.	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0, –15° DC to 20kHz, 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V, 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9¾" Deep

Other models in the range: D60 — 60 watts per channel D150 — 150 watts per channel

MACINNES LABORATORIES LTD

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WW—018 FOR FURTHER DETAILS

WW—019 FOR FURTHER DETAILS

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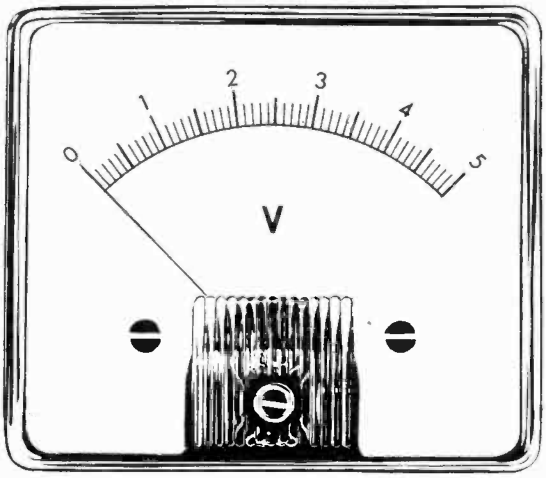
METER PROBLEMS?



A very wide range of modern design instruments is available for 10/14 days' delivery.

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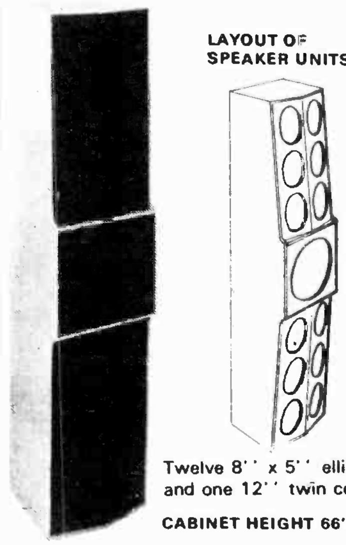
DAVENPORT

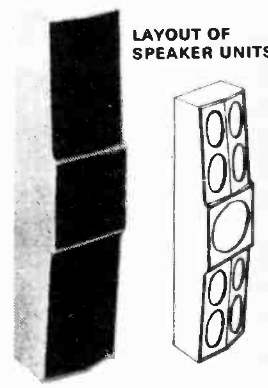
New

FULLRANGE LINE SOURCE PUBLIC ADDRESS SPEAKERS



Twelve 8'' x 5'' elliptical and one 12'' twin cone

CABINET HEIGHT 66''



Eight 8'' x 5'' elliptical and one 10'' twin cone

CABINET HEIGHT 48''

A BROCHURE GIVING FULL SPECIFICATION, INCLUDING SPECIFIC SOUND PRESSURE LEVELS, FREQUENCY RESPONSE GRAPHS AND POLAR DIAGRAMS. AVAILABLE FROM THE MANUFACTURERS.

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TELEPHONE FARNBOROUGH (HANTS) 514551

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Five RCA VOM's priced from £8.00 to*£32.50

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*Excluding V.A.T.

RCA
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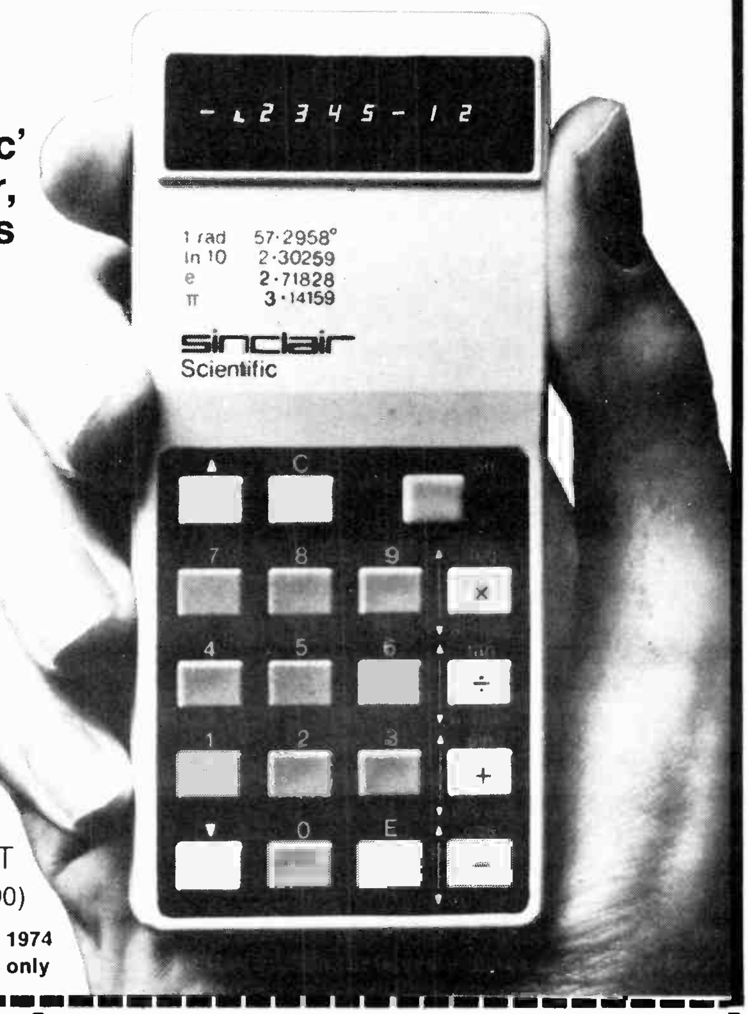
WW—028 FOR FURTHER DETAILS

SAVE £8.90! A Wireless World special offer



'Sinclair Scientific' pocket calculator, exactly the same as advertised on pages 40 and 41.

Logs, trig, arithmetic – at a price that makes sense!

The new 'Sinclair Scientific' pocket calculator is a 12-function machine designed to meet the primary requirements of engineers in industry and research fields, physicists, statisticians and advanced science students. For full details of this remarkable calculator please refer to the Sinclair advertisement on pages 40 and 41. Then use the coupon on this page to order yours at the special price available to readers of Wireless World.

£45 including VAT
(normal price £53.90)

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Offer applies to UK and USA readers only

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375 Park Avenue New York NY 10022

Please send me .... Sinclair Scientific calculators at the special offer price of $99.00 each (Add on your own local sales tax, where applicable). I enclose cheque value .... payable to Sinclair Radionics.

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- AK 156 Loudspeaker
- H.F. Horn
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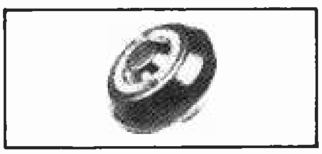
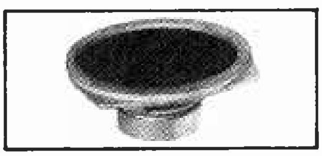
The matchless range -now better than ever . . .

Giving You . . .

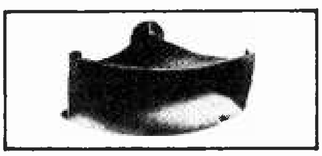
S — Sensitivity



P — Power



E — Efficiency



C — Craftsmanship

VITAVOX Limited
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London NW9 9RJ
Telephone: 01-204 4234

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WW—035 FOR FURTHER DETAILS

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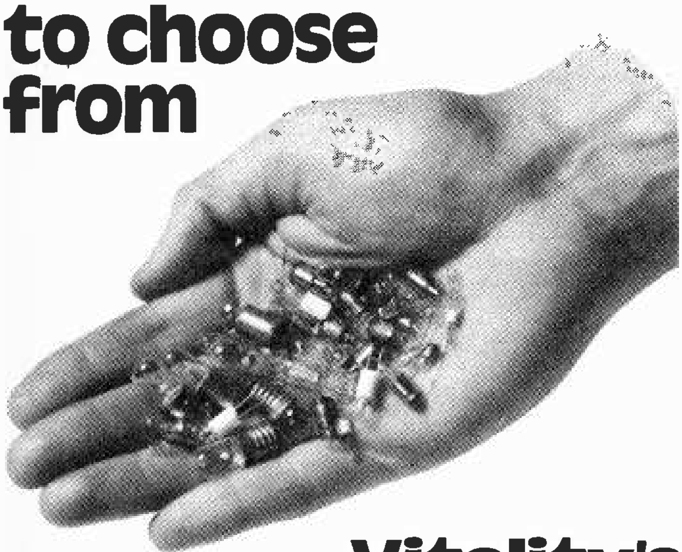

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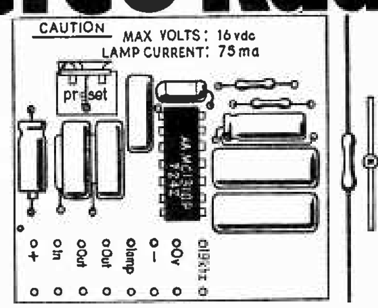

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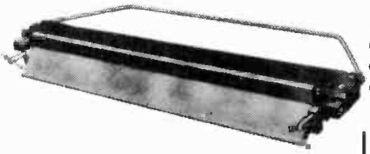

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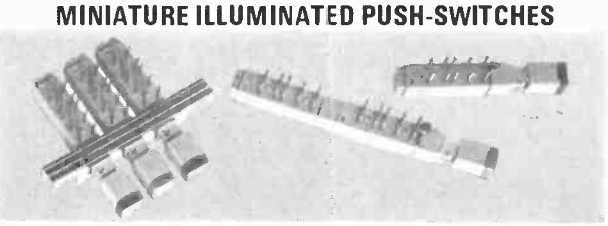

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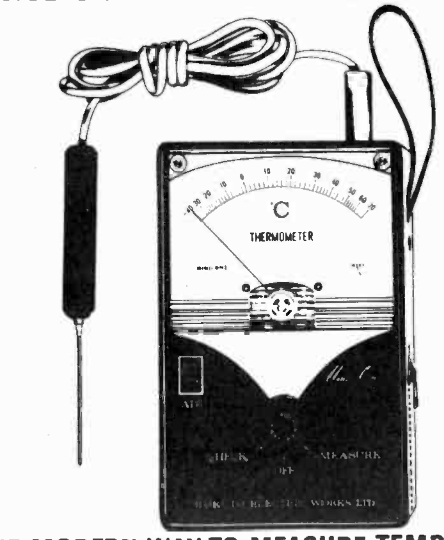

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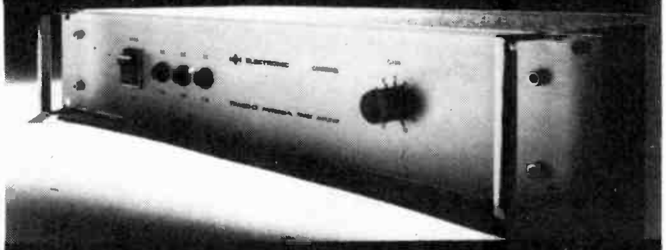
TPA SERIES – D
integrated circuit power amplifier



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
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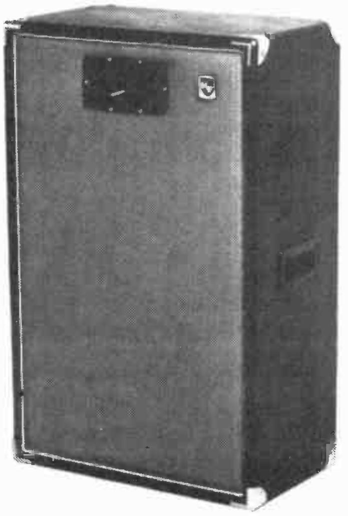

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LAP81

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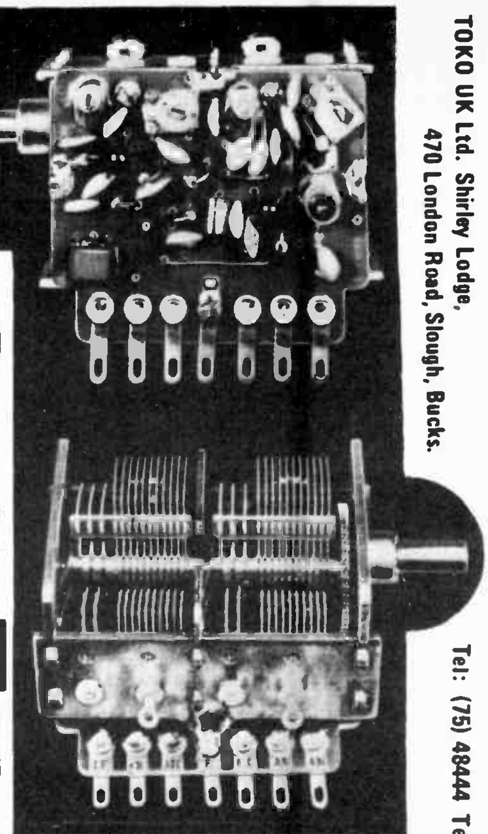
TOKO new low cost AM/FM TUNER



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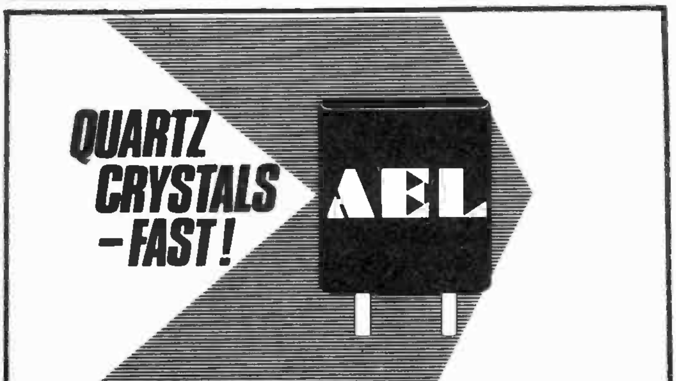

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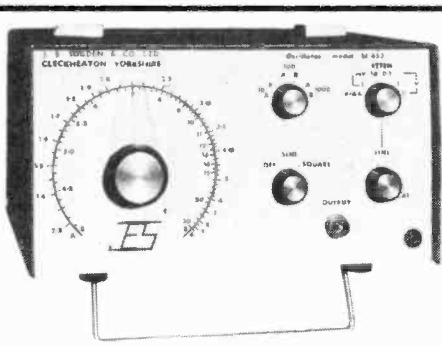

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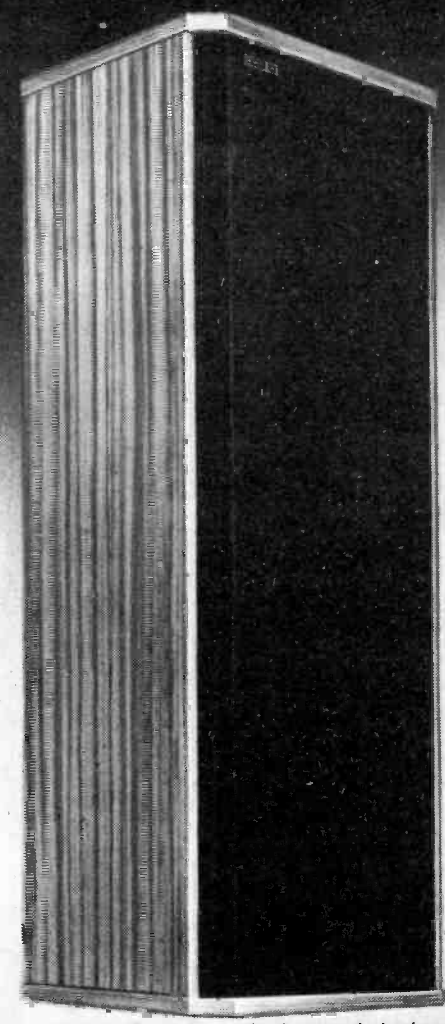

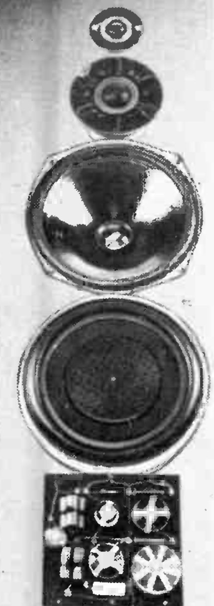

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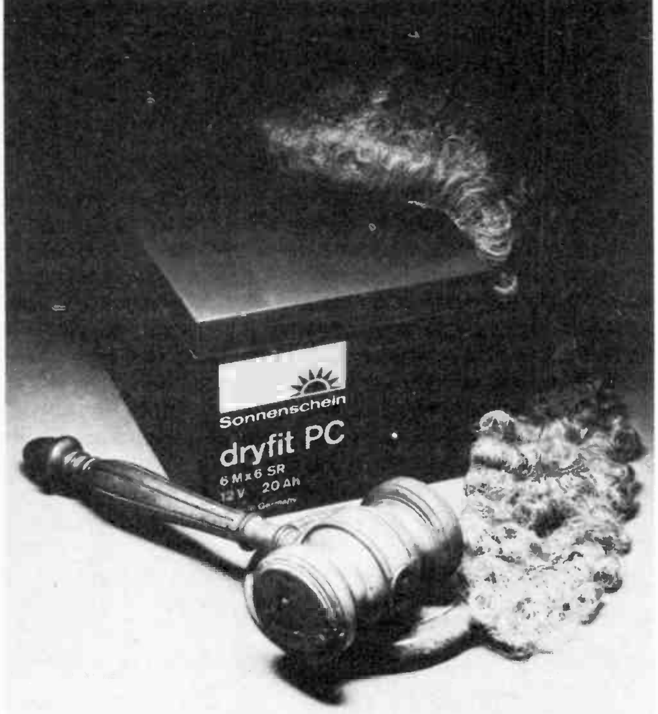

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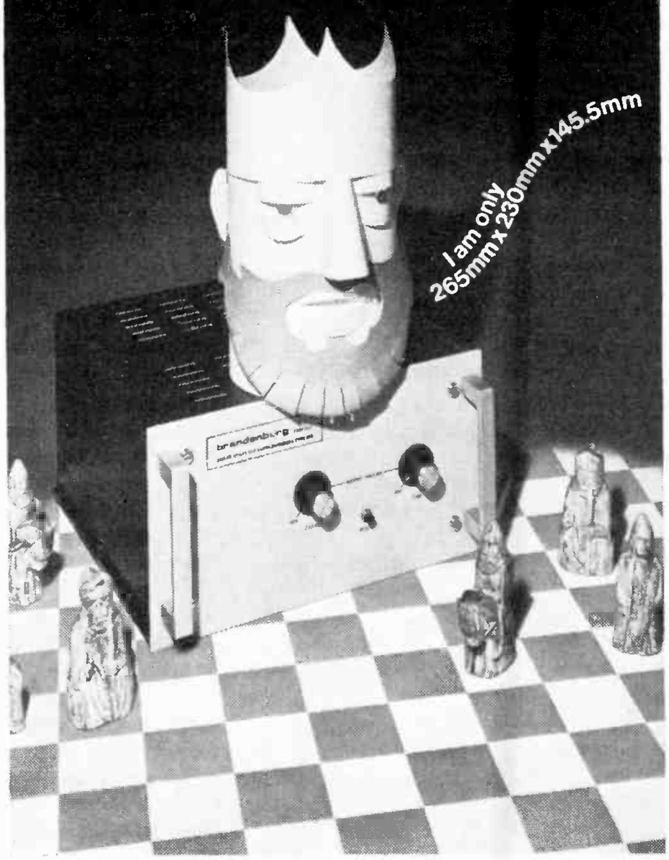

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JULY 1974 Vol 80 No 1463

SIXTY-FOURTH YEAR OF PUBLICATION

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4CX1500B	4CX1500B	1.5	2.7	3.0	30	6.0	9.0
4CX5000A CV8295	4CX5000A	5.0	16	7.5	30/110	7.5	75
4CX10,000D CV6184	4CX10,000D	10	16	7.5	30/110	7.5	75
4CX15,000A	4CX15,000A	15	36.5	10	110	6.3	160
4CX35,000C CV11107	4CX35,000C	35	82	20	30	10	300
CV9343 RS726	BR1161	35	100	14	10/30	11	155
Theirs	**Ours**	**Anode dissipation max. (kW)**	**Output power (kW)**	**Anode voltage max. (kW)**	**Frequency (MHz)**	**Filament ratings (V)**	**Filament ratings (A)**
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YD1202	BW1184	80	120	14.4	30	12.2	255
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LAP83

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Personal data

It's sometimes suggested that the most important thing to know about a girl is certain personal statistics such as 36-24-34 (British girls are not yet fully SI), but it might also be important in special circumstances to know her telephone number, paging code, employee number, map reference or other identification data. It is now technically possible for individual workers such as policemen to transmit such data back to base by personal hand-held radio sets fitted with data input switches. In another context it is technically possible for private citizens at home to receive data of personal interest on their television sets by means of the CEEFAX/ORACLE type of system. It is all technically possible but we don't yet know whether it is really wanted.

With modern technology, invention seems to be the mother of necessity. There are engineering advantages in being able to send data over existing systems such as domestic TV or mobile radio, and the engineer therefore feels that the public ought to be able to think up ways of using these advantages. The wide bandwidth and inherent redundancy of the television signal allow binary pulses to be inserted into the field blanking period of the transmitted video waveform; with mobile radio, signalling tones occupying only a few hertz of bandwidth can be slotted into a speech channel without difficulty. At the transmitting end alpha-numerical data may be assembled at any speed suitable to the user, stored and transmitted at a speed suitable to the system. At the receiving end the data may again be stored to await the requirements of a visual display unit, TV set or other form of read-out. The whole thing can be designed for economical utilization of time, space, power and bandwidth according to the principles of communication theory.

In one sense these techniques might seem retrogressive. What is data communications, after all, but the 19th century Wheatstone telegraph and wireless telegraphy in modern dress? One avoids the redundancy of speech for conveying information, but that very redundancy in fact carries a wealth of intelligence in various non-verbal expressions, such as urgency or anger, and all the nuances that go in the spaces between words. What one gains by data communications are the advantages of literal methods —symbols held on a screen or paper to be read and analyzed; permanent storage and data processing if required; and syntactical and numerical precision. With personal data communications, whether for the policeman on his beat or the citizen at his TV set, these advantages have to be considered against the immediacy of speech and the instant visual recognition of spatial patterns in pictures. The cognitive processes involved must be studied as part of the communicating systems.

The attraction of literal methods of conveying intelligence can be already seen from the growth of fixed data communications, such as the Post Office's Datel services. Mobile data communications for vehicles is following fast. We have now to see if the idea will move off on Shanks's pony.

Electronic ignition techniques

Current methods applied to engines

by J. R. Watkinson, M.Sc.

The present day petrol-engined motor vehicle, with few exceptions, relies on an ignition system devised last century. The mass production orientated motor industry has largely resisted incorporating electronics into motor vehicles on both economic and reliability grounds. Modern electronic component developments, coupled with a dramatic change in the role of the private motor car, have given rise to a number of attempts to improve on the traditional ignition system. This article describes a number of ways in which the shortcomings of the contact breaker are minimized or eliminated, and outlines the capacitor discharge system which does not rely on a coil for storage of the spark energy.

For the mass market, the main targets of electronic ignition are lengthened servicing intervals and improved cold-weather starting. However, these features will not be adopted if there is a cost penalty. Other benefits possible with some systems are improved acceleration, better fuel consumption, reduced exhaust emission, increased plug life and lower current consumption.

Electronic ignition systems fall into one of two major categories: electromagnetic storage and electrostatic storage. The first-mentioned (e-m for short) uses a coil or inductor, and the last-mentioned (c.d. for short) uses a capacitor. Either may be controlled by a conventional contact breaker, or by a number of devices which replace it. Thus there are a large number of combinations possible, and most of these are available commercially. The Table compares the relative merits of these techniques taken singly and together. It shows the effect of using a particular technique with all other parameters remaining equal. The fact that many of the systems allow parameters to be changed should be borne in mind.

Current techniques used in ignition systems are now described, beginning with the simplest and most economic systems. Methods of eliminating the contacts are next dealt with followed by an explanation of capacitor discharge techniques. Finally there is a look at areas of development.

Ignition ballast resistor with conventional ignition

This is hardly "electronic" but merits inclusion firstly because it has proved effective and secondly because it is sometimes used in conjunction with more complex systems. Battery output on starting may fall to only seven volts, and this problem is overcome by using a seven-volt coil, connected to the battery through a ballast resistor to prevent coil overheating. When the starter motor is operated, the ballast resistor is shorted out and the coil can still operate at full power. The technique is widely used in production vehicles, because the only extra cost is that of the resistor and an extra contact on the starter solenoid or switch.

Assisted contacts

This was the first truly electronic ignition system, developed about ten years ago. The coil and contact breaker are retained, but the coil primary current is switched by a power transistor, and the contacts only handle the base current and battery voltage. As contact wear is thereby reduced, the intervals between servicing are lengthened. With this technique, however, the transistor is presented with an arduous task, and in many systems it is protected against over-voltage by a zener diode. The system is often used in conjunction with the ballast resistor technique, and some types require additional resistors for optimum performance.

Elimination of contact breaker

There are several approaches:

- magnetic induction
- magnetic proximity detection
- rotating transformer
- optoelectronic

Magnetic induction. Inside the distributor, a toothed rotor of permeable material turns within an internally toothed ring. The number of teeth on each is equal to the number of engine cylinders. A ring magnet beneath the stator provides a source of m.m.f. and as the rotating teeth pass the stationary teeth, the flux rises and falls. This induces a waveform in a coil wound round the flux path, which can be amplified to trigger the ignition circuitry. The shape of the pole pieces varies between manufacturers[2,7]. As the output voltage is proportional to $d\phi/dt$ (rate of change of flux), a problem may arise at very low speed, i.e. starting the engine with a handle. The waveform induced is shown in Fig. 1, and the falling edge where it passes zero is readily detected as a repeatable signal.

Effects of improvements made to ignition systems

Improvement Technique	Cold weather starting	Acceleration or fuel cons.	Increased rev/min	Servicing intervals	Plug life	Lower ignition current
Coil resistor	●					See note 2
Assisted contacts	● See note 1	● See note 1		●		See note 2
Eliminate contacts	● See note 1	●	●	●●		See note 2
C.D. with contacts	●●	●	● See note 3	●	●	●
Contactless c.d.	●●	●●	●●	●●	●	●

Notes 1: When coil resistor is used.
2: Some systems increase current demand.
3: Anti-bounce firing circuits can be used to retain existing contact breaker at high rev/min.
● Improvement
●● Further improvement

Characteristic of spark plugs

The spark plug can be represented as a gap with a certain breakdown voltage, V_b, in parallel with the stray capacitance, C_p, of the plug and its associated leads (Fig. A). Voltage V_b depends on the spacing between the electrodes, the pressure of the mixture and its temperature, the worst case being wide spacing, high pressure and low temperature. To charge the stray capacity to V_b, an amount of energy given by $\frac{1}{2}C_p V_b^2$ is necessary. If this is not exceeded, sparking will not occur. As soon as the gap breaks down, it ionizes and conducts, rather like a neon lamp.

The source impedance then reduces the voltage across the gap, so it is very difficult to say how much energy is actually dissipated in the spark, but it is not more than a few percent of the total energy consumed by the ignition system. To illustrate this point, experiment has shown[1] that as little as 1mJ of spark energy will ignite a mixture, but practical ignition systems may unleash as much as 50mJ to achieve the same end. How much loss the distributor causes is also unknown.

Typically a conventional spark plug requires at least 15kV for satisfactory operation, but another type exists called a surface discharge plug, which will operate on as low as 3kV. These are primarily used on outboard motors, power-saws and "snow-mobiles", where damp can present an even more severe problem than that which the car encounters.

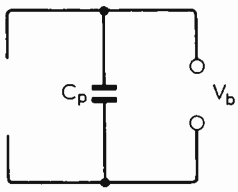


Fig. A

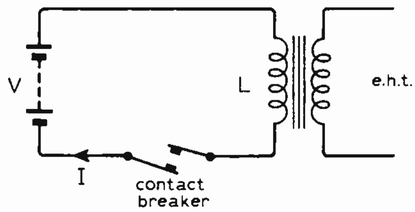


Fig. B

Operation and drawbacks of conventional Kettering system

The primary of the coil, of inductance L and resistance R, is in series with the battery V and the contact breaker CB (Fig. B). When the contact breaker closes, current begins to flow in the coil primary. Because of the presence of the inductance a finite time is taken to build up the current to a maximum value dictated by the resistance, when the energy stored in the coil will be $\frac{1}{2}LI^2$. When the points open the flux in the coil collapses, and in doing so generates a high voltage in the secondary, which has many turns. Unfortunately, several hundred volts are also developed across the contact breaker, which in conjunction with the high current switched causes rapid wear and pitting of the points. To alleviate this and to give a faster collapse of flux, leading to a higher secondary voltage, a capacitor is connected across the contact breaker, which forms a kind of resonant circuit with the coil.

At high engine speeds, particularly with six- and eight-cylinder engines where the spark rate is high, the primary current will have insufficient time to rise to its maximum value between sparks so the amount of stored energy per spark will fall. As the sprung contact breaker points can be considered as a mass/compliance system, then at high speeds they may bounce apart momentarily just after closing. The combination of the two effects causes misfiring and roughness.

Probably of more interest to the average motorist is the poor starting performance obtained with a conventional ignition system. In cold weather, the torque needed to turn an engine from rest is greater, and the starter motor may draw over 200A from the battery. Unfortunately, a cold battery resents this kind of exercise, and its output may fall to around seven volts. This means that the energy released by the coil is only about a third of the maximum. At low engine speeds the contact breaker opens slowly, and the rise time of the secondary voltage is low. Under these conditions it needs only a little leakage, caused by damp, to completely prevent ignition.

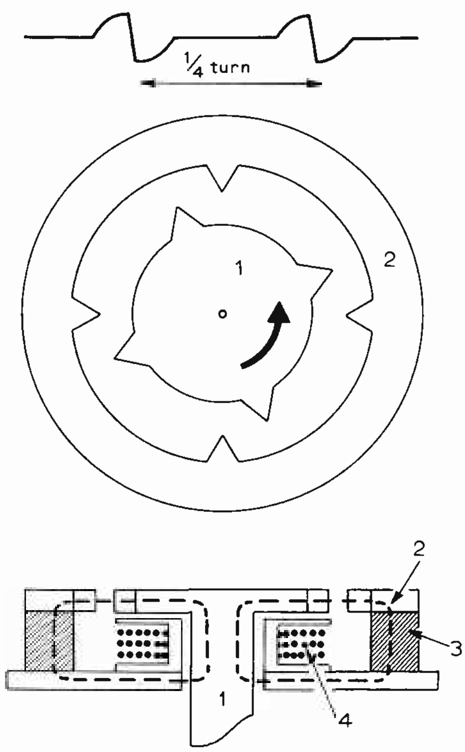
Perhaps the only saving grace of Kettering ignition is that it is not beyond the ability of the average motorist to fix it.

Magnetic proximity detection. Intended primarily as a conversion for existing vehicles[3], the contacts are removed and replaced by a magnetic sensor unit, which uses the existing cam to complete its flux path (Fig. 2). When one of the lobes of the cam is close to the sensor, magnetic saturation is reached, and as one of the flats approaches, the point where the flux path comes out of saturation is detected.

As most of the existing distributor is retained after conversion, the cost is low, and fitting the device is simple.

Rotating transformer. This system[4] also uses a permeable rotor, but instead of a permanent magnet, the field is provided by a high-frequency oscillator which drives the primary coil of the stator. The "carrier" frequency is induced into the secondary winding on the stator, and its envelope varies in amplitude with the coupling as the rotor turns. The waveform is rectified to provide a trigger signal.

Theoretically this system can work down to zero rev/min, but the circuit complexity raises costs, and reliability might suffer.



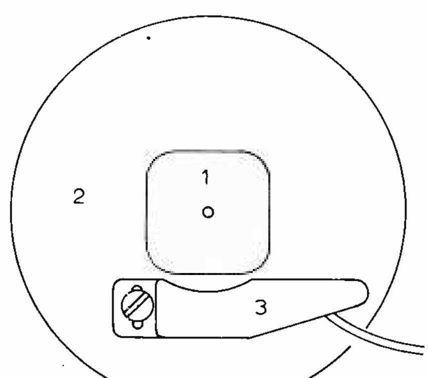


Fig. 2. Designed to quickly convert conventional contact breakers, the magnetic proximity detector (3) is bolted to "action plate" (2) to use existing cam (1).

Fig. 1. In the magnetic induction contact breaker, rotation of the toothed rotor (1) within the stator (2) varies reluctance of flux path (shown with broken line) of ring magnet (3), resulting in the waveform shown from the coil (4).

Optoelectronic. Designed for conversion, this system uses an infra-red beam, generated by a light-emitting diode. A toothed disc clipped to the existing cam interrupts the beam, which is detected by a phototransistor, see Fig. 3. The recent increase in production of optoelectronic components is a point in favour of this system, and costs could be very low. Many manufacturers have shied away from this approach because of a fear that dirt could obstruct the light path, but one manufacturer[5] claims to have perfected a system which will still work with 95% of the light obscured.

Capacitor discharge

The energy stored in an inductor is given by $\frac{1}{2}LI^2$, and the energy stored in a capacitor by $\frac{1}{2}CV^2$. As it is easier to generate a high voltage than a high current, the squared term means that it should be possible to deliver more energy with a capacitive system.

There are many different types of c.d. ignition, but all share certain basic features, see Fig. 4. A d.c.-powered invertor/rectifier provides a high voltage to charge the capacitor. In most systems the invertor automatically compensates for reduced battery voltage without the output voltage falling. On cost and reliability grounds, most systems use around 400V on the capacitor, so the conventional coil is retained, but used instead as a pulse transformer, to step up the capacitor voltage. A type of c.d. ignition exists for surface discharge plugs, in which the capacitor is charged to several kilovolts and fed directly to the plug. As no coil is required, the extra cost of the high voltage capacitor is absorbed. This technique is used on certain aircraft engines. Returning to Fig. 4, the obvious semiconductor to employ for the discharge is a thyristor, and for this reason the system is also called thyristor ignition.

When the capacitor has been charged through the coil, the thyristor can be triggered. When this is done, the capacitor and the coil inductance form a resonant circuit, and the first half-cycle of current flows through the thyristor, which then turns off. The next half-cycle of current flows in the reverse direction through the rectifier and partially recharges the capacitor. As the thyristor is no longer triggered, no further oscillation takes place, and the inverter fully recharges the capacitor.

The advantages of capacitor discharge are many. The rise time of the voltage is very short—less than 50µs—better than one fifth of that of the conventional system. This means that the breakdown voltage of the plug is reached before resistive losses have absorbed much energy. Up to 35kV is available, which is more than adequate to fire a plug in any conditions. The near symmetry of the spark current reduces material transfer at the electrode tips, giving longer plug life. The high spark power, i.e. rate of delivery of energy, is a more effective igniter, as the longer a spark lasts the more energy is required to achieve ignition. Partial recharging of the capacitor makes the system very efficient, and the invertor can be of low power. One manufacturer of such a system[3] claims that the reduction in power consumption is such that a heated-rear window can be used on a vehicle so equipped where it was not previously possible.

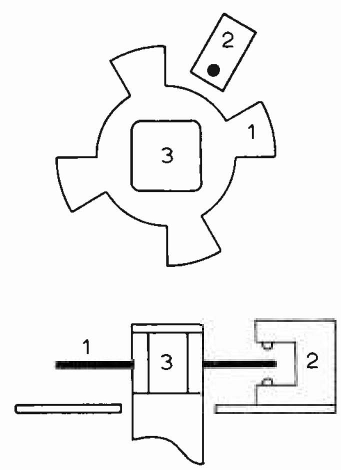


Fig. 3. Optoelectronic contact breaker shown also uses existing cam (3), the rotor (1) being clipped to it. Rotor interrupts light beam from source to detector (2).

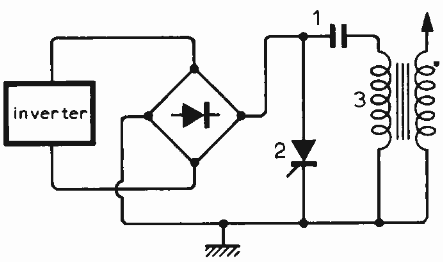


Fig. 4. Energy storage is achieved by a capacitor instead of inductor in the c.d. or thyristor system. Inverter charges the capacitor (1) which is discharged at appropriate times by thyristor (2) into pulse transformer (3).

With some systems the vehicle can be push started with a six-volt dry battery in place of the car battery. There are two types of c.d. ignition system for motorcycles; one[6] uses a rechargeable battery to power the unit (BCDI) and the other[7] uses the windings of the magneto to charge the capacitor (MCDI). In both cases the system is independent of the generator, and for racing purposes none need be fitted, giving more engine power for performance needs.

The only drawback to the c.d. principle is that in some systems the spark duration is occasionally insufficient to ignite a very lean mixture[1]. The reason is that a very lean mixture is not homogenous, but appears to consist of pockets of ignitable mixture in a relatively inert medium. If the spark is of very short duration, no pocket of mixture may have passed the electrodes before its extinction. Knowledge in this field is still lacking, but it appears that a minimum spark duration of 100µs is desirable. Matching the coil inductance to the capacitor is a useful step. It is, however, very unlikely that the above effect can be observed on mildly tuned mass-produced engines, therefore the c.d. system is potentially still superior to the e-m system, as the Table shows. Despite the extra circuit complexity, there are no highly stressed components by modern standards.

It is evident from Fig. 4 that when the thyristor fires, it places a dead short across the invertor. The potentially damaging effect of this is eliminated in a variety of ingenious ways.

The one-shot invertor. In the Delcotronic system[8], the invertor is capable of charging the capacitor in one cycle. During starting the invertor runs continuously, but as soon as the engine fires it reverts to single-shot mode. As the invertor runs between sparks, the intermittent short of the thyristor has no effect on it. Although this is an unusual approach, it has the advantage that an extra winding on the invertor transformer can feed a tachometer at spark rate.

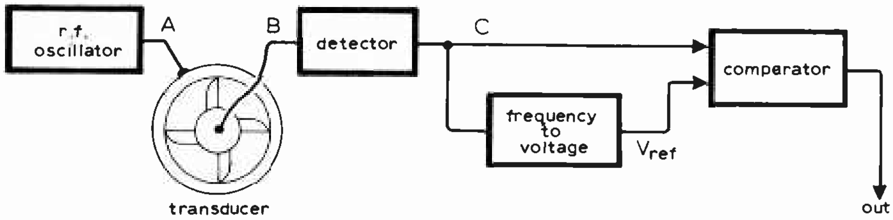
Inhibited invertor. In this system[9] the invertor runs continuously, and can be of lower instantaneous power than the above. The trigger signal which fires the thyristor is also fed to the invertor via a monostable type circuit, so that oscillation cannot occur for the duration of the firing cycle.

Short-circuit proof invertor. This is possibly the most elegant solution[10] as the minimum of components are used. The invertor transformer is deliberately wound with some leakage inductance. The continuously-running invertor shifts its operating frequency when shorted to a higher frequency determined by the leakage inductance. Careful circuit design will ensure that the transition occurs smoothly and instantaneously.

The frequency of invertors used varies from design to design, but obviously the higher the frequency used, the less the mass of the transformer required. It is not economic to use ferrite transformers, so that a laminated iron transformer operating near the top of its frequency range seems to be the most cost effective choice.

Areas of development

In all the techniques so far described, it is only the contact breaker which has been eliminated, and the timing advance with engine speed is still achieved mechanically. It is established that there is a fairly constant delay between the firing of the spark plug and the onset of pressure rise in the cylinder. Obviously the faster the engine runs, the greater must be the advance in spark timing. In all of the systems described above, advance is achieved by centrifugal weights which fly out against springs and turn the cam or rotor and rotor arm relative to the distributor shaft. The moving parts are prone to wear, and the springs fatigue with age.



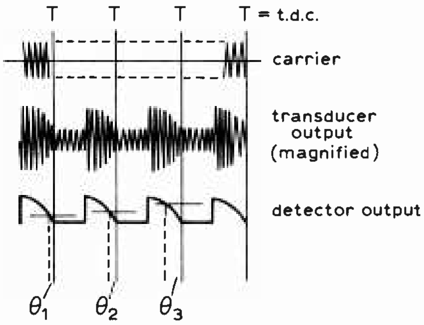


Fig. 5. Output from a capacitative transducer is compared with an engine-derived reference to give automatic advance of ignition timing.

In addition to the centrifugal advance, the so-called vacuum advance alters the timing to correspond with the inlet manifold depression. This is achieved by turning the "action plate" (that part of the distributor which normally holds the contacts) with a diaphragm mechanism.

The next encroachment of electronics into ignition systems will be replacement of these mechanisms with circuitry which performs the same task without wear.

The timing advance angle is not linear with engine speed and the shape of the advance curve partly determines the torque versus speed curve of the engine. What this means to the driver is that a "highly tuned" engine needs to be operated near to its peak power engine speed with a great deal of use of the gearbox, whereas a "flexible" engine although developing less peak power, will deliver power over a wider speed band. The important point is that the advance curve must not vary as the vehicle ages, or performance will suffer.

At present there are two known techniques. It is self evident that an "advance" circuit as such cannot be built, as it is not possible to generate an output before the input! It is, however, possible to use the output from the previous timing mark, and delay the firing point by an amount which varies with engine speed. The alternative is to start afresh at the source of the timing information. With this approach the device which replaces the contact breaker assembly is made to give a continuous output which can be decoded to generate pulses at any advance angle required.

Some kind of carrier frequency system is needed, with coupling either through a rotating transformer assembly, or through a capacitive transducer. The output of such a device is a sawtooth-like waveform, and comparison of the output voltage with an engine-speed derived reference will give the correct advance. Waveforms are shown approximately in Fig. 5.

The capacitive transducer has the advantage that the advance curve can be incorporated in the shape of the plates[11], and by using a printed circuit transducer, a common distributor body can accommodate a whole family of curves simply by changing the circuit board. The vacuum advance can be either of the mechanical type or a vacuum transducer can be used to influence the reference voltage to give vacuum advance with no moving parts.

The amount of electronics in motor vehicles is certain to increase rapidly. It is hoped that servicing techniques will keep pace with the technology, or many of the advantages of electronics will be lost. Perhaps the keen motor enthusiast of the future will pay as much attention to his oscilloscope as he now does to his oil pressure gauge.

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6. Literature received from Future Tecmatics, Waldeck Road, Maidenhead, Berks.
7. Literature received from Bosch Ltd.
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Books Received

Medical Electronics Vol. 2, by D. W. Hill and B. W. Watson, is designed to be a source of reference material to those involved or interested in medical electronics. Subjects discussed include microelectrodes and input amplifiers, fundamental properties of physiological electrodes, cardiac pacemakers and myoelectric control. Price £4. Pp. 172. Peter Peregrinus Ltd, P.O. Box 8, Southgate House, Stevenage, Herts SG7 1HQ.

Electronic circuits for the Amateur Photographer and **Second Book of Hi-Fi Loudspeaker Enclosures**, both by B. B. Babani. The former has 13 circuits including timers, electronic flash and an enlarging exposure calculator. The latter provides constructional details on most types of speaker enclosures from p.a. to omnidirectional. Both are priced 60p and have 80 and 96 pages respectively. Babani Press, The Grampians, Shepherd's Bush Road, London W6 7NF.

Applications of Operational Amplifiers, by Jerald G. Graeme, describes applications which have evolved since the publication of a companion volume. The book shows the use of operational amplifiers in a variety of electronic equipment such as signal conditioners, waveform generators and processors. Price £7·70. Pp. 233. McGraw-Hill Publishing Co UK Ltd, Shoppenhangers Road, Maidenhead, Berks SL6 2QL.

New books in the Foulsham-Tab series include **Servicing the Solid State Chassis**, by Homer L. Davidson, **Installing Hi-Fi Systems**, by Jeff Maskell and Jay Stanton, both priced at £1·40. **How to Repair Musical Instrument Amplifiers**, by Byron Wels, **New Ways to Diagnose Electronic Troubles**, by Jack Darr, both priced at £1·50. Foulsham-Tab Ltd, Yeovil Road, Slough, Berks.

Electrical insulating materials and their application, by R. W. Sillars, provides the reader with a background enabling him to understand current practice on electrical insulation. It describes recent developments in materials and methods including mechanical, thermal and electrical behaviour of polymeric materials. The second half of the book deals with individual materials indicating their various properties and limitations. Price £7. Pp. 287. Peter Peregrinus Ltd, PO Box 8, Southgate House, Stevenage, Herts SG1 7HQ.

Automotive Electronics is an analysis of electronics in the American motor industry. The book deals briefly with the complete industry and then looks at the market and the segmentation occurring in it. Automobile entertainment, electronic test equipment, braking controls, ignition and regulators are some of the categories dealt with. The analysis concludes with sections on technology and competition within the industry. Most of the divisions are supplemented with tables, graphs and figures. Price $450. Pp 53. Creative Strategies Incorporated, The Executive Building, 1032 Elwell, Suite 100, Palo Alto, California 94303, USA.

News of the Month

Advance in magnetic-tape technology

Some months ago news was received from Japan of a new development in audio magnetic-tape technology. Manufactured by Sony under the name Duad, the new tape is incorporated into a compact cassette and should appear here in the late autumn. The special feature of the tape is a dual layer construction with conventional ferric oxide as the base layer and a thin skin of chromium dioxide on the top. This takes advantage of two factors which determine the high-frequency performance of tape and machine. Normal biasing for a tape tends to produce optimum performance in the mid-frequency range at the expense of the high-frequency, short-wavelength recording. Reduction of bias current to improve short-wavelength response correspondingly reduces mid-range performance. By using a higher coercivity material on the surface of the tape, the bias current setting can be optimized for ferric oxide at mid-frequencies and will, because of the higher coercivity of the CrO_2 surface layer, be optimized for short wavelengths also.

However, Sony appear to have been beaten to the starting post (at least in the UK) by 3M who have announced a new range of tapes generically called the Classic range, and included among these is a new cassette tape using precisely the same technology. The correct bias setting is claimed to be that for CrO_2 and the tape is said to produce up to 7dB improvement in high-frequency dynamic range over the previous Scotch High Energy cassettes, with a 2dB improvement in the mid-range.

Also in Japan, Fuji have produced a dual layer "ferri-chrome" tape using similar technology, but it is unlikely to appear in the UK since at the present no distributors have been appointed.

Flat-screen television sets?

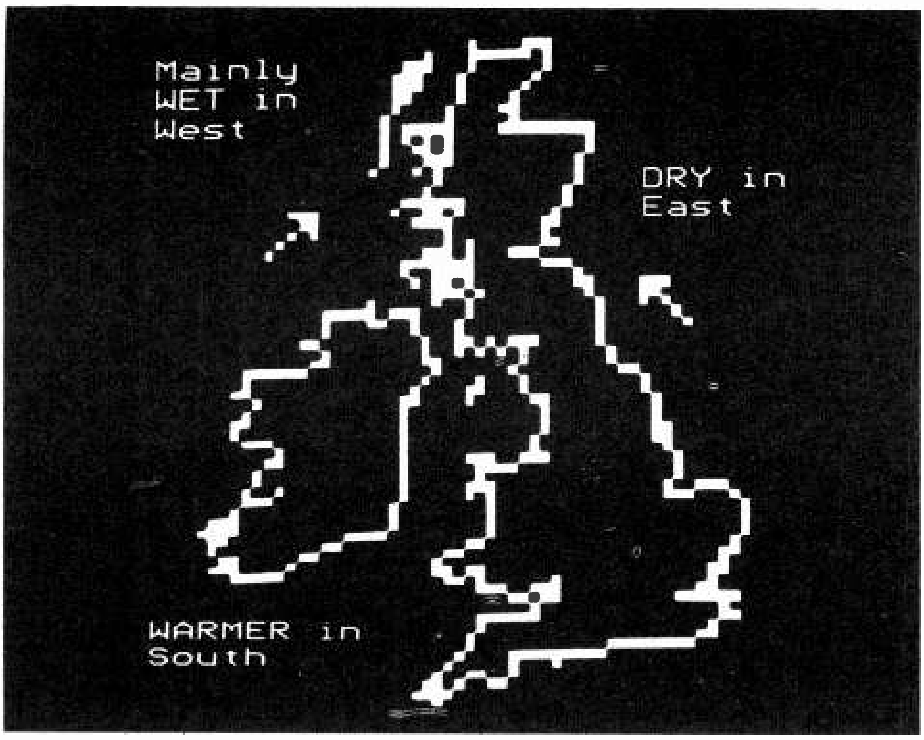
The June 8 issue of *The Economist* carried a full-page advertisement by Hitachi announcing "the world's first working prototype for a flat-profile colour tv". The *Daily Telegraph* for that day picked up the lead, but there were no details of how it was done in the original advertisement, neither were there in the *Daily Telegraph* report; nor in the subsequent report that appeared in a trade paper, which picked it up from the *Daily Telegraph*!

We are hoping to receive full details from Japan but meanwhile, from a brief note translated from the Japanese by Hitachi UK, the display device appears to be a gas-discharge panel, similar to one being developed at Philips Research Laboratories, Eindhoven, and reported in the August 1973 issue of *WW* (page 408).

A well-known technique in flat-panel displays is to use a gas-discharge matrix, in which a matrix of gas-filled holes is placed between a transparent front electrode with, say, horizontal conductors, and a back electrode with vertical conductors. The problem is how to get coloured displays.

What Philips have done, and what Hitachi also appear to have done, is to use a positive-column gas discharge, as in "neon" signs, instead of the negative glow of small neon lamps, thus allowing the use of ultraviolet-sensitive phosphor coatings on the inside of the matrix holes to get the required colours. In applying the technique to television Hitachi feed the "fluorescent diode" cathodes with timing information derived from the sync signals and the video modulation is fed to the anodes.

Problems with this kind of display are the relatively high ignition potentials, 700–800V, which in the Philips panel is reduced to 250V using an auxiliary anode, and luminous efficiency which though higher than neon lamps is lower than c.r.t. phosphor screens.



The BBC are seeking Government approval to put their unique new-standard Ceefax transmissions (see May 1973 issue, page 222) on a pilot basis, carrying useful rather than "dummy" information to help gauge in what areas of information demand will occur. In addition to news, sports results, weather data, superposed sub-titles and newsflashes, simple diagrams of the kind shown are possible. Transmissions are on lines 17 and 18 (330 and 331 in the alternate field) from all BBC-1 transmitters and, by the autumn, should comprise a 100-page magazine transmitted over a 24-second period.

Holography of loudspeaker drive units

A new technique for examining the behaviour of loudspeakers under dynamic conditions has been developed from earlier applications of laser holography, the method being refined by Dr Fryer of the Acoustics Laboratory at Rank Radio.

The drive unit to be examined has a monomolecular layer of aluminium sputtered on to the cone to render it reflective and the unit is then illuminated by a fraction of the total output of a laser via a beam-splitting mirror. The direct and reflected light is then recorded as a holographic interference pattern by a photographic plate.

By driving the loudspeaker drive unit with a sine wave signal and interrupting the reflected light from the cone with a rotating shutter, a series of images representing the behaviour of the cone over a complete cycle can be recorded on one hologram. The series of images thus produced can be reproduced as separate photographs which look rather like a contour map and indeed this is what they are since the pattern produced shows the location of standing wave nodes and antinodes for the particular driving frequency.

Changes in the input signal frequency can be made and the pattern examined for signs of cone break-up, poor mechanical impedance matching of cone-to-edge surround, or points where spurious vibration occurs, such as at the point of attachment of voice-coil connections.

Rank Radio claim that the holographic technique has been valuable in the development of new mechanical damping materials for use on drive-unit cones, for improving cone design and finally for improving reliability under conditions of abuse.

Making the Teldec video disc. In order to achieve studio quality, the master lacquer is cut at a fraction of playback speed. Recording speed is at 60 r.p.m. and playback at 1500 or 1800 r.p.m. depending on the TV line and field system used. The disc will be launched in Germany later this year.

Future of calculators

Development of the electronic calculator market is expected to reveal a continuing rapid increase in the number of calculators sold, but a much slower growth in the value of the market (at 1974 prices). Japanese manufacturers are showing signs of closing the technology gap in l.s.i. and also in producing calculator displays, but the Americans now have such a strong lead in the market that they are unlikely to lose it—unless the Japanese can come up with a major technical innovation.

At present, calculators which print out their results take a relatively small share of the market, because of their high cost. If the £100 price barrier can be broken, a very large market would be opened up. The strongest possibility of breaking this barrier is with the thermal printer. In this device, heat-emitting components generate numerals as a pattern of fine dots on sensitized paper. The mechanism promises to be silent, fast, reliable, easy to manufacture and cheap, but the drawback at present is that it needs expensive special papers. The first manufacturer to find a way round this problem will have a valuable lead in the printing-calculator market.

These are extracts from a Finresearch report "Electronic calculator markets and suppliers", available at £36 from Ovum Ltd, 22 Grays Inn Road, London WC1.

New type of u.h.f. relay

The first of a new design of u.h.f. television relay stations to be introduced by the Independent Broadcasting Authority over the next few years was opened at Luton, Bedfordshire, during June. This new low-power station on Channel 59 provides 625-line colour and black-and-white pictures from Anglia Television. It will improve reception for about 16,000 viewers in those parts of Luton where reception of the high-power transmitters at Sandy Heath or Crystal Palace is unsatisfactory.

The new design relies entirely on semiconductors instead of incorporating valves to provide the power output. It is expected to increase reliability.

All earlier IBA local transposer (channel-changing) relay stations have used thermionic devices (tetrodes or travelling-wave tubes) in the power amplifier, providing output powers of from 50 watts to 1kW. The new range of semiconductor units have a maximum output of only 10 watts although the effective radiated power may be over 100 watts, depending on the power-gain provided by the transmitting aerial. The amplifier stage in this type of station consists of four u.h.f. power transistors whose outputs are combined to give an output of 10 watts. An important feature of the new equipment, apart from the greater reliability and stability that it is hoped to achieve with semiconductors, is that no special test equipment is needed at the station. A built-in meter indicates any faulty modular sub-unit which is then exchanged, using spares carried by the maintenance team.

This permits the equipment to be designed for installation in compact prefabricated buildings. In future stations of this type, an increasing amount of installation work will be carried out centrally before the prefabricated building or container is taken to the site.

About 200 of these low-power local relay stations are expected to be brought into operation over the next five years or so to provide good reception in small unserved areas where local hills screen viewers from the higher power stations. While the Luton relay will benefit some 16,000 viewers many of the low-power relays will normally serve 2000 to 9000 people. The maximum range of a low-power transmitter (e.g. 100 watts e.r.p.) depends on many factors, including local topography and the directional characteristics of the transmitting aerial, but could be about three to four miles in the absence of intervening hills.

Data off the beat

Dorset and Bournemouth police are about to start an experiment at Poole with data transmission from hand-held u.h.f. personal radios carried by policemen on foot. For this purpose the Home Office Directorate of Telecommunications is providing them with 30 hand-held transmitter/receivers fitted with data encoders and miniature data input switches. Data transmission will be in one direction only, from personal transmitter to base receiver. The format of the encoded information will be: three numbers designating the transmitter unit or user; one letter for the map area in which the unit is operating; two numbers for the duty (or status) engaged upon; and two letters designating the location within the map area.

Having set the encoding switches, the user will operate the radio transmitter button, followed some time later by a "data" button. Both switches will be held until the data sequence has run through. This will be very short—a second or less. The microphone transducer will probably be brought into circuit as a loudspeaker when the data switch is operated, so that the encoding tones are audible and will thus indicate when the sequence has finished. This will also give the user confidence that the unit is working correctly. If the radio transmitter button only is operated, the unit will function for speech communication.

A decoder unit at the base station will check the incoming codes to ensure that they have the correct format and, if correct, will "signal back" to the personal radio receiver with an acknowledgement tone. Although all users on the channel will receive this tone, the last policeman signalling in data will assume that the acknowledgement is intended for him. The code received at the base will have a suitable extra character added to it, to indicate that it originated from a personal radio.

On the dilemma of a horn

by Heather Ann Dinsdale

When I wrote about my husband's antics with amplifiers[1], I thought that I had become reasonably well accustomed ("house-trained", he called it) to having an audio engineer in the house, and that little else was likely to surprise me. But this was before the coming of the horns. I have always considered myself reasonably adaptable and easy-going, and I quickly got used to the large loudspeakers we listened to in the "good old days"; in fact, I was lulled into such a sense of false security that I missed the first early warning signs that anything might be going wrong. We often have friends in to a "coffee and hi-fi" evening, and while the men discuss crossover distortion and feedback, we wives talk about prams, babies and bringing the feed forward. (Of course we also get feed back from babies, but that is a different story.) Sometimes I used to keep one ear open to the men's conversation (that is what continuous listening to stereo does for one) and I began to hear the word "horn" repeated with suspicious frequency. After a while I deduced that this was not the musical instrument, but a form of loudspeaker, and still the awful truth failed to dawn. My husband continued to express his firm belief that horns offered the most realistic sound and it eventually occurred to me that he was not referring to the early twenties—he meant now. Any illusions I may have had about reverting to primitive early gramophones were shattered one day when he announced that he was thinking of building a pair of horns to replace our existing loudspeakers (I suddenly realized how attached I had become to these). "How big will they be?" I asked tremulously. "Oh, about 15ft long and with 8-sq.-ft mouths," he replied, "but of course I'll have to fold them." I still could not grasp the full facts; 15ft is longer than our living room, and he couldn't possibly mean that. "I suppose there will be two for stereo," I commented knowledgeably. "Oh no. Four for quadrasonic," he replied in all seriousness—and at that moment I knew that our lives were about to suffer another earthquake.

The next week panels of wood arrived and the work began. Luckily we have a good working arrangement for carpentry (he makes cupboards and shelves fairly frequently) and I comforted myself that this would be no worse than another cupboard. But when the horns appeared, I was speechless. For a start they had to sit in the corners ("But if you move them out of the corners, you'll have to double the mouth area, and you *know* you wouldn't like that"), and I suddenly realized how useful corners can be—once you no longer have them. The early horns were still "in the white", and hardly resembled furniture, but the sound was fantastic. The first time he played the record of breaking glass, I was about to punish the children before I realized they were all safely asleep in bed. As for the organ music, the whole house shook to the pedal notes, and the neighbours came round to ask if everything was o.k. Luckily they too appreciate good music, and the evening ended happily—at 3 a.m.

But this wasn't the end. We had, many years ago, been through the craze for sewage pipes ("column-loading", I mean). I arrived home from a Suckerware party one evening (I always end up as the sucker who buys something) to find two large, dirty, concrete sewage pipes standing on the living room carpet. "Concrete columns," he said as I opened my mouth to scream, "I picked them up at the building site. They've been used, but I've cleaned them out." I shuddered as I thought about what they must have been used for, and then I simply gave up and went to bed. Even when coated with matching wallpaper they still looked like sewage pipes. These disappeared after a while, and we reverted to the rectangular boxes until one evening I returned from baby sitting and couldn't believe my eyes: there in my living room were two lavatory pans. "I picked them up from a builder—they're cracked, no good to anyone." "What are they here for?" I asked in bewilderment. "Listen to this," was the reply, and out of the sitting part came music! You mount the loudspeaker in the S-bend and the whole thing acts as a horn. Luckily they didn't last. A friend christened the system "Loohorn" and it provided a topic of conversation between records (one advantage of a complex hi-fi installation is that it takes longer to put a record on than to play it, so we have not lost the art of conversation—yet).

Now horns are clearly here to stay. We moved house last November, and it was the disused living room chimney adjacent to the integral garage that finally clinched the deal. We can build the horns partly inside the chimney, and partly over the top of the garage (which will then only be suitable for a Mini). The sound will be superb, my husband will be satisfied (for a while at least) and I will not have to sacrifice my corners. Sorry, my enthusiasm has carried me away. I had forgotten that we are due to go four-channel next year. The corners will be needed, after all, and I can't even light the fire. But who cares? My husband is happy, we have a ready topic of conversation, and I am about to apply for my first patent: did you know that the finale of Mahler's 8th symphony is an excellent mechanism for cleaning chimneys? The soot simply pours down just as the chorus . . .

Reference
1. Dinsdale, Heather Ann, "Living with Hi-Fi," *Wireless World*, Nov. 1969, pp. 526–527.

Audio f.e.t. power transistors

New technology for amplifiers developed in Japan

Present day solid-state high power amplifiers use dual, triple or even more transistors in parallel to obtain high output power. Unless the transistors are perfectly matched, problems can be presented by unbalanced standing currents resulting in increased distortion. In this case, low distortion and wide bandwidth can be obtained only by applying large amounts of negative feedback. This is turn confronts the circuit designer with problems regarding closed loop stability, especially when the widely varying types of loudspeakers that the amplifier may have to drive are taken into consideration. To obtain an amplification device of initial low distortion, good linearity and high power output, the audio development group of the Japanese Yamaha company has successfully created a series of f.e.ts for audio application and a high grade, high power prototype amplifier with direct coupling of all stages using these f.e.ts. The new device is based on an invention by Prof. Jun'ichi Nishizawa of the Electronic Telecommunications Research Laboratory of Tohuku University. Development work was undertaken by Yamaha who were commissioned by the Japan Technology Development Foundation.

Structure and characteristics

As the channel (current route) cross-sectional area of a conventional f.e.t. is changed by the depletion layer, drain current, I_D, is controlled (Fig. 1). When $V_{GS} = 0$ and when the depletion layer just reaches its maximum width, V_{DS} is then defined as the pinch-off voltage. No matter how much V_{DS} may rise above this value, I_D exhibits saturation characteristics which do not rise. When V_{GS} rises, the value of maximum depletion layer thickness may drop below that for $V_{GS} = 0$, so that the saturation current drops, giving rise to the output curves shown in Fig. 2.

The characteristics of the conventional junction-type f.e.t. make it a voltage driven active element capable of controlling output current according to changes in gate voltage. Saturation is caused by high internal channel resistance so the conventional f.e.t. construction does not lend itself to high power applications.

A model of the newly developed "vertical" f.e.t. is shown in Fig. 3 together with its equivalent circuit. On top of the n+ base silicon wafer, a high resistance n− silicon layer is formed by an epitaxial method in vapour. After selective diffusion of the highly doped p+ gate, an n-type silicon layer is again formed by the vapour epitaxial method. The gate differs from conventional f.e.ts with a control condition interposed between the source and drain, analagous to a valve grid.

The output characteristics of the vertical f.e.t. are shown in Fig. 4. The voltage amplitude versus frequency curve is shown in Fig. 5.

Bipolar power transistors have inherent disadvantages when compared with the f.e.t. and include tendency to secondary breakdown, thermal instability and, more important, the carrier storage effect which causes notch distortion.

Prototype amplifier

The output stage of the prototype amplifier is equipped with high power f.e.ts of 300W permissible drain dissipation, 2Ω resistance when switched fully on, a voltage amplification factor of 5, breakdown voltage of

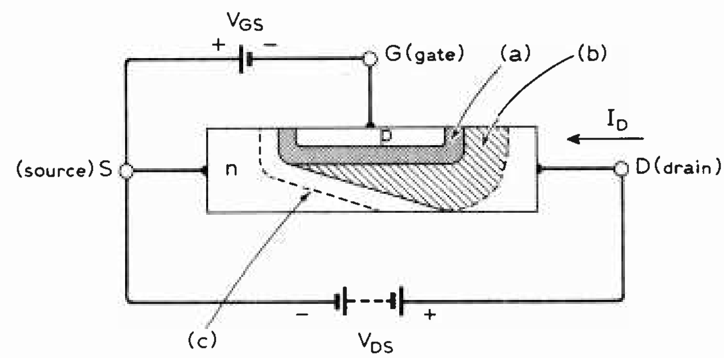


Fig. 1. Conventional f.e.t. and its operating principle: (a) condition of depletion layer across the channel when $V_{GS} = 0$ and $V_{DS} = 0$, (b) depletion layer condition when $V_{GS} = 0$ and V_{DS} is increased to the point at which pinch-off occurs, (c) condition when V_{GS} is raised and V_{DS} reaches saturation.

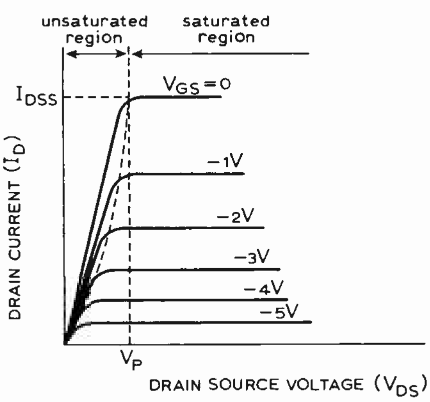


Fig. 2. Conventional f.e.t. output characteristics.

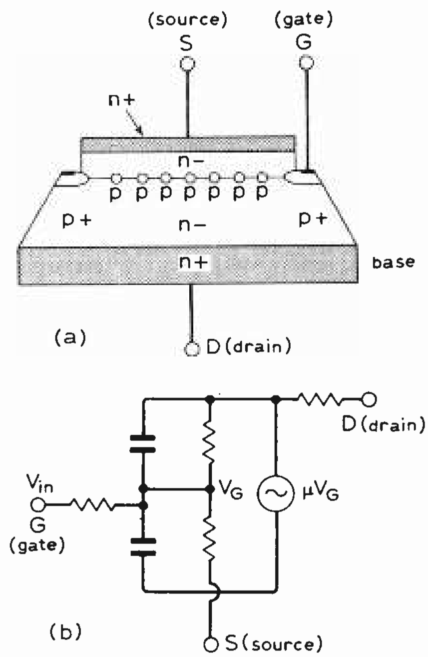


Fig. 3. (a) Model of the vertical type f.e.t. and (b) equivalent circuit.

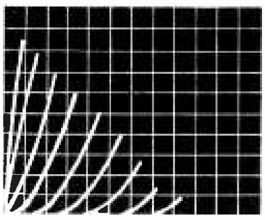
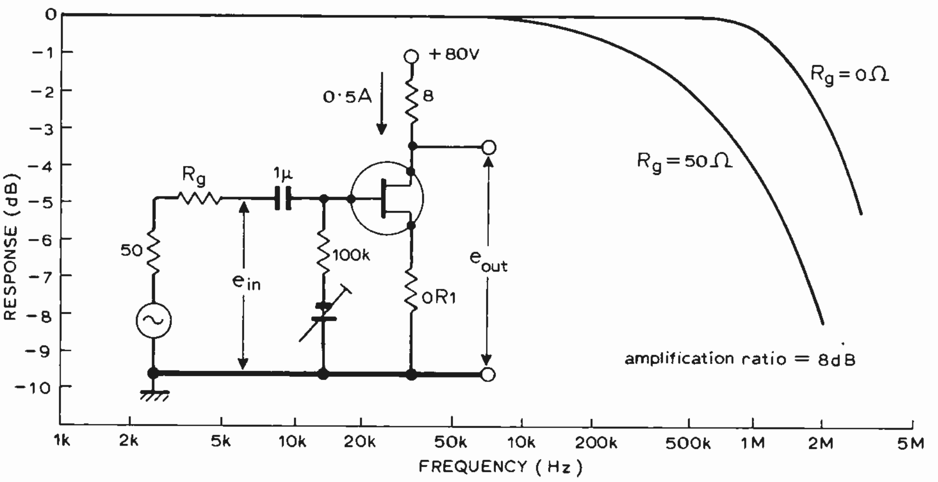


Fig. 4. Output characteristics of the vertical f.e.t.

Fig. 5. Amplitude response as measured from the test circuit shown.



over 200V and drain current of 10A. The driver stage is also from vertical junction type f.e.ts of high voltage breakdown and high voltage gain of 50.

The output circuit delivers 150W per channel into 8Ω loads over the 20Hz to 20kHz band with both channels driven. Single push-pull construction permits easy selection of matched pairs and aids high operating stability. Total harmonic distortion at 1kHz, 8Ω load and 100W per channel (both driven) is claimed to be below 0.01%, while over the 20Hz to 20kHz band, it remains below 0.03%. Frequency response, improved by the low drive impedance of all stages, goes from 5Hz to 100kHz +0, −1dB and the damping factor at 1kHz relative to 8Ω is approximately 100.

The circuit is a quite conventional design with two-stage differential amplification and source-follower direct coupled symmetrical drive. Bias to the driver and power f.e.ts is stabilized by a method permitting correct circuit operation even without a stabilized power supply. Differences in f.e.t. characteristics can be compensated with a semi-fixed variable resistor.

Temperature compensation, a requirement absolutely necessary in bipolar transistor amplifiers, becomes superfluous because of the much smaller current fluctuation caused by temperature changes in f.e.ts—their tendency is to reduce current flow at high temperatures and no thermal run-away can occur. An independent power supply has been provided for each channel so that output per channel remains the same irrespective of whether a single channel or both are driven.

Amplifiers using f.e.t. power transistors have also been produced by Pioneer, Toshiba, JVC and Sony, although Yamaha only seem to have overcome the problem of high current dissipation and hold the patent application in Japan for the process involved in producing the vertical f.e.t.

Digital tuning aid

Rapid tuning of keyboard instruments in equal temperament

by Winthrop S. Pike

RCA Laboratories, Princeton, N.J.

The equal tempered scale is virtually the only scale in wide usage today for keyboard instruments such as the organ, piano and harpsichord. Though many experimenters and amateur musicians might like to try tuning their own instruments, it is not easy for most nonprofessionals to tune a musical instrument correctly in equal temperament. With the aid of the digital tuning aid described, anyone who can hear beats between two tones sounded together can tune in equal temperament with an accuracy approaching that of a veteran tuner. The tuning aid, shown in Fig. 1, accurately generates all 12 notes of one actave. It is portable, battery operated, convenient to use and relatively inexpensive to construct.

A full explanation of the theory of equal temperament would unduly lengthen this paper. For such an explanation the reader should consult one of the standard musical texts[1,2]. Suffice to say that in equal temperament the only true intervals are the octaves. For this reason, one cannot tune other intervals (the violinist's fifths, for instance) to exact zero beat. One must "temper" them—in effect, slightly mistune them. Further, the mistuning must be skilfully distributed among the 12 notes of the octave in a prescribed pattern. Mathematically, the tempering process divides the octave into 12 equal semitones, each of which differs in frequency from its neighbours by the 12th root of two, a factor of 1.0594. How much to "temper" each note to obtain this state of affairs is the *bête noire* of the novice tuner.

Frequency division is the working principle of the digital tuning aid. As shown in the block diagram, Fig. 2, a master oscillator operating at a frequency much higher than that of the notes produced drives a programmable frequency divider which digitally divides the master oscillator frequency by any one of 12 switch-selected factors ranging from 959 to 508. The output of the divider system is filtered and applied to an audio amplifier and loudspeaker. With this technique, the intervals between notes are determined only by the divisors chosen. They cannot get out of tune if the master oscillator is stable and the dividers are correctly wired. On the other hand, the overall pitch level of all the notes produced is determined by the master oscillator. It can be moved higher or lower to accommodate various tuning situations without impairing the relative accuracy of the intervals.

A practical choice of master oscillator frequency is 250.830kHz. Using this frequency and the range of divisors quoted above, all twelve tones of the "middle C" octave (from 261.6225Hz to 493.8833Hz) can be generated using only five integrated circuit packages in the programmable divider. Three of these are decade dividers and the remaining two are multi-unit gates. Table I lists the frequencies desired, the frequencies actually produced, the divisors used for each note and the resulting errors. The errors are about equally distributed above and below the correct frequencies and the largest absolute error occurs on the note F. It is only 0.033%. Much more important is the fact that the largest relative error between any two tones is approximately 0.06%. This is about equal to one musical cent or the 100th part of a semi-tone and represents quite sufficient accuracy for tuning purposes.

The particular set of divisors chosen here is not the only possible set[3,4]. In theory, if one makes the master oscillator frequency arbitrarily high and the divisors arbitrarily large, one may approach arbitrarily close to the desired frequencies. However, aside from the greater complexity and expense of such an approach, it turns out that the reduction of frequency errors so produced is not monotonic. There are sizeable fluctuations and certain sets of divisors are much better than others. Hence, though it might appear advisable to use the highest divisor available in the programmable divider (here 1,000) for the lowest note, this would produce larger errors among the other 11 notes. Mathematically inclined readers with access to an electronic calculator may amuse themselves by verifying this phenomenon.

Circuit description

The inner workings of the device are shown in Fig. 2. It breaks down logically into a number of modules, each of which can be built separately and then assembled into the final device. They are readily identifiable in Fig. 6, and their detailed circuit diagrams are given in Figs. 3, 4 and 5.

The master oscillator unit, Fig. 3, is a good module to build first. It is similar to a Colpitts circuit but the oscillator transistor Tr_1 is tapped well down on the coil by the capacitive divider C_2, C_3 and C_4. This reduces the tuned circuit loading, thereby improving the circuit "Q" and the oscillator stability. The prototype oscillator, for example, changed frequency only 0.002% when the power supply voltage was reduced from 9 volts to 5 volts. Tr_2 interfaces the oscillator with the logic levels required by the integrated circuits. Capacitor C_1 trims the frequency so that the tuning screw of inductor L_1 protrudes far enough from the coil so that a knob may be mounted on it for vernier tuning.

The programmable divider, shown in Fig. 4, comprises integrated circuits IC_1 through IC_5. These units, RCA COS/MOS devices, were selected for their very low power consumption. Signal from the master oscillator is buffered in one section of IC_1, a triple NAND gate, then fed to decade dividers IC_3, IC_4 and IC_5. Each divider has built-in decoding of its ten possible states, a feature which considerably reduces the number of integrated circuits required in the tuning aid. The remaining gates in IC_1 and IC_2 are used in conjunction with the note selector switch S_2 to reset the divider to zero each time the desired count is reached. A detailed explanation of the reset system may be found in the manufacturer's application notes[5].

An output signal is taken from pin 7 of the last decade divider, IC_5 to drive the audio amplifier shown in Fig. 5. An integrated circuit audio amplifier[6] is shown although the prototype tuning aid actually used an amplifier "liberated" (with a hacksaw!) from a transistor radio in which the "front end" had become defunct. As it handles only a single tone at a time, neither the distortion, frequency response nor power of the amplifier is at all critical. A power of 100 milliwatts is entirely adequate for most situations[7].

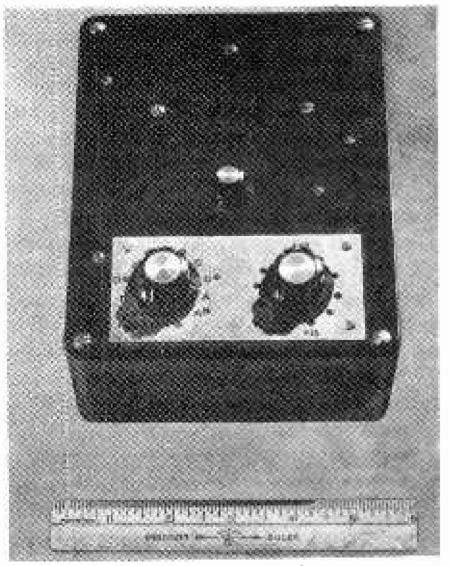


Fig. 1 The digital tuning aid.

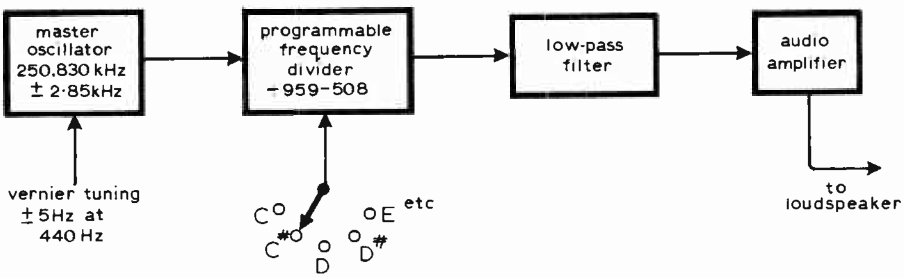


Fig. 2 Block diagram of digital tuning aid.

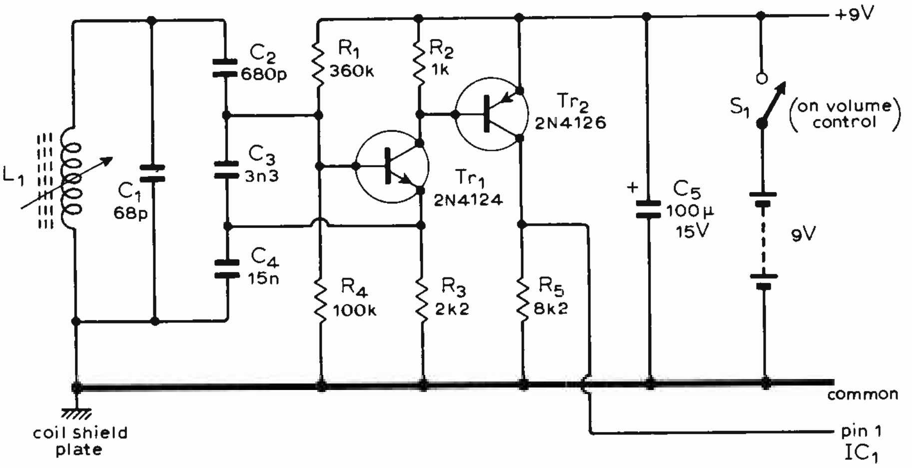


Fig. 3 Master oscillator circuit.

TABLE I

Note	Correct Frequency	Divisor	Actual Frequency	Per Cent Error
C	261.6225	959	261.5537	.026 flat
C#	277.1826	905	277.1602	.008 flat
D	293.6647	854	293.7109	.016 sharp
D#	311.1269	806	311.2034	.024 sharp
E	329.6275	761	329.6057	.007 flat
F	349.2282	718	349.3454	.033 sharp
F#	369.9944	678	369.9557	.010 flat
G	391.9954	640	391.9218	.018 flat
G#	415.3047	604	415.2814	.005 flat
A	440.0000	570	440.0526	.011 sharp
A#	466.1637	538	466.2267	.013 sharp
B	493.8833	508	493.7498	.027 flat

The above is based on a master oscillator frequency of 250.830kHz.

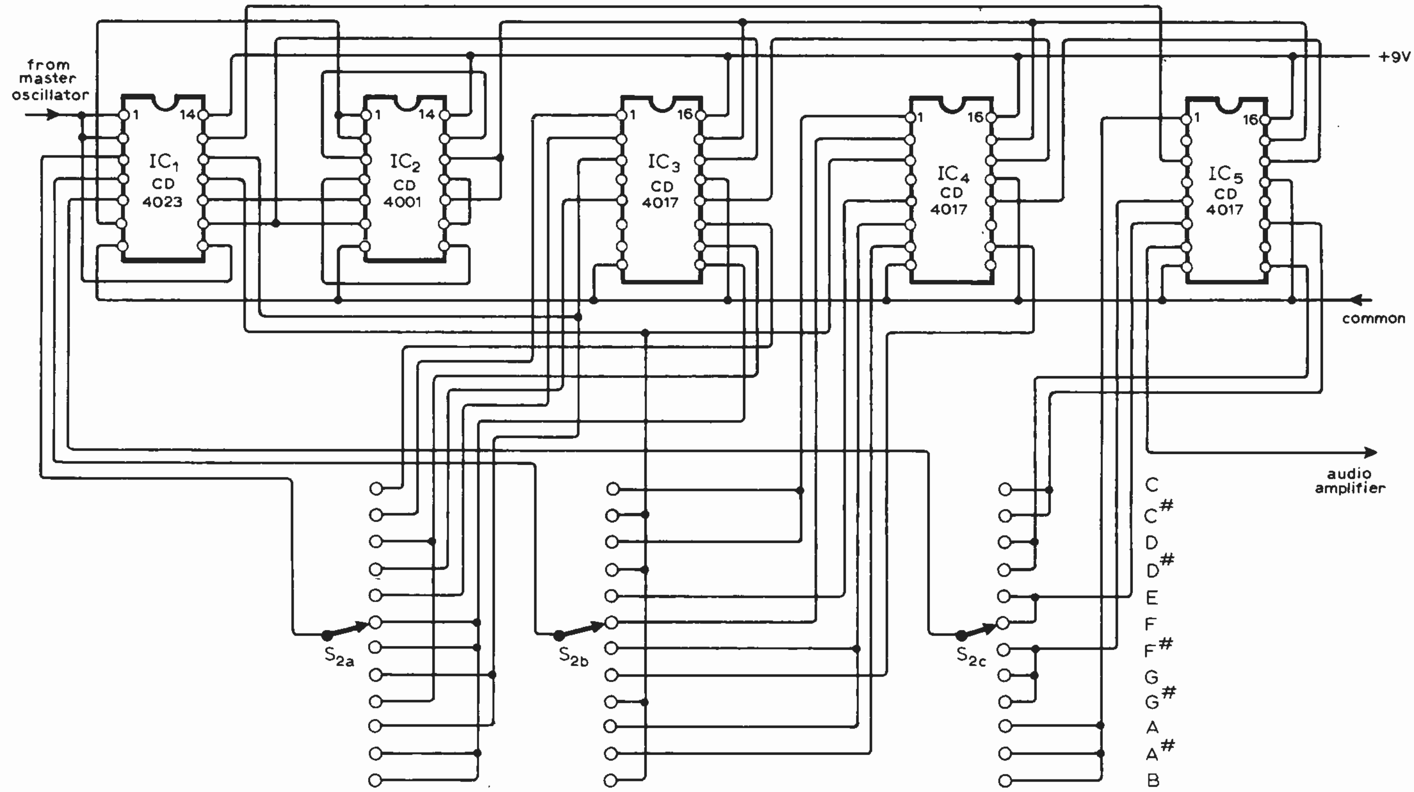


Fig. 4 Programmable divider circuit.

In the amplifier, the signal from the programmable divider is first filtered by R_6, R_7, C_6 and C_7 to reduce some of the unpleasant-sounding higher harmonics of the pulse output waveform of the divider. It is then applied to the volume control R_8. A 220 ohm resistor R_9 has been placed in series with the low end of the volume control. This prevents the user from reducing the digital tuner's output to zero even when the control is turned all the way down. Thus, the unit cannot be left on without making its presence known audibly, a simple expedient which consumes less power than a pilot light and is quite effective.

Construction

An advantage of the COS/MOS integrated circuits is a high noise immunity. This means that the programmable divider is not particularly vulnerable to false triggering due to stray capacitances or faulty layout. In the prototype, the master oscillator is constructed on one piece of pin-board, the divider on a second and the audio amplifier on a third. The dual-in-line integrated circuits comprising the divider sub-assembly are mounted by simply bending the thin portions of their leads out into a plane parallel to the flat top of each package and soldering each corner lead. Thin wire is then used to make the necessary interconnections.

One other mechanical problem is worth comment. The length of the master oscillator coil L_1 slightly exceeded the depth of the meter box in which the prototype was constructed. As this component had to be mounted with its tuning screw protruding through the panel for use as a frequency vernier, special mounting provisions were necessary. The solution was to cut a hole in the top of the box large enough to clear the coil terminals and mounting. As can be seen in Fig. 1, an aluminium plate was then cut to cover this hole (and that for switch S_2). The coil was mounted to this plate and the plate connected to the common negative terminal of the battery to ground the coil tuning screw and alleviate possible hand capacitance effects. The dial markings for the vernier tuner and note selection switch were placed on the aluminium plate with a rub-on lettering set, the end result being quite neat in appearance.

The total power consumption of the prototype measured 72 milliwatts (8 mA at 9 volts) at a moderately loud sound level. As the audio amplifier operates Class B, its power consumption is dependent on its operating level.

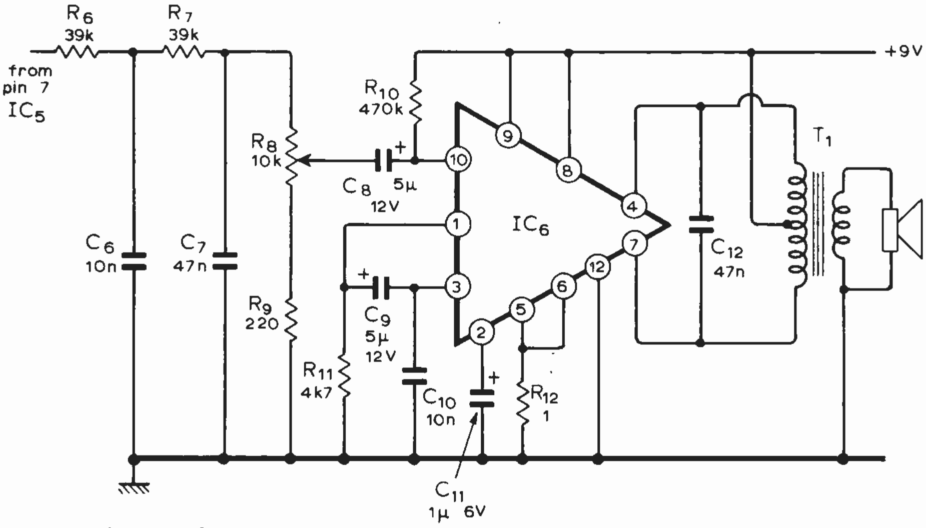


Fig. 5 Audio amplifier circuit.

Calibration

After wiring the unit, there is only one adjustment to prepare it for use. The master oscillator must be set on frequency. If you have access to a frequency meter, connect the loudspeaker of the tuning aid temporarily to it. Set the note selector switch S_2 on the note A and adjust the frequency vernier control, L_1 for a frequency of 440Hz. If you wish, a mechanical stop may now be placed on this knob to keep it from being rotated more than one turn and the dial may be calibrated as in the prototype. Fortuitously, one turn of the vernier tuning knob will change the frequency of the note A about $\pm$ 5Hz, a comfortable range which is quite ample for most situations.

If you do not have a counter, probably the simplest procedure is to audibly zero beat the tuning aid against a freshly tuned piano or electronic organ. Another durable, portable and inexpensive standard is the classical tuning fork. Some music stores carry them and an A (440Hz) fork usually costs only a few pounds. Once tuned, the master oscillator will be found very stable, but it is easy to recheck it against a fork or other standard at any time. When the tuning aid is correctly set for A it will inherently be correct for all other notes too. This is worth remembering. Suppose, for example, that you encounter an organ or other instrument tuned to the older (A= 435Hz) standard. There is no problem. Simply match the tuning device A to the A from the instrument to be tuned, then tune the remaining notes.

Using the tuning aid is simple. Suppose one wishes to tune an electronic organ. First, if the organ has a tremolo stop, vibrato stop or one of the popular rotating loudspeaker devices such as the Leslie, turn it off while tuning. All of these devices produce a periodic undulation of the organ sound which will hopelessly confuse the process of listening for beats. Next, turn on an eight-foot or four-foot stop of moderate harmonic content such as a Principal or Diapason on one of the organ manual keyboards. Avoid using a stop of very dull tone, such as a Flute, or very highly coloured tone such as a Clarinet. Extremes of timbre make the zero beating process more difficult. Set the tuning aid note selector to C and sound "Middle C" on the organ. For easiest tuning, adjust the volume control of the tuning aid to make its apparent loudness about the same as that of the organ note being tuned. Now, successively tune each of the 12 notes of the "Middle C" octave to the appropriate note of the tuning aid. Take your time on each of these 12 notes. They are to be the sub-standard to which the rest of the organ will be tuned. Listen for at least ten seconds to each note after you think it is in tune. If you do not hear any beats in this time interval, you have tuned to an accuracy of about 0.1Hz. Obviously, the accuracy can be improved by listening for a longer interval.

If your organ is of the frequency divider type, having only 12 tuning adjustments, the job is done. If it is the individual oscillator type, you must now tune the remaining notes of the keyboard in octaves to the middle octave which has just been tuned. The tuning aid can be dispensed with at this point. Beats between notes an octave apart are quite easy to hear on a Principal stop but often quiet difficult on a Flute stop, hence the original choice of a Principal. Once the Principal is completely in tune over the whole keyboard, any other stops perhaps derived from a different set of tone generators may be tuned to it note for note. One precaution is appropriate here. If the organ has a celeste stop (Voix Celestes, Flute Celeste) using a separate rank of oscillators, leave it until last. It should then be tuned note for note very slightly sharp or flat to the already tuned rank with which it is normally used. You may have to experiment a bit to find out how sharp or flat to tune it for the most pleasing effect. It is impossible to give further detailed instructions as different makes and models of organs will have different requirements.

The same general principles will apply in tuning other keyboard instruments although the non-sustained nature of the tone of the piano and harpsichord makes the beats slightly more difficult to hear until one has gained a little experience. Do not, by the way, tackle a good piano without a proper tuning wrench. Anything else may seriously damage the tuning pins.

Parts List

Capacitors:

C_1	68pF. Mica, 10%
C_2	680 pF. Mica, 10%
C_3	0.0033 μF. Mylar, 10%
C_4	0.015 μF. Mylar, 10%
C_5	100 μF. 15 volt, electrolytic
C_7, C_{12}	0.047 μF. Not critical
C_8, C_9	5 μF. 12 volt, electrolytic
C_{10}, C_6	0.01 μF. Not critical
C_{11}	1 μF, 6 volt, electrolytic

Resistors:

R_1	360kΩ
R_2	1kΩ
R_3	2.2kΩ
R_4	100kΩ
R_5	8.2kΩ
R_6, R_7	39kΩ
R_8	volume control potentiometer, 10kΩ, audio taper, with switch
R_9	220 ohm
R_{10}	470kΩ
R_{11}	4.7kΩ
R_{12}	1 ohm

All fixed resistors $\frac{1}{4}$W, 10%.

Transistors:

Tr_1	RCA SK 3124 or Motorola 2N4124
Tr_2	RCA SK 3114 or Motorola 2N4125

Coils:

L_1	0.15 to 1.0 millihenry.
T_1	transformer, primary 200 ohms c.t., secondary 3.2 or 8 ohms to match loudspeaker.

Switches:

S_1	part of volume control
S_2	3 pole, 12 position, non shorting

Loudspeaker:
8 ohms, 2in or equivalent.

Box:
ITT die-cast box 0077B or equivalent, about 7×5×2in.

Battery:
9 volt

Integrated Circuits:

IC_1	RCA CD4023 triple 3-input NAND gate
IC_2	RCA CD4001 quad 2-input NOR gate
$IC_{3,4,5}$	RCA CD4017 decade counter/divider
IC_6	RCA amplifier kit KC-4003 (includes a p.c. board, transformer T_1 and associated resistors and capacitors).

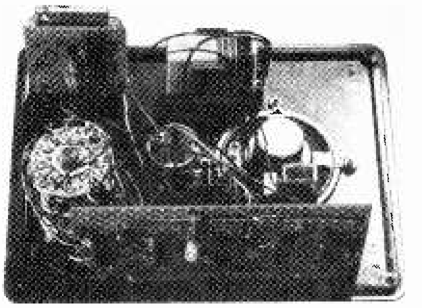


Fig. 6 Interior of tuning aid.

In conclusion, the goal of this project has been to design and construct a simple, accurate and inexpensive tuning aid. Though other features such as a crystal frequency standard or additional dividers for other octavely related notes might have been included, their deliberate omission has been in the interests of economy and portability. Over a year's experience in using the device on a variety of pipe and electronic organs as well as harpsichords and pianos has amply proven the design objectives.

Acknowledgement

The encouragement of Dr J. J. Brandinger and the photographic assistance of Mr William Cobb are gratefully acknowledged.

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4. "Tempered Scale Generation from a Single Frequency Source", R. B. Cotton, Jr., *Journal of the AES.*, Vol. 20, No. 5, June 1972.
5. Application Note ICAN–6166, RCA Solid State Division, Somerville, N.J., 08876.
6. RCA HM–91 Hobby Circuits Manual, RCA Solid State Division, Somerville, N.J., 08876.
7. There are other options for audio amplifiers. For example, several radio supply houses stock inexpensive 100 milliwatt amplifiers. Most of these have either three or four transistors and require input signals of 5 to 50 millivolts for full output, thus having an excess of gain for this application. However, they may be successfully interfaced with the output of the programmable divider in the tuning aid by the simple expedient of adding some series resistance (51 to 220kΩ) between the junction of R_7 and C_7 and the volume control R_8. Alternatively, these amplifiers often have a by-passed emitter resistor in the first stage. Simply clipping out the by-pass capacitor may reduce the gain sufficiently.

A quick scan of back issues of *Wireless World* also turned up another possibility which may be attractive to UK readers. A readily adaptable general purpose 150 milliwatt design may be found on page 236 of the May, 1970 issue.

Letters to the Editor

Damping factor

Referring to Mr Walker's letter on damping factor (May issue) it would appear that even more confusion has been added to the subject. The equation is very nice, but I can't see a prospective amplifier buyer going around with test equipment, slide rule and a thermometer. The very high damping factors quoted in manufacturers' specifications are impressive but academic in so far as the performance of the system is concerned. When calculating the damping factor, as was rightly pointed out, one assumes two components, Z_{vc}, the speaker's impedance, and R_s, the amplifier's source resistance. (The reactive component of a well-designed amplifier is small compared to that of even a moderately efficient speaker, especially below resonance.) So with a speaker of 8 ohms impedance and an amplifier of 0.5 ohms, the rated damping factor is 16. In reality, what the speaker "sees" is not only the amplifier's source resistance but also the speaker leads' resistance—not as low as one would like to think sometimes—the crossover's resistance, and, not the least important, the loudspeaker's own voice coil d.c. resistance. So the equation should read:

$$\frac{Z_{vc}}{R_s + R_{vc} + R_L + R_{cr}}$$

Forgetting the crossover's and speaker leads' resistance, a voice coil d.c. resistance of typically 6 ohms will actually provide a damping factor of 1.23. Doing a series of similar calculations with various values of R_s, it can be seen that any improvement of the rated damping factor over 15 provides little if any difference to the actual damping factor. As for the voice coil's d.c. resistance changing significantly with "The first four bars of Beethoven's fifth played at any reasonable level . . ."—any loudspeaker which does that should be filed under the Trade Descriptions Act.

So, assuming that the third paragraph in the letter wasn't meant to cover two entirely different phenomena (back e.m.f.?), it means that unless a user intends to feed a 2-ohm array of efficient speakers with 50 ft of bell wire, he is unlikely to hear any difference whether the amplifier has a rated damping factor of 15 or 115. It is only when the amplifier's source offers a rated damping factor of significantly less than this that he is likely to meet any problems, which in the case of Mr Walker's amplifier I imagine is a highly pertinent point.

S. J. Court,
Dennington Acoustics,
London, N.W.6.

Mr Walker replies:

Confusion arises because the same amplifier comes up with very different damping factor ratings depending upon which laboratory does the measurement, hence my letter drawing attention to the appropriate British Standard. The procedure involves the measurement of two voltages and is simple in the extreme. I also gave a formula, shorn of inessentials, to show the damping of simple loudspeaker system in order to indicate that if a single figure for damping factor is required the BSI method is the most appropriate.

Damping factor is a property of the amplifier (its regulation). It should not be confused with loudspeaker damping since the connection between the two is remote and, in the case of many modern loudspeakers with more than one degree of freedom, the relationship can reverse—an increase in damping factor actually reducing the loudspeaker damping (the rate at which the stored energy is dissipated).

There is nothing particularly wrong with a high damping factor and its name certainly gives it a high emotional appeal. Nevertheless, in drawing attention to the method of measurement I thought it wise to put it in proper perspective by the perfectly sound statement that "The first four bars of Beethoven's fifth" played at a reasonable level will warm up the speech coil and change the loudspeaker damping by an amount greater than any difference in amplifier specifications.

Take an 8Ω loudspeaker, feed it with 3 and 4 watts for just three or four seconds whilst monitoring the d.c. resistance. It will grow around half an ohm during the process. Now whether or not this does any harm to the loudspeaker damping, it quite clearly will have exactly the same effect whether we consider the $\frac{1}{2}\Omega$ to be added to the speech coil resistance or to the amplifier internal source resistance. But if we consider the latter viewpoint it would mean that an amplifier's super damping factor of 200 (say) has been reduced to a measly 15, enough to make many an audiophile turn off in disgust.

Now I am reliably informed that high quality monitor speakers in recording studios on a pop programme frequently reach such a temperature that the speech coil resistance doubles. No prize for the horrifying answer expressed as an equivalent change in amplifier damping factor.

If the zealot next door will turn down the volume a bit, it will spare his neighbours and do wonders for his "damping factor".

Current flow controversy

As "Cathode Ray" has kindly offered some further comment about current flow (Letters, May) may I also add a few more?

I see no point now in entering into argument about his explanation of what he means by the "positive direction of current" nor his example of the jargon used only by British railwaymen, because I note that in spite of his defence of "conventional current" against, presumably, "unconventional current" he nevertheless thinks that "if we could start from scratch, we in electronics would almost certainly vote for the direction of electron flow". Because a handful of people started off one way, we surely do not have to go on for ever following this convention if a better alternative turns up.

Changes occur all the time in all fields of learning. Certainly we are rarely able to re-start anything from scratch, and if changes could be made only under such circumstances there would indeed be very few changes made no matter how desirable.

Since my original letter was published I have been pleasantly surprised to learn how many teachers and books already deal with electron flow as current and it would seem to be only a matter of time for the change-over to be complete. I think it was Aristotle who said of the old something like " . . . in all things they err on extreme caution".

Perhaps it is better in some cases to make changes gradually, such as we are doing in the change to decimals, so long as the changes do eventually get made.

C. H. Banthorpe,
Northwood,
Middlesex.

Using pocket calculators

Regarding your leader in the May issue on "Pocket numeracy", may I please comment? Calculator errors need not go undetected. We can still re-check a wrong entry via the keyboard. Repeating takes little time. Errors in the machines—I have not met any faults other than low battery voltage in two years with experience of several different models—are likely to be so gross as to give ridiculous results. If $7 \times 8 = 54$ or $6 \times 9 = 56$ is in one's head as part of a calculation, an immediate re-check is unlikely to eliminate such an error, temporarily fixed in one's own short-term memory.

In electronics (as I suppose in most numerate activities) calculations tend to be crude, in "cut and try" development, or precise. May I quote two typical recent examples from personal experience? (1) I wanted to increase the current through a resistor of 1kΩ by some 10% so I chose 10kΩ to put in parallel. This is mental arithmetic. (If it had been to correct a shunt on a calibrated meter, I should have used a calculator for the "right" answer and a close tolerance resistor.) (2) I wanted a precise audio frequency of 364.05Hz (what for is another story). I did think of making a self-maintained tuning fork and grinding an F or loading an F-sharp fork for it. However, I have a box of odd assorted quartz crystals with marked frequencies mostly ranging from 1.8 to 10MHz. I soon found that a crystal of nominal frequency 2.096MHz could be divided by 10, 12, 12 and 4 to bring it close to my goal. A judicious rub of the rock with turpentine and carborundum on a piece of plate glass, a final slight pull with a 40pF series trimmer in the crystal oscillator and four cheap SN74 series (7490/92/92/part 93) gave me what I wanted. I doubt whether I would have had the patience to do the preliminary arithmetic on 20 crystals without the calculator.

John Osborne,
Westminster School,
London, S.W.1.

Printed circuits the easy way

The letter from Mr Rowe (Sept. 1973) contains many useful points but I find it much easier when transferring the drawing to the board to use a piece of Vero board as a drilling jig. If the holes required are marked on a suitable piece of 0.1in matrix Vero board, which is then clamped to the blank circuit board, the holes can be drilled easily and accurately. The copper can then be cleaned and any burrs removed before adding the lines and etching.

Drilling the holes before etching does not appear detrimental to the finished product in any way and the holes are easier to see than centre pop marks, They show clearly even when covered with the resist if the board is laid on an illuminated glass.

J. S. Worthington,
Wallasey,
Merseyside.

Soldering-iron leakage

Mr Adamson is, I am sure, living in a world of his own, if he believes that a three-core mains lead obviates the problem of earth leakage currents (Letters, May). The truth of the matter is that, deplorable though it may seem, there are, and I suspect always will be, those engaged in electronics who, in order to facilitate modifications to their breadboard circuits whilst still operating, remove the earth connection to allow their soldering iron to assume the potential of the joint they are soldering.

The second problem, which I believe is the cause of Mr Sproxton's worries (Letters, March) is more likely to be caused by static charges accumulating on any one of a number of objects usually found in the process of soldering. Static is most likely to damage devices such as f.e.ts, particularly insulated gate devices, either in discrete or integrated form. The objects I refer to are the pliers, cutters, and non-earthed soldering irons, which are usually left lying on a plastic work top, the polythene reels of solder, and most important, the operator with his nylon shirt, rubber-soled shoes, etc.

The professional electronics industry is becoming aware of this problem, and is taking steps to reduce the vulnerability of insulated gate devices, and using conductive rubber work tops and wrist straps to bond the operator to his work.

As far as Mr Sproxton is concerned, he should, in my opinion, advise those of his customers purchasing sensitive devices to work on a metal sheet such as cooking foil, to which he should connect himself and his tools by way of a suitable piece of wire, the connection to his person being made via a metallic watch strap or bracelet. In the interest of safety, he should ensure that any mains operated equipment complies with the relevant British Standard and that, where earthing is required, this has not been disconnected.

Peter M. Clare,
PMC Consultants,
Basingstoke,
Hants.

Sound and light

Having been associated with the design and manufacture of "sound-to-light" units for some years, I was particularly interested in the "Colour-sound system design" by J. R. Penketh in the May issue. Mr Penketh says that he is not aware of any published work relating to the relationship between pitch and colour. While this subject is not easy to investigate, I have come across some references which may be of interest.

It would appear that the first publication on this subject was "Sound and Colour" by J. D. McDonald, published in 1869. In 1883, F. J. Hughes wrote a book entitled "Harmonics of Tones", suggesting a system of matching colours to notes, and in 1884 D. D. Jameson wrote "Colour Music", which proposed additional theories on sound-colour combinations. Building upon these theories, Professor Alexander Wallace, of Queen's College in London, began work on a note-to-colour matching theory, using a mathematical scheme for assigning colour to sounds. His version of the theory states:—

"Taking the spectrum band as the basis of all colours, there are two remarkable points of resemblance between it and the musical octave. The first of them is that the different colours of the one, and the different notes of the other, are both due to the various rates of vibration, acting on the eye or the ear . . .

. . . If we measure the rate of vibration at the first visible point at the red end of the spectrum, we shall find it is approximately one half of what it is at the extreme violet end. Now in music, as we all know, this relationship is the same. If we take the first and last notes of the octave, the latter has nearly double the number of air vibrations and the first note of the new octave has exactly double. This is the case also with the spectrum band. So far as one octave is concerned, the lowest red stands for the first note of the octave and the highest violet for the 12th or last note . . ."

By the late 1800s, using these basic analogies, Rimington had conceived a complete sound-to-colour scale (reproduced here) which allowed him to translate musical scores into colour.

In 1925 Mary Hallock Greenewalt, a "colour musician" of the time, decided to challenge the, by now, classic theory of Rimington. She maintained that no sound finds an exact counterpart in any one colour. She also noted that few musical compositions excited the same sensations in every performer or listener. Her feeling was that colours should not be tied inflexibly to notes, but that each "colour organist" should be free to interpret for himself the colour composition of the music which he was playing.

B. J. McNaughton,
Dabar Electronic Products,
Walsall,
Staffs.

Wavelength of light. Å	395	433	466	500	533	566	600	633	666	700	733	757	Invisible
Approximate colour	deep red	crimson	orange/crimson	orange	yellow	yellow/green	green	bluish green	blue/green	indigo	deep blue	violet	
Musical note	middle C	C#	D	D#	E	F	F#	G	G#	A	A#	B	C_1
Frequency of sound Hz	256	277	298	319	341	362	383	405	426	447	469	490	512

A rather special environmental plea

In an excellent review of the uses of and pressures on the radio spectrum "No room in the radio spectrum" (*New Scientist* 30 May, 1974, page 533), some brief references were made to radio amateurs. There is plenty of evidence that amateurs are regarded by commercial and political interests as uneconomic users of valuable (though limited) bands. They produce neither revenue nor propaganda.

Most of the population is aware of the many pressures from government and big business to reduce or exclude his right as an individual to enjoy special parts of environment. *New Scientist* has pointed out examples such as military occupation of beautiful country, mining in national parks, offshore oil rigs near beautiful coastlines, property development in green belts around cities and so on.

The pressures on the radio amateur are more subtle because his case is not likely to be understood by the population at large. Being a small scattered minority unlikely to be able to produce effective pressure groups and effective influence to protect his interests at critical moments, his position in the spectrum is tenuous and vulnerable. Perhaps the only large body of opinion which can appreciate his case is the scientifically orientated part of the community, broadly represented by your readership and that of *New Scientist.*

Over the years following Marconi's demonstration that he could do the scientifically impossible, enthusiastic amateurs have been doing the same in parts of the spectrum often allocated to them in the first place as being of little commercial value.

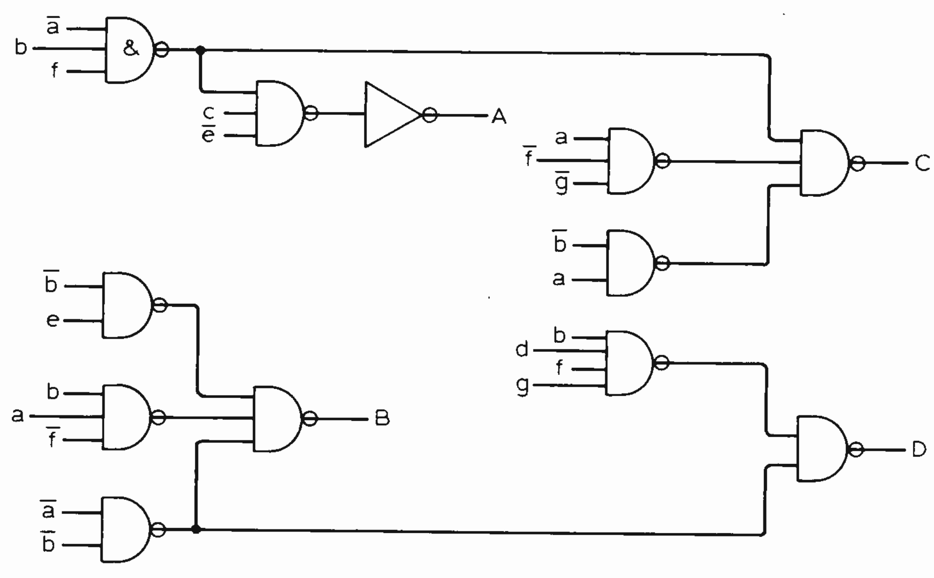
In practice the radio amateur is so individualistic as to defy classification beyond an interest in some form of radio. He is both classless and ageless; numbered among his ranks are schoolboys and Post Office engineers, country parsons and executives in the electronics industry. However, we do tend to fall into two main groups; communicators and experimenters. The communicator is the one who is on the air whenever his wife and his work will let him. He may natter across the parish on top band shared with "fish phone". Or from under the high multi-kilowatt power propaganda stations in the East, operating illegally in the amateur bands, he may winkle out another amateur, both using morse code and internationally recognized amateur jargon, in a remote Pacific island. Such communication is strictly non-commercial and, more important, non-political. Not only do radio amateurs bridge the generation gap but we feel very much part of the "brotherhood of nations".

Then there is the experimenter, such as myself. We use little time on the air, being for ever rebuilding to try something new. But we do need the equivalent of national parks and uninhabited mountains in the form of wavebands where we can roam as the fancy takes us. From our ranks come some of the most inventive and productive electronic engineers, frequently contributing more to the welfare of their firm than those who may have better paper qualifications. In the last world war the radio amateurs' know-how provided a nucleus of reserve specialists whose invaluable contribution to the war effort can hardly be over-estimated, whether in MI5 or the radar valve factory. God forbid the need should arise again but in times of natural disaster the radio amateur again and again has, with inbuilt gift for improvisation, provided communication from within the disaster area when other forms of communication have been completely disrupted.

From the one-valve transmitter in the boy's bedroom to the Californian Kilowatter, we need our recreational space in the electromagnetic spectrum.
G3HMO.

Calculator i.c.

I agree with Mr Coppin that a b.c.d. output of the calculator chip recently advertised for building in to "extended ability" calculators would ease the design problem. Although the full truth table (see below) for the conversion to b.c.d. from 7-segment code suggests a lot of gates, fortunately the 7-segment code is highly redundant and there are some useful "accidents" in the design of numbers. For example, the absence of illumination of the "e" segment occurs on numbers 1, 3, 4, 5, 7 and 9, allowing simple elimination of the 4 to give the "A" line of the b.c.d. code by inversion.



The converter for my home-brewed calculator built round the GIM C500 chip uses four t.t.l. i.cs (costing a total of 80p) arranged as in the diagram. I have chosen to indicate the minus symbol as the 11th code. All gates are NANDs.

Truth table

Display	a	b	c	d	e	f	g	D	C	B	A
0	1	1	1	1	1	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	1
2	1	1	0	1	1	0	1	0	0	1	0
3	1	1	1	1	0	0	1	0	0	1	1
4	0	1	1	0	0	1	1	0	1	0	0
5	1	0	1	1	0	1	1	0	1	0	1
6	1	0	1	1	1	1	1	0	1	1	0
7	1	1	1	0	0	0	0	0	1	1	1
8	1	1	1	1	1	1	1	1	0	0	0
9	1	1	1	1	0	1	1	1	0	0	1
–	0	0	0	0	0	0	1	1	0	1	0

(Columns a–g: 7-segment input*; columns D C B A: b.c.d. output)

*Illuminated segment = 1

D. N. Gregory,
Welwyn Garden City,
Herts.

"A problem of measurement"

I was very interested to read in Thomas Roddam's article "A problem of measurement" (May issue) of his use of the analogy of the Class D amplifier to show that any number of harmonics can be eliminated from a digital waveform similar to his Fig. 2 since the Class D amplifier is in fact forced to do this. Naturally the waveform with its abrupt transitions must contain copious high harmonics but these are, of course, removed by the filter.

(In the Class D amplifier the load is switched via filtering means, alternately to the positive and negative supply lines, at some tens of kHz. The filtered output is made to conform to an audio input by negative feedback to a discriminator, and the result is a modulation of the complementary duty cycles of the two switching output transistors. This secures a modulation of the amplitude of the filtered output. Its attraction is the high efficiency and the small output transistors that may be used.)

I have been using the same "Class D transform" as it might be called, to think about using sequential-access r.o.ms of, say, 64 bits to give fancy digital waveforms which when filtered would be right for electronic organ tones. The class D business obliges by proving that this is possible (though 60 bits would be better) but this is not seen as an alternative to filtering one single pulse per cycle, as the latter gives good opportunities for harmonics from 5th to 20th and on up. It is, however, an alternative to using digital-to-analogue converters fed with sequential data words, which is what computers do when they play little tunes to entertain visitors.

Bernard Jones,
London, W1.

Amateur radio book

Many readers of *Wireless World* are also members of the Radio Society of Great Britain, and will be familiar with the book "World at Their Finger Tips". This was written by the late John Clarricoats and covers the work of many of its members from 1913 to 1963.

The RSGB have honoured me with the task of writing a sequel to this book in order to bring the society's historical records up to date. In order for me to make a success of this and do the society justice I must have information; therefore I appeal to RSGB members who read this journal to send me details of their radio achievements during the past ten years. I would like to have this information by August 31, because there is a lot to do, and I hope to have the work complete within a couple of years.

Ron Ham,
Faraday,
Greyfriars,
Storrington,
Sussex.

PROJECT

A digital clock and calendar

Part 1: A quartz crystal controlled digital clock combined with a ten-millennium calendar, which formed a school project at Cranleigh School, is described by the authors.

by J. F. K. Nosworthy, M.A., Grad.I.E.E. and N. J. Roffe

Ten years ago the construction of a digital electronic clock as a school project would have been considered impossible. The multitude of discrete components, their cost, and the consequent near-certainty of frequent breakdowns in service, would have ruled the project out of consideration. Today, of course, digital integrated circuits have completely reversed this. Provided one has the mental agility to cope with logic design, the digital approach is in many ways much easier than the analogue one, and in most fields results indeed in a better end product. When therefore we decided three years back to commence work on an electronic clock, one of the reasons for this choice of project was that it would provide for the boys and the teaching staff involved a thorough practical introduction to modern digital electronic practice and logic design.

With this criterion in mind, we decided to carry the digital programme through to the point of incorporating with the clock a perpetual calendar since this would take us, via a gentle introduction in the form of digital dividers and counters, right through to memory circuits and multi-variable programming. To complete the job, we also decided that the frequency source for the unit should be a high-accuracy crystal oscillator; that we would incorporate a running monitor of accuracy by comparing our frequency with that of the BBC 200kHz transmission; and that we would incorporate such refinements as stand-by power supply with automatic changeover, electronically lockable controls, and a "hold seconds" device which would give us a partial stopwatch facility. The programming, we decided, should be really 100% and contain all the fixed conditions of which we had advance knowledge, so that no routine adjustments or alterations to the clock and calendar should be necessary during its designed cycle. Thus, not only are the number of days in each month automatically adjusted, but a further adjustment is made in each leap year, and a further adjustment still in each century leap year. We set the total cycle of the clock at 10 millennia, since this allowed us to display all four digits of the year and also set the end of the cycle to a point in time sufficiently remote for us not to have to worry about the adverse comments which would occur on the day when it would finally read a long row of noughts! (Dec 31, 9999 is, we consider, a reasonable time ahead). The total number of digits displayed by the clock is therefore 15; comprising the year (4 digits), the month (2 digits), the day (2 digits), the hour (2 digits, 24-hour basis), the minute (2 digits), the second (2 digits), and tenths of seconds (1 digit). The displays are by Nixie tubes, the choice of display methods being determined mainly on grounds of capital cost. The complete unit is made up of five rack-mounting panels. The top panel houses the oscillator, divider chain down to the 0.1-Hz point, the BBC comparator and the setting-to-time controls. There are two small indicators which monitor the functioning of the crystal oven. The next panel contains all the display tubes (starting with years on

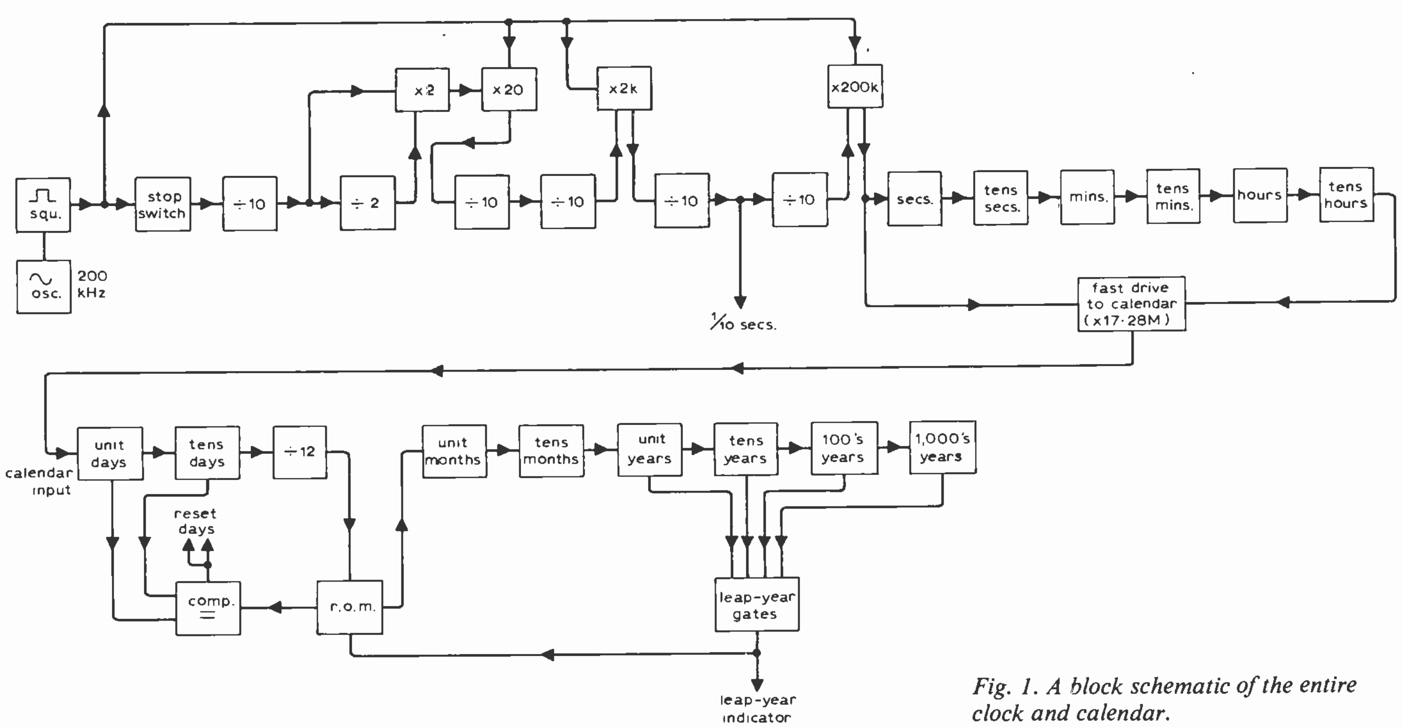


Fig. 1. A block schematic of the entire clock and calendar.

the left, finishing with 1/10th sec. on the right); a small l.e.d. indicator to the left of the years shows leap years; the switch above the seconds aperture is the "hold seconds" control. This panel also houses the remainder of the divider chain, i.e., down to one pulse per millennium, plus the drive units for the Nixies, plus the calendar logic. The two remaining panels are concerned with power supply, that for the Nixies being the topmost and the main power unit being the lower of the two.

The overall measurement of the assembly is 36 × 24 × 12 in. Much of this space is in fact wasted because the layout had to be designed so that a number of boys could work on each unit simultaneously, which implies a larger than necessary number of physical sub-units each containing only a few components. Actually an exception to this principle had to be made for the more complex units such as the calendar logic board and the BBC comparator, which could be allocated to relatively skilled individuals.

Fig. 1 gives the (simplified) overall block diagram. The main circuit-chain for the clock unit is perfectly conventional, starting with a 200kHz quartz crystal-controlled oscillator and finishing with the display of hours—these are displayed on a 24-hour basis, the 24th hour registering as 00 for the sake of simplicity in the hours reset circuitry. The three seconds displays are fed via storage elements so as to provide the facility for "freezing" the seconds and tenths count for spot-readings (i.e., semi-stopwatch facility). We are not describing the divider-chain circuitry in this article since it has been done several times before. However, the crystal oscillator circuit and waveform shaper may be of interest and is given in Fig. 2. The production of a stable frequency and its interfacing with t.t.l. does in fact present a certain amount of difficulty. It will be seen that the crystal is resonated in the series-resonance mode, and whatever the oscillator circuit adopted it is vital that the mode of resonance should be firmly delineated by the circuit conditions. Certain commonly used crystal oscillator circuits show indecision as to whether the crystal shall resonate in the series mode or the parallel one; and since the two modes are almost invariably not synonymous (although they may be close), hunting between the two can occur, giving effectively frequency modulation of the output at a sub-harmonic of the crystal frequency.

Running parallel with the clock divider chain are the circuit blocks providing setting to time and adjustment facilities. These are, in essence, simply bypasses for selected portions of the divider chain, allowing various degrees of fast running, also a "Stop" facility. The fastest setting speed provided bypasses the oscillator straight through to the calendar unit (i.e., days input), giving a multiplication of 17,280,000,000 and allowing the entire ten-millennium loop to be run through in 18.25 seconds (this is rather fun to play with). Simple mechanical switches, at first sight the obvious way to do the job, cannot be used because it would be difficult to render them inoperative. Instead, the bridging is achieved by logic blocks. (See Fig. 3.) In each block, the output follows either of the two inputs according to the setting of S_1, the fast-run switch. All the fast-run switches are locked out of operation simply by lifting their common earth via S_2, which is a key-lock switch. S_3 gives the "Stop" facility, and this is also locked out by S_2. This circuit could in fact be simplified by the use of AND-OR-INVERT gating, but our method gives the advantage of using components already required in quantity for the rest of the clock.

Accuracy monitor. The circuit diagram for this is given in Fig 4. The monitor is, as has been said, a running comparison of the clock oscillator frequency with that of the BBC Droitwich 200kHz transmission. So far as we are concerned, the latter may be regarded as a frequency standard, since it is maintained to within two parts in 10^{11} (representing a clock accuracy of within 0.0006 seconds per year). The monitoring method adopted is a continuous display of the phase angle between the two frequency sources; we are not of course concerned with the angle itself but with whether or not it changes, and if so at what rate. The phase angle is displayed on a centre-zero meter which will therefore, as the wave trains move relative to each other, beat from +ve f.s.d. to 0 to −ve f.s.d., corresponding to relative phase angles of 0° to 90° to 180°. Simple arithmetic reveals that one complete cycle of the meter movement

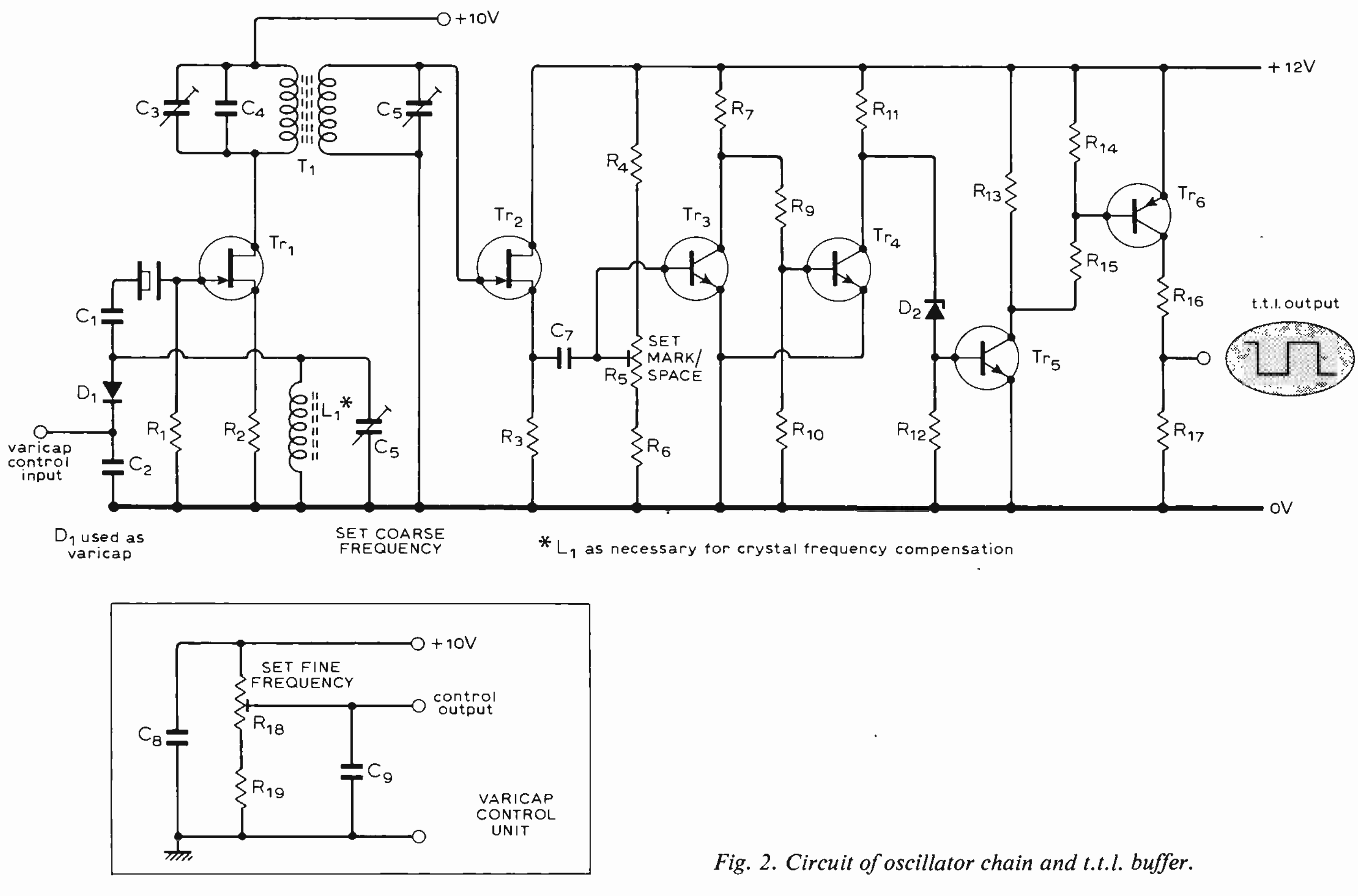


Fig. 2. Circuit of oscillator chain and t.t.l. buffer.

indicates an accumulated time error of 1/200,000th sec. Our design accuracy is 1 part in 10^7, so that it is necessary that the beat frequency shall be less than one cycle per 42 seconds.

It is necessary to process the BBC signal to a pure carrier wave, i.e., the a.m. signal content must be removed. This is done by means of a phase-locked loop, IC_1 Fig. 4. Detailed explanations of p.l.l. action can be obtained by reference to manufacturers' literature (Signetics do an excellent publication), and was also covered in outline in a previous *Wireless World* article[1]. The sensitivity of the device is high, but its input impedance is low; and since also it works best in the balanced-input mode we found the front-end circuitry to be necessary. Capacitor C_{13} sets the nominal v.c.o. frequency of the p.l.l. and has been quoted at varying figures by different authorities for the same frequency (200kHz in this case). The manufacturers show a very small-scale graph in their data sheet of C versus frequency, which leaves the exact value pretty vague. The answer appears to be to adjust on test, as we did; so that the value shown should perhaps not be taken as authoritative. The output from the p.l.l. contains a d.c. component (6V), accounting for buffer capacitor C_{17}. The a.c. output is a square wave, of equal mark-space ratio, locked precisely in frequency to the incoming carrier, and of amplitude 0.6V pk-pk. This amplitude is too small for direct use, so two stages of amplification follow, Tr_9 and Tr_{10}; the latter being driven between saturation and cut-off so that a total swing of V_{cc} magnitude (15V in this case) is obtained at the top end of R_{29}. Between the p.l.l. output and this amplifier, Tr_8 is inserted as a buffer and impedance-converter. This was found to be necessary in order to preserve the squareness of the waveform, which is essential for correct operation of the phase angle comparator.

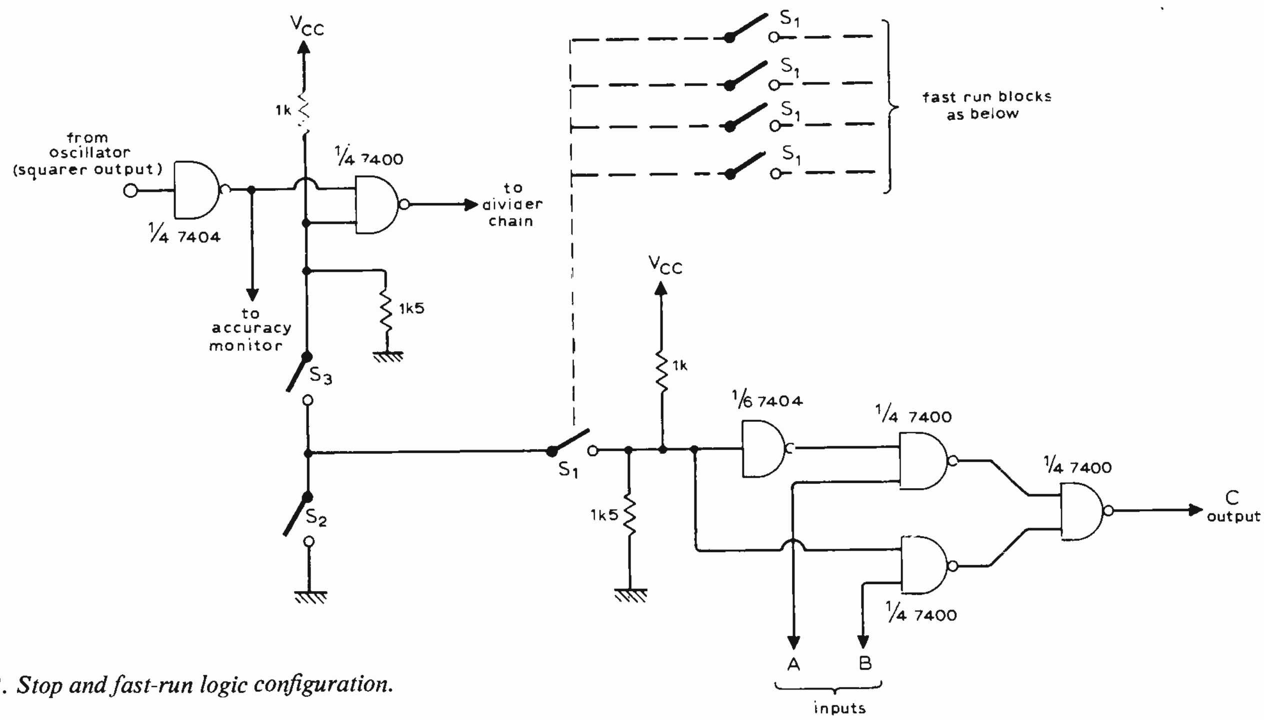


Fig. 3. Stop and fast-run logic configuration.

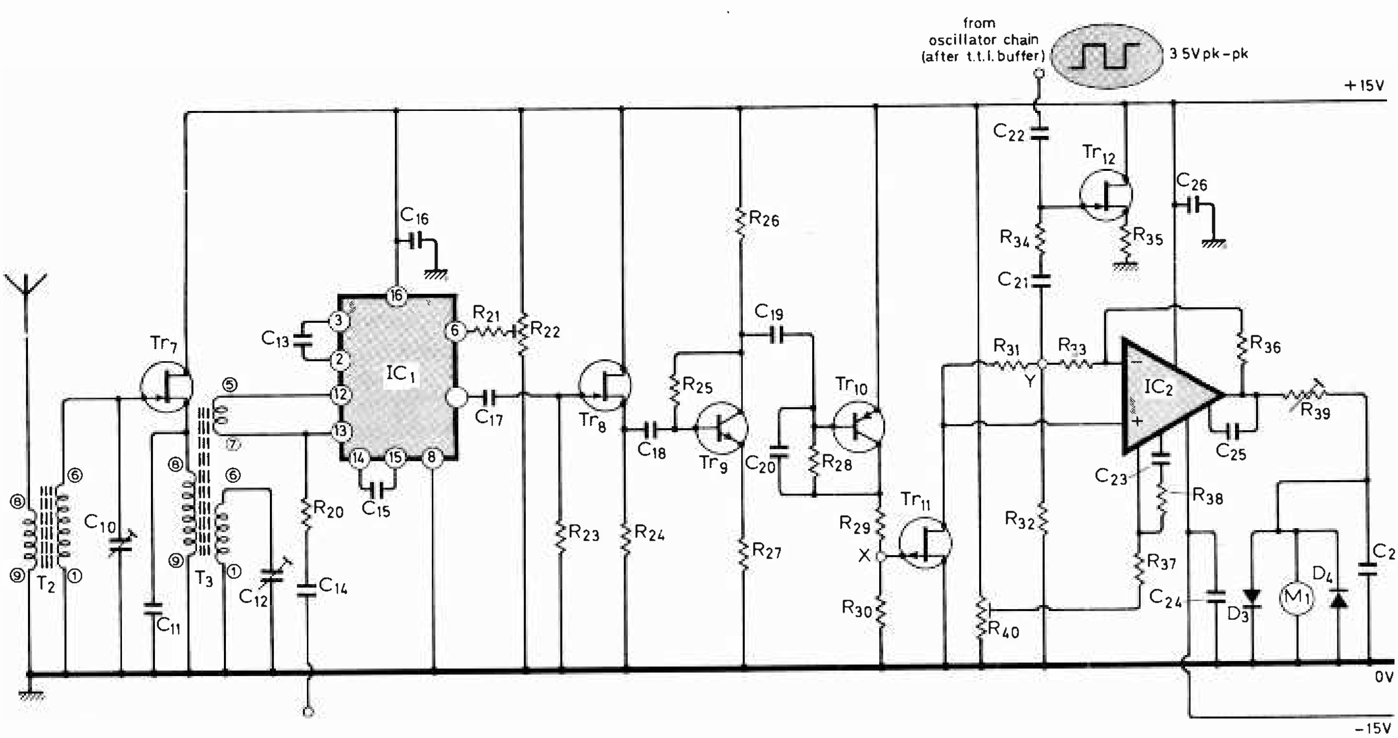


Fig. 4. Circuit of the accuracy monitor which compares oscillator output with a BBC transmission.

Comparison of the relative phase angle is carried out by IC_2 and Tr_{11}, the two inputs being fed in at points marked X and Y on the diagram (note Tr_{12} buffer for the other channel input). This part of the circuit has been recently dealt with in this journal[2].

The output from IC_2 is fed to a centre-zero meter M_1 via integrating network R_{39}, C_{27}, so that provided the relative drift frequency is sufficiently low the meter will give a direct reading of instantaneous phase difference. The resistor R_{39} adjusts for meter sensitivity (it also in fact changes the integration time-constant, but this is unimportant in this application). Resistor R_{40} is provided to adjust for zero offset voltage at the output of IC_2, which would otherwise appear as a constant added to the reading on M_1. It should be noted that Tr_{11} must be a p-channel f.e.t., since it is fed with a +ve-going signal. The magnitude of this signal must be such that it swings Tr_{11} fully between the fully-conducting and the cut-off states; this is why we have first of all amplified the X signal to approximately full V_{cc} magnitude, to ensure full positive swing, and then attenuated it by tapping down on the R_{29}, R_{30} network in order to avoid overloading of Tr_{11}. In our initial design we did in fact allow for R_{29}, R_{30} to be adjustable, but in the event such precision proved to be unnecessary.

One rather interesting point which emerges from analysing this comparator circuit is its action on a square waveform for both channels. The circuit is usually analysed with a sine wave applied to the controlled channel (Y) and a square wave to the controlling channel (X). Under these conditions, the d.c. output from IC_2 is proportional to the cosine of the relative phase angle (i.e., to cos ϕ). With two square waves, however, the output is proportional to ϕ direct, i.e., the meter could be scaled linearly in degrees or radians.

(To be continued)

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I.Cs for radio, audio and television

The Electronics Components and Materials division of Philips at Eindhoven recently showed us a range of integrated circuits for use in consumer applications. The remarkable total of 26 new circuits has been released—or will be towards the end of the year—16 of them intended for use in television receivers, 10 for radio and audio equipment. In some cases, the new i.cs replace first-generation types, others offering the advantages of integration for circuit functions not previously attacked.

The intention has been, in developing these more comprehensive modules, to reduce the number of adjustments and peripheral components a manufacturer has to cope with, not simply to reduce the number of i.cs by larger-scale integration. For example, a TV receiver using the new circuits needs the adjustment of 10 controls, in contrast with one using the older units which required 20 adjustments. Again, the receiver now needs 160 external components against a previous minimum of 320. All this has been brought about by the ability to use a larger chip in the same technology as before.

Television

Two new **vision i.f.** circuits, TDA2540 and 2541, for n-p-n and p-n-p tuners respectively, are 3-stage, low-noise amplifiers with a.g.c. on each stage (S:N −56dB at 40dB a.g.c.). Interference spikes are clipped and inverted, giving a grey rather than a peak white spot. Several combinations of i.cs can be used in **colour decoders** —a no-compromise set including the TDA2500, the TDA2510 and TDA2520. Contrast and Luminance control, chrominance processing and demodulation are carried out, the two colour reference signals being obtained by digital means from a crystal-controlled oscillator.

The TDA2650 **vertical deflection** chip, working in Class B and capable of supplying 4A p.p. with current feedback, contains trigger-pulse shaper, oscillator, S-correction and height adjustment. The current is sufficient for monochrome and small colour receivers; for larger colour tubes, the i.c. supplies half the deflection current, being assisted by a BD201 transistor. The switched-mode deflection circuit TDA2600 dissipates less than half the power of the TDA2650, and contains sawtooth oscillator, switched-mode amplifier and pre-amplifier subjected to current-derived feedback for linearity and temperature-insensitivity.

Three **touch-control** i.cs, the TDA2620, 2630 and 2631 provide selection for up to 16 channels, indicating the selected programme by gas-filled indicator, mute the sound during selection and allow a chosen programme to be always selected on switch-on.

Other television i.cs include **Sync. processor** units and a switched-mode **power supply** drive. The TDA2570 sync. module is unusual in that the frame sync. is derived from the line frequency by a digital 625 divider.

Sound reproduction

The TBA570 **a.m./f.m. receiver** includes on the one chip, mixer, local oscillator, i.f. amplifier, a.g.c. amplifier and detector for a.m., a 10.7MHz amplifier and limiter for f.m., a front-end bias stabilizer for f.m. and most of the audio section. External circuitry is limited to the front ends, i.f. filter, f.m. detector and audio output.

Most of the functions of a **tape-recorder** are provided by the TDA1002 and 1003. The former incorporates a preamplifier for use as mic. input stage or playback preamplifier, and a recording amplifier with automatic level control, which operates as a dynamic limiter. The TDA1003 provides for motor speed control, delivering a voltage-stabilized motor drive, and, as the speed control is only operative when a pulse train produced by the spool mechanism holds off the stop circuit, the automatic stop function is built in. On the same chip is a temperature-stabilized voltage reference source with an a.g.c. amplifier which controls the bias and erase oscillator—also on the chip.

Several **car radios** and **audio power amplifiers** are included in the new range and some of the i.cs are specifically intended for use in high-fidelity sound systems. There are stereo decoders, a.m./f.m. receiver chips, preamplifiers and some very interesting **d.c control circuits** for volume, balance, contour (loudness) and tone controls. These, the TCA730 and TCA740 (tone) employ differential amplifiers for remote control. The controlling potentiometers can be mounted where convenient, for the signal is not required to leave the chip. Rumble and scratch filtering is afforded by the use of a tone control chip, the function needed being selected by external components. An additional benefit conferred by the use of these chips is that single potentiometers control both channels.

Two modules have been produced for use in **electronic tuning** systems. TCA530 provides a stabilized tuning voltage, the reference diode being on the chip, together with a heater and thermostat. A.f.c. is generated and is automatically disconnected during tuning. The same functions are contained in TCA750 (external reference diode needed) with the addition of two extra voltage stabilizers to power receiver stages and a stereo indicator. A search tuning facility is provided.

An **interference suppressor** for f.m. reception, the TDA1001 works by delaying the audio signal in a low-pass filter and amplifier, deriving a trigger pulse from it to initiate a gating waveform at the onset of an interference spike and interrupting the delayed audio signal by means of the gating pulse. The audio signal is kept constant during this period, as is the 19kHz pilot tone.

The new circuits are the result of co-operation between development teams in the Netherlands, Germany and the U.K., and represent a considerable European lead in the consumer application of integrated circuitry.

Quadraphonic quandary

Comments on surround-sound development

by B. J. Shelley

International Recording Studios, Rome

If we can succeed for a while in subduing the recent quadraphonic-ambisonic-tetraphonic-pantophonic pantomime of word-building, and should we succeed in controlling our possibly premature matrixidal tendencies, it might be possible to produce some kind of clear over-all view of the current philosophies, practices, and possibilities, in a rather more methodical and illuminating fashion. This might give us a better idea about the present consensus, if any, of technical opinion and psychoacoustic knowledge concerning augmented stereo systems.

One ought to be very appreciative of every serious contribution which helps to advance the recording art, and of every theoretical discussion which can throw useful light on a very confused situation. Some of the more recent articles appear to have originated with such intention, but have in many instances caused greater confusion.

What, for instance, is one to make of the statement that two channels can only carry two channels-worth of information, followed a moment later by the assertion that two channels can be encoded to carry unambiguous directional information, not only round a circle but also over a whole sphere?[1] Is the phrase "unambiguous directional information" to be interpreted as meaning signals which the ears can use to obtain an adequate directional impression in a prescribed listening arrangement? How many loudspeakers are required? Pressure radiators or dipole? If the "information" is "encoded" does that mean that it has to be "decoded" for playback? What role does ear-summation play in such a system? Does it satisfy the inherent requirement for simultaneous spatial image distribution? What prevents the adoption of such a system where only two channels are postulated for 360° of directional effect, or is there some practical objection to *this* two channels-worth? Does it fail, perhaps, to hold to a reasonably benign limit the effects of cue perversity? Or is the "unambiguous directional information" merely an academic device for describing a set of relationships within a frame of reference not quite relevant to the purposes of the ears of a listener using a small number of discrete loudspeaker sources? Is the "information" not *accessible*, or is it just *wrong*?

Questions of this sort must arise in the mind of any serious enquirer when critical points of a subject are presented with such evident, though possibly unintended, semantic abuse.

Controversy in the evolution of various technologies is no novelty and its usefulness is recognized in many cases. In the present confused state of multichannel development it is difficult to avoid the impression that controversy has sprouted a disproportionately large growth of loose and premature conclusions. Thus, contrast the statement of Bauer[2] that 90° of phase shift spreads the image over the whole span of the loudspeakers, with that of Cooper and Shiga[3] that there is no stereo source spread when 90° of phase shift are imposed. There is obviously something amiss here.

"Contrast the statement of Bauer that 90° of phase shift spreads the image over the whole span of the loudspeakers with that of Cooper and Shiga that there is no stereo source spread when 90° of phase shift are imposed."

Or again, contrast the position of Bauer[2] when he declares that the efficacy of a system or matrix is to be appraised by asking how well it replicates the sound of an original master tape, with that of Fellgett[4] who condemns as a fallacy the supposition that the objective is to imitate a blended four-channel tape. Or the suggestion of Fellgett[4] that the "overhead" quality experienced by some listeners to normal stereo may be the result of an incorrect relation between pressure and particle velocity, with the work of Leakey[5] who demonstrated by a mathematical analysis that head movement can explain the ofttimes apparent elevation of a stereo image.

Faced with such apparently opposed positions the quadraphonic quagmire comes as no surprise.

I do not propose to investigate the important details underlying the existing controversy. But much can be learned by retracing one particularly important step in the development of stereophony.

The very earliest proposals in stereo were based on the extremely rational concept of a system in which the "ears of the auditor are effectively transferred to an original sound scene" by means of a double channel using a dummy head and earphones. This theoretically ideal system, with its then dazzling superiority to mono somehow gave birth to an almost unconscious traditional idea and subsequent misdescription of a stereo system as the transmission of an original sound field. Whereas, of course, it is the transmission of signals from a very limited number of representative static points of a sound field—two in the binaural case about eight inches apart—but producing for a listener with headphones a remarkable stereophonic illusion.

It is this two-points-to-two-points that constituted the "effective transfer" to the original sound field. The subjective impression may indeed be overwhelming but there is no doubt that the listener's head has not been placed into a sound field or that an original sound field has been recreated. Physically, we have merely presented him with the pressure variations corresponding to two selected points of a complex original field.

All this may be well enough known and understood, so that the point may seem to be rather laboured. But the curious deceptive habit of thinking in terms of the transmission of a sound field was probably one of the main reasons for the continued fallacious use of the dummy-head technique with loudspeakers, long after the time that spaced loudspeakers came to be used. The fallacy was noted and explained[6] in 1931 but passed unnoticed for many years.

". . . we are still at the present time in need of much more psychoacoustic knowledge about multiple-source listening and localization."

The important step in development, i.e. the use of spaced loudspeakers, required for its proper implementation that the signals be generated in quite a new way to fit the changed pattern of listening, where each loudspeaker contributes a crossed-over signal to the ears. Some good results were obtained on an empirical basis*. Even better results were forthcoming by noting experimental and theoretical findings which demonstrated the need to fill certain basic requirements, such as the creation of appropriate intensity differences in the two channels.

The "recreated sound field" now becomes an array of virtual images. These result from the interaction at the listener's ears of two signals so processed as to give a composite interaural relationship adequate for an illusion of spatial distribution. We do not recreate for him an original sound field. We give him suitable raw materials and his ears and brain do the rest. If this were not so we would not have the problem of the whole thing moving when the listener moves.

Thus, neglecting reflections, what is physically present in the room is two distinct intersecting wave systems, one from each loudspeaker; not an original sound field. Similarly in the case of quadraphony, and again neglecting room effects, what is physically present is four intersecting waves radiated by four separate loudspeakers. There is just no purely physical mechanism whereby these four wave systems are made to combine or interact so as to modify their fixed source positions. This can be done only by the ears, if the four signals have been suitably tailored. And the operative word here is suitably. It is in order to find out what is suitable that we are compelled to study those practical and scientific findings which apply to the four-source listening pattern.

". . . It is no tragedy that the first clarinet is 15° off true position . . . Nevertheless it is not easy to escape the conviction that proper directionality is desirable at least as a design objective in a standardized listening pattern."

Any tendency to proceed on the basis of creating or recreating a sound field, divorced from considerations of the ear-summation process, is merely a continuance of the previously-noted fallacy. After over a decade of schooling in two-channel stereo techniques it is perplexing not to find a wider awareness of this ideational trap. Fanciful diagrams of a reproduced sound field, of "rotational symmetry", and so on, all need very cautious evaluation. They may have definite validity if clearly used as psychophysical models, i.e. as subjective projections by an average listener. But even when such representations are clearly so intended we are still at the present time in need of much more psychoacoustic knowledge about multiple-source listening and localization.

*The remarkable fact that some kind of improvement or enhancement results for many people with almost any kind of two-source listening is not surprising. The optimization process may be regarded as still unfinished.

The new four-source listening proposal makes it necessary to extend the more limited previous frontal localization studies. For example, where previously we were concerned with a listening angle of about 60° we now have a new frontal angle closer to 90° with the additional two sources at the rear. Assuming that empirical and/or theoretical laws for computing localization are of practical usefulness in the design of such a system, it seems obvious that the rules applicable to the two-channel case may not be quite suitable for this new and more complex pattern. This may apply especially to the stereophonic law of sines[5], which was in any case rather imprecise, as noted by Leakey, notwithstanding its later adherents and notwithstanding its continued widespread use and the existence of improved computational formulae[5].

Of course, one can agree with Crowhurst[7] that it is no tragedy if the first clarinet is 15° off true position as long as all the instruments sound real and individual. Nevertheless it is not easy to escape the conviction that proper directionality is desirable at least as a design objective in a standardized listening pattern. The post-transmission variables may be quite numerous (exact speaker placement, room quality, etc.), but this is no reason to produce a system whose characteristics might turn out to be quite outside the normal expected range of variations of this sort.

In spite of flagrant claims it is doubtful if we are yet in a position to draw up a relatively valid specification of signal relationships for four-speaker listening with separate channels. Gerzon's assertion that "the optimum characteristic is not known" in regard to a particular tetraphonic technique[8] could be equally well applied to any quadraphonic system. The optimum characteristic is still very much in the melting pot, and its refinement therein seems to have been slowed down by the premature addition of an ingredient called 4-2-4 matrixing. The resulting alloy: optimum characteristic plus 4-2-4 matrix, might turn out to be quite an attractive compromise; but I have the feeling that the whole process would benefit greatly from an independent refining of the first and principal component.

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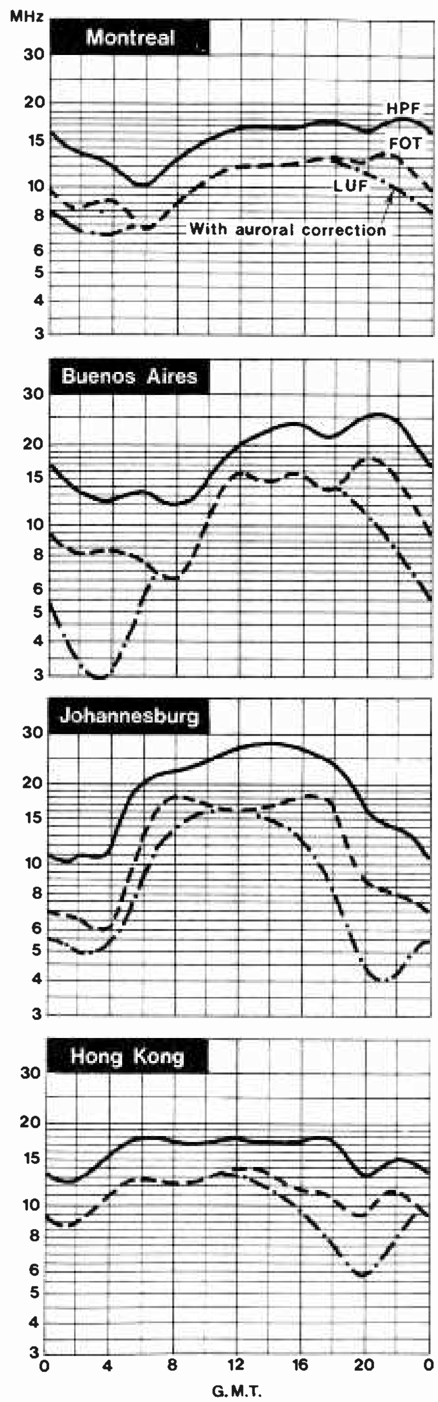
HF predictions for July

For consistent day to day communication operating frequencies should lie between FOT and LUF. Outside these limits reliability decreases. For example 14MHz for South Africa will fade in between 04 and 06 GMT, stay open until 08 GMT, come in again at 15 GMT and fade out between 18 and 22 GMT.

Magnetically disturbed days are forecast as June 26 to 30, July 7 to 18 and 22 to 27.



Dolby f.m. transmission in the UK?

by Basil Lane

Assistant Editor, Wireless World

The name Dolby has become almost a household word amongst those hi-fi enthusiasts and professionals who specialize in cassette and, for that matter, reel-to-reel tape recorders. This is because it has now become a universally popular method of reducing the noise contribution introduced by the recording process. At the domestic level, the less complex B System has been applied with considerable success in a wide variety of products. However, it now seems possible that the Dolby noise reduction system will become an even more familiar term in the near future.

In America, over the past year, many f.m. broadcast stations have been examining the possibilities of using the B system to reduce high-frequency distortion, improve s/n ratio and produce an improvement in the area of stereo coverage and a reduction in the likelihood of interference. Such has been the response by the broadcast stations who have tried the system, that recently the American Federal Commission gave permission for Dolby B transmissions to be made on a regular basis and also, in conjunction with the introduction of the noise reduction processor, to reduce signal pre-emphasis time constant to 25μs from 75μs.

This move has lent weight to a recent request made by Gerry O'Reilly, Chief Engineer of Capital Radio, to the IBA for permission to experiment with the Dolby B processed transmissions. Using this system it is hoped that an improvement in the quality of reception in its area of London and the surrounding districts will be obtained. At the moment, the IBA is actively considering this proposal and is having meetings with Dolby Laboratories. It is to be hoped that this will produce a rapid and favourable decision as, in the opinion of this author, any experiment likely to result in an improvement of broadcast quality is worth carrying out. However, it may be apposite to consider the proposals in detail and further examine the likely impact upon the listener as seen in the light of the American experience. First, however, a brief description of the Dolby B process as applied to broadcasting.

Dolby B and f.m. broadcasting

Two papers have been published on this topic, one of which[1] outlines the system and the results of a full-time broadcast experiment made in New York. The second[2] provides more comprehensive description of the proposals, from which the following has been drawn.

The B-type noise reduction system is complementary, that is to say a compressor is required at the transmitter and an expandor at the receiver. Since, subjectively, it has been shown that the perception of noise is mostly confined to the high frequencies, the B system is designed to take advantage of this and operates only on high frequencies. The processor used for companding consists of a main signal path and a side chain containing a variable-bandwidth filter which continually adjusts itself to accommodate changes in the amplitude and frequency content of the incoming signal.

Although the B-type system has seen its widest application in the sphere of the cassette recorder, it was designed from the outset with f.m. broadcast applications in mind and it is fortunate that the noise problems are in many ways similar to those of tape recording. Taking this into account, it was also considered by the designers to be a useful opportunity to correct any minor faults in the present system of f.m. broadcasting which can be eliminated as a result of the introduction of the B-type noise reduction system.

One prominent problem with modern f.m. transmissions lies in the value of pre-emphasis applied. In America, the time constant used at the moment is 75μs and here and in Europe a 50μs standard is applied. This results in 3dB boost points at around 2kHz and 3kHz respectively and a final boost at 10kHz of about 14dB and 10dB respectively. In recent years, with an improvement in the bandwidth of microphones and line transmission systems and, above all, the development of modern styles of music with greater high-frequency energy content, this has been a cause of some embarrassment to the transmitter engineer. The possibilities of over-modulating the transmitter at these frequencies has increased so much that now it has become recognized practice to accept the unpleasant requirement for a signal limiter before the transmitter.

Dolby claims that the introduction of the B-type system makes a unique opportunity to correct for this problem by reducing the time constant and to correct the subjective effect that such a reduction in time constant produces, by taking advantage of the happy coincidence that the subjective effect of B-type compression is the opposite to reduction in time constant. In this way, the combination of the two can produce a reduction of high-frequency distortion by eliminating the need for limiting, and a reduction of noise received by using the B-type processor.

A principal factor which brought the original problems to light was the introduction of the present stereo transmission system which results in a poorer received signal-to-noise ratio than the monophonic transmission. The actual values are 23dB for 75μs and 21.5dB for 50μs. Using the reduced time constant proposal and adding the B-type compressor makes it possible for broadcasters to increase modulation levels and thus improve the stereo coverage in areas of poor signal strength. The remaining factor to be considered is the problem of receiver compatibility, since this has been one of the principal factors which has prevented a change of time constant in the past.

Compatibility

The subjective effect of a B-type transmission is to provide a signal which is bright, with the high frequencies being boosted by up to 10dB. However, the reduction in the time constant of pre-emphasis nicely compensates for this and Dolby claims that the final effect upon an unmodified receiver is a very satisfactory compatibility, with no improvement in signal-to-noise ratio.

Naturally, there are, as yet, few receivers available which incorporate the B-type noise reduction processors and to cope with this Dolby recommend the addition of the so-called B-type adaptor at the output from the decoder or tuner together with the addition of a simple compensator to reduce the receiver time constant to 25μs. A circuit recommended for such a purpose by Dolby is reproduced in Fig. 1 together with a graph of its effect in Fig. 2.

Since it seems likely that experimental transmissions of the B-type processed form are likely to start fairly soon, it may be worth considering purchasing and making these units up, should any reader wish to listen in and obtain the full advantage of the improvements. How-

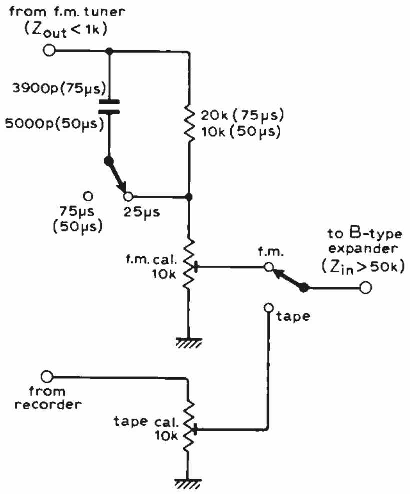


Fig. 1 Time constant compensator for use with non-Dolby tuners and receivers and tape recorders.

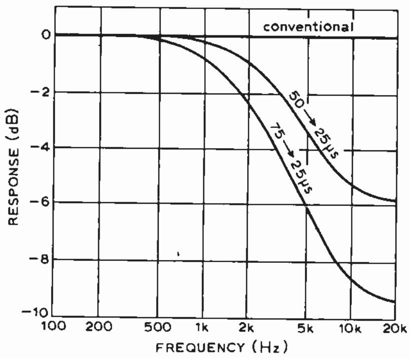


Fig. 2 The characteristics of the time-constant compensator.

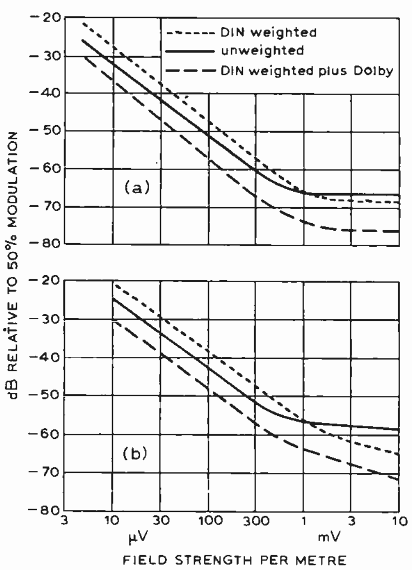


Fig. 3 (a) Noise performance of a Sony ST-5000FW for stereo and mono signals. (b) Noise performance of the Radford FMT2 MPX.

ever, please note that announcements about the commencement of any such experiments will be made on Capital before the event and readers should be patient if these seem to be some time coming. Further developments and a questionnaire will be published in a future issue of *Wireless World* to enable readers to report on the standard of reception to the Chief Engineer at Capital and a report will also follow in the journal.

Experimental results

Experiments have been made at several levels to evaluate the results of these proposals, the first of these being laboratory experiments made by Dolby Laboratories of London. These involved the use of a Radiometer SMG1 Multiplex generator connected through calibrated attenuators to two tuners. These were the Sony ST-500FW and the Radford FMT2 MPX. With the signal calibrated in terms of that produced by a dipole in a field of given strength, the wideband signal-to-noise ratio of each of the tuners was plotted for given signal strengths and with mono and stereo transmissions. An additional measurement was also made using the DIN weighting characteristic. All measurements were made using the 50μs characteristic and the results are reproduced in Fig. 3. In both instances the tuners required a signal strength of about 1mV/m to produce the signal-to-noise ratio of 60dB and, in addition, the increase in noise predicted theoretically for a stereo signal is confirmed by the measurements. The weighting characteristic used for the DIN measurement demonstrates that the main effect is an increase in high-frequency noise when switching from mono to stereo.

Further experiments showed that when B-type encoding was employed, the signal strengths required to produce an equal signal-to-noise ratio to the non-encoded signal dropped by about 9dB for the Sony tuner. It was also reported that listening tests under conditions of 40dB or better signal-to-noise ratio confirmed that a drop in signal strength of up to 10dB was adequately compensated for by the introduction of B-type processing and the time constant change.

Subsequent to these experiments, demonstrations were carried out by WFMT broadcast station in Chicago in which listeners were invited to report on the standard perceived by them of both processed and non-processed signals. Some had been properly equipped with Dolby receivers, others had made modifications of their own and added Dolby adaptors. The results were broken down into several categories and of those who were properly equipped, 85% reported an improvement in signal-to-noise ratio. In the non-equipped sector, receivers were subdivided into hi-fi and low-fi. In the former case, 80% preferred the encoded transmission and 12% indicated no particular preference, whilst in the low-fi bracket, 60% showed a preference for the encoded signal and 25% were "don't know".

Subsequent to these experiments, several American stations have commenced full-time broadcasting of Dolby processed signals and such is the mark of their success that the FCC have given approval for the use of the combination of Dolby processed transmissions using the 25μs characteristic.

Calibration

Since the B-type process is complementary and involves the use of both compressor and expandor and it does not rely upon pilot tones to provide a reference for the correct restoration of the received signal, it is of great importance to ensure that the complete system, from compressor to expandor, is properly aligned.

This alignment can be achieved through the use of a reference tone which, in the case of the f.m. system, corresponds to a modulation level of 50%, or a deviation of ±37.5kHz. Normally the decoders incorporated at the time of manufacture can be adjusted to the correct calibration during the production process, but in the case of the add-on units, a tone will have to be broadcast at intervals to permit the correct threshold to be set.

As far as the transmitting end is concerned, no alterations are required apart from incorporating the compandor since it has built-in adjustment for the pre-emphasis.

For those who have a Dolby equipped tape recorder or cassette recorder, it is possible, with the use of the compensator, to record the Dolby transmissions direct without the use of the processor and then to subsequently decode the signal using the tape recorder's own processor. The broadcast calibration tones should be used to set up the tape recorder in the usual way as outlined in the user manual.

Conclusion

This, then, represents the state at the present moment; Capital feel confident that the use of this system will bring advantages to their listeners and have asked for the co-operation of *Wireless World* readers in checking on quality. It is hoped that the IBA will arrive at a favourable decision for the early experiments and should these take place in the near future, a questionnaire will appear in this journal to enable readers to take part in what could be a significant development in UK broadcasting.

References

1. Robinson, D. P., *JAES*, June 1973, Vol. 21, No. 5, p 351.
2. Dolby, Ray M., *JAES*, June 1973, Vol. 21, No. 5, p 357.

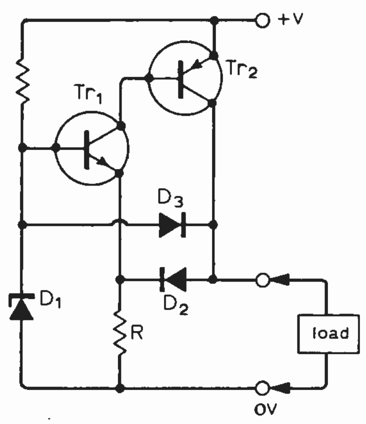
Circuit Ideas

Foldback in current-limited supply

A simple and useful addition to the current-limiting supply of A. E. T. Nye (*WW* June 1973, page 285) is a diode which will provide current foldback with overload conditions.

The diode D_3 is added between the zener point and the load. This normally has a small reverse voltage across it, and does not affect the operation of the circuit until current limiting occurs (see Nye for mechanism) and the load voltage starts to drop. It will then become conducting, diverting current from the zener diode, reducing the zener point voltage and hence the load voltage further. At high output current settings (output current limit is set by R: high means currents above the β maximum for Tr_2) a current foldback action occurs. As the load resistance is reduced below that which produces limiting the output current decreases progressively until at short circuit the output current is only that flowing through the zener bias resistor and D_3. At low current settings, the output is immediately bootstrapped down to the zener resistor current, but will bootstrap itself up again with a small increase in load resistance.

Foldback limiting characteristics are of course preferable to crowbar or fuse protection because the circuit is self-starting as

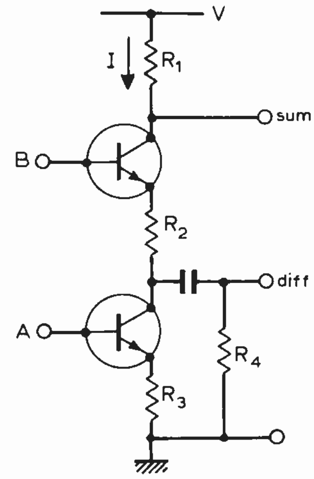


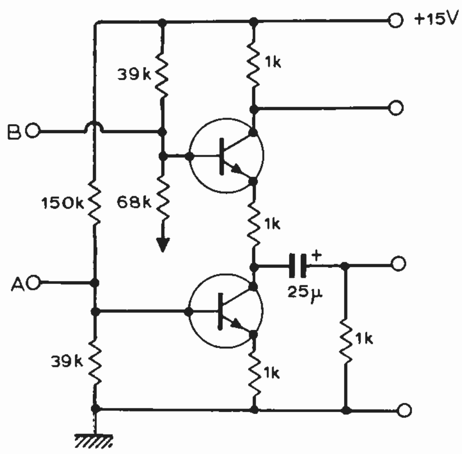
soon as the overload is removed. They are also usually preferable to current-limiting characteristics as they produce shutdown of both the power supply and any driven circuit, avoiding the worst case of heat dissipation on short-circuit.

P. C. Bury,
Victorian College of Pharmacy,
Parkville, Australia.

Active sum and difference circuit

The first circuit below shows a simple, economical and effective method for summing and differencing two signals and is particularly effective in stereo and quadraphonic applications. When $R_1 = R_2 = R_3 = R_4$ the upper output is $-\frac{1}{2}(A+B)$ and the lower output is $-\frac{1}{2}(A-B)$. Using the values shown in Fig. 2, with $V = 15$V and $I = 2$mA, input signals up to 1.4 volts





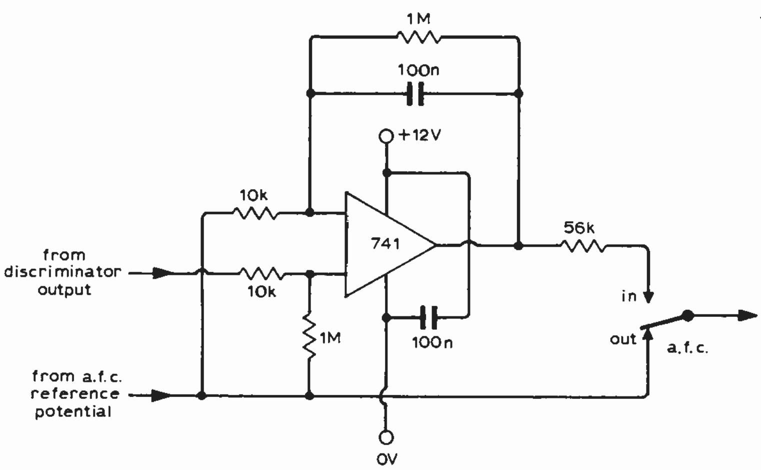
r.m.s. may be applied. Transistors may be BC109 or similar. Slight adjustment to R_4 may be made to obtain exact null for equal antiphase inputs. By using other values for the resistors in the collector and emitter leads different weighting factors can be easily obtained. An A output is also available at the lower emitter, and a B output at the upper emitter, both at fairly low impedance and with low crosstalk. NB: Bottom of the 68-kΩ resistor should be earthed.

B. J. Shelley,
Rome.

Improved a.f.c. for f.m. tuners

A simple d.c. amplifier can be added to the a.f.c. circuit of virtually any f.m. tuner, and, for all practical purposes, will eliminate tuning errors over the entire lock-in range of the existing circuit. This has proved particularly useful with the Nelson-Jones tuner, where the loop gain is rather low, and where conversion to varicap tuning has introduced several potential sources of drift. The additional components cost less than 50p, and can be mounted on a piece of 1 + 1½-in fibreglass p.c.b.

J. S. Wilson,
Amersham,
Bucks.



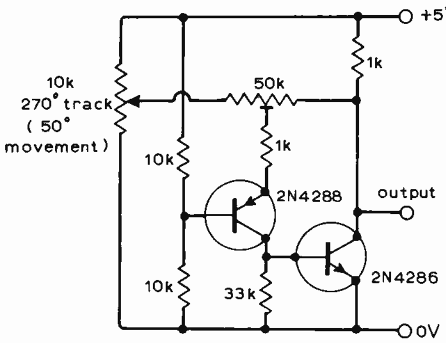
Phase-locked loop teleprinter unit. K. S. Beddoe, whose circuit was published in the December issue page 605, tells us the following components should be added to the MC1310P integrated circuit:

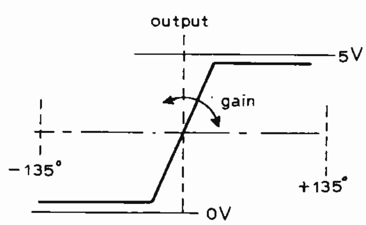
250nF capacitor between pins 8 & 9
50nF capacitor between pins 3 & 11
5.1kΩ resistor from pin 4 to the +12V rail
5.1kΩ resistor from pin 5 to the +12V rail.

Wide-range "joystick" control

Joystick control potentiometers are finding new applications, but some of these are hindered by the necessity of obtaining or modifying potentiometers to work with the relatively small 60° or so movement given by a joystick lever. Normally, standard potentiometers are modified by the inclusion of a tapping at the 60° point (approximately) or by special manufacture of potentiometers for specific applications. This is not only expensive but can also create problems if replacement potentiometers are required at short notice.

The circuit shown is versatile, inexpensive (certainly compared to obtaining special potentiometers), and due to the negative feedback of the two-stage amplifier, can give significant saving in current drain for a given output impedance. Additional power supplies are unnecessary.





The two-stage feedback amplifier compares the output with the voltage at the wiper of the control potentiometer. The preset control allows the gain of the amplifier to be set to any required value, and thus match any given mechanical movement of a standard potentiometer to the output voltage swing required. In practice, this matching is achieved much more easily than by exact mechanical matching of the angle of travel of a special potentiometer to a particular joystick unit. It has the further advantage that as the control potentiometer is always operated well away from its terminations; there is no "jump-on" non-linearity.

I. R. Francis,
Flight Link Control Ltd,
Hounslow.

APRS 1975

Seventy-two exhibitors displayed the latest equipment in the field of professional sound recording at the Connaught Rooms, Kingsway, London, on June 21 and 22. About 2,000 visitors including 122 representatives from overseas attended the 7th annual exhibition. Many developments in equipment and techniques have taken place over recent years in the industry (see "Professional Sound Recording" June issue, p.211) and this was reflected in the high quality and wide range of facilities offered by the equipment on display.

Items of interest included a multichannel peak programme meter utilizing a colour TV tube. The meter can indicate the levels of up to 28 channels in groups of four by vertical bars of changing length. In the overload condition the colour of the displayed bars changes to red and, in order to identify particular channels, the colour of these bars may be changed remotely from the monitor desk. The scale is electronically generated, while the video signal is based on the 625-line TV standard. The RGB output enables a standard colour TV monitor to be used. Cost for 16-track plus four master channel displays is around £1,700 and the unit type 377-100 is manufactured by NTP Electronik, Copenhagen.

The MSR series 2000 disc-cutting lathe system is the result of several years' development and has been designed to cut monophonic and stereophonic masters and direct replay acetates to exacting requirements. A range of four turntable speeds has been arranged to facilitate half-speed cutting of quadraphonic masters. The 16in diameter turntable weighs 40lb and is driven direct by a servo controlled d.c. motor without the need for belts, idler wheels, flexible gears, etc. An opto-electronic device mounted on a motor shaft generates pulses relative to the turntable speed; these pulses are compared with a reference pulse train derived from a crystal controlled clock and any error is fed back for correction to the motor driving the turntable. The shaft of the motor and the turntable conveys a vacuum to retain the recording blank and also serves to collect swarf from a point directly behind the cutting stylus. A method of "varigroove/varidepth" control enables optimum use to be made of the available record surface. This requires three programme inputs from the tape replay machine, namely left and right advance head channels and the left programme channel. These signals are analyzed for programme level and frequency spectrum, and equalized to the RIAA recording characteristic, thus making space available on disc for the stylus excursions due to programme modulation. Control information applied to the above signals is used to compute both the vertical and lateral mode of operation.

The Millbank Electronics group were exhibiting a new input module for studio mixers, designed for incorporation into recording desks for replacement or new installations. Circuitry is mounted on a small p.c. board which can be plugged into separate controls. It is expected that in its final form the facilities offered will be mic (low Z balanced and line) inputs, l.f., m.f., and h.f. equalization, echo send and pan control. Another new Millbank product on display was an announcement machine, designed for use in broadcast stations to announce forthcoming events, jingles, etc., at the press of a button. The unit automatically fades out programme material, which can be in mono or stereo.

The Studio 8 series of professional recording machines shown by Ferrograph are now of adaptable construction and were on view in transportable and console arrangements. Trolley and rack-mounting versions will be produced later.

An interesting cartridge, designed specifically for broadcast and studio applications where a closely controlled frequency response and a robust stylus assembly for back-cueing are required, is the model SC35C available from Shure. The blue-coloured stylus grip has a cut-away for improved visibility of the irradiant orange-coloured stylus tip for accurate positioning when cueing. A "heavy duty" shield minimizes stray electromagnetic hum pick-up.

A new standard level studio tape is now available from Pyral (UK). This is a ferric oxide polyester based tape, CJ86, available in $\frac{1}{4}$, $\frac{1}{2}$, 1 and 2in widths. The main specifications for this tape are: coating 11μm: backing 35μm; intrinsic coercivity 25×10^3 A/m; remanent induction $0.092\,\text{Wb/m}^2$; output level for 3% distortion + 11dB; s/n ratio 58dB, s/print-through ratio 62dB; stability at 10kHz is ± 0.01 dB (this is an improvement over the previous specification due to coating on a new type of machine), reference level is 320nWb/m. A standard $\frac{1}{4}$-in sample at 38 cm/sec will give an output of + 2dB at 1kHz, + 2dB at 10kHz and + 3dB at 15kHz.

The show was organized by the Association of Professional Recording Studios.

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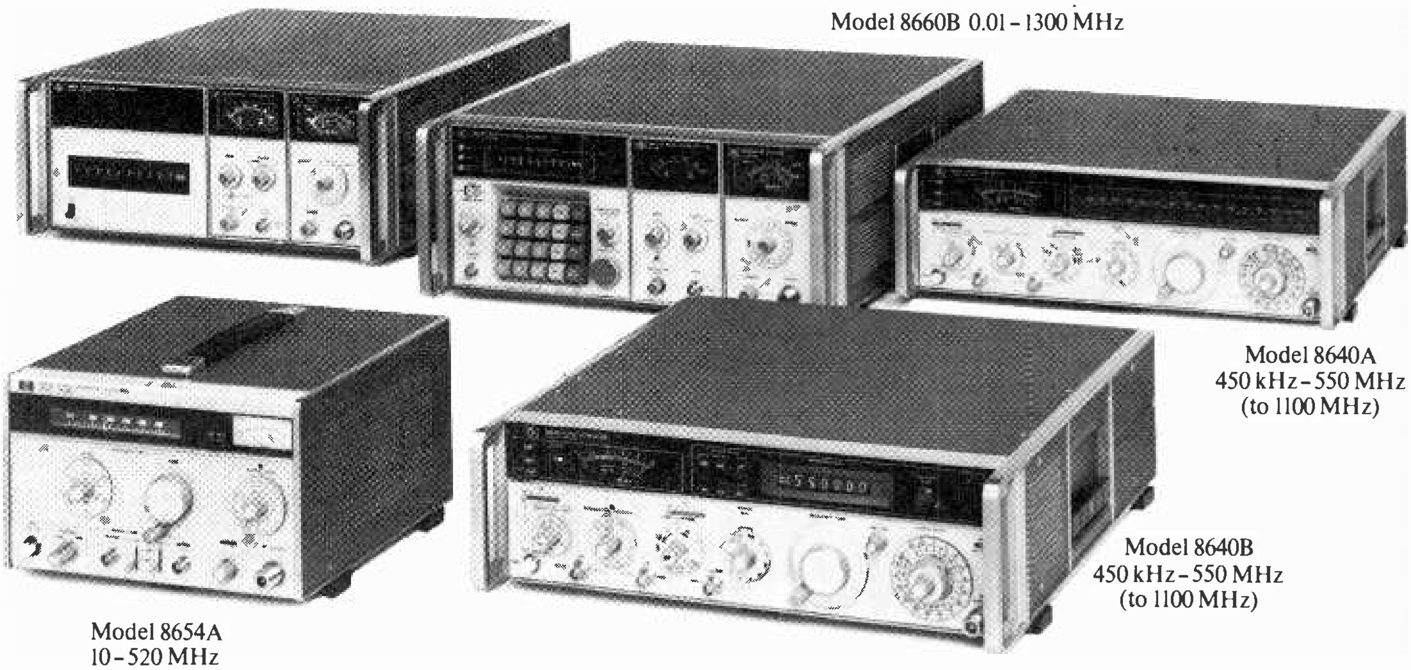

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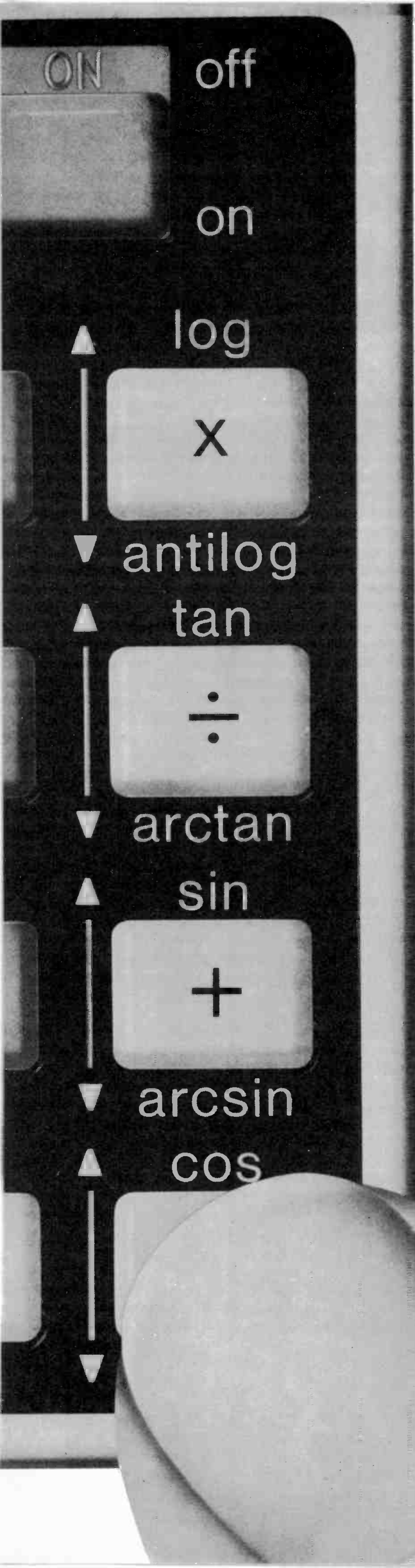

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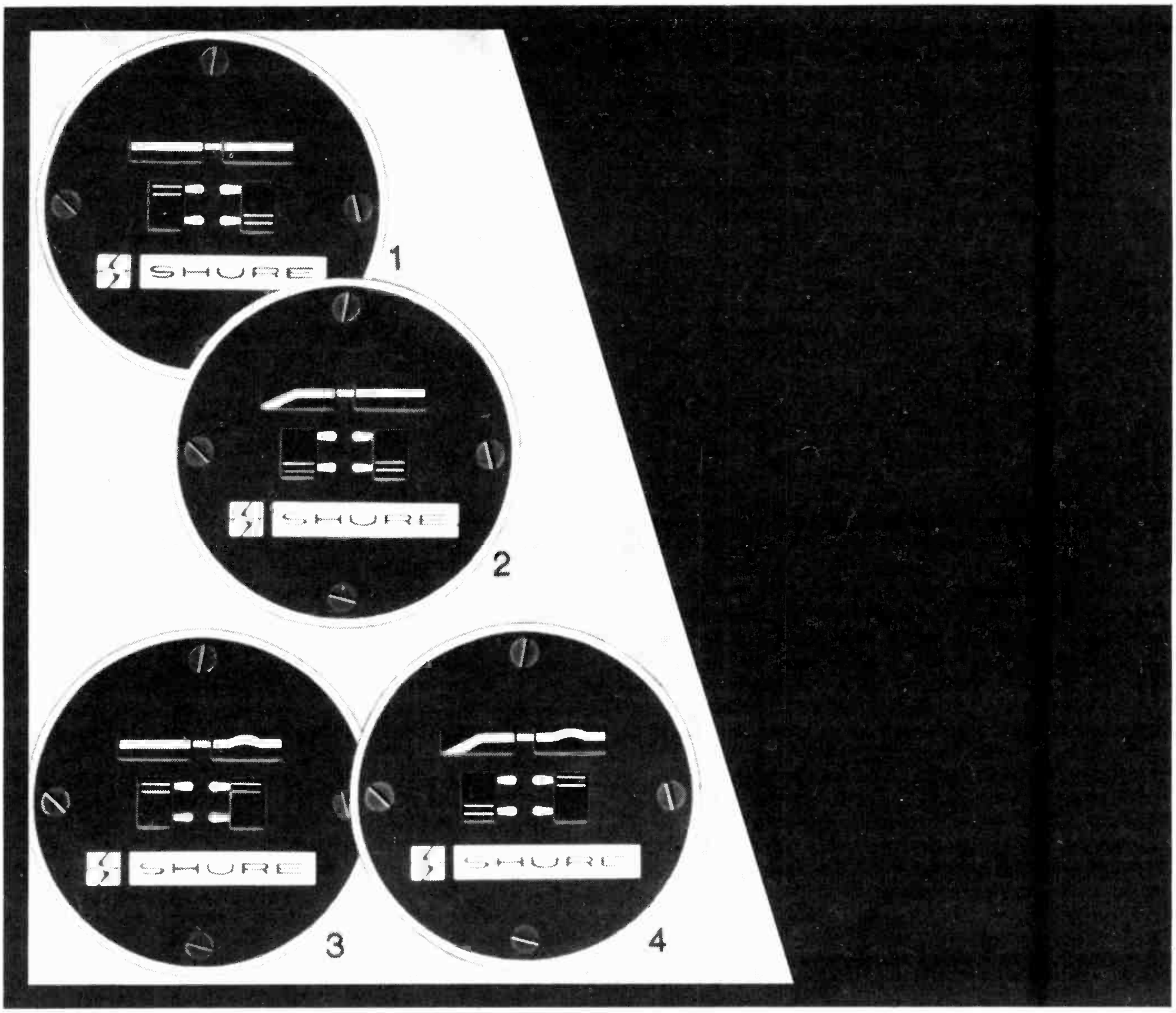
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Electronic telephone exchanges

Conclusion: computer-controlled systems

by M. T. Hills

Department of Electrical Engineering Science, University of Essex

The previous article explained the requirements of a telephone exchange designed to work with the existing network. It also explained the role of electronic techniques, which was primarily in the control rather than the actual switch. This article deals exclusively with the application of computers to the control of telephone exchanges. This type of system is frequently referred to as stored programme control (s.p.c.), In general the computers used are specially designed for the purpose in order to meet the very stringent system reliability requirements and the switches they control are still electro-mechanical as explained in the earlier article.

The major advantage accruing from the use of s.p.c. is that of flexibility. Since a telephone exchange has a life of 20–40 years then many changes are necessary as the system evolves. If the system is controlled by a computer, it is a simpler process to modify the programme than to institute wiring changes and the design and construction of additional relay sets. A further advantage is the possibility of providing remote supervision and maintenance of an exchange via a data link.

A computer-controlled exchange can, in addition, provide a range of new facilities for the actual subscriber, some of which are described later. However, there is little that an s.p.c. system can provide that cannot also be provided by other modern exchanges but usually with less convenience.

From the manufacturers' viewpoint, the advantage of s.p.c. is that hardware can be provided to cater for a wide variety of practical needs and it is possible to produce a family of systems by means of standard processors which interface the appropriate memory and switching equipment.

Principle of s.p.c. system

The first major system based on this principle was the No. 1 ESS designed by Bell Telephone in the USA and put into service in 1965. The general diagram of this system is shown in Fig. 13. The switching network itself consists of "ferreeds" (Fig. 14) which are a modification of a reed relay using magnetic latching rather than an electrical latching.

The complete system is under the control of a central processor which communicates with the switching network by

Fig. 14 A "ferreed"—a magnetically latching reed relay.

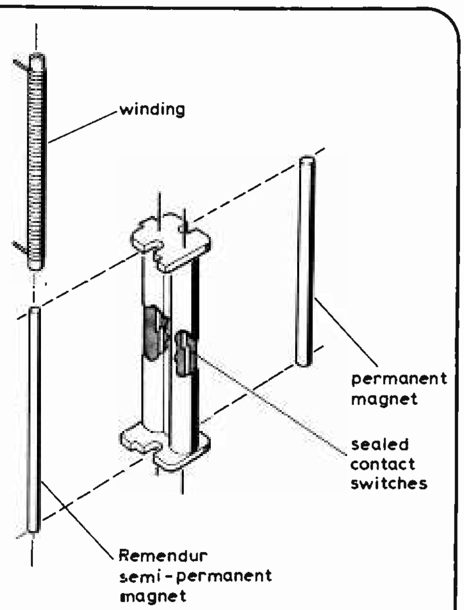
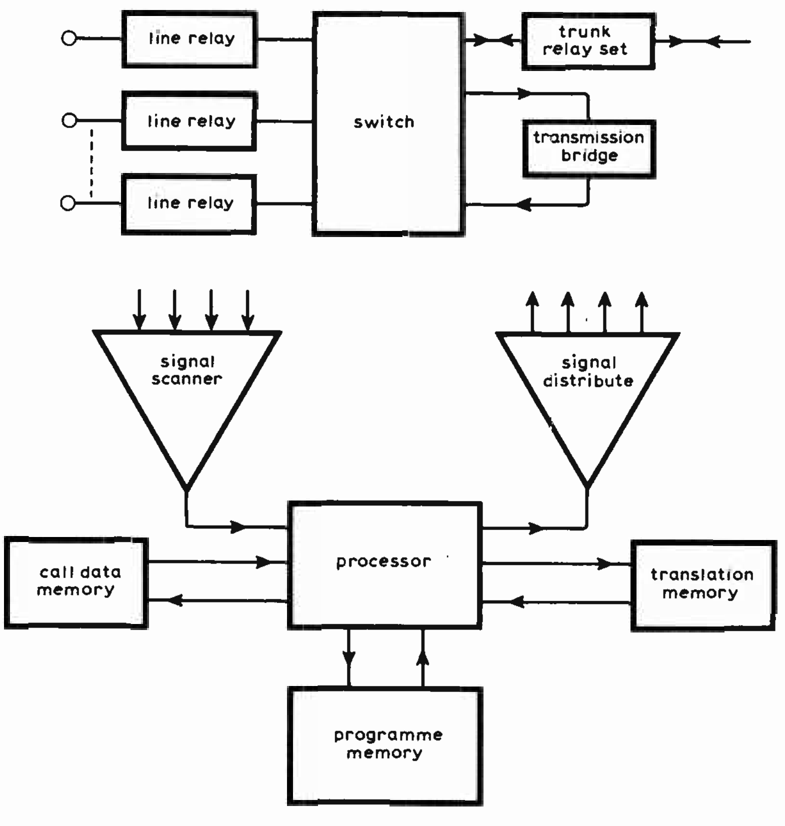


Fig. 13 Block diagram of No. 1 ESS stored programme control exchange.



means of a scanner to sense the state of subscribers' lines and relays, and a distributor which operates relays on instructions from the processor. Within the processor there is a real-time clock which interrupts the normal operation of the processor every 10ms and forces it to start a scan programme. The processor then issues a series of instructions which sequentially interrogate the line conditions of all subscribers. The line condition is detected by means of a device called a ferrod; this is a saturable transformer whose windings are in series with the subscriber's line. To interrogate the line a pulse is applied to one winding, and if there is no line current the device acts as a normal transformer and the pulse may be detected at a sense winding. When there is line current flowing, the device saturates and no output is obtained.

On each 10ms interruption a proportion of the lines are scanned, so that each line is scanned at least once every 200ms. Within the computer memory is stored the result of the previous scan and this is compared with the current result to determine whether any change has occurred. If a change has occurred then the address of the line, together with the change, is placed on a list within the computer member for further processing.

When the processor discovers that a subscriber's line has gone from open to closed circuit, it is necessary to connect that subscriber to a register to receive the routing information. The scan programme would have placed the address of the calling subscriber in a list associated with the set-up programme. This set-up programme is initiated at regular intervals and first checks whether the calling subscriber has any special facilities, such as tone signalling. The programme must now find a suitable free register, a path between the calling subscriber and that register and then operate the switch to set up that path.

In order to find the free register and suitable path, the processor maintains a map in its memory of the state of the network. Within the store there is one bit for each register and each link. If the register or link is busy then that bit is set to "1". A simple check of the appropriate bits will find the free items needed. Instructions are then issued to the distributor to operate the relevant relays and the appropriate bits within the map are set to "1". When call clear down is detected the processor must instruct the distributor to release the relevant relays and clear the appropriate bits within the map.

Once the subscriber is connected to the register he will receive dial tone. If the subscriber has dial pulse signalling the computer can determine the dialled code if it samples the line condition every 10ms. A simple programme counts the number of make and break pulses to interpret the digits.

When enough digits have been received the programme can determine their meaning which will usually be to a subscriber within the same exchange or to an outgoing trunk line to a particular route. By use of the map in its memory the computer can find the free path and set it up.

It is at this stage that the power of an s.p.c. system may be felt since quite complicated programmes may be used to interpret the dialled digits into actions. Some of the functions that may be performed are described later.

Processor organization

The processor is a specially designed system and has three separate memories.

1 Programme. This contains all the sequences of instructions needed to operate the exchange and provide all the diagnostic aids needed. In the original No. 1 ESS this consisted of a mechanically alterable read-only store. A more recent development of the No. 1 ESS uses an electrically alterable read-only store.

2 Data store. This contains the transient information pertaining to a particular call. In effect it provides the register function. It uses a form of magnetic core store.

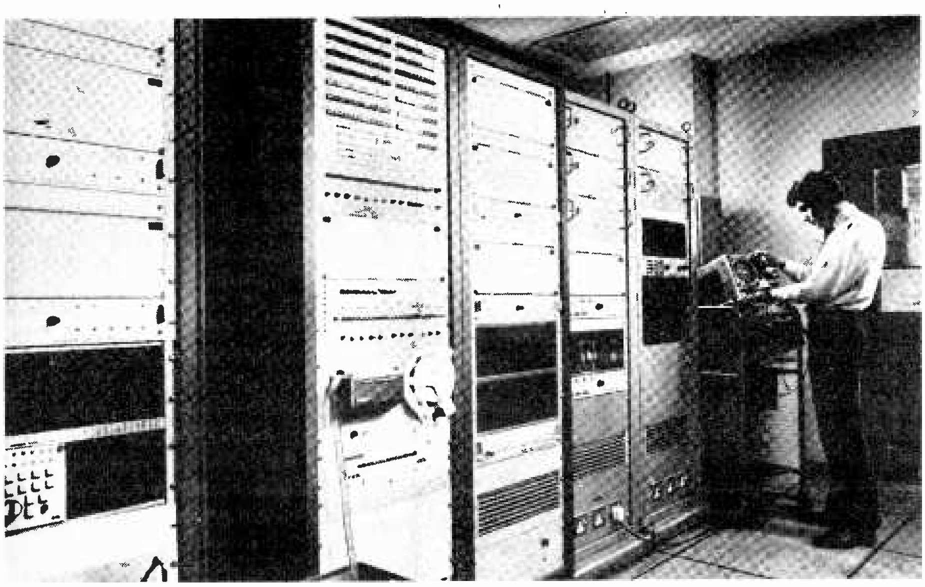
3 Translator store. In any particular telephone exchange there is a large amount of fixed data which gives information about the directory number and facilities of individual subscribers, the route translations corresponding to the dialled codes, etc. Since the system is designed to have the same programme in all exchanges, the translation data also includes the parameters giving the size and configuration of the particular exchange. In the original design this, too, was a mechanically alterable read-only store and this, too, is converted to an electrically alterable read-only store in the recent developments.

One of the main design problems of a computer-controlled system is that of reliability. A single fault in the processor could make the complete exchange inoperative. Existing electromechanical systems have a very high system reliability and the probability of an electromechanical system going off the air for more than a few seconds is of the order of once in 50 *years*. The mean time between failure for a processor is far below this. In the No. 1 ESS system the processor is completely duplicated. There are two memories, two processors, two highways, two scanners, etc. A number of fault-detection circuits are incorporated in the system and if any malfunction is detected then both processors are automatically put into a self-diagnosis routine in order to find which processor is working and which subsystems, such as translator memory, are working. Unless the detected fault is severe this self-diagnosis will merely deny service requests for a few seconds and it will not affect established calls. However, if the fault has been such that the stored information has been corrupted it may be necessary to break down all established calls and restart the programme with a clear memory.

Because of the self-diagnosis and the necessity for a range of restart procedures depending upon the severity of the fault, this part of the programme can be as much as that used for normal processing. In the No. 1 ESS the total programme size is over 100,000 words, each of 44 bits.

The cost of this type of system is high and it is therefore only economic when it is controlling a large number of lines. Another area of application is the exchanges providing access to the international network, where the signalling requirements for the many different international circuits are complex.

The other main area where computer-controlled systems will have an immediate application is in the computerization of operator-assistance positions. The use of a computer-controlled system can provide a wide range of additional facilities to the operator and thereby make her work more efficient. This represents a large saving to her administration and therefore pays for the computer system. A further saving in this application results from the use of p.c.m., since it is possible to locate the operator boards up to several hundred miles away from the actual switch and interconnect via p.c.m. links. This



The Plessey System 250 multi-processor.

means that the operators may be located in places where there is a ready availability of labour and one does not have to rely on their location at the centre of large cities where accommodation and labour are scarce.

Additional facilities offered by s.p.c.

The main economic advantage of s.p.c. is to the administration in that it can save manpower in the process of managing the exchange. For instance, with an s.p.c. system it is possible to change the subscriber's information by means of a teletype situated at some central point. One use of this would be to set in the data store information which indicated to the programme that a subscriber was barred outgoing calls. Thus when a subscriber is late in paying his bill, all the administration need do is to type his number plus a code, rather than send an engineer to the local exchange to make a wiring change. Other management facilities are traffic measurement, remote maintenance, etc.

A wide range of additional facilities is also available to the subscriber himself, but it is not yet clear how much more he would be prepared to pay for these services. Some examples of services are:

Personal code calling. Each subscriber can maintain a list in the exchange of frequently called numbers. If this list has fewer than 100 numbers they can be recalled by means of a two-digit code only.

Transfer of calls. By dialling a special prefix code followed by another number the computer can arrange that any future calls to the subscriber's number will be transferred to the new number. This is a service which is currently provided for doctors but needs prior arrangement with the Post Office. Under computer control the facility would be available to anybody and to any other number (within the same exchange area). This could be very useful if someone was visiting a neighbour but expecting a telephone call.

"Follow-me." This is an alternative version of the transfer of calls, whereby a person may dial a special code followed by his *own* telephone number which will divert calls made to his number to the telephone at which he initiates the request. In other words his calls can be made to "follow him around". Naturally, precautions must be taken to prevent unauthorized use of this facility.

Call waiting. When a subscriber is already on a call, if a further person tries to ring him he may be given a short tone to inform him that somebody else is trying to get him. He then has the option of terminating his existing conversation, in which case he will be rung as normal, or, in some cases, by sending a signal to the exchange he can switch to the new call and talk privately to this person while still holding the original call.

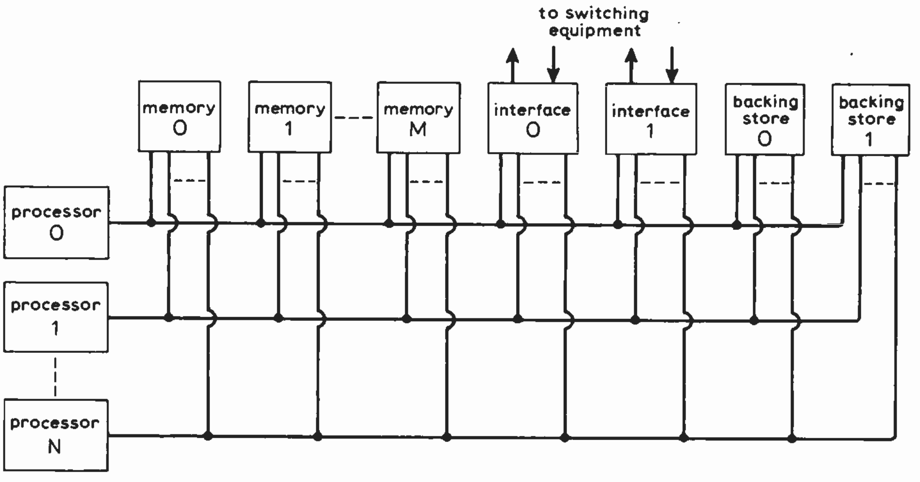


Fig. 15 Principle of multi-processor control system.

Alarm-clock calls. By dialling a code followed by a time the subscriber can arrange for his telephone to be rung at that time and connected to some recorded announcement.

These are only a few of the facilities that can be offered, but at the present time these are just a useful bonus to the use of s.p.c. rather than an economic justification for s.p.c. itself.

Current developments in computer systems

In order to increase the area of application of computer-controlled systems, a considerable reduction in their cost is necessary for the smaller exchanges. Current development of systems in North America and Europe is aimed at reducing the cost of the existing systems by using up-to-date technology and more streamlined construction. Since a high proportion of the cost resides in the programme memory, ways have to be found to either reduce the cost of the memory or reduce the amount of the memory that is necessary. In a duplicated system there are two copies of the programme contained in a magnetic core store (or possibly semiconductor memory store). Alternative approaches to duplication are being developed in the UK by GEC and Plessey. These aim to reduce the total cost of the memory and increase the reliability of the system by using what is called a multi-processor system. In this type of system (shown in Fig. 15) the processor part of the computer is separate from the memory and two or more processors each have access to all memory banks. In general only one copy of the programme is stored in the memory bank, and sophisticated hardware checks are used to ensure that it has not been corrupted. A spare copy of the programme is kept on some form of backing store such as a magnetic drum. This type of backing store provides a much lower cost storage medium but the access time would be too slow for normal use. However, under fault conditions it is possible to copy a new version of the programme into a magnetic core store. The GEC Mk. IIB and the Plessey system PP250 are both examples of this type of organization.

An alternative approach to cost reduction, being pursued by the British Post Office as well as by many other administrations abroad, is that of area control. Although a particular exchange may need extensions of only 1,000 or so lines in any particular year, within an area the total number of lines installed in a year could be sufficient to justify a computer-controlled exchange. The concept of area control envisages a computer centre which can control a number of remote extensions by means of data links. Thus the cost of the centralized processor system may be shared by a number of installations.

One of the other design problems of a computer-controlled system is the massive programme needed to control and maintain the system. Of recent years much effort has been put into the development of software aids to simplify the programming tasks and to make possible the modification of the programming to add new facilities, etc., once the system has been accepted into service. The first conference on software Engineering for Telecommunication Switching Systems took place at the University of Essex. This drew an international audience of experts from as far away as Australia to discuss and compare the techniques that have been developed, which include high-level real-time programming languages and other software aids.

The future

The British Post Office has recently announced its plans for the modernization of the telephone network. This provides for a gradual replacement of Strowger equipment by more modern systems which are capable of providing not only improvement in service quality but also additional customer facilities. These plans involve a continuation of cross-bar systems and the introduction of the new TXE4 reed-relay system for the new large exchanges. Development is proceeding towards what has been called System X for the future, which is likely to be introduced from about 1980. The details of System X and the balance between electronic switching, computer control, digital transmission and so on, is currently being decided. The next few years should be very exciting for the telephone engineer.

World of Amateur Radio

Solid-state 1296MHz beacon

More than a thousand man-hours of work spread over nine months have enabled Dunstable Downs Radio Club to bring on the air an all-solid-state 1296.05MHz beacon station, GB3DD. This is located near Luton, Bedfordshire, with the frequency-shift-keyed transmitter providing 18 watts output.

An HB9CV-type two-element aerial enclosed in a glass-reinforced plastic sphere is mounted 130ft above ground (805ft above sea level) with the main lobe directed northwards. The crystal-controlled exciter built by club members provides 600mW drive at 1296MHz from a MA-4661 varactor multiplier driven by 5 watts from a 2N3632 transistor. The drive is fed to the power amplifier through a tuned filter which reduces all spuriae to better than 45dB below the 1296MHz signal.

The power amplifier (2N6265/2N6266/TA8695) has been specially developed for the club as an experimental project of the RF Applications Division of RCA, Sunbury-on-Thames, using strip-line construction for the tuned lines and matching sections. The diode-matrix keyer repeats the callsign every 15 seconds with 800Hz frequency shift.

Reception reports will be welcomed by the beacon keeper (G3ZFP). Early reports confirmed reception of the station up to about 30 miles away with reduced power.

A clearer Top-Band?

Stewart Perry, W1BB, in his latest "160 metre DX bulletin" reports that there is a good chance that the Loran A transmissions just under 2MHz may be fully phased out by July 1, 1980, in favour of low-frequency Loran C or Omega navigational aids. Loran A pulse transmissions have been a major source of clutter on the band ever since World War II. American amateurs are hoping that as a result the full 1.8MHz band will be restored to them.

Stew Perry also comments on the recent kidnapping of Fred Laun, LU5HFI (a prominent DX station on 1.8MHz and h.f. bands), from his house in Cordoba, Argentina; later to be shot and left gravely wounded on a river bank. Fred Laun is an American amateur, W9SZR, who as a member of the US Information Service, has in recent years been very active both in Argentina and in the Far East under such callsigns as XV5AV, HS5ABD. It seems that his elaborate amateur station caused him to be suspected by local guerillas of clandestine activities and his equipment was taken by them.

Interest in long-distance operation on 1.8MHz continues unabated although W1BB urges amateurs to "check the band more often, several times when conditions have been good there has been no one on to take advantage of them". W4HYY now has 45 ground radials, from 20ft to 130ft long, under his 75-ft tower. G3RBP has a 600-ft-long wire aerial, 150ft high. The general view is that vertical aerials are best for long-distance working but only if used with a very good earth system. W1BB believes that the ideal system is to have a vertical and a dipole plus several different receiving aerials such as Beverage and a loop—the use of loop receiving aerials which allow Loran or other interference to be nulled out has become increasingly popular. One recent design for a receiving loop uses 20ft of coaxial cable to provide a shielded construction; another popular design consists of several turns of wire on a frame with about 40-in sides.

Gaps in the ranks

Sadly, the deaths of a number of well-known amateurs have been reported in recent months. Prof. Werner Nestel, DL1ZB, was very well known in professional as well as amateur circles for his pioneer work in encouraging v.h.f. broadcasting in West Germany just after the war and his distinguished career with AEG-Telefunken. Jean Lips, HB9J, was one of the first European amateurs ever to work 100 countries in the 'thirties. Leslie Cooper, G5LC, was the 1953 president of RSGB and for some years the president of the Thames Valley Amateur Radio Transmitters' Society.

Realistic aerial gain?

One of the problems of the amateur operator (and the professionals) is that of accurately measuring the radiation from an aerial. Over the years this has led to the creation of various myths and "old wives' tales". One well-known example is the widely held belief that even a moderate v.s.w.r. on coaxial cables, say 1.5 to 2.5, implies that considerable power is being lost by reflection. Similarly h.f. aerial gain from rotary beams is still frequently overestimated despite considerable efforts by Leslie Moxon, G6XN, to show that very few rotary h.f. beams can expect to break a "gain barrier" of about 6dB (reference dipole) and that much of the time, effort and money spent on constructing monster arrays could be put to more effective use by resting content with a two-element beam but putting it at the maximum possible height; he also disputes the view that there are "optimum" heights for horizontally polarized aerials that produce more low-angle radiation when erected over "real" earth. One method of breaking the gain barrier is to use two separate two-element arrays which even without careful phasing can provide up to 8dB of power gain. But despite his efforts one still finds many claims of rotary h.f. aerials giving power gains of from 8.5 to 10dB.

In brief

The Crystal Palace repeater transmitter, GB3LO, may be operational by about mid-July. . . . During May the 150-ft dish aerial of the Stanford Research Institute in California was used for a series of 144MHz moonbounce tests, with WA6LET transmitting on 144.080MHz and listening 144.075 to 144.105MHz. . . . There appears to have been a marked reduction of Sporadic E in late spring this year compared with 1973. . . . Ionospheric solar activity predictions have been revised downwards and by late autumn may be very low and approaching minimum. . . . Although FCC figures show that less than 1% of US radio frequency interference complaints are actually due to amateur transmissions, the ARRL recognizes that this is still an important source of tension between amateurs and their neighbours and has set up a new "RFI task group" to co-ordinate efforts to obtain new legislation on receiver immunity and to improve consumer education about r.f.i. . . . The British Amateur Radio Teleprinter Group recently sampled opinions of members on the use of 45.5 or 50.0 bauds for v.h.f. and h.f. teleprinter operation; in both cases there was a better than two-to-one vote in favour of 50.0 bauds. . . . A US Supreme Court ruling has postponed the higher licence fees that FCC were seeking to impose and one result is that American amateurs will continue to pay $9 for a licence lasting five years. . . . An ARRL Foundation has been formed with a view to funding worthwhile projects including support for Amsat (Radio Amateurs Satellite Corporation). . . . In proposing a basic frequency allocation plan for 40GHz and above, the FCC has proposed that amateurs should share the following bands with radiolocation services: 48–50, 71–76, 165–170, 240–250GHz and all above 300GHz. . . . Senator Barry Goldwater, K7UGA/K3UIG, has received the new David Sarnoff Award of the Radio Club of America—and a firm recently announced "We will gladly install your beam antenna on the White House at no charge". PAT HAWKER, G3VA

Pocket v.h.f. transceiver

Continuous "on-call" facilities with long battery-life

1 —Design considerations

by D. A. Tong, B.Sc., Ph.D. (G8ENN)

Working in the amateur band, 144–146 MHz, the transceiver described provides reliable communication between identical units at ranges up to three miles. A continuous on-call mode provides for a "bleep" tone call-warning.

Pocket radiotelephones are no longer unusual in the commercial world but commercial and amateur requirements are different in some respects and this is reflected in the detailed specification of the units described here. Although the r.f. design is obviously crucial to the success of any transceiver, other more unusual parts of the design are equally important in equipment of this type. They arise from the requirements that the receiver must be able to monitor a frequency for long periods without flattening the battery or annoying the operator, and therefore, it must emit no sound when not receiving a genuine call, and that controls must be reduced to an absolute minimum (in this case on/off, volume, push-to-talk, and preset squelch).

Further points which apply especially to the amateur situation are as follows. The transceiver is likely to be carried in a variety of locations such as pocket, handbag, or briefcase, and it is essential that any call should be easily heard despite high acoustic noise levels. This makes some kind of loud calling device essential. Good weak-signal reception is more important than high signal-to-noise ratios when the signal is fairly strong and therefore amplitude modulation seems more appropriate than narrow-band frequency modulation. S.s.b. and d.s.b.s.c. were ruled out (but only just) at the time of construction for reasons of complexity and therefore ordinary clipped a.m. was chosen. Traffic on the channel is liable to be very sparse since there will be few stations in the net. In a typical twelve hour period the transceivers tend to be used for only about five minutes in all. The minimum duration of an initiating call is about ten seconds since one is obliged by the terms of the amateur licence to recite two call-signs of four or five letters each. The equipment need not meet such stringent spurious response and emission regulations as in the commercial case.

The very low active periods allow the power consumption problem to be solved at the expense of circuit complexity by making the receiver function for only 200ms in every three second period; the mean current drain on standby is then only 2mA. If a signal is present during the "on"-period the receiver must lock on and open the squelch, and this must occur reliably even though the signal is very weak. In this receiver a signal of 0.2 microvolts measured at the aerial socket is sufficient to do this. Such a signal is not quite intelligible and therefore the system is fail-safe since any usable signal is certain to be detected.

It is important to the user that false alarms be very rare and this means that the squelch setting has to be independent of temperature, interference levels, and the state of charge of the battery. In this design compensation against these parameters is such that the squelch control can be preset. When, however, the battery voltage begins to fall rapidly at the end of its charge, the squelch sensitivity alters and the receiver unmutes as a warning. This feature relies on the very flat voltage versus time characteristic of sintered plate nickel cadmium batteries. When discharge is nearly complete the battery voltage drops rapidly. This type of battery is by far the most economical and practical choice for this kind of equipment. Its operational lifetime is over two hundred charge cycles, its low internal resistance simplifying decoupling problems and allowing quite large currents to be taken on "transmit". In this design the battery is soldered in and the transceiver case need only be opened for servicing.

General view of the pair of two-metre transceivers ready for use. Also shown is the mains battery-charging unit which plugs directly into a 13 amp power point.

Mechanically the transceivers are designed around the battery and loudspeaker since these determine the thickness of the complete unit. Overall dimensions of the transceiver case are 122 × 67 × 28mm, which is smaller than any of the commercial equipment known to the author.

Although details of the printed circuit layout are given later it must be realized that the construction of the transceiver requires a lot of dexterity, skill and patience, and also access to test equipment. Failure to appreciate this could result in the waste or even destruction of some quite expensive components. Construction should only be attempted by those with successful previous experience of miniaturized construction, and with large amounts of patience and a steady hand. On the other hand if the circuitry were built on a larger scale the construction would be much simplified. It is believed that the basic circuit is fairly reproducible and, indeed, this was one of the design criteria. Two identical units have been built by the author and a third complete unit existed during development in the form of a bread-board three square feet in area. All worked satisfactorily. It is still likely however that some combinations of components may require slight changes in component values and this is where a full understanding of the circuit operation and much manual dexterity become essential.

The transmitter

On the basis of previous experience with a portable transceiver[1] and in the interests of battery life, the average r.f. power output is limited to a nominal 100mW. With such low power it is very important that the modulation percentage is kept high but that over-modulation is prevented. Further, to obtain maximum "talk-power" it is essential that the mean-to-peak amplitude ratio of the speech waveform is increased by clipping. Clipping to the extent of 20dB causes little reduction in the intelligibility of a received signal but increases its "loudness" enormously. A modulator with speech clipping imposes several requirements. The clipping should be symmetrical so that only odd harmonics are generated and distortion is therefore reduced. Clipping levels should be proportional to battery voltage so that a constant modulation depth is maintained. A low-pass filter must follow the clipper, otherwise the harmonics of the audio signal which are generated in the clipping process greatly broaden the transmitted bandwidth and cause interference on adjacent channels. The frequency response of the modulator after the clipper should extend to very low frequencies to avoid differentiation of the square low-frequency waveforms from the clipper. Pre-emphasis of high frequencies is desirable before the clipper so that the more intense low frequencies in the speech waveform do not dominate the clipping process. The signal-to-noise ratio of the microphone amplifier should be good in view of the high gain involved.

All of these properties are achieved with an unusual economy of components in the modulator section of the complete transmitter circuit shown in Fig. 1. Advantage is taken of the high gain and low offset of the 741 operational amplifier. Moreover, the 741 has a very clean overload response and its output voltage swing limits at about 1 volt and $(V_{cc}-1)$ volts so it performs well as an amplifier and supply voltage-compensated clipper. Because of its internal frequency compensation the open loop gain of a 741 falls from 100dB at d.c. to only 50dB at 3kHz. The gain needed between the microphone and pin 6 of the 741 is that needed to raise the microphone output with a quiet talker (say 20mV peak-to-peak) to $(V_{cc}-2)$ volts peak-to-peak plus an extra 20dB to allow for the clipping. The total gain is therefore $20+20 \log 7.6/0.02 = 72$dB and therefore the gain of the 741 alone is insufficient, especially since negative feedback is desirable at 3kHz. Because of this a further low-noise transistor Tr_1 is included in the feedback loop. Remembering that an op. amp. in a negative feedback configuration tries to maintain its two inputs at the same potential, it will be seen from Fig. 1 that the d.c. feedback loop will act so as to bring pin 3 of IC_1 to the potential defined by the potential divider $R_{9,10,11}$. But the base-to-emitter voltage of a silicon planar transistor remains close to 600mV for a wide range of input currents; therefore, since the junction of R_9 and R_{10} has a well-defined voltage, so has the base of Tr_1. In turn, this means that so does the output terminal (pin 6) of the op. amp. and by suitable choice of $R_{7,8,9,10,11}$ the mean output voltage of the op. amp. can be made to remain midway between the two clipping voltages i.e., at a voltage of $((V_{cc}-1)+1)/2 = 4.8$ volts. The full d.c. gains of IC_1 and Tr_1 are available to maintain this condition which is subject only to the small temperature variation of base-to-emitter voltage of Tr_1.

The gain to a.c. is given by $(R_{12}.Z_{C14})/(Z_{C14}+R_{12})(Z_{C12}+R_6)$ and these values were chosen to give a rising response up to about 3kHz and then a falling response.

Great care is necessary in high gain modulators to avoid rectification of the modulated r.f. signal in the input circuits of the speech amplifier, otherwise serious instability is likely. Stability is ensured here by isolating Tr_1 from r.f. with the two r.f. chokes $RFC_{3,4}$ and resistor R_7. The connection between the transistor case and these components must be as short as possible (less than say 6mm). It is also very desirable (possibly essential) to use a version of the 741 in an earthed metal can. Pins 1 and 5 (offset null) should also be clipped off at source to reduce pick-up.

The function of $Tr_{2,3,4}$ is firstly, to bring the $+1$ to $+(9.6-1)$ voltage swing at pin 6 of IC_1 nearer to the nominal 0 to $+9.6$ swing, at low source impedance, required for the supply to the r.f. power amplifier Tr_7. Secondly they provide the low-pass filter function and therefore saturation or cut-off in Tr_4 must be avoided. The output voltage at Tr_4 collector is an amplified version of the voltage at the base of Tr_2 minus the 0.6 volt base-emitter drop of Tr_2. Thus if R_{13} and R_{14} are such that the minimum voltage at pin 6 of IC_1 (i.e., 1 volt) is reduced to just above 0.6 volts, that at Tr_4 collector will be close to zero. The ratio of R_{16} and R_{17} will not affect this lower end of the output swing but can be chosen to give the correct voltage gain to make the upper end of the voltage swing nearly cause Tr_4 to cut-off.

Between the emitter and base of Tr_2 there is close to unit voltage gain and this fact is utilized to form a Sallen and Key type of low-pass filter with a cut-off frequency of about 3kHz. Tr_3 is used to increase the power gain of Tr_4.

Turning now to the r.f. section of the transmitter, only three stages are needed to generate 500mW peak power. Tr_5 is used in a conventional overtone oscillator circuit and uses a p-n-p transistor to allow direct-coupling to the following class B doubler stage, Tr_6. The power amplifier uses a 2N4427 which has good v.h.f. power gain at low supply voltages and is proof against almost any abuse, such as transmitting without an aerial, when used at this power level. The interstage matching networks are conventional in form but unconventional in that fixed capacitors are used in the final construction. Tuning is carried out by altering the pitch of the coils, which are initially close wound with 34 s.w.g. enamelled copper wire using miniature 1/8th watt carbon resistors as formers. The actual component values were determined during initial test work on the bread board circuit. Several

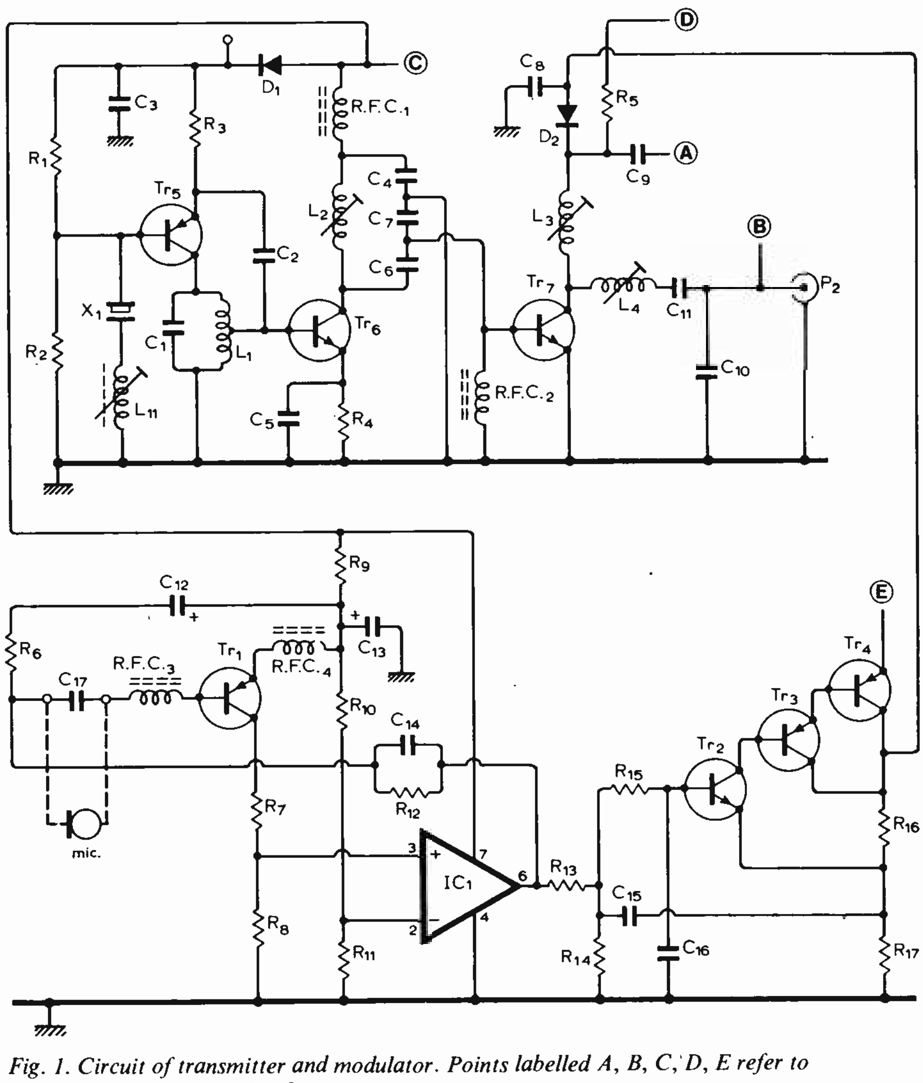


Fig. 1. Circuit of transmitter and modulator. Points labelled A, B, C, D, E refer to corresponding points in Fig. 3.

versions of this design have also been built up in larger form for use as separate low-power transmitters and it is then more convenient to use film dielectric trimmers for $C_{1,6,7,10,11}$ (e.g., Mullard 80801001, 5 to 60pF for C_1 and 80800006, 2 to 20pF for the others).

The send/receive switching for the aerial is novel and purely electronic. In the transmit mode the supply voltage is applied to the crystal oscillator and doubler stages and therefore Tr_7 draws current and this current passes through D_2. The dynamic impedance of this diode (R_{D2}) is then low and the r.f. voltage at C_9, and hence that fed to the receiver, is equal to the voltage at Tr_7 collector multiplied by R_{D2}/Z_{L3}. This fraction will be small and the receiver is fully protected but little or no transmitter power is wasted. When receiving, on the other hand, Tr_7 has no drive and its collector is effectively isolated from base or emitter except for interelectrode capacitance. Moreover D_2 anode is at chassis potential (because pin 6 of IC_1 is also at chassis potential) but D_2 cathode is at +9.6 volts because of R_5. Hence D_2 is reverse biased and behaves like a small capacitor of say 2pF. The equivalent circuit is now as shown in Fig. 2, where C_x is the capacitance of D_2 and C_y is the output capacitance of Tr_7. In effect, the receiver is connected to the aerial via a low-pass filter and matching network and very little attenuation occurs.

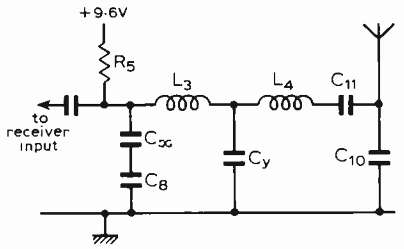


Fig. 2. Equivalent circuit of transmitter r.f. output network in the receive mode. C_x is the capacitance of D_2 and C_y is the output capacitance of Tr_7.

Receiver

General description. Because of its quite stringent and unusual performance requirements the receiver section of these transceivers is much more complex than the transmitter. For this reason, after an initial outline of its overall design, the discussion will be split into sections dealing with major aspects of the complete circuit.

Unlike most amateur receivers, the actual radio frequency sections of this receiver comprise only about 50% of the total hardware. The rest includes the equally essential squelch, battery-saving and "bleeper" circuitry. In order to fit all this into a small space integrated circuits have been used wherever possible. This has other advantages also. Integrated circuit i.f. strips generally comprise a broad-band amplifier with a.g.c. followed by an active detector. It is then practicable to "lump" all the i.f. selectivity into one filter unit so that no alignment or coil winding is required. Also, since gain is cheap and convenient to obtain in integrated circuit form, it is feasible to trade gain for convenience in other parts of the circuit. In this case, for example, m.o.s.f.e.t. mixers are used with resistive loads in order to eliminate a wound tuned circuit. In the control parts of the receiver, i.e., in the squelch, battery saving, supply routing, and bleeper sections integrated logic circuits are used and allow complex properties to be built-in using very little extra space.

One disadvantage of i.cs is that many of them consume more supply current than a design using discrete transistors. When this is taken into account, the number of devices suitable for equipment of this type is drastically reduced. The LM372 (National Semiconductor (U.K.) Ltd.) is exceptional in consuming only 2mA total supply current while providing a complete a.m. i.f. strip with a.g.c. and active detector. Its internal biasing is also well temperature compensated and this is exploited in the squelch design. The Plessey Semiconductors SL600 communications series of i.cs also have a high performance which it would be uneconomical to match with a discrete design, and two of these, the SL612 i.f. amplifier and SL630 class-B push-pull audio amplifier are used here. The first consumes only 4mA at 6 volts and the second 5mA (quiescent) at 6 volts. Of the many logic families now available, only the m.o.s.f.e.t. types have a power consumption low enough for use in the battery saver. The reason is that the logic circuitry is continuously energized and its consumption must therefore be negligible compared to the time-averaged receiver current during stand-by (2mA).

As yet there are no competitive i.cs available for use as low-noise input amplifiers at signal frequencies as high as 145MHz. A dual-gate m.o.s.f.e.t. is therefore used. Similarly, although a double-balanced i.c. mixer operating up to 200MHz (but with unspecified balance figures) with 2mA current drain is available (Siemens SO 42P), its use would incur a size penalty compared with a dual-gate m.o.s.f.e.t. and a significantly better performance seems unlikely. The more sophisticated Plessey SL640 double-balanced mixer has a quoted upper limit of 150MHz at reduced performance but consumes about 12mA.

R.f. design. In the preceding discussion the superheterodyne type of receiver was assumed. This choice is dictated partly by the high radio frequency involved but mainly by the availability of suitable filters and i.cs. In fact a double conversion design was chosen with intermediate frequencies of 10.7MHz and 455kHz, despite the current trend to single conversion in commercial equipment. Every conversion process introduces possible spurious responses and complicates the overload properties, but the former are not quite so important in amateur work and are more than outweighed by the following considerations. Quartz crystal block filters at 10.7MHz tend to be larger and more expensive than ceramic filters operating at 455kHz; the low-current LM372 i.f. strip has a specified upper frequency limit of only 2MHz; monolithic ceramic block filters at 10.7MHz with a bandwidth of 300kHz and 50dB stop-band attenuation are readily and cheaply available because of their widespread use in domestic f.m. tuners. The use of two of these filters virtually eliminates the second image response which is often a serious problem in amateur v.h.f. receivers since, when translated up by the first mixer, the second image frequency lies within the amateur band. (By "second image" is meant the response at 10.245 − 0.455MHz, where 10.245MHz is the second local oscillator frequency.)

The complete circuit diagram of the receiver is shown in Fig. 3 and the r.f. sections will now be discussed in detail. The signal input is applied via the tuned circuit, L_5–C_{42}, to gate 1 of a 40673 dual-gate m.o.s.f.e.t., Tr_{21}. After amplification, the signal is coupled to the first mixer, Tr_{22}, inductively through two further tuned circuits. This gives over 40dB rejection of the first image frequency at $f_{in} - (2 \times 10.7)$MHz which is adequate in this application. The high input and output impedances of f.e.ts are a great help in obtaining good working Q values. Local oscillator injection is applied to gate 2 of Tr_{22}, again by inductive coupling between two tuned circuits (L_8 and L_9) since good selectivity at the injection frequency is important in reducing other spurious responses. The local oscillator Tr_{23} functions as a combined overtone oscillator and frequency doubler. Oscillation at the correct overtone is ensured by L_{10}–C_{53} which tune to the quoted crystal overtone frequency, whereas L_9–C_{51} are resonant at the second harmonic of this. Remote selection of alternative crystals can be achieved using diode switches as shown in the alternative local oscillator circuit shown in Fig. 4. Separate trimming capacitors are then required for each crystal frequency. The receiver could easily be made to tune the whole two-metre band if a suitable tunable oscillator replaced the crystal controlled oscillator.

Instead of the usual tuned circuit, a resistor is used as the load for Tr_{22} and the 10.7MHz ceramic filter (Vernitron FM4) is directly connected. Similarly the output of the filter is directly coupled to the input of the first i.f. amplifier, IC_8. The quoted input and output impedances of the FM4 are only 330 ohms but mismatches affect the pass-band ripple rather than the stopband attenuation and the former is of little importance in this application. A load resistor of 1.8kΩ is therefore used since the use of a 330 ohm load would throw away too much gain.

The SL612 has a noise figure of 3dB, a voltage gain of 50 defined by internal negative feedback, and an a.g.c. range of 70dB. Gain decreases as the voltage at pin 7 rises from +2 to +5 volts (nominal). The few connections to the SL612 amplifier typify the simplicity of circuitry using the SL600 series. Note however the need to treat the input earth connection (pin 4) independently of the output earth (pin 8) to avoid "common impedance" instability. The supply voltage to IC_8 is dropped by R_{65} and r.f. decoupling is "on-chip". Because of the excellent a.g.c. range of the SL612 and the intentionally low gain preceding it, it has not been found necessary to apply a.g.c. to the r.f. stage.

A second FM4 filter (FL2) is used to couple the output of the SL612 to gate 1 of the second mixer, Tr_9. Again the mismatching is deliberate. On the other hand the main selectivity-determining filter at 455kHz (FL1) must be correctly terminated and the load resistor (R_{25}) for Tr_9 is close to the value of 2kΩ quoted for the filter (Murata type CFS–4551). The latter is a 15-element ladder filter with a bandwidth of 4kHz at −6dB and 10kHz at −70dB. The insertion loss is 10dB and overall dimensions are only 29.0 × 9.5 × 7.5mm wide. Unfortunately the importers are unable to supply one-off quantities of this filter but *Wireless World* have made arrangements to supply the filters to intending constructors. The worst spurious response quoted for the filter is 52dB below the passband and is at about 1.1MHz. In order to further attenuate this and other weaker responses a single ceramic resonator (Murata type BFB–455A) is used to bypass the source of Tr_9.

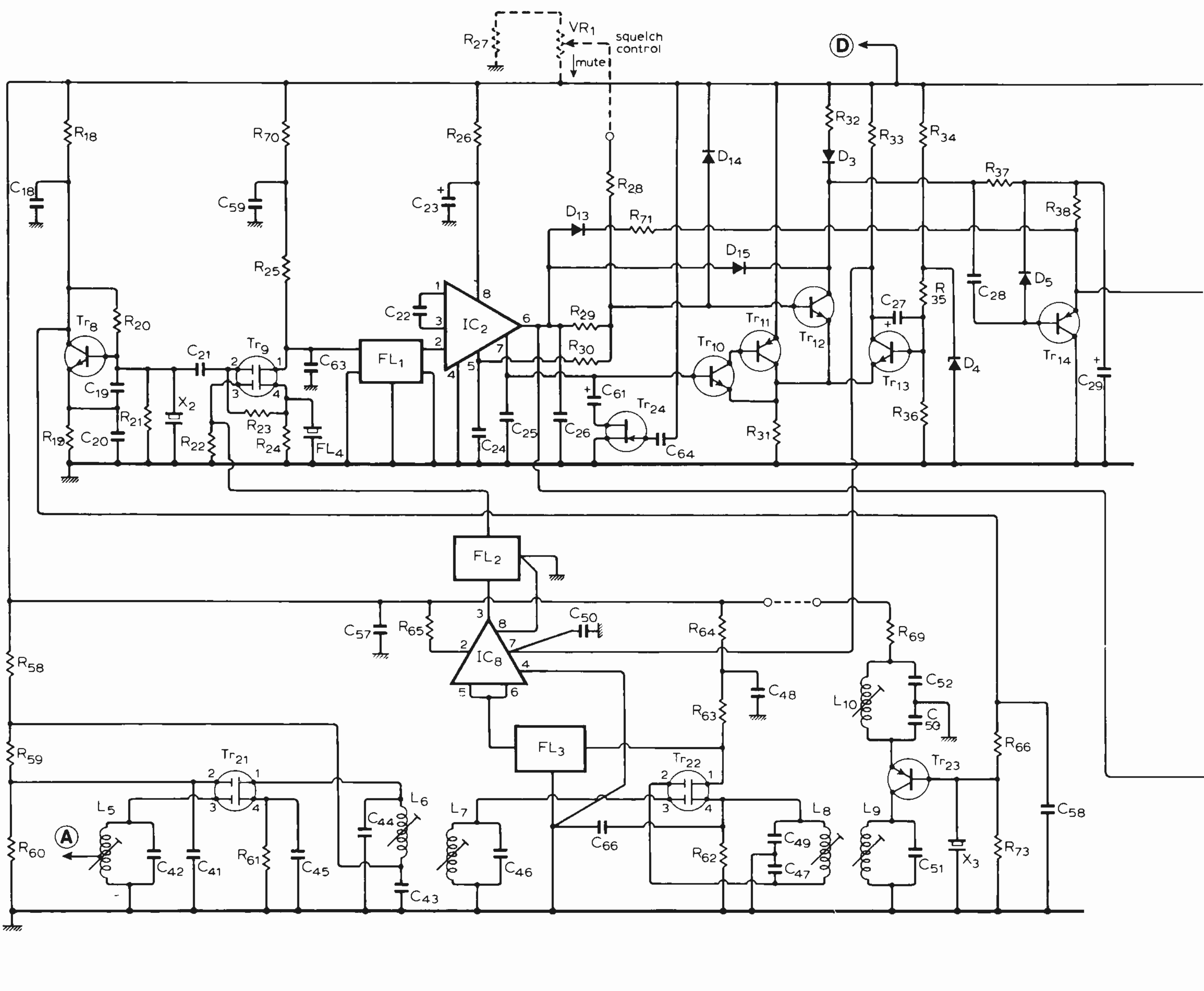
The second local oscillator, Tr_8, is crystal controlled at the frequency 10.245MHz. Although quite good, its waveform purity is not so important as for the first oscillator because of the better selectivity preceding the second mixer.

The remaining part of the r.f. section is the 455kHz a.g.c. unit, gain block, and active detector (IC_2). The LM372 contains two amplifiers, the first of which has an a.g.c. range of about 60dB and the second of which has a fixed gain. Coupling between them is by C_{22}. The output of the detector (pin 6) consists of a steady voltage, V_0 (about 1.6 volts), superimposed on a voltage proportional to the carrier level of an incoming signal, V_1, and an alternating component representing its modulation (e.g. $V_1 \sin \omega t$ for 100% modulation). An internal resistor of 50kΩ connects pin 6 to the a.g.c. point (pin 5) and in conjunction with an external capacitor removes the modulation component. For reasons explained in the battery saver section, the a.g.c. capacitor, C_{61}, is gated by a f.e.t., Tr_{24}, whose "on" resistance is too great to allow good r.f. bypassing and therefore C_{25} is also added. Pin 5 of the LM372 is an internal feedback point and must be decoupled to a.c. by C_{24}. The remaining d.c. connections to IC_2 are used for squelch, noise-limiter, and first i.f. a.g.c. purposes and these are discussed later.

It will be noted that there are no wound inductors after the first mixer. This was deliberate and greatly simplifies the stable miniature construction and alignment of the complete receiver. Further the inductive coupling at both inputs to the first mixer reduces the component count and yet allows ready adjustment of overall gain and oscillator injection level. Fixed capacitors are used for the r.f. tuned circuit and alignment is carried out as in the transmitter (details are given later).

Audio section. In this receiver the audio power amplifier (IC_7, an SL630) has a dual function. On receipt of a call after a period of stand-by operation it is made to act as an audio-frequency oscillator to generate a loud calling tone in the loudspeaker. Having served this alerting purpose it must then function as a normal linear amplifier. Two audio gates are used to achieve this. The first, Tr_{19}, is a p-channel junction f.e.t. and gates the path from the demodulator in IC_2 to the input of IC_7 (pin 5). The second, D_{10}, controls a positive feedback path between output (pin 1) and input of IC_7. The frequency of oscillation depends on C_{38}, the current through D_{10}, and the loudspeaker impedance. Both audio gates are controlled by a logic system (see later section). The gain of the SL630 depends logarithmically on the potential at pin 8 and is controlled by the volume control, VR_2. Since, however, VR_2 is fed from the logic system, the latter can always increase the gain to maximum when oscillations are required by lowering the voltage on VR_2 to chassis potential.

The SL630 can be muted by shorting pin 7



to pin 10 and this is done by Tr_{20} when so commanded by the squelch and noise limiter circuitry. An odd backlash effect during squelch operation was cured by adding C_{62} to the unused differential input (pin 6). High-frequency roll-off in the frequency response curve is obtained with C_{37}. The available audio power output is about 100mW and is quite adequate for the internal speaker.

Squelch and noise silencer. The combined squelch and noise silencer system used in this receiver is believed to be novel and uses a single audio gate which is opened when an incoming signal exceeds a preset threshold level but which closes momentarily for the duration of any interference pulse which exceeds the level of 100% modulation on the incoming signal. Moreover the squelch is noise-compensated so that impulse interference does not remove the muting. We first discuss the squelch aspects of the circuit.

The provision of reliable squelch for a.m. receivers is complicated by the similarity in the smoothed detector output resulting from both genuine a.m. signals and the many forms of interference. The weakest signal to be detected will produce only a small voltage change at the detector and the squelch circuitry must be designed as a low-drift d.c. amplifier. In the case of integrated i.f. strips, the built-in detector usually has a much larger quiescent voltage superimposed on its signal-derived output and even small drifts in this quiescent level due to temperature and supply voltage can be large relative to changes caused by the wanted signal. A more subtle point related to this is that when a battery saving technique is used, the chip temperature and hence the quiescent output voltage, will depend on whether or not the supply voltage is being pulsed or is on continuously. If neglected, this effect causes the squelch threshold in the two cases to differ: a highly undesirable result.

These difficulties have been overcome by using a differential system and this is made possible by the fact that the d.c. feedback point (pin 5) on the LM372 has virtually the same voltage shift with temperature and supply voltage as does the detector output. Fig. 5 shows the squelch part of the circuitry in simplified form. Tr_{12} and the composite transistor formed by $Tr_{10,11}$ form a long-tailed pair amplifier fed differentially from the a.g.c. line and the voltage at pin 5 of the LM372 (1.26 volts). The complementary pair, $Tr_{10,11}$, are used so as to avoid loading pin 7 (its internal resistance is 50kΩ) but without the extra temperature-dependent offset voltage that an ordinary Darlington pair would introduce. In the absence of a signal, Tr_{20} must conduct to mute IC_7 and therefore so must Tr_{12}. This is arranged by adding a small, variable voltage increment to Tr_{12} base from the squelch potentiometer VR_1, which is adjusted so that just enough current flows in R_{32} to bring the gate of the m.o.s.f.e.t. below its threshold potential (about $+V_{cc}-4$ volts relative to chassis). Then, when the a.g.c. line rises slightly Tr_{12} tends to turn off and therefore so do the m.o.s.f.e.t. and Tr_{20} and the muting is removed. The overall gain is sufficient to give "snap-action" without any backlash.

It will be observed that VR_1 introduces a non-compensated fraction of supply voltage *variation* into the otherwise balanced system. This is however an advantage since it tends to cancel out the effect of increased gain in the r.f. section of the receiver when the battery voltage is high.

The m.o.s.f.e.t. shown in Fig. 5 is in fact an input transistor in a logic gate. Its high input impedance is essential for the battery saver circuit which is described later.

The noise silencer part of the circuit must compare the detector output voltage with a threshold voltage which is equal to the detector output on peaks of 100% modulation for any incoming signal strength. Then whenever the detector output exceeds the threshold, the squelch gate must close. In practice it is more convenient to use the a.g.c. potential as the threshold and to halve the amplitude of the demodulated audio signal before the comparison. These voltage relationships are shown in Fig. 6. The differential amplifier is readily altered to include this extra comparator function. The a.c. component at the detector output is attenuated by the pair of resistors R_{29} and R_{30} which are connected in series and returned to pin 5, which carries no a.c. component. It is then simply added to the input to Tr_{12}. When VR_1 is set so that the receiver is just muted with no signal the noise silencer threshold is automatically correct.

The mere addition of R_{29} to the circuit of Fig. 5 gives a squelch threshold which is not well defined because of the high output of random noise from the receiver at full sensitivity. A smoothing network is required between Tr_{12} and IC_{3a} to give a sharp squelch threshold, yet fast negative-going transitions at Tr_{12} collector must still be transmitted without delay or attenuation. This result is achieved by Tr_{14} and associated components. Rapid negative pulses are transmitted by C_{28} to the base of Tr_{14} causing it to conduct and clamp the input of IC_{3a} to chassis potential. In the absence of noise spikes however, Tr_{14} is effectively disconnected and R_{37} and C_{29} ensure that the input to the m.o.s.f.e.t. is well smoothed. A fast rise-time for the noise gating pulses is essential and is ensured by having active pull-down or pull-up at each stage. Thus large load resistors can still be used to reduce current consumption.

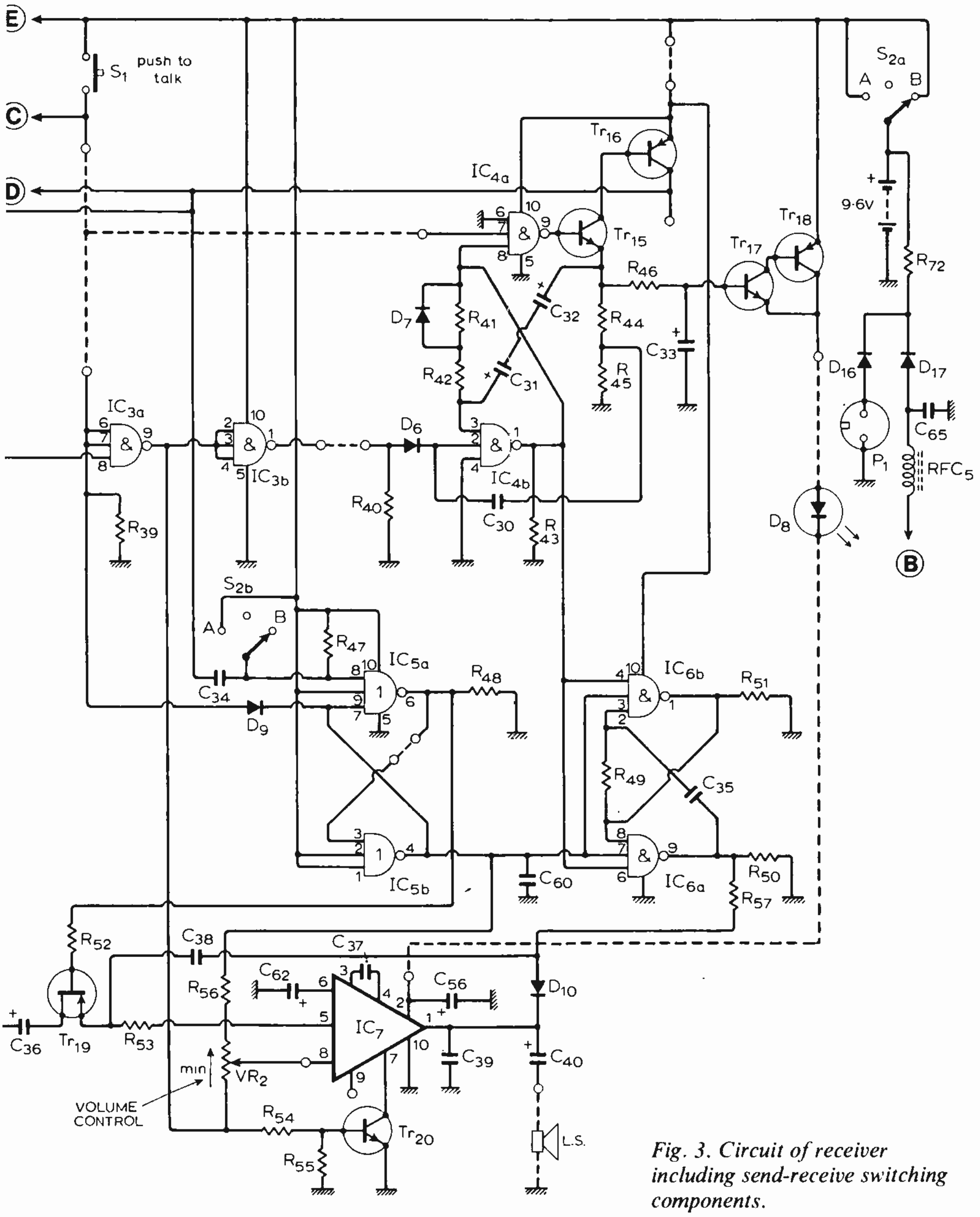


Fig. 3. Circuit of receiver including send-receive switching components.

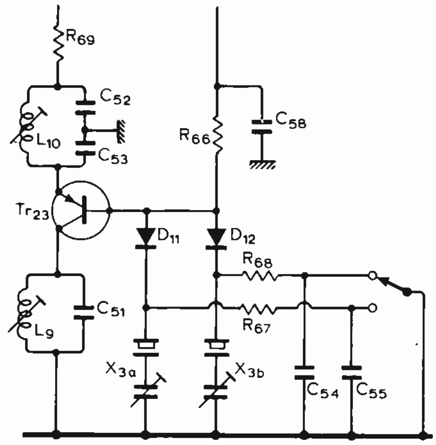


Fig. 4. Alternative crystal oscillator circuit for the receiver. The two trimming capacitors are used to trim the frequencies of oscillation. L_{10} tunes to the crystal overtone frequency and L_9 to its second harmonic.

A further important function of Tr_{14} is to compensate the squelch against noise. Every time Tr_{14} conducts, an increment of charge is subtracted from C_{29} via R_{38} and the squelch threshold is raised. By suitable choice of R_{38} relative to R_{37} this is made to balance the effect on C_{29} of charge build-up in the a.g.c. capacitor from impulse interference. Moreover some compensation for changes in receiver "hiss" level is obtained since these random noise components are rectified by Tr_{14}, thereby reducing the charge in C_{29}. Modulation components on an incoming signal do this only to a negligible extent both because C_{28} has a low value and because, whereas the mean amplitude of an audio waveform is one half of the peak amplitude, that of random noise is much less. This means that very little modulation component appears at Tr_{12} collector. Compensation is also improved slightly by allowing D_{13} and R_{71} to apply negative feedback to the detector output on large impulse noise spikes, thus helping to reduce charge build-up in C_{61}.

Car ignition noise is inaudible in the receiver when no incoming signal is present and with the squelch advanced just sufficiently to unmute the receiver. Each interference spike is stretched from its original sub-microsecond width to one of nearly 2ms by the narrow i.f. filter so that when their repetition rate is greater than about 500Hz the receiver becomes desensitized (e.g., from 0.2 microvolts to 1 microvolt at a pulse rate of 1kHz). Noise silencers which use gating prior to the main filter can handle far higher p.r.fs[2,3] but the present circuit is quite effective in most situations.

Automatic gain control. A.g.c. for the second i.f. amplifier is built-into the LM372 and it is desirable that the first 20dB of gain reduction (approx.) should occur there so that wideband noise is reduced. Thereafter the gain control should occur in the SL612 so that overload is avoided in the second mixer and in the SL612 itself. Finally when the limit of the gain control range in the SL612 is reached the gain of the LM372 should be further reduced.

These properties are obtained by using an a.g.c. amplifier to drive pin 7 of the SL612. When the receiver is not muted (i.e., signal present), Tr_{12} will be cut-off and can be neglected. Tr_{13} then performs as a comparator in conjunction with Tr_{10} and Tr_{11}, and when a threshold set by R_{35}, R_{36}, and the breakdown voltage of D_4, is exceeded by the LM372 a.g.c. voltage, the collector voltage of Tr_{13} begins to rise and the gain of IC_8 is reduced. The fairly high gain of the differential amplifier ensures that most of the resulting gain control occurs in the SL612 until Tr_{13} is cut-off. Stability in the feedback loop is ensured by C_{27}.

The overall a.g.c. performance is such that, with the squelch advanced, the audio volume is subjectively independent of signal strength with a well modulated signal. With no signal the output is entirely random noise whereas with signals above about 2 microvolts it is mainly modulation. The overload point depends on the exact choice of a.g.c. threshold for the first i.f. but, typically, one transceiver has to transmit within ten feet of the other to cause obvious distortion when using helical whips on each.

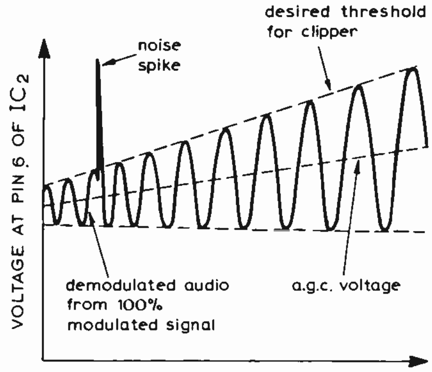


Fig. 6. Voltage relationships in the noise-silencer circuit. The receiver input is assumed to be a 100% sine wave modulated carrier whose amplitude increases steadily. A noise impulse is superimposed.

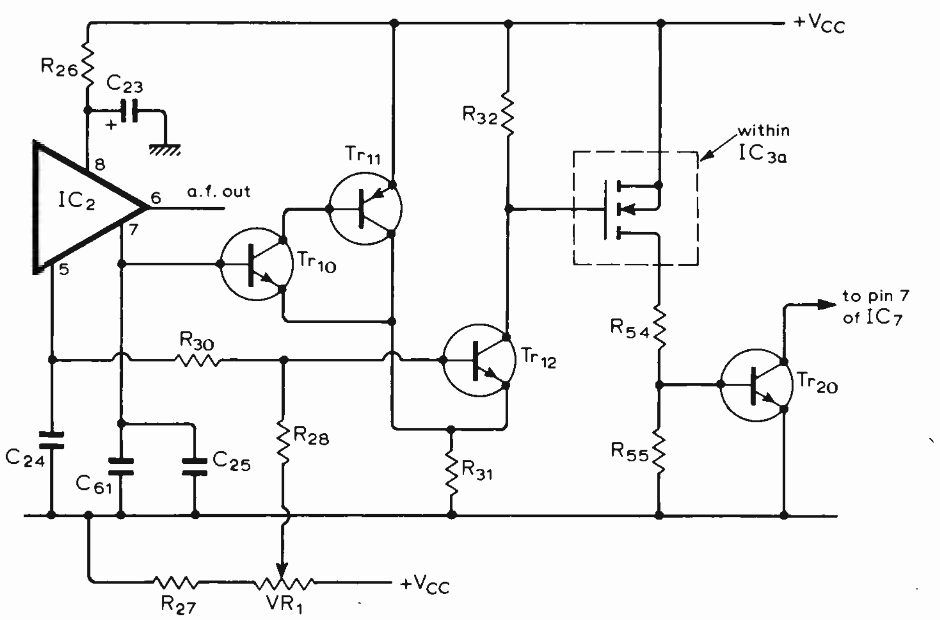


Fig. 5. Simplified version of the squelch circuitry.

Battery saver and h.t. switching. This section of the receiver is part of the logic control system and determines whether the receiver, transmitter, or neither receive supply current at any particular time. The logic circuits are energized continuously. The following design for a battery saving system represents an improved and more up-to-date version of one previously described by the author[4].

M.o.s.f.e.t. logic is used because of its very low power consumption, and high input impedance. Logic gates are also used as d.c. amplifiers for the squelch section. The more recent complementary m.o.s. logic (e.g., RCA "COSMOS" or Motorola "McMOS") would be ideal but conventional m.o.s. logic based on p-channel enhancement m.o.s.f.e.ts is just as satisfactory in this application if the internal active f.e.t. load resistors are replaced by external resistors of high value. At the supply voltages used in this equipment this occurs automatically but in any case can be achieved by connecting the negative supply voltage terminal to the positive terminal of the integrated logic circuits. (In the printed circuit board described later this was not done due to lack of foresight.) The internal connections of the two devices used, the Plessey MP104B and MP102B, are shown in Fig. 7. In terms of "negative logic", i.e., logical "1" represented by a logic level close to the negative supply rail, these are dual three-input NOR and NAND gates respectively. This same logic convention is used in the following discussion since it corresponds with that used in the data sheet. The terms "high" and "low" will, however, be used to denote voltage levels close to the positive and negative supply rails respectively. Thus "high" here corresponds to logical "0". Further, a logic gate will be said to be "on" when current flows in its load resistor.

The design philosophy is that the operator should not need to be aware that the receiver does not operate continuously. Two modes of operation will be distinguished. In the "normal" mode the receiver is energized continuously, whereas in the "stand-by" mode the receiver is energized for only

200ms in every 3-second period. The logic system has the properties that when the transceiver is first switched on it enters the stand-by mode, any signal which exceeds the squelch threshold during the 200ms on-time causing the receiver to enter the normal mode. The receiver remains in its normal mode for ten to fifteen seconds after such a signal has disappeared and then reverts to the stand-by mode, and the same thing happens after a period (even momentary) of transmission.

These properties are obtained by using a multivibrator ($IC_{4a,b}$) which can also be forced to remain in either of its two states. The basic multivibrator circuit is shown in Fig. 8 and is an interesting application of enhancement m.o.s.f.e.t.s. Only one capacitor is needed to define the duration of both states. Assume that Tr_1 and Tr_2 have just turned off and on respectively. The drain of Tr_1 has therefore just dropped to 0 volts from V_{cc} and therefore the gate of Tr_2 has received a negative step of magnitude V_{cc} because of the capacitor. The latter then charges via R_1 the diode from the drain potential of Tr_2, i.e., close to V_{cc}. As soon as the gate potential of Tr_2 reaches the threshold potential, typically 4 volts negative with respect to source for the MP102 and MP104, Tr_2 turns off, its drain potential drops to 0 volts and Tr_1 goes on. The rapid rise to V_{cc} at the drain of Tr_1 raises the gate of Tr_2 by the increment V_{cc} via the capacitor, and the latter subsequently discharges via R_1 from the drain potential of Tr_2 (now 0 volts). The mark-to-space ratio is unity if $R_2 = 0$ but can be made otherwise by choosing R_1 and R_2 accordingly.

The multivibrator is inhibited by adding extra m.o.s.f.e.t. switches in series with Tr_1 and Tr_2. Thus if the source of Tr_2 is disconnected from V_{cc}, the drain of Tr_2 cannot go positive even though the multivibrator reaches the state where Tr_2 has a gate potential of zero (i.e., Tr_1 on and C fully discharged). Multivibrator action resumes however, the instant that Tr_2 source is reconnected to V_{cc}, and Tr_2 and Tr_1 will then go on and off respectively.

The MP102 is used in the actual receiver circuit (Fig. 3) and each half of the circuit is gated separately. In the stand-by mode, IC_{4a} is on for 200ms and off for 3 seconds. Pins 2 and 7 are then both low. $IC_{3a,b}$ are used as squelch amplifiers and pin 1 of IC_3 goes high when a signal is present and low otherwise. If the squelch output goes high during the receiver on-time, C_{30} charges via D_6, and pin 2 of IC_{4b} goes high, inhibiting the gate and ensuring that IC_{4a} and the receiver remain on. When pin 1 of IC_{3b} goes low again C_{30} begins to discharge via the reverse resistance of D_6. After about ten seconds pin 2 of IC_{4b} reaches its threshold voltage and IC_{4b} begins to conduct and multivibrator action restarts. In order to speed up the transition between modes, C_{30} is returned to the junction of R_{44} and R_{45} instead of to chassis thereby introducing positive feedback.

When the transmit button is pressed, the battery is connected to the transmitter, and at the same time IC_{4a} is cut off (pin 7) and the receiver power supply is removed. Further, IC_{3a} is also held off (via pin 6) and this has the same effect as when a signal is received in that C_{30} is charged. The receiver then remains on for at least ten seconds when the transmit button is subsequently released.

Interruption of supply current to the receiver uses two separate switches, Tr_{16} and Tr_{18}, one of which is exclusive to the class B power amplifier to avoid decoupling or motor-boating problems. None of the receiver circuitry requires a stabilized supply and Tr_{16} is connected in common emitter to give minimum voltage drop. Base current is the collector current of an emitter follower, Tr_{15}, which is also used to reduce the output impedance of IC_{4a} enough to drive the timing capacitor C_{31} and C_{32}. The audio amplifier has to be switched relatively slowly otherwise loud clicks are produced by the loudspeaker in the stand-by mode. Also the quiescent current drain of the SL630 increases with supply voltage and it is better to drop the supply voltage to 6 volts. Tr_{17} and Tr_{18} are used as a complementary emitter follower and are fed from the emitter of Tr_{15} via a suitably long time constant. The total voltage drop is increased to about 2.8 volts by adding a light-emitting diode, D_8, in series with the supply to IC_7. The power consumed by the lamp is "free" yet it gives a useful indication of the receiver mode and that it is switched on. No decoupling capacitors larger than 1 microfarad are required in the complete transceiver and tantalum bead capacitors provide this in a very small volume.

It is essential that when the supply to the receiver is interrupted or restored by the multivibrator, C_{30} is not charged by any transient. If it were the stand-by mode would never be achieved. This requires that the switching be rapid, especially relative to any voltage changes at the output of IC_2. This is ensured by the decoupling components C_{23} and R_{26}. Once the V_{cc}-end of R_{32} has dropped to 0 volts there is no further possibility of C_{30} being affected. Similarly, when the supply is reapplied, the base of Tr_{10} must rise more slowly than that of Tr_{12} because of the capacitors connected to pin 7 of the LM372, and therefore there is no switch-on transient large enough to charge C_{30}.

In order that the squelch threshold be independent of receiver on-time, more subtle effects must be considered. There are two time constants which are long compared with the on-time during sampling; these are the a.g.c. time constants of 50kΩ and C_{61} and the squelch smoothing (R_{37} and C_{29}). Both these capacitors must therefore be made to store their charge during the receiver off-time. Isolation of the a.g.c. capacitor, C_{61}, is the function of Tr_{24}, which is driven via C_{64} from the switched supply line to the receiver. When the receiver goes off, a negative step appears at the gate of Tr_{24} and its channel becomes effectively an open circuit. Isolation of C_{29} is carried out through diodes D_{14} and D_3. When V_{cc} drops to zero, D_3 is reverse biased and therefore C_{29} is isolated from the supply line. Provided Tr_{12} remains fully cut off, C_{29} is fully isolated and this is ensured by adding D_{14} to actively pull down the base of Tr_{12}. Since IC_{3a} has a m.o.s.f.e.t. input the only significant leakage from C_{29} is via its own leakage

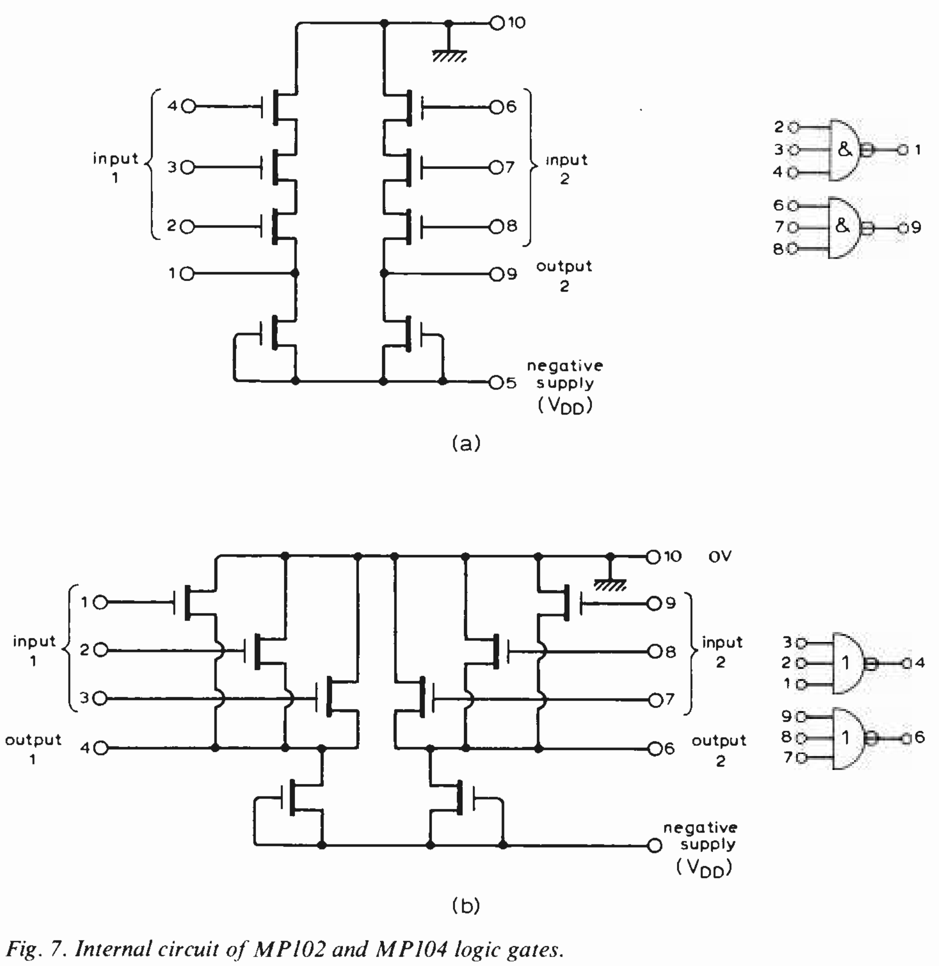


Fig. 7. Internal circuit of MP102 and MP104 logic gates.

resistance which for a tantalum electrolytic is negligible in this application.

The thresholds for the squelch and the battery saver lock-on process should be the same and this is ensured by a suitable choice for R_{54} and R_{55} which are best adjusted on test.

"Bleeper". As mentioned in an earlier section, the audio output amplifier IC_7 functions either as a normal amplifier or as a power oscillator. The control logic which determines which mode is selected comprises two NOR gates (IC_5) and two NAND gates (IC_6). The former pair are used as a bistable memory and the second as a gated astable multivibrator with a period of about two seconds and with unity mark-to-space ratio. The astable is included to make the loud warning tone intermittent since it is then far more noticeable in high ambient noise levels. The power consumption is also halved.

The two stable states of the astable will be referred to as "bleep-enabled" and "bleep inhibited". In the former state Q_{19} is a very high resistance and the only input to IC_7 is from the positive feedback capacitor C_{38}. This feedback is interrupted by the bistable since gate D_{10} is driven from its output (pin 9 of IC_{6a}). The fact that pin 4 of IC_5 is low means that the astable is enabled (via pins 3 and 7) and that the audio stage is set to maximum gain via the volume control (and pin 8 of IC_7). Muting transistor, Tr_{20}, is still effective however so that in the bleep-enabled state, whenever the squelch threshold is exceeded, the receiver bleeps loudly.

In normal operation (i.e., during a conversation) the receiver must not bleep but a bleep on-off switch is undesirable; this is the reason for the bistable. Whenever the supply to the receiver transfers from high to low the bistable is set (via C_{34} and R_{47}) into the bleep-enabled condition. Therefore this condition occurs automatically whenever the stand-by mode is regained and the next incoming call activates the bleeper. On receipt of a call the bistable must be reset manually to the bleep-inhibited state and this is done by momentarily depressing the transmit button. Whenever the transmitter supply line is high, D_9 conducts and pins 4 and 7 of IC_5 are latched high. During a conversation the bleep-enabled condition cannot be regained. Spare gate inputs on IC_6 (pins 6 and 4) are used to disable the multivibrator when the receiver is not operating.

The aerial

The aerial plays a crucial part in determining the practicability of equipment that must remain operational in the pocket. Conventional telescopic whips are unsuitable both because they might be left retracted and because of their fragility. A flexible wire can be fitted into clothing but complicates the manipulation of the set. Internal tuned loops are often used at u.h.f. in commercial equipment but this demands a plastic case and also is less effective at v.h.f. The aerial finally adopted for the author's pair of transceivers is the "normal-mode helix"[5] made from a steel spring and this has proved extremely convenient and effective.

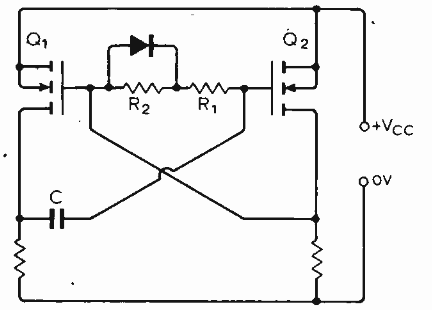


Fig. 8. Basic circuit of the multivibrators used for the battery saver and the "bleep" interruptor.

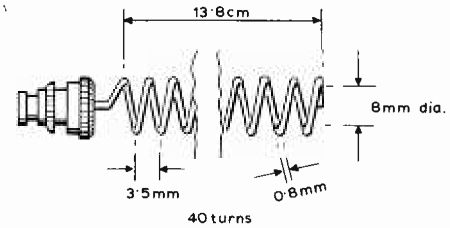


Fig. 9. Helical aerial used with the transceiver. The helix was made from a steel spring and the coaxial plug is a sub-miniature Belling Lee type. Although not applied to the originals, copper plating should reduce the losses slightly.

A wire helix with diameter and pitch small compared to a wavelength in free space (λ_0) has the property that electromagnetic waves travel along it at a reduced velocity which depends on its dimensions. A velocity reduction of one third gives an effective quarter wavelength of only six inches at 145MHz compared to nineteen inches for a straight whip. On the other hand the more an aerial is shrunk the more its *Tr* increases and therefore the more difficult it is to maintain it in tune. Design information for normal-mode-helix aerials is given in reference 6 and the following expression for the total number of turns (N) in the helix is derived from formulae given therein:

$$\log_{10}\frac{N}{h} = \frac{1}{2.5}\cdot\log_{10}\left\{\left[\left(\frac{\lambda_0}{4h}\right)^2 - 1\right]\frac{\sqrt{\lambda_0}}{20d^3}\right\}$$

In this equation h is the overall length of the helix, λ_0 is the wavelength in free space, d is the diameter of the helix.

The helices used by the author have the dimensions shown in Fig. 9 and were obtained by adjusting empirically the helix predicted by the above equation. The diameter and number of turns are critical and interdependent. If two helices have diameters and numbers of turns equal to d_1, N_1 and d_2, N_2 respectively and if they are to resonate at the same frequency in the same physical length, the following equation holds:

$$\left(\frac{N_2}{N_1}\right)^{2.5} = \left(\frac{d_1}{d_2}\right)^3$$

This result can be used to convert the details in Fig. 9 to suit other springs. Note however that springs with diameter much less than the one shown tend to be less efficient.

The input impedance of a parallel helix is less than that of a straight whip and it is best to match the transmitter to the helix using a field strength meter (e.g., the one shown in Fig. 11) placed several yards away. First the helix is adjusted in length for the best output and then the transmitter matching is adjusted. Both are then readjusted iteratively. Satisfactory results are still obtained when the transceiver is used with a 50 or 75 ohm fixed aerial installation.

Performance

Both sets have been in continuous daily use by the author (G8ENN) and his wife (G8ENO) since July 1972. Reliable contact is usually obtained back to a 30ft high outside aerial when using the helix within a radius of two to three miles. From particularly favourable locations this limit increases to at least forty miles and when propagation conditions have also been good ranges of up to 150 miles to a well-sited high gain aerial have been achieved using the helix. The helix-to-helix range is much more limited and is typically about one mile in a suburban area. From favourable locations however a range of ten miles helix-to-helix is obtainable.

The squelch and noise limiter system has proved very satisfactory and false triggers are very rare, even with the helix inside a car. Unless interference levels are severe the receiver bleeps reliably on signals which are too weak to read. If the squelch is set for maximum sensitivity (0.2 microvolts) when the battery is on the flat part of its discharge characteristic (i.e., discharged to between 30 and 80% of total capacity and battery voltage 9.6), the squelch sensitivity in the first few hours after removal from the charger is reduced to about 0.8 microvolts, unless the squelch is temporarily readjusted. At about 80% discharge the battery voltage begins to drop and the receiver begins to unmute on background noise. This provides a warning and after a single subsequent squelch adjustment about one day of normal use (say ten hours stand-by and five minutes of talking) remains before recharge is essential. With normal use in the author's system charging is required only every five days. Apart from this no attention is required.

(To be continued)

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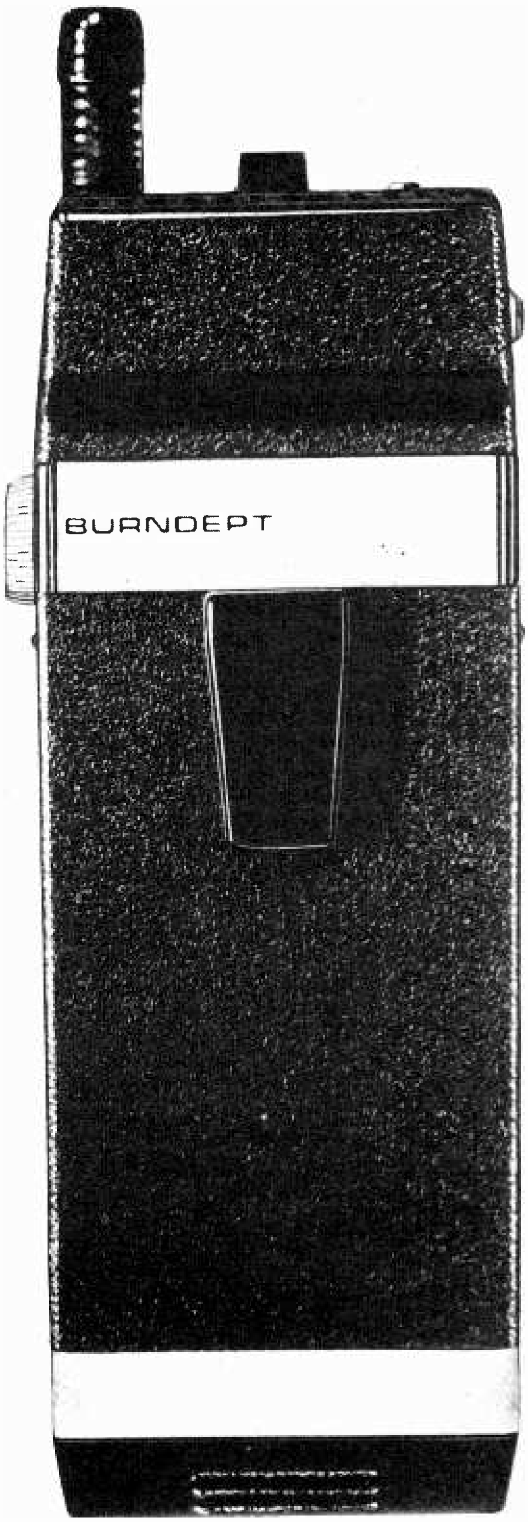

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With all its calculating capability, the Cambridge still measures just $4\frac{1}{3}$" x 2" x $\frac{11}{16}$". That means you can carry the Cambridge wherever you go without inconvenience – it fits in your pocket with barely a bulge. It runs on U16-type batteries which gives weeks of normal use before replacement.

Easy to assemble

All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

Total cost ? Just £14.95 !

The Sinclair Cambridge kit is supplied to you direct from the manufacturer. Ready assembled, it costs £21·95 – so you're saving £7 ! Of course we'll be happy to supply you with one ready-assembled if you prefer – it's still far and away the best calculator value on the market.

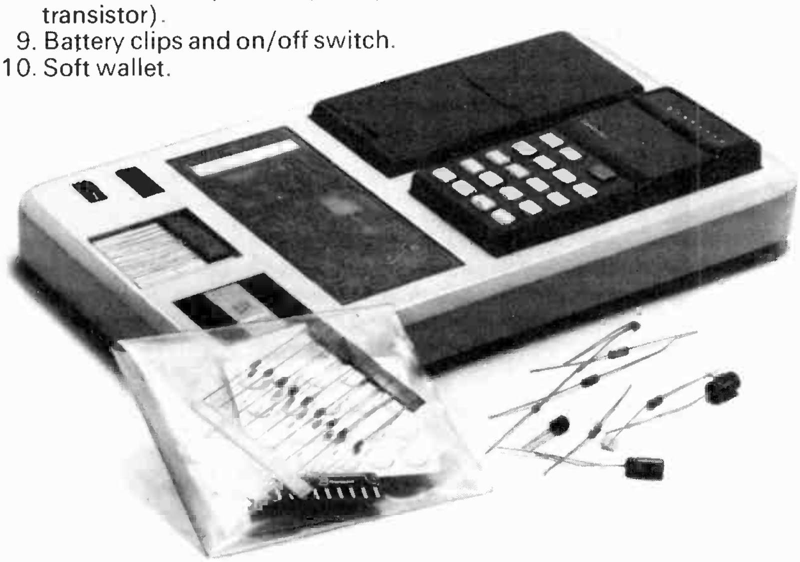
Features of the Sinclair Cambridge

* Uniquely handy package. $4\frac{1}{3}$" x 2" x $\frac{11}{16}$", weight $3\frac{1}{2}$ oz.
* Standard keyboard. All you need for complex calculations.
* Clear-last-entry feature.
* Fully-floating decimal point.
* Algebraic logic.
* Four operators (+, –, x, ÷), with constant on all four.
* Constant acts as last entry in a calculation.
* Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £15.
* Calculates to 8 significant digits.
* Clear, bright 8-digit display.
* Operates for weeks on four U16-type batteries (MN 2400 recommended).

A complete kit!

The kit comes to you packaged in a heavy-duty polystyrene container. It contains all you need to assemble your Sinclair Cambridge. Assembly time is about 3 hours.

Contents:
1. Coil.
2. Large-scale integrated circuit.
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
8. Electronic components pack (diodes, resistors, capacitors, transistor).
9. Battery clips and on/off switch.
10. Soft wallet.



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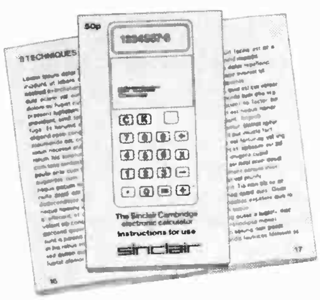

ow? It's all explained in this unique ɔoklet, written by a leading calculator ɜsign consultant. In its fact-packed 32 ıges it explains, step by step, how you can ɜe the Sinclair Cambridge to carry out ɔmplex calculations.

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WW/7/74

WW—076 FOR FURTHER DETAILS

Ohms per volt

A question of voltmeter manufacture

by "Cathode Ray"

Having to keep up an appearance of infallibility is one of the stresses of youth that cause many to die young. But those that escape it, or with maturity learn better, enjoy not adding loss of face to the discomforts of old age. Thus, instead of being upset by receiving a letter from Mr A. J. Sargent pointing out a slip in my treatise on magnetism in the January 1973 issue I was happy to see in it an excuse for further chat.

The said slip had nothing to do with magnetism, so would not have occurred if I'd stuck to the point. It was a slightly faulty buzz from a particularly energetic bee escaping from my well-stocked bonnet. Its motive force was the practice of voltmeter makers of specifying the current load of their products in ohms per volt. My correspondent pointed out to me that it was the reciprocal of current that was so specified. He tactfully refrained from adding "Fancy Cathode Ray forgetting Ohm's Law!".

Well of course he was perfectly right, and although I doubt if anyone was misled by my error, and it was only the generally accepted kind of sloppiness of speech we use in reckoning petrol consumption in miles per gallon. I really ought always to practise what I preach and use my words carefully.

This particular side swipe comes out at the slightest pretext (such as an article on magnetism) because I hope some day to provoke a voltmeter maker into explaining why he specifies the current load of his meters not only reciprocally but also clumsily in ohms per volt. One doesn't ask for a 13 volts-per-ohm plug, suitable for a 240 amp-ohms power supply.

It is in fact an even clumsier practice than at first appears, for in full it has to read "ohms per volt of full-scale reading". So if you want to know how much current is leaking away through your 20,000 ohms per volt voltmeter (to impress you the makers always say 20,000Ω, not 20kΩ) when it is reading, say, 195V on the 300-V range, you have to divide 195 by 300 times 20,000; and if you concentrate on it sufficiently you get 32.5μA as the answer. Personally I think it would be a lot easier if below the voltage scales there was a voltmeter leakage (or load) scale, 0 to 50μA, in grey to be distinct from the volt scales and less conspicuous, but there whenever you wanted it. The deflection that indicated the voltage would at the same time show the voltmeter current.

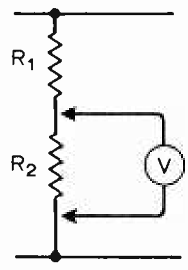
If you did want to know the voltmeter resistance on any range you would simply divide that range (in volts) by the 50μA or whatever full-scale current was shown on that particular instrument. In our example, on the 300-V range it would be 300/50, which (as the current is in μA) is 6MΩ.

Most voltmeters use the same current on all ranges, hence the simplicity of specifying that figure. As for the exceptions that are complicated by more than one full-scale current, note that equally they have more than one ohms-per-volt of full-scale voltage. I'm still waiting to hear why the makers prefer to work in the latter involved terms. M. G. Scroggie, who is very much at one with me in such matters, has been waiting at least 12 years, since the question was first put bluntly in *Radio & Electronic Laboratory Handbook*, 7th edition, and again in the 8th.

What we really want to know, of course, is neither the current nor the resistance. We want to know the voltage between A and B before we connected the voltmeter to those two points. Being very accommodating we would settle for the drop in voltage due to the connecting; it is easy enough to add this to the indicated voltage to give the true reading (subject of course to the possible meter error; and if you haven't studied the relevant British Standard, BS 89, you'd be surprised to see how large that could be. For example, if the reading at 0°C on a portable multi-range moving-coil instrument with a 3in scale was 30V on the 100-V range, the true reading within the tolerances allowed in the Industrial Grade—previously called British Standard First Grade—could be anything from 24.75 and 35.25V. So there would be no sense in logging it to several places of decimals!).

Unfortunately the load error, which is extra, depends on the impedance of the circuit to which the voltmeter is connected. If that is hundreds of times less than the voltmeter resistance then you have little to worry about. But we rarely know what it is, and (especially in circuits subject to feedback) may not even be able to make a reliable guess at the order of magnitude.

One particular but often occurring case is the potential divider (see Figure). Let's suppose it is connected across a relatively low-resistance d.c. source. That puts R_1 and R_2 practically in parallel, so far as the resistance in series with the voltage source and the voltmeter V is concerned. If you have any hesitation about accepting that statement, study of the theorem ascribed to Thévenin (by the French) and Helmholtz (by the Germans) is indicated. Note that this effective source resistance is the same regardless of whether one is measuring the voltage across R_1 and R_2. It is equal to $R_1R_2/(R_1+R_2)$. Call it R_s. The drop in voltage in it due to V is of course I_vR_s, where I_v is the current taken by the voltmeter, read off the scale which the voltmeter manufacturing industry will be rushing to insert when it has finished reading this article. (Oh yes?) So we just add I_vR_s to the voltage reading.



Current load with a potential divider.

If we haven't a clue what the source resistance is, or alternatively have but can't be bothered to perform the above simple calculation or tap it out on the pocket computer, we can get a correction by shunting V by a resistance equal to the resistance of V. Doing this will reduce the reading. This drop is the correction we should add to the first reading. If it is more than about 10% then the correction itself is appreciably inaccurate and we should get a higher-resistance voltmeter.

The late Bainbridge-Bell described a method in which a multi-range voltmeter itself is used to provide an alternative resistance. A reading is obtained on two ranges, the ratio of the higher voltmeter resistance to the lower being m. In most instruments it is the same as the ratio of full-scale readings. Then if V_1 and V_2 are the readings on the upper and lower ranges respectively, the corrected voltage is

$$\frac{(m-1)V_1V_2}{mV_2-V_1}$$

A disadvantage of this method is that readings which come low on the scale are less accurate. Both these altered-resistance methods rely on the circuit as a whole being ohmic (i.e., linear) so may not work well in electronic circuits. In transistor circuits it may be helpful to remember that the base-to-emitter voltage is fairly constant at about 0.55–0.6V for silicon and 0.16–0.2V for germanium.

These methods of correction can be used for a.v. provided also that the a.v. voltmeter is not used on a non-linear part of its range (most of them include a rectifier). And if the circuit is reactive the correction is likely to be very inaccurate. Remember too that a.v. voltmeters are in general less accurate than d.v.

Another curious thing about the habits of meter makers is that although their most popular products measure current as well as voltage (for which they specify voltmeter ohms per volt of full-scale reading) rarely if ever do they act logically by specifying the ammeter in siemens per ampere of full-scale reading. Again, I wonder why, and hope an answer may be forthcoming. Now that the voltages in most electronic circuits are so much lower than they used to be, the voltage lost in the meter when measuring current is correspondingly more significant and ought to be allowed for, or at least allowable for by those who want to do so. But the information is not given. Of course the S/A of f.s.r. form of supplying it is logical only in the context of the illogical Ω/V of f.s.r. which I've been busy deploring. The sensible way would be to have an unobtrusive voltage-drop scale for use when reading current.

I have no doubt that if any instrument makers are taking a blind bit of notice of my constructive criticisms they will be already asking their dictating machines to take a letter pointing out that there are already too many scales to have to find room for on their multi-range test meters, and adopting my suggestions would only make confusion worse confounded. (I don't think on second thoughts they would phrase it just like that.) Perhaps so, but now that a branch of industrial endeavour dignified by the name of ergonomics has been introduced why not use it? If however even this resource fails, at least may we have the full-scale voltmeter current and ammeter voltage included in the specifications in place of the ohms-per-volt rubbish?

MARCH 1974 ISSUE

The issue number on the spine of the March 1974 issue was incorrectly printed as 1461. It should have been 1459, as correctly printed on the contents page. We apologize to readers, librarians and others to whom this error may have caused inconvenience.

Literature Received

PASSIVE DEVICES

Advance Filmcap have sent us a copy of their new capacitor data book, which gives full information on ranges of polycarbonate, polyester, a.c. types, electrolytics and film types of capacitor. Advance Filmcap Ltd, Rhosymedre, Wrexham, Denbighshire WW401

Erie have sent us a wall-chart which covers capacitance ranges and working voltages of their ceramic, electrolytic, paper and film capacitors, together with outline drawings. Erie Electronics Ltd, South Denes, Gt. Yarmouth, Norfolk WW402

EQUIPMENT

A short-form catalogue describing a range of pulse generators, word generators, a.f. oscillators and distortion meters has been published by Lyons Instruments Ltd, Hoddesdon, Herts WW403

Two new product ranges are described in a supplement to the Radiatron short-form catalogue. The Electromatic range of timing, sensing and control modules with relay output is listed and there is a description of the Hopt electromechanical and electronic counters. Radiatron Components Ltd, 76 Crown Road, Twickenham, Middlesex WW404

Constant-potential battery chargers are the subject of a leaflet from Erskine Systems Ltd, Newby, Scarborough, Yorkshire, YO12 6UE. Chargers of capacity from 24V, 3A to 220V, 15A are described in both chassis and cubicle forms WW405

Two low-noise microwave sources are fully described in leaflets from Microwave Associates. The ML13000 series, on Bulletin L/0013, provides signals in the range 1.25GHz to 17GHz, while Bulletin L/0009 details the performance of the ML12000 multi-channel series, working between 1.7 and 10.3GHz. Microwave Associates Ltd, Dunstable, Bedfordshire LU5 4SX WW406

Intended principally as an IEA promotional leaflet, a publication by Feedback, "Teaching Technology", forms a short-form catalogue of a range of equipment for the teaching of electrical, mechanical and control technology. Feedback Instruments Ltd, Park Road, Crowborough, Sussex WW407

Moore Reed have sent us a leaflet on their VT111 "Intelligent" video display terminal, which is field-programmable, containing a central processing unit and a 4k memory. Moore Reed & Co Ltd, Walworth Industrial Estate, Andover, Hants WW408

We have received a leaflet describing a range of kilovoltmeters measuring up to 200kV or more from Hipotronics Inc, Brewster, NY, USA WW409

Bulletins 7602 and 7603 describe a series of Gunn oscillators intended for use as local oscillators in remodulation-type link equipment receivers, between 5.855GHz and 13.27GHz at 3W nominal. Microwave Associates Inc, Burlington, Mass., USA WW410

Data sheets are now available on the Mini 400 series of bench power supplies by Weir Instrumentation Ltd, Durban Road, Bognor Regis, Sussex .. WW411

We have received from Bradley a wall-chart which, in addition to brief information on their range of measuring instruments and microwave sources, contains some interesting general information in the form of conversion tables, pulse parameters, Fourier analysis and the like. G. & E. Bradley Ltd, Electral House, Neasden Lane, London NW10 1RR WW412

APPLICATIONS

We have received from Nordmende a booklet, in English and German, intended to assist technicians in the servicing of digitally-controlled TV receivers by Nordmende. The booklet is a very simple introduction to basic logic circuitry in addition to the television information on the Telecontrol II system. Norddeutsche Mende Rundfunk KG, Zentralkundendienst, 28 Bremen, Postfach 44 85 08, Germany WW413

Mullard have reprinted an article, originally in *Mullard Technical Communications*, entitled "Cleaning Processes for Mullard Resistors and Capacitors on Printed-wiring Boards", which deals with the use of various types of cleaning agent and their effect on component materials. Ref. TP1448, Instrumentation and Control Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD WW414

Equipment designed by the BBC Designs Department is often described on information sheets for the benefit of manufacturers who may wish to exploit the designs commercially. We have recently received EP14/1, CO8/501 and RLE, describing a.f. test equipment, 8-bit a-to-d, and d-to-a converters and radio link equipment. BBC Designs Department Liaison Unit, BBC, London W1A 1AA WW415

GENERAL CATALOGUES

A catalogue of liquid-tight fittings, strain-relief terminations, Ty-rap harnessing, connectors, tools and wire-markers, has been produced by Thomas and Betts Ltd, Greenhill House, 90/93 Cowcross Street, London EC1M 6JR WW416

The 1974 index and price list from ECS is now available, covering products from RCA, SGS-Ates, IR, Keyswitch, AEG/Telefunken, Emihus, Seatronics, Allen Bradley, Guest International, Semitron and Litesold. ECS (Windsor) Ltd, Thomas Avenue, Windsor, Berks. WW417

MISCELLANEOUS

The Final Acts of the World Administrative Telegraph & Telephone Conference held in Geneva in 1973 has just been published by the ITU. The Acts contains Telegraph and Telephone Regulations which come into force in September 1974, and are published in French, English and Spanish. Each volume costs 17 Swiss Francs from Sales Service, International Telecommunications Union, Place des Nations, CH-1211 Geneva 20, Switzerland.

About People

Howard Steele, ACGI, B.Sc(Eng), FIEE, Director of Engineering of the IBA, was awarded an Honorary Fellowship of the British Kinematograph, Sound and Television Society at the Fellows' Luncheon in May. The award is in recognition of his "unremitting efforts to progress the highest standards of motion picture film technology and usage in colour television broadcasting". Mr Steele played an important part in the selection of the European colour television system and was awarded two Royal Television Society premiums for his contributions.

Senri Miyaoka, manager of television tube development at Sony, received the 1974 Vladimir K. Zworykin Prize Award for his contribution to the development of new concepts in colour television tubes. Mr Miyaoka was responsible for the development of the single-gun, three-beam tube—the Trinitron, released in 1968. An article on this tube by Mr Miyaoka appeared in our December, 1971 issue.

Radio interference

Concluding a review: methods of measurement

by A. S. McLachlan, J. H. Ainley and R. J. Harry

Directorate of Radio Technology, Home Office

For successful control of interference it is necessary to ensure that the bulk of equipment is suppressed before being placed on the market. Because of the wide variety of equipment which may cause interference and the great diversity in the design of any particular type of equipment it is not possible to prescribe a single physical form of suppression which will meet every case. Instead it is necessary to lay down limits in a particular form for each class of equipment in conjunction with a standardized method of measurement[9] and a method of production control. There are generally four different ways in which interference may be coupled from an equipment to a receiving installation: by conduction along leads such as mains supply wiring, telephone or control cables; direct radiation from the equipment itself; radiation from the leads; or radiation from an aerial connected to a radio transmitter or receiver.

Thus there are requirements for two basic forms of measurement—a voltage measurement at the power supply terminals (and in the case of radio transmitters or receivers at the aerial terminals) of the equipment and a radiated field strength measurement.

For equipment which itself radiates, it is generally necessary to apply both methods in the frequency range up to 30MHz but because power at higher frequencies is poorly conducted along wires a radiation measurement only is necessary at frequencies above 30MHz. For equipments such as small domestic appliances which do not themselves radiate appreciably, a terminal voltage measurement only is necessary in the frequency range up to 30MHz to control conducted interference, with some other form of measurement to control the radiation from the leads in the frequency ranges above 30MHz. The terminal voltage measurement on all equipment with the exception of television receivers is made using a standard V network in which the measured voltages V_1 and V_2 are a combination of the symmetric voltage, e_s, and the asymmetric voltage e_a which are shown in the equivalent circuit in Fig. 4. The 150 ohms termination is chosen to represent the mains impedance which has been shown to have a median value of this order. For television receivers a delta network is used in which the symmetric and asymmetric voltages are measured separately.

At frequencies above about 30MHz conducted interference ceases to be important and coupling is mainly by radiation from the equipment and its leads. When radiation takes place from the equipment itself, e.g. from motor vehicle ignition systems and large radio frequency heating devices, measurement of radiated field strength must be made. This is done in a standard manner usually at a distance of 3m, 30m, 100m or 300m from the appliance, depending upon the frequency range and size and power of the source. The measurement of ignition interference at a distance of 10m is shown in Fig. 5.

Field strength measurements are difficult and expensive; their accuracy and repeatability with normal equipment and techniques tends to be low and the measurements usually have to be made outdoors. To overcome the drawbacks of the direct measurement of field strengths the CISPR has developed substitution methods of measurement in which the results are quoted in terms of c.w. power from a signal generator to give the same output on the measuring receiver as the equipment or appliance under test.

Two different methods are in use. In the first, which is used for battery operated appliances with self-contained batteries in the frequency range 30–300MHz and for microwave ovens in the frequency range 1 to 18GHz, the equipment is placed on a turntable at a convenient distance from a measuring aerial and rotated for maximum indication on the measuring receiver. The equipment is then replaced by a half-wave dipole fed from a standard signal generator which is adjusted to give the same output on the measuring receiver. The interference power of the equipment is then quoted as the power (pW) at the terminals of the dipole. The second method utilizes a ferrite current transformer and associated power absorbing ferrite rings arranged in a manner to be described later.[10] The transformer and associated ferrite rings are moved along the supply lead to obtain a maximum indication on the measuring receiver. The interference power of the equipment is quoted as the c.w. power from a standard signal generator to give the same output on the measuring receiver under defined conditions. This method is used in the frequency range 30–300MHz for domestic and other appliances which radiate mainly from the supply leads.

At present in the UK and a number of other countries the greatest number of complaints from a single source of interference are those caused by contacts, mainly of thermostats. Measurement of the discontinuous interference caused by contacts presents difficult problems. The solutions in current use are not entirely satisfactory and the resultant methods of measurement which have developed over a great number of years are very complicated and not readily understood. Originally discontinuous interference ("clicks") was distinguished from continuous interference ("buzzes") by listening in the audio circuits of the measuring set. Clicks, which were disturbances

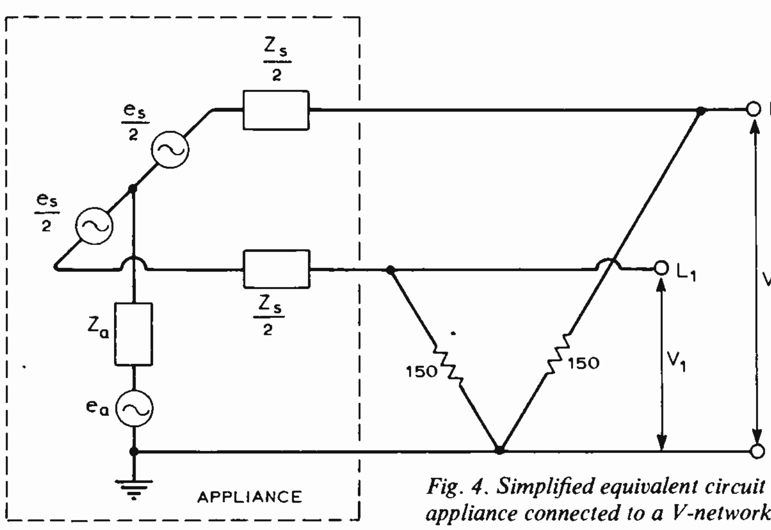


Fig. 4. Simplified equivalent circuit of an appliance connected to a V-network.

judged to last less than 200ms, were counted by the operator and a weighting factor of $20 \log_{10} 30/N$, where N equals the number of clicks per minute, was added to the limit for continuous interference to arrive at that for the discontinuous interference for the appliance under test. The appliance was then judged to pass or fail the test by the application of the upper quartile method in which if more than 25% of clicks exceeded the limit the equipment was rejected.

Fig. 5. Measurement of ignition interference.

This method is extremely tedious and time consuming and, relying as it does on the judgement of individual operators, yields results which are far too inconsistent for use in modern conditions. Recently, as an interim measure to enable test houses and laboratories to speed up measurements and achieve more consistent results, especially on programmed appliances such as automatic washing machines, the CISPR has rationalized its recommendations on discontinuous interference and has produced a more rigid definition of a "click" to enable the measurement of duration and repetition rate to be made using a special electronic counter specified in CISPR Recommendation No. 41. Fig. 6 shows the block schematic of the method of measurement in the v.h.f. range.

A click is now defined as a disturbance which lasts not more than 200ms and is separated from a subsequent disturbance by at least 200ms. If more than two of these clicks appear in any two-second interval the limit for continuous interference applies. For clocks which are repeated less often than twice in two seconds the weighting factor $20 \log_{10} 30/N$ applies as before.

The method of counting the number of clicks during the observation time is important and where possible, i.e. in general for simple appliances, the number of openings and closings of the switch or thermostat is used. For programmed appliances and other complex equipment where it is impossible to count the number of openings and closings of contacts the number of clicks which exceed the limit for continuous interference is counted by the interference analyser and the upper quartile analysis is then applied as before.

The input to the disturbance analyser is taken from the i.f. stage of the measuring set which retains the function of the measurement of amplitude. The disturbance analyser's functions are the counting of clicks and the assessment of duration and repetition rate. The operation is semi-automatic in that the apparatus may be set up and left unattended for the duration of each test which may last as long as several hours.

Limits of interference

When suitable methods of measurement have been developed it is then possible to fix limits of interference. To a large extent these are a compromise between that which will give protection in all circumstances and that which it is possible to achieve economically without affecting the operation or safety of appliances to be suppressed. For the broadcasting bands the limits are based on calculations which take into account the minimum field strength at which a particular broadcasting service is expected to provide satisfactory reception, the median value of the measured decoupling factor between an appliance and sound radio or television installations in homes, the protection ratio required for satisfactory reception and the effective length of the receiving aerial. It is then common practice to monitor the effectiveness of these limits by analysing the statistics of complaints as described earlier. Limits used in the UK are in general in accordance with the recommendations of the CISPR which are based on compliance in production of 80% with a confidence of 80% assuming a gaussian distribution.

Measuring apparatus

Measuring receivers. Interference measuring equipment was first designed for use in the protection of amplitude-modulated sound broadcasting in the l.f. and m.f. bands. Extensive testing was undertaken to determine the electrical characteristics required to give measured values corresponding to the subjective effect of disturbances. For the l.f. and m.f. bands this resulted in a specification for an r.f. value voltmeter having a bandwidth of 9kHz and detector time constants of 1ms charge and 160ms discharge. The bandwidth of 9kHz was, of course, chosen to represent the bandwidth of the a.m. sound broadcast receivers in use at the time. For the protection of other type of services it would be ideal to have measuring apparatus specially designed to correspond to each service. Unfortunately for general use this would be uneconomic and also there would be a difficulty in correlating the results of measurement by different apparatus to achieve

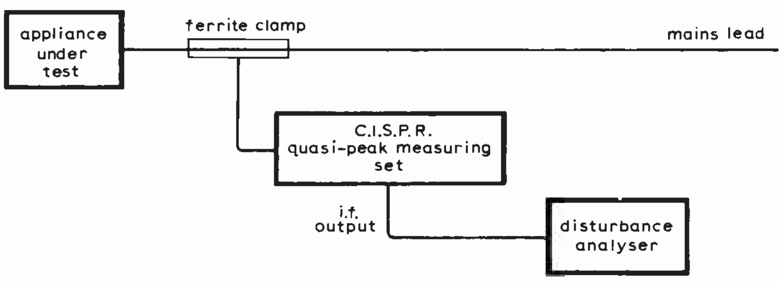


Fig. 6. Measurement of discontinuous interference in the frequency range 30–300MHz.

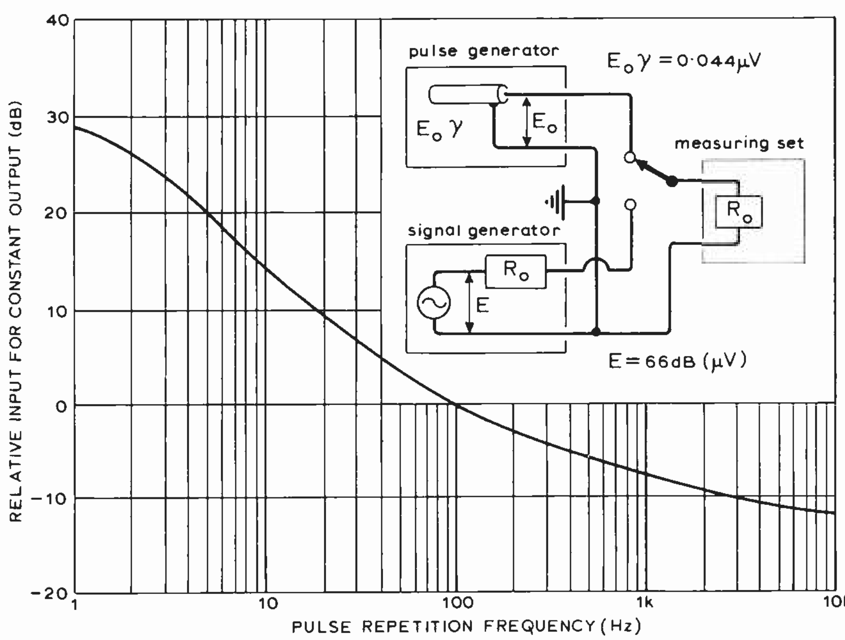


Fig. 7. Pulse response curve 25–1000MHz of CISPR interference measuring receiver

a common limit to apply to interfering equipment. The CISPR therefore decided to standardize on fixed bandwidth receivers with specified time constants. There are three specifications for the frequency range 0.15–1000MHz, the essential characteristics of which are shown in Table 2. The use of the specified characteristics in a CISPR receiver has the effect of requiring a larger amplitude input to give the same output as the pulse repetition rate decreases. Fig. 7 shows the pulse response curve for the frequency range 25–1000MHz. A measuring receiver built to the CISPR specification is essentially of the superheterodyne type with solely manual gain control by means of calibrated attenuators and a built-in calibrator for setting the receiver gain to a standard value.

Impulsive interference is unlikely to be a problem at frequencies above 1GHz. At present the only likely major source of interference at these frequencies is the microwave oven which is designed to operate at a frequency of 2450±50MHz or 5280±100MHz but which also generates energy at other frequencies not necessarily harmonically related to the fundamental but extending throughout the spectrum from the l.f. band up to the s.h.f. bands. Experience has shown that each such spurious radiation may occupy a bandwidth in excess of 50MHz and that the energy is not uniformly distributed over this bandwidth. Thus measuring receivers with different bandwidths may give different results and it is not possible to apply accurate correction for bandwidth in order to correlate them.

It has been argued that the best correlation with the disturbing effects of this type of interference would be obtained with the use of a measuring receiver having a very wide bandwidth and an r.m.s. detector. The CISPR, however, has taken the view that the construction of a special receiver for the measurement of interference from microwave ovens would be so expensive that very few would be built and that effective control would be much more likely to be achieved if it were based on a commercially available receiver which is already in widespread use. It has therefore recommended the use of a spectrum analyser having the characteristics shown in Table 3.

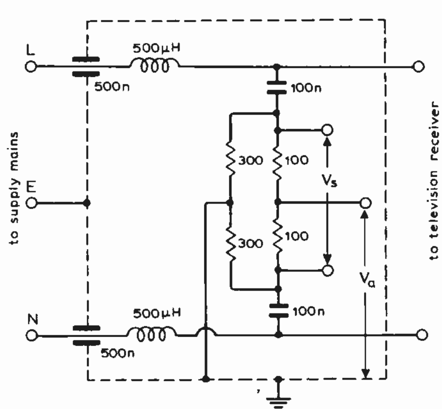


Fig. 8. Basic circuit of a delta "artificial mains" network.

TABLE 2
CHARACTERISTICS OF CISPR QUASI-PEAK MEASURING APPARATUS

Characteristics	Frequency range (MHz)		
	0.015 to 0.15	0.15 to 30	25 to 1000
Bandwidth at 6dB	200Hz	9kHz	120kHz
Charge time constant	45ms	1ms	1ms
Discharge time constant	500ms	160ms	500ms
Mechanical time constant of meter	100ms	100ms	100ms
Overload factor (r.f. and i.f. amplifiers)	24dB	30dB	43.5dB
Overload factor d.c. amplifier	12dB	12dB	6dB

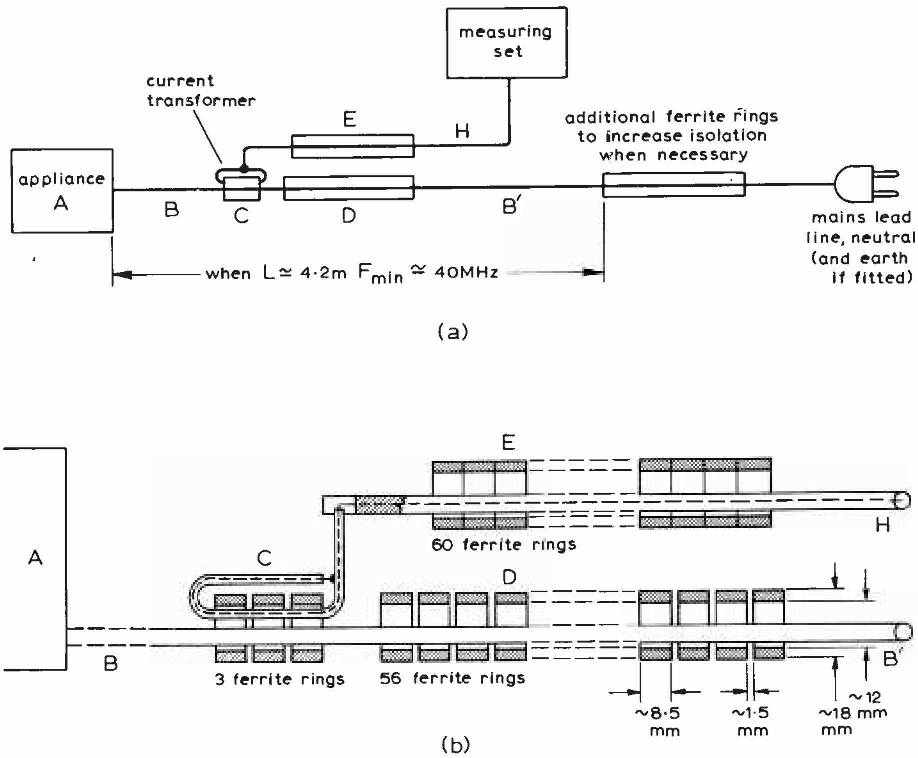


Fig. 9. Construction and use of the CISPR ferrite clamp.

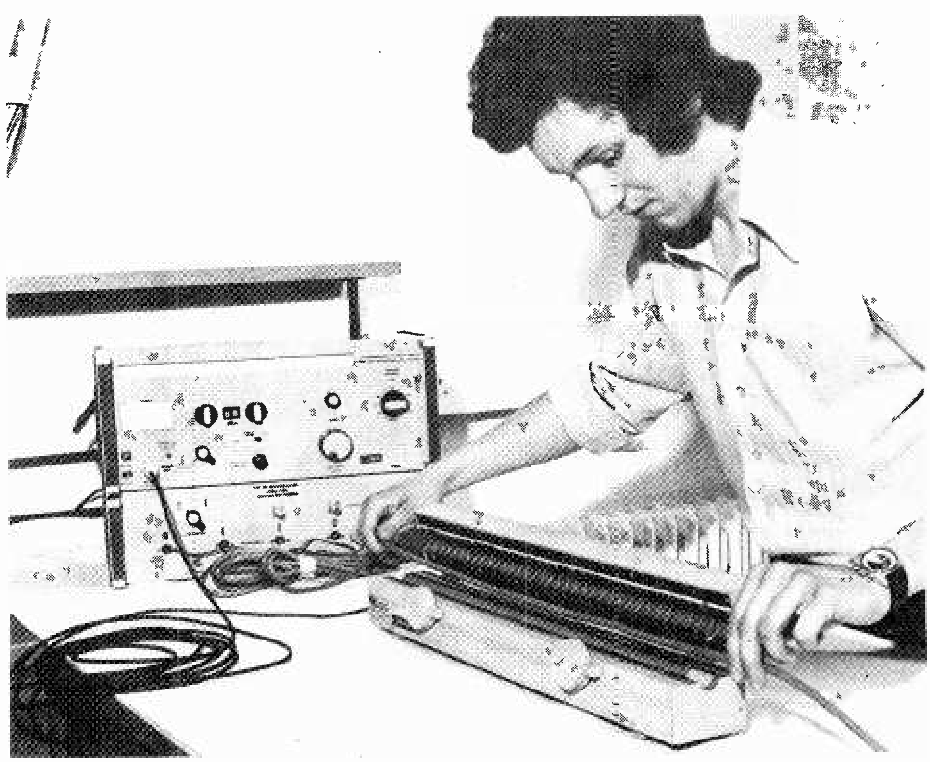


Fig. 10. The CISPR ferrite clamp.

TABLE 3

Characteristics of a spectrum analyser for use in the frequency range 0.3–18GHz

Spurious responses: 40dB below response at the instantaneous tuned frequency. (A pre-selector may be used.)
Bandwidth: 125±25kHz.
Variable attenuation in both r.f. and i.f. sections of receiver.
Screening effectiveness: 60dB.
Sweep time: variable from at least 0.1 sec. to 10 secs.
Display tube: storage type (or other means of storing information).

Note: During measurements a filter shall be provided at the input of the analyser, having at least 30dB attenuation at the operating frequency of the equipment under test.

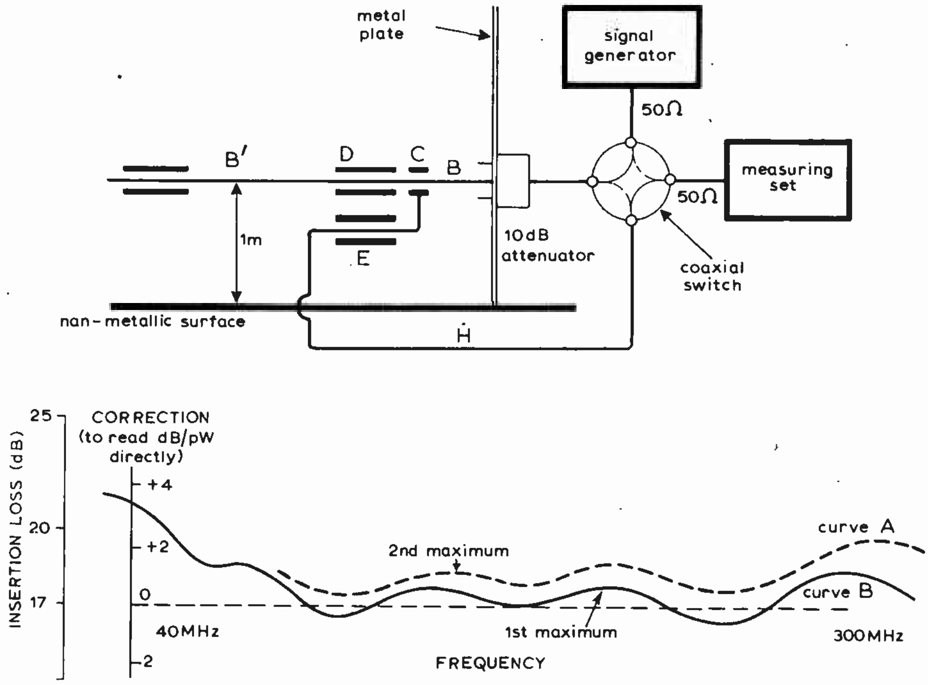


Fig. 11. Method of calibration of CISPR ferrite clamp.

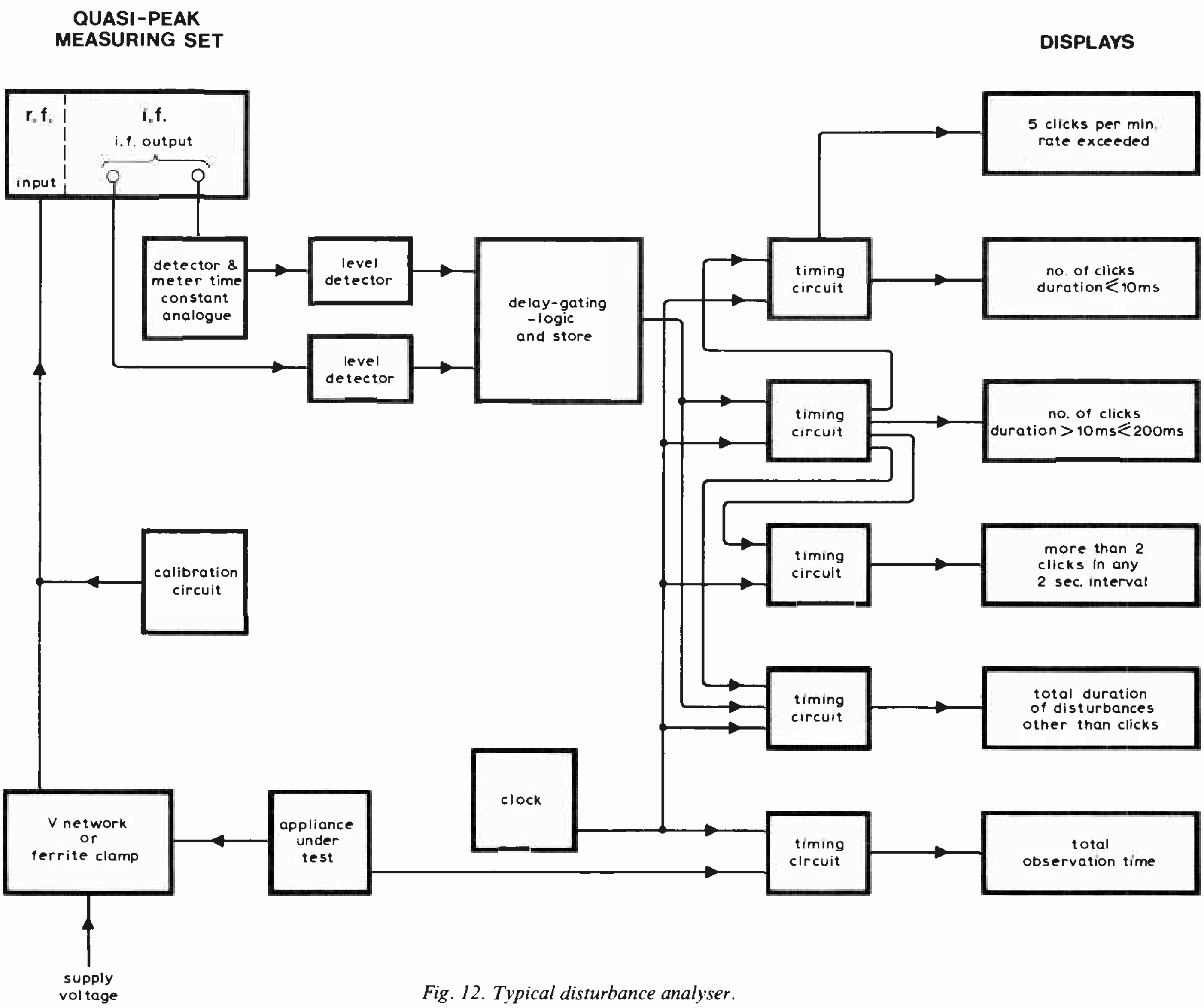


Fig. 12. Typical disturbance analyser.

Auxiliary apparatus. As already stated the interference measuring receiver is essentially a valve voltmeter and has to be used in conjunction with certain auxiliary apparatus including antennae and terminating networks. For field strength and substitution measurements the use of a half wave dipole antenna is normally specified with the proviso that broadband and other types of antenna such as horns may be used where these can be shown to give the same results.

For measuring terminal voltages in the frequency range up to 30MHz terminating networks of specified form are used. These range from simple attentuators for antenna terminal voltage measurements to V and delta[11] "artificial mains" networks for measurement on mains supply and other lines. Fig. 8 shows an example of a basic delta network for measuring r.f. voltages on the supply terminals of television receivers. The network is required to provide a defined impedance, at radio frequencies, between the mains input terminals of the television receiver and between each of these terminals and earth. In addition a suitable filter is incorporated to isolate the measuring receiver from radio frequency voltages on the supply mains. In practice this is somewhat difficult to use and a modified version using a balun is employed.

For the assessment of interference radiated from the mains lead of an appliance in the frequency range 30–300MHz a ferrite clamp is used. The construction and use of a typical CISPR ferrite clamp[10] is shown in Fig. 9. It consists basically of a ferrite cored current transformer in which the mains cord of the appliance under test is one winding and the lead to the measuring set is the other. To stabilize the impedance at the point of measurement and provide some r.f. isolation from the mains, a large number of ferrite rings, usually between 50 and 65, are placed over the mains lead as shown in Fig. 9(b). A like number of rings are placed round the lead to the measuring set to reduce standing waves on the screen. In practice the rings are split and mounted in a hinged plastic case as shown in the photograph in Fig. 10. This allows appliances having mains leads with moulded-on plugs to be measured without cutting or changing the lead. At each frequency of measurement the clamp is moved along the stretched out main lead to give maximum reading on the meter at the current antinode closest to the appliance. At this point the clamp presents to the appliance a substantially resistive impedance of between 100 and 250 ohms.

The clamp method of measurement is essentially a substitution one in which the appliance is replaced by a standard signal generator. The interference power is taken to be that from the generator at the input to the clamp. To avoid the tedious process of substituting the signal generator on every measurement a calibration curve is prepared for each clamp under defined conditions. Fig. 11 shows the details of the calibration in which the clamp is placed 1m above a non-metallic surface and connected to a signal generator and a measuring set to enable a measurement of insertion loss to be made. Radio interference measuring receivers are usually calibrated to give voltage readings in dB (μV) (i.e. decibels relative to 1μV). To convert a voltage across a 50-ohm resistor expressed in dB (μV) to power in the *resistor* expressed in dB (pW) (i.e. decibels relative to 1 pW) it is necessary to subtract 17 (i.e. $10 \log_{10} 50$). Quite fortuitously the insertion loss of a well-made clamp connected between 50-ohm impedances is nearly equal to 17dB, thus for many purposes it is possible to read the interference power in dB (pW) directly from a measuring receiver which is calibrated in dB (μV). For greater accuracy the calibration curve for the particular clamp can be used.

The clamp has been developed empirically and the precise theory is not yet well understood. For instance the selection of the correct grade of ferrite presents a difficulty and is essentially a matter of trial and error. Nevertheless the performance of correctly constructed clamps has been checked in many different countries and it has been confirmed that it provides a most satisfactory method for the measurement in the v.h.f. bands of interference from equipment which radiates mainly from the supply leads.

For the measurement of discontinuous interference an automatic analyser has been developed. A schematic diagram of a typical analyser is shown in Fig. 12. The function of the disturbance analyser is the recognition and recording of different durations and repetition rates of interference generated by switching devices. Measurement of the amplitude of these disturbances remains the function of the quasi-peak measuring set. The disturbances which are being measured are of fairly high amplitude and comparatively long duration and there are thus none of the problems of coping with short duration, fast risetime pulses of low amplitude. The main problems have been the difficulty, because of the varying delay times, of associating each pulse in the intermediate frequency stage with the corresponding meter deflection, and the precise interpretation of the various, sometimes conflicting, requirements which had been laid down at different times in different CISPR recommendations. The CISPR, as already mentioned, has rationalized the requirement for the measurement of discontinuous interference and included all of them in one recommendation. This has removed one difficulty. The other problem has been tackled in different ways in different countries and it will require further work to standardize the analysers to ensure reasonable correlation of results.

Conclusions

A large measure of success has been achieved both nationally and internationally in the control of radio interference. There is still much to do, however, and the rapid changes which are taking place in every facet of modern life make it essential to keep existing equipment and practices under review.

For the present, the emphasis, from a standardization and regulatory point of view, has shifted to the treatment of radio interference measurement and suppression requirements so that they no longer form a possible barrier to trade. In the UK this will mean a change from a predominantly voluntary system of co-operation to one in which almost all equipment will be required by law to be suppressed at the time of manufacture. This in turn may lead eventually to the extension to other products of the type testing and conformity marking scheme now in operation for motor cars.

Acknowledgement is made to W. Goldsmith for his contribution on international aspects, to the staff of the Ministry's radio interference laboratory for their assistance in the preparation of the article and to the Director of Radio Technology for permission to publish it.

References

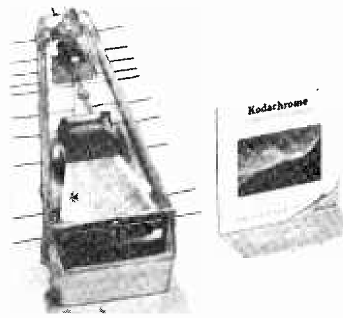
9. Towards Standardization of Radio Interference Measuring Equipment and Techniques: G. A. Jackson. Proceeding of the Joint Conference on Radio Interference Measurements and Standards, Proc. No. 10: IERE Conference Proceedings No. 10.

10. La Pince Absorbante. J. H. L. Meyer de Stadelhofen, *Bulletin Technique PPT Suisse*, No. 3, 1969, pp. 96–104.

11. IEC Publications 106 and 106A. Recommended methods of measurement of radiation from receivers for amplitude-modulation, frequency-modulation and television broadcast transmissions.

The short view

The cathode-ray tube in the photograph has been designed by A. V. de V. Krause for the Sinclair television receiver, now under development. The tube is 100mm long and presents a picture which is about the same size as a 35-mm slide. The directly-heated filament, working at 0.75V, consumes 30mW. Electrostatic deflection is used, requiring 100Vp.p. per 1000V on the third anode, which is run at 1–2kV (beam current 35µA). Grid voltage for cut-off is −20V per kV of first anode potential. Novel techniques are used in the tube construction, the body being made in two parts, split longitudinally. No graphite coating is applied, a metal shield being used to collect the beam current—screening has not been found necessary. It is intended that the tube should be mounted directly on a p.c. board by its lead-out wires.



Miniature tube for television and applications in other types of display.

New Products

Distortion analyser

The model DA1A combined harmonic distortion measuring set, low distortion oscillator and voltmeter features a switched high-pass filter, an input level of 500mV with an optional level of a 100mV minimum and isolated earths between the oscillator and distortion measuring set by the use of separate supplies.

The meter has eight ranges in a 1, 3, 10 sequence covering 0.03% to 100% f.s.d. Six spot frequencies are used from 30Hz to 10kHz with an oscillator distortion of 0.03% and 0.003% respectively. The total noise plus distortion for the instrument is typically 0.005% at 1kHz. The DA1A is available with either mains or battery power and priced at £120 (battery power). Two complementary instruments are also available, the AFU1 audio band pass filter priced at £57 and the IMD1 intermodulation distortion analyser priced at £76. Marshall Penrose Instruments, 70 Heybridge Avenue, London SW16 3DX.
WW 319 for further details

F.m. aerial

Now available in Britain is the Fuba UKA Stereo 8 aerial. This model has a detachable junction box with correct matching for either 75Ω coaxial cable or 300Ω balanced feeder. An average gain of 9.0dB, average front-to-back ratio of 24dB, typical standing wave ratio of 1.2 and a horizontal/vertical angle of acceptance of 49° and 70° respectively is offered by the aerial. The unit, which measures 255 × 180cm, has a retail price of £18.90 inc. VAT. Audio Workshops Ltd, 29 High Street, Robertsbridge, Sussex.
WW311 for further details

Crimping kit

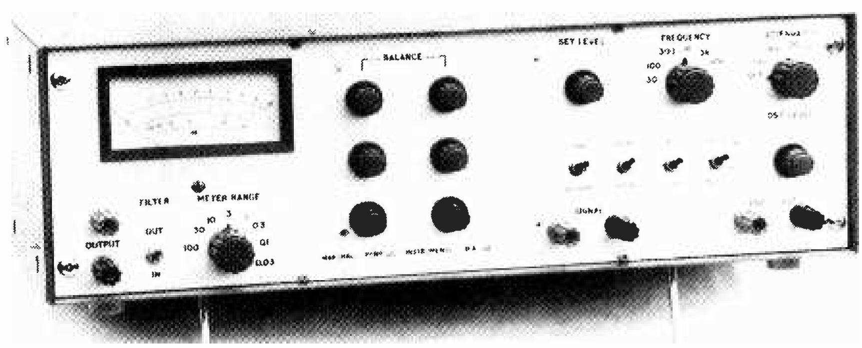
A termination kit comprising ten terminal packs, a crimping/stripping tool and metal case is available at the price of £16.50. Replacement packs of ring, spade and lug types in 36 styles of termination are available at the standard price of 96p. Invader Components Ltd, 30 Tribune Drive, Trinity Trading Estate, Milton, Sittingbourne, Kent.
WW 317 for further details

Turns counting dial

A potentiometer turns-counting dial, model 2626, provides ten-turn adjustment with readings of 1/50 of a turn. The dial mounts on a ¼in shaft and projects 0.9in from the panel surface. A positive locking mechanism prevents accidental changes in setting due to vibration. Beckman Instruments Ltd, Queensgate, Glenrothes, Fife.
WW313 for further details

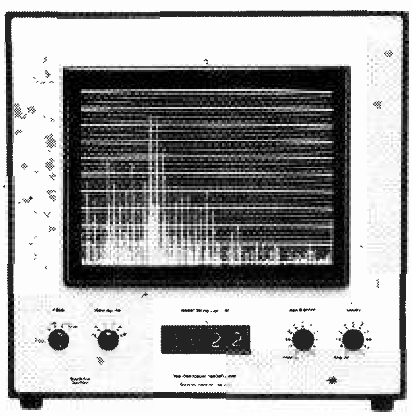
Real-time analyser

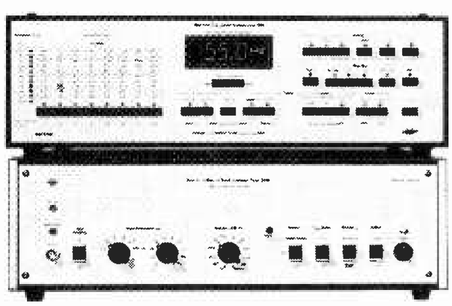
The real-time narrow-band analyser type 3348 produces a 400-channel constant-bandwidth calibrated spectrum which is updated every 45ms. This spectrum is displayed on a 12in c.r.t. The system features 11 internally selectable frequency ranges between 0 to 10Hz and 0 to 20kHz in a 1, 2, 5 sequence. The system may be used to analyse continuous signals in real time, within the selected frequency range. Short duration, shock and transient signals may also be analysed using a transient capture function. The controls of the 3348 feature electronic interlocking for error-free operation. All of the important functions can be controlled externally, for example in con-

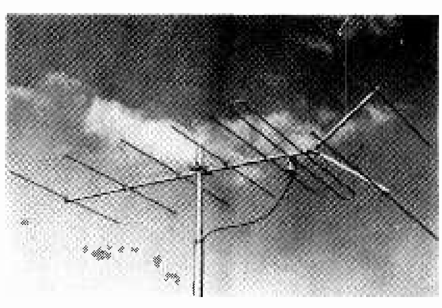


WW319


WW310




WW301


WW311

nection with an on-line computer or simply with a pre-wired plug. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middx TW3 2AE.
WW 301 for further details

Plug-in power supply

The 90202–D plug-in power supply will provide up to 1400V d.c. accelerating potential, and filament heating power for small and medium size c.r.t. displays. With a 1.1mA external d.c. load the ripple voltage is less than 1.5V r.m.s., rising to less than 3V for a 3mA load. This power supply is not regulated or stabilized and the output voltage is therefore proportional to the input voltage. It is possible to adjust the output voltage within reasonable limits by varying the load current. The circuit allows grounding of either the positive or negative terminal of the d.c. high voltage. James Millen Manufacturing Company Inc, Malden, Massachusetts 02148, USA.
WW314 for further details

D.c. voltage calibrator

The model 501 is a high-speed programmable d.c. voltage calibrator with a resolution of 10μV from 0 to 10V d.c. and an optional range of 100mV with a resolution up to 0.1μV. The instrument features a settling time of less than 100μs to within 0.01% of programmed value. Programming inputs accept standard t.t.l. or d.t.l. positive logic levels with an option on negative logic. The b.c.d. 8-4-2-1 format is standard, and all industry-accepted codes including ASCII can be interfaced by plug-in accessory boards. Hepworth Electronics, Bank Buildings, Kidderminster DY10 1BG.
WW 315 for further details

D.i.l. pin headers

A range of 14-, 16- and 24-pin "plug" assemblies with either a high or low profile is available from Jermyn. The low-profile version can be used with multicolour flat cable to provide an inexpensive means of board-to-board connection. The high-profile type is suitable for constructing potted circuits. Discrete components can be soldered across the pins and once the snap-on cover is in place potting compound can be injected through a hole or slot in the assembly. Jermyn Manufacturing, Sevenoaks, Kent.
WW 306 for further details

Photometer

The lightmaster, which is suitable for measurements of interior and exterior lighting, gives readings of 0–100, 0–1000 and 0–10,000 lux for interior and ×10 for exterior lighting. A 0–20 lux scale can be supplied for low light levels. Each photometer is individually calibrated against a standard test lamp, verified by the NPL. The complete unit is housed in a leather carrying case, measuring 25×13×10cm. Diffusion Systems, 43 Rosebank Road, London W7.
WW310 for further details

Ten watt i.c.

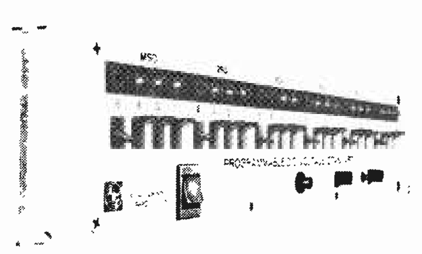
The TCA940 monolithic audio-amplifier features thermal shut-down and power-limiting short-circuit protection. The amplifier will deliver 10W into 4Ω at 10% distortion with a 20V supply. Input bias current is 0.5μA and the standby current is 20mA. An input resistance of 5MΩ with an open-loop voltage gain of 75dB and a 40Hz to 20kHz bandwidth is offered by the device, which is available in a 12-pin package. SGS-Ates Componenti Elettronici SpA, Via C. Olivetti, 2 20041 Agrate Brianza, Milan, Italy.
WW312 for further details

Gas monitors

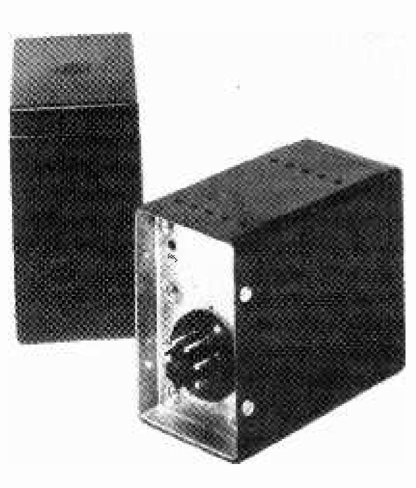
The Neotronics series of gas monitors automatically samples the atmosphere at four-minute intervals and assesses the concentrations of any inflammable gases that may be present. An audible and visual alarm is given at a concentration which, although it is still safe, indicates a potential danger of explosion. The monitor will not respond to non-explosive fumes such as cigarette smoke. The basic sensing element is a pellistor which is a catalytic detector. This sensor is operated in a pulse mode which extends the useful life appreciably.

WW317

WW313



WW315



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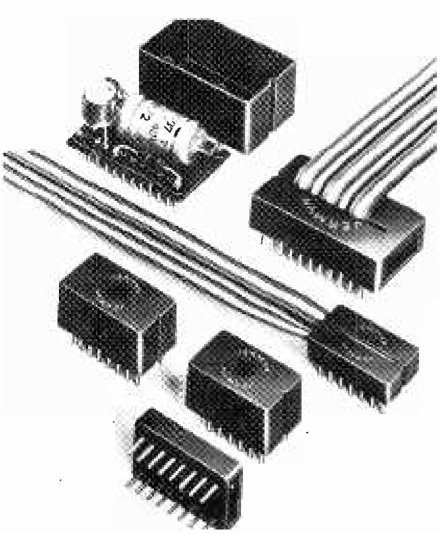


WW306

WW300

There are two basic types of monitor in the series, a portable model and a model for fixed installation. Special features of the instrument include a self-checking operation at four-minute intervals. In the event of a critical component failure a "fault" signal is given. In addition, a gas-test control is provided which artificially simulates a gas alarm condition for operational checks. Neotronics Ltd, Building 102, FSTS Site, Stansted Airport, Stansted, Essex CM24 8CX.
WW 300 for further details

Open pocket-plate batteries

Ever Ready are introducing a range of open nickel cadmium storage batteries using the pocket plate construction technique. This range is divided into two groups: the T range for continuous discharge and the TS range for high current loads and impulse discharge. The cells are available in either sheet steel or plastic cases depending on capacities. In addition a range of battery crates is available of either wooden or plastic construction. Ever Ready (Special Batteries) Ltd, Hockley, Essex SS5 4AH.
WW 318 for further details

Multicolour penetration screens

The penetration screen is made of two separate fluorescing phosphors of different colours and/or different persistences, separated by a barrier layer. The low-energy electrons (e.g. 9keV) excite the first phosphor and are stopped by the layer. The phosphor fluoresces according to its absorption characteristics. Higher-energy electrons (e.g. 17keV) penetrate the layer and excite the second phosphor to give its characteristic emission. The absence of a mask results in improved resolution and brilliance. If the tube is driven by conventional logic, pictures with four colours may be obtained. The penetration screens are available in deflected c.r.ts ranging from small-diameter types to 22in round or 21in rectangular face-plate sizes. Thomson-CSF Electronic Tubes Ltd, Bilton House, Uxbridge Road, Ealing, London W5 2TT.
WW 309 for further details

Isolation amplifier

A high-voltage isolation amplifier, type 709, has been designed to transmit a.c. and d.c. signals produced at or near ground potential to circuits having potentials up to 4kV with respect to ground. The amplifier will also amplify the input signal up to × 100, providing an output of 200V peak-to-peak. The input impedance is not less than 100kΩ, load current is 25mA maximum, drift is in the order of 1% and the frequency response is 0 to 60kHz, 3dB down at half full output. Microtest Ltd, 18 Normandy Way, Bodmin, Cornwall.
WW 304 for further details

R.m.s. to d.c. converter

A true r.m.s. to d.c. converter, designated 4340, in a hermetic and shielded packaging, offers an unadjusted reading of ±2mV ±0.2%. By adding two external resistors this can be improved to ±0.3mV ±0.1% reading. The 4340 will accept input voltages from 0 to 20V peak-to-peak and give a d.c. output, the amplitude of which is equal to the r.m.s. value of the input voltage. The device has an input impedance of 5kΩ, an output impedance of 1Ω and will supply 5mA at +10V d.c. Input and output protection is incorporated for overvoltage and short-circuit conditions. Burr-Brown Research Corporation, International Airport Industrial Park, Tucson, Arizona 85734, USA.
WW 316 for further details

Miniature load cell

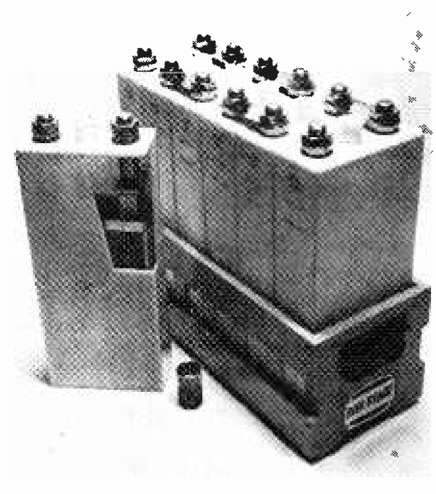
A load cell called the SELF-1000 is only 0.150in thick and can be used as a load washer or under direct compression. The device is constructed from a bridge of piezoresistive sensors giving a full-scale output of 250mV at low impedance. The case is constructed from stainless steel and is designed to withstand rugged environments. Linearity/hysteresis is ±1% full scale, thermal zero shift is ±1% full scale per 100°F and thermal sensitivity shift is ±2% full scale per 100°F. The SELF-1000 is available in a range of 10 to 1000lb. SE Laboratories (EMI) Ltd, North Feltham Trading Estate, Feltham, Middx.
WW 308 for further details

Crystal frequency standard

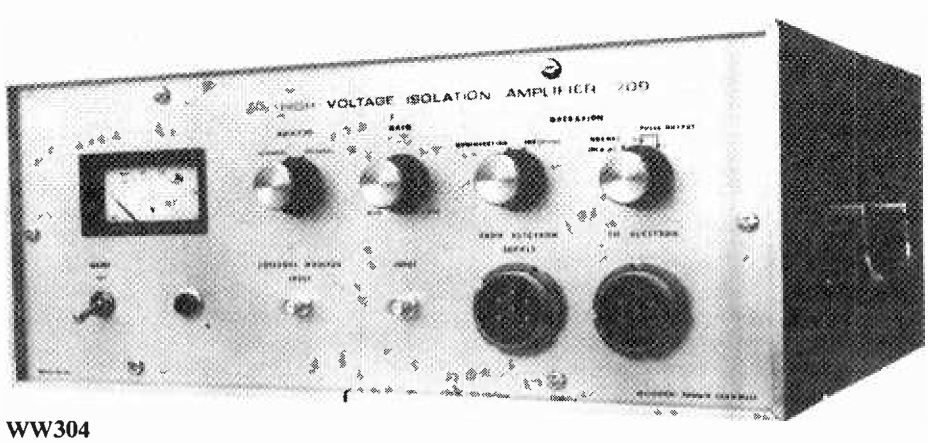
The RCS 101 provides t.t.l.-compatible square wave outputs of 10kHz, 100kHz and 1MHz at 3V peak-to-peak. The short-term stability is 5 parts in 10^9 with an ageing rate of 1 part in 10^8 per day. An internal battery supply is provided in addition to the normal mains supply. This battery is kept continuously on trickle charge by an internal charging circuit. In the event of a power failure an emergency power supply is available for up to five hours. Radio Control Specialists Ltd, National Works, Bath Road, Hounslow, Middx TW4 7EE.
WW 302 for further details

Random noise generator

The NS110 uses a solid-state noise source and wide-band amplifiers to produce an output of 150mV r.m.s. (typical) from a 9V 12mA supply. The amplifiers are separate and connections are brought out to terminal pins which allows the introduction of a filter or attenuator. The output amplifier presents an impedance of 600Ω for matching to standard equipment. Spectral uniformity is ±1dB (model NS110S) and ±3dB (model NS110G) over the range 60Hz–300kHz and ±5dB ±10dB respectively over 20Hz to 3MHz. The module measures 51×29×16mm. ADM Electronics Division, Siliconix Ltd, Morriston, Swansea SA6 6NE.
WW 307 for further details



WW318



WW304

Printed-circuit switch

A miniature p.c.b. switch measuring 10.5 × 5 × 6mm has a breaking capacity of 12V d.c. 0.5A to 24V d.c. 0.3A. The switch, which has three switching options, is constructed from fibreglass, and the contacts are plated with 0.5 microns gold on 2 microns nickel. The dielectric strength between contacts is 500V at 50Hz with a contact resistance for 2V of less than 20 milliohms, and a capacitance between contacts of less than 1pF. A life of 5000 operations is quoted in an operating temperature range of −40 to +85°C. The 100-up price for the switch is 50p. Souriau UK Ltd, Shirley Avenue, Windsor, Berks.

WW 303 for further details

Ceramic capacitors

A range of axial, glass-encapsulated ceramic ITT capacitors feature high capacitance with stability over a wide temperature range. Layers of the ceramic dielectric and noble metal electrodes are stacked alternately and fired at high temperature to produce a fused monolithic structure. The capacitance range is 220 to 33000pF with rated voltages of 50 and 100V d.c. and a rated temperature range of −55 to +125°C. ITT Components Group Europe, Standard Telephones and Cables Ltd, Capacitor Division, Brixham Road, Paignton, Devon.

WW 305 for further details

Solid State Devices

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

40ns rectifiers

Fast recovery rectifiers rated at 6A forward current and 100V repetitive peak reverse voltage are now available from GDS Sales Ltd. These stud-mounted rectifiers have a maximum reverse recovery time of 40ns making them suitable for use in modern switching power supplies. Two versions are available, the EF100N6 with cathode connected to stud, and the EF100R6 with anode to stud. An additional feature of these epitaxial rectifiers is the high surge current rating; peak forward overload current is 125A for 20ms. Supplied in the standard British SO-10 package, the EF100N6 and EF100R6 are available from stock.

WW358 for further details GDS

Three-phase 50A bridge rectifiers

Semtech have introduced their Alpac R-50 SC3BK05-6 series. Alpac, short for aluminium package, features insulated terminals and efficient thermal design. This construction secures and insulates the internal components to temperatures above 300°C. Alpac-R50 is designed for utilization in power supplies, a.c. to d.c. converters, motor control circuits.

WW359 for further details Bourns

Schmitt trigger i.cs

New from Sprague are four trigger threshold detector i.cs which will sustain battery reversal indefinitely without damage. Two single and two dual triggers are available in eight-pin mini-d.i.l. plastic packages. All circuits are capable of operating over a supply voltage range of 2·2–6·0V and at temperatures between −40 and +100°C, featuring high-output breakdown voltage, stable switching levels and input-to-output isolation. Type ULN-3303M, a single Schmitt trigger with complementary outputs can switch a 75nA resistive load with less than 50nA input current. Type ULN-3304M, also a single Schmitt trigger, but with a zener diode clamped output can control a 150nA inductive load with less than 50nA input current. The dual Schmitt trigger type ULN-3305M contains two ULN-3303M devices while the ULN03306M has a zener diode clamped output for driving inductive loads and contains one ULN03304M device plus a second Schmitt trigger circuit in one package.

WW360 for further details Sprague

Latching trigger module

An encapsulated switching device capable of switching 1A continuous is actuated by either a short or open circuit input and reset by switching off and then on again. The device operates from a 12V supply and has a current drain of 2.5mA. The unit, which was designed for use in burglar alarms, measures 1.75 × 1.15 × 1in and cost £2.90 plus VAT, plus 20p post and packing.

WW 350 for further details
Franken Systems

256-bit c.m.o.s. RAM

The type MCM 14537 is a 256-bit static RAM which has eight address inputs, one data input, one write enable input, one strobe input, two chip enable inputs and one data output. If the chip enable inputs are used in conjunction with the address inputs, four MCM 14537s can be connected together to form a 1,024-bit RAM without any additional circuitry being needed. With a power supply of 10V, access time is typically 700ns and power consumption is 10μW (quiescent state) in a temperature range from −55 to +125°C.

WW 351 for further details Motorola

Low-leakage tuning diodes

The SQ5461A-76A series of tuning diodes cover a 6.8 to 100pF range in 16 types with corresponding Q values ranging from 600 to 250 at 4V bias and at 50MHz. The diodes exhibit a four nanoamp reverse current rating at 30V which minimizes spurious f.m. noise that originates from reverse diode current in r.f. circuits.

WW 352 for further details MSI

Low-noise transistors

The K6000 series of low-noise transistors for use in i.f. amplifiers exhibit maximum noise figures of 1.0dB at 60MHz and 1.6dB at 450MHz. Typical 1dB compression points are +16dB at both 60 and 450MHz at 5mA IC.

WW353 for further details
Microwave Associates

Current-regulated l.e.ds

A range of l.e.ds known as the red-lit C200 series, features an integral current-regulating i.c. This ensures constant brightness over a range of input voltages from 4.5 to 12.5V for the RLC200, and 4.5 to 16V for the RLC201. The RLC210 is a miniature version giving a constant intensity between 4.5 and 11V.

WW 354 for further details Guest

Opto-couplers

A range of opto-coupler modules, manufactured by Morirca of Japan, is now available from Photain Controls. The photocell used is a cadmium selenide device which provides a variable resistance directly proportional to the light emission of the diode. These devices can operate at voltages up to 200v a.c. or d.c. and have a power dissipation of 125mW with a response time better than 1ms in an operating temperature range from −30 to +80°C.

WW 355 for further details Photain

Suppliers

Franken Systems and Supply Ltd, 18 Greenacres Road, Oldham, Lancs.
Motorola Inc, Semiconductor Products Division, European Headquarters, PO Box 8, 16 Chemin de la Voie-Creuse, 1211 Geneva 20, Switzerland.
MSI Electronics Inc, 34–32 57th Street, Woodside, NY 11377, USA.
Microwave Associates Ltd, Dunstable LU5 4SX, Bedfordshire.
Guest Electronic Distribution Ltd, Redlands, Coulsden, Surrey CR3 2HT.
Photain Controls Ltd, Randalls Road, Leatherhead, Surrey.
GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Berks.
Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.
Sprague Electric (UK) Ltd, PO Box 32, 159 High Street, Yiewsley, West Drayton, Middx.

Real and Imaginary

by "Vector"

ELECTRONICS; THE ROAD AHEAD?

Guglielmo Marconi, I see, once asked "Have I done the world good or have I added a menace?" Now, that's what I call a jackpot question. Perhaps, with his vision, he saw what was coming to us, like Wonderful Radio One; in which case it wasn't any wonder that the poor chap got depressed.

I'm not really changing the subject, but did you read about those recent experiments at Yale University? If you didn't, the set-up, briefly, was that a volunteer citizen was set down in front of an impressive switchboard and a row of 30 switches labelled from 15V to 450V in progressive steps. The object of the exercise, he was told, was to see whether electric shocks would prove to be an aid to learning, and he was to be the "teacher". Another subject, "the learner", was strapped into a kind of electric chair; the idea was that he should be asked questions; if he answered incorrectly it was the teacher's job to operate the first switch and administer a mild shock. Further incorrectly-answered questions called for progressively increasing shocks; the "teacher" had first to call out the applied voltage and then dish it out, right up to the 450V maximum. Just to show him what it was all about, he was given a sample shock from the third switch. The whole operation was in the charge of a stern-faced laboratory man with an authoritative manner.

As if you haven't guessed, the whole thing was a "con", with the teacher as the guinea-pig. The victim in the chair was an actor who got no shocks whatsoever but simulated an appropriate reaction whenever he (intentionally) gave a wrong answer. These reflexes graduated from slight twitches through to grunts, agonized screams, appeals to stop, pleadings of a heart condition, on to a final stage of incoherence and frenzied drumming of his feet. Whenever the "teacher" showed signs of wanting to give up, the experimenter in charge told him firmly, but without threats, that he must carry on.

Forty people, chosen at random over a cross-section of the social structure, participated. Of these, no fewer than twenty-six completed the exercise right through to the final "450V", inflicting, (as they believed) considerable suffering. Sixty-five per cent. Not hand-picked sadists; just ordinary human beings. I don't know how you react to this but it quietly scares the pants off me.

Are we, I wonder, losing our capacity for compassion because of over-familiarization with suffering at second hand? At almost any hour of the day or night the turn of a switch permits a retreat into an escapist world—and, by and large, a violent world it is, too. After an hour or so of a gangster film it becomes difficult to appreciate that those bodies lying in a Belfast gutter aren't actors too.

In warfare, also, electronics is steadily divorcing us from reality. Aerial dogfights are in the museum; no longer is the victor confronted with the horror of an aircraft plunging earthwards with its crew roasting alive. Miles away from the hostile object an order is given, a button is pressed and a target-homing missile is on its way. A symbol disappears from a radar screen and that's that. Its the difference between having to go into a slaughterhouse and hack a chunk of meat from an animal corpse and strolling into a supermarket and selecting a nicely-packaged chop. And who's morally responsible? The designer of the electronics weaponry? Those who built it? The chap who gave the order? The one who pressed the button? Or who? The text-books don't tell us, neither do the technical journals. And yet, the fundamental importance of electronics, as Marconi foresaw, lies not in the challenge of devising clever-clever circuitry but in its impact on human nature and relationships.

I hope I'm wrong, but the way electronics is developing could be conditioning us towards acceptance of a computer-controlled society. After all, shorn of their emotive content, the problems which consistently baffle Harold, Ted and Co. become elementary arithmetic to a super number-cruncher. How to make the UK self-supporting? Simple. With a population of around 60 million and a comfortable self-sufficiency for only 10 million, a computer's amoral and unsentimental memory-banks would merely order the extermination of everybody over the age of 50 and all those unable or unwilling to work. And that's just for starters. Population-stability could be achieved by introducing Pill-like ingredients into all food, with permits issued to selected breeding pairs enabling them to obtain non-contraceptive foodstuff for a requisite period. The realization of the materialist millenium needs only the applied logic of a computer.

The last time we met, if you remember, the subject under discussion was the crisis over the impending famine of raw materials. If you don't altogether fancy the computer recipe for salvation (and at least all readers over the half-century mark will be agin it, I fancy), there are fortunately other ways in which electronics could help to stave off disaster.

For instance, we could re-deploy the world's research effort into tapping a virtually inexhaustible source of energy which is at present largely going to waste. I mean, of course, the sun. The whole of the earth's supplies of coal and oil were laid down by the equivalent of three days of sunlight. What's the sense in scrabbling dangerously for second-hand sunlight when we could get our power supplies by direct down-conversion from the 1.3kW per square metre which is the mean rate at which solar energy falls on the earth's surface?

As "Cathode Ray" reminded us in the Feb. 1961 issue of *WW* there are at least three main ways of doing this. One is by magnetohydrodynamics (MHD), in which a conducting fluid or plasma cuts a magnetic field. In this application, sun-energy could probably be used to heat the plasma; thus, the approach would eliminate fossil fuel, steam boiler, turbine and the rotary aspect of the alternator. Another approach is by thermionic generation. In this a cathode is heated non-electrically (sun-energy?) to a high temperature, boiling off electrons which reach an anode and create a voltage between it and the cathode. The third method is by thermoelectric generation, in which a current is produced when one of the junctions between two dissimilar metals is heated.

There are other means as well. Solar energy systems for heating or cooling houses and commercial buildings are now coming into use—a new addition to the RCA Building in New York is a recent case in point. Solar voltaic cells could, by intelligently-planned mass production, be fabricated very cheaply and the coverage of a hundred square miles or so of presently-useless Sahara Desert could provide the power requirements of Europe and Africa.

Neither is direct sunlight our only bet. The sun generates high-velocity winds, and chains of wind-driven rotors of advanced design could provide much useful power. Tides and thunderstorms have been neglected as energy sources. The earth itself is a vast reservoir of heat for direct conversion and in many places it's virtually on the surface. Hot spring areas and volcanoes provide immense power sources.

With direct-conversion systems, present efficiencies are not good, but not so bad as you might think, so that's where concentrated research would pay off, particularly in semiconductor areas. Just as a multi-stage turbine extracts as much energy as possible from steam, so too might MHD, thermionic and thermoelectric "engines" be combined into a highly-efficient three-stage generator, with the waste heat from the first fed into the second and then the third. And, after all, the overall coal-to-electricity efficiency of a large, modern power station is only about 32% anyway.

But we shall probably go along the same old tram-tracks, taking orders and the line of least resistance simultaneously; in that event, Guglielmo Marconi's premonition will be justified. The Science Museum has called his centenary exhibition "A Girdle Round About the Earth". Perhaps if Marconi could see the road we've taken since his time he might want it amended to "My Girdle's Killing Me".

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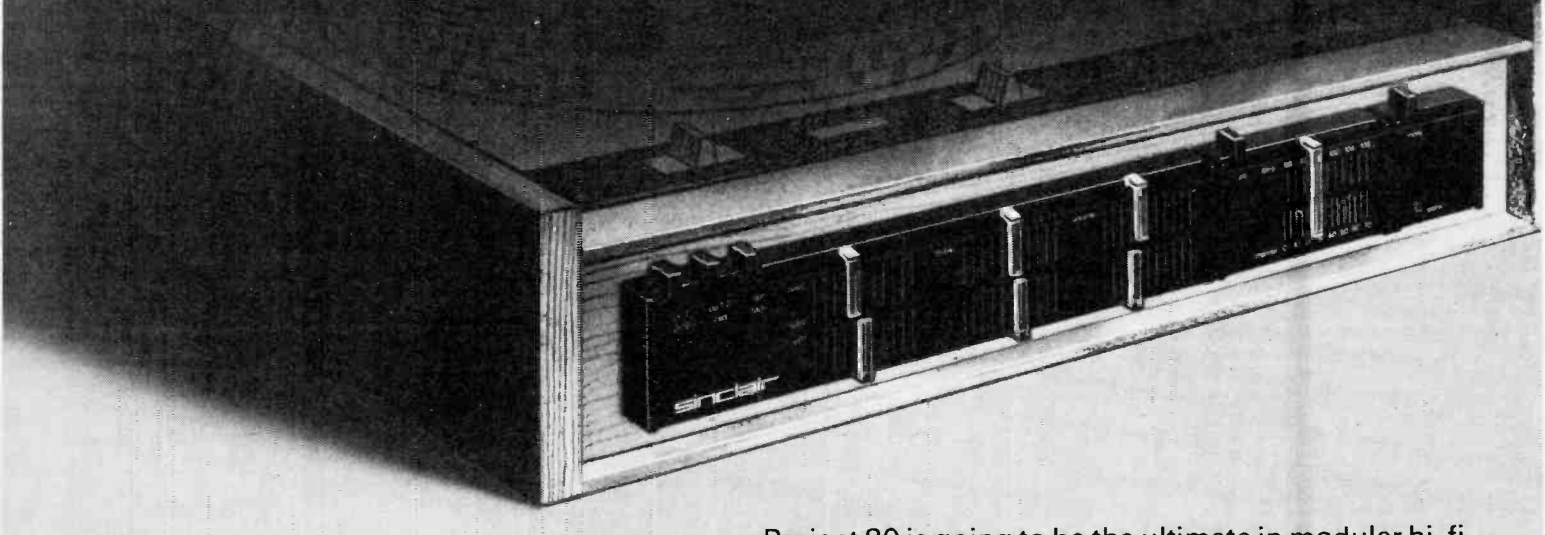

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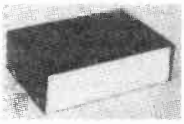
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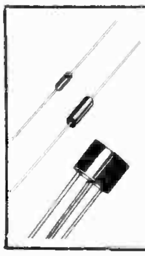

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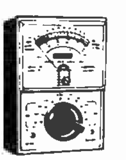
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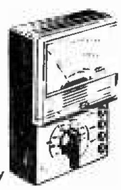
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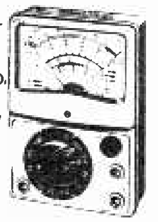
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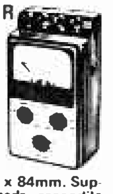
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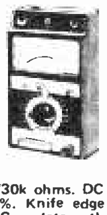
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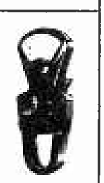
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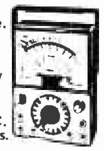
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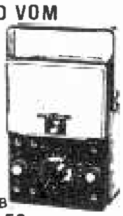
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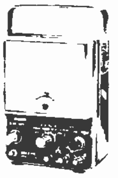
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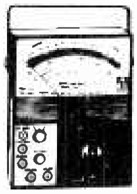
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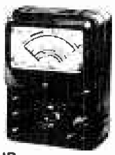
Features AC current ranges. 20,000opv. 0/0.5/2.5/10/50/250/500/1000V DC. 0/2.5/10/50/250/500/1000V AC. 0/50uA/1/10/100 mA/1/10A DC. 0/100mA/1/10A AC. 0/5k/50k/500k/5 Meg/50 Meg. Decibels: –20 to +62dB.
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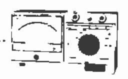
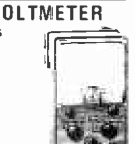
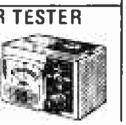
U4317 MULTIMETER

High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: –5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.
OUR PRICE £15.00 P&P 40p

MODEL U4311 Sub-standard Multi-range Volt-Ammeter

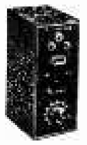
Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC. 1% AC. Scale length: 165mm. 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A AC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/750mV/1.5/3 /7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.
OUR PRICE £49.00 P&P 50p

TE65 VALVE VOLTMETER

28 ranges. DC volts 1.5–1500V. AC volts 1.5–1500V. Resistance up to 1000 Megohms, 200/240V AC operation. Complete with probe and instructions.
OUR PRICE £17.50 P&P 50p
Additional probes available: RF £2.12, HV £2.50

LB3 TRANSISTOR TESTER

Tests ICO and B. PNP/NPN. Operates from 9V battery. Instructions supplied.
OUR PRICE £3.95 P&P 20p

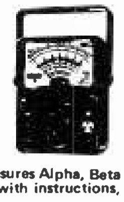
MODEL AF.105 VOM

50,000 opv. Mirror scale. Meter protection. 0/·3/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30µA/6/60/300 mA/12 Amp. 0/10K/1m/10m/100 Meg Ohms. –20 to +17dB.
OUR PRICE £12.50 P&P 30p.

LB4 TRANSISTOR TESTER

Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.
OUR PRICE £4.50 P&P 20p

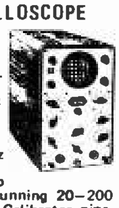
U4341 Multimeter & Transistor Tester

27 ranges. 16,700opv. Overload protected. Ranges: 0.3/1.5/6/30/60/150/300/900V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.6/6/60/600mA DC. 0.3/3/30/300mA AC. Resistance: 0.06/0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.
OUR PRICE £10.50 P&P 30p

S100TR MULTIMETER TRANSISTOR TESTER

100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC 0/10k/1 Meg/100 Meg. –20 to +50dB. 0.01–0.2 MFD Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.
OUR PRICE £19.95 P&P 25p

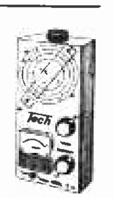
KAMODEN HMG500 insulation resistance tester

Range 0–1,000 Megohms, 500V. Battery operated. Wide range clear meter 4"x4¾". Complete with deluxe carrying case, batteries and instructions.
OUR PRICE £19.95 P&P 30p

C15 PULSE OSCILLOSCOPE

For display of pulsed and periodic wave-forms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Bandwidth: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3–25 Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.
OUR PRICE £39.00 Carr. paid

RUSSIAN CI16 Double Beam OSCILLOSCOPE

5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base, 50Hz–1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.
OUR PRICE £87.00 Carr. paid

MODEL TE15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscillator, Absorbtion Wave Meter and Oscillating Detector. Frequency range 440kHz–280MHz in six coils. 500uA meter. 9V battery operation. Size: 180 x 80 x 40mm.
OUR PRICE £19.95 P&P 30p

Also see following pages

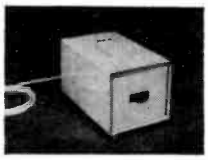
ALL PRICES EXCLUDE VAT

NEW FROM A.S.P.

CARBON FILM RESISTORS

also available ¼ watt at 70°C E 12 range 10Ω-1MΩ. 5% tol. above 470 KΩ 10% tol. at 97p per 100.

AUTO TRANS-FORMERS



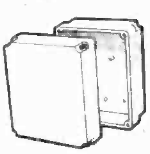
Cased versions are 240 Volt Mains to 115 Volts, smart steel cased units coated in tough resin with power lead, fuse and 115 Volt American type socket up to 500VA, above 500VA cable entry.

VA (Watts)	Ref. No.	PRICE CASED	PRICE OPEN	POST
Tapped at 115, 220, 240 Volts.				
20	113		1·32	0·22
20	113		1·32	0·22
75	64		2·63	0·30
Tapped at 115, 200, 220, 240 Volts.				
150	4		3·29	0·39
200	65	5·56	3·96	0·40
300	66		4·64	0·52
500	67	9·50	8·03	0·67
1000	84	15·92	13·50	0·82
2000	95	29·70	25·30	1·50
3000	73		33·00	1·20
20VA version uncoated, no fuse:—		2·52		0·30

POWER UNIT Type P6200

Supplying 6 or 9 Volt DC at 200 mA
In moulded case forming a 2 pin 5 A mains plug.
2 metre output lead with 4-way multiplug giving 2·1 and 2·5 mm sockets and 3·5 mm plugs.
Price £2·25. Post 10p.

QUALITY INSTRUMENT CASE



Strongly moulded in High Gloss Grey Plastic (Flame Retardant ABS). Two interlocking halves secured by four corner bolts (supplied).
Interior Size: 6½" × 5½" × 2¾".
Wall Thickness: ⅛".
Weight: 11½ ozs.
Price £1·50. Post 15p.

TRANSFORMERS

SAFETY ISOLATING

Prim. 120/240V. Sec. 120/240V. Centre Tap with screen

VA (WATTS)	REF. No.	PRICE Cased £	PRICE Open £	Post £
60	149	—	3·74	0·38
100	150	—	4·16	0·52
200	151	9·48	7·48	0·52
250	152	12·05	9·57	0·65
350	153	14·00	11·44	0·80
500	154	15·80	13·20	1·00
1000	156	30·70	27·48	1·20
2000	158	60·95	55·44	O.A.
3000	159	79·63	72·49	O.A.

CASED VERSION in plastic coated steel case with Powerlead. Please state 115V or 240V output British or American outlet sockets up to 500VA. Over 500VA Cable Entry.

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS Sec. 1	VOLTS Sec. 2	MILLIAMPS Sec. 1	MILLIAMPS Sec. 2	TYPE No.	PRICE £	Post £
3-0-3	—	200	—	238	1·23	0·10
0-6	0-6	500	500	234	1·30	0·10
0-6	0-6	1000	1000	212	1·68	0·22
9-0-9	—	100	—	13	1·23	0·10
0-9	0-9	330	330	235	1·43	0·10
0-8-9	0-8-9	500	500	207	2·28	0·22
0-8-9	0-8-9	1000	1000	208	3·03	0·30
15-0-15	—	40	—	240	1·23	0·10
0-15	0-15	200	200	236	1·30	0·10
20-0-20	—	30	—	241	1·23	0·10
0-20	0-20	150	150	237	1·30	0·10
0-15-20	0-15-20	500	500	205	2·97	0·38
0-20	0-20	300	300	214	1·76	0·22
0-20	—	3500	No Screen	1116	3·00	0·40
20-12-0-12-20	—	700 (D.C.)	—	221	1·55	0·30
0-15-20	0-15-20	1000	1000	206	3·80	0·38
0-15-27	0-15-27	500	500	203	3·08	0·38
0-15-27	0-15-27	1000	1000	204	3·24	0·38

12 and 24 VOLTS PRIMARY 200-240 Volts.

AMPS 12V	AMPS 24V	TYPE No.	PRICE £	Post £
0·3	0·15	242	1·34	0·22
0·5	0·25	111	1·34	0·22
1	0·5	213	1·59	0·22
2	1	71	2·09	0·22
4	2	18	2·75	0·38
6	3	70	3·56	0·42
8	4	108	3·96	0·52
10	5	72	4·67	0·52
12	6	116	5·67	0·52
16	8	17	6·64	0·52
20	10	115	10·23	0·69
30	15	187	13·75	0·97
40	20	232	18·26	1·00
60	30	226	22·52	1·10

30 VOLTS

PRIMARY 200/240V.
SECONDARY 12, 15, 20, 24, 30V.

AMPS	Ref. No.	Price £	Post £
0.5	112	1·58	0·22
1	79	2·20	0·38
2	3	3·19	0·38
3	20	3·96	0·42
4	21	4·68	0·52
5	51	5·80	0·52
6	117	6·93	0·52
8	88	9·00	0·67
10	89	10·00	0·67

50 VOLTS

PRIMARY 200/240V.
SECONDARY 24, 30, 48, 60V.

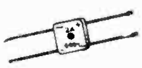
AMPS	Ref. No.	Price £	Post £
0·5	124	2·10	0·38
1	126	2·97	0·38
2	127	5·77	0·42
3	125	7·15	0·52
4	123	9·35	0·67
5	40	11·55	0·67
6	120	13·57	0·82
8	121	16·00	1·00
10	122	19·40	1·00
12	189	21·62	1·10

60 VOLTS

PRIMARY 200/240V.
SECONDARY 19, 25, 33, 40, 50V.

AMPS	Ref. No.	Price £	Post £
0·5	102	2·11	0·30
1	103	3·08	0·38
2	104	4·29	0·42
3	105	5·77	0·52
4	106	7·48	0·52
6	107	11·00	0·67
8	118	14·19	0·97
10	119	17·60	0·97

BRIDGE RECTIFIERS



ONE AMP	Price	TWO AMP	Price
50 P.I.V.	0·25	50 P.I.V.	0·35
100 P.I.V.	0·25	100 P.I.V.	0·40
200 P.I.V.	0·28	200 P.I.V.	0·45
600 P.I.V.	0·30	400 P.I.V.	0·50
FOUR AMP		**SIX AMP**	
100 P.I.V.	0·55	50 P.I.V.	0·65
200 P.I.V.	0·59	100 P.I.V.	0·70
400 P.I.V.	0·65	200 P.I.V.	0·80
600 P.I.V.	0·75	400 P.I.V.	0·90

ELECTRONIC MAINS TIMER

A reliable unit ideal for timing Bathroom/Toilet Ventilators, Stairway / Cloakroom Lighting etc. Gives up to 30 mins. delay before switching off. Delay: 1-30 mins. adjustable. Max Load: 400 VA or 1000 Watts resistive. Ivory Case: 3⅜in.×3⅜in.× 2in. Fittings Instructions included. Trade Price: £5·80. Post 20p.

MAINS KEYNECTOR

The safe, quick, connector for electrical appliances, 13 Amp rating, fused will connect a number of appliances quickly and safely to the mains, ideal for testing, demonstrating, window displays, etc., Warning Light, interlocked to prevent connecting when live.
Trade Price: £2·95. Post 25p.

PLEASE ADD 10% FOR V.A.T.

A·S·P

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WW—086 FOR FURTHER DETAILS

		P.P.
Collins TCS R/T 1·5-12 mcs in 3 bands, v.f.o. plus crystals 25 watt out	£25·00	£2·00
Frequency meter 125-20,000 kcs w/calibration books with A/C power supply	£35·00	£1·50
Solartron Storage Scope QD 910	£40·00	£3·00
Cossor D/B Rough	£6·00	£1·50
Telechrome Square Sign Wave Generator	£10·00	£1·00
Mullard TV Line Selector Type L 190	£10·00	£1·00
Voltage Regulator Lang Thompson 220 or 240 out at 100 BA	£45·00	£3·00
Pye Rangers VHF Transistorised Radio Telephones Mobiles	£10·00	£1·00
UHF Marconi Signal Generators TF 762C 299-610 mcs	£40·00	£2·00
Wayne Kerr VHF Frequency Standard	£8·00	£1·00
Avo Valve Voltmeter	£10·00	£1·00
Communication Receiver Skyrider 500 kcs-60 mcs. Poor condition	£16·00	£2·00
Test Card C Videcon	£10·00	£1·00
1" Videcon	£7·00	£0·50
Voltexion 4 Way Mixer	£8·00	£1·00
Aircraft Modulator Unit (Radio/Tel) 440-LRV 3B	£4·00	£1·00
Radar Aircraft No Indicator	£15·00	£1·50
Tape Cartridge Players Built-in 10 Watt Amp	£10·00	£1·00
Amplifier Clark and Smith 15 Watt	£8·00	£1·50
As above with VHF Radio	£15·00	£1·50
Phamphomic 25 Watt Amplifier and 4 way Mixer with Base Treble Controls	£15·00	£1·50
1" Tube Oscilloscope Rack Mounting	£10·00	£1·00
Delay Lines 1-300 Milli Secs Adjustable	£12·00	£1·50
Marine Radio Telephone Rediphone	£25·00	£2·50
Decca Radar Marine Complete	£175·00	£5·00
Metrix Wobulator 1·20 mcs	£12·00	£1·00
Resistance Bridge	£10·00	£1·00
Sperry Gyro's MK 4	£8·00	£0·50

		P.P.
Dubilier Radio noise filters 9-20 amps	75p	£0·50
Inverter 24 v. input out 28 v. 400 kys	£3·00	£0·75
Stand and 4 Plug-in Units—220 mcs. Good condition	£60·00	£5·00
Beckman Digital Voltmeter Type BIE 2116 and Ratio Meters	£25·00	£2·00
Vacuum Compressor Pump with 240V Motor	£15·00	£1·50
RCA Marine Direction Finder and Radio	£28·00	£1·00
Telequipment Test Card C Generator	£30·00	£5·00
Ferrograph 3 Speed Series 6	£50·00	£2·00
Frequency Counter Marconi TF 1345/2 Complete with Stand and 4 Plug-in Units—220 mcs. Good condition	£60·00	£5·00
Beckman Frequency Time Counters Model 7360JH	£35·00	£2·00
Output Power Meter TF 340	£10·00	£1·00
Airmec Signal Generator 300 kcs to 30 mcs 7 Bands	£20·00	£2·00
Standard Signal Generator GRC (USA) Type 205/B 7 Bands 9·5 kcs to 30 mcs	£35·00	£2·00
Spectrum Signal Analiser Model SB/12 with Tuning Head 2 mcs-4umcs	£150·00	£6·00
Signal Generator TF 937 85 kcs-30 mcs 8 Bands Effective L. Length of film Scale 50 ft.	£40·00	£2·00
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600/1 Electrical Gearbox High Torque 12-24v Electronic Brake. Rough exterior	£5·00	£1·00
Racal Digital Frequency Meter Modul SA520. As new condition	£48·00	£2·50
Electrolytic Capacitors 60v Working. Brand New. Unused	£0·45	£0·10
Mixed Surplus Components Pack. Not less than 35 useful components	£1·00	£0·15
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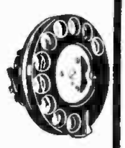
24 HOUR ANSWERING SERVICE

WW—087 FOR FURTHER DETAILS

E.H.T. POWERUNIT. 110/240v. 50Hz giving 5 K.V. at 50 m/a. METERED OUTPUT. **£17·50.**

COPPER LAMINATE P.C. BOARD
11 x 3½ x 1/16 in. **12p** sheet. 5 for **50p.**
10 x 4 x 1/16 in. **12p** sheet. 5 for **50p.**
10½ x 5½ x 1/16 in. **15p** sheet. 4 for **50p.**
10 x 7 x 1/16 in. **18p** sheet. 3 for **50p.**
Offcut pack (smallest 4 x 2 in.) **50p** 300 sq. in.
P&P single sheet **4p.** Bargain packs **20p**

TELEPHONE DIALS (New) £1 ea.



RELAYS (G.P.O. '3000'). All types. Brand new from **37½p** ea. 10 up quotations only.
EXTENSION TELEPHONES (Type 706) Various Colours **£3·50.** P.P. 25p. Excellent condition.
RATCHET RELAYS. (310 ohm) Various Types **85p.** P P 5p.
UNISELECTORS (NEW) 25 way 12 Bank (Non Bridging) 68 ohms. **£6.** P.P. 30p.

PRECISION A.C. MILLIVOLTMETER (Solartron) 1·5m.v. to 15v: 60db to 20db. 9 ranges. Excellent condition. **£22·50.** P.P. £1·50.

HIGH CAPACITY ELECTROLYTICS
2,200µf. 100v. (1½ x 4in.) **75p.** 3,150µf. 40v. (1½ x 4in.) **60p.** 10,000µf. 25v. (1½ x 4½in.) **60p.** 12,000µf. 40v. (2 x 4in.) **75p.** 16,000µf. 16v. (2 x 4in.) **60p.** 21,000µf. 40v. (2½ x 4in.) **£1.** 2,800µf. 100v. (4 x 2in.) **80p.** 15,000µf. 63v. (4½ x 2½in.) **£1.** 35,000µf. 40v. (3 x 4½in.) **£1.** P. & P. 8p.

H.D. ALARM BELLS. 6 in. Dome 6/8 volt D.C. **£2·25** P.P. 50p.

HIGH VACUUM DIFFUSION PUMPS (Metrovac 093C). New condition. **£40.** P.P. £2. **A.E.I. P10. ION Pump Control Units. £17·50.**

OVERLOAD CUT-OUTS. Panel mounting (1¾ × 1¾ × ¾ in.) 800 M/A/1·8 amp/10 amp. **35p** ea. P.P. 5p.

BULK COMPONENT OFFER. Resistors/Capacitors. All types and values. All new modern components. Over 500 pieces **£2.** (Trial order 100pcs. 50p.) We are confident you will re-order.

REGULATED POWER SUPPLY. Input 110/240v. Output 9v. DC. 1½ amp. 12v. D.C. 500 m/a. **£4.** P.P. 30p.

U.K. ORDERS 10% V.A.T. SURCHARGE

TRANSFORMERS

ADVANCE "VOLSTAT" TRANSFORMERS. Input 242v. A.C.

CV50. 38v. at 1 amp: 25v. at 100 m/a. 75v. at 200 m/a. **£2** ea. P.P. 40p.

CV75. 25v. at 2½ amp. **£2·50.** P.P. 50p.

CV100. 50v. at 2 amp: 50v. at 100 m/a. **£3.** P.P. 50p.

CV250. 25v. at 8 amp: 75v. at ½ amp. **£5.** P.P. £1.

CV500. 45v. at 3 amp: 35v. at 2 amp: 25v. at 3 amp. **£7.** P.P. £1.

L.T. TRANSFORMER. Prim. 240v. Sec. 13v. at 1·5 amp. **75p.** P.P. 15p.

L.T. TRANSFORMER. Prim. 240v. Sec. 24v. at 1½ amp. **£1·20.** P.P. 20p.

L.T. TRANSFORMER. Prim. 110/240v. Sec. 0/24/40v. 1½ amp. (Shrouded). **£1.50.** P.P. 30p.

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L.T. TRANSFORMER (H.D.) Prim. 200/250v. Sec. 18v. at 27 amp: 40v. at 9·8 amp: 40v. at 3·6 amp: 52v. at 1 amp: 25v. at 3·7 amp. **£15.** P.P. £2.

H.T. TRANSFORMER. Prim 110/240v. Sec. 400v. 100 m/a. **£2.** P.P. 50p.

E.H.T. TRANSFORMER. 240v. Sec. 1800v. 50 mA. **£2·50.** P.P. 50p.

1000W. ISOLATION TRANSFORMER. 220/240v.-242v. ('C' Core type). **£12.** P.P. £1·50.

1000W. STEP-DOWN TRANSFORMER. (Double wound) 240/110v. 50 HZ. **£12.** P.P. £2.

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6 core (6 colours) 3 screened, 14/0048. **15p.** yd. 100 yds. **£12·50.**
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24 core (24 colours) **20p.** yd. 100 yds. **£17·50.**
30 core (15 colours) **22½p.** yd. 100 yds. **£18·50.**
Minimum order 10 yds

RIBBON CABLE (8 colours)
£1·25 10m. **£10** 100m.
8 cores. 7/·mm. bonded side by side in ribbon form.

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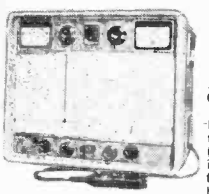

MARCONI TF 867 SIGNAL GENERATOR
Range: 15KHz to 30MHz. Output 0.4µV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. **£138**

T.F.801D/1/S A.M. SIGNAL GENERATOR. Freq. range: 10 MHz to 485 MHz. Built-in crystal calibrator. Internal and external sine a.m. External pulse modulation. Calibration Accuracy: Using crystal calibrator, within ±0·2% over entire frequency range. R.F. output level 0·1µV to IV source e.m.f. **£249.**

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Fluorescence: Yellow. resolution: 40 lines/cm E.H.T.: 8kV. display time: 10 mins–1 hr approx.. storage time: 1 week approx. **£128.**

CD 1212 WIDE-BAND GENERAL-PURPOSE OSCILLOSCOPE.
Employing plug-in pre-amplifiers for single or dual trace displays.
Wide-band pre-amplifier CX 1251. Bandwidth: DC –40Mc/s (–3dB ±1dB): 2.5c/s–40Mc/s AC coupled (–3dB ± 1dB). Rise time 8 nanosec approx. Sensitivity: 50mV/cm–50V/cm in nine calibrated ranges with fine gain control.
Dual trace pre-amplifier CX 1252. Bandwidth: DC –24Mc/s (–3dB ±1dB) AC coupled. Rise time: 14 nanosec approx. Sensitivity: 50mV/cm–50V/cm in nine calibrated ranges with fine gain control. Full specification on request. **£128.**

T.F.801B/3/S A.M. SIGNAL GENERATOR. Freq. range: 12 MHz to 485 MHz in five bands. Built-in crystal calibrator. Full spec. on request. **£220.**

TEKTRONIX 5458 OSCILLOSCOPE. Accepts multi-trace differential, sampling spectrum analyser and special-purpose plug-in units. Bandwidth: DC to 33MHz at 3dB down, depending on plug-in unit. Rise time: 11ns, depending on plug-in unit. Delay line: permits viewing leading edge of displayed waveform. Price and full specification on request.

TF.937 F.M./A.M. SIGNAL GENERATOR. Freq. range 85 KHz to 30 MHz. The carrier freq. can be standardized against a built-in dual freq. crystal calibrator, which is complete with miniature loudspeaker as an aural beat detector. **£87.**

TF.114H/S SIGNAL GENERATOR. Frequency range: 10 KHz-72 MHz. Stability: 0·002%. High discrimination, plus crystal calibrator. Good r.f. waveform at all frequencies. Protected thermocouple level monitor. Full spec. on request. **£220.**

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RACAL UNIVERSAL COUNTER/ TIMER SA550 (CT488)

8 digit in-line read-out. Facilities include: direct frequency measurement up to 100 MHz; pulse, perlod, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. on request. **£145.**

AVO MULTIMETER Model 7X (Panclimatic). **£19·80.**

AVO MULTIMETER Model 8X (Panclimatic). **£32.** Cases, prods and leads extra.

CT. 373 TEST SET. Oscillator: 17c/s–170kc/s ±1%, ±1c/s at ambient temp. 0°C–45°C. Distortion Meter: Freq. range: 20c/s to 20kc/s. distortion range: 10%. 30%, 100% f.s.d. 0.5% readable. Signal input: approx. 500mV to 130V basic range. 250mV to 1300V extreme limits. Full spec. on request. **£98.**

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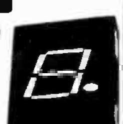

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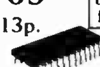

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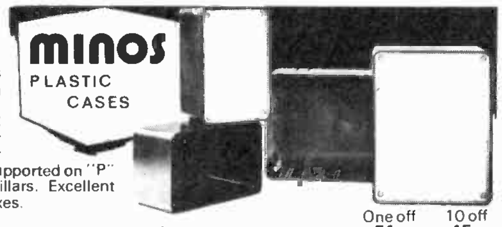
The West Hyde prestige case

The smartest of the West Hyde cases, all anodised aluminium, with top and bottom panels only; in black PVC-covered steel (plain or louvered). Free standing or 19" rack mounting with aluminium brackets. Supplied ex-stock, fully assembled, with SS Pozidriv screws.

Brightcase	1 off	Pr. Brackets	Extra for Louvres
BC21 (3½" whole rack)	£13·46	88p	74p
BC22 (3½" half rack)	£10·90	88p	74p
BC31 (5¼" whole rack)	£15·53	£1·24	74p
BC32 (5¼" half rack)	£12·79	£1·24	74p

Prices include panels, feet, P. & P. and VAT. State whether ¼, ½ or full panels required.

Prices correct 31 May, 1974

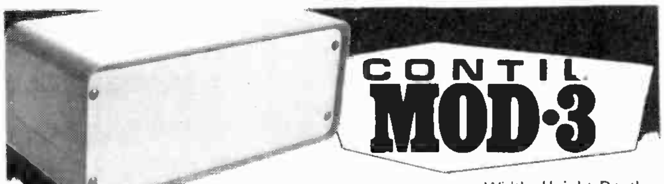


A smart miniature case in tough, rigid, high-gloss black ABS. Front panels in either aluminium or white PVC/Steel. Built-in slots for PC cards, dividers, or screens. Chassis or PC boards can be supported on "P" clips for internal pillars. Excellent as encapsulation boxes.

		One off	10 off
M2	65mm × 100mm × 50mm 2½" × 3¾" × 2"	51p	45p
M3	100mm × 130mm × 50mm 3¾" × 5" × 2"	67p	58p

Prices include P. & P. and VAT. Less for quantities.

Also available without panel and screws. Prices correct June 1974. Minimum order £1



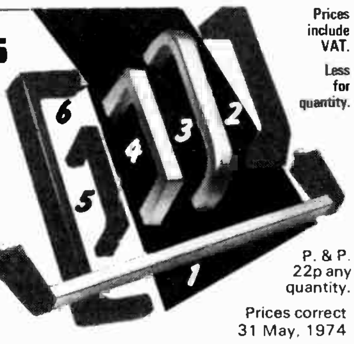
Contil Mod-3 cases are in six sizes and offer the manufacturer of small instruments an attractive low cost case available ex-stock. Made in blue PVC-coated steel and complete with front and rear panels and chassis, they are light, strong and rigid. PCB and PSU mounting systems available.

		Width	Height	Depth
Mod 301	£4·02	7"	3"	5¼"
Mod 302	£4·22	7"	4½"	5¼"
Mod 303	£4·78	7"	6"	5¼"
Mod 304	£4·78	11"	3"	5¼"
Mod 305	£5·69	11"	4½"	5¼"
Mod 306	£6·58	11"	6"	5¼"

Less for quantities

Prices correct 31 May, 1974

CONTIL handles



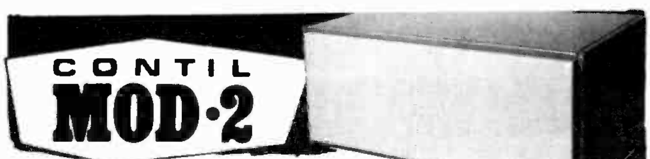
(1) No. 265. Anodised aluminium centre bar. Black plastic brackets with moulded-in core. 75mm @ **97p**. Five more sizes up to 154mm.
(2) No. 281.1. Nylon 112mm. Load 50Kg @ **45p**.
(3) No. 277. Ali., ground, polished, anodised. 88m @ **94p**, 120mm @ **£1·06**.
(4) No. 268. Satin ali. 57·5mm @ **94p**, 102mm @ **£1·01**, 145·5mm @ **£1·17**.
(5/6) No. 250. Black nylon, very comfortable. 75mm @ **29p**, 110mm @ **41p**, 155mm @ **67p**.

Prices include VAT.

Less for quantity.

P. & P. 22p any quantity.

Prices correct 31 May, 1974



The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes.
Low cost. Blue PVC/steel with white PVC-coated aluminium panels.

Width	Height	Depth	1 off	Width	Height	Depth	1 off
A 4·5"	3"	6·5"	£3·60	M 4·5"	3"	13"	£4·44
B 4·5"	7"	6·5"	£4·44	N 4·5"	7"	13"	£5·44
C 4·5"	10"	6·5"	£4·91	O 4·5"	10"	13"	£6·91
D 9"	3"	6·5"	£4·91	P 9"	3"	13"	£5·44
E 9"	7"	6·5"	£5·44	Q 9"	7"	13"	£6·91
F 9"	10"	6·5"	£6·28	R 9"	10"	13"	£8·41
G 13"	3"	6·5"	£5·44	S 13"	3"	13"	£6·91
H 13"	7"	6·5"	£6·28	T 13"	7"	13"	£8·41
I 13"	10"	6·5"	£6·91	U 13"	10"	13"	£10·20
J 18"	3"	6·5"	£6·28	V 18"	3"	13"	£8·41
K 18"	7"	6·5"	£8·91	W 18"	7"	13"	£10·20
L 18"	10"	6·5"	£10·20	X 18"	10"	13"	£12·21

Woodgrain: D @ **£5·44**, E & G @ **£6·28**, H @ **£6·91**.

Prices include screws, rubber feet, one or two chassis according to size, and P. & P. and VAT.

Prices correct June 1974.

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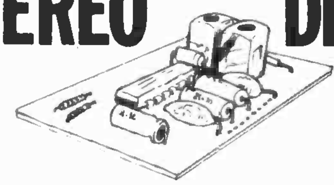

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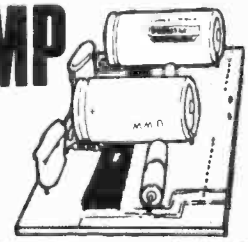
3 W R.M.S. I.C. AMP



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On P.C. Board with all components or 2 on one board for £2.86. Order Code I.C.A. 1/S.
These amps, are supplied with a free booklet on connecting up, specifications and easy to build projects using the I.C.A. 1.

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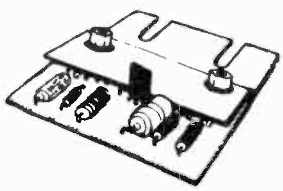

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Stereo Pre-Amp 1 (Pre 1). This unit is for use with low gain crystal or ceramic pick up cartridges. **£1.21.**

Stereo Pre-Amp 2 (Pre 2). This unit is for use with magnetic pick-up cartridges. **£1.69.**

Stereo Tone Control (STC). This unit is an active tone control board and when used with the right potentiometers will give bass and treble boost and cut. **£1.21.**

Instruction leaflet supplied with all units. Post and Packing and VAT included in Prices.

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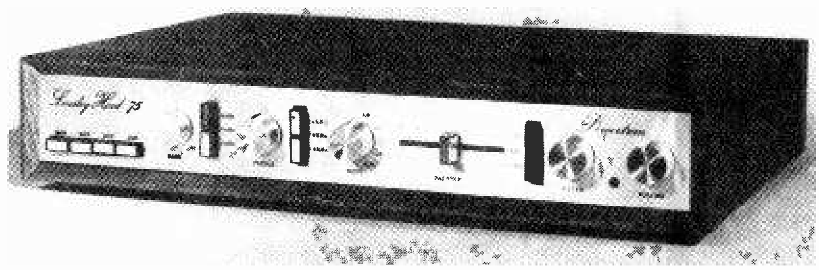
DESIGNER-APPROVED KIT

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.

Hi-Fi News Linsley-Hood 75 W Amplifier Mk III Version (modifications as per Hi-Fi News April 1974)



Full circuit description in handbook (pack 15—price 30p)

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. (now using BDY56, BD529, BD530)	£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, semiconductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting 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	£7.35
	2 each of packs 1–7 inclusive are required for complete stereo system	
	Total cost of individually purchased packs	£69.75

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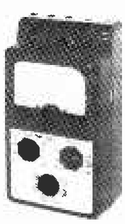
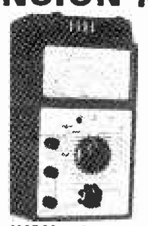
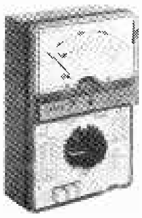


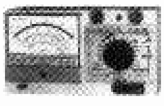
U435; 30-ranges. AC/DC Volts and Amps. Sensitivity 20.000 / 2.000 o.p.v. Accuracy 2.5/4% £8.75



U4341; 27-range multimeter, with AC/DC voltage and current coverage *plus* transistor tester giving current gain measurements from 10 to 350. Sensitivity 16.700/3.300 o.p.v. Accuracy 2.5/4% £10.50



U4324; 32 ranges, AC/DC Volts and Amps. Sensitivity 20.000/4.000 o.p.v. Accuracy 2.5/4% £9.25



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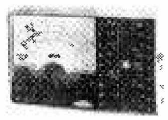

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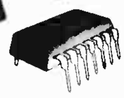

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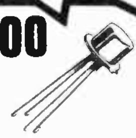

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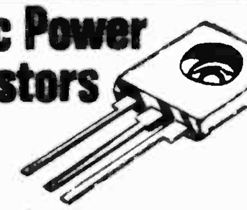

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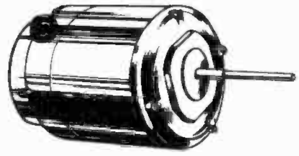

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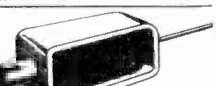

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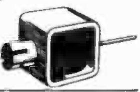

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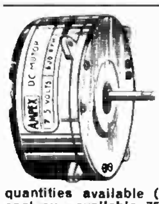

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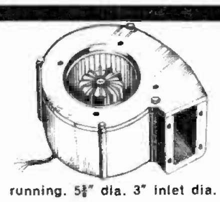

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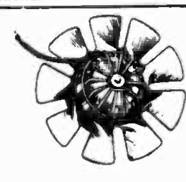

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SN7408	20p	SN7442	75p	SN7484	90p	SN74145	£1·50	SN74182	£2·00
SN7409	45p	SN7443	£1·00	SN7486	45p	SN74150	£3·35	SN74184	£2·45
SN7410	20p	SN7445	£2·00	SN7490	75p	SN74151	£1·10	SN74185A	£2·40
SN7411	23p	SN7446	£2·00	SN7491 AN	£1·00	SN74153	£1·35	SN74190	£1·95
SN7412	42p	SN7447	£1·75	SN7492	75p	SN74154	£2·00	SN74191	£1·95
SN7413	30p	SN7448	£1·75	SN7493	75p	SN74155	£1·55	SN74192	£2·00
SN7416	30p	SN7450	20p	SN7494	80p	SN74156	£1·55	SN74193	£2·00
SN7417	30p	SN7451	20p	SN7495	80p	SN74157	£1·80	SN74194	£2·50
SN7420	20p	SN4753	20p	SN7496	£1·00	SN74160	£2·60	SN74195	£1·85
SN7422	48p	SN7454	20p	SN7497	£6·25	SN74161	£2·60	SN74196	£1·50
SN7423	48p	SN7460	20p	SN74100	£2·50	SN74162	£3·40	SN74197	£1·50
SN7425	48p	SN7470	30p	SN74104	£1·45	SN74163	£3·40	SN74198	£4·60
SN7427	42p	SN7472	30p	SN74105	£1·00	SN74164	£2·75	SN74199	£4·60
						SN74165	£4·00		
						SN74166	£4·00		

S.C.R.s

CRS1/05	40p
CRS1/10	56p
CRS1/20	60p
CRS1/40	65p
CRS1/60	90p
CRS3/10	62p
CRS3/20	62p
CRS3/40	90p
CRS7/400	£1·00
CRS16/100	85p
CRS16/200	90p
CRS16/600	£1·60
C106B	45p
C106D	70p
40669	90p
TIC44	35p
2N4444	£1·90
BT10/500A	90p

BRIDGE RECTIFIERS

W02 1A 200V	38p
BY164 1·4A 200V	57p
MDA952/2 6A 100V	80p

ZENER DIODES

BZY88 Series 400mW

3·3V-33V, 5%	11p
1·5W range	25p
10W range	45p

L.E.D.

TIL209	28p
HP5082	28p
MA2082R	25p

L.D.R.

ORP12	60p
NE555 Timer	90p

TRIACS

TXL228B 8A 400V	95p
SC40D	£1·40
SC40E	£1·65
SC45D	£1·70
SC45E	£2·10
SC50D	£2·42
SC50E	£2·70
DIAC	25p

LINEAR I.C.s

LM309K 5V. 1A. Voltage Reg.	£2·10
LM723C 2·37V. 150mA Voltage Reg.	£1·05
MFC4000 250mW Audio	60p
TBA800 5 Watt Audio	£1·50
709C Op Amp D.I.L./TO99	45p
741C Op Amp 8/14 D.I.L./TO99	55p
748C Op Amp D.I.L.	75p
747C Dual Op Amp	£1·20
ZN414 Radio I.C.	£1·25
TAD100 Radio I.C. inc. Filter	£1·90
CA3014	£1·55
CA3018	£1·00
CA3028	£1·20
CA3036	£1·00
CA3046	95p
CA3048	£2·35
CA3075	£1·60
CA3090Q	£4·85
MC1303L	£2·20
SN76023 6w audio with circuit	£1·75

METAL BOXES

ALUMINIUM BOXES IDEAL FOR VEROBOARD WITH BASE AND P.K. SCREWS

	Long	Wide	High	
AB7	2¾"	5¼"	1½"	50p
AB8	4"	4"	1½"	50p
AB9	4"	2¾"	1½"	50p
AB10	4"	5¼"	1½"	50p
AB11	4"	2½"	2"	60p
AB12	3"	2"	1"	44p
AB13	6"	4"	2"	70p
AB14	7"	5"	2½"	84p
AB15	8"	6"	3"	£1·06
AB16	10"	7"	3"	£1·22
AB17	10"	4½"	3"	£1·00
AB18	12"	5"	3"	£1·20
AB19	12"	8"	3"	£1·60

ALUMINIUM BOXES WITH SLOPING TOP PANEL—IDEAL FOR PRE-AMPS, ETC., USING SLIDER CONTROLS

AB20 8" Long 9" Wide 3½" High at back 2" High at front 6" Slope to front With P.K. Screws .... £2·00
AB21 As above but 10" long .... £2·20
AB22 As above but 12" long .... £2·40

V41 VU METER £2·50
The V41 is calibrated —20 to +3 and 0-100%, making it suitable for use as a recording level meter or as a power output indicator.
Sensitivity: 130 µA. **Internal resistance:** 600 ohms. **Dimensions:** 40 x 40 x 29 mm.

ALSO STOCKED
Electrolytic Capacitors Mullard, Sprague, Lorlin etc. Polyester, Polystyrene, Silver Mica Capacitors, etc. Resistors ⅛W-10Watt. Potentiometers; carbon, wirewound, Preset, Rectilinear multiturn. Antex Soldering Irons switches, rotary, slide, toggle, etc. Cable, veroboard.

★★SPECIAL OFFERS★★

MINIATURE MAINS TRANSFORMER. PRI. 240V. SEC, 12V. 100MA Manuf.: Hinchley. Size: 36 x 45 x 40mm. F.C. 53mm. Price 1-65p. 100-60p ea. 1,000-50p ea. 10,000-40p ea.

3 CORE PVC INSULATED MAINS CABLE, GREY ML6650. 3x7/0·2mm Price 100m-£4·50. 1000m-£35. 10,000m-£330.

0·47mfd. 50V MYLAR FILM CAPACITOR. Size 1" x 0·35" x 0·65" P.C. Mount. Price 100-4p ea. 1000-3p ea. 10,000-4·3p ea.

240V. A.C. SOLENOID. Reversible operation; twin coil. Size approx. 2¾ x 1½ x 1¾in. **90p ea.**

30 unmarked OC71 transistors £1·00
25 Unmarked 250mW Zenerdiode, 4·7V, 5·1V, 6·2V, 7·5, 9·1V, 10V. Measured and tested. £1·00
Please state voltage required.
50 GE Diode OA47 equivalent. £1·00

TRANSFORMER: DOUGLAS PRI, 0, 115, 200, 220 240 SEC. 25-0-25-0-6V, 2½A, £4·50 + 50p p.p.

TRANSFORMER
PRI. 0, 115, 160, 205, 225, 245. SEC. 35-0-35, 1·2A £4·50 + 50p. p.p.

MULLARD TUBULAR CERAMIC UHF TRIMMERS (PROFESSIONAL)

Type		
092	0·8-2·2p	Price 10p ea.
801	0·8-2·2p	
991	0·5-1·3p	

QUANTITY DISCOUNTS PLEASE TELEPHONE

1000pF Feedthrough capacitor 5p ea.
Miniature tubular P.C. trimmers
3·5-13pF
6-30pF 10p ea.
4p c/o Varley 700Ω relay 50p ea.

TO3 VOLTAGE REGULATORS
L005 5V 650mA
L036 12V 500mA
L037 15V 450mA £1·60 ea.

VEROBOARD

	0·1	0·15
2½ × 3¾	32p	23p
2½ × 5	35p	35p
3¾ × 3¾	35p	35p
3¾ × 5	40p	41p
17 × 2½	£1·05	79p
17 × 3¾	£1·43	£1·12
17 × 5	£1·84	—
PIN INS. TOOL	72p	72p
SP.F. CUTTER	52p	52p
100 PINS SS	30p	30p
100 PINS DS	30p	30p
500 PINS SS	£1·20	£1·20
500 PINS DS	£1·20	£1·20

Prices Correct June 12

NEW SERIES TRANSISTOR DATA BOOKS
1. DTA3 USA Band 3 Transistor Characteristics. 2N21—2N6269 all numbers.
2. THT Thyristor, Triac, Diac, Put, UJT's.
3. DT15 Japanese Transistor Characteristics. 2SA, 2SB, 2SC, 2SD numbers.
4. DVT Diode, Comparison Tables.
5. Band 1. Transistor Characteristics. European numbers AC, AF, BC, BF, etc.
6. TVT. Transistor Equivalent Tables. All books contain pin connections and semiconductor outlines.

PRICE. £1·10 per book. £6 per 6 books inc. post.

V.A.T.
Unless otherwise stated all prices are EXCLUSIVE of V.A.T. Please add 10% to all orders. Carriage: orders under £5 + 20p. Over £5 post free.

AUDIO ACCESSORY SHOP, 17 TURNHAM GREEN TERRACE, CHISWICK W.4

VALVE AMPLIFIERS

5 Watt	£12·50	50 Watt	£36·25
15 Watt	£24·50	150 Watt	£75·90
30 Watt	£29·50	500 Watt	£124·50

TRANSISTOR AMPLIFIERS

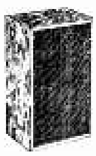
FAL Phase 50W .... £39·93 | FAL Phase 100W .... £69·95

DISCO CONSOLES

FAL Disco Mk. 2 .... £82·99 FAL Power Disco .... £123·75 (with 70W. rms. Amp.)

All Prices include V.A.T.

TEAK VENEERED SPEAKER CABINETS



For	Size	
8×5in. Speaker	7¾×11¾×5¼	£3·50
8in.+Tweeter	9¼×13¼×5¾	£5·00
13×8in.	10½×17×6	£5·75
13×8in.+Tweeter	12×18¼×8¾	£7·50
12in+Tweeter	15¾×18×8¾	£9·00

ALSO: Audio Connecting Leads, Tape, Cassettes, Stereo Systems, Mixers, Mic. Stands, Speaker Cloth, Turntables, Plynths, Covers, etc., etc.

REXINE COVERED SPEAKER CABINETS
Suitable for P.A. or DISCO use; takes 12in. speaker unit. Size approx. 18×18×8in. £9·00.

SPEAKER CLOTH
Available in Black or Green; Approx. width 54in. £1·75 yd.

HEADPHONES
Type H-202 Features· Mono/stereo switch, Volume controls on each channel. Freq. response· 20-20,000Hz. Impedance 4-16 ohms. £4·50.

DISCO LIGHTING

Oil Wheel 6 in. dia.	£5·25
Suitable ½ rpm Motor	£1·00
Strobe 4 Joule	£25·00
Single Flash Box (100W Red, Blue, Gn., Yel.)	£7·50
Triple Flash Box	£16·25
150W Projector plus Wheel	£25

Full Range of Eagle and TTC Products available at Discount Prices.

Secondhand Bargain Basement Now Open High Quality Hi-Fi and Audio Equipment.

8in. HI-FI SPEAKER

Dual cone plasticised roll surround. Large ceramic magnet. 50-10,000 c/s. Bass resonance 65 c/s. 8 ohm impedance. 8in. 10 watt. Each.

£3.75 EACH
Post 25p.

E.M.I. 13½ x 8in. SPEAKER SALE!

With twin tweeters and crossover, 10 watt.

£4.50
Post 25p.

ALSO IN STOCK

CHASSIS SPEAKERS: Goodmans, Fane, Celestion, etc.

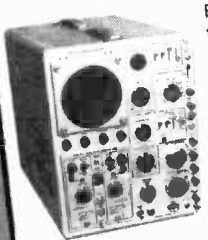
Reel to Reel Tape by BASF, E.M.I., etc.

Cassettes: Memorex, Phillips, etc.

Generous discounts on bulk purchases. Please send S.A.E. for price list.

All mail order and enquiries to 270 Acton Lane Tel: 01-994 6275

LIMITED QUANTITY TEKTRONIX WIDE-RANGE OSCILLOSCOPES



THE WORLD FAMOUS 545 in the DC to 30MHz range. Can be used to operate with Tektronix letter series plug-in unit for virtually any application.

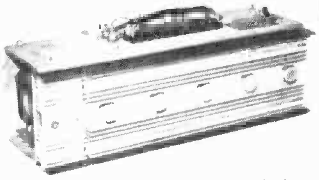
Fantastic value at **£175** (Main Frame only)

Tektronix 545 complete with CA Double Beam Time Base. **£235**

Also available:
TEKTRONIX 545A with CA plug-in **£255**
TEKTRONIX 535 with CA plug-in **£175**

HIGHLY STABILISED POWER SUPPLIES

YOURS AT A FRACTION OF ORIGINAL COST

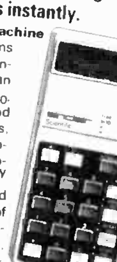


These modular units incorporate overload protection on both INPUT and OUTPUT. Load regulation of 1% or better. Low ripple and fast response time. Input voltage 120–130 50 Hz. Available in the following types:

6 Volt 8 Amp	£12·00	12 Volt 12 Amp	£22·00
6 Volt 12 Amp	£17·00	12 Volt 20 Amp	£24·00
6 Volt 16 Amp	£20·00	30 Volt 7 Amp	£19·00
12 Volt 4 Amp	£20·00		

SPECIAL OFFER

The Sinclair Scientific. Logs, trig and arithmetic. All at the touch of a button. At last there's a pocket calculator which gives you log and trig functions instantly.



Full 12-function machine With the functions available on the scientific keyboard, you can handle directly $\log_{10}$, antilog$_{10}$, sin and arcsin, cos and arccos, tan and arctan, automatic squaring, automatic doubling, x^y (including square and other roots), plus, of course, addition, subtraction, multiplication, division and any calculations based on them. **7-digit scientific notation, 200-decade range. Reverse Polish logic and 25-hour battery life. Send for further information.**

DIGIKELVO MULTI FUNCTIONAL DVM

★ With 4 independent inputs ★ 3 digits plus polarity ★ range switching without breaking current measuring circuit ★ High input impedance on voltage ★ low input impedance on current.

Frequency Range 300Hz–500Hz on volts. Measures 0.01mV–600VDC. 1nA–999mA current. 1mV–600VAC. 100nA–999mA NEW CONDITION IN MANUFACTURER'S ORIGINAL PACKING

£49.50

Power Supplies

Portable Power Supply

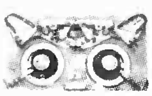
+ 7 Volts — 0–7 Volts at 1.5 Amps. Solid State Stabilised, four outputs. High limit + or — 10 Volt at 1 Amp. Low limit + or — 5.6 Volt at 2 Amp. Incredible Savings. Cost over £25 to produce.

PRICE: £12·50

7-TRACK DIGITAL MAGNETIC TAPE STORAGE DECK

These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay Heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools. 230 V to 380V. Capstan motor speed 1,500 r.p.m. 48 V DC rewind motors complete with vacuum assembly. Finished in brush aluminium and matt black. Size 27 in. X 26 in. X 8 in. Weight 90 lbs. Price **£89·50.**

RCA 301 TAPE DECK MODEL 381



PRICE £35

Technical Data. ½" wide Magnetic Tape. Power supplies: Input 208-230V AC 60 c/s. Single phase Magnetic recording head. read/write and erase. Seven channels each head. Speed 30"/sec. forward or reverse. 90"/sec. during rewind. The recording density of 333 characters per inch is maintained, thus giving the nominal read and write rate of 10,000 characters per second. Maximum diameter of 8" tape reel. Accommodates 1200ft. of Magnetic Tape, which gives a minimum of 1,150ft. available for recording.

MINITRON

K.G.M. Type 3015F 7 Segment display showing figures 0–9 plus decimal point. Character of 9mm height. In 16 DIL case.
NEW LOW PRICE £1·25
SN7447N BCD Decoder Driver **£1·00.**

Potentiometers

TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
100	0.5	Beckman	A.S.	£2·00
200	0.5	Beckman	A	£2·00
500	0.1	Beckman	S.	£2·50
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07–10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·1	Beckman X	A.	£3·50
15K		Colvern	CLR2402	£3·00
25K	0·5	Helipot	SAJ337	£3·00
29K	0·05	Beckman	SA1244	£4·50
30K	0·1	Beckman	A 88	£3·50
30K	0·5	Beckman	SA1692	£3·00
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K	0·5	Beckman	A	£3·00
100K	0·1	Beckman	A.	£3·50
100K		Colvern	2501	£2·25
29BK	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A	£3·50

THREE TURN 780° ROTATION

25Ω		Beckman	Type C	£2·25
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C ss.	£2·25
20K/20K	0·1	Beckman	C.S.	£3·00
10K/10K	0·1	Beckman	C.	£3·00
50K	0·5	Beckman	C.S.	£1·75

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification

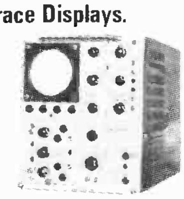
Measurement ranges:—Current 10–25–100–250–500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283 X 94 X 36mm. Weight 1.5 lbs.

£10·50

WANDEL & GOLTERMANN

Distortion Measuring Set VZM-1 for colour t.v. 625 lines PAL. **£750.**
Distortion Measuring Set VZM-2 556KHz-12MHz. **£250.**
Distortion Measuring Set VZM-83 52/304/556KHz comprises a generator and receiver used mainly to measure transmission distortion on FM radio link systems. **£245.**
Voltage & Level Meter 10KHz-14MHz TFPM 43 measuring range 8v-40uv (+20–86dB). **£339.**
Selective Level Oscillator 10KHz-14MHz TFPS 42. **£349.**

Solartron C.T.484 oscilloscope. DC–40 MHz. 3% accuracy. Dual Trace Displays.



TIME BASE. 100 nanosecs/cm—5 secs/cm or continuously variable up to 12 secs/cm. Sweep expansion x 5. Accuracy: ± 3%.
X AMPLIFIER. Bandwidth: D.C.—150 Kc/s. Sensitivity: 200 mV/cm and 1 V/cm. Input Impedance: 1 M.ohm 40 pF.
INTERNAL CALIBRATOR. Accuracy: ± 3%.
DUAL TRACE Y AMPLIFIER. Bandwidth: D.C.—24 Mc/s. Rise Time: 14 nanosecs. Sensitivity: 50 mV/cm. Input Impedance: 1 M.ohm 26pF. Measuring Accuracy: ± 5% direct. ± 3% with calibrator.

£149.50

WIDE BAND Y AMPLIFIER PLUG ALSO AVAILABLE. Bandwidth: D.C.—40 Mc/s. Rise Time: 8 nanosecs. Sensitivity: 50 mV/cm—50V/cm. Input Impedance: 1 m.ohm 22pF. Measuring Accuracy: ± 5% direct. ± 3% with calibrator. P.O.A.

Stop Press

PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi-pole multi-throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 2 planes. 24 X 50 **£29.** 20 X 11 **£15.**

Carriage and packing charge extra on all items unless otherwise stated.

Please note: all instruments offered are second-hand and tested and guaranteed 12 months unless otherwise stated.

ADD 10% VAT TO ALL PRICES

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THESE ACCESSORIES CAN BE USED IN CONJUNCTION WITH THE SUPERTESTER 680R. ALSO IN MANY CASES WITH POPULAR MAKES OF TEST METERS.

Amperclamp
For measuring a.c. currents from 250mA to 500 amps. **£11.95**

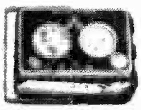
Signal Injector
Producing 1KHz and 500 KHz signals for circuit testing. **£5.95**

Transistor Tester
For transistors and diodes. **£11.95**

Gauss Meter
For measuring magnetic field strengths. **£11.95**

Phase Sequence Indicator
To indicate the phase sequence of a 3 phase supply. **£5.95.**

Temperature Probe
Covering the range −50 to +200°C **£11.95**



Electronic Voltmeter
Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£18.00**

OTHER ACCESSORIES AVAILABLE

SHUNTS D.C. 25, 50 and 100 amps. **£4.50** each.
CURRENT TRANSFORMERS A.C. 25 and 100 amps. **£7.00** each.
E.H.T. PROBE Extends D.C. voltage to 25,000v. **£5.95.**

THE REVOLUTIONARY SUPERTESTER 680R

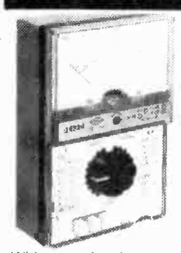
FOUR INTERNATIONAL PATENTS — SENSITIVITY 20,000 Ohms per Volt
10 FIELDS OF MEASUREMENT
AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.

OUTSTANDING FEATURES:
20,000 Ohm per Volt sensitivity ● Fully screened against external magnetic fields ● Scale width and small case dimensions (128 x 95 x 32mm) ● Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading ● Simplicity and ease of use and readability ● Full ranges of accessories ● 1000 times overload ● Printed circuit board is removable without de-soldering ● More ranges than any other meter. VOLTS A.C. = 11 ranges: 2–10–50–250–1000–2500. Volts and **4–20–100–500 and 2000 Volts**. VOLTS D.C. = 13 ranges: 100mV–2V–10–50–200–500-1000 Volts **200 mV-4V-20-100-400 and 2000 Volts** AMP D.C. = 12 ranges: 50μA-500μA-5 mA-50 mA-500 mA-50 Amp and **100μA-1 mA-10 mA-100 mA-1 Amp and 10 Amp.** AMP. A.C. = 10 ranges: 250μA-2.5 mA-25 mA-250 mA-2.5 Amp and **500μA-5mA-50 mA-500 mA-5 Amp.** OHMS REACTANCE = 6 ranges: **x1-x10-x100-x1000-x0.000 and Low Ohms.** DETECTOR = 1 range: from 0 to 10 Megaohms. FREQUENCY = 2 ranges; from 0 to 500 and from 0 to 5000 Hz. V OUTPUT VOLTAGE = 9 ranges: 10-50-250-1000-2500 V and **20-100-500-2000 Volts**. DECIBELS = **10** ranges: from −24 to +70 db. CAPACITY = 6 ranges: from 0 to 50,000 and from 0 to 500,000 pF using the mains and from 0 to 20, from 0 to 200, from 0 to 2,000 and from 0 to 20,000 Micro farad using the incorporated 3 Volts battery.
Bold figures indicate depress button.

£18.50 with shockproof case

ALL I.C.E. EQUIPMENT POST FREE

METERS PROBES, ETC.

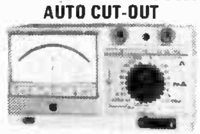


AC/DC MULTI-METER
With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC. 0.3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts. 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz. 500Ω. 5-50-500kΩ resistance. Decibel range −10 to +12dB. Accuracy (% of F.S.D.):—DC and resistance measurements +2.5. Price with test leads and storage case **£8.00** POST FREE

AMPERTEST 690
NEW CLAMP TYPE AMMETER

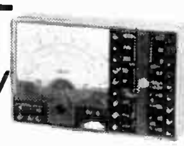
With unique self-locking meter system retains reading until released, enabling engineer to obtain accurate results after testing inaccessible places etc.
Designed for use in one hand, measures without breaking the circuit. It has six current ranges from 3A to 600A f.s.d. with the first division at 100mA, a 10-to-1 current transformer supplied with the instrument provides ranges from 300mA to 60A f.s.d. with the first division at 10mA. Two a.c. voltage ranges of 250V and 600V f.s.d. are provided.
£39.50 POST FREE
inc. leather case

MULTIMETER WITH FULLY AUTO CUT-OUT



With taut suspension movement and full coverage of AC and DC current and voltage ranges. The instrument incorporates all facilities needed for field and laboratory measurements. Knife edge pointer and 86mm long mirror scale allow the high inherent accuracy of the instrument to be utilized in full. The movements and circuits are fully protected by transistorized triggering circuit.
Scale length: 86mm D.C. current ranges: 50μA. 0.5, 1, 5, 10, 50, 250mA 1, 5 Amps. A.C. current ranges: 0.25, 0.5, 1, 5, 10, 50, 250mA, 1, 5 Amps. D.C. voltage ranges: 100mV, 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. A.C. voltage ranges: 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. Transmission level: −5 to +10db. Resistance ranges 0.5, 200; mid-scale reading 13 10Ω–3kΩ; mid-scale reading 200Ω, 100Ω, 30kΩ; mid-scale reading 2000Ω, 1kΩ–300kΩ mid-scale reading 20kΩ. Accuracy, % of F.S.D.: D.C. ranges — 1.5 A.C. ranges — 2.5. Sensitivity: D.C. ranges, 20,000Ω/V. A.C. ranges, 4,000Ω/V for all ranges except 2.5V and 10V. 1000Ω/V for 10V range 200Ω/V for 2.5V range. Batteries required: 2 dry cells 1.5V for automatic cut-out. 1 dry cell 1.5V for resistance range. Overall dimensions: 210 x 115 x 90mm. in carrying case, complete with test leads.
POST FREE **£15.00**

FANTASTIC VALUE
UNIQUE MULTI-METER/ SIGNAL GENERATOR



Taut suspension movement. Simple multimeter combined with audio/I.F. Test Oscillator providing AC and DC Voltage ranges. D.C. current ranges and resistance ranges. 1kHz and 465kHz oscillator output makes the instruments suitable for general tuning of receivers etc.
Scale length: 65mm. D.C. voltage ranges: 0.5, 2.5, 10, 50, 250, 500, 1000V. A.C. voltage ranges: 2.5, 10, 15, 250, 500, 1000V. D.C. current ranges: 0.05, 0.5, 5, 50, 500mA.
Sensitivity: 20,000Ω/V. Resistance ranges: 5–1000Ω mid-scale reading 50Ω 500Ω 10k; mid-scale reading 500Ω. 500Ω–100kΩ: mid-scale reading 5kΩ 5kΩ–1mΩ. mid-scale reading 50kΩ.
Accuracy: 5% of F.S.D. Internal battery: 3V dry cell.
Oscillator output: 1kHz squarewave. 465kHz sinewave modulated by 1kHz squarewave signal. Output voltage: 1V minimum.
Overall dimensions: 160 x 97 x 40mm. in carrying case, complete with test leads.
£7.00 POST FREE

MODEL 300 LOGIC PROBE

A compact easy-to-operate logic probe. As a light-emitting diode is used the unit actuates with low power. It does not affect the circuit under test because of high input impedance. Up to as high a frequency as 12 MHz.
POST FREE **£5.50**

ADD 10% VAT TO ALL PRICES
Carriage and packing charge extra on all items, unless otherwise stated.

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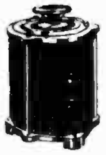
SERVICE TRADING CO

VARIABLE VOLTAGE TRANSFORMERS

Carriage extra

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.



BRAND NEW. All types.

0.5 KVA (Max. 2½ Amp)	£10·00
1 KVA (Max. 5 Amp)	£14·70
2 KVA (Max. 10 Amp)	£28·10
3 KVA (Max. 15 Amp)	£31·25
4 KVA (Max. 20 Amp)	£72·50
(Max. 37.5 Amp)	£102·50
200W (1 Amp)	£9·00
1 Amp OPEN TYPE (Panel Mounting)	£9·00

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Post
1	30, 32, 34, 36 v. at 5 amps.	£6·90	45p
2	30, 40, 50 v. at 5 amps.	£9·15	60p
3	10, 17, 18 v. at 10 amps.	£7·20	50p
4	6, 12 v. at 20 amps.	£8·60	60p
5	17, 18, 20 v. at 20 amps.	£9·15	60p
6	6, 12, 20 v. at 20 amps.	£8·65	60p
7	12, 20, 24 v. at 10 amps.	£6·75	50p
8	4, 6, 24, 32 v. at 12 amps.	£8·60	60p
9	6 and 12 v. at 10 amps.	£4·30	40p

Large selection of other types in stock, phone for details.

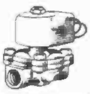
VOLTAGE CHANGING TRANSFORMER

M.f. to highest W.D. spec. Auto wound, and tapped 0-130, 160-200-250 at least 2KVA. Can also be used as 230-240V. Input, 115V. out for U.S.A. equipment, or reverse to obtain 240V. from 115V. The ideal transformer for making up solid state constant voltage unit, by use of taps the following voltages may be obtained: 30-40-50-70-90 Volts at 10 amps. Weight 40 lbs., length 260 mm., height 190 mm., width 230 mm. In original maker's wooden case. **£8·00**, carr. £1.

300 VA ISOLATING TRANSFORMER

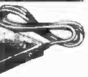
115/230–230/230 volts. Screened. Primary two separate 0–115 volts for 115 or 230 volts. Secondary two 115 volts at 150 VA each for 115 or 230 volts output. Can be used in series or parallel connections. Fully tropicalised. Length 13.5 cm. Width 11 cm. Height 13.5 cm. Weight 15 lb. SPECIAL OFFER PRICE Only **£5.00** Carr. 80p.

240 V A.C. SOLENOID OPERATED FLUID VALVE



Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring. ⅜ in. b.s.p. inlet/outlet. Precision made. British mtg. PRICE: **£1·75.** Post 25p. Special quotation for quantity. NEW in original packing.

FOOT SWITCH



Suitable for Motors, Drills, etc., etc. 5 amp. 250 Volt. Price 75p. Post 15p.

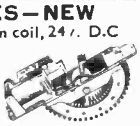
VENNER TIME SWITCH TYPE MSQP

200/250 Volt 2-ON/2-OFF every 24 hours at any manually pre-set time. 20 amp contacts. Fitted die-cast case. Tested and in good condition **£4·75** Post 25p.

A.C. MAINS TIMER UNIT

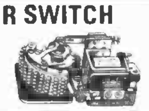
Based on an electric clock, with 25 amp. single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm × 130 mm × 60 mm. Price **£2·00.** Post 20p. (Total inc. VAT & Post **£2·42**).

UNISELECTOR SWITCHES—NEW



4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C operation **£6·90.** Post 30p.
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. **£7.90.** Post 30p.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation **£9·50.** Post 40p.

MINIATURE UNISELECTOR SWITCH

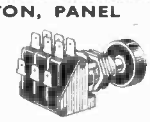


2 Bank, 12 position, 24 volt D.C. operation, full wiper with ancillary contacts. NEW Price **£2·50** Post 20p.
As above but with 5 Bank, 12 position. Price **£3·50** Post 20p.

VERY SPECIAL OFFER

Miniature Roller Micro Switch. 5 amp. c/o contacts. Mfg. BONNELLA. NEW. Price 10 for **£1·50.** Post 10p. (Min. order 10.)
As above without roller. 20 for **£2.00.** Post 10p. (Min. order 20.)

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY



Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ⅜ in. Prices: 1-bank 30p, 2-bank 40p, 3-bank 50p. (Illustrated) inc. P. & P. Special quotes for quantities.

24 VOLT DC SOLENOIDS

UNIT containing: 1 heavy duty solenoid approx. 25 lb. pull at 1 in. travel; 2 solenoids of approx. 1 lb. pull at ⅛ in. travel. 6 solenoids of approx. 4 oz. pull at ⅛ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price: **£2·50.** Post 60p. **ABSOLUTE BARGAIN.**

STROBE! STROBE! STROBE!

FOUR EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS, PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 30 Flash per sec. All electronic components including Xenon Tube + instructions **£6·30.** Post 30p.

INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. Adjustable 1-80 f.p.s., approx. ¼ output of Hy-Lyght. Price **£14·00.** Post 50p.

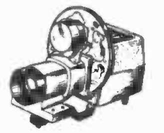
HY-LITE STROBE Mk IV
Designed for use in large rooms, halls and utilizes a silica tube, printed circuit. Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price **£14·00.** Post 50p.

'SUPER' HY-LIGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Variable speed from 1-13 flash per sec.
Reactor control circuit producing an intense white light. **ONLY £22·00.** Post 75p.

ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE for the Super Hy-Lyght Kit including reflector. **£8·00.** Post 60p.

FOR HY-LYGHT STROBE incl. reflector, **£5·75.** Post 25p.

COLOUR WHEEL PROJECTOR



Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. £18·50. Post 50p.

1 R.P.M. MOTOR and COLOUR WHEEL
200/240 volt A.C. 1 r.p.m. motor, and wheel **£5.60.** Post 40p. (Motor not available separately.)
6 INCH COLOUR WHEEL ONLY. Price £4.50. Post 30p.

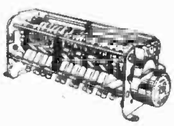
AUTO FADE COLOUR BLEND MODULE

Will control up to 750W. of lighting. **Automatic** fade-up, fade-down at a manually pre-selected timing, which may be varied between 1 second to 1 minute. Based on 10 amp. triac for maximum reliability. Ready built with switch and Time Control, on 4½" × 5" glass P.C. board. Three modules or more can be sequenced to obtain fantastic colour blending effects. Price **£12·50.** Post 30p. Per module. (Send S.A.E. for further details.)

BIG BLACK LIGHT
400 Watt. Mercury vapour ultra violet lamp. Extremely compact and powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb **£16·00.** Post £1. Spare bulb **£7·00.** Post 40p.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price £5·50. Post 30p. 2ft. 20 watt £4·25. Post 25p. (For use in stan bi-pin fittings.) MINI **12in. 8 watt £1·60. Post 15p. 9in. 6 watt £1·30. Post 15p. Complete ballast unit and holders for either 9" or 12" tube.** £1·70. Post 25p. (9in. x 12in. measures approx.).

PROGRAMME TIMERS



230/240 Volt A.C. 15 RPM Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays etc. Ex equipment tested.

4 cam model	£2·50 post 30p.
6 cam model	£3·25 post 30p.
12 cam model	£4·00 post 35p.
6 cam model 3 RPM	£3·25 post 30p.

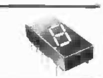
High Visibility Panel Mounting LED'S

·25 inch mounting, ·16 inch lens. Typical parameters 2 volt 20 m.a. all types. Supplied complete with snap in mountings and data. Red 4 for **£1·00**, Green 3 for **£1·00**, Yellow 3 for **£1·00.** Post 5p. (Min. order £1·00.)

GENERAL ELECTRIC POWER-GLAS TRIACS

10 amp. Glass passivated plastic Triac. Latest device from U.S.A. Long term reliability. Type SC 146D 10 amp. 400PIV **£1·00.** Post 5p. Type SC 146E 10 amp. 500PIV. **£1·30.** Post 5p. (Inclusive of data and application sheet) suitable Diac **18p.**

LED READOUTS



7 series I/h DP ⅓" high characters. 14-pin D.C.L. Available in red or green. **£1·65**, post 10p; 4 for **£6·00** post paid.

VAT All prices are subject to 10% VAT. (10p in the £)

To all orders add 10% VAT to total value of goods including carriage/packaging.

RELAYS

SIEMENS PLESSEY, etc. MINIATURE RELAYS

1	2	3	4	1	2	3	4
52	4-6	6M	60p*	700	6-12	1c/oHD	50p*
58	5-9	6 c/o	80p	700	20-30	6 c/o	80p
150	4-9	2 c/o	70p*	2500	36-45	6 M	60p*
185	8-12	6 M	60p*	2400	30-48	4 c/o	60p
308	9-14	4 c/o	75p*	2500	31-43	2 c/o HD	60p*
700	16-24	4M2B	60p*	5800	24-26	2 c/o	60p
700	16-24	4 c/o	80p*	9000	40-70	2 c/o	60p*
				15k	85-110	6 M	60p

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

6 VOLT D.C. 1 make con. **35p**. Post 5p.

9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil **75p**. Post 5p.

12 VOLT D.C. RELAY
3 c/o 5 amp contacts 120 ohm coil **75p**. Post 5p.

24 VOLT D.C. 3 c/o 600 ohm coil **75p**. Post 5p.
2 HD c/o 700 ohm coil **75p**. Post 5p.

100 VOLT A.C.
2 c/o sealed type, octal base **£1·00**. Post 10p.

24 VOLT A.C.
Mfg. by ITT. 2 h.d. c/o contacts. **55p**. Post 5p.

240 VOLT A.C. RELAY ITT
240V. A.C. heavy duty c/o contacts. Octal plug in base. Price **75p**. Post 5p.

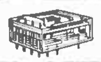
DIAMOND H, Heavy Duty Relay
230/240V A.C. 2 c/o contacts 25 amp RES at 250v A.C. Price **£2·00**. Post 10p.

HEAVY DUTY SEALED RELAY
110 Volt 2 c/o 20 amp contacts. **£1·25**. Post 10p.

220/240 VOLT AC RELAY
3 c/o 5 amp cont. Sealed, incl 11-pin base. **£1.25.** Post 10p.

CLARE-ELLIOT Type RP 7641 G8
Miniature relay. 675 ohm coil. 24 volt D.C. 2 c/o. **70p**. Post Paid.

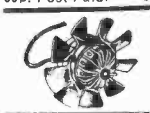
ITT LOW PROFILE RELAY 500 ohm coil. 12–24 volts D.C.. 4 c/o. Price **85p**. Post 5p each.



DRY REED RELAYS

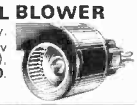
M.f.g. by ERG 12 volt D.C. encapsulated.
Single c/o 65p. Post Paid. Two c/o 85p. Post Paid.
STC 280 ohm coil 6/12 V D.C. 3 make contacts metal shrouded 60p. Post Paid. Large range of other types available.

BLOWER UNIT



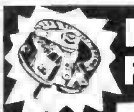
200-240 Volt A.C. **BLOWER UNIT** Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 120mm. dia. x 60mm. deep. Price **£3·00.** Post 30p.

PRECISION CENTRIFUGAL BLOWER



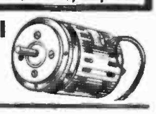
Mfg. Airflow Developments Ltd.. Heavy Duty, continuously rated, smooth running, 230/240v A.C. motor. Size: 16 × 14 cm. (case only). OAL 15 cm. Aperture 6 × 6 cm. **£6.50.** Post 50p.

POWER RHEOSTATS



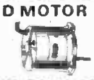
New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/100/250/300/500/1k ohm **£1·15** Post 10p.
50 WATT 1/5/10/25/50/100/250/500/1·5k ohm **£1·60.** Post 10p.
100 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/3·5k/5k ohm **£2·35.** Post 15p.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats, **22p** ea.

A.C. MOTOR M.fg. AEI



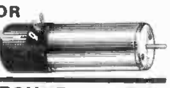
Smooth running, powerful, continuously rated, reversible motor. 230/250V. A.C., 50 cycle 1/50th H.P., 0·25 amp. 900 r.p.m. **£3·50.** Post 30p.

230/240V SYNCHRONOUS GEARED MOTOR



Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox. 2 RPH, 3 RPH, 6 RPH, 12 RPH. Price 90p. Post 10p.

CONSTANT SPEED, PRECISION MADE, 6 VOLT D.C. GOVERNED MOTOR

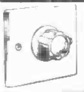


2,750 r.p.m. Length 2⅜ inch, dia 1⅜ inch, shaft ⅛ inch. No load 40mA. Ideal for portable recorders etc. **£1.50.** Post 15p.

METERS NEW! 2½in. FLUSH ROUND

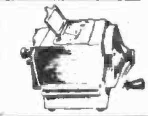
available as D.C. Amps 1, 5, 10, 15, 20 or A.C. Amps 1, 5, 10, 15, 20. Both types **£2·00.** Post 15p.
VOLTMETER 0-300V. A.C. **£2·00.** Post 15p.

600 WATT DIMMER SWITCH



Easily fitted. Fully guaranteed by makers. Will control up to 600 watts of all lighting except fluorescent at mains voltage. Complete with simple instructions. **£2·75.** Post 25p.

INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., H. 6 in., weight 6 lb.
500 VOLTS, 500 megohms **£28·00.** Post 60p. **1,000 VOLTS,** 1,000 megohms **£34·00.** Post 60p.

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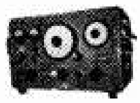
SIGNAL GENERATORS



MARCONI TF801D/1S. 10-480 mHz P.O.A.
MARCONI TF801B/2S. 10-480 mHz **£225.**
MARCONI TF144H 10kHz—72 mHz P.O.A.
MARCONI TF1370 RC Oscillator 10kHz-10mHz. Sine/Square.
ROHDE & SCHWARZ SMAF (illustrated) AM/FM 4-300 mHz.
ROHDE & SCHWARZ SMLR 15-30mHz power generator. P.O.A.
RACAL/AIRMEC 201A. 30kHz-30mHz. As new. P.O.A.
ADVANCE SG21 VHF Square-wave generator 9kHz-100mHz. **£25.**

OSCILLOSCOPES

TEKTRONIX 555 (Late model) with two 'L' plug-ins and '21A' and '22A' plug-ins.
TEKTRONIX 545A with CA unit. DC-30mHz. Price only **£295·00.**
DYNAMCO D7100 with 1Y2 and 1X2 plug-ins. DC-30mHz. **£249·50.**
ITT METRIX miniature portable scope. DC-10mHz. Brand new. **£50.**
NB: Due to the fragile nature of CRTs we regret that these oscilloscopes cannot be despatched by post. Collection only or delivery could be arranged.

MISCELLANEOUS TEST EQUIPMENT

MARCONI TF1245 Q-METER with 1246 & 1247 oscillators. Excellent.
MARCONI TF1400S double pulse generator with TM6600/S secondary pulse unit. **£105.**
MARCONI TF791D deviation meter. 4-1024mHz. 0-100kHz deviation.
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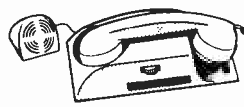

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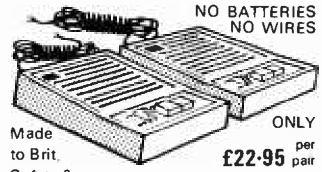

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(as in 'W.W.' July '72)

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Separation: 40dB 50Hz-15kHz. Distortion: 0·3%
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PHONE : Allan Petters on 01-261 8508 or 01-928 4597.
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Advertisements accepted up to 12 noon Wednesday, July 31st for the August issue subject to space being available.

Taking our torpedo from Portsmouth through a Scottish loch to the open sea needn't be such a trial

Not, that is, for experienced Trials Engineers. Marconi Space and Defence Systems in Portsmouth are building up a trials team, at the Applied Electronics Laboratories, to work on the assembly, test and commissioning of the new NASR 7511 lightweight torpedo. The following grades of staff are required, some to remain in Portsmouth, others to spend 50% of their time off-site, on trials in Scotland and at sea.

2 Senior Trials Engineers

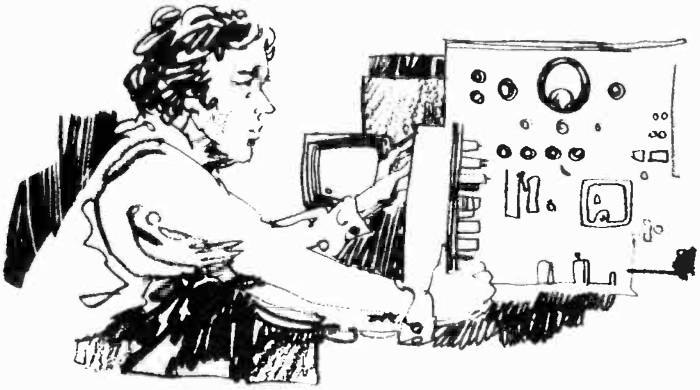
to supervise preparation work, assembly and test.

Trials Engineer

who must be qualified to HNC or Forces equivalent.

Trials Technicians

aged 30-32 years, qualified to ONC standard or Forces equivalent.



The areas of operation to be covered are assembly and test to prepared schedules, utilising the latest automated test equipment employing digital techniques, through to the designed-proving stage in forward areas including on-the-spot troubleshooting and refurbishment.

This is an excellent opportunity to join a company where the policy is progression — and that includes your career. Salaries will be realistic and there are many generous company benefits. Assistance with relocation expenses will be given, where appropriate, to this part of the South Coast that has so much to offer in terms of recreation and amenities.

Please apply for an application form to W. Lamin, Marconi Space & Defence Systems Limited, The Applied Electronics Laboratory, The Airport, Portsmouth PO3 5PH. Tel: Portsmouth 64966.

Marconi Space & Defence Systems (Portsmouth)

A GEC-Marconi Electronics Company

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A technical and creative genius to take charge of an ultra-modern purpose built production studio and provide a commercials production service for local and national advertisers.

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A job in the Post Office Maritime Service is the key to an interesting career, whether you have recently qualified and are looking for a shore-based job, or are seagoing and wish to swallow the anchor. A progressive future in the Post Office could be yours if you hold a General Certificate in Radiocommunications, issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay at age 19 is £1,567 a year, including contributions to a compulsory pension scheme, with an additional allowance averaging £300 for shift duties. After two years' satisfactory service your pay becomes £2,054, rising to a maximum of £2,622 at age 25 years. If you are over 19 years of age your salary is dependent upon age at entry.

There are opportunities for further promotion to positions with a basic salary of £3,475 and prospects for advancement into Senior Management.

For further information, write to the Inspector of Wireless Telegraphy (L525), MRSD/ET17, Room 643, Armour House, St. Martin's-le-Grand, London EC1A 1AR.

Post Office Telecommunications

193

Telecommunications Technical Officers

(men and women)

Join NATS and share in the varied and interesting telecommunications work associated with Air Traffic Control and Air Navigation.
The National Air Traffic Services of the Civil Aviation Authority has vacancies in its Telecommunications Division for Telecommunications Technical Officers Grade III.

Qualifications and Experience

You should be at least 21 years of age and have obtained either the Ordinary National Certificate in Engineering with a pass in Electrical Engineering A (or the equivalent electronics paper), or City and Guilds Telecommunications Technicians Course No 270 Part I Certificate and passes in Course No 271 Part II (T3) Mathematics 'B' Telecommunications Principles 'B' and Radio and Line Transmission 'B.' In addition you should have had skilled working experience in radio, radar or another branch of electronics.

Once appointed, you would supervise or personally carry out the work of installing, calibrating, and maintaining some of the worlds most advanced radio and radar, air navigational and landing aids, and computer and data processing equipment at Civil Airports and Air Traffic Control Centres.

The work is challenging and requires the ability to keep abreast of the most up to date electronic techniques.

At present the majority of posts are located in the South East of England.

Salary c. £1745 at age 21 to c. £2365 at age 28 or over, scale maximum c. £2587. Posts in the London area receive an additional allowance and some posts attract shift duty payments.

There are excellent promotion prospects and opportunity and assistance may be given to study for higher qualifications.

Write to the address below for an application form, which should be completed and returned by 17th August 1974.

Mr E P Savage C. Eng., MIEE
Personnel Branch (P2), Room 518,
Civil Aviation Authority, Aviation House, 129 Kingsway, London
WC2B 6NN

NATS
National Air Traffic Services

3897

Technicians

TELEVISION AND ELECTRONICS TECHNICIANS

For the Educational Television Unit at Guildford County College of Technology. To join, at both senior and junior levels, an existing team in this expanding college television service

Duties include the operation and maintenance of television studio and mobile equipment and other audio-visual aids. The work is interesting and varied with excellent opportunities for training advancement.

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Further details and application form from Vice Principal, Guildford College of Technology, Guildford, Surrey. Tel: Guildford 73201. [3917

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Sound Developments Ltd., require an Installations Manager to work from their office in London. The work involves the planning and installation of many types of sound equipment, and the maintenance of existing installations undertaken by the company. The right person will be required to supervise the electrical staff and the electronic maintenance engineers and the arrangements for the purchase and delivery of the components required for the installations. Some quotation work is involved.
The applicant should have a background of engineering knowledge, a university degree in electronic engineering is desirable. Experience with most aspects of sound equipment, including public address, recording and broadcasting, is essential and some knowledge of theatre lighting installations and digital techniques would be useful. The successful applicant is required to start as soon as possible. The ability to drive is essential, some travel within the UK may be involved. Salary negotiable from £2,400 p.a. with expenses paid where applicable.
Please apply in writing or telephone
Alan Brill Esq., Sound Developments Ltd., Unit 11 Spencer Court, 7, Chalcot Road, London, N.W.1. 01-586 4488.
[3882

UNIVERSITY OF BATH

SCHOOL OF ENGINEERING

ASSISTANT EXPERIMENTAL OFFICER

An Ássistant Experimental Officer is required to join the School of Engineering Instrumentation Service.

The applicant should have an HNC or Degree in electrical or electronic engineering with an interest in data collection and processing involving up-to-date digital and analogue techniques.

The post is tenable for a period of 2 years and results from a Science Research Council grant relating to computer-aided design.

Salary in the range £1,848 to £2,163 p.a.

Application forms, obtainable from The Registrar(S), University of Bath, BATH BA2 7AY, quoting reference 74/113, should be returned as soon as possible.
[3893

ROYAL COLLEGE OF ART

Applications are invited for a part-time appointment (two or three days per week) as

TECHNICIAN

in the

DEPARTMENT OF ENVIRONMENTAL MEDIA

Applicants should have expert knowledge within at least two of the following areas and the capacity to make both technical and creative contributions to the Department.

Audio Workshop
Research in Light and Colour (including Lasers and holography)
Electronics Systems Research
Plastics, Resins and Glass
Film and Video

Please write in the first instance giving full details to Mr H. W. Denyer, Royal College of Art, Kensington Gore, London SW7 2EU. [3909

Engineering Information Dept.

Central London

has a vacancy in Engineering Publicity Section. The post requires an ability to write clearly and attractively on technical subjects for other engineers and more especially for members of the general public. Experience in the design and layout of printed material is important.

Duties include writing leaflets and booklets, mainly about broadcast reception, and drafting reports and letters. Some exhibition work may also be included.

Applicants must have a good basic understanding of radio theory, television technology, and audio reproduction, allied to a natural flair for public relations.

Minimum qualifications—HNC Electronics or equivalent. Salary depending upon experience and qualifications in the range £3,243 to £3,555 rising to £4,023.

Requests for application form to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference number 74.E.2180/WW and enclosing addressed foolscap envelope. Closing date for return of completed applications forms, 14 days after publication.

[3836

BBC

EAST AFRICAN POSTS AND TELECOMMUNICATIONS

ASSISTANT ENGINEERS

required for the following duties in Kenya and Tanzania.

A. Surveys for single and multichannel VHF, UHF and microwave routes; radio path calculations; installation and commissioning of VHF, UHF and microwave equipment; preparation of plans estimates and indents for transmission and radio projects.

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Candidates (over 25) must have an Intermediate City and Guilds Certificate.

SALARY in the range £2,350 to £3,210 p.a. which includes an allowance, normally tax free, of £890 to £1,330 p.a. Terminal gratuity 25%. For a married man with two children paying tax at the standard rate the total emoluments described above, including gratuity, approximate to a gross (i.e. before tax) UK return of £3,950 to £4,950 and for a single man about £3,800 to £4,750 p.a.

Other benefits include low income tax, subsidised accommodation, education allowances and holiday visit passages, free family passages, appointment grant £100 or £200 and car loan £600, normally payable, 2 or 3-year tour.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to:

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/730669/WF.

[3899

GOVERNMENT COMMUNICATIONS HEADQUARTERS

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EITHER

C & G Telecomms Technicians Intermediate Certificate or equivalent technical qualifications

OR

GCE "O" level in English Language, Maths and Physics.

Salary scale is from £1,500 at age 19 to £2,309 plus London Weighting allowances as appropriate. Posts are unestablished, but opportunities exist for establishment.

Apply to:

Recruitment Officer, G.C.H.Q.,
Block 2, Government Buildings,
Eastcote Road, RUISLIP,
Middx. HA4 8BS.

[3915

INTERNATIONAL COMPANY

requires

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to instal and maintain analogue and digital computers supplying a service to the colour printing industry.

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For experienced electronic engineers capable of applying their experience to a wide range of industrial applications, there are quite a few interesting positions open.

There's the chance to travel abroad extensively providing a complete installation and back-up service for complex colour scanner/separators in trade houses. Young men at least 22 years old with experience in computers, radar/fixed/variable pulse techniques will also be considered.

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Practical electronic engineers with experience on systems testing and finite equipment will be interested in these positions. A minimum of HNC electrical engineering and a practical interest in constantly changing technology is essential. Knowledge of analogue and digital techniques is desirable.

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Successful technicians with ONC or equivalent qualifications will get a tremendous amount of experience at the bench testing electronic sub assemblies, and repairing, modifying and testing relevant design specifications. Excellent opportunities for College or University graduates, or young technicians with some industrial experience behind them.

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WALTHAM FOREST COLLEGE

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Housing accommodation and mortgage facilities available in approved cases. Application forms from the Personnel Officer, Town Hall, Forest Road, London E17 4JF. Tel. 527 5544 Ext. 207. Quote ref. Q.995.

[3896

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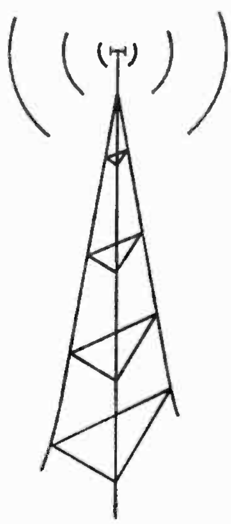

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Freepost, Macclesfield,
Cheshire SK10 2YF.

Telephone: (0625) 32363 or
Telex: 667636 Asgomacc

[3901

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Ferranti Ltd. require people to join design teams involved in the development and application of electronic and avionic systems. As members of groups closely identified with advanced areas of technology, successful candidates will work on genuinely absorbing projects with colleagues already acknowledged as experts in their field.

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(Ref. A) Preferably with avionics experience —ample opportunity to contribute to the development of advanced electronic systems. Salary up to £3,500.

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(Ref. E) With general D.O. experience, preferably in light mechanical engineering and/or electronics. Salary £1,800-£3,000 according to qualifications and experience.

Working with Ferranti in Edinburgh offers unique opportunities in terms of professional and environmental satisfaction. And to make moving here easier, the Company will assist with relocation expenses. A contributory Pension and Life Assurance scheme is in operation.

Candidates should apply in writing, quoting appropriate reference and giving details of qualifications and experience to:
Staff Appointments Officer, Ferranti Limited, Ferry Road, Edinburgh, EH5 2XS

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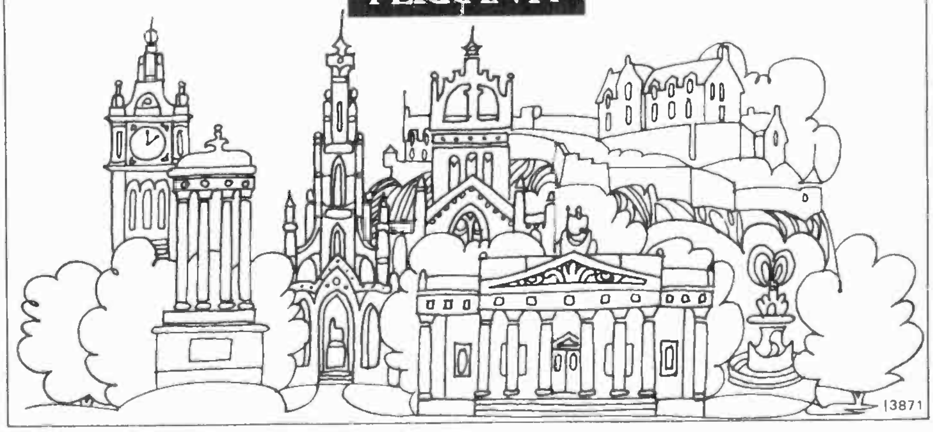

[3871

TRAINEE/SCHOOL LEAVER

required to assist in the maintenance and repair of undergraduate teaching laboratory equipment in the department of Psychology, University of Surrey.

Excellent opportunity for gaining experience of operating and maintaining audio-visual aids equipment.

Day Release. Salary according to age.

TECHNICIAN WITH ONC ELECTRONIC ENGINEERING

to be responsible for construction, the maintenance and repair of undergraduate teaching laboratory equipment in the department of Psychology. This involves a wide range of bench skills, with particular emphasis on basic electronics. Assistance will also be given on postgraduate research, and attendance at laboratory classes may be required.

Some experience of operating audio-visual aids equipment an advantage. Applicants should hold City & Guilds or O.N.C. Electronic Engineering, and have some previous experience of working in a laboratory.

Salary up to £1,920 per annum.

Application forms may be obtained from the Staff Officer, University of Surrey, Guildford GU2 5XH, or Tel: Guildford 71281, Ext. 452. [3919

Northampton College of Technology
Department of Engineering

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To teach Telecommunication Technician course students, and have specialist knowledge in Telephony. Applicants should possess appropriate qualifications and have suitable industrial experience. Applicants will be expected to commence duties on 1st September, 1974 or as soon as possible thereafter. Salary Scale £1,800-£2,874, according to experience and qualifications.

Forms of application and further particulars may be obtained from the Chief Administrative Officer, Northampton College of Technology, St. George's Avenue, Northampton NN2 6JB, telephone 34286, to whom completed applications should be returned as soon as possible.

[3879

TEKTRONIX

TELEQUIPMENT

TEKTRONIX UK LTD
ELECTRONIC SERVICE ENGINEERS

We have vacancies for Service Engineers who are seeking interesting and varied work servicing oscilloscopes and measuring instruments.

Applicants should have a good basic knowledge of electronics and preferably ONC or RTEB considered. Would appeal to engineers who have experience in servicing of electronic equipment or the television servicing industry.

Holiday arrangements honoured, competitive salary plus profit share scheme, day release negotiable, sick pay, non-contributory life assurance and pension scheme after qualifying period.

Write or phone
Mr. R. A. Jonas
TEKTRONIX UK LTD

Coldharbour Lane **Tel: Harpenden 63141**

[3870

ELECTRONIC DEVELOPMENT ENGINEERS

Radio Frequency

Multitone—world leaders in specialised radiocommunications systems—are looking for senior and junior development engineers to be responsible for the design and development of radio frequency equipments.

We are interested in meeting engineers who have experience in the design of radio receivers and transmitters, and who now want to use that experience to extend their career opportunities.

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A degree, HNC, etc., is required, and for the senior posts the ability to manage complete projects is a decided advantage. Please apply, giving relevant career details to date, to:

Personnel Manager,
Multitone Electric Co. Ltd.
10–28 Underwood Street, London N1 7JT. Tel: 01-253 7611.

[3888

ELECTRONIC VACANCIES

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Draughtsmen ● Designers
Service and Test Engineers
Technicians ● Technical Authors
Sales Engineers

£1,600-£5,000 pa

Permanent or Contract

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01-388 0918
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ELECTROSONIC LIMITED
S.E. LONDON

PROJECT ENGINEER

SALARY £2,500/£3,000 p.a.

Electrosonic Limited, a leading company in the rapidly expanding fields of lighting control, audio and audio-visual systems, require an Audio Project Engineer for design installation and commissioning of professional sound systems.

Applicants aged 25+ should have systems design experience, initiative and a capacity for hard work.

Excellent working environment, pension scheme, good prospects and interesting opportunities.

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Telephone: 01-855 1101.

[3922

KINGSTON POLYTECHNIC

CCTV Technician

required for educational closed-circuit TV. Sound basic knowledge and competence in the maintenance and repair of TV equipment including cameras and video recorders. Keen interest in the development of TV facilities within the Polytechnic and ability to co-operate with academic staff essential. Desirable qualifications: HNC in electronics or equivalent C & G Cert. Previous experience in educational TV and advantage. Salary range T3/4 £1,521-£2,031.

Application forms from Assistant Registrar, Kingston Polytechnic, Penrhyn Road, Kingston upon Thames KT1 2EE. 01-549 1366.

[3872

TEST/ COMMISSIONING ENGINEERS

Are you in an ever deepening rut?

Why not join a progressive Company engaged in the production of sophisticated equipment for use in the Graphic Arts Industry? This is interesting work in the field of Digital Electro/Optical Phototypesetting. Advanced digital display technology is used in conjunction with Digital Computing Techniques. Test and Commissioning Engineers of all grades are required for our rapidly expanding production programme. We offer good salaries, excellent terms and conditions of employment, but most of all an exciting working environment.

Ring 01-205 0123—ask for Maurice Alberts. He will tell you more.

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Kingsbury Works,
Kingsbury Road,
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D-day for the South African Broadcasting Corporation's television service is approaching fast and we need the following staff urgently!

Television Studio and Transmitter Engineers

at all levels — Johannesburg and also other centres

Programme and Operational staff

with several years' experience — Johannesburg

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FILM LABORATORY TECHNICIANS
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RIGGER/DRIVERS
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CAMERAMEN
VISION MIXERS
SOUND OPERATORS

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WE OFFER: ★ Contract or permanent appointments ★ Good starting salaries ★ Excellent Pension or Provident Fund ★ Life Assurance and Medical Aid Scheme ★ Generous leave benefits ★ Excellent opportunities for advancement ★ Transportation to South Africa ★ Assistance with transporting of personal belongings ★ Settling Allowance

These are excellent career opportunities. Interested? Then write immediately, giving full details. Don't forget to mention the type of post applied for. The most promising candidates will be required to attend an interview in the U.K. or Europe during August/September, 1974. Therefore, please provide a telephone number. Applications should be airmailed to the address below, to reach us not later than July 31, 1974.

The Director: Personnel, S.A.B.C., P.O. Box 8606, JOHANNESBURG 2000, Republic of South Africa.

[3878

SABC

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Department of Photography and Teaching Aids Laboratory
Film and Television Section

Applications are invited for the post of

COLOUR CCTV ENGINEER

which will become vacant in September. The duties are to provide and maintain an off-air recording/transcription and playback system in colour, partly mobile, and to supervise a loan facility of a monochrome camera and recorder.

Salary at a point on the scale £1,494-£2,718 (from October 1974 the scale is £1,683-£2,931) according to age, qualifications and experience. Membership of F.S.S.U. required.

Applications, as soon as possible, with full details of age, education, job experience, names of two referees, and availability for interview should be sent to C. J. Duncan, Director, Department of Photography & Teaching Aids Laboratory, The University, Newcastle upon Tyne NE1 7RU, from whom further details may be obtained.

[3925

TIMEX CORPORATION

Research & Development Laboratory engaged in Design & Development of special purpose instrumentation & control systems has the following vacancies in

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—H.N.C. or equivalent familiar with design & development of low frequency linear & digital circuitry. Opportunity to work on interesting projects from inception to completion, excellent salary & prospects.

DRAUGHTSMAN

—Fully experienced in P.C. layouts circuit diagrams, chassis work. This is a unique position within the Laboratory and offers considerable scope for personal initiative.

Apply in the first instance giving brief details of experience to date plus present salary to:

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River Gardens,
North Feltham Trading Estate,
Feltham, Middlesex.
Tel: 01-890 3611.

[3873

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QUALIFIED OR NOT!

OPPORTUNITIES for challenging work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from Ex-Services technicians.

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37½ hour, 5-day, working week.

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Educational Technology Department

SENIOR TELEVISION TECHNICIAN

Senior Television Technician for a Closed Circuit System required as soon as possible to take responsibility for the operational efficiency of: a three Vidicon camera television studio, a lightweight mobile unit, Sony, Ampex helical scan V.T.R.s, Phillips V.C.R.s and a V.H.F. distribution system. The Studio is attached to a Resource Centre and in addition to the services of an assistant technician the facilities of the Centre are available.

Salary Scale Technician Grade VI £2,235-£2,535 (Salary award pending)

Application forms, together with further particulars, available from the Senior Administrative Officer, Berkshire College of Education, Bulmershe Court, Woodlands Avenue, Earley, Reading RG6 1HY to be returned within 10 days.

[3833

Find your place in British Gas

SENIOR TECHNICIAN

Communications

We need a Senior Technician for the Communications Section of the Engineering Department and based at Headquarters, Potters Bar.

You will be involved in assisting the Radio Planning Engineer in all aspects of planning, designing and commissioning of micro-wave radio links, etc., conducting field trials and survey work.

You should preferably possess an HNC or equivalent qualification but consideration will be given to all applicants. A working knowledge of micro-wave techniques, frequency division multiplex, UHF, VHF and control systems would be essential.

A current driving licence is necessary and you must be prepared to travel throughout East Anglia and the Home Counties and to climb towers and structures as the necessity arises.

Salary will be within the range £2203–£2571 per annum.

Please write or telephone for an application form to Mr. H. A. Lloyd, Personnel Officer, Eastern Gas, Star House, Potters Bar, Herts. Telephone Potters Bar 51151.

EASTERN GAS

3877

SITUATIONS VACANT

HI-FI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [19

INSTALLATION ENGINEERS and Test Engineers for the servicing, testing and installation of lighting control, audio and audio visual equipment and systems. An excellent opportunity for applicants with ability, initiative and a sound knowledge of basic electronics. Starting salary according to ability. The company offers an attractive working environment and opportunities for travel. Apply Personnel Director, Electrosonic Ltd., 815 Woolwich Road, Charlton, S.E.7. Telephone 01-855 1101. [3921

TECHNICAL ASSISTANT required to work for a period of six months (full or part-time) with the COMMUNICATIONS STUDIES GROUP at University College London, to build new telecommunications equipment for use in laboratory experiments. The Communications Studies Group is an interdisciplinary group of engineers, psychologists, operational researchers and survey researchers working on the assessment of new telecommunications systems, particularly video (e.g. videophone) and audio for groups of users. Electrical engineering or similar technical background would be required and the work would involve designing, building and testing various telecommunications terminals. Salary about £1,860 per annum (part-time rate negotiable) depending on age and experience. Applications giving full details of qualifications and experience to Dr. Ederyn Williams, Communications Studies Group, 172 Tottenham Court Road, London W1P 0BS. [3910

TECHNICAL WRITER (ex RAF Radar) available for work on electronic and radar subjects on freelance basis. Write Box No. WW 3903.

YOUNG ELECTRONICS TECHNICIAN required for the construction, testing and servicing of electronic equipment at our works in N.W.1. Very varied work. Qualifications: ONC or C&G or ex-apprentice or similar desirable. Excellent opportunity for right person with a small expanding company. Please write for an application form to: Young Electronics Ltd., 54 Lawford Road, London, NW5 2LN. [3816

YOUNG Medical electronic technician required for a vision research unit. Previous knowledge and experience in workshop and electronics and a genuine interest in scientific research are essential. Day release for pursuing studies available. Please contact Mr. Kneller, Physiology Dept., St. Thomas' Hospital Medical School, Lambeth Palace Road, LONDON SE1 7EH. Tel: 01-928 9292 Ex. 2241 or 2247. [3916

ARTICLES FOR SALE

AARVAK ELECTRONICS, 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23

BRENELL TAPE DECK Mk. 6, brushed aluminium, with cabinet and 3 quarter track Bogen heads for transistor circuit, e.g. J. R. Stuart design, £65.00. Tel: 01-223 1986 (Battersea, London). [3894

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2¼ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

Classifieds continued on p. 101

Classifieds continued from p. 100
Articles for Sale continued

COLOUR, UHF and TV SPARES. Colour and UHF lists available on request. New Philips G6 single standard convergence panels complete, incl. 16 controls, coils, P.B. switches, leads, etc. and circuit data £3.75, or with yoke £5.00, P/P 30p. New Colour Scan Coils, Mullard or Plessey plus convergence yoke and blue lateral, £10.00, P/P 40. Mullard AT1025/05 Convergence Yoke, £2.50, P/P 25p. Mullard or Plessey Blue Laterals, £1.25, P/P 10p. BRC 3000 type Scan Coils, £4.00, P/P 40p. Delay Lines DL20, £3.50, DL1E, DL1, £1.50, P/P 25p. Lum. Delay Lines, 50p, P/P 15p. EHT Colour Quadrupler for Bush Murphy CTV 25 111/174 series, £8.25, P/P 25p. EHT Colour Tripler ITT TH25/1TH suitable most sets, £2.00, P/P 25p. KB CVC1 Dual Stand. convergence panels complete incl. 22 controls, £3.75, P/P 35p. CRT Base Panel, £1.75, P/P 15p. Makers Colour surplus/salvaged Philips G8 panels part complete: Decoder incl. I/C, £2.50, IF incl. 5 modules, £2.50, T. Base, £1.00, P/P 25p. CRT base, 75p, P/P 15p. GEC 2040 panels, Decoder, £3.50, T. Base, £1.00, RGB and Sound, £1.00, P/P 25p. Pye CT70 Colour LOPT assembly incl. EHT output and Focus Control, £3.50, P/P 35p. B9D valve bases 10p, P/P 6p. VARICAP TUNERS. UHF ELC 1043 NEW, £4.50, Philips VHF for Band 1 and 3, £2.85 incl. data. Salvaged VHF and UHF Varicap tuners, £1.50, P/P 25p. UHF TUNERS NEW, Transistorised, £2.85 or incl. slow motion drive, £3.85. 4 position and 6 pos. push-button transistd., £4.95. UHF/VHF basic integrated tuners, £3.25, Cyldon UHF valve tuners, £1.50. All tuners P/P 30p. Transistd. UHF/VHF IF panels salvaged, £2.50 P/P 25p. MURPHY 600/700 series complete UHF Conversion Kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories housed in cabinet plinth assembly, £7.50 P/P 50p. SOBELL/GEC 405/625 Dual standard switchable IF amplifier and output chassis incl. cct., £1.50 P/P 35p. THORN 850 Dual standard time base panel, £1.00 P/P 35p. PHILIPS 625 IF amplifier panel incl. cct., £1.00 P/P 30p. VHF turret tuners AT7650 incl. valves for K.B. Featherlight, Philips 19TG170, GEC 2010, etc., £2.50. PYE miniature incremental for 110 to 830, Pam and Invicta, £1.95. A.B miniature with UHF injection suitable K.B. Baird, Ferguson, 75p. New fireball tuners Ferguson, HMV, Marconi, £1.90 P/P all tuners 30p. Large selection LOPTs, Scan Coils, FOPTs available for most popular makes. PYE/LABGEAR transistd. Masthead UHF Booster, £5.75, Power Unit, £4.65 P/P 30p or Setback battery operated UHF Booster, £4.65 P/P 30p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28, 59, 159 Buses or W. Hampstead Bakerloo and Brit. Rail). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751.

CONSTRUCTION AIDS—Screws, nuts, spacers etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 6p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. [28

FENLOW Data Recorder. D.C. to 100 c.p.s. tape recorder with Ferrograph tape deck. Twin inputs for dual recording of temperature gauges, strain gauges, accelerometers, etc., £75.00. 35mm Cosser oscilograph camera with cassettes, variable speed drive, £15.00. Vectron A.G.C. mic., output 15mV, A.G.C. range 60 dB, input threshold gives 'no signal' conditions to background noise, £10.00. R. M. Smith, 20 Elmsmere Road, Didsbury, Manchester, M20 0FL. Tel: 061-445 3303. [3900

GENEVAC EC/12/4/1 vacuum coating unit. Substrate heater rotary work holder as new. Offers 061-428 3235. [3458

IBM GOLFBALL Typewriter on desk, £68. IBM Standard, £19. AMPEX FR1400 14 channel Instrumentation Recorder, only 72 hours on clock, £185. KIENZLE 4800 Computer, £185. FLEXOWRITER (paper tape typewriter), £38. Immaculate Creed Teleprinter with tape read and punch, £38. Ekco ttl counter-timer, £18. Singer 7151 Telegraph Adapter Unit, £15. H-P 6 speed mag. tape (new), £38. FRIDEN 5 register, 13 digit calculator display-ing on CRT, £35. 400Hz Inverter, £12. EMI Studio Echo, £75. 14 dc Amplifiers (a lot), £14. HIGHEST QUALITY WORD PROCESSING MACHINES ALWAYS AVAILABLE. Computer Appreciation, Godstone 3106. [3918

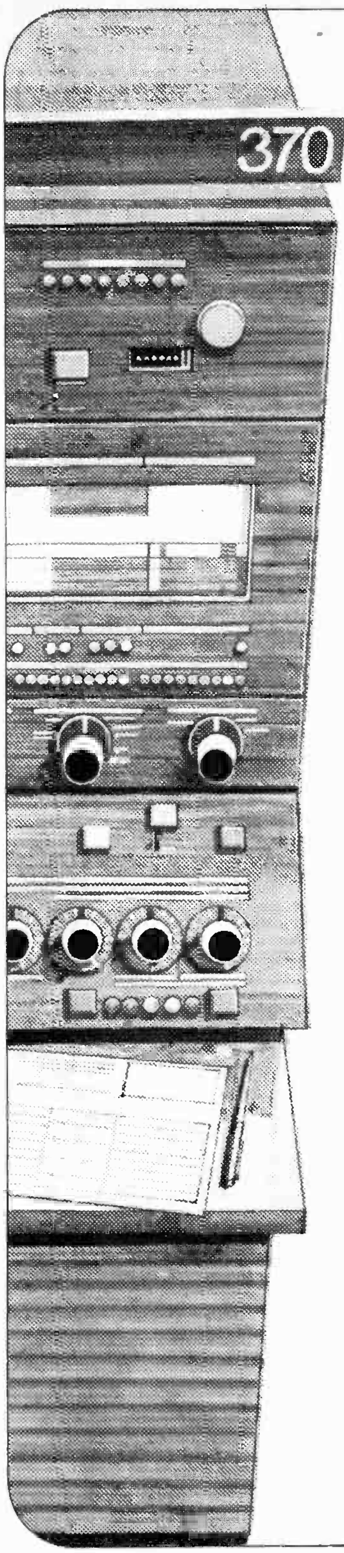
LADDERS 8ft 10in closed—21ft extended, £23.54, delivered. Home Sales Ladder Centre (WW2), Haldane (North) Halesfield (1) Telford, Shropshire. Tel: 0952-586644. [23

MIROR Aluminising, optical filters and components, vacuum coatings. Frew-Smith Optics, 94 Main Street, Prestwick, Ayrshire. Tel. 0292 70003. [3886

OFFERS WANTED, Wireless World 1937 to 1945, bound, indexed; 1946 to 1958 loose, 5 missing, less adverts; Harmsworths Wireless Encyclopedias, 1924; 5 Newnes Servicing books, pre-1961 together. Parlour, 30 St. Andrews Road, Enfield, Middlesex. [3908

PRINTED Circuit Board in 6 widths: 2 in., 2½ in., 3 in., 3½ in., 4 in. and 5 in. x any length; 1/16 in. single-sided fibreglass, 2p per 3 sq. in. Double-sided 1p per sq. in. P & P 5p per order. SAE quotations for other sizes and quantity discounts.—J. Knopp, 11 Connaught Gardens, Braintree, Essex, CM7 6LY. Tel. Braintree 25254. [15

SUPERB Instrument Cases by Bazelli, manufactured from heavy duty PVC faced steel, choice of 70 types. Send for free list. Bazelli Instrument Cases, Dept. 22, St. Wilfrids, Foundry Lane, Halton, LA2 6LT, near Lancaster. [3646



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VACUUM is our speciality. New and second-hand rotary pumps, diffusion outfits, accessories, coaters, etc. Silicone rubber or varnish outgassing equipment from £40. V. N. Barrett (Sales) Ltd., 1 Mayo Road, Croydon. 01-684 9917. [24

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12.5 Ministry approved. Exchange price £7.50. Kcs Pye (Cambridge) 455Kcs Block filters. Austen, Burgess Hill 3409. [3880

60 KHz MSF Rugby and 75 KHz Neuchatel Radio Receivers. Signal and Audio outputs. Small, compact units. Two available versions £35 and £60. Toolex, Bristol Road, Sherborne (3211), Dorset.

ARTICLES WANTED

CASH AVAILABLE for surplus semiconductors and I.C. Phone 01-452 2583. [18

PRIVATE Collector wishes to purchase service sheets, manuals, catalogues, etc., for pre-war domestic radio receivers. Particularly pre-1930. Also magazines, books, etc. Collection arranged. W.W. Box No. 3881.

TOP PRICES paid for surplus materials, components, semiconductors. Chandlers of Brighton, 4 Wentworth Street, Brighton, Sussex. 0273-688010. [3884

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Classifieds continued on p. 102

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Phone (0353) 860185 (Tues. - Sat.)

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NOISE GENERATOR, RF1237, £50·00

VALVE VOLTMETER, TF428C, £28·00

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500V at 350mA, plus 6·3V at 8A, £5·00 each, carriage 50p

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16V at 6A, £3·20 each, carriage 50p

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20-0-20V at 1·5A, 60p each, 2 for £1

13-0-13V at 100mA, 40p each, 3 for £1

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HIGH QUALITY SPEAKERS, 6in x 4in elliptical, 2in deep, 4ohm, 90p each, 2 for £1·70

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PLEASE ADD 10% V.A.T.

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S.A.E. FOR ALL ENQUIRIES PLEASE

CALLERS WELCOME BY APPOINTMENT

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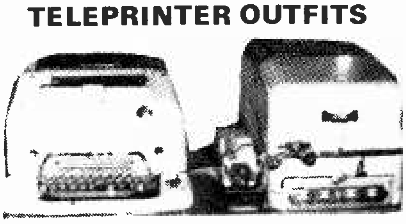

Comprising. Teletypewriter (page printer) type TT-271B/FG (known as Kleinschmidt 160) Reperforator-Transmitter (tape printer) type TT-272A/FG with table FN-65/FG. Both units are supplied with change wheels. the whole equipment operates on 115 or 230V 50 cycles in very choice condition £55. (carr £4).

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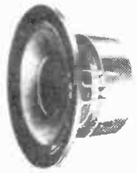

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FD	40	22	24	72	£14·00
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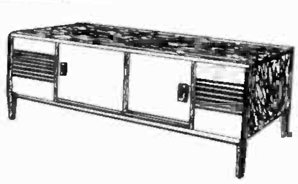

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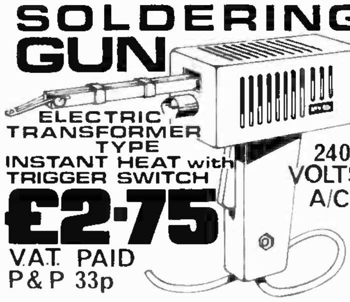

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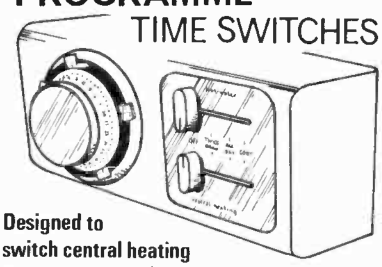

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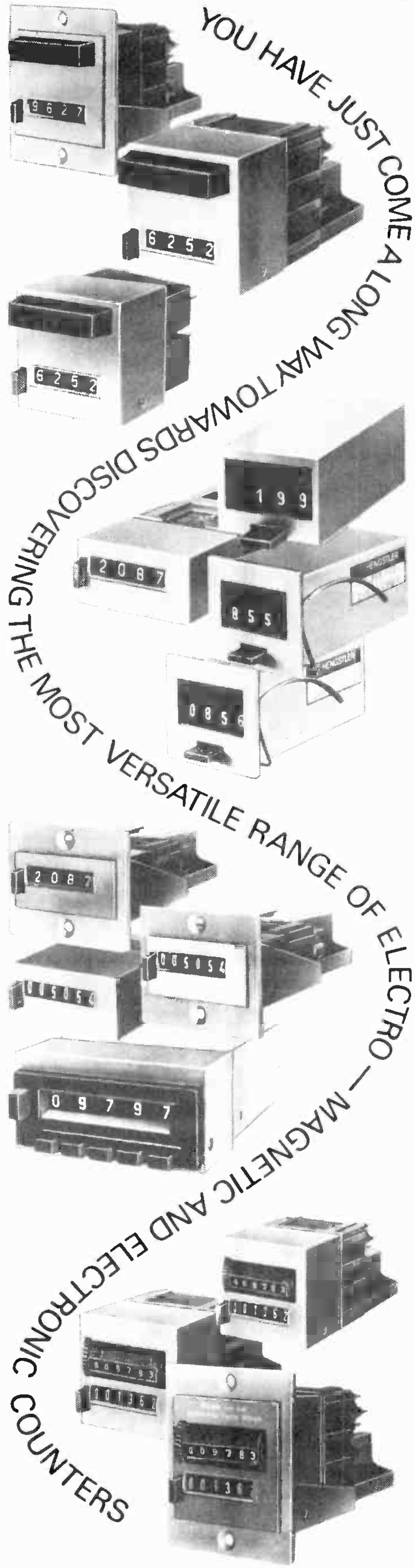

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Our Quality Control at all stages of manufacture is guaranteed and recorded by the batch number on every reel.

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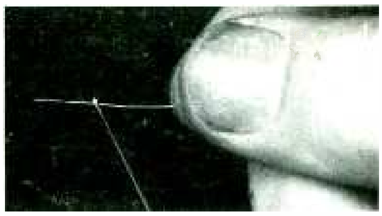

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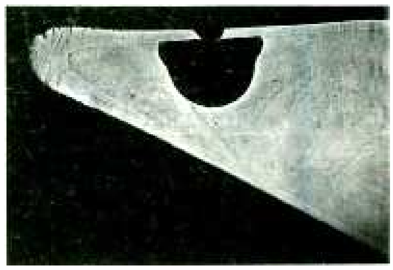
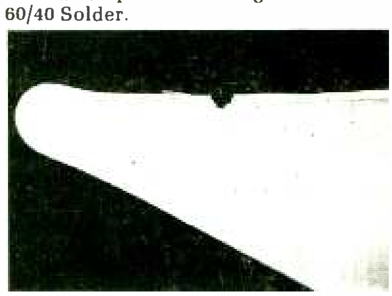
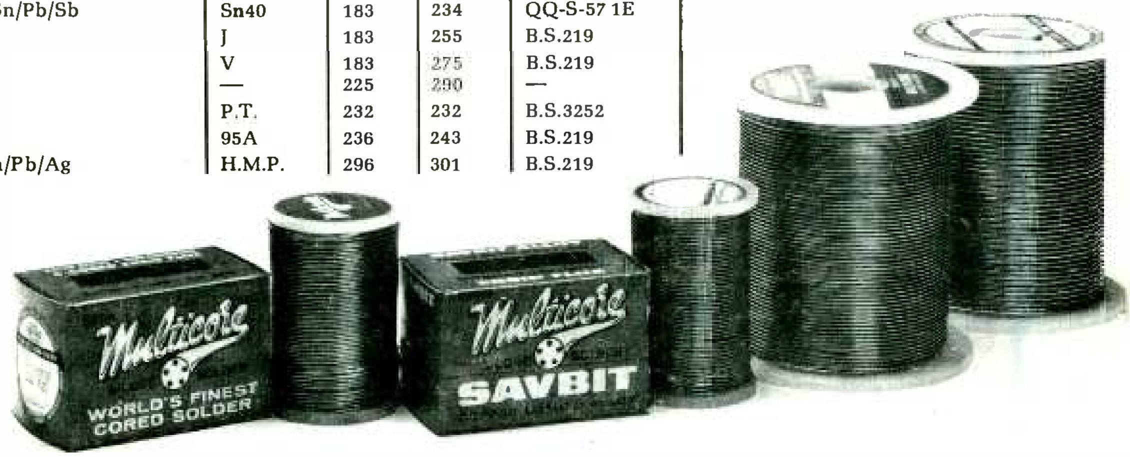


Sectioned iron-plated bit, after 40,000 simulated operations using 60/40 Solder.



Sectioned iron-plated bit, after 40,000 simulated operations using SAVBIT Solder.

ALLOY Composition (nominal major elements)	Grade	Melting Temperature Solidus °C	Liquidus °C	Specification
50/33/17 Sn/Pb/Cd	TLC	145	145	DIN 1707
62/36/2 Sn/Pb/Ag	LMP	179	179	DIN 1707
62/35.7/2/0.3 Sn/Pb/Ag/Sb	Sn62	179	179	QQ-S-57 1E
63/36.7/0.3 Sn/Pb/Sb	Sn63	183	183	QQ-S-57 1E
60/40 Sn/Pb	K	183	188	B.S. 219
60/39.7/0.3 Sn/Pb/5b	Sn60	183	188	QQ-S-57 1E
50/50 Sn/Pb	F	183	212	B.S.219
50/49.7/0.3 Sn/Pb/Sb	Sn50	183	212	QQ-S-57 1E
50/48.5/1.5 Sn/Pb/Cu	Savbit 1	183	215	DTD 900/4535 DIN 1707
45/55 Sn/Pb	R	183	224	B.S.219
40/60 Sn/Pb	G	183	234	B.S.219
40/59.7/0.3 Sn/Pb/Sb	Sn40	183	234	QQ-S-57 1E
30/70 Sn/Pb	J	183	255	B.S.219
20/80 Sn/Pb	V	183	275	B.S.219
15/85 Sn/Pb	—	225	290	—
Pure Tin	P.T.	232	232	B.S.3252
95/5 Sn/Sb	95A	236	243	B.S.219
5/93.5/1.5 Sn/Pb/Ag	H.M.P.	296	301	B.S.219



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