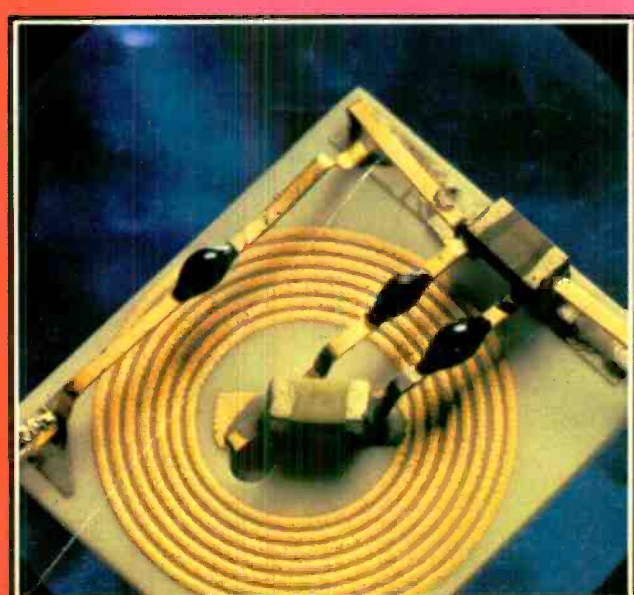
wireless world

APRIL 1975 30p

Video recorders

Artificial vision



Australia	80 Cents	Malaysia	M $2.60
Belgium	Fr. 52.00	New Zealand	78 Cents
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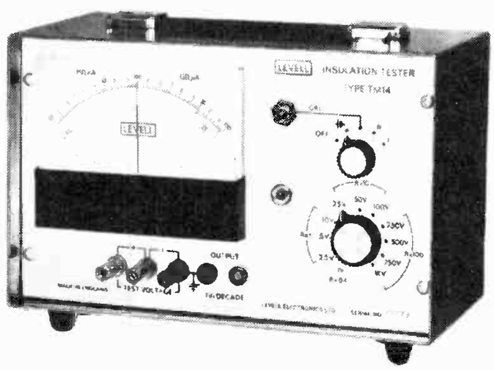
LOW COST TESTERS

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

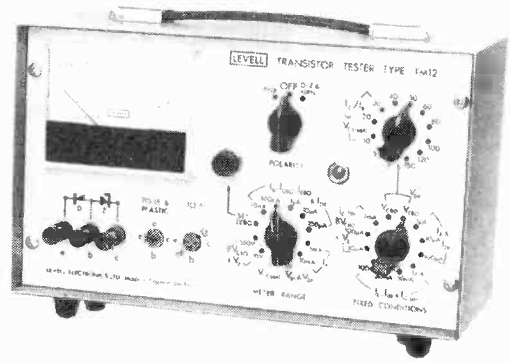
< 3s for resistance on all ranges relative to CAL position.
< 10s for resistance of 10G Ω across 1μF on 50V to 500V.
Discharge time to 1% is 0.1s per μF on CAL position.

RECORDER OUTPUT

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

type TM14 **£80**

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 **£80**

LEVELL ELECTRONICS LTD.
Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

Prices include batteries and U.K. delivery. V.A.T. extra. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

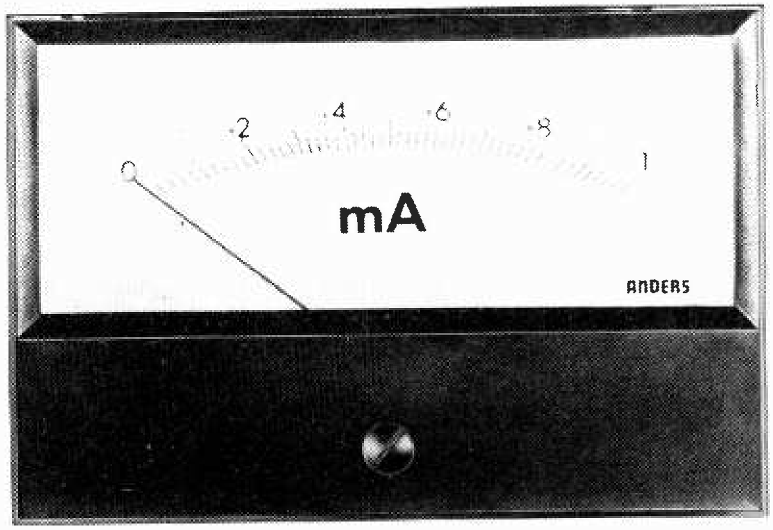
WW—036 FOR FURTHER DETAILS

ANDERS MEANS METERS...

REGAL RANGE

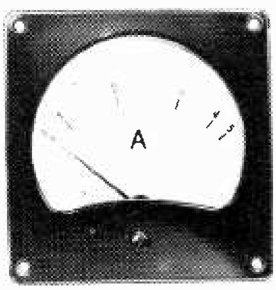
- **New 100° arc high quality meters at low prices.**
- Rugged taut band construction
  — pivot and jewel available to order
- Sensitivities to 10 μA
- Very competitively priced for OEM quantities
- Modern styled meters in matt black plastic cases with flattened arc giving long scale.

TWO MODELS
R55 2.5in (63.5mm) Scale length
R65 3.2in (81.3mm) Scale length

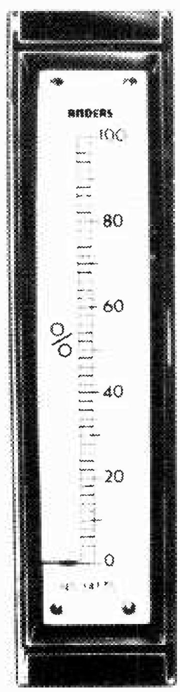


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.

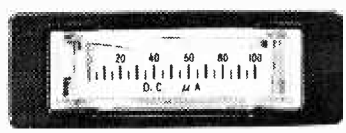


Vulcan Moving Iron. 4 models, 1·5", 1·8", 2·7", 3·7" scales. Voltmeters, ammeters and motor starting meters.

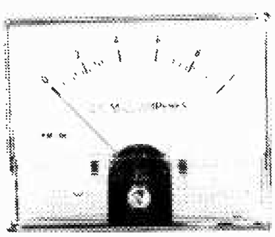


Profile 350 edgewise 4·3" scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.

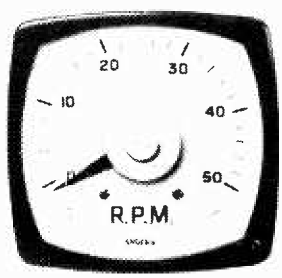
Recorders 60 or 120 mm. charts. Non-ink marking. DC moving coil and AC rectified.



Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2" and 2". Available in sensitivities from 50 microamps Moving Coil.



Kestrel Clear Front. 7 models, 1·3"—5·25" scales. DC moving coil, AC moving coil rectified, AC moving iron.



Stafford Long Scale 240° 6 models, 3·5"—11·5" scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.

Lancaster Long Scale 240 . 2 models, 4", 5·5" scales. DC moving coil and AC moving coil rectified.

Send for fully illustrated catalogue.

ANDERS ELECTRONICS LIMITED 48/56 Bayham Place, Bayham Street, London, N.W.1. Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers requirements.

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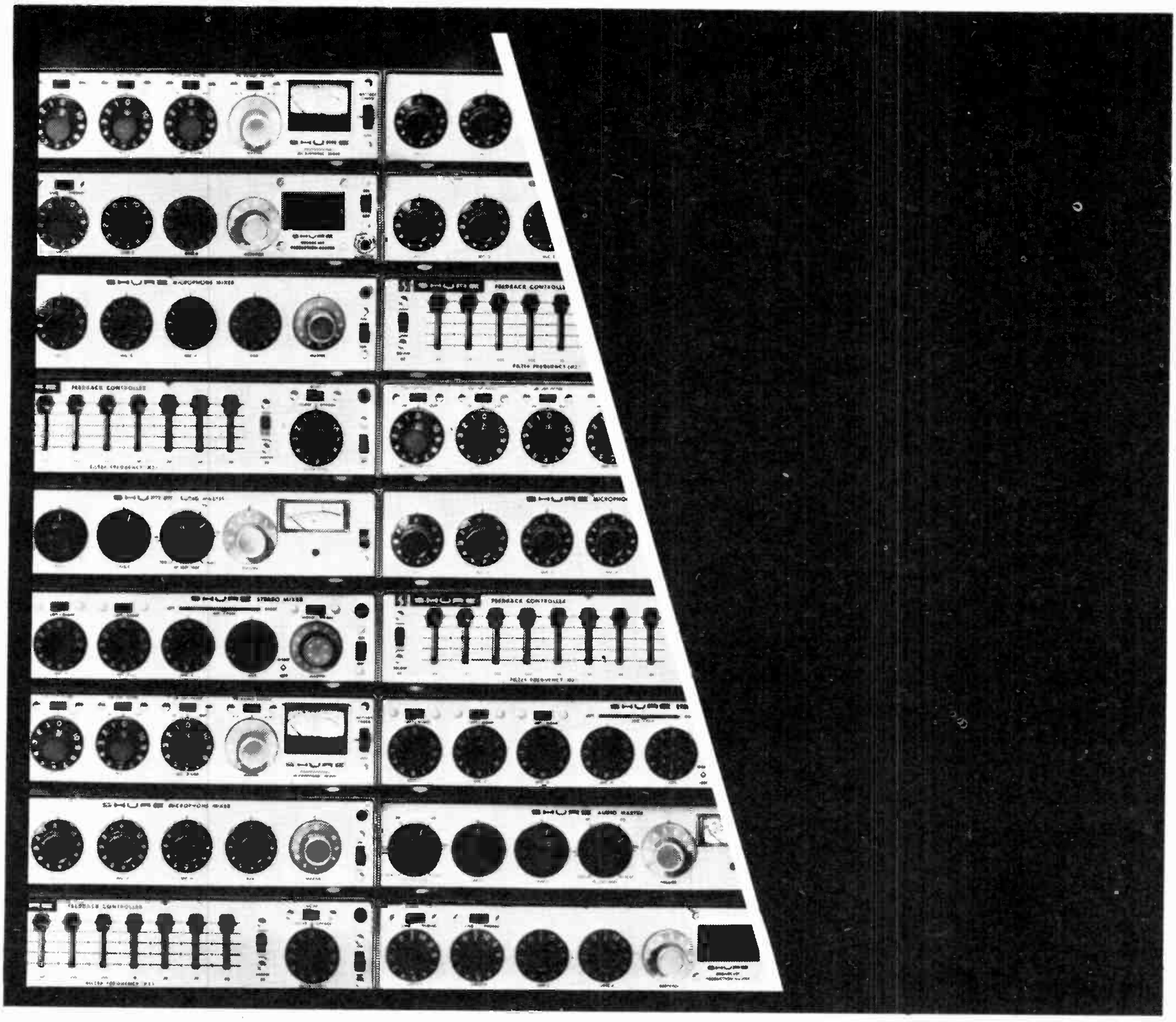

It's a mod. mod. modular world.

The fact is that all too few music lovers realise that while certain high fidelity components can be less than best, there is one component that cannot endure a sacrifice in quality: the cartridge. Because the hi-fi cartridge functions as the *source of sound* (the point at which the recording is linked with the balance of the hi-fi system), its role is absolutely critical. Just as the camera can be no better than its lens, the finest hi-fi system in the world cannot compensate for an inferior cartridge. Suggestion: For a startling insight into the role of the cartridge in the overall hi-fi system, and a breath-taking re-creation of your favourite recording, see your nearby Shure cartridge dealer. He'll introduce you to the Shure cartridge that is correct for your system and your exchequer. Or, next best, send for our brochure:

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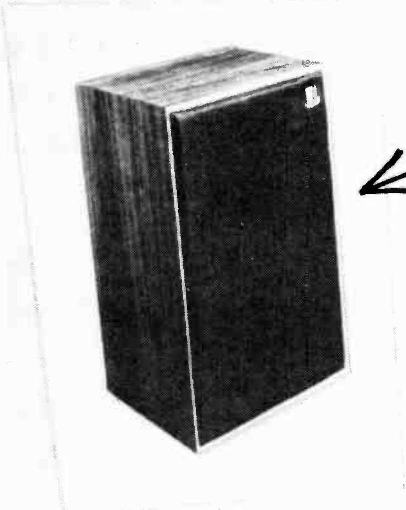
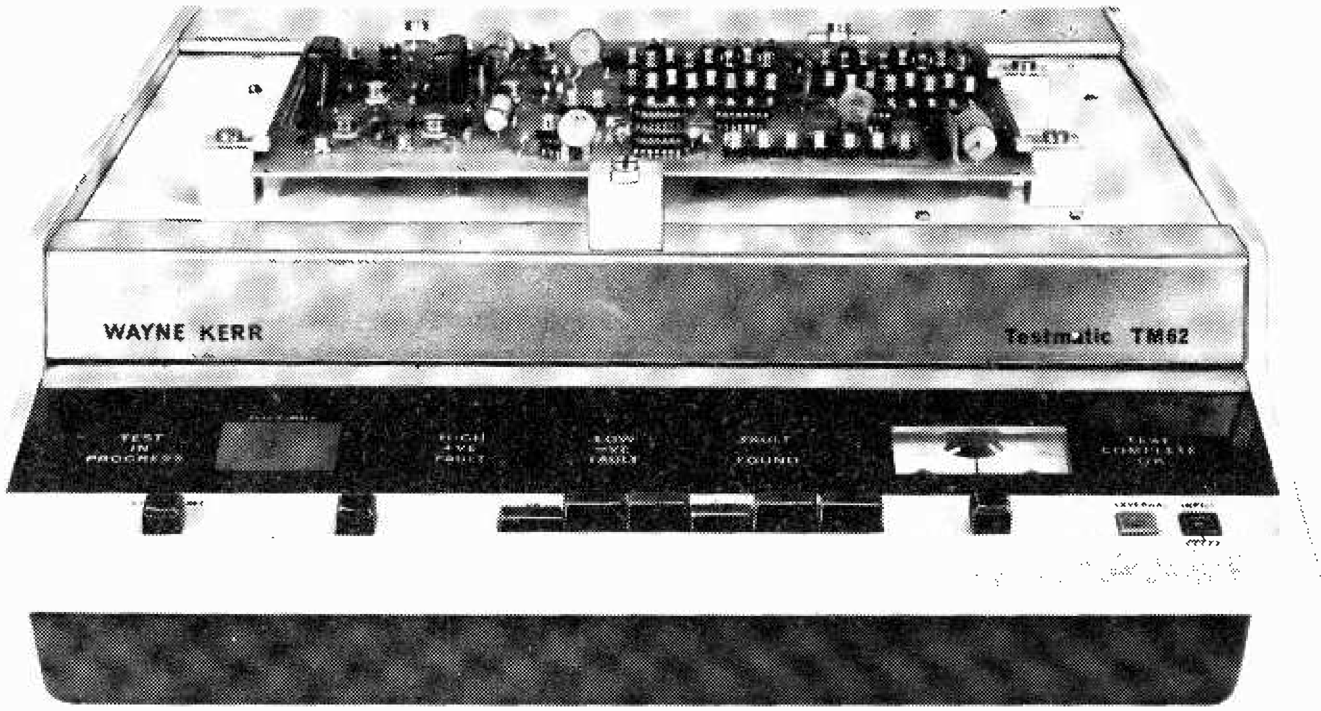
WW—095 FOR FURTHER DETAILS

WW—126 FOR FURTHER DETAILS



New Automatic P.C.B. Tester

Has 60-point electronic scan



Testmatic TM62, designed as a self-contained on-line test station, is a new addition to the Wayne Kerr range of low-cost automatic test equipment. Plug-in test panels can be changed-over in 5 seconds to suit different production lines. Operation is simple: assembly staff can check circuit boards as soon as each one is completed.

The TM62 increases productivity and saves valuable fault-finding time.

All this adds up to reduced costs through early fault detection.

For all the technical data, and further information on the TM62, please fill in the coupon, or phone Bognor Regis (02433) 25811. It could well be the first step in saving your company money.

WAYNE KERR
A member of the Wilmot Breeden group.

Please send me details of the TM62.

For the attention of Mr ________________

Company name and address ________________

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Post to Wayne Kerr, Durban Road, Bognor Regis, Sussex PO 22 9RL

WW/APR

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.

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.
Also available: Oryx safety stand.

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

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.

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.

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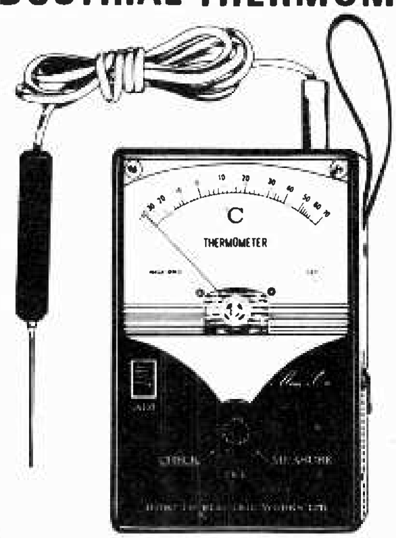

THE MODERN WAY TO MEASURE TEMPERATURE

A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop, Probe, and internal 1½ volt standard size battery.
Model "Mini-On 1" measures from − 40°C to + 70°C, price £17.50
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WW—094 FOR FURTHER DETAILS

Now suitable for U.K., European and American voltages...

Minimod, the versatile British made range of encapsulated power supplies first introduced in 1973, has now been extended to cover European and North American mains voltages (and is interchangeable with most American types). Normally available ex-stock, all units are fully stabilised with fold back current limiting – the 5V models have over voltage crowbar too!

STANDARD MODELS

Type Number	Output Voltage	Output Current Amps	Short Circuit Current mA (Typical)	% Regulation Line and Load (Typical)
PU01	5 ± 0.1	0.5	370	0.3
PU02	5 ± 0.1	1.0	770	0.5
PU03	15–0–15 ± 0.2	0.10	37	0.1
PU04	15–0–15 ± 0.2	0.20	84	0.1
PU05	12–0–12 ± 0.2	0.12	45	0.1
PU06	12–0–12 ± 0.2	0.24	120	0.2

Input voltage ranges 103 - 126V, 200 - 240V. 210 - 250V. Frequency 50 - 400 Hz all types.

Comprehensive specification given in brochure GT 29b which is available on request.

★SPECIAL DESIGN SERVICE

Custom built units for applications requiring different specifications are produced as part of our standard service. Try us first.

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RADFORD

AUDIO MEASURING INSTRUMENTS

LOW DISTORTION OSCILLATOR SERIES 3

A continuously variable frequency laboratory oscillator with a range 10Hz–100kHz, having virtually zero distortion over the audio frequency band with a fast settling time.

Specification:

Frequency range:	10Hz–100kHz (4 bands)
Output voltage:	10 volts r.m.s. max.
Output source resistance:	150 ohms unbalanced (optional 150 ohms unbalanced. plus 150/600 ohms balanced/floating)
Output attenuation:	0–100dB (eight. 10dB steps plus 0–20dB variable)
Output attenuation accuracy:	1%
Sine wave distortion:	Less than 0.002% 10Hz–10kHz (typically below noise of measuring instrument)
Square wave rise and fall time:	40/60 n.secs.
Monitor output meter:	Scaled 0–3, 0–10, and dBV.
Mains input:	110V/130V, 220V/240V
Size:	17" (43cm) × 7" (18cm) high × 8¾" (22cm) deep

Price: 150 ohms unbalanced output: £250
150/600 unbalanced/balanced floating output: £300

DISTORTION MEASURING SET, SERIES 3

(illustrated above)

A sensitive instrument with high input impedance for the measurement of total harmonic distortion. Designed for speedy and accurate use. Capable of measuring distortion products down to 0.001%. Direct reading from calibrated meter scale.

Specification:

Frequency range:	5Hz–50kHz (4 bands)
Distortion range (f.s.d.):	0.01%–100% (9 ranges)
Input voltage measurement range:	50mv–60V (3 ranges)
Input resistance:	47K ohms on all ranges
High pass filter:	12dB/octave below 500Hz
Power requirement:	2 × PP9, included.
Size:	17" (43cm) × 7" (18cm) high × 8¾" (22cm) deep
Price:	£200

Now available in reasonable delivery time

RADFORD LABORATORY INSTRUMENTS LIMITED

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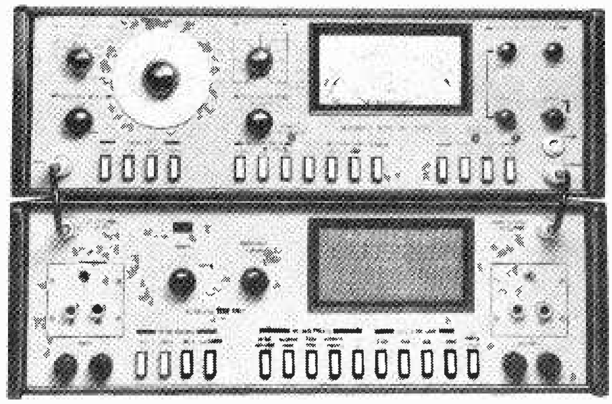
Audio Test Set



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. . . in one compact unit.

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ITT instrument services

ITT Instrument Services is a new concept in the supply of electronic instruments and power supplies based on the same business strategy as the already successful component distributor ITT Electronic Services. The service is aimed at providing a very broad based line of test equipment from various suppliers both in the U.K. and abroad with deliveries from stock.

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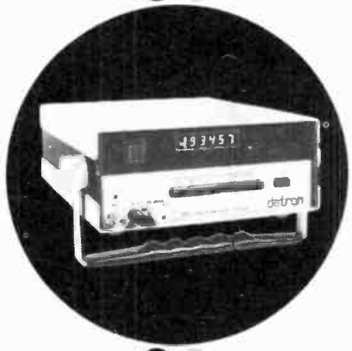

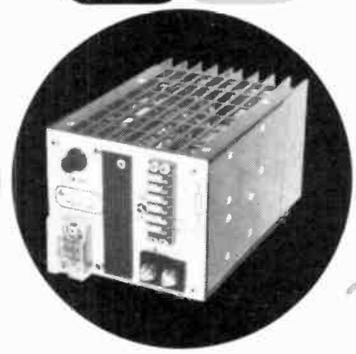

OSCILLOSCOPES

ANALOGUE MULTIMETERS

TESTERS

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Telex: 81146 (Sentercel Harlow)
Telephone: Harlow 29522

ITT instrument services

WW—197 FOR FURTHER DETAILS

Purpose-built servo and actuator systems using standard components

McLennan Engineering Ltd. have considerable experience in the solution of actuator and servo problems using synchronous, stepping and DC motor techniques, an important facet of our skill lying in purpose-designing around standard components for speed and economy.

The illustrations show a selection of modules from the standard range and include the new EM/ 100/100A servo drive system. All items are available individually or can be supplied engineered to custom-built systems.

1. EM 100/100A SERVO AMPLIFIER. A new addition to the range. A complete servo drive system including power supply which is eminently suitable for driving printed circuit motors and other servo motors up to 1/6 h.p. EM 100 - output ±24V, 4 amps continuous, 45 amps peak. EM 100A - output ±24V, 7 amps continuous, 75 amps peak.
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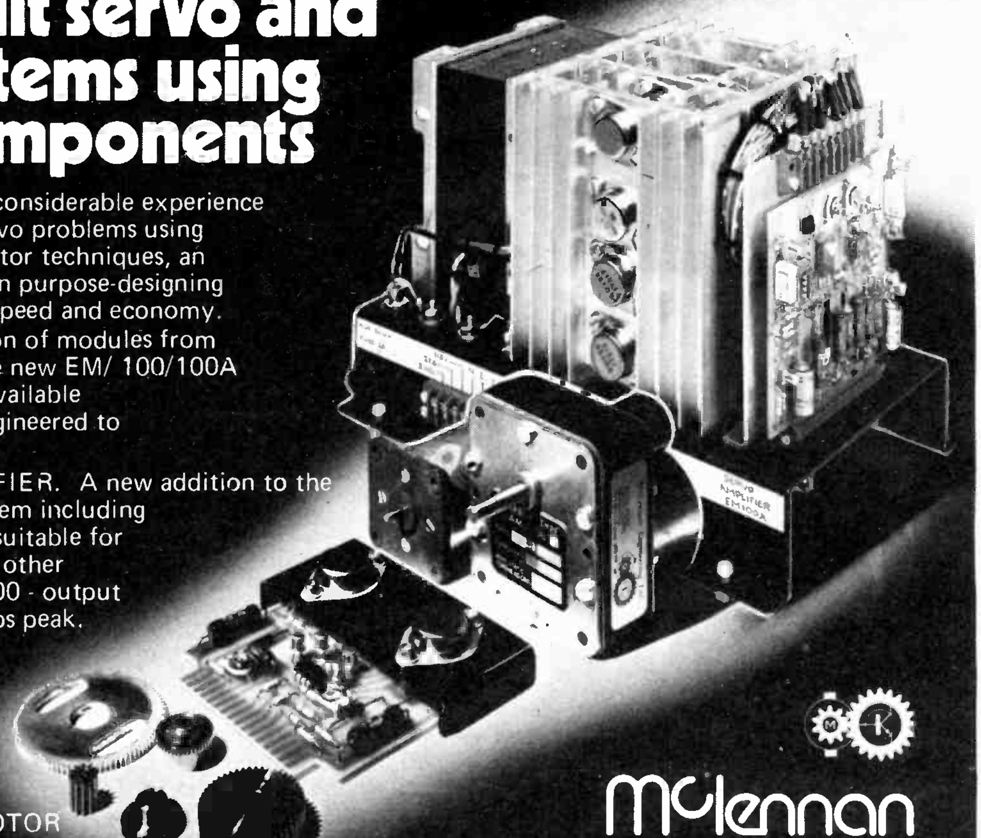
3. LOW INERTIA DC SERVO MOTOR Output 5W
4. CONTROL AMPLIFIER EM 40 Output ±15V 0.5 amp
5. TYPICAL PRECISION GEARS 120 to 32 DP



McLennan

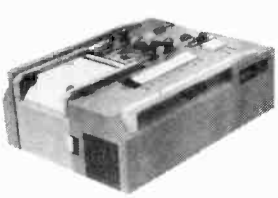
McLennan Engineering Ltd
Kings Road, Crowthorne, Berkshire.
Tel: Crowthorne 5757/8.

WW—106 FOR FURTHER DETAILS

STRIP CHART RECORDERS

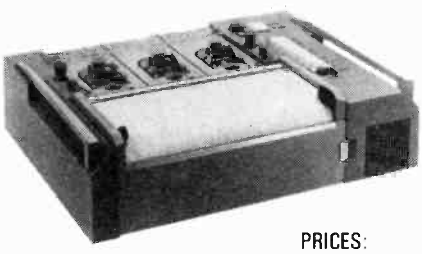
Made in USSR

Series H3020 Recorders



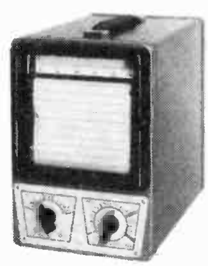
Sensitivity:	8mA F.S.D.
Speed of response:	5Hz
Chart width:	80mm per channel
Chart drive:	230–250V AC mains
Chart speeds:	0.1-0.2-0.5-1-2.5-12.5-25 mm/sec

Time and event marker pens fitted.



PRICES:
Single pen model H3020-1 **£80.00**
Three pen model H3020-3 **£130.00**

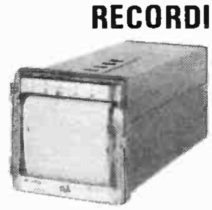
MULTI-RANGE UNIVERSAL PORTABLE AC/DC RECORDING VOLTAMMETER H390



Measurements ranges, AC/DC:	5-15-150-250-500mA, 1.5-5 Amps 5-15-150-250-500V
Accuracy:	1.5%DC, 2.5%AC
Chart width:	100mm
Chart drive:	220-250V AC mains
Chart speed:	20-60-180-600-1800-5400 mm/hour

PRICE: **£78.00**

SWITCHBOARD PATTERN MINIATURE RECORDING MILLIAMMETER H3100



Full scale deflection:	1mA DC
Accuracy:	2.5%
DC resistance of the coil:	18,100Ω
Chart width:	80mm
Chart drive:	220/250V AC mains
Chart speeds:	20-60-180-600-1800-5400 mm/hour

PRICE: **£44.00**

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Tel: 01-727 5641 **Telex: 261306**

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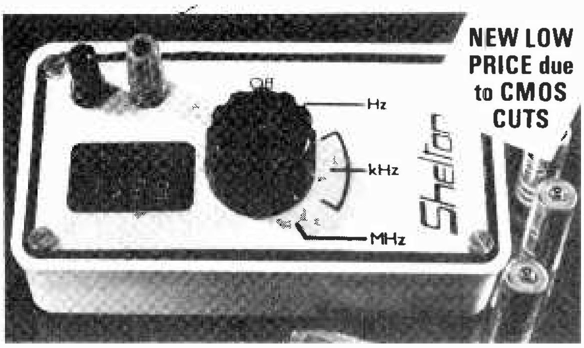
Latest technology miniature device uses four 0.3" LED digits to display frequency. 5 ranges with coupled decimal point give resolution of 0.1 Hz to 1 kHz in decade steps.

TAKES UP ALMOST NO BENCH SPACE.

NEW LOW PRICE. £67.50 inc p&p ex vat.

Mains PSU available which fits inside ready drilled case.



NEW LOW PRICE due to CMOS CUTS

MINIATURE BATTERY FREQUENCY METER FM-1

FOUR-DIGIT MEMORY DISPLAY
FIVE RANGES
4 ppm CRYSTAL
SIZE $6\frac{1}{4}$ x $3\frac{1}{4}$ x $2\frac{3}{4}$ in —including knob and terminals

* Also: FX-1 FREQUENCY MULTIPLIER (X 60, X 100) —see December W.W. **£29.50** *

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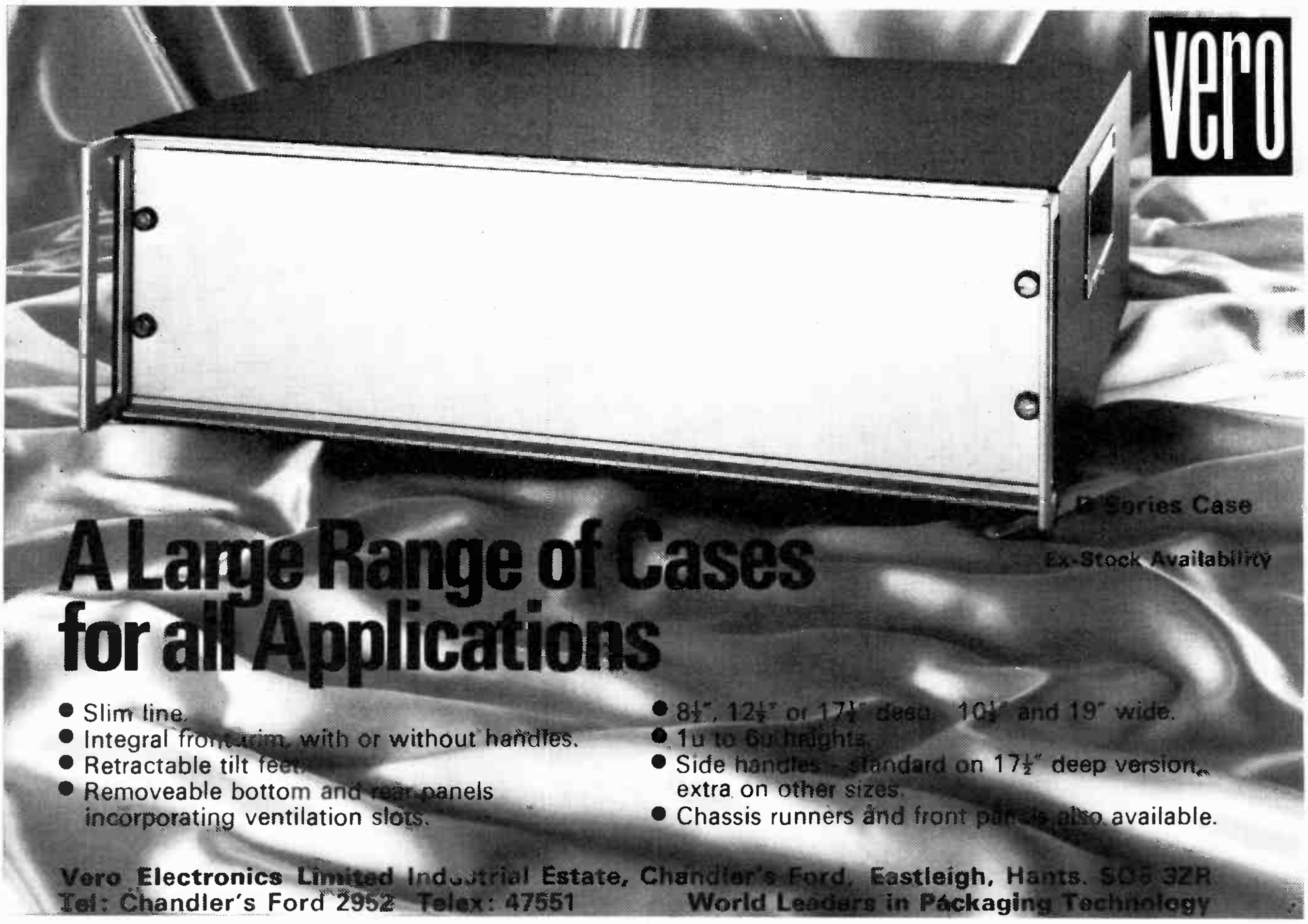

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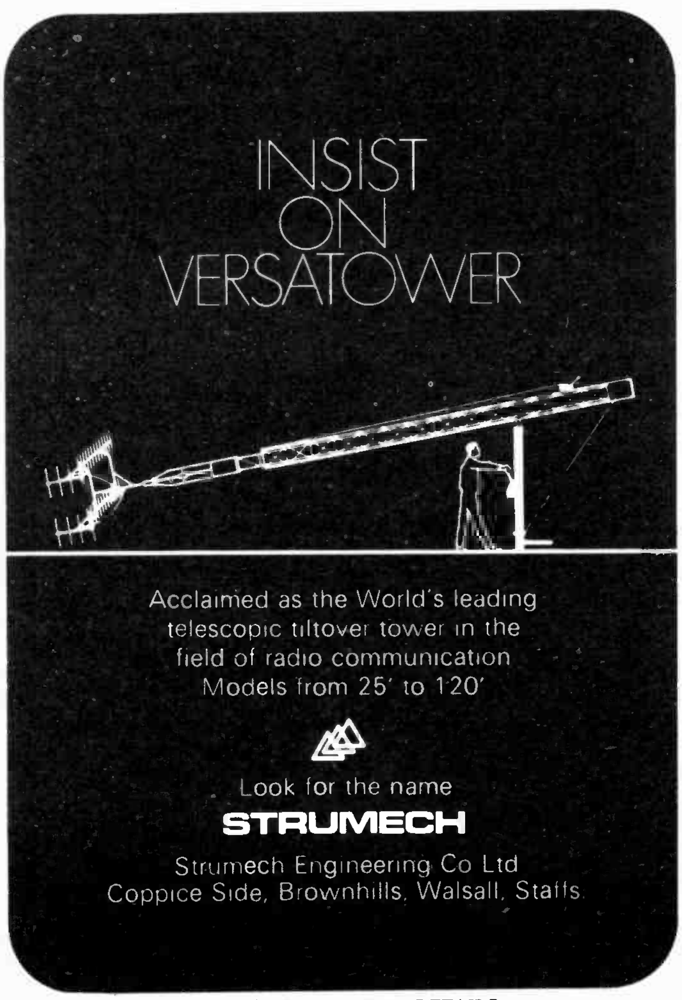

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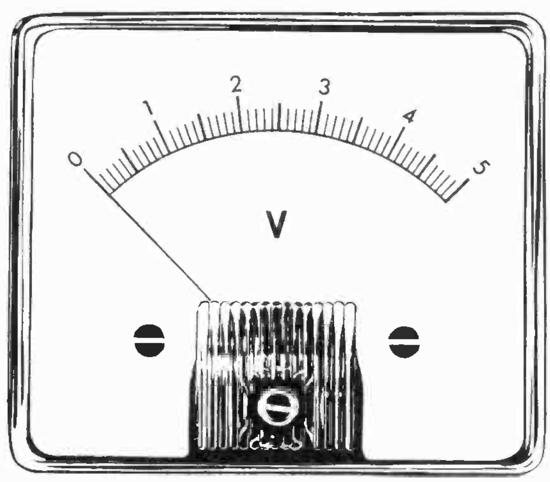
METER PROBLEMS?



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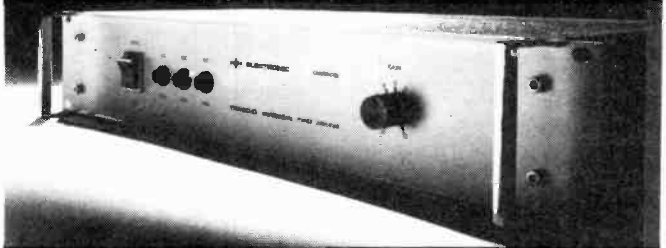
integrated circuit power amplifier



TPA 50 - D Specification

Power Output	100 watts rms into 4 ohms 65 watts rms into 15 ohms
Freq Response	±0·1dB 20Hz to 20KHz into 15 ohms. -1dB at 150KHz
Total harmonic distortion	Less than 0·04% at all levels up to 50 watts rms into 15 ohms
Input sensitivity	OdBm
Noise	-100dB
Rise time	2 u seconds
Price	£70 plus V.A.T.

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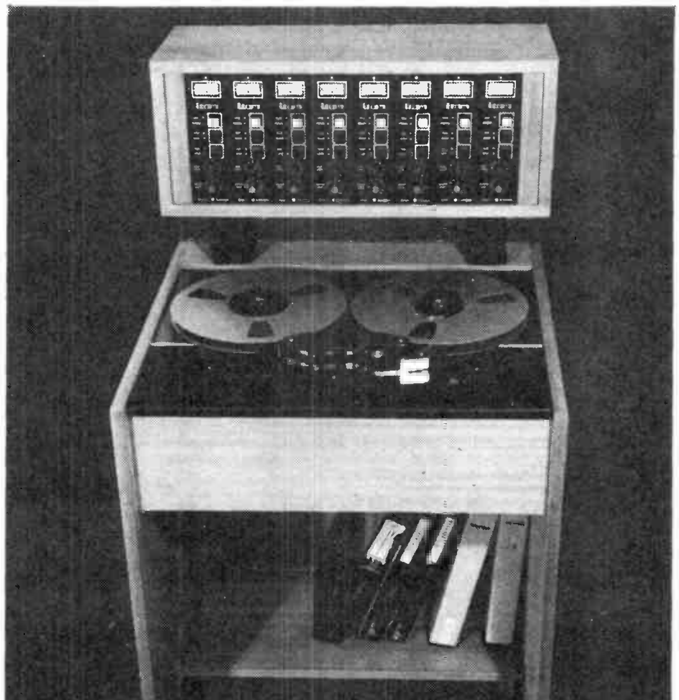
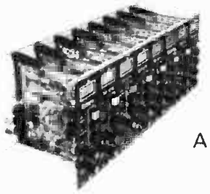
A revolution in the recording industry

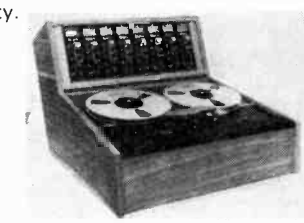


The Itam 805 8-track master recorder. £1790

Comprehensive facilities include sync on all channels, servo controlled capstan, modular electronics, variable speed (optional), relay solenoid operation.



Fully modular electronics using plug-in PCBs throughout. Separate sync and replay amps give identical levels. Switchable VUs with slow decay. Individual oscillator for each channel. Dolby A switching facility.



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itam

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Whiteley

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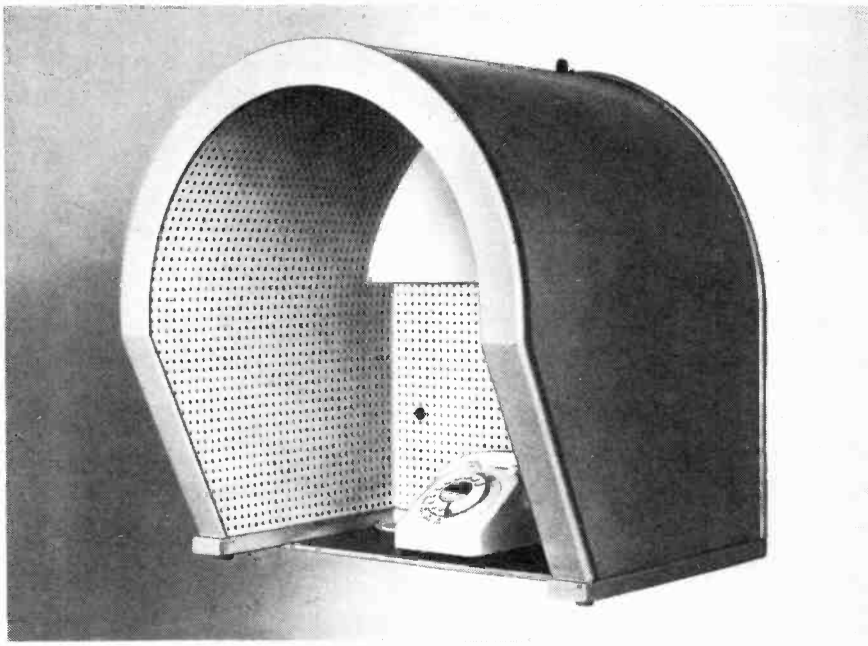

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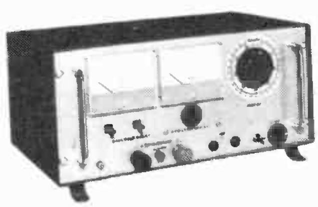

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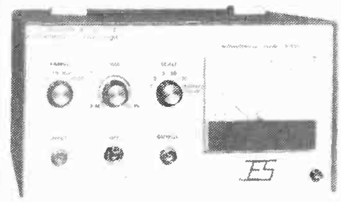

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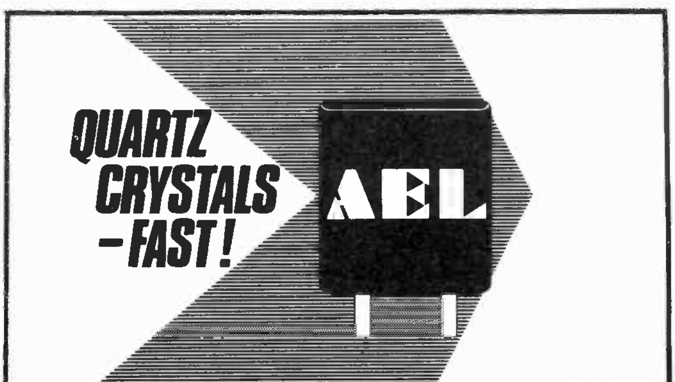

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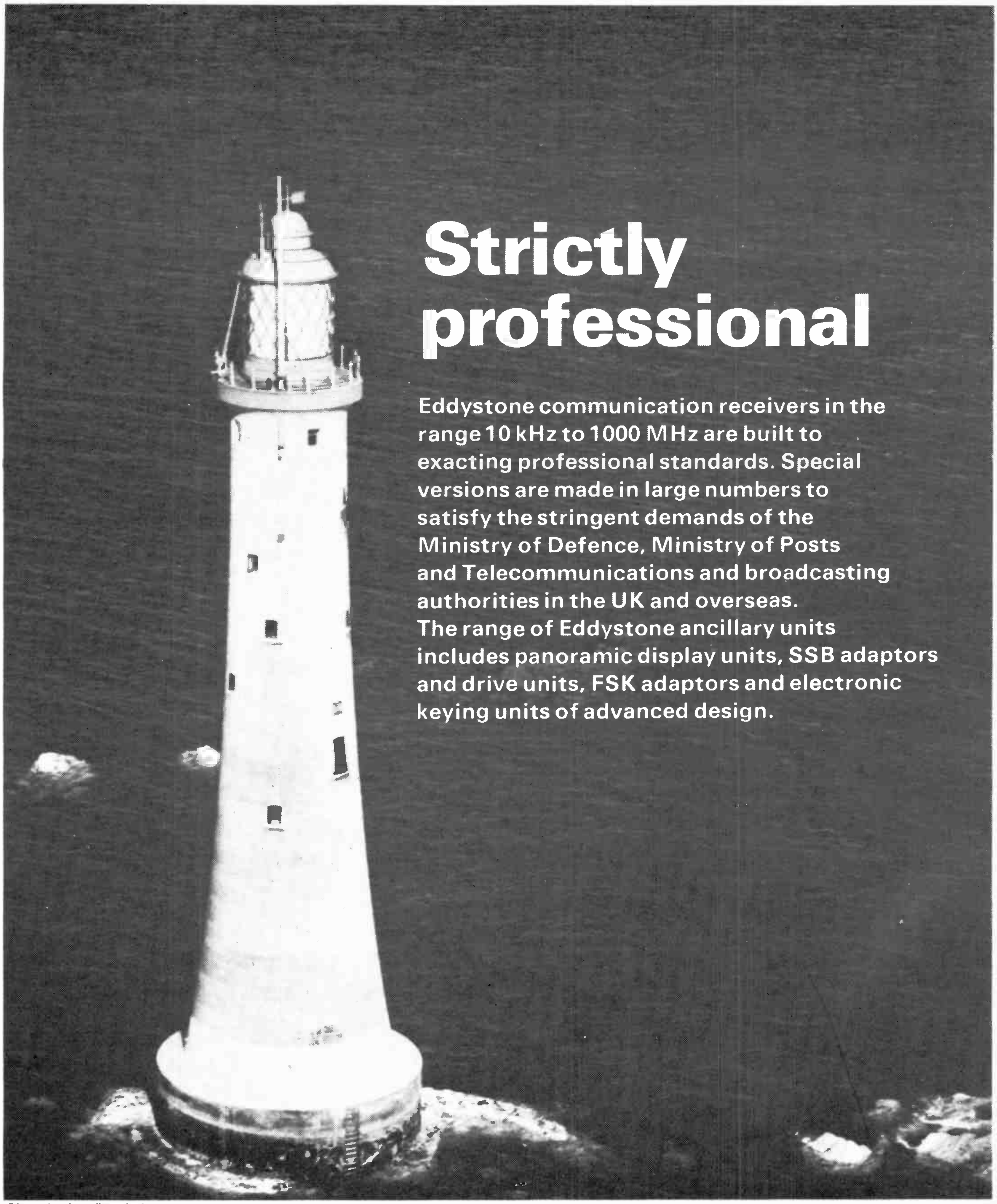

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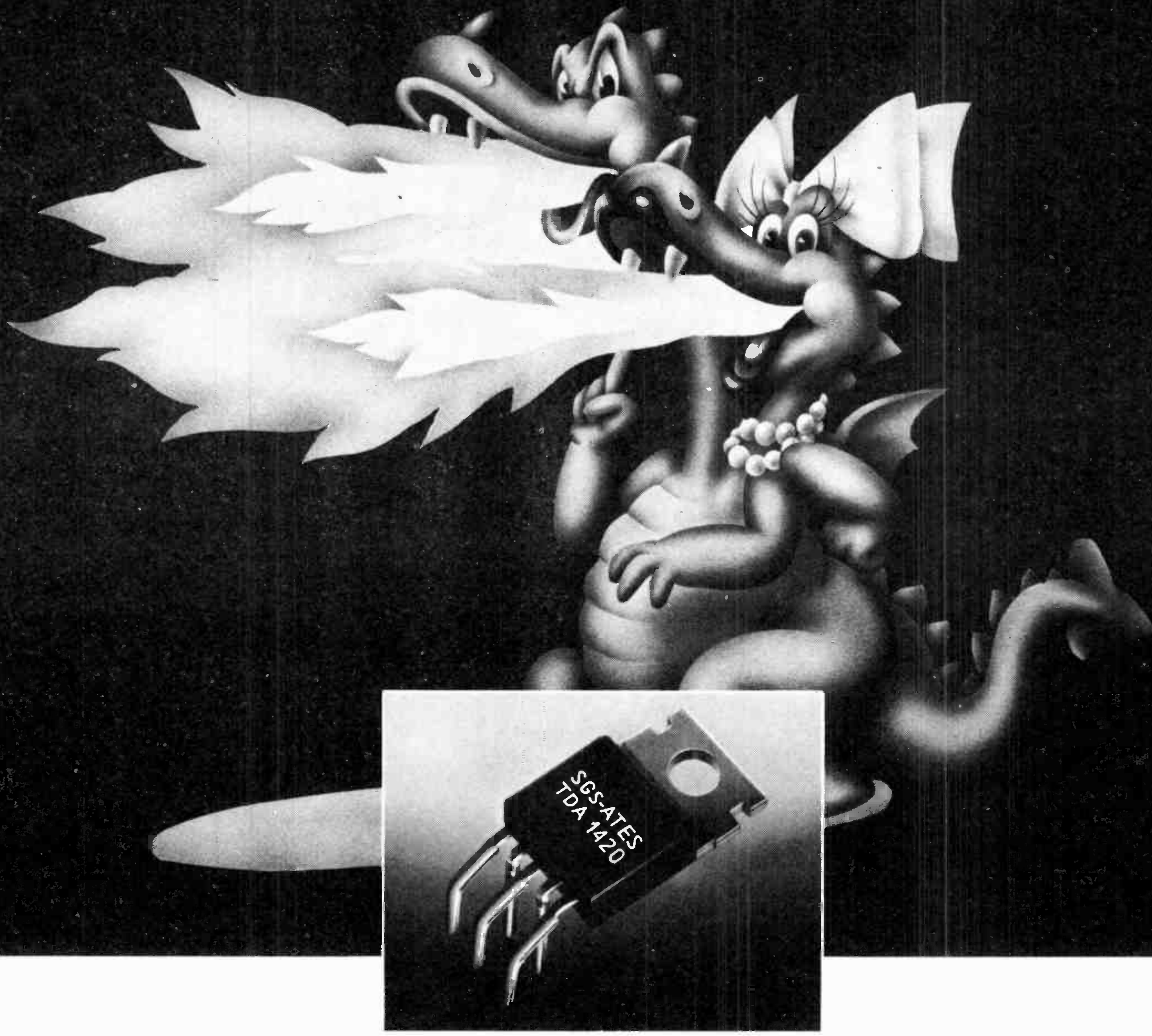
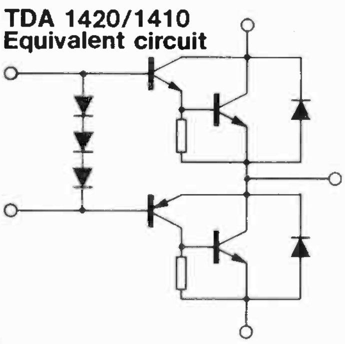


1 st monolithic complementary darlington pair

TDA 1420/1410
Equivalent circuit



The TDA 1420 integrates a quasi-complementary (NPN/PNP) darlington pair and biasing diodes for perfect electrothermal matching. Applications for this versatile power IC include DC or stepping motor drivers, op amp power boosters, audio output stages, etc.

All this in Pentawatt®, the rugged 5-pin plastic pack.

For lower voltages try the TDA 1410.

Key parameters	TDA 1420	TDA 1410
V_{CEO}	44 V	36 V
V_{CES}	60 V	50 V
I_C	3 A	3 A
P_{tot} @ $T_c \leq 60°C$	30 W	30 W

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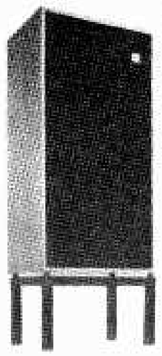

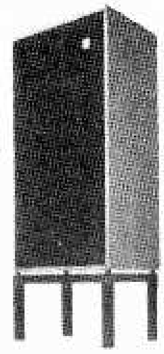

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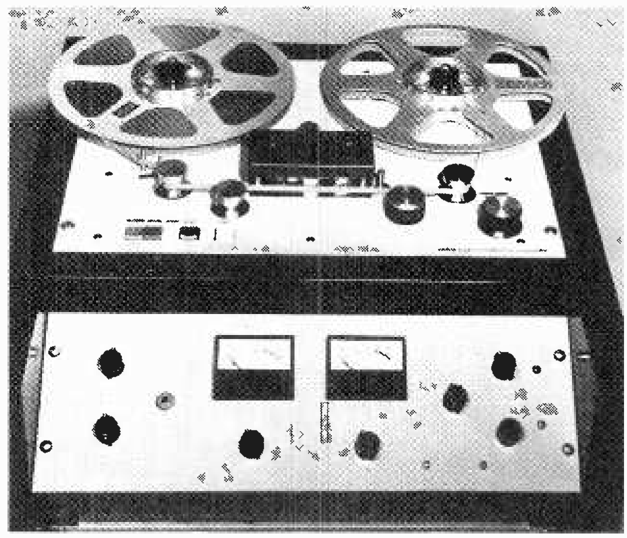

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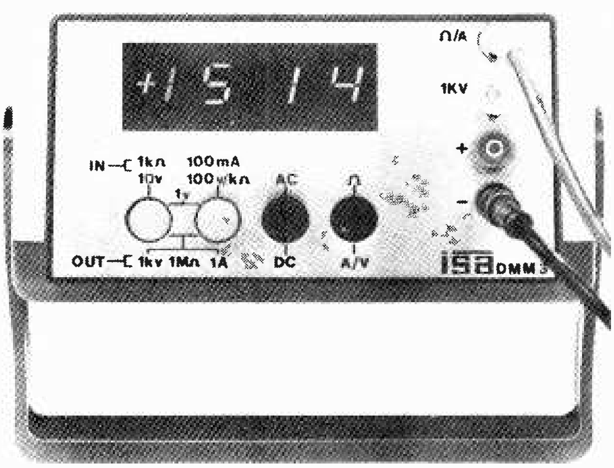
The ISA DMM3 dual polarity portable digital multimeter



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Size it up for yourself. For performance and value the new ISA DMM3 is just that little bit better. Easy touch buttons give 15 ranges in five functions: DC volts ± 2V — 20V — 200V — 2KV; AC volts 2V — 20V — 200V — 1KV <15KHz; AC-DC amps 200mA — 2A; Resistance 2K — 200K — 2M. The large 8mm LED display has a maximum reading of ± 1999 with automatic polarity indication on DC, with overload indication by the flashing of the most significant digit (1).

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With dual slope integration, high accuracy and resolution, the DMM3 runs on either four HP2-type (D cells) batteries giving up to 30 hours life, or four MN1300's (alkaline) giving up to 90 hours. Optional extras include mains power pack or rechargeable cells.

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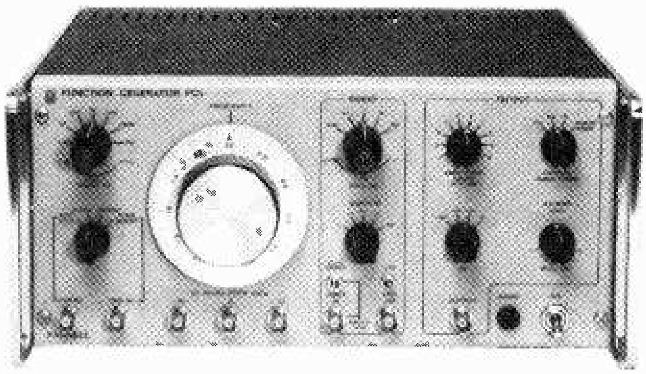

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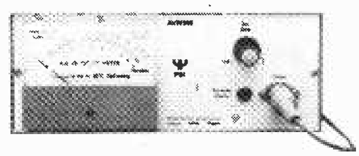

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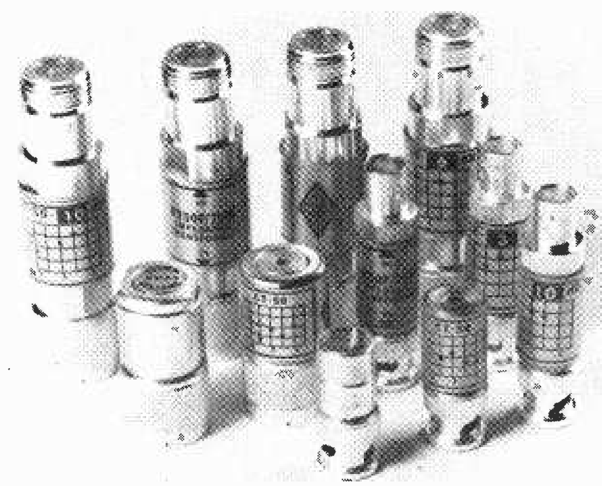

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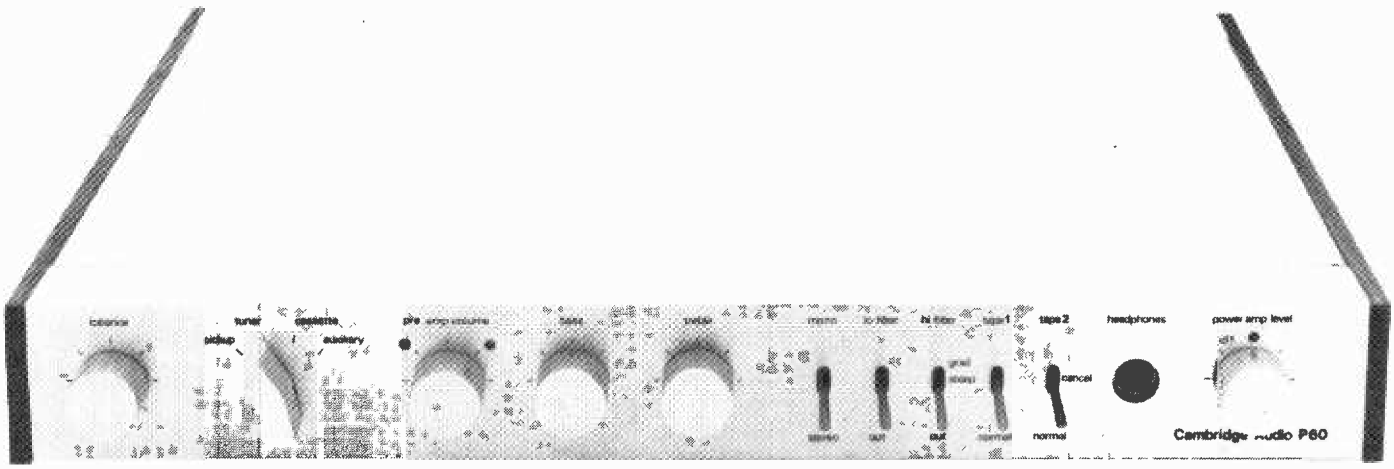

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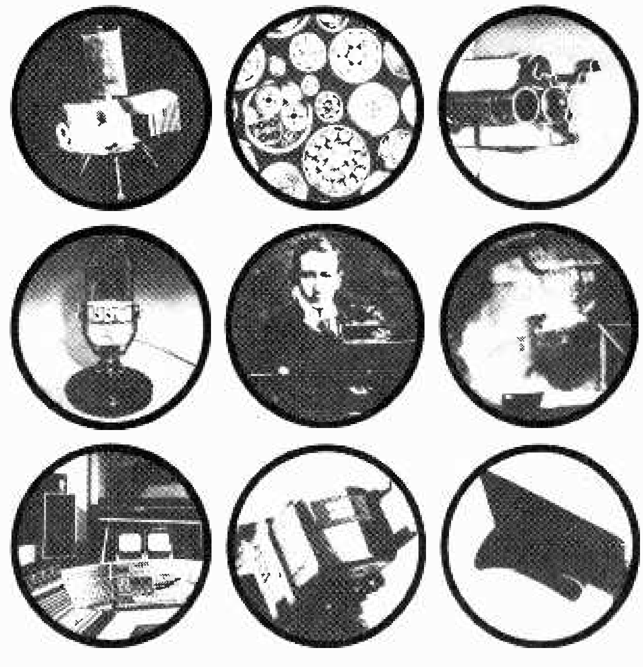

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1350 watts
DC-Coupled

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Driving shakers, and vibrators, motors, and difficult speaker systems, providing power for material or components testing, or used as a large distribution amplifier, the M600 is equally at home.

Brief specifications:

RMS power out	750 watts into 8 ohms 1,350 watts into 4 ohms
DC output	20 amps (supply fuse limited)
Power bandwidth	DC to 20 kHz +1 db, −0 db, 600 W into 8Ω
Phase response	+0 db, −15 db DC—20 kHz
Slew rate	16 V/μsecond
Damping factor (8Ω)	greater than 400 DC—1 kHz
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THD	less than 0.05% DC—20 kHz, 600 W into 8Ω
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APRIL 1975 Vol 81 No 1472

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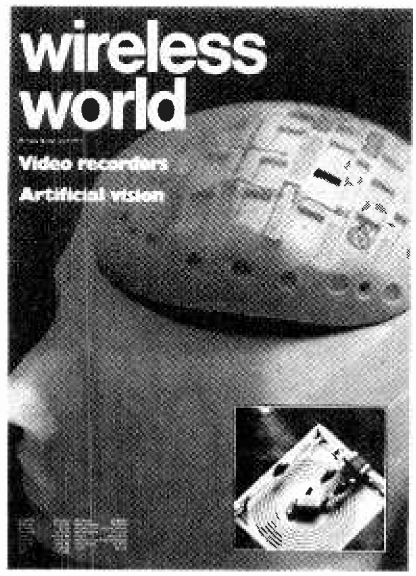

This month's cover picture, showing part of an uncompleted implant for the human head and a thick film implant receiver, made by Eric Sayer, introduces the article on artificial vision on p.156 of this issue. *(Photographer Paul Brierley)*

IN OUR NEXT ISSUE

Wireless World noise reducer
Constructional project based on the Dolby principle for which we are supplying a kit of parts (see page 173)

Build an oscilloscope
Professional standard design for home construction with 50MHz Y-amplifier bandwidth and extensive facilities

Display devices survey
Review of techniques used in alpha-numeric display devices and characteristics of types now on the market

Price 30p (Back numbers 50p)
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SIXTY-FIFTH YEAR
OF PUBLICATION

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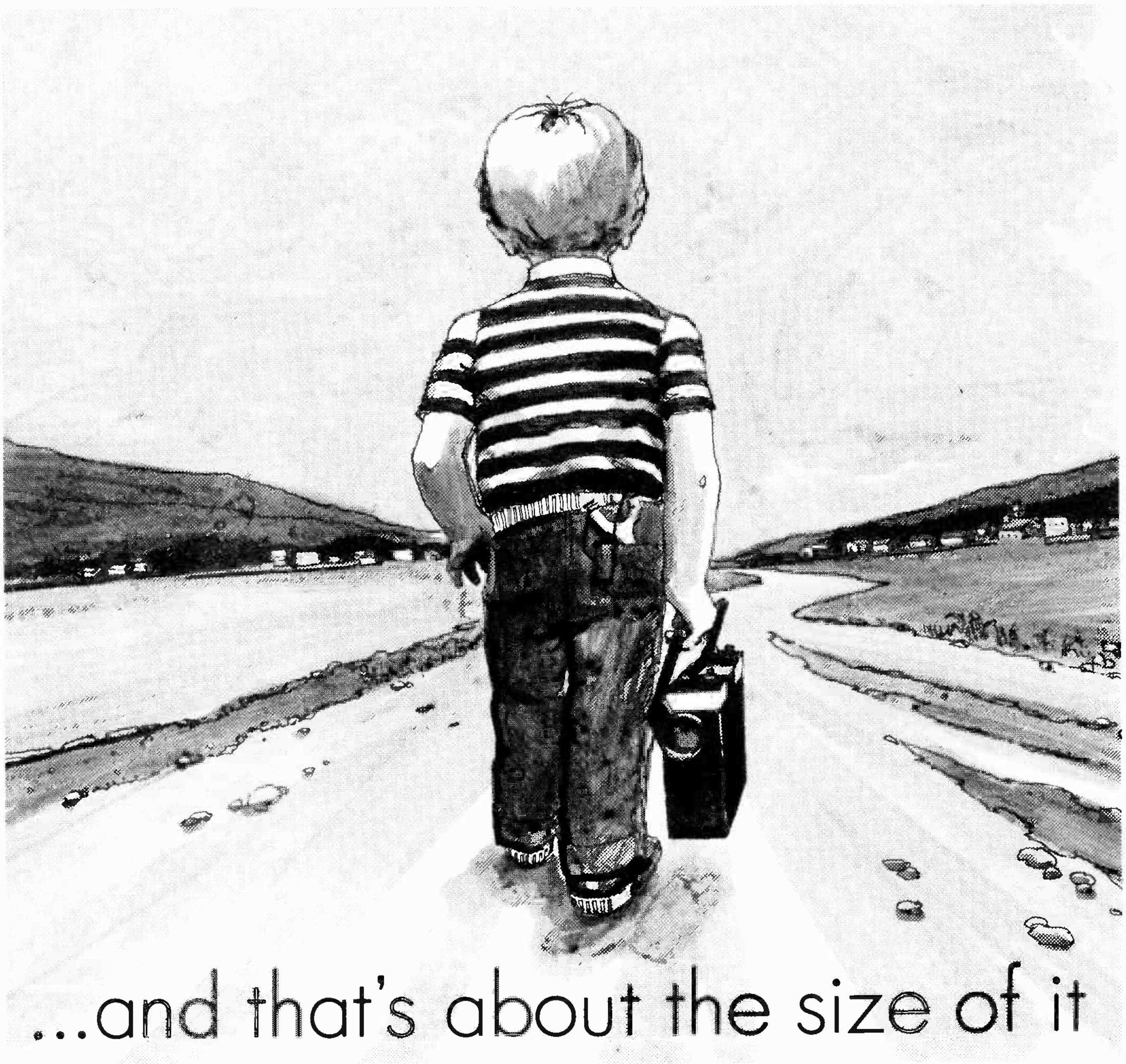
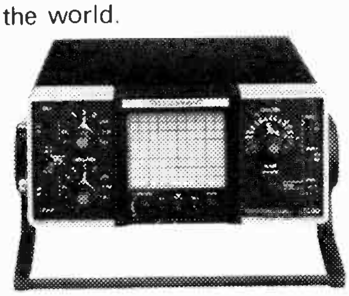
Telequipment's new dual trace 10 MHz battery operated oscilloscope



4 x 9 x 11 inches! Weight, less than 10lb!
Price, only £275*.

Small in all but specification, Telequipment pack into the tiny frame of the D32 features normally associated with instruments twice its size.

Easily carried on any assignment the D32 is probably the smallest and least expensive scope of its kind in the world.



*Exclusive of VAT

Priced at £275* (including re-chargeable batteries) this dual trace scope offers 10MHz bandwidth at 10mV/div sensitivity; automatic selection of chopped or alternate modes; automatic selection of TV line or frame displays; and the choice of battery or mains operation.

Size up the D32 for yourself and write or phone for a demonstration of this truly remarkable instrument now.

Telequipment gives you more scope for your budget

TELEQUIPMENT

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TQ14

wireless world

Outlook for cable television

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It's a pity that the cable television companies' experiments with local origination of programmes, at Bristol, Greenwich, Sheffield, Swindon and Wellingborough, have not proved very successful. Greenwich is virtually closed down (except for three hours at weekends when the station is run by outside volunteers), other stations are facing criticism about uninteresting programmes and some are doubtful whether they will be able to carry on after 1976. This may prove that the companies are not very good at producing programmes, that the type of material they are providing is not wanted or that they have insufficient finance from their private sources to produce the programmes they would like. It would be a pity, though, if this experience threw doubt on the whole principle of originating programmes locally and distributing them on cable, for this is what the cable television companies are well fitted technically to do, especially if in the future a large number of programmes and/or interactive information services is required.

Whereas in broadcasting the number of programmes that can be transmitted is limited by the amount of electromagnetic spectrum available, there is theoretically no limit, from an engineering point of view, to the number of programmes/information services that can be distributed by cable. In practice, judging from recent developments such as the "dial-a-programme" system and experimental work on using bundles of optical fibres for local distribution, it should be possible to bring 30–40 interactive channels into a household. The fact that programme material is originated locally does not mean that it has to be about local affairs, in the manner of a local newspaper. By analogy with the education service it can be material of general or national interest but with a "mix" adjusted to local circumstances and demand.

But now into this scene steps the Post Office with a claim that it should take over the whole of cable television. In its evidence to the Annan Committee on the future of broadcasting it says "The transmission of information is Post Office business . . ." and "If and when there is an increase in television broadcasting, leading to a wide-scale requirement for cable-TV networks, the Post Office is, we believe, the organization to provide such networks on a national basis to meet the demands both for enhanced television and for the broadening range of telecommunication services—voice, vision and data—that we foresee".

Of course the Post Office is the right organization to handle the large-scale transmission of information—probably by integrated digital systems in the future—on trunk routes between cities. And this rightly includes the long distance transmission of television signals. But this doesn't mean that the Post Office is necessarily the best organization to handle local distribution. It certainly has extensive plans but lacks the experience of the cable television companies (at present it provides networks in six new towns) and as a public corporation it does not have the spur of competition that gives a keen assessment of the market and often leads to valuable technical developments.

The cable companies have made a considerable investment in their networks. This is not to say they should necessarily be guaranteed a good return—after all it was a risk they took. But this is also a national investment and as such should be taken into account in any plans for the future.

Using ferrite pot-cores

Basic inductor design for the development engineer

by D. E. O'N. Waddington, M.I.E.R.E.

When, as a schoolboy, I became interested in radio, I blamed all my failures to persuade crystal sets to work on the coils. As I lived about 50 miles from the nearest transmitter which radiated a meagre 2kW, I now feel that this was a bit unjust to the coils. Nevertheless, coil design remained a bogey for many years. One of the main reasons was that so many variables are involved that the design is always complicated. To design a single layer coil with a specified inductance value, one has to assume diameter, winding length, wire diameter and winding pitch before starting on the calculation of the number of turns. The odds are that the first try will produce a ridiculous answer and it will probably be necessary to try several times before a practical result is achieved. Even at the end of all this, there will be a nagging doubt as to whether the result is correct or not! Multi-layer coils are even worse, if possible, as the dimensions predicted by theory are seldom realizable in practice. In fact the only method appears to be to take an "educated" guess at the coil design and to check by calculation. Thus it was with a great sense of relief that I learned to use ferrite pot cores. At last here was an inductor which could be designed (most of the time!).

I will start with a short description of the core material and manufacture. It is well known that placing a magnetic core inside a coil increases its self-inductance. However, the alternating magnetic field causes eddy currents to flow within the core absorbing energy from it and reducing the effective Q of the coil. This loss occurs mainly because of the low resistivity of the core material. It also increases with frequency. In transformers it is usual to reduce this loss by laminating the core material and insulating each lamination from its neighbour. The thinner the laminations, the lower the eddy current loss, and the higher the frequency to which the core may be operated. However, a practical limit is reached very quickly so that this technique, while giving a substantial improvement, does not provide the answer for radio-frequency coils.

One method of overcoming the limitations of laminations is to use a powdered iron dust core in which finely divided particles of iron, or other ferro-magnetic material, are suspended in an insulating medium and moulded into a core. This effectively insulates the particles from each other and reduces eddy current flow but, at the same time it reduces the effective permeability of the core to ten or less. Nevertheless, these iron dust cores are very useful at radio frequencies as not only do they increase the effective inductance of coils, but, when used in cup form, they tend to confine the magnetic fields within the coil, providing a measure of screening. For high frequency work iron dust cores are superior to ferrites both in performance and cost. The design methods which I will be describing can also be applied to iron dust cores.

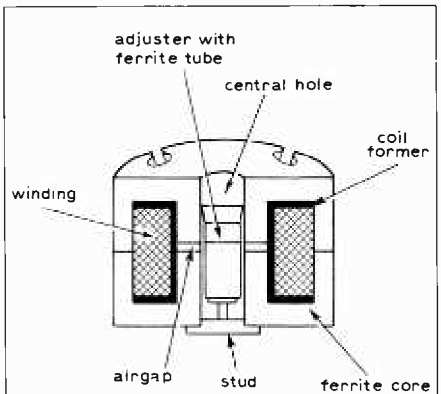

Fig. 1. Cross section of a typical pot cure.

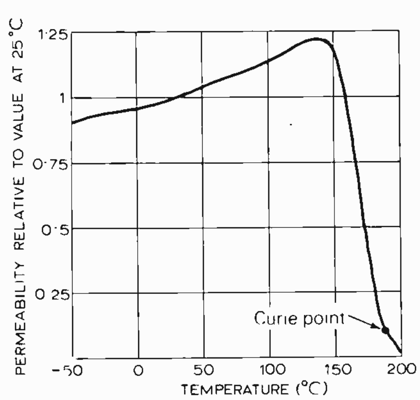

Fig. 2. Variation of permeability with temperature for a low-frequency ferrite material.

Unlike iron dust cores, ferrite cores are primarily made of non-conducting materials, which belong to the family of ferrites. The ferrites are non-metallic refractory materials composed of the oxides of iron and other metals, usually cobalt, copper, manganese, magnesium, nickel or zinc. The most important ferrites for pot cores are manganese zinc and nickel zinc-ferrite[1]. In manufacture the correct proportions of the relevant oxides are milled together so that they are thoroughly mixed. They are then moulded into the desired shape in a press and fired at a temperature in the range from 1000°C to 1300°C. During this process chemical reactions occur and when the resultant cores are cooled to room temperature, they are hard and brittle. This firing or sintering process is a very critical one as the properties of the finished core depend largely upon the precise firing temperature and the time for which it is "cooked". The cores shrink appreciably (between 20 and 25%) during the firing process and, as the ferrite is very hard to machine, it is also essential that the density of the moulded core must be correct before firing as subsequent adjustment would be very costly. The cores used for inductors are said to be "soft". In this context soft means that the core does not remain magnetized to any appreciable extent after a magnetizing field has been applied. This is analogous to "soft" iron cores recommended in text books for electric bells, etcetera.

For use in inductors, the cores are usually made in the form of cups as shown in Fig. 1. The mating surfaces are ground smooth and polished so that the air gap is reduced to a minimum. The effective permeability of the basic core material will be of the order of 2000 for low frequency ferrites, reducing to 100 for high frequencies. This basic permeability is very sensitive to temperature variations, the degree of sensitivity depending upon the composition of the ferrite. Normally the permeability increases fairly steadily with temperature until it suddenly falls off very rapidly to the Curie point (see Fig. 2). Curie point is generally defined as the temperature at which the permeability has fallen to 10% of its maximum value and lies in the range from 150 to 200°C for most ferrites although some ferrites have Curie points as high as 500°C. For inductors, the cores are usually modified by grinding the centre spigot so that there is an air gap in the magnetic path. The working permeability of the finished core depends upon the length of this gap which also confers two very desirable properties. Firstly, the temperature coefficient is greatly reduced and now depends to a greater degree upon the physical dimensions of the core. Thus it is possible to specify the temperature coefficients of various cores with fair accuracy. Secondly, by adjusting the position of a ferrite slug so that it "bridges" the air gap, it is possible to adjust the working permeability of the core and hence the inductance of a coil wound on it. As would be expected, cores with small gaps (high permeability) have less adjustment range than those with large gaps although neither has a very large range (5% to 25%). In early cores, the adjuster was not a built-in feature and it was necessary for the user to grind the core himself to adjust the inductance. This was done by rubbing the core on fine emery paper taking great care to keep the surfaces flat. I mention this method as it still has its uses when an inductor is just out of the adjuster range. However I would not recommend its use as cores are easily cracked by the overheating which can be produced by too vigorous rubbing. For repeatable and stable performance, it is essential that the two halves of the core are adequately clamped together. Most manufacturers supply excellent clamping systems although gluing, with Araldite for example, is a very effective assembly method. Cores are usually made in matched pairs so it is best to keep them in pairs. Sorting is both tedious and frustrating.

Core losses

The losses which occur in ferrite cores are of three main types; hysteresis, eddy-current and residual.

Hysteresis loss. This is usually very small compared with the other losses and, at low drive levels, it may be ignored. At high signal levels, however, it can contribute an undesirable effect in the form of non-linear distortion, mainly third order. The degree of distortion depends upon the flux density and can be predicted by calculation[1]. Normally this effect is of little significance but, in some audio applications, it may become important. The cure is

Abac to determine number of turns from core data

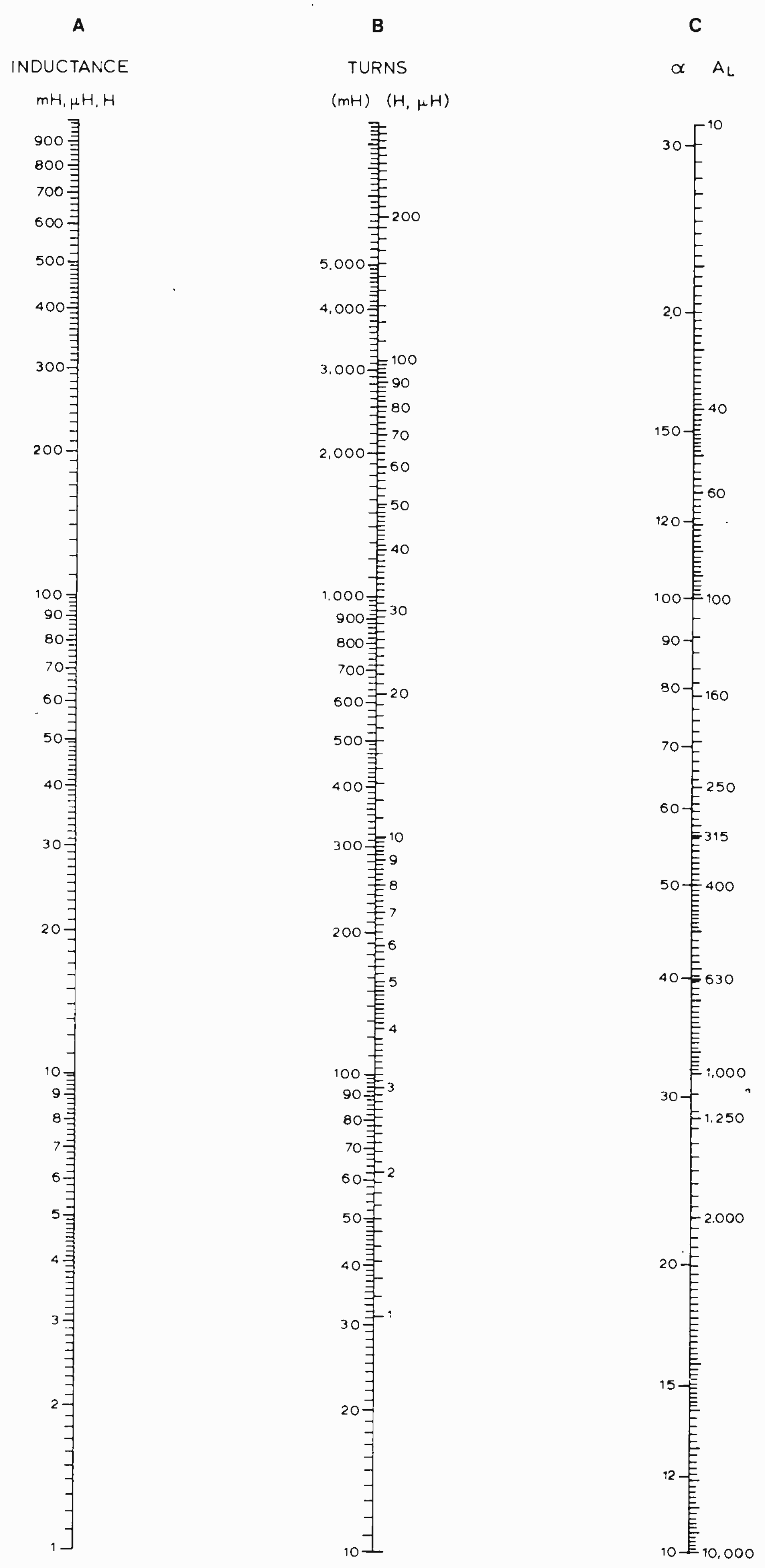

Fig. 3. To work out the number of turns required to give a specified inductance value, lay a ruler across the abac connecting the required inductance (on scale A) with the A_L or α (on scale C) of the core used. The number of turns is read from scale B.
Note. For micro-henries use the right-hand calibration of scales A and B. For milli-henries use the left-hand calibration of scales A and B. For henries use the same scales as for micro-henries but multiply the number of turns by 1000.

either to run the core at a lower level or to use a larger core (which amounts to the same thing!).

Eddy-current loss. This depends mainly on the resistivity of the core material. Thus, in most ferrites this loss is small so that it is normally lumped in with the residual losses. There are exceptions where the eddy-current losses "resonate" with the dimensions of the core at high frequencies[2]. The discussion of them, however, is beyond the scope of this article.

Residual losses. These depend upon the composition of the ferrite and will vary with the different grades. These losses are frequency dependent, usually increasing relatively slowly up to a "critical" frequency after which they increase drastically. Thus the grade of ferrite determines the high frequency operating limit.

Coil losses

These are far more severe than in air-cored coils because, in addition to skin effect, there are eddy-current losses in the conductors caused by proximity effects. This means that the Q of the inductor will also depend upon the type of wire used as well as the core losses. In general, solid conductors give a maximum Q at a very much lower frequency than that for maximum Q with stranded wire and the Q will also be lower. One manufacturer quotes the following:—

Solid wire $Q_{max} = 200$ at 20kHz (10–100mH)
Stranded .06mm $Q_{max} = 600$ at 150kHz (.2–1mH)
Stranded .04mm $Q_{max} = 700$ at 200kHz (.2–1mH

This information is usually included in the manufacturers' data books in the form of typical ISO–Q curves although it is sometimes in tabular form. The word "typical" seems to have the meaning ascribed to it by a cynical engineer; namely "It has actually been achieved once!" In all fairness, however, the quoted Q can be attained under ideal conditions with all details fully under control. However, even if the final Q is less than that predicted, it should be far higher than could have been obtained using an air-cored coil and, of course, the dimensions of the coil will be considerably smaller.

Inductor design

The calculation of the number of turns necessary to achieve a particular inductance value is very easy as manufacturers quote either A_L (induction factor) or α (turns factor). These can be defined as follows:—

A_L (induction factor)—The self-inductance, in nano-henries, that a coil wound on the core should have if it consisted of a single turn.

$$A_L = \frac{L}{N^2} \text{ or } N = \sqrt{\frac{L}{A_L}}$$

L is in nano-henries
N is the number of turns.

The term α (sometimes C or K) is the turns factor or the number of turns required for a coil wound on the core to give an inductance of 1 milli-henry.

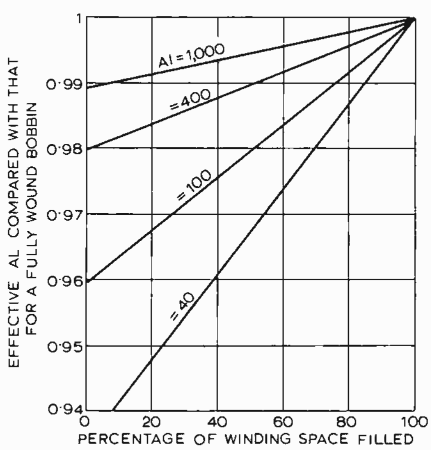

Fig. 4. This family of curves shows how the induction factor varies with the "fullness" of the available winding space for an 18mm pot core. Other core sizes will exhibit similar variations.

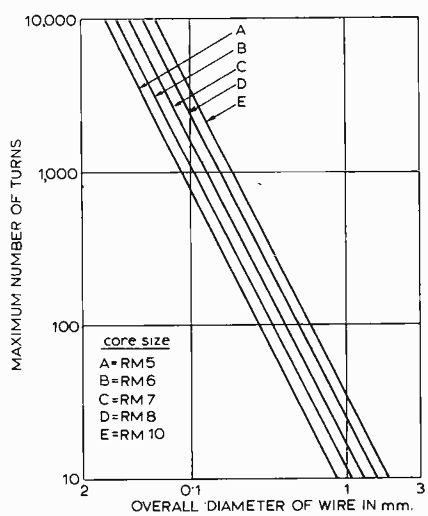

Fig. 5(a). These curves apply to round cores conforming to B.S.4061 range 2 or I.E.C. Pub.133.

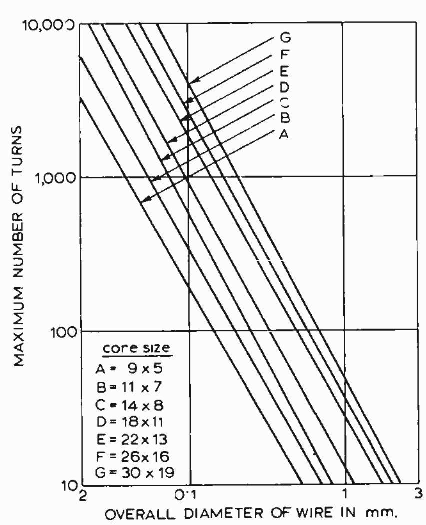

Fig. 5(b). These curves apply to R.M. (rectangular module) cores.

$$\alpha = \frac{N}{\sqrt{L}} \text{ or } N = \alpha\sqrt{L}$$

L is in milli-henries
N is the number of turns

e.g., required—a 9mH inductor. The core selected has an A_L of 400 or α of 50. $N = \sqrt{9 \times 10^6/400} = 3 \times 10^3/20 = 150$ turns or $N = 50 \times \sqrt{9} = 50 \times 3 = 150$ turns

The abac shown in Fig. 3 provides a simple alternative method of determining the number of turns. Lay a ruler across the abac connecting the A_L or α on the right-hand scale with the required inductance value on the left-hand scale and read the number of turns from the centre scale.

Normally the winding factors given in the manufacturer's data will refer to a coil wound so that it fills a predetermined percentage of the winding space and it may be necessary to adjust the number of turns slightly depending upon whether the bobbin is fuller or emptier. Fig. 3 shows the sort of variations which can be expected with a typical core. In general it will be seen that, with high permeability (i.e., "small gap"), the degree of "fullness" of the bobbin has very little effect upon the turns factor. On the other hand, lower permeability cores (i.e., "large gap"), are more affected by the "fullness". This effect is caused by fringing of the magnetic field in the gap. It is good practice however to choose a wire gauge which fills the winding space as completely as possible. This gives the lowest d.c. resistance together with the highest Q value. Most core manufacturers give tables or charts showing the numbers of turns which will fill the various bobbins. Now that there has been a degree of standardization of core sizes (British Standard B.S.4061 range 2 and International I.E.C. Pub.133) it has been possible to prepare some winding charts which have fairly universal application. Fig. 5(a) shows winding data for the round cores and Fig.5(b) gives data for r.m. (rectangular module) cores. The numbers of turns which should fit the cores are nominal so that it is generally safer to use a slightly thinner gauge than suggested by the chart.

I feel that a word of warning is necessary here. As George Orwell says, "All animals are equal but some are more equal than others." This comment could well be applied to ferrite pot cores. So far the standardization only goes as far as specifying the dimensions of the cores and formers and A_L. Nothing is said of clamping systems, termination methods or adjusters so far as I know. At least, if it is specified, it is frequently ignored. In general British manufacturers produce reasonably compatible systems but the same cannot be said for all the imported products. This means that it is necessary to study alternative core types very carefully before accepting them as equivalents.

Earlier in this article I referred to the temperature coefficient of the permeability. Obviously this will affect the stability of the finished inductor. In practice there are one or two more points to be watched if the best stability is to be obtained. Movement of the coil in the core will change the inductance slightly so the coil should be locked in position. Similarly movement of the individual turns of the coil can also introduce instability. This makes it desirable to impregnate the coil. Actually, if moisture penetrates the coil it can degrade the Q so there is a second reason for impregnation.

If the impregnation is carried out with the coil fitted to the core care must be taken that the adjuster system is kept clear. While moisture does not affect the permeability of the basic core to any measurable extent, it can affect the adjuster system so that it is wise to check this point. Personally I have found that the adjusters which consist of a ferrite tube fitted on a plastic sleeve with a hole up their centres to screw onto a brass screw are the best. A further point to watch is a phenomenon known as "disaccommodation". This is a temporary change in permeability which occurs if the core is subjected to a thermal or mechanical shock. However, provided that final adjustment of the inductance is not carried out until 24 hours after the shock, this effect should not prove troublesome.

In conclusion I would like to thank Mullard Ltd for permission to reproduce illustrations of their cores and graphs.

References

1. Snelling, E. C. "Soft ferrites, properties and applications", Butterworths, London 1969.
2. Mullard Ferroxcube. Mullard Components Division, May 1955.

Sixty Years Ago

In 1915, spy scares were getting well into their stride and the still-new invention of "wireless" was fuel to the fire. Suitcase transmitters were still in the future, however, and it seems that people's imaginations tended to become a little over-heated. A note in our April 1915 issue commented: "Mr Charles R. Gibson has been contributing long articles recently to the *Glasgow Herald* on the present use of wireless by the belligerents, and in the course of one of them tells an amusing story which, according to the writer, was repeated to him with portentous seriousness as an incident of the greatest gravity which had recently come under the narrator's personal observation:

'Two German workmen had been arrested as spies, and there had been discovered, hidden beneath the hearthstone of the kitchen in their two-roomed tenement house, a complete wireless installation capable of transmitting messages to Berlin.'

Mr Gibson comments that it is possible to send wireless messages as far as from here to Berlin, but not with apparatus that can be stowed away beneath a kitchen hearthstone, or even contained in a large room."

Meetings

LONDON

7th. IEE—"Mechanical shock protection in the design of electrical equipment" by L. A. Ward at 17.30 at Savoy Pl., WC2.

8th. IEE—Discussion on "Microprocessors versus programmable logic arrays" at 17.30 at Savoy Pl., WC2.

9th. IERE—Colloquium on "Radar and associated systems for vehicle guidance" at 14.00 at 9 Bedford Sq., WC1.

9th. IEE—Discussion on "Is there a future for pointer instruments?" opened by G. D. H. Keen, Dr R. B. D. Knight and A. H. Silcocks at 17.30 at Savoy Pl., WC2.

10th. IERE/IEE—Colloquium on "Computers in transport" at 10.00 at 9 Bedford Sq., WC1.

10th. IEE—"The work of the House of Commons Select Committee on Science and Technology" by Airey Neave followed by discussion at 17.30 at Savoy Pl., WC2.

10th. RST—The Fleming Memorial lecture "Television: parliament and the people" at 19.00 at the Royal Institution, Albemarle St., W1.

11th. IEE—Colloquium on "Spectrum allocation management and engineering in radio communication" at 10.00 at Savoy Pl., WC2.

11th. IEE—Colloquium on "Innovatory ideas in energy generation and conversion" at 10.30 at Savoy Pl., WC2.

14th. IEE—Colloquium on "Electronic counter measures—components and systems" at 10.30 at Savoy Pl., WC2.

15th. IEE—"Replaceable control systems" by B. Welch at 17.30 at Savoy Pl., WC2.

15th. AES—"Speech perception and speech synthesis" by D. B. Fry at 19.15 at the IEE, Savoy Pl., WC2.

16th. IEE—Colloquium on "Hardware and software aspects of parallel processors" at 11.00 at Savoy Pl., WC2.

16th. BKSTS—"Portable power systems for cinematography" by V. F. Saunders, R. W. Scarr and F. R. Cloke at 19.30 at Thames Television Theatre, 308–316 Euston Rd., NW1.

17th. IEE—Colloquium on "Techniques for designing for reliability" at 10.30 at Savoy Pl., WC2.

17th. IEE—"Engineering management and the professional unions" by A. Grosschalk at 17.30 at Savoy Pl., WC2.

18th. IEE—Colloquium on "Alpha numeric display devices" at 14.30 at Savoy Pl., WC2.

23rd. IERE—Colloquium on "Recent developments in turntable design" at 10.00 at 9 Bedford Sq., WC1.

23rd. BKSTS—"The factors affecting the image quality of 16mm film for television" by Arthur Branson at 19.30 at Thames Television Theatre, 308–316 Euston Rd., NW1.

24th. RTS—A.G.M. followed by "Television special effects using electronics and photography" by A. B. Palmer at 18.30 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

25th. IEE—Colloquium on "Digital microwave relay systems above 10GHz" at 14.30 at Savoy Pl., WC2.

28th. IEE—Colloquium on "Message switching" at 10.30 at Savoy Pl., WC2.

30th. IERE—Colloquium on "Trends in testing telecommunications materials" at 10.00 at 9 Bedford Sq., WC1.

30th. IEE—"Artificial vision" by P. E. K. Donaldson at 17.30 at Savoy Pl., WC2.

BIRMINGHAM

9th. IEETE—EASCON 75 on "The Partnership? training—education" at 10.30 at the City of Birmingham Polytechnic.

EDINBURGH

28th. IEETE—"Electronics versus the criminal" by J. S. T. Charters at 19.00 at Carlton Hotel, North Bridge.

GLASGOW

29th. IEETE—"Electronics versus the criminal" at 19.00 at Royal Stuart Hotel, Jamaica St.

GRAVESEND

3rd. IERE—A.G.M. followed by "The application of digital computers to radar and navigation at sea" by Bruce Williams at 19.00 at the Tollgate Motel, Watling Street.

LIVERPOOL

8th. IEETE—"Automatic flying controls" by D. I. Jackson at 19.30 at MANWEB Social Club, Thingwall Road.

MANCHESTER

10th. IEETE—"Intruder alarms" by E. Tanham at 19.30 at UMIST, Reynold Building, Sackville St.

READING

8th. IERE—"Project management" by Dr. I. Maddock at 19.45 at the J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

SWINDON

29th. IEETE—"Technician engineers and technicians—their role, status and qualifications" (speaker from IEETE secretariat) at 19.30 at The College, Regent Circus.

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

Literature Received

ACTIVE DEVICES

We have received a 24-page catalogue giving specification of the Siemens range of charge storage varactors, varactor diodes for frequency conversion, tuning varactor, PIN, Schottky, tunnel, backward, IMPATT diodes and Gunn elements. Siemens Ltd, Great West House, Great West Road, Brentford, Middx TW8 9DG WW401

Also available from Siemens is an applications booklet on the subject of surge voltage protection WW402

A price list and complete set of data sheets describing the Monolithic Memories Inc. range of semiconductor memories is availabe from Memory Devices Ltd, Central Avenue, East Molesey, Surrey KT8 0SN WW403

Books on c.m.o.s. logic devices and applications by Motorola are available from Jermyn. The McMOS Handbook (applications) is available free with each order for the McMOS Data Book, which is priced at £2.50. McMOS is the Motorola name for c.m.o.s. Jermyn Distribution, Sevenoaks, Kent.

The seven-volume set of RCA Data Books for 1975 is now available. The complete range of RCA semiconductors is described, including diodes, transistors, integrated circuits of all kinds, thyristors and microwave devices. Each volume costs £1.80, the price for the complete set being £8. RCA Ltd, Solid-State-Europe, Sunbury-on-Thames, Middx.

We have received from OVUM a bibliography of charge-coupled devices, containing abstracts on general information, theory, technology, bucket brigades and several other subjects. The book is well-indexed and is entitled "International abstracts on charge-coupled devices 1970–74". It is available from Ovum Ltd, 22 Grays Inn Road, London WC1 at £30.

Many applications of a variety of semiconductor devices are described in a new book by Siemens. Both discrete semiconductors and integrated circuits, both digital and analogue, are dealt with in applications from industrial control to audio. The book is available free of charge from Marketing Services Department, Siemens Ltd, Great West House, Great West Road, Brentford, Middx. WW404

Artificial vision progresses

Improved design of microelectronic implant giving more stimulation points on the brain and greater reliability

by T. E. Ivall

Editor, Wireless World

Work by the Medical Research Council's Neurological Prostheses Unit in providing some degree of vision for blind people by means of microelectronic implants in the head was described in our May, 1971 issue*. Two implants have been made and fitted, one in a female patient in 1968 and one in a male patient in 1972, and both have given encouraging results. Since 1972 research and development led by P. E. K. Donaldson has been continued with the object of improving the design of the implant, notably to increase the number of electrical stimulation points on the visual cortex of the brain and to make the implanted electronic devices neater and more reliable.

The principle of the MRC's visual prosthesis is directly to stimulate a large number of points on the visual cortex of the brain of a person who has become blind, for example, through damage to the optic nerve[1, 2, 3]. As a result the patient "sees" spots of light, called phosphenes, which are fixed in the visual field. By suitably organizing the electrical stimulation these phosphenes can be arranged into meaningful patterns for the patient, such as letters of the alphabet or Braille characters. The stimulation is applied by 500μs pulses of current fed to electrodes mounted in two flexible silicone rubber cups which fit round the two occipital lobes of the brain. The stimulating pulses come from microelectronic inductive-loop receivers and logic units which are implanted, as packages in a silicone rubber "cap", between the skull and the scalp (Fig. 1). No implanted battery is needed as all the required power comes from the external bank of inductive-loop transmitters (mounted in a hat-shaped shell similar to a hair-drying hood) which activate the implanted receivers.

*Artificial vision, *Wireless World*, May, 1971, pp. 214–217

The d.c. outputs of the implanted receivers are electrically arranged to form a matrix of rows and columns, so that when a particular "row receiver" and a particular "column receiver" are energized simultaneously by their transmitters their d.c. outputs activate a particular AND gate (at the "intersection" of that row and that column). The d.c. output of the AND gate then provides the stimulating pulse for a particular electrode on the visual cortex. Thus if there are x row receivers and y column receivers in the implant it is possible to identify xy unique pairs of receivers and therefore to have xy stimulating electrodes. The external transmitters are arranged in a corresponding matrix of rows and columns. Row-transmitters generate 500μs pulses of r.f. at 10MHz while alternate column-transmitters give 500μs pulses at 8MHz and 6MHz (this arrangement of different frequencies for adjacent column-transmitters being a means of avoiding cross-talk).

In the implant described in our May, 1971 issue there were nine row receivers and 20 column receivers, giving 180 stimulation points. It was designed for a 64-year-old male patient who had been blind for 30 years with retinitis pigmentosa. When a dummy of the device was handed over to the neurosurgeon who was to perform the implantation operation he said it was too big and he would have difficulty in closing the scalp over it. Would the engineers please think again? It was therefore decided to reduce the number of row receivers from nine to five and the number of column receivers from 20 to 15. In addition it was decided to eliminate the 1.0μF tantalum capacitors in series with all but three of the AND gate outputs (see May, 1971 issue, p.216). Capacitance is needed in these outputs to keep the mean stimulating current zero and so avoid electrolysis at the electrodes and consequent tissue damage, but it is possible to rely on the capacitance-like properties of the electrode-tissue interface. (More about this later.)

A dummy 5 × 15 device was accepted as satisfactory by the surgeon in July, 1971 and the actual 5 × 15 implant, giving 75 stimulation points instead of the 180 originally intended, was implanted into the patient on February 4, 1972. As a result of testing[4] it was found that the

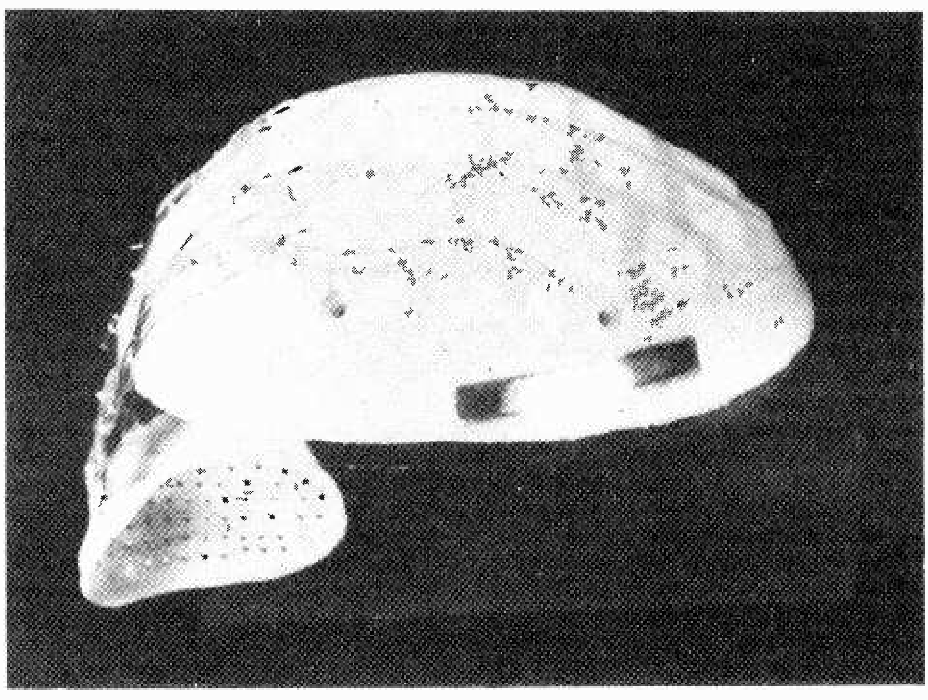

Fig. 1. Completed second implant, showing the stimulating electrode assembly at the end of its cable (bottom left), before surgical implantation in the head of a 64-year-old male patient. See also front cover.

patient could in fact "see" 55 phosphenes of the theoretically possible 75. These, however, were disappointing for pattern organization purposes because the phosphenes were larger than those experienced by the first patient and when pairs were elicited simultaneously they tended to fuse together into a single, bigger phosphene. Finally six good phosphenes—bright and clearly defined—were chosen lying in two vertical columns of three, the format for Braille characters, and the subsequent tests on this patient were mainly confined to the reading of Braille text fed to the transmitters character by character by a punched tape apparatus.

Experience gained from this second implant clearly showed that it was desirable to provide many more stimulation points on the visual cortex to make possible more detailed patterns of phosphenes and to allow for possible failures of stimulation points after implantation. Moreover it was believed that the patient had himself inadvertently put some electrodes out of action simply by scratching and bumping his head, and this suggested some mechanical fragility in the wiring between the microelectronic packages. It was therefore decided to produce a third design of implant which would overcome these problems.

To provide more stimulation points it is of course necessary to put more receivers and AND gates into the implant, but in order to keep the implant size down to that required by the neurosurgeon the packages obviously have to be made smaller. The most bulky packages in the second implant were the hermetically sealed logic units containing transistor and diode AND gates. These logic units are also the most environmentally sensitive of the packages—the environment being a warm saline "mist" produced by the body fluid—hence the need for particular care in sealing them. It was decided, however, to do away with the hermetic sealing, which required rigid ceramic packages measuring 29mm × 20mm with projecting connection tags. Instead, after experiments with various materials, straightforward encapsulation with silicone rubber adhesive was chosen. At first sight this seems a very unsuitable process, for silicone rubber has a high permeability and a low water absorption, and it must therefore transmit water vapour rapidly. But in fact hybrid electronic components are not very susceptible to water *vapour.* Thick film resistors, chip capacitors, cross-over glazes, conductors and passivated semiconductor devices can be operated successfully in the presence of such vapour. On the other hand, water as liquid affects the operation of the circuit in two ways: it can provide spurious conduction paths which cause malfunction; and it may allow electrolysis to occur, filling up the package with electrolytic debris, which causes further shorts, and allowing the generation of gas under enormous pressure. Water as liquid will condense from water vapour in any voids which may be present in the encapsulating material, and it is the voids at the interface between the encapsulant and the electronics which cause the trouble.

The requirements of the encapsulant in the implant packages are therefore not only the usual one, that it shall penetrate the surface convolutions of the microelectronic circuitry everywhere so that no voids are left when the device is first made, but also that it shall discourage the formation of new voids subsequently. This means that the adhesion of the encapsulant must be good, and that the encapsulant should be a rubber and not a resin, so that small strains set up at the encapsulant-electronics interface (as a result of, say, slight swelling of the encapsulant because of its water load) do not nevertheless set up large stresses which break the adhesive bonds. Fortunately silicon rubber adhesives are both rubbers and very adhesive in the presence of water, and this is why they work. The conclusions of the MRC workers are, therefore, that moisture-protecting encapsulants work not because they are in any sense a wall, but because they displace water as liquid from the surface of the microelectronics.

Using this encapsulation technique, logic packages containing 19 AND gates have been produced measuring only 26mm (long) by 7mm (wide) by 3mm (deep) as shown in Fig. 2. Unlike the previous hermetically sealed packages they have flying leads. The hybrid microelectronics forming the circuit (Fig. 3) are laid on a

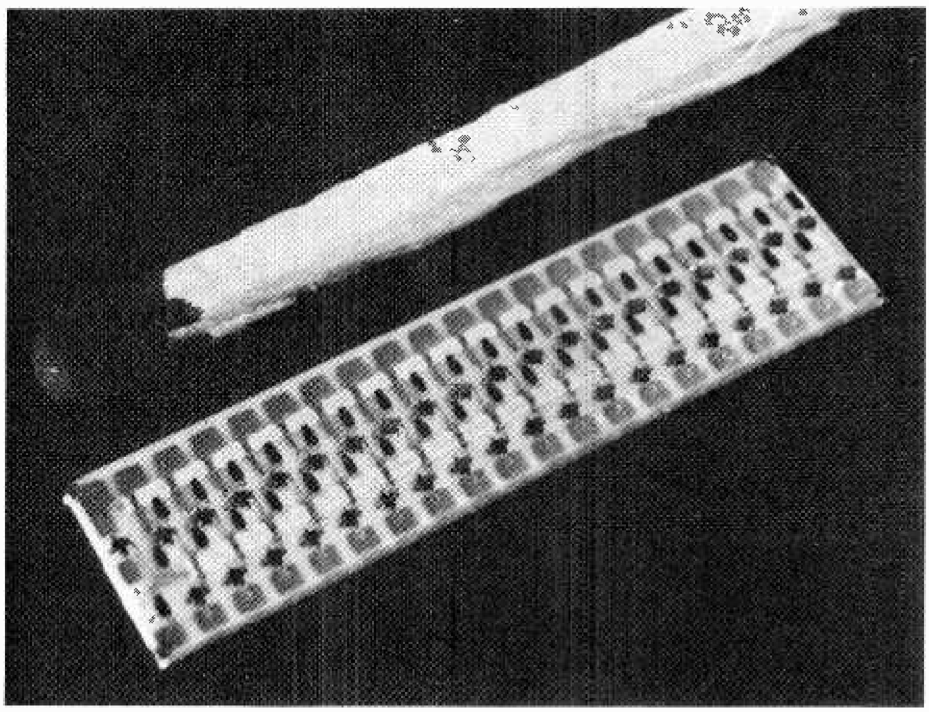

Fig. 2. Thick-film microelectronic circuit of the logic package, carrying, on a 26mm × 6mm substrate, transistors, diodes and resistors for 19 AND gates (see Fig. 3).

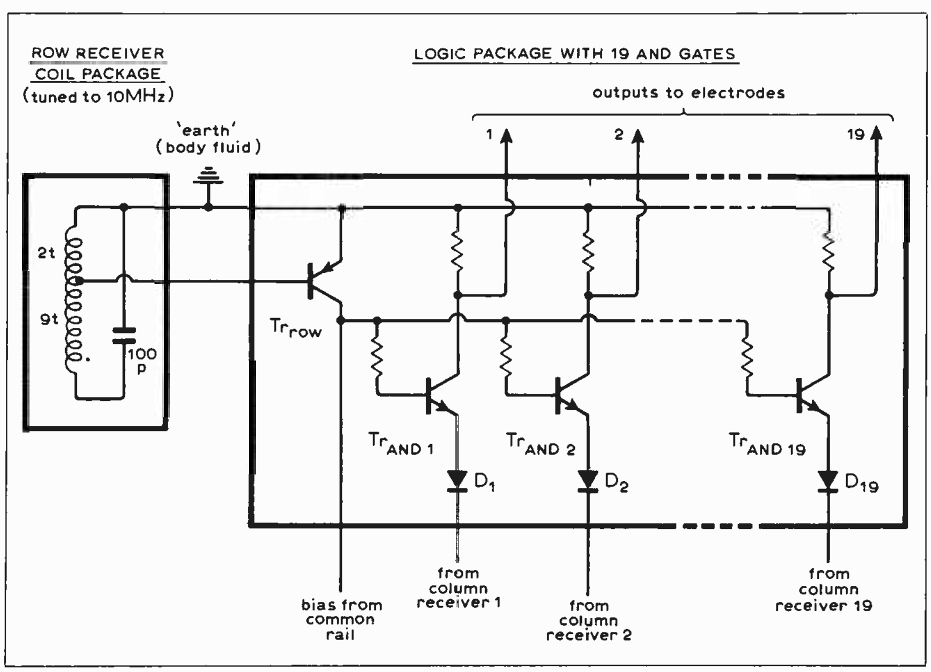

Fig. 3. One of the 16 logic packages fed by (left) one of the 16 row-receiver coils. Outputs from the 19 column-receivers are fed into the diodes. All resistors are 10kΩ.

25mm × 6mm ceramic substrate and the thick film parts of the circuit are successive layers of resistor material, palladium silver conducting pads and cross-overs, glass for insulation, and gold for transistor connecting pads and the two bus-bars shown in Fig. 3. The transistors and diodes attached to this thick film circuit are beam lead devices, and have a silicon nitride impermeable skin put over them.

Although there are fewer AND gates in this new logic package (19 as against the previous 20) the smaller size of the package allows more logic units to be used and in fact the third implant will contain 16 of these units (instead of nine). These will be fed with d.c. pulses from 16 row receivers (one is shown in Fig. 3) and 19 column receivers, giving 16 × 19 unique pairs of receivers on the matrix and therefore allowing 304 stimulating electrodes. Thus, relative to the second implant with its 75 outputs, the number of stimulation points will be quadrupled in this new implant.

The row and column receivers will be encapsulated in the same silicone rubber adhesive as is used for the logic packages. Samples of units made in this way have been tested by operating them under normal electrical conditions while immersed in a warm saline bath (1% sodium chloride solution at 50°C)—a more literal meaning for "soak testing"!—and in many months of continuous testing no insulation failures have been detected.

The thick film receiver circuits themselves have been modified to make them smaller and safer. Most notably the inductive pick-up coils are now made in thick-film form (see illustration on front cover) instead of being coils of copper wire. The coiled conductor deposited on the ceramic substrate is of platinum, gold plated to bring the coil resistance to below 2 ohms. This has the advantage of allowing a thinner receiver package and avoiding the use of copper, which could be chemically harmful to the patient. Moreover it allows more stringent cleaning methods to be used on the circuit. The tuning capacitors are chip devices while the detector rectifiers are passivated diodes.

The final space-saving expedient is to do away with, as mentioned above, the 1.0μF wet tantalum electrolytic capacitors connected between the outputs of the AND gates and the stimulating electrodes. In the project described in our May, 1971 issue these were housed in packages each containing 15 capacitors. The alternative, as explained, is to combine the capacitor and stimulating electrode into one by coating the electrodes with a suitable dielectric layer. Thus the metal electrode forms one plate of the capacitor while the surrounding biological tissue forms the other plate. Experiments at the MRC Unit have in fact shown that tantalum electrodes coated with tantalum pentoxide can perform stably as capacitor anodes when implanted into biological tissue[5]. Capacitances and leakages (typically 1μA at 5V in a 1μF device) do not differ much from those obtained in the electrolytes of conventional tantalum capacitors. It therefore seems likely that this technique will be successful when such capacitor-electrodes are used in future implants.

Resistance to mechanical shear forces on the implant, with consequent breaking of inter-package wiring, will be sought by virtually wiring the implant with springs.

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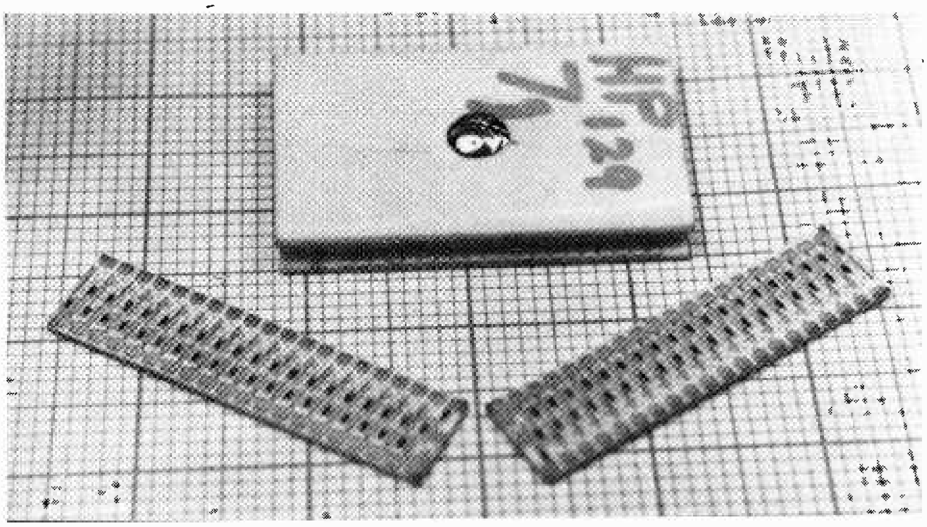

Fig. 4. Two of the new thick-film logic circuits compared in size with the hermetically sealed logic package (above) used in the second implant.

Announcements

The basic methods and techniques used in **Industrial Digital Control Systems** and their applications in both computer and non-computer systems. is the subject to be studied at a vacation school on Industrial Digital Control Systems. It is being organized by the Control and Automation Division of the Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, in association with the Institute of Measurement and Control, to take place at the University of Oxford between April 7 and 11th.

An agreement has been signed between Keighley Instruments, 1 Boulton Road, Reading, Berks RG2 0NL. and Neff Instruments of Duarte, California, USA for marketing Neff's range of **data amplifiers** for laboratories in the UK and Ireland.

The fourth Salon International Audiovisual et Communication (**International Audiovisual and Communication Show**) will be held in Paris, Porte de Versailles, from April 2–8th. On April 3rd, the presentation-discussion will be concerned with "Cable Television in France Today".

Arrow-Hart (Europe) Ltd have announced the appointment of Radio Resistor Co Ltd, 9–11 Palmerston Road, Wealdstone, Harrow, HA4 7RS, to their network of stockists and distributors for Arrow switches including the subminiature ranges.

GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks. has announced that its franchise for Hewlett Packard **optoelectronic components** has been extended. Under the new agreement GDS will be stocking HP Schottky and PIN v.h.f./u.h.f. diodes.

A new business **ITT Instrument Services** is being established by the Distribution Division of ITT Components Group, Edinburgh Way, Harlow, Essex, with effect from the beginning of February. ITT Instrument Services takes over from the Instrument Product Group of ITT Electronic Services. It is a much larger and independent marketing operation with its own field force, catalogue and internal sales engineers, but utilizes the computer system and stores operation of ITT's Distribution Division. The catalogue covers the following product areas: oscilloscopes, digital multimeters and voltmeters, analogue multimeters, analogue and digital panel meters, signal sources, counter timers, testers, modular power supplies, bench power supplies and variable transformers.

This year's AGM of the National Association of **Hospital Broadcasting** Organisations is to be held on April 12 and 13th. The host station will be Radio Whittington, Whittington Hospital, North London.

Calvert Engineers Ltd has moved to new premises at 44a Elmsdale Road, Walthamstow. London E17 6PW. CEL has been involved in the manufacture and installation of telecommunication equipment and with this new move production capacity is being increased to include **cable television** equipment.

Celdis Ltd, 37/39 Loverock Road, Reading, Berks RG3 1ED have announced that they are the UK agents for the range of small **electric motors** manufactured by Papst Motoren KG in Germany.

The Electronic Component Show (RECMF) will this year be held at Olympia, London from May 13th to 16th, 09.30–17.30 daily. Organizers of the show are Industrial and Trade Fairs Holdings Ltd, Radcliffe House, Lennon Court, Lode Lane, Solihull, W Midlands.

News of the Month

DICE throws a double

Latest version of DICE, the Digital Intercontinental Conversion Equipment designed by engineers of the Independent Broadcasting Authority, can convert 525-line NTSC colour pictures as used in the USA and Japan into 625-line PAL or SECAM pictures used in most other parts of the world, and will now also operate in the reverse direction, taking advantage of the availability of higher-speed integrated circuits. Improvements are mainly in the field of vertical resolution, particularly relevant to pictures coming in to the UK. This two-way DICE was first demonstrated outside the IBA Engineering Laboratories in December 1974 and an agreement has recently been signed giving Marconi Communication Systems exclusive world-wide manufacturing and marketing rights.

The standards conversion is essential not only for "live" relays via satellite, but also where programme material or videotape is exchanged between countries working to different television picture standards. A number of different types of standards converters have been developed over the years, but IBA engineers were the first to develop the unit based on digital techniques to eliminate the need for careful alignment and adjustment and to provide conversion without perceptive picture impairment.

The latest DICE occupies no more floor space than the original unit and uses about 8,000 integrated circuits, while the main storage devices alone represent the equivalent of more than 15 million transistors. Five-line interpolation is now used rather than the three-line integration of the experimental digital converter and the spatial filters have been improved. The converter is available for operational use within 30s of switching on from cold.

IEE recommends reconstruction of engineering profession

The following is a summary of the conclusions reached by a council of the Institution of Electrical Engineers concerned with the future organization of the engineering profession.*

The council agreed that the structure of the engineering profession was in need of change and endorsed the President's proposal that any change, whether in the form of an adjustment of the Council of Engineering Institutions or the setting up of a new central body to replace it, should be based on these principles:

- Authority and responsibility for learned-society and professional matters affecting special branches of engineering must remain in the hands of the individual specialized institutions.
- The central professional body should progressively become the single effective authority and instrument for qualifying chartered engineers, assisted wherever appropriate by experts nominated by the specialized institutions.
- The central body should not include technician engineers.
- The central body should not be federal in structure but should comprise individual engineers of all disciplines, the members of its council being elected in a suitable manner by the chartered engineers.
- Provision should be made to enable well-qualified members of certain non-chartered societies to become chartered engineers, provided that their education, training and experience were judged by the central body to be of sufficiently high standard.
- A person should not be eligible for registration as a chartered engineer unless he was a member of a specialized institution recognized for the purpose.

*"The importance of status", *Wireless World*, Oct, 1974, p.363.

First production c.c.d. memory

The first c.c.d. memory to be put into large-scale production has been introduced. The new device is a 1-kilobyte serial storage element claimed to represent a significant advance in the density of solid-state memory storage. It is aimed at memory applications in terminal buffers, video display refresh, microprocessor-control data stores and electronic switching in data communication networks. The memory utilizes a buried channel, ion-implanted barrier structure in the storage registers combined with n-channel silicon-gate m.o.s. structures for timing, charge detection and level conversion circuitry. The nine two-way data lines are t.t.l. compatible and have three-state output buffers for wired-OR application.

The device is organized as 1,024 words by nine bits each. It contains nine 1,024-bit low power c.c.d. registers which are shifted in parallel to provide storage and retrieval of nine-bit words in a byte-serial mode. Each register is accessed by its own two-way data line and all nine registers are serviced by common two-phase data transfer clocks and read/write control functions. The device operates in four modes: read, write, read/modify/write and recirculate. Power dissipation in the read and write modes is said to be 250mW maximum and only 30mW in standby recirculate mode. Average random byte access time is 200μs. The device uses simple two-phase clocking and is packaged in a standard 18-pin ceramic

Engineer uses EMI's portable Privateer telephone scrambler device to transmit confidential information back to head office.

d.i.l. Data rate is 50kHz to 3MHz. Evaluation quantities of the CCD450, manufactured by Fairchild are available on four-week delivery, while production quantities will be available in the fourth quarter of 1975.

High-speed waveform recorder

Since 1969 the National Research and Development Corporation has been supporting a work programme at the University of Manchester aimed at developing a novel type of storage cathode-ray tube to be used for signal averaging. A 16-channel laboratory prototype has been built and NRDC would now like to hear from companies who would be interested in completing the development and assessment of the instrument and in its subsequent commercial exploitation.

The basic principle of the waveform recorder is as follows. The electron beam in a c.r.t. is focused so as to form a beam whose cross-section at the face of the tube is narrow (approximately 0.5mm) in the x-direction but broad in the y-direction (approximately 1cm). This rectangular beam falls upon a faceplate consisting of a series of parallel, electrically isolated strips of aluminium that are also narrow in the x-direction but broad in the y-direction. The electron beam can be scanned across the strips in the x-direction. The signal being investigated is fed to the c.r.t. electrodes controlling the y-deflection of the beam and the strips are located within the tube so that the amplitude of the signal determines how much of the beam's area falls upon any particular aluminium strip. With zero signal there is no overlap and when the signal is maximum the entire beam falls on an aluminium strip. Each strip is connected to a storage capacitor which is charged by the impinging beam, the quantity of charge being determined by the degree of beam overlap. As the beam scans repeatedly in the x-direction, charge is accumulated and, by monitoring the potential of each capacitor, the average signal can be extracted.

Study on teleconferencing

The Stanford Research Institute in California has recently undertaken a nine-month study of "teleconference" systems that enable people to communicate to a mass audience across the span of a continent. Audio and visual systems that are substitutes for bringing together conference participants offer an attractive means of saving costs, but only if people use them. An engineer-economist of the institute states, "We know a lot about the technology of such systems, but we need to know a lot more about their psychological and sociological aspects". The findings will document effectiveness of the systems, usage patterns over a period of time and how the cost, quality and types of capabilities offered by a system affect its usage. In the UK the Post Office runs a service of this type called Confravision.

TV deliveries still down

Deliveries to UK distributors of UK made and imported colour television receivers reached 165,000 in December, a 23% decrease compared with December 1973, according to the latest statistics compiled by the British Radio Equipment Manufacturers' Association. This brought the total for the year to 2,209,000, a fall of 20% compared with 1973.

Total monochrome television deliveries for December of 51,000 brought the total for the year to 821,000, a fall of 42% compared with January to December 1973. BREMA members delivered 59,000 audio stereo systems in the month, a fall of 27% compared with December 1973, bringing the year's total to 831,000, a fall of 17% compared with 1973. Deliveries of radio receivers reached 259,000 for the month, a 44% drop on December 1973, bringing the 1974 total to 4,798,000 compared with 6,681,000 in 1973, a fall of 28%.

These figures are for deliveries of UK made and imported deliveries to home distributors including those to rental and relay companies.

Bell Laboratories celebrate fifty years

The research and development unit of the Bell System marked its 50th anniversary in January. In its first 50 years Bell Labs scientists and engineers have been awarded more than 17,000 US patents, two Nobel physics prizes (in 1956 for the invention of the transistor), three National Medals of Science and hundreds of other prizes.

One of the largest industrial laboratories in the world, Bell Labs is now an organization of about 16,000 employees, with 18 locations in nine states of the USA. It was established in New York City in 1925 with the reassignment of 3,600 staff members of Western Electric Co's engineering department and some additional supporting personnel from the American Telephone & Telegraph Co.

Charge coupled image sensor, the "eye" of RCA's new tubeless TV camera held below. The image sensor and camera will be available in Europe early in 1976.

Briefly

Radio City on v.h.f. The Independent Broadcasting Authority's new v.h.f. f.m. stereo transmitters at Allerton Park, Liverpool are now in operation on 96.7MHz, carrying the programmes of Radio City, previously available only on 194 metres medium wave. The IBA's local 95.9MHz relay station in Rotherham is also now in service, carrying the programmes of Radio Hallam.

Merseyside slant polarized. Since the start of programmes on January 24, the v.h.f. service of BBC Radio Merseyside (95.8MHz) has used slant polarization. This will provide improved reception for portable receivers and v.h.f. car radios, particularly towards the limit of the service area. Listeners using outdoor horizontal aerials should find reception unchanged.

New SERT president. The Council of the Society of Electronic and Radio Technicians has elected as its third President, Sir Cyril English, who took the chair on the occasion of SERT's 10th anniversary on January 30.

75 years of magnetic recording

2—The dark years

by Basil Lane

Assistant Editor, Wireless World

Up to about 1915 the use of valves had been extremely limited and rarely applied to the telegraphone type of recorder. However, from that date on until the mid-1950s it was to play a massive part in turning a declining technology into a brilliant new era. The dark years of World War II were also approaching to produce a remarkable dichotomy in recording media. In this article the story advances to 1945.

The combination of World War I and mismanagement of the technical development of the Telegraphone, brought about the demise of the Poulsen companies by about 1918. From then on there are only passing references to magnetic recording in the literature, mostly connected with Poulsen models or slight variants of them. As mentioned in Part I of this series, it was Kurt Stille who revived interest in magnetic recording and this through the medium of the Dailygraph, later developed into the Textophone-[6], and a steel tape machine originally conceived for synchronized film sound track.

In Britain, Stille's ideas were exploited by Ludwig Blattner, who, according to a contemporary account,[27] was a small, lively man with a keen showman's mind. He, with his engineers, developed a machine called the Blattnerphone, an early model of which was used to provide synchronized sound for demonstration films. These films were used as part of a sort of "circus show" where a public audience would come to see the "talkies" and in the intervals Ludwig Blattner, also a keen dancer, would pull ladies from the audience to dance with him on stage to recorded music from the Blattnerphone!

More seriously, the BBC took an interest in these machines and by 1931 at least one had been bought and installed at Savoy Hill (Fig. 1). This was a machine that used steel tape 6mm wide running at a speed of 1.5 metres per second with a playing time of 20 minutes. Since the drive was by d.c. motor, it suffered from wow and speed drift, which had to be corrected by operating a rheostat and observing a stroboscope attached to the capstan.

Pressure was increasing within the BBC to provide an Empire Service and since the government of the day had taken so long to produce a decision to allocate funds for the capital investment, the BBC took an independent decision to finance the initial stage and open service just after Christmas 1931. Since the long-distance transmissions had to be timed to obtain reasonable hours of reception—usually early evening local time—broadcasts were beamed by using directional aerials, with the transmitters switched to each aerial at two hour intervals. Thus, to enable a programme broadcast to Australia to be heard in Canada the material had to be available for repeat. Disc recording had not been used in the BBC up to that time, and in any case the playing time was rather limited. The Blattnerphone seemed to provide just the right answer.

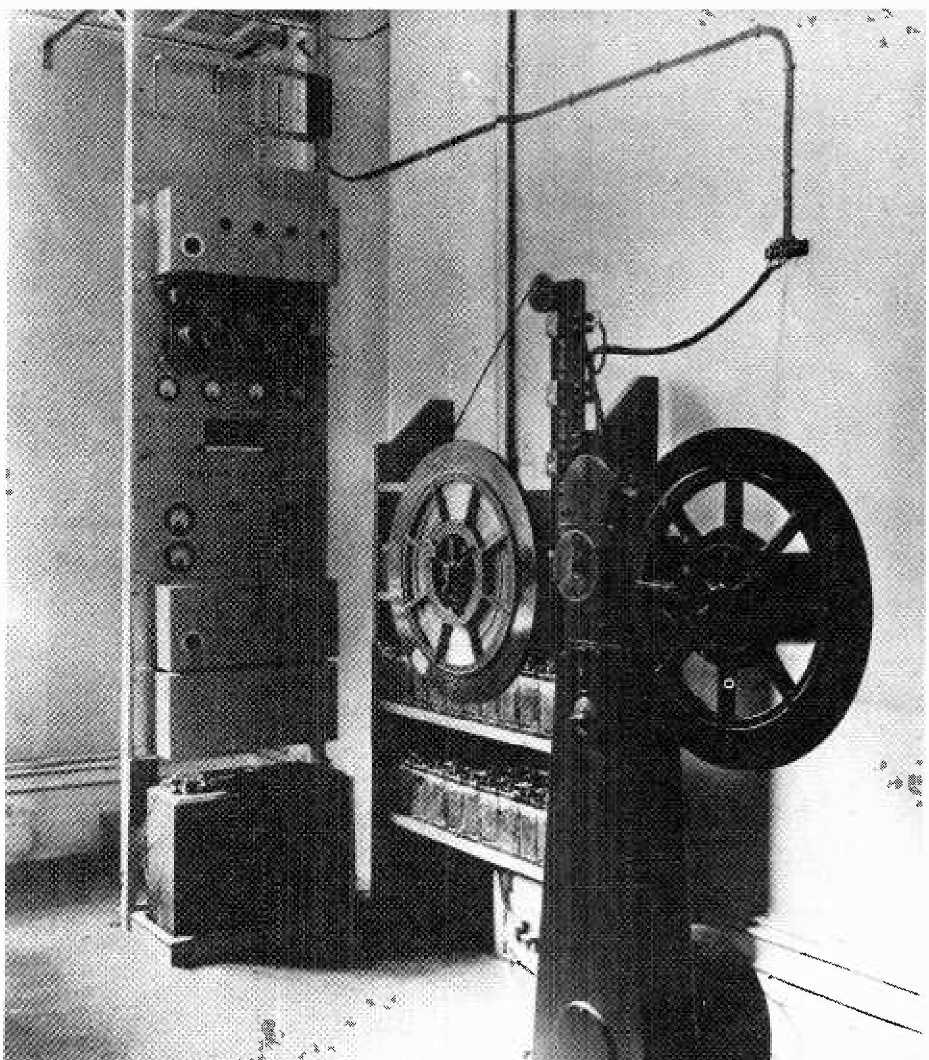

Fig. 1. An early 6mm Blattnerphone machine installed in Savoy Hill in 1931. (Courtesy BBC).

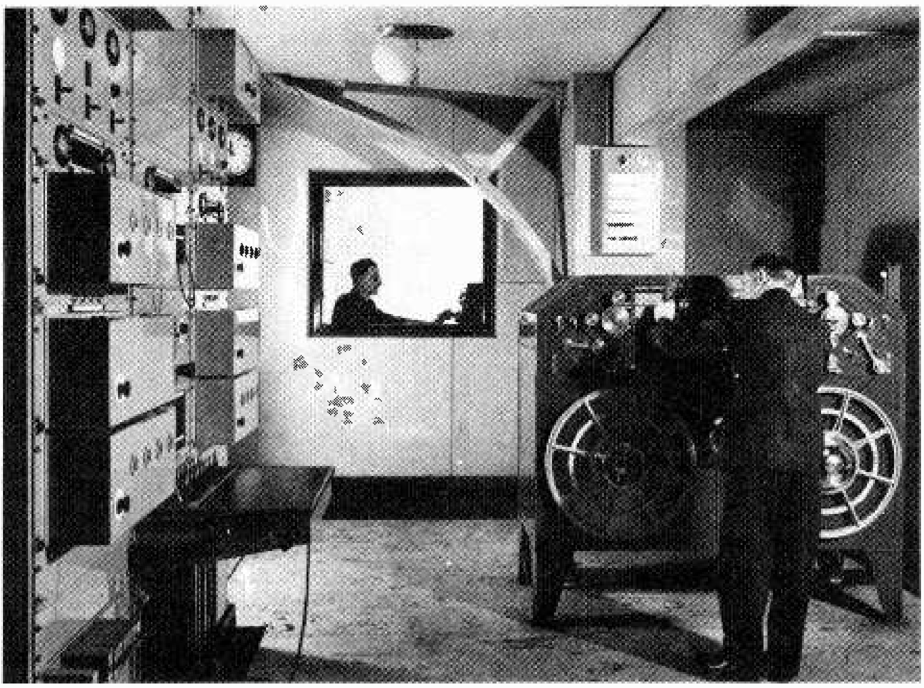

Fig. 2. A Marconi-Stille recorder installed in BBC Maida Vale studios from 1934.

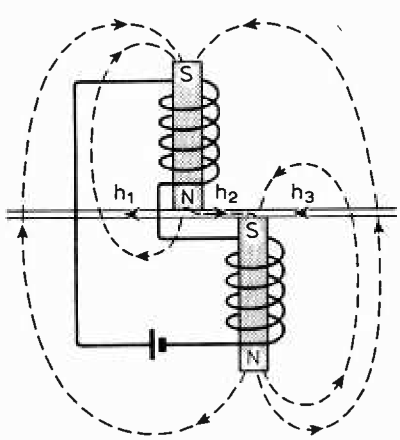

Fig. 3. The Stille erase head assembly showing the saturating flux fields.

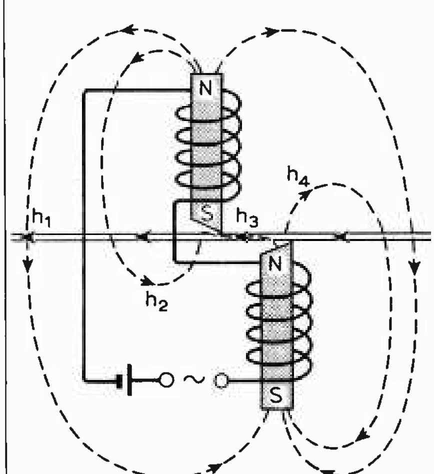

Fig. 4. The record head flux field of a Marconi-Stille machine.

Having pointed out the deficiencies in the 6mm Blattnerphone, the BBC then encouraged an engineer, von Heising of the British Blattnerphone Company, to develop a machine meeting the BBC requirements[28]. After only three months, two prototypes were produced and installed, first at Savoy Hill and then at Broadcasting House. Further technical details on these and later machines follow, but for the moment, suffice it to say that the speed stability was improved and tape width reduced to 3mm. Apart from the somewhat dangerous operating conditions, the steel tapes were also difficult to edit.

Nevertheless, it was obvious that this represented somewhat of a challenge to the engineers of the day, since several magazine programmes were broadcast during late 1932 and in 1933. One of these included a composite programme of the 1932 Economic Conference in Ottawa which was compiled from seven miles of recorded steel tape[29]. However, the fact that steel tape was a new recording medium coupled with the prospect of being able to erase the tapes made it unreliable, in the minds of the BBC, as a source of archival recordings. What confirmed this thought was that part of the first Christmas Day, 1932 feature programme was accidentally erased. Godfrey[29] goes on to say that subsequently arrangements were made, with the British Homophone Company, to record highlights onto disc from Blattnerphone tapes, the signal being fed from Maida Vale to Kilburn by telephone lines. He also remarks that this must have been the first time discs were produced from magnetic recordings.

Shortly after 1932, the Marconi Company bought rights in the Blattnerphone machine and produced a slightly lighter version which was mounted on a wooden table. By 1934 this, however, was superseded by what surely must have been one of the largest audio magnetic recorders ever — the Marconi-Stille machine. This was mechanically very sophisticated and six were ordered and installed in Maida Vale from 1934 (Fig 2). Two more were added during the war and these machines were in constant use during this period and after, the last one being taken out sometime around 1950.

A fascinating tale is told of one of the early Blattnerphones. This machine was one of the original two 3mm recorders installed at Savoy Hill and as part of the move to Broadcasting House they had to be shifted overnight. It had just been connected, though not tested, when a telephone call came through to the tape room to get a machine going, whatever it took. The switches were thrown without further ado and with, it would seem, a good deal of finger crossing, to record an historic interview with Amelia Earhart. The date was May 21, 1932, the very day she landed after an epic flight across the Atlantic.

History was to repeat itself since during 1939 it was resurrected from the embryo BBC museum to be the first tape machine installed at the dispersed BBC wartime location in Worcestershire. Once again, the same engineer, with other colleagues, had hardly completed the installation when they were told to get the machine going, this time to record the Prime Minister. The date was September 3, 1939 and the Prime Minister was Chamberlain broadcasting the declaration of a state of war between Britain and Germany[30].

This self-same machine was again resurrected to record some items for the 50th Anniversary of the BBC and now rests in a well earned retirement at Bristol City Museum, awaiting location in a new gallery.

Technical specification

The second generation Blattnerphones were driven with an a.c. synchronous motor which improved speed stability. Since this was an era before the adoption of a.c. bias, the tape was erased and biased with d.c. set from preset controls on the amplifier rack. The replay amplifier was a standard BBC type A amplifier[31], modified to permit an equalization circuit to be connected to the grid of one of the valves. A power output stage, capable of giving up to 10W, provided the loudspeaker monitoring facility. The microphone and head-driving amplifier were specially designed for the job. The Blattner machines were only fitted with three head block assemblies, the later Marconi types having five, the reason for which was not at first obvious to the author. Contact was therefore made with the engineer mentioned in the previous anecdotes, R. C. Patrick, for an explanation. It would seem that the idea originated with Patrick, who at that time was working in BBC Research. Marconi had just taken over the licence to produce the machines and had asked the BBC, as largest users of Blattnerphones, what improvements could be made.

Editing of steel tapes was then quite common but unfortunately the actual edits, which consisted of a soldered joint, destroyed the knife-edge pole pieces of the record and replay heads. Patrick suggested that two standby heads, one record and one replay, were fitted which during operation of the machine were left out of contact with the tape. After the passage of an edit, the spare heads would then be quickly brought into contact and the damaged heads opened to permit replacement of the spring-loaded pole pieces and wait for another edit!

Of the three basic types of head assembly used, one was erase, one record and one replay. The design consisted of two simple pole pieces, solenoid wound, one on either side of the tape. The erase-head pole pieces had a flat contact surface with the tape and were made of Stalloy, also used for the record head. The assembly could be hinged open to facilitate threading.

Erasure was by saturation magnetization of the tape[31], illustrated in Fig. 3. Briefly, a direct current of about 20mA was passed through the coils connected in series. When the tape approached from the left, the field h_1 applied, the strength being above tape saturation as it passed under the first pole piece. There then followed a reversal of flux under the influence of field h_2 and finally another reversal caused by h_3. The tape was left in a saturated state in the direction of this field.

The record head was of similar construction, though the interchangeable pole pieces were this time shaped to a knife edge to improve short wavelength performance. Of the alternative arrangements possible, single pole piece or double narrow stagger, double wide stagger or double pole piece with one being idle, the BBC adopted the double pole narrow stagger arrangement (Fig. 4).

Again, the coils were connected in series and a 4mA direct current bias applied with the signal. Here the tape saturation field h_1 was reduced by field h_2, restored to saturation by h_3 and finally subjected to the demagnetizing influence of h_4. Since h_4 was also modulated by the signal the remanent flux in the tape followed the current fluctuations in the head.

Finally, the replay head used by the BBC had only one pole piece, made of Permalloy, since the setting of two pole pieces, which produced better high-frequency performance, was too critical for practical purposes.

The actual tape deck of the Marconi-Stille machine represented a considerable advance on early models with the tape drive being achieved through three motors. Tape was drawn off the feed spool by drive No. 2 and fed into a box reservoir where a loop would build up. When the earthed loop contacted a metal surface at the bottom of the box the bias was removed from the grid of a thyratron and a relay in the anode operated, to switch a resistance into the motor circuit, slowing the motor down.

The tape was drawn from this reservoir by a capstan drive, which in turn fed a loop of tape into a second, larger reservoir. Again, when the loop of tape contacted the bottom of a reservoir a thyratron operated relay would remove resistance from the winding motor circuit speeding the motor up.

Despite sterling service and a surprisingly good performance for its day, disc recording gained the ascendancy during the World War II and after 1947, the impact of plastic based tape was to sound the death knell for this remarkable machine.

Recording in Germany

Going back to the late 1920s the seeds were being sown, in Germany, of a new-old idea which, in later years, was to revolutionize the art of magnetic recording. This was the revival of the idea of coating a flexible insulated base with a finely divided magnetizable substance. An independent engineer from Dresden, Fritz Pfleumer, was struggling to develop both a recording tape which had a flexible insulated base with a magnetizable surface and also a suitable machine. Presumably his funds and resources were too limited, since although he had secured a patent[32] for such a tape (filed in February 1929), by 1930 he soon after sought the help of a German electrical company Allgemeine Elektrizitats Gesellschaft of Berlin (A.E.G.).

It is not too clear just how good a chemist Pfleumer was, since his early patent sounds rather more like a recipe for a pudding than a tape coating! In the introduction, he acknowledges that there prior inventions regarding the use of magnetizable substances on a flexible base but then goes on to describe the methods for his type of tape. I quote, "... a powder of soft iron is mixed with an organic binding medium such as

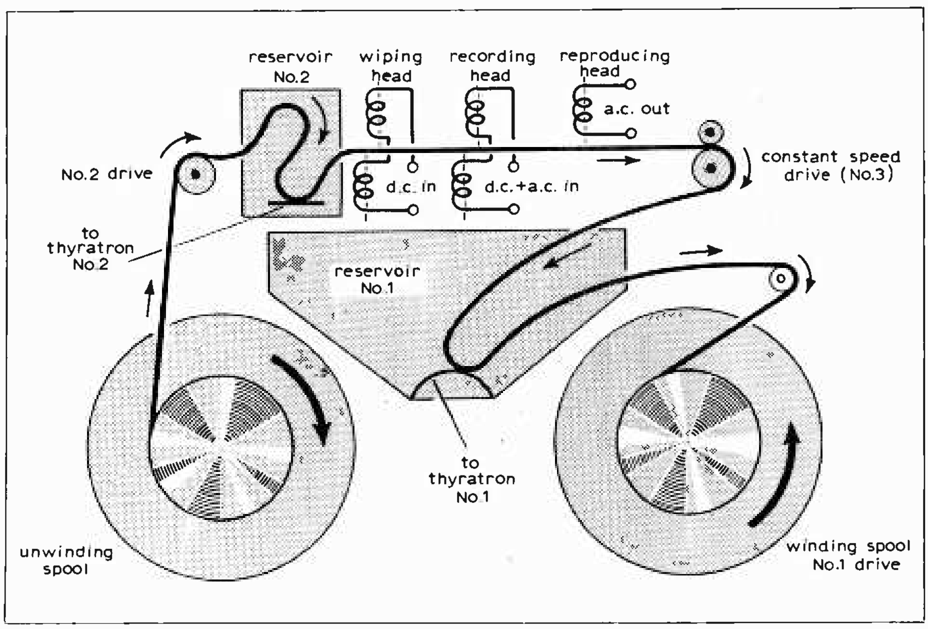

Fig. 5. Tape drive system for the Marconi-Stille machine.

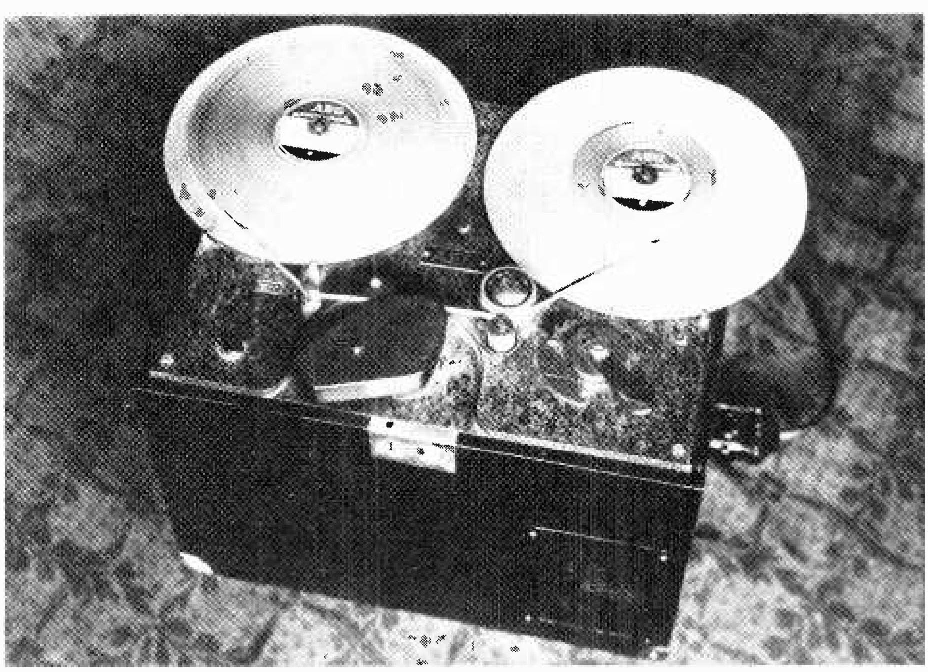

Fig. 6. The first model Magnetophone shown at the Berlin Radio Exhibition, August 1935.

dissolved sugar, molasses or the like, which is then dried and finally caramelized or carbonized, that is, the carbon chemically combined in the iron by heating. The steel powder so produced is then, while in a heated state quenched in water or other liquid, dried and again powdered. The use of such a material has for its object that phonograms are thereby obtained which last many years without loss of strength of sound."

He went on to suggest that this powder could be then mixed with a water-insoluble binder and coated onto paper or cellulose type films. Also in the patent he suggests the coating of sound stripes on moving picture film. Several alternative magnetic materials were included in the specification, such as nickel-iron alloys, ferrosilicon or iron-hydrogen compounds. At least one reference[33] indicates that Pfleumer did succeed in making paper tape, and also one coated on a cellulose hydrate film.

Fortunately for Pfleumer, A.E.G. were very interested in the proposition, but very soon realized that specialists would have to be used to manufacture a suitable tape. They chose I. G. Farbenindustrie Aktiengesellschaft of Ludwigshaven. This company specialized in the production of a wide variety of chemicals including fast opaque pigment dispersions and carbonyl iron used in the manufacture of loading (Pupin) coils for the telephone system.

Hermann Bücher of A.E.G. was soon in contact with a brilliant physical chemist at I. G. Farben, Wilhelm Gaus, who readily responded to the proposals and set to work on a suitable tape. The pace thus far seemed to have been a little slow from Pfleumer's first ideas, but now it increased—though not without quite a few problems, both technical and in company politics.

Some eighteen months after the initial approach Gaus reported back to Bücher that progress was good having received favourable reports on the quality of the first tapes delivered to A.E.G. In return, A.E.G. suggested that their machine was nearing completion and should be ready for launch in 1934 at the autumn Radio Exhibition in Berlin. With this air of optimism circulating, the two companies prepared for a grand launch. Designers at Ludwigshaven produced an exhibit which ran riot with ideas of the potential at domestic and broadcast level.

In July 1934, a decision to produce the first 10,000 metres of tape was taken, and by August this was in the hands of A.E.G. A further 40,000 metres was to be produced in time for the exhibition which was to be held from 17th to 27th August. With time getting short, internal politics started to show, since press releases and a prior announcement to a meeting of the Technisch-Literarische Gesellschaft du Berlin showed considerably greater restraint than the designers of the Ludwigshaven exhibit. Here an emphasis was laid on the speech recording aspect of the invention, rather than on music. Someone had suggested that any flaws in the performance would damage the prospects of the invention if exaggerated claims had been made initially. So, the plan was to underplay the potential, but as events were to show, this sudden pessimism was the precursor to real problems. A joint meeting of management from both companies, was held one week before the exhibition and demonstration given. The result was that the recorder was withdrawn, delivery of tapes stopped and the press information suppressed as far as possible.

The trouble was two-fold, first that the prototype machine made in breadboard form, suffered from amplifier instability when condensed into a practical cabinet. Second, the performance did not come up to that of the competition. Remember, the Marconi-Stille and its predecessors had been in practical service in broadcasting for at least two years and similarly, in Germany C. Lorenz had introduced the Stahlton-Band Maschine[34,35]. This was a steel tape machine using Stille's principles, but considerably smaller than the British versions having a frequency response up to 5kHz. The best achieved by the prototype A.E.G. machine was 3kHz at a tape speed of 1m/s. In addition the noise performance was hardly up to broadcast standards, so it was natural that there should be much soul-searching before taking any further commercial decisions.

Eight weeks later, the A.E.G. engineers announced that they had overcome the problems and a second demonstration was arranged. The resulting decision was favourable and so development went ahead to finally produce, in the summer of 1935, a completely redesigned model meeting all requirements and available for the 1935 Radio Show in Berlin.

With a potential success on their hands, I. G. Farben suddenly ran into internal political problems with two of their factories —Ludwigshaven, who had developed and produced the first tape, and Wolfen entrenched in film coating, squabbling over who should mass-produce the tape. Wolfen, by the way, was later to be split, by an Occupying Forces Commission, away from I. G. Farben to become the Agfa tape and film concern—but that is a separate story to be told later. The final decision was delayed until 1938, due to vacillation by the Reichs-Rundfunk-Gesellschraft, (German Radio) on which recording system to adopt. By 1938, Ludwigshaven was so firmly in full production that no decision needed to be taken.

However, this takes us beyond August 1935 and the Radio Exhibition where the first eight A.E.G. machines, now called the Magnetophone, were shown and demonstrated with success, indeed with so much success, they were all immediately sold. The first Magnetophone tape was cellulose acetate, coated with carbonyl iron powder. Since at the time, the steel tape, wire, and direct-cut disc were firmly entrenched in broadcasting it was to be some years of hard selling before A.E.G. was successful in getting the Magnetophone accepted by the German broadcasting stations and during that time several stages of evolution were to occur. The first model (Fig. 6) was to be superseded by the FT2 an elegant console model, and the K3, a portable machine in three parts—deck, amplifier and loudspeaker. These appeared in 1937[36] to be followed later by the K4, a broadcast machine made in portable or rack-mounted form. One interesting incident occurred in 1936 during the period of promotion; Sir Thomas Beecham was invited, with the London Philharmonic Orchestra, to go to Ludwigshaven to record the first public concert on magnetic tape. Beecham, being quite interested in recording, accepted and on November 19, 1936 made a tape recording parts of which survive to this day.

However, even he could not have been too impressed with the Magnetophone, since during that season he purchased two German optical sound recorders and had them installed in Covent Garden, where he later made private recordings of his seasons in 1937 and 1938!

Iron powder produced by the carbonyl process was not ideal as a magnetic material for tape since it had low coercivity and the individual particles were still too large to permit high-frequency recording. In addition the particles were spherical, a disadvantage not realized until much later when a study of small particle magnetics was to reveal the advantages of shape anisotropy.

However, there were other promising materials and one of these was magnetite (Fe_3O_4) suggested in 1934 by Erwin Leher. Some tape was eventually produced using this oxide, but it had rather too high a coercivity which made erasure a problem, and so brown gamma-ferric oxide, still with spherical particles, was eventually adopted.

It was in January 1938 that seal of success was to be set upon the Magnetophone when the technical manager of Reichs-Rundfunk Gesellschaft, Dr. Hans-Joachim von Braunmuhl gave an announcement at a lecture that the Magnetophone had been adopted by R.R.G. for broadcast service.

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Letters to the Editor

AMPLIFIER CLAIMS

I was much amused by the letters from Mr Paravicini and Mr Radford in the January issue.

If one accepts that the best equipment from the two companies can look each other in the eye without too much neck stretching, then one must give Mr Radford the laurels for reaching this rarefied level with a much lower component count, and hence a better cost/price ratio.

Unfortunately, this does not guarantee success.

The lesson that British manufacturers, whether of amplifiers or motorcycles, have signally failed to learn is that the buying public is notoriously indifferent to specifications.

Lux will win the battle in the shops because, sadly, the most important parameter of all is the shiny knob area.

R. A. J. Glowacki,
London, N.W.3.

RIBBON MICROPHONES

John Dwyer's statements with regard to ribbon microphones in your "Microphone survey" in the October 1974 issue would seem to be drawn from references which relate to microphones produced in the 1930s and not of present day manufacture.

Beyer Dynamic have, for the last twelve years, been producing a hand held ribbon microphone. In fact within the range they have three different microphones serving the entertainment industry. All of these are supplied to broadcasting authorities and corporations throughout the world. They are also much in demand within the club circuits where microphones are not always treated very well and the Beyer microphones withstand the rough treatment in this area.

We would like to draw your attention to an extract from a letter we have received from the Revox Corporation of New York.

"I had thought that the English reviewers were somewhat more *au fait* with current ribbon microphone technology than their American counterparts, as here in America, I am constantly battling to overcome odious remarks and comparisons made against the ribbon transducer technique.

"It therefore came as some shock to note Mr Dwyer's same old hackneyed statements: to whit: 'The ribbon corrugations provide some control of the tension as well as increasing the mass of the ribbon and making it more rigid: it is still delicate, though, and susceptible to rumble and wind. The ribbon exhibits the worst susceptibility to handling noise.'

"'. . . Ribbon microphones tended to be bulky in the past and their delicacy has tended to encourage them being abandoned in favour of the capacitor or moving coil types. They can be used for pressure operation by providing a cavity at the back of the ribbon to provide an acoustical resistance.'

"These damaging remarks, of course, cannot be applied to the Beyer ribbon. However, all ribbons seem to be 'tarred with the same brush' no matter whether they are described on your side of the Atlantic, or mine."

This we feel expresses the views of Beyer and, of course, of the Revox Corporation.

Douglas Ireland,
Eyeline Communications Ltd,
London WC2.

Mr Dwyer replies:

Naturally the ribbon microphone can be constructed in such a way as to make it as good as other types.

The article was intended as a guide to the basic principles of operation of the various types of transducer now in wide use for good quality sound reproduction. All of the various types of transducer have disadvantages of one kind or another if only the basic construction is used. It is obviously true that a well designed unit of any type can overcome its inherent limitations. Nevertheless it is equally true that the cost of doing so may become an added limitation, as may the complexity of the unit so produced, and I think, if I may suggest so, that the simpler a unit is the more reliable it is. This may explain why, on the numerous occasions on which I have visited recording studios, the type of microphones predominantly in use were those either of the capacitor or the moving coil type. Every studio has at least one ribbon, but the occasions on which it is used tend to be rather specialised. I can only rely on the use to which the microphones are put as a guide to their value, though it may be that British recording engineers, like those elsewhere, have been subjected to a propaganda campaign of massive proportions conducted by the makers of capacitor and moving coil types in concert. If that is the case I can only say that I am sorry I have become an unwitting instrument of such propaganda. In addition, I am sure that Beyer microphones mentioned in the letter are every bit as good as Mr Ireland says Beyer say they are. My remarks were not intended to suggest that no ribbon microphone could be as robust or as rumble-free as any other type, and it would be misleading to suggest that that was what I was saying.

dB CONVERSION ON A SLIDE-RULE

The article by Mr Nelson-Jones "Electronic engineers' slide rule" in the February issue prompts me to mention a technique for dB conversion using the LL2 and LL3 scales on a standard slide rule. If "6" on the C scale is set opposite "1000" on the LL3 (corresponding to 60dB = 1000), other ratios may be converted to dB by reading from the LL3 scale to the C scale; 6 on the C scale is also opposite 2 on LL2 (corresponding to 6dB = 2) so lower ratios may be read from the LL2 scale to the C scale.

Certainly the new rule should be a great deal more convenient, but the above technique may be of use to someone.

R. A. Scott,
Bury St. Edmunds,
Suffolk.

Mr Nelson-Jones replies:

I have tried the method suggested by Mr Scott and it is certainly ingenious, but I find it hard to remember which scale is which, and in addition the accuracy is not good. I am sure I would soon get used to the method, but I find it much easier to use the new scale with the A and B scales, and the accuracy is much higher. I had in fact heard of the method before, but had never tried it out until Mr Scott's letter arrived.

EMERGENCY POWER GENERATOR

Congratulations to Mr J. M. Caunter for tackling the power disruption problem (February issue), but I feel that the car dynamo could have been more effectively converted by making use of the principles embodied in the most recent alternators fitted to cars. In these designs it is the rotating armature which is excited by the battery and the fixed stator windings which are used to generate the a.c. This has several advantages: the currents flowing into the armature via the brushes are smaller, and steady, and the armature heat dissipation is lower. The stator, by contrast, being heavily heat-sinked can develop quite large amounts of power, and, since plenty of winding space is available, can be more readily wound for 240V. In modern car alternators, the regulating equipment is carried within the frame of the alternator, and consists of a power transistor controlling (on/off system) the armature current. The armature current is reduced whenever the output voltage causes a zener diode to conduct, so that the armature current is rapidly pulsed. This method of control, though suitable for battery charging, would not be suitable for a mains-output

alternator, and a voltage-controlled current regulator with a non-pulsed output would be needed.
I. R. Sinclair,
Braintree,
Essex.

Mr Caunter replies:
While I agree with Mr Sinclair that most alternators work on the principles he describes, and there are several obvious advantages to be gained from using this method of construction, his suggestion is not applicable to the conversion of a dynamo for two important reasons.

Firstly, the dynamo has a solid steel yoke and cast-iron pole pieces and is therefore not designed for rotating field operation. If this were attempted, a large amount of power would be lost in circulating eddy currents within the solid stator. The armature, on the other hand is laminated to reduce this loss to a minimum when rotated within the stationary field supplied by the existing field winding. Secondly, since the stator is not of true annular form, the variation in reluctance of the magnetic circuit seen by the rotor as it rotated would produce serious distortion to the output waveform.

The best way to improve the performance of the alternator is to get as much copper as possible into the armature slots. This necessitates using a finer gauge wire to improve the filling factor, and either winding for 240V in a single winding taking great care over the insulation, or by winding several parallel windings together and operating at a lower output voltage as in the present design. It is quite possible that the output could be increased to over 300W in this way.

Incidentally, if anyone has been put off the idea of building this generator because of the machining needed to construct the slip rings, and has no scruples about passing a current through the dynamo bearings, the following suggestion passed to me by a colleague may be worth trying. Connect one end of the armature winding to the shaft and the other to all the commutator segments shorted together. With the earth brush removed, the output can now be taken from the alternator casing and the live (insulated) brush output.

A NOVEL CLASS B OUTPUT?

As far as I know all class B output configurations are based on the same principle: two emitter followers are tied together and the circuit is improved, in a more or less elaborate way, by replacing a single emitter follower by a two- or three-transistor circuit in an attempt to approach an "ideal" emitter follower.

An example of this is the Quad 303 which has two triplets in the output stage. Although a very fine amplifier, it exhibits clearly the shortcomings of this type of output circuit, which are: (a) the quiescent current has to be adjusted; (b)

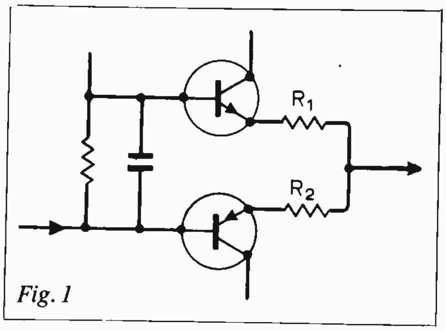

Fig. 1

the quiescent current is dependent on the temperature; and (c) too much quiescent current results in a kind of "take over distortion". This kind of distortion is due to a signal current flowing through the resistors R_1 or R_2 (Fig. 1), cutting off the quiescent current of the other stage, which results in a voltage shift at the input necessary to keep the output following the signal.

It is obvious that crossover distortion decreases with increasing bias current. From the facts mentioned before it is also obvious that an increasing bias current causes an increasing "take over distortion". So, with this type of output there is an optional value for the quiescent current.

It is possible to overcome all these shortcomings by using the circuit shown in Fig. 2. This circuit has none of the limitations mentioned in (a), (b) and (c). The quiescent current is set at 15mA by Tr_7. (Later on 5mA proved to be sufficient.) For d.c. this transistor forms a constant current source as long as diode *D* is not forward biased. For small signals Tr_1 and Tr_4 can be regarded as a long-tailed pair without a tail, for positive signal the upper half (Tr_1, Tr_2, Tr_3 and Tr_4) is active behaving as a super emitter follower. The same for negative signals, but this time with Tr_1, Tr_4, Tr_5 and Tr_6.

Since Tr_1 and Tr_4 are used in both modes of operation and the output resistors are missing, no "take over distortion" is possible.

One advantage is a lower output impedance due to the missing output resistors.
Nico M. Visch,
Rotterdam,
Netherlands.

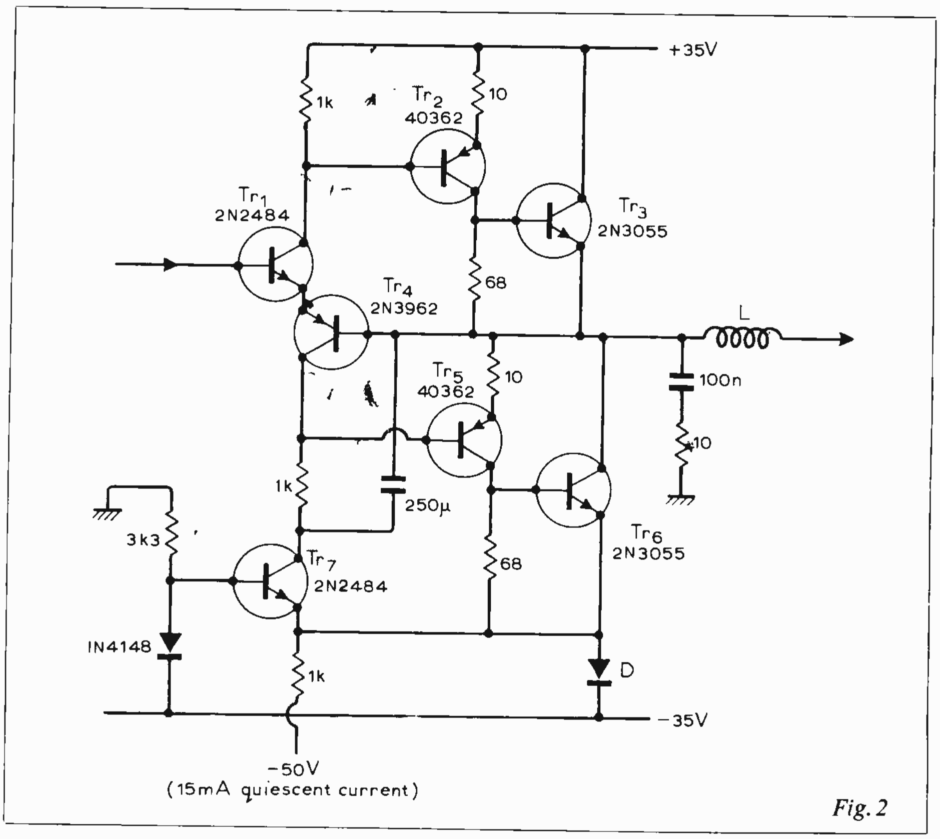

Fig. 2

DIGITAL SPEEDOMETER

I read the articles on the digital speedometer by Bishop and Woodruff in the September and October issues with great interest, but I feel that "average speed" is not really the parameter of interest. What one really wants to know is the difference between the elapsed time and the time which should have been taken to travel that distance at a particular speed.

The above comment arises from the fact that one usually knows the distance to be travelled and a reasonable average speed which one can hope to maintain during the whole journey. What is required is an indication of how much time you have in hand or how far you are behind the clock at any time during the journey. This is the information provided mechanically by the Halda Speed Pilot used by many trials drivers.

I would thus be interested in a modification to the design of the average speed part of the project to substitute an electronic equivalent of the Speed Pilot. This only requires multiplying the actual distance travelled by the inverse of an

average speed set in by hand and subtracing this from the actual time elapsed, to arrive at a plus or minus indication of the time in hand.
G. B. Weston,
Wooburn Moor,
Bucks.

SOUND BROADCASTING DYNAMIC RANGE

There has recently been comment in the press[1,2] on the undesirability of a large (but relatively natural) orchestral dynamic range, as broadcast by the BBC. The opinion expressed is that a lightly compressed programme is unsuitable for domestic loudspeaker reproduction. Thus a reduction in transmitted dynamic range is demanded. Such a step would be regressive and could not be easily compensated for by those who have the facilities to appreciate a natural dynamic range.

My suggestion is that domestic amplifiers should incorporate a switchable dynamic range compressor. Thus the transmitted dynamic range could remain high, and those people (including myself, at times) who require music at reduced dynamic range could then adjust the compression as necessary, while retaining the option to appreciate the full dynamic range.

It is well known that simple compressors are unsatisfactory on high-quality equipment—manufacturers would be expected to fit circuits and controls appropriate to the quality of the rest of the equipment. It is my belief that most people who demand an increase in compression would not notice the transient distortion which automatic control introduçes. This innovation would also encourage the record companies to decrease their compression.
J. M. Hughes,
The University,
Nottingham.

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2. Tim Souster, "The Mike Oldfield concert", *The Listener*, January 23, 1975.

TWIN VOLTAGE STABILIZED POWER SUPPLY

Mr Linsley Hood is to be congratulated on an excellent piece of writing and a very nicely conceived design ("Twin voltage stabilized power supply", January issue). Nevertheless there are one or two points about which I am not entirely happy, and on which he may care to comment:

1. An output smoothing capacitor has been used, of 32μF. This is far too big since it will make nonsense of the current-limiting under conditions of initial connection (i.e., the current-limit won't work until the capacitor has discharged its surplus coulombs into the luckless load). In theory there is no need for an output smoothing capacitor at all: in practice one will probably be found necessary to maintain stability, but it should not need to be greater than 1μF or so.

2. I am not at all happy about the 12-volt reference supplies. As Mr Linsley Hood rightly points out, the overall performance of the whole circuit depends basically on the stability of the reference voltage; and the simple series-fed zener which he uses is not really good enough. A further defect is that he has chosen a 12-volt zener, and this will have quite a large voltage/temperature coefficient. Three possible solutions to these defects present themselves: (a) change the zener voltage to 5.6, which is a zener with practically zero temperature coefficient; (b) use two zeners in series (8.2V + 3.9V, say) so that their temperature coefficients, which of course will be of opposite sign, cancel to near zero; (c) replace the zener with a suitable proprietary potted regulator.

Solutions (a) and (b) have, apart from the stated advantage regarding temperature-coefficient, no other virtues. In fact they also have a number of fairly obvious drawbacks. Solution (c), on the other hand, is ideal—potted regulators are cheap (Signetics, for instance, do a very high quality one for 67p); their stability, both long and short term, is excellent; and the external circuitry with them is not only simple but allows for a precise adjustment of regulated voltage. In short, a suitable choice of potted regulator provides such an obviously ideal reference source for Mr Linsley Hood's excellent design that I cannot for the life of me see why he has failed to use it!
J. F. K. Nosworthy,
Cranleigh School,
Surrey.

Mr Linsley Hood replies:
I am grateful to Mr Nosworthy for his kind letter and his helpful comments. To take his second point first, the suggestion of replacing the zener stabilization of the regulators appears to be an excellent one. I only wish I had thought of that idea myself! However, the intention of the design in its published form was not to provide a very high degree of precision and the simple arrangement shown was adequate in practice.

On Mr Nosworthy's first point, concerning the size of the output capacitor, and the magnitude of the energy stored in this, the answer is not so simple. In practice, all engineering design is a matter of compromise between conflicting requirements; between performance and economy of means; between versatility and simplicity. Depending on the design specification or the order in which the designer places his priorities, so the nature of the design which will be evolved.

Because, in this instance, I was prepared to accept the use of a 32μF output capacitor, it became practicable to use a relatively simple loop stabilization configuration, having a straightforward 20dB/decade roll-off in open-loop gain and a good gain and phase margin with a wide range of output load reactances coupled with a very high d.c. stabilization factor. The use of a smaller output capacitor would have demanded a lower open-loop gain and a flatter open-loop frequency response, and a different balance between the conflicting requirements of source and load ripple rejection.

LOW-COST PRACTICE ELECTRONIC ORGAN

Electronic organs have continued to improve and prices are still competitive. In fact the "pop" enthusiast who is happy with a one-octave pedalboard is well catered for. However the "straight" organist who wishes to practise at home and needs two manuals and a 32-note radiating and concave pedalboard to RCO dimensions has much less choice and faces a much higher outlay. A low-cost practice instrument is therefore proposed, on which one manual and the pedalboard are monophonic, i.e. capable of playing only one note each at a time. If the other manual is polyphonic (i.e. chords can be played on it) much of the classical repertory can then be practised on it, including Bach's trio sonatas. Much "pop" music can also be played on it.

Monophonic manuals already exist and the u.j.t. gives single-resistor tuning though not an ideal waveform; other circuits are available[1] and tunable i.c. tone generators are now on sale. No monophonic pedalboard with 30 or 32 notes has yet been marketed, though a separate one-octave pedalboard is on sale. It would appear desirable to market a 32-note monophonic pedalboard which could be used in conjunction with instruments lacking a pedalboard, and/or incorporated in the low-cost practice instrument proposed. In either event the pedalboard might be arranged to tip on end when not in use. 32-note pedalboards are priced at £40 or more without circuits, and it might prove cheaper to mould the pedals etc. in plastic. A more drastic price reduction might perhaps be achieved by moulding the whole pedalboard in flexible plastic. The further alternative of moulding the whole pedalboard in rigid plastic and relying on proximity detectors to actuate the note played seems unlikely to find favour.

It is possible that a further reduction in cost might be achieved by limiting the polyphonic manual to a maximum of four notes at a time, as described by J. Asbery[2]; other methods might be developed for selecting from four tunable oscillators, e.g. by the interruption of light beams, but the devices used have of course to be shown to be cheaper than a conventional full range of oscillators. The practice organ might well have a headphone socket (with safe isolation), so that practice can be made inaudible to other people.

Opinions are invited from users as to

whether a low-cost practice instrument is worth developing, and if so what features should be included.

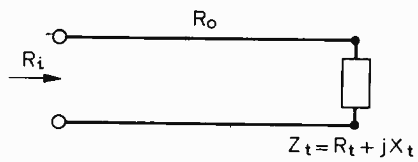
K. J. Young,
61 Madeley Street,
Derby DE3 8EZ.

References

1. Oscillators and networks with single-potentiometer frequency control, Young, K. J. *Electron. Compon.*, Vol. 12, No. 19, Oct. 1971.
2. Multiphonic organ, Asbery, J. *Wireless World*, June 1973.

IMPEDANCE OF A TRANSMISSION LINE

I read with interest the articles on transmission lines: "Graphical analysis of pulses on lines", in the September 1972 issue and "Transmission lines for the birdwatcher" by P. I. Day in the September 1974 issue. They have been very useful to me, as I could take some hints from them and they led me to a successful method of analytical and graphical resolution of transmission line problems which is different from that of the Smith Chart. I have been able to achieve a thorough knowledge of the Smith Chart, and it seems to me that it cannot help to solve the problem of matching a transistor to a line without a stub, as suggested in the second article. The problem in fact is to find the impedance of the matching line, and its length, and it is impossible to properly enter into the Smith Chart if the impedance of the line is unknown.



I am sending the resolution of the first part of that problem which may also help in the use of the Smith Chart to solve many other problems.

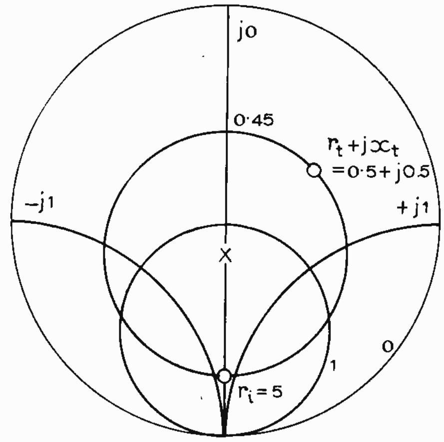
$$R_o=\sqrt{R_iR_t-\frac{R_iX_t^2}{R_i-R_t}}$$

In the transistor-matching circuit of the example in the article ($R_i=50$; $R_t=5+j5$;) the impedance is 14.9 and the length 0.193λ. I think the formula is original, and hope it will be useful.

Romolo Aratari,
Gioia Dei Marsi,
Italy.

Mr Day replies:

Sr. Aratari has obtained a result which certainly enables one to enter directly the Smith Chart, but he is incorrect in assuming that the Smith Chart cannot be used to determine the line impedance. There is a very simple construction by which we can find the impedance of a line needed to transform from one complex impedance to another. Obviously the situation he describes when we are transforming to a resistance is a special case of the general construction.



Basically we rely on the fact that a circle centred on the Smith Chart real axis can be transformed by a change of normalizing impedance to a circle anywhere on the chart axis. So to match $5+j5$ to 50 ohms, as in the example, a possible procedure is as follows.

Choose any normalizing impedance, say 10 ohms, then the normalized impedances are $r_t+jx_t=0.5+j0.5$
and $r_i=5$

Enter both points on the Smith Chart and construct a circle passing through both with its centre on the axis. The circle intercepts the axis at 5 and 0.45 so the required line impedance is

$$10\sqrt{5\times0.45}=15 \text{ ohms}$$

To find the line length the simplest method is to re-enter the Smith Chart using 15 ohms as the normalizing impedance. The original choice of normalizing impedance is completely arbitrary, but greater accuracy is obtained the nearer the circle is to being central.

The constructed circle must not intersect the chart boundary. If it does then the simple matching is insufficient; this condition is identical to the requirement that R_o be real, so R_i must lie outside the range $R_t \rightarrow R_t+X_t^2/R_t$.

Unfortunately I am not aware of any references covering the use of the Smith Chart in this off-centred mode, but undoubtedly they must exist somewhere in the technical literature.

ELECTROLYTIC CAPACITORS

I was most interested to read the survey on capacitors by Mr R. A. Fairs (December issue) and feel that the presentation was extremely useful. There is, however, one criticism which I would offer on his article, where he refers to the practice of etching aluminium foil in electrolytic capacitors (see p.512). The point is that etching does not increase the permittivity of aluminium oxide, which is generally between 7 and 10. Etching is applied to the base aluminium foil and this can increase the surface area by up to three times that of a plain foil. The oxide layer is then formed over the etched foil, resulting in the subminiature capacitors which we see today.

The etch factor and permittivity "constants" can be better recognized when the formula for a capacitor is examined.

i.e. $C_{pF}=\dfrac{\Sigma\times A}{4\pi t\times 9\times 10^{11}}$

which becomes $C_{pF}=\dfrac{0.0885\Sigma A}{t}$

where Σ=permittivity, i.e. 7–10 for aluminium oxide, A=the area of each plate in sq.cm, and t=distance between plates in cm; (in the case of electrolytic capacitors this is the thickness of the oxide layer).

The question of etched foil capacitors being unable to withstand high currents is not entirely correct as multi-tab internal connections ensure that the high peak and/or ripple currents can be applied. Certain limitations to ripple currents do exist with regard to low CV products, due to the dissipation of heat (generated by the I^2R loss inherent in the electrolyte and connections) from the surface area of the can, but, in the main, etching of the foil only marginally degrades the tangent of loss angle ($\tan\delta$).

P. D. Habermel,
Mullard Ltd,
London W.C.1.

Mr Fairs replies:

The statement concerning the increase in permittivity of etched aluminium foils was not entirely correct. The point here is that, although etching increases the effective area of the foil, it does not alter the thickness of aluminium oxide coating applied after etching has taken place.

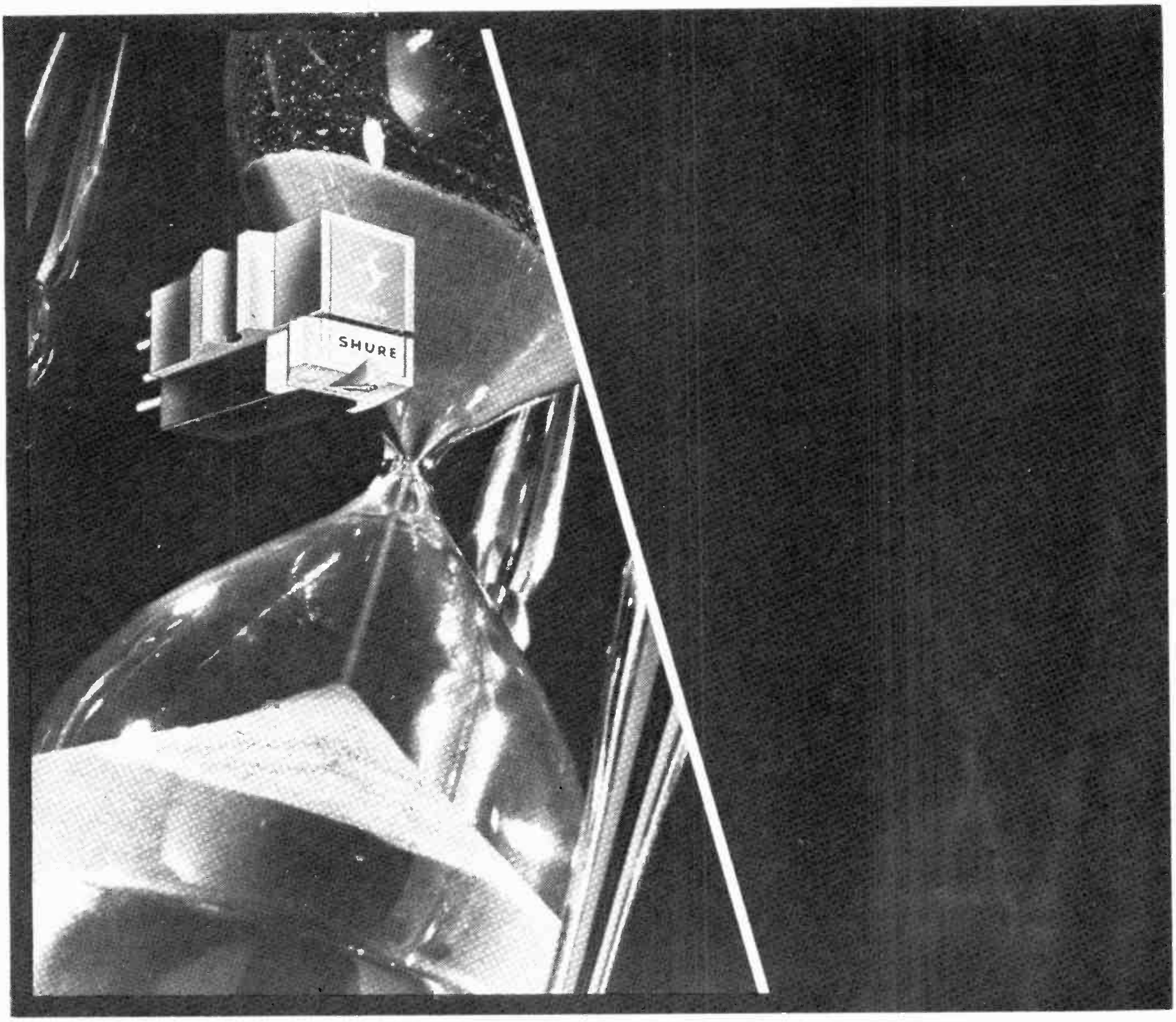
In the early days of manufacture of etched aluminium electrolytic capacitors, the aluminium oxide coating may have been inconsistent due to imperfections in the etch; this explanation would support my statement on this matter, the material for this part of the article being drawn from several research papers on this topic.

I do take Mr Habermel's point on this "increase" in permittivity and support the arguments he gives showing that etching does not cause an increase in permittivity of the aluminium oxide in present-day manufacture of electrolytics.

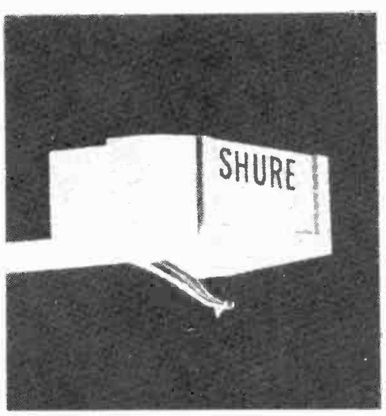
As Mr Habermel points out, the current rating of etched foil electrolytic capacitors is only slightly different from plain foil types. My statements on this matter were not intended to deter any would-be purchasers of etched film capacitors (which are usually adequate for almost every application) but merely to point out the design limitation that exists between the two types. It was unfortunate that space in the article did not permit a more fuller discussion on the differences between the two types of capacitor.

There is not much I can add to Mr Habermel's informative letter except that one can argue a slightly greater dissipation factor in etched film electrolytics due to tortuous paths in the etched film followed by the oxide layer; this argument can be considered trivial in present-day technology.

I thank Mr Habermel for his kind comments and his interest in the article.



If you bought a Shure M55E cartridge in, say, 1970...



It's almost certainly time you bought a new stylus if you have not already done so.
Although the stylus tip is a finely polished diamond, wear cannot be eliminated entirely and a gradual, perhaps imperceptible, deterioration in performance has taken place since your system was installed.
Fit an N55E stylus to restore the performance to the original standard or consider replacing the cartridge to upgrade the performance of your system. Why not ask Shure Electronics Limited for their recommendation?

Shure Electronics Limited
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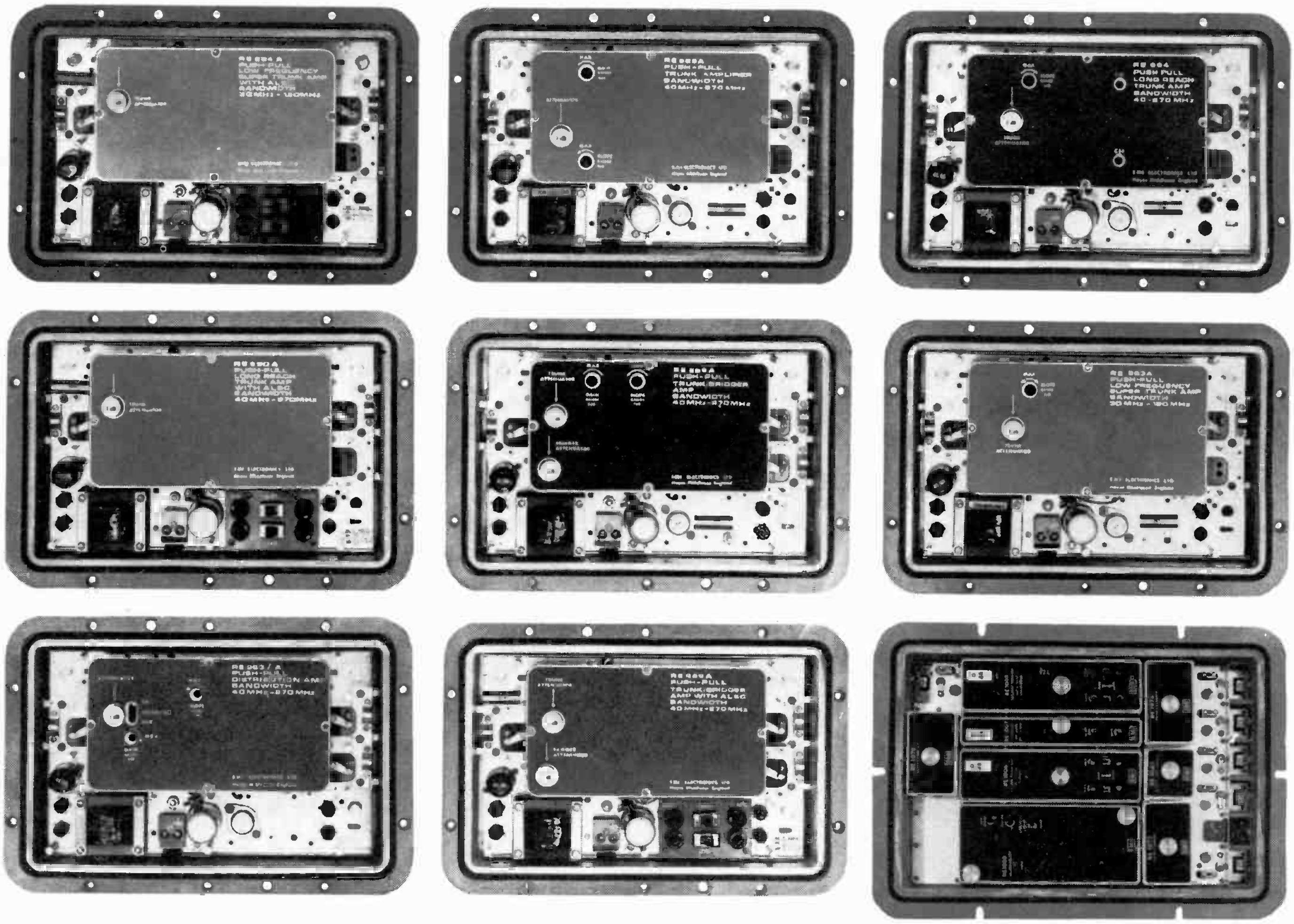
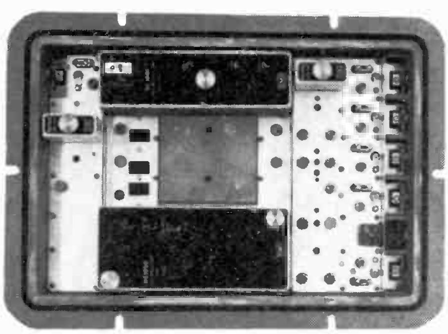
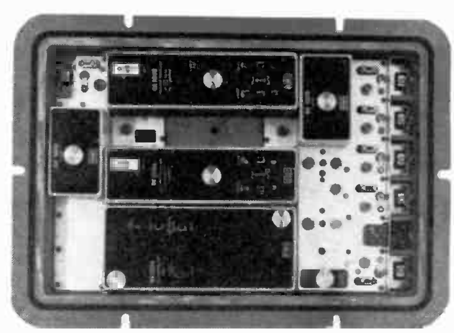




EMI offers a wider choice of options in cable TV.



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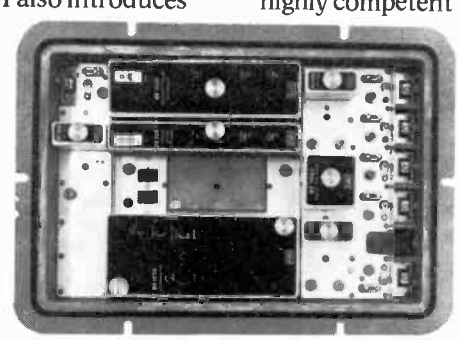

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Noise—confusion in more ways than one

2—Noise temperature and noise generators

by K. L. Smith
University of Kent at Canterbury

In part 1, temperature was shown to play a large part in discussions about noise. In this part the noise temperature concept is discussed more fully, together with methods of measurement at low frequencies using a noise generator.

If a resistor at room temperature is connected across the input terminals of an amplifier of bandwidth B(Hz), the available noise power kT_0B is amplified by the gain G_A. This means that the output power from the amplifier is G_AkT_0B. The noise power added by the amplifier must also be taken into account. If this amplifier contribution is P_{Na} at the output, it can be added to the above expression directly, because noise powers from different sources can simply be summed if they are unrelated. The total available output noise power P_{NO} becomes $G_AkT_0B+P_{Na}$ as shown in Fig. 5(a).

This is the point at which we think up our first bit of convenient fiction. We imagine that the amplifier is completely noiseless and account for P_{Na} by a (now fictitious) extra noise power available at the input terminals. So we write $P_{Na}=G_AkT_eB$. By this dodge we can replace a noisy amplifier by a noiseless equivalent, Fig. 5(b), whose output is

$$P_{NO}=G_AkT_0B+G_AkT_eB$$

or $$P_{NO}=G_AkB(T_0+T_e).$$

The whole thing is equivalent to an input source resistor at a temperature of T_0+T_e connected to a noise-free amplifier, where T_0 is the room temperature of the actual resistor at the input terminals (=290K) and T_e is the effective input noise temperature of the amplifier. Like available gain, T_e varies with input matching conditions, so there is not a unique T_e for every system. It will depend on how the system is used. An amplifier with a low T_e is better noisewise than one with higher temperatures, other things being equal. The idea of T_e is a little abstract because it is not a physical temperature (the input of an amplifier with $T_e=4000$K would not be glowing white hot!).

One or two points arise at this stage. The first is that we are not limited to a source temperature of T_0 in every case. Thus the noise power output for a receiver whose effective input temperature is T_e and connected to an aerial whose aerial temperature is T_a is

$$P_{NO}=G_AkB(T_a+T_e).$$

Another point arising is to do with the bandwidth B—I have been assuming that we know all about it. B is not the normal 3-dB bandwidth used by radio engineers, but is the noise power equivalent bandwidth and involves notions about the available gain-bandwidth product (G_AB). I have relegated these ideas to a brief discussion in Appendix B.

There is another very easily overlooked complication and that is the possibility of more than one channel allowing signals and/or noise to pass through the system. An obvious example is the superhetrodyne receiver with a response at the image frequency. I often wonder how many experimenters measure the noise performance of their v.h.f. converters, oblivious of the fact that they have a wide open channel at the image frequency. Incidentally, this "improves" the (erroneously) measured single-channel noise performance figures, so one should beware of excellent-looking figures on some manufacturers equipment specifications.

A useful concept in connection with the above arguments is that of the operational noise temperature, T_{op}. This is a measure of the overall system performance. A knowledge of T_{op} enables the all important output signal to noise ratio to be calculated. As an example of how this idea arises, consider a superhet with a gain G_s at the signal frequency and G_i at the image frequency, as outlined in Fig. 6. The noise bandwidth is usually B_{IF} for all channels, because it is set by the i.f. amplifier. The signal may occupy a bandwidth $B_s (B_s<B_{IF}$ because if the i.f. is narrow it will limit B_s to $B_{IF})$. The total available output noise power from this receiver will be

$$P_{NO}=k(T_s+T_e)B_{IF}G_s+k(T_i+T_e)B_{IF}G_i \quad (3)$$

where T_s is the temperature of the aerial, signal generator etc., at the frequency of the signal channel, and T_i is the same quantity but at the image frequency. If the temperature is constant over the two channels, then $T_s=T_i$.

The question arises, how do we handle P_{NO} for signals to noise ratio purposes? The answer is that if the available output signal power is P_{so}, the signal-to-noise ratio is given directly by P_{so}/P_{NO}, a little thought shows this to be the important

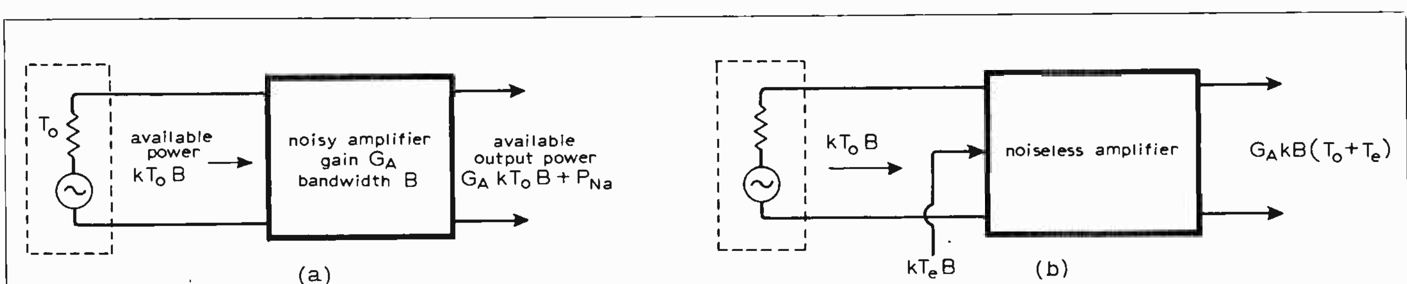


Fig. 5. It is more convenient to replace a noisy real amplifier (a) with a noiseless one (b), and account for the noise by inventing a fictitious noise temperature T_e at the input.

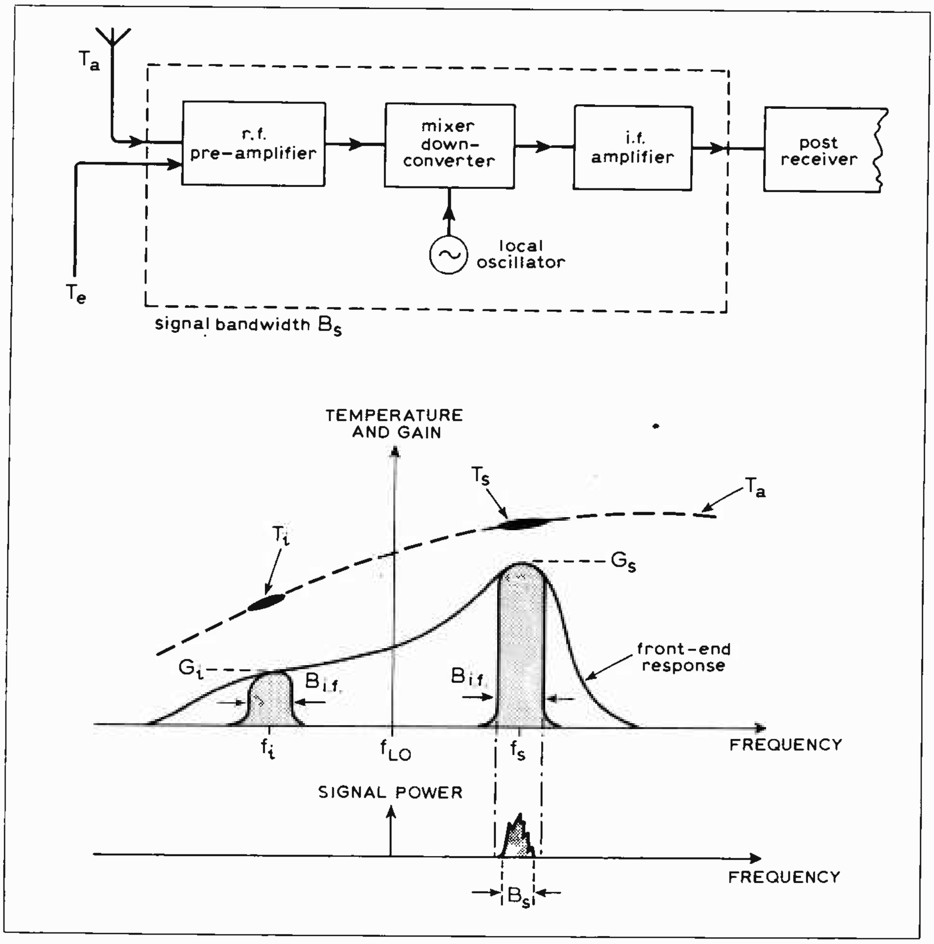


Fig. 6. In a superhet receiver there are usually at least two channels through which noise can pass to the output. Unless signal information is also coming in via the image frequency f_i, it is always advantageous to reduce G_i to the smallest possible value. The "shape factor" of the i.f. bandpass, B_{IF} also has a significant effect on the noise performance.

final parameter in any data link or communications system. The effect of the noise power is as though all of it is concentrated into the signal bandwidth B_s. Therefore we define another temperature, the operating noise temperature, T_{op} as P_{NO}/kB_sG_s.

Notice the particular gain bandwidth product used. You will be pleased to know this is about the limit of abstract thinking we need, so we will soon be back to more concrete things!) Substituting for P_{NO}, by using equation (3), and assuming for simplicity that $T_s = T_i$ and relabelling them T_a, the aerial temperature, operating noise temperature becomes

$$T_{op} = \frac{(T_a+T_e)B_{IF}(G_s+G_i)}{B_sG_s}$$

$$= \frac{B_{IF}}{B_s}(T_a+T_e)(1+\frac{G_i}{G_s}).$$

This equation offers considerable meat to get one's teeth into. First, it illustrates the rationale of using temperatures in noise discussions. Awkward Boltzmann's constants cancel out and one is left with the various temperatures and parameters of the amplifier only. Clearly, the output signal to noise ratio degrades as T_{op} becomes larger. The lowest T_e should be the aim when designing the equipment and is achieved by noise matching and low noise components in the front end.

Care should be taken to understand the significance of T_a. For instance, the signal from a satellite is not enhanced when it is originating from the direction of the sun! (T_a shoots up.) Significantly, simple but all too easily-forgotten pieces of work need to be attended to, such as making sure B_{IF} is not greater than B_s. If the receiver bandwidth is twice as wide, say as that required to pass the signal, then T_{op} is doubled. The noise coming in via the image channel increases T_{op}. If $G_i = G_s$ (as in microwave receivers) T_{op} is again doubled. The receiver designer should reduce the bandwidth to the minimum (B_s) and filter out the image, (make $G_i = 0$) to obtain the minimum operating noise temperature. Then $T_{op} = T_a + T_e$.

There are certain wideband signals which are received with a sensitivity advantage if both channels are wide open. Radio astronomical signals are themselves wideband noise powers. This means that useful signal powers are received in both sidebands. In fact the wider the bandwidth of the radio astronomy receiver the more signal power will be received. There is a worsening of signal-to-noise ratio by a factor of two if a double-channel receiver is used to receive a single-channel signal.

If the gain of the first stage of an amplifier or receiver is high, intuition might suggest that noise power contributions by later stages are not significant. Although intuition is not very trustworthy sometimes, in this example it is all right, as the following argument shows.

If we consider the three stages with gains and effective temperatures as shown in Fig. 7 then the output noise power is

$$P_{NO} = G_1G_2G_3kB(T_i+T_e) \qquad (4).$$

The noise output of the first stage is the noise power from the resistor times G_1 plus the contribution represented by T_{e1}.

Therefore the available noise output from stage one is $G_1kB(T_i+T_{e1})$. The output from the second stage is its own noise, represented by T_{e2}, plus the input from stage one multiplied by G_2. The output from stage two is

$$G_2kB[G_1(T_i+T_{e1})+T_{e2}].$$

Similarly the output from stage three, which is the final output noise power, is

$$G_3kB\{G_2[G_1(T_i+T_{e1})+T_{e2}]+T_{e3}\} \; (5).$$

Equations (4) and (5) are both expressions for P_{NO}, therefore,

$$G_1G_2G_3kB(T_i+T_e) = G_3kB\{G_2[G_1(T_i+T_{e1})+T_{e2}]+T_{e3}\}.$$

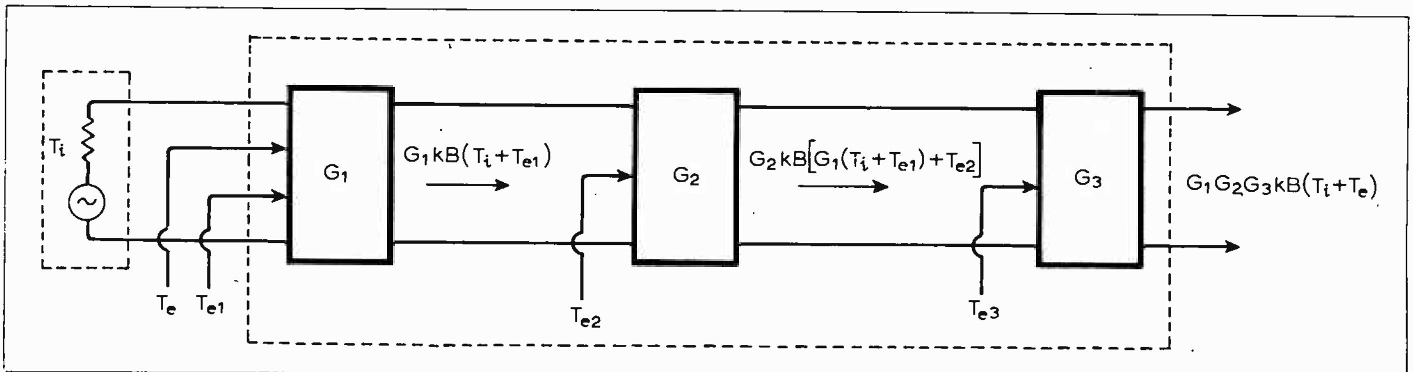


Fig. 7. Overall noise temperature of a cascade of amplifier stages can be deduced as shown here.

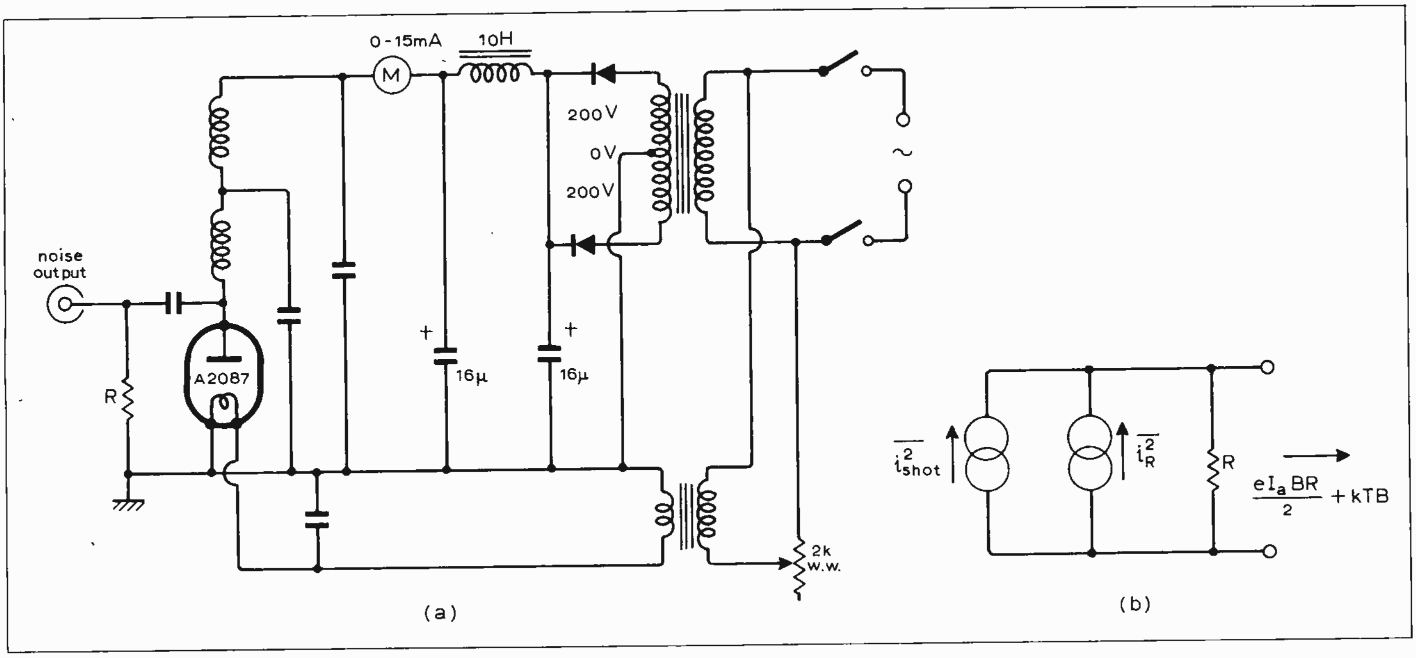


Fig. 8. Still an extremely useful noise source for measurement purposes, the saturated thermionic diode is an absolute noise generator. (a) shows a typical circuit using an A2087, (b) is the equivalent circuit for calculation purposes.

This cancels down to the final simple equation:

$$T_e = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1G_2}.$$

Notice that the term containing T_i conveniently subtracts from both sides. This equation shows that if the first stage gain is, for example, 100 times and the effective noise temperature of the second stage is 300K, then the contribution to the overall T_e by stage two is only 3K. Usually the third term can be neglected, unless G_2 is very small. The gain of stage three (G_3) has not entered into the picture. The argument can be extended to any number of stages. The equation is conveniently termed the cascading formula and in effect describes how the various noise temperatures throughout a chain of stages can all be referred to the front-end terminals as a single T_e, the system of stages is regarded from then on as noiseless.

Measuring T_e

The way in which I have discussed the role of the absolute temperature in noise problems, shows the convenience of dividing the output noise power from a signal handling system into two parts. One part is the noise that comes in with the signal represented by T_a and the other is that introduced by the local equipment, which accounts for the T_e term. This means that all the various noise powers produced in the local equipment are lumped together under the title T_e —whether they originate as thermal noise in the resistors, shot effect in the transistors or valves, flicker noise and so on.

If you have just built a receiver or a customer has ordered a system to be designed with a stated maximum T_{op}, it is essential to be able to make fairly accurate measurements of T_e, so that you know what you are talking about. The basis for any noise measurements involves generating accurately known noise powers. The standard noise generators are based on physical mechanisms including the saturated thermionic diode, the gas discharge tube and the noise generated in a reverse biased semiconductor diode. Sinewave signal generators can be used as standard power sources, but because they produce narrow band signals, their use in noise measurements involves difficulties interpreting what bandwidths mean and errors are very likely.

Before going on to the construction of noise sources, I will discuss a technique for measuring T_e. The following way for determining T_e might be termed the ratio method. A noise source with an effective temperature T_{hot} when it is fired, is coupled into the amplifier or receiver and the output $P_{NO(hot)}$ is noted on a power meter. The noise source is now switched off but still connected to the system. The temperature when the noise source is not fired can be labelled T_{cold}, with a corresponding output power from the system, $P_{NO(cold)}$. It is not necessary to know accurately the actual values of the output powers, only their ratio, A.

As an example, consider the superhet receiver for which equation (3) applies. Putting in the appropriate values for the "hot" and "cold" conditions, gives

$$P_{NO(hot)} = kB_{IF}(T_{hot}+T_e)(G_s+G_i)$$

and $P_{NO(cold)} = kB_{IF}(T_{cold}+T_e)(G_s+G_i)$.

Dividing them gives A

$$A = \frac{P_{NO(hot)}}{P_{NO(cold)}} = \frac{T_{hot}+T_e}{T_{cold}+T_e}.$$

From which we get

$$T = \frac{T_{hot} - A\,T_{cold}}{A-1} \qquad (6).$$

All we require to know is T_{hot}, T_{cold} and A. The bandwidths, gains and k have cancelled. This straightforward result applies for any system whether there are more channels than two or any other complexities. For best results, the value of A is often chosen to be two (the minimum error occurs near this value).

As usual, the assumptions made should be considered to avoid, or at least understand, errors that might creep in. T_{cold} is usually taken to be T_0, but the temperature of the lab or workshop in which the measurements are made could very well differ by a few degrees from 290K, and there will be a corresponding error introduced. T_{hot} must be known accurately for the particular noise source. The matching conditions of the noise source to the receiver or amplifier should duplicate the conditions that will apply in the operational system. It is not certain that the source impedance of the noise generator when it is fired will be the same as when it is cold. Any difference that does exist will introduce an error in T_e, but it is difficult to establish any such impedance shift.

The output meter should be a true square-law device with voltage or current. In other words it should be accurately linear as a function of power. Any overloading or non-linearity in the amplifier will introduce errors. For instance, the common f.m. receiver is non-linear for amplitude changes, and cannot be investigated by the above method. (The front end could be checked separately, but we are discussing a.m. noise, which would normally be eliminated in this kind of receiver anyway. In f.m. systems the more difficult f.m. noise has to be considered). Errors also arise at the higher frequencies, mainly because of the usual effects of the stray reactances.

Sources of wideband noise, diode noise generators

One of the most useful noise generators for frequencies up to a few hundred megahertz is based on the temperature limited diode. The full shot-noise generated by a thermionic diode operated under these conditions can be calculated exactly, but involves fairly complex statistical ideas such as Campbell's theorem. A treatment can be found in reference 9 (see part 1). Pierce derived the shot noise equation very simply but his method lacks the rigour demanded by. purists. It is an interesting derivation and I have included an outline of it in Appendix C. The full shot noise produced on a direct current I_a in a bandwidth B, is

$$\overline{i^2}_{shot} = 2eI_aB$$

where e is the charge on an electron.

Because the diode is saturated, the effective source resistance of the shot noise generator is very high indeed. Fig. 8 shows a typical circuit for a diode noise generator with a source resistance, R. The equivalent circuit is also shown. The total available noise power from the generator is the sum of the noise power from the shot source and that from R, which is at the ambient temperature T. The two sources of noise power are not correlated, so that their outputs add directly as we have seen earlier. From Fig. 8(b) the available power from the two current generators is

$$P_N = \frac{\overline{i^2}_{tot}}{4G} = \frac{\overline{i^2}_{shot} + \overline{i^2}_R}{4G}$$

where the conductance G is equal to $1/R$.

$$\therefore P_N = \frac{eI_aBR}{2} + kTB.$$

Excess noise temperature, T_D, for a saturated diode is obtained by equating the first term on the right hand side of this last equation to kT_DB, so that $T_D = eI_aR/2k$. The numerical values of the physical constants, e and k give the value 11,600 for the quotient e/k. Therefore $T_D = 5800I_aR$. The total noise temperature of the fired source is T_D plus the contribution from R

$$T_{hot} = 5800I_aR + T \qquad (7).$$

The cold temperature is simply T, because with the diode off, $I_a = 0$ and no contribution is forthcoming from the shot noise term. From these considerations we know the values of T_{hot} and T_{cold} to use in equation (6). Putting in the quantities gives

$$T_e = \frac{5800I_aR + T - AT}{A-1}$$

which conveniently simplifies to

$$T_e = \frac{5800I_aR}{A-1} - T.$$

A number of authors have used the ideas of the noise ratio and excess noise ratio. I think we have enough detail from the preceding discussions to illustrate at this point, how these ideas are used. You may recall the definition involves the ratio of the temperature to 290K or the ratio of the excess temperature to 290K respectively. The ratios obtained are really noise power ratios, in which the bandwidth and Boltzmann's constant cancel. Being a power ratio, the results are often expressed in decibels. By dividing the equation above by 290K we obtain the noise ratio t_e

$$t_e = \frac{T_e}{290} = \frac{20I_aR}{A-1} - \frac{T}{290}$$

Often T is taken equal to 290K (but see my earlier cautionary note); in that instance this equation becomes

$$t_e = \frac{T_e}{290} = \frac{20I_aR}{A-1} - 1.$$

The *excess* noise ratio for a diode generator can be obtained from equation (7) by subtracting 290K from both sides, then dividing by 290K

$$\frac{T_{hot}}{290} - 1 = 20I_aR + \frac{T}{290} - 1$$

and again if $T = 290$K

$$\frac{T_{hot}}{290} - 1 = 20\, I_aR.$$

The diode noise source is very convenient because the temperature and noise ratios are directly proportional to I_a, and by just winding up the filament temperature, I_a can be set to any convenient values on an accurate anode current meter. (With due care not to burn out the filament of course!)

Ordinary lumped-component circuitry begins to fail as the frequency of operation rises toward the GHz region. The diode noise generator is no exception and errors begin to affect the result when measuring at the frequencies in question. Another effect becomes important at the same time: transit time of the electrons across the cathode to anode space is significant in the hundreds of megahertz range and the shot noise equation begins to break down.

To be continued

Appendix B

Noise equivalent bandwidth

Perhaps you have noticed in the discussion so far, I have blandly assumed that G_A is "the power gain", without any real attempt to discuss how this quantity varies with frequency. Most amplifiers, whether intended or not, are severely limited in their frequency response. This means that G_A is a maximum somewhere near the centre of the band and drops off towards zero at both ends of the response, except for d.c. amplifiers. If you think of a constant distribution of energy over the frequency spectrum (white noise) then the bandpass function "weights" the contribution in each very small band at points across the response. The total output power is a sum of all these weighted contributions. This is the kind of reasoning we do when finding averages. Fig. B shows an example to make the point clear.

We can imagine G_A to stay at its maximum value for a bandwidth B, then drop off sharply to zero at each side. If the width B of this fictitious rectangular bandpass curve is such that the output power is the same as from the actual response, then B is defined as the "equivalent noise power bandwidth". What we have really said is that the area of the rectangular curve is made the same as the area of the actual curve. This gives us a clue about the mathematical approach to writing down the definition. If the available noise power is constant over the band then the available noise power in *any* small band df, is Kdf. K is the constant level. Therefore the available output power is $G_A(f)Kdf$ and the total output power is

$$P_{No} = K\int_{bandpass} G_A(f)df.$$

By definition, the total output power is also

$$P_{No} = KBG_{A(max)} \qquad \text{(B1)}$$

Equating these gives

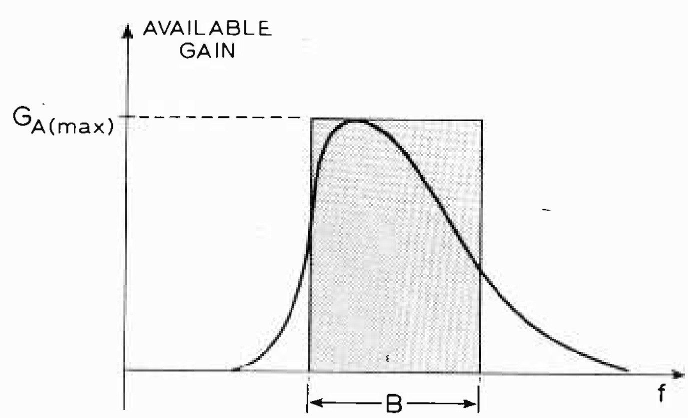
$$B = \frac{\int_{bandpass} G_A(f)df}{G_{A(max)}} \qquad \text{(B2)}$$

This is alright if you can do the integration or look it up in tables, but if, as usual, no simple function exists for $G_A(f)$, then the integral would have to be solved numerically. Equation (B1) shows that the amount of noise power emanating from the output of a system is proportional to the gain-bandwidth product $BG_{A(max)}$.

Note that B is not the ordinary "half-power" bandwidth; a simple example shows this to be true by relating the two bandwidths.

Consider the bandwidth to be limited by a series tuned circuit. The reactance at any frequency will be $X = \omega L - (1/\omega C)$. Using the equation for G_A (p.110) available gain is

Fig. B. Area of the shaded rectangle is equal to area under response curve. Height is $G_A(max)$ and width is definition of equivalent noise bandwidth, B.



$$G_A=\frac{K'R_{in}{}^2R_gn^2}{(n^2R_g+R_{in})^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}$$

which can be written

$$G_A=\frac{constant}{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}$$

where R has been written for $n^2R_g+R_{in}$. From this, $G_{A(max)}$ is $constant/R^2$. At the 3-dB points $|X|=\pm R$ because G_A is then equal to $\frac{1}{2}G_{A(max)}$. This condition enables us to write down the frequencies of the 3-dB down points. From $R=\omega C-(1/\omega L)$ and $-R=\omega C-(1/\omega\ L)$ we get two quadratic equations whose solutions are

$$\omega_1=\frac{R}{2C}\pm\left(\frac{R^2}{4C^2}+\frac{1}{LC}\right)^{\frac{1}{2}}$$

and $$\omega_2=-\frac{R}{2C}\pm\left(\frac{R^2}{4C^2}+\frac{1}{LC}\right)^{\frac{1}{2}}$$

Subtracting gives the frequency difference

$$B_{3dB}=f_1-f_2=\frac{\omega_1-\omega_2}{2\pi}=\frac{R}{2\pi C}.$$

Using equation (B2)

$$B=\frac{1}{2\pi}\int_o^\infty\frac{1}{1+\left(\dfrac{\omega C}{R}-\dfrac{1}{\omega LR}\right)^2}d\omega$$

The integral is a "do-able" one, and involves $\tan^{-1}$ type solutions. Carrying out this solution, B is $R/4C$, which means that the relationship between B and B_{3dB} for a single tuned circuit is $B=\pi B_{3dB}/2$. Thus B is somewhat wider than B_{3dB}. The Table shows a few relationships for other band-limiting filters.

Circuit	Relationship
Two cascaded tuned circuits	$B=1.22B_{3dB}$
Three cascaded tuned circuits	$B=1.16B_{3dB}$
A staggered pair	$B=1.11B_{3dB}$
A 4-pole Butterworth filter	$B=1.11B_{3dB}$
A 6-pole Butterworth filter	$B=1.05B_{3dB}$

The noise bandwidth approaches the 3dB bandwidth more and more closely as the "shape factor" improves. For ordinary i.f. amplifiers with a number of tuned stages, there is very little error if you assume $B\doteq B_{3dB}$.

Appendix C
Shot noise equation

A simple but not very rigorous derivation of the shot noise current equation was ingeniously put forward in J. R. Pierce's paper, "Noise in Resistances and Electron Streams" published in the *Bell System Technical Journal*, volume 27 (1948). It goes something like this:

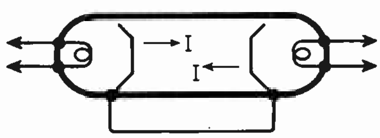


Fig. C. Artificial double cathode "diode" used by J. R. Pierce to derive the shot noise equation.

If a diode consisting of two emitting cathodes (Fig. C) has a potential V between them, a current I will pass equal to $I_V=I_0exp(eV/kT)$, where I_0 is the current that passes when $V=0$; that is, by the thermally energetic electrons "bridging the gap". Differentiating gives

$$\frac{dI_V}{dV}=\frac{1}{r_a}=\frac{I_oe}{kT}e^{eV/kT}$$

As the mean square noise current expected from a resistance r_a is $\overline{i^2}=4kTB/r_a$ and the diode "resistance" at zero volts is $r_a=kT/I_0e$, it follows that $\overline{i^2}=4eIB$ after substituting for r_a. This is the total noise current produced by the special case of two cathodes exchanging current. Because noise powers add, then the mean square current of one cathode is half the value and therefore $\overline{i^2}=2eIB$, which is the shot noise equation.

(To be continued)

Wireless World noise reducer

Next month's issue will contain the start of an article describing the *Wireless World* noise reducer, an add-on Dolby processor mainly for use with magnetic tape cassette machines. This constructional design, the only one of its kind, has been planned in close collaboration with Dolby Laboratories and will be available from *Wireless World* in kit form.

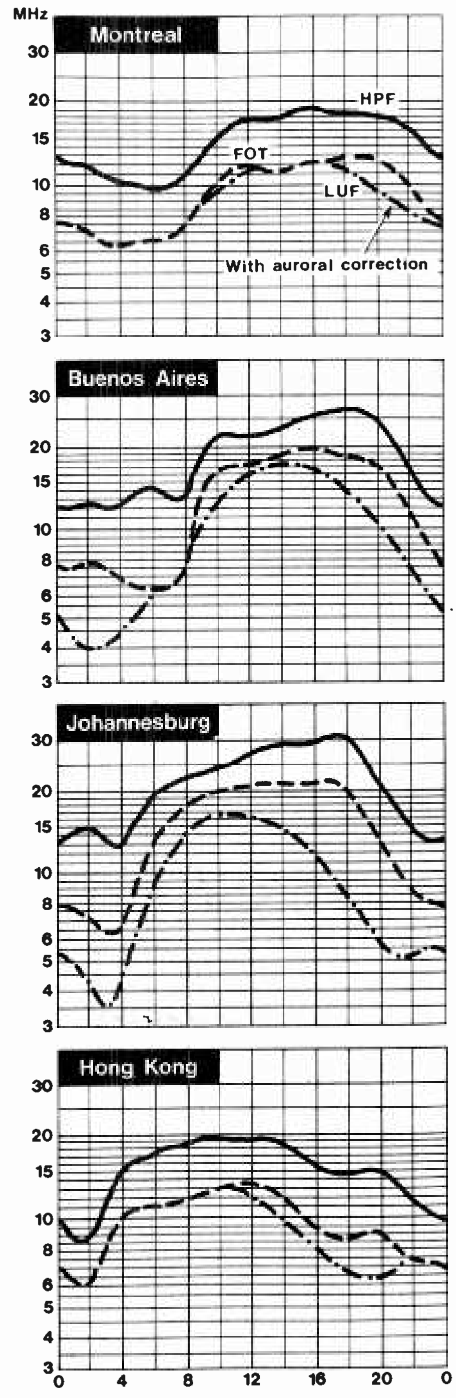
The unit includes a stereo Dolby B processor that is switchable for both encoding and decoding. This means that as well as decoding commercial Dolby B cassettes, encoded tapes can be prepared. For recording stereo broadcasts, a switched 19kHz pilot-tone filter is included. And should B-type encoding be adopted for f.m. transmissions, as in the USA, the unit will also decode those. There is another use of the processor. Because of the improved signal-to-noise ratio obtained with the unit, recordings can be made at a lower level that would otherwise be possible. Consequently some of the noise reduction can be traded for a lower distortion level at peak recorded levels.

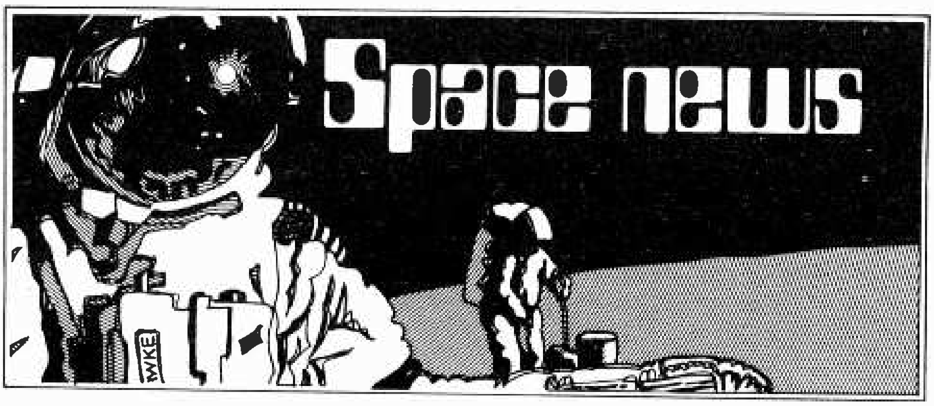
The *Wireless World* Dolby processor can be aligned without using additional instrumentation. The circuit board has been designed to include the required alignment facilities—400Hz and 5kHz oscillators are constructed from components in the *WW* kit, together with a 1-kHz meter calibration oscillator. Full alignment and calibration instructions are included in the article, which starts in the May issue with a description of the Dolby system and its functioning.

HF predictions

Predicted disturbed periods are March 23–28, April 4–10 and 19–25.

Seasonal trend and low solar activity combine to produce FOTs and LUFs which give a restricted choice of time and frequency for reliable day-to-day communication. The charts show that the restriction is severe when both ends of a circuit are in the northern hemisphere.





Seventh Intelsat IV Launch

The seventh in the series of Intelsat IV commercial communications satellites was launched on February 20 after a delay of two weeks from Cape Canaveral.

Final position of the 1400kg satellite is on the equator over the Indian Ocean. When in position there will be three Intelsat IVs over the Atlantic Ocean, two over the Pacific and two over the Indian Ocean, completing the world-wide network originally planned. Each of these satellites is able to carry approximately 3,500 two-way telephone conversations and 12 television channels. Despite the growth already experienced, the pressure of rapidly growing demands for international telephone, television and data transmission has led to the development of even larger communications satellites. The first of a new series designated Intelsat IV-A, with twice the capacity of Intelsat IV is scheduled for launch in the summer of 1975. The satellites are owned by the International Telecommunications Satellite Organization. Frequency re-use by means of a modified communications subsystem using 20 transponders and a novel antenna configuration with separate antenna beams will aid the capacity doubling of the A series. The opening of the frequency spectrum above 10GHz to satellite communications approved by the World Administrative Radio Conference in 1971 will eventually provide communications capacity at least five times higher than that available at the presently used frequencies of 4 and 6GHz.

The delay in launching the most recent Intelsat IV satellite which was scheduled for launch on February 6, was due to the failure of a single electronic component in the spacecraft.

Weather Satellite for Western States

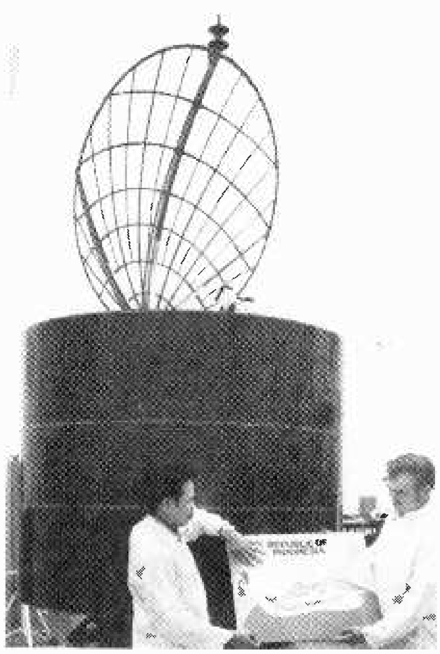
The second in a series of weather satellites, Synchronous Meteorological Satellite-B, was scheduled for launch by NASA from Cape Canaveral aboard a Delta rocket at the end of January.

SMS-B (called SMS-2 in orbit) is to be placed in geosynchronous orbit over the equator at 36,357km altitude at 135 degrees west longitude, which is directly south of Sitka, Alaska, and about 15 degrees southeast of Hawaii. From this position it can view the western half of the United States and Hawaii while its sister spacecraft, SMS-1, can view the eastern US from its perch at 75 degrees west longitude on a line with New York City and just south of Bogota, Columbia.

The two spacecraft will be able to keep a 24-hour watch on the western hemisphere and provide cloud-cover pictures every 30 minutes to weathermen of the National Oceanic and Atmospheric Administration. Each carries a visible and infrared spin-scan radiometer that returns visible light daytime pictures of 0.9km resolution day and night. This continuous coverage is of special importance for short term phenomena such as the severe storm conditions that precede tornadoes. In addition, the west coast of Africa, breeding ground for hurricanes that strike the Caribbean, Florida, Gulf of Mexico and US east coast areas, will be kept under the surveillance of SMS-1. The primary types of data to be obtained consist of meteorological, seismic and tsunami information. Both SMS spacecraft also carry a space environment monitoring system that monitors solar particle flux, X-ray emission and magnetic field direction and strength.

The US synchronous orbit spacecraft are expected to be joined, beginning in 1977, by similar spacecraft placed in orbit by the European Space Research Organization, Japan and Russia to form a global network of synchronous orbit satellites. The two SMS spacecraft, including all on-board instrumentation cost about $60m, the Delta launch vehicles about $4.5m each.

Copy of Indonesia's national communications satellite, scheduled to be in orbit after mid 1976, is pictured at Hughes Aircraft Company in California.



Self-repairing Memories

A technique for the self-checking of a faulty memory on board space-craft* is under development by Intertechnique, a firm best known for its nuclear instruments and minicomputers. The concept was reported at the Large Scale Integrated Circuits Conference in Paris early in December. The self-check of a memory removes the data stored in it so the feature would be of little value in missiles after they have been fired but could be valuable for satellites. The check can be made after the memory is dumped and its contents transmitted to a ground station, but before it starts to store information again. Intertechnique's concept, which has been patented, is for the memory to check itself at two levels. The lower level is in the basic memory elements, made up of one or several shift registers. These basic elements are grouped together on a printed circuit board along with complementary-m.o.s. test and control logic integrated on a custom chip. Each element has a set of control logic and when a test sequence reveals a faulty one, the associated logic, in effect, shunts it out of the shift-register chain. These so-called elementary cards in turn work under control of a "system card" which contains circuits that interface the memory with the rest of the telemetry system plus c.m.o.s. logic to start tests of the elementary cards. If the test logic on one of them is faulty, meaning that reorganization at the lower level can no longer be made, the system logic shunts around the card and reconfigures the memory accordingly. The European Space Research Organization has so far funded the work.

**Electronics International*, December 1974, pp.14E, 16E, 18E.

Briefly

The Mariner-Jupiter mission scheduled by NASA for launch in 1977 will be the first deep-space probe to use X-band for telemetry and video transmission.

Skynet II, Europe's first communications satellite has recently been accepted as an operational system by the RAF acting on behalf of the Ministry of Defence.

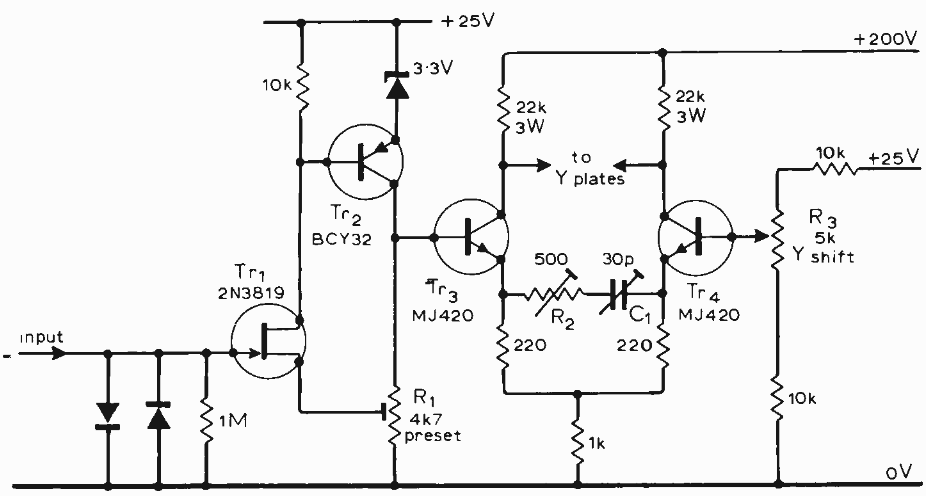
Deflection amplifier for oscilloscopes

The circuit combines the advantages of a differential output stage and a high-impedance j.f.e.t. input stage. The silicon input diodes form a crude overload protection for the input of the f.e.t. amplifier. Transistors Tr_1 and Tr_2 act together as both an amplifier and a level shifter, the quiescent output voltage of Tr_2 being set by R_1 to approximately 15V. This also sets the gain of the amplifier unfortunately. A multi-turn preset was used for this purpose as the setting can be quite critical.

Transistors Tr_3 and Tr_4 form a differential output stage enabling an output saving of about 400V pk-pk. Feedback is introduced through the 220 ohm emitter resistors and high-frequency compensation is brought about by R_2 and C_1. Resistor R_3 forms the Y-shift control.

To set up for operation, set R_2 and C_1 to their maximum values. Set +15V at the collector of Tr_2 using R_1. Inject a 10kHz square wave into the amplifier and increase C_1 to give the sharpest possible corner to the display without overshoot. Then increase R_2 as far as possible without losing too much of the squareness of the display.

G. A. Johnston,
Stechford,
Birmingham.



Oscillator uses passive voltage-gain network

It is frequently necessary to make a simple oscillator when a limited range of components are available. Most phase sensitive networks used to define the frequency of oscillation have attenuation at zero phase shift. A Wien bridge attenuates three times, a three-stage RC iterative filter 29 times. It is therefore necessary to use an amplifier, but the bandwidth of the convenient 741 is limited and it is a significant item of expense in this context.

Consider the circuit of Fig. 1. When $a=2+2\sqrt{2}$,

$$\frac{V_o}{V_i}=\frac{2}{2\sqrt{2}-1}=1.094$$

for zero phase shift and $\omega CR=1$.

It is easy to obtain an output from an emitter follower greater than 1/1.094.

The circuit of Fig. 2 was tried using a super-alpha pair.

An output of 20V pk–pk was obtained. Factor a was fixed at $4.7\approx 2+2\sqrt{2}$ as a preferred value.

A 4-V, 0.2W capless pilot bulb was used to stabilize the loop gain to unity, rather than the rarer R53 thermistor.

W. R. Jackson,
University of Bristol.

Fig. 1

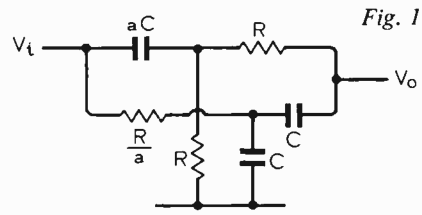
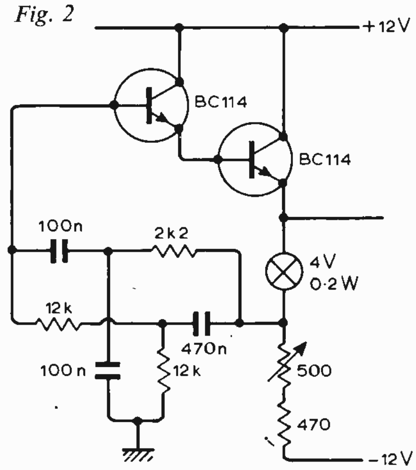


Fig. 2



Low battery voltage indication

May I add something more to the interesting idea of P. C. J. Parsonage (*Circuit Ideas*, January 1973).

- The low battery voltage indicator circuit can be modified to work as a high battery voltage indicator, or simply a high voltage indicator, just by interchanging gate and cathode connections of the thyristor. In particular, say a battery voltage is 8.3V and needs to be charged to 9V, then the circuit of Fig. 1 can be used. The l.e.d. lights when battery charges to 9V.

Fig. 1

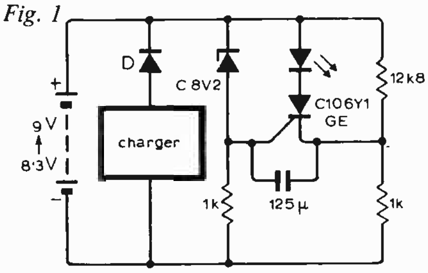


Fig. 2

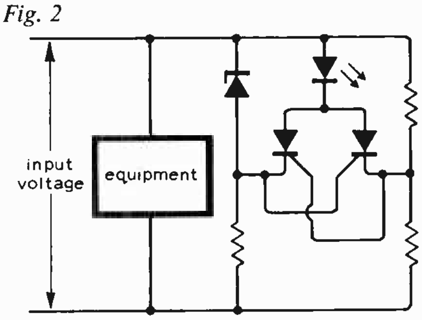
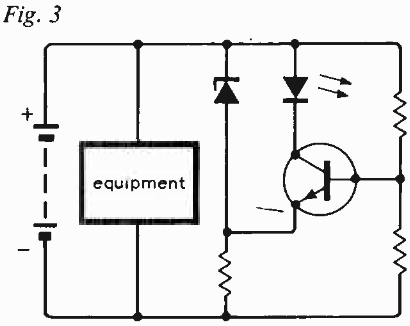


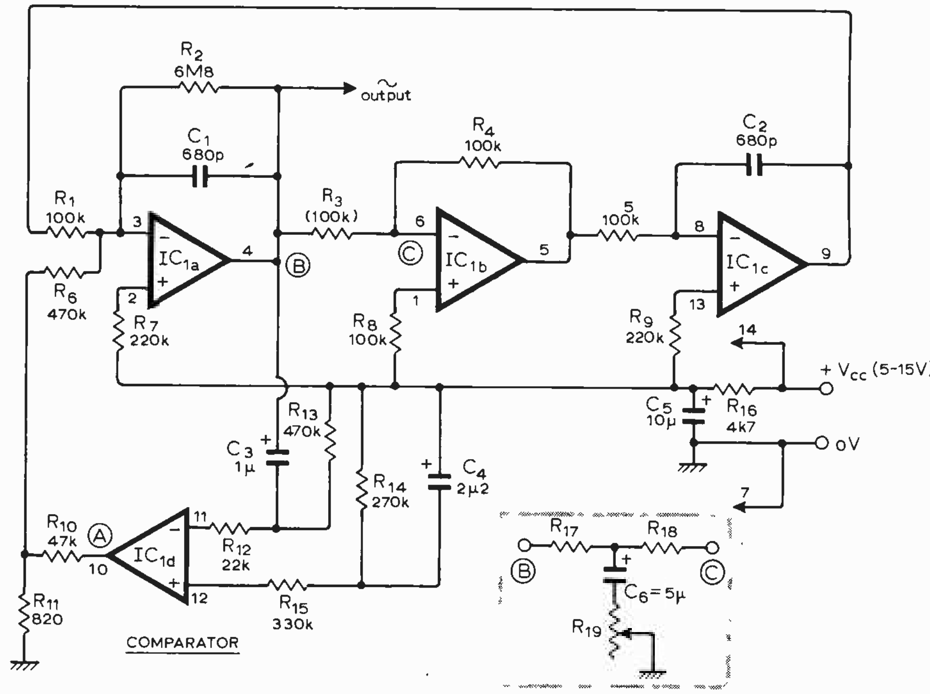
Fig. 3



- The l.e.d. in the circuit of Fig. 2 lights up when the input voltage is > or < $(V+\Delta V)$, where V is the normal voltage at which circuit is designed and ΔV is the change in input voltage at which l.e.d. lights up.
- The cost of the equipment can be cut slightly by replacing the thyristor with a less costly silicon switching transistor, Fig. 3. This circuit can return to its original state (l.e.d. off) when the voltage returns to its design value.

P. R. K. Chetty,
ISRO,
Bangalore.

Circuit Ideas



Sine oscillator uses c.d.a.

The circuit, new in realization but not in principle, produces moderately low-distortion sinewaves (typically 0.5% t.h.d.) which have negligible amplitude bounce on changing frequency. Further advantages are the ability to alter frequency with a single component and the low cost of the quad differential amplifier (LM3900N).

When the supply is switched on the comparator output initially goes to $+V_{cc}$; after about a second C_4 has charged and the output rapidly slews to 0V. This shocks the bandpass filter, formed by the two integrators IC_{1a}, IC_{1c}, and the inverting amplifier IC_{1b}, and causes it to ring. The resultant sinewave causes the comparator to produce a square wave which is fed back into the loop to sustain oscillation. Sinewave amplitude is stabilized by virtue of the constant square wave input and is typically $0.25V_{cc}$ pk–pk, its purity being proportional to filter Q.

Frequency of oscillation (2.34kHz) and Q(62) are:

$$2\pi f=\sqrt{\frac{R_4}{C_1 R_1 C_2 R_5 R_3}} \qquad Q=\omega C_1 R_2$$

Note that owing to the internal compensation of the amplifiers significant Q-enhancement occurs at frequencies greater than a few kHz and this may lead to oscillation of the filter itself.

To vary the frequency the inset network can be used in place of R_3, the effective impedance being

$$R_{13}=R_{17}+R_{18}+\frac{R_{17}R_{18}}{R_{19}}$$

T. J. M. Rossiter,
Corpus Christi College,
Cambridge.

Pulse height modulator

This circuit reduces the spike feedthrough in series f.e.t. gates by always limiting the gate voltage swing to between the source voltage and the pinch-off voltage. Referring to Fig. 1, if the input voltage (V_i) is

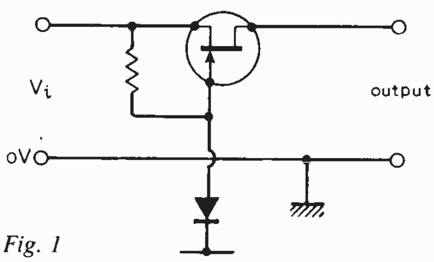


Fig. 1

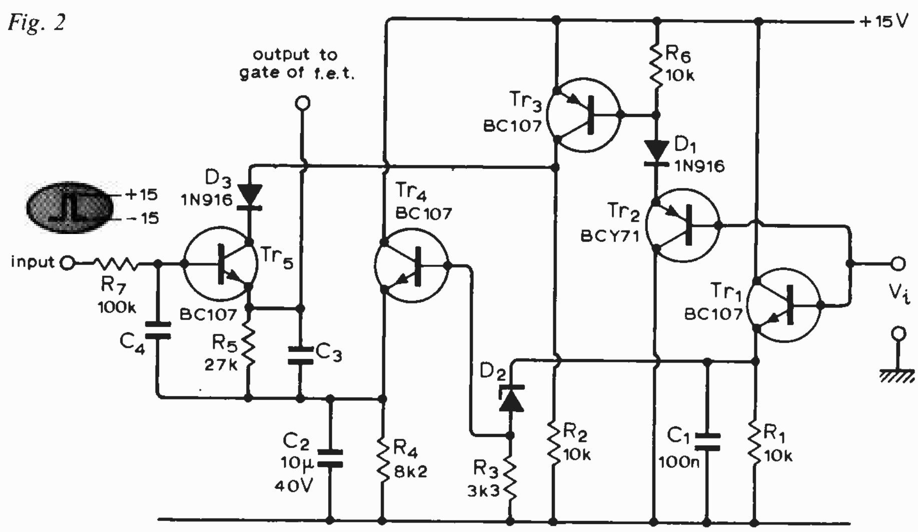
varied between 0 and 13V, say from an op-amp, then the f.e.t. gate would have to be swung from +13V to $-V_p$ volts (V_p is pinch-off voltage). Fig. 2 shows one version of a circuit used to limit the voltage swing on the f.e.t. gate to approximately V_i-V_p. Input voltage is monitored by the emitter followers Tr_1 and Tr_2 and Tr_1 emitter is maintained at $V_i-V_{be}\approx V_i-0.7$V. Zener diode D_2 is matched as nearly as possible to the *measured* V_p of the particular f.e.t. in use. If $V_p<1$V a forward-biased diode (e.g. 1N916) may be used. The emitter of Tr_4 is therefore established at $V_i-V_p-1.4$V. Tr_2, Tr_3 and D_1 establish the upper limit of the voltage swing to $\approx V_i$. The switching waveform, a ±15V squarewave with fast rise and fall times, drives the base of Tr_5. Clearly from Fig. 2 the output waveform cannot go below $V_i-V_p-1.4$V or above V_i.

Capacitors C_3 and C_4 are optional. Capacitor C_4 increases the rise time of the output signal and C_3 increases the fall time. Very slow turn off times can be obtained by suitable adjustment of C_3 thereby giving further spike reduction. Resistor R_7 should be kept high because for low values of V_p and high values of V_i the emitter-base junction of Tr_5 will become reverse biased. Alternatively a diode can be placed between the emitter and R_5.

The modulator was tried with a number of different types of f.e.t.s and always reduced the spike amplitude when compared to the spike produced by a full ±15V swing on the gate. By using a slow fall time the spike amplitude for this edge could easily be reduced by an order of magnitude. The circuit may need slight modification to suit individual requirements but works well with a slowly changing analogue signal and with switching rise/fall time of the order of 1µs.

M. D. G. Dabbs,
Home Office Central Research Establishment,
Aldermaston, Berks.

Fig. 2



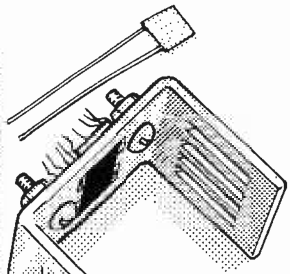
New. Sinclair IC20. 20 watts stereo amplifier kit for only £7.95 (plus VAT)

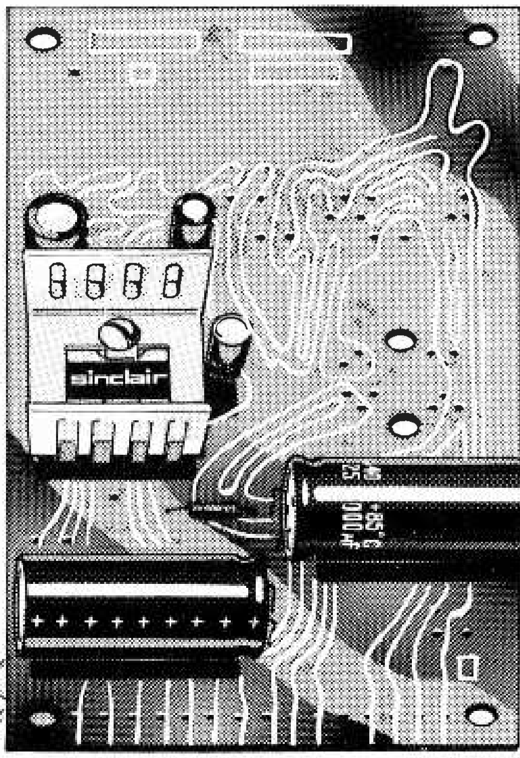
A build-it-yourself stereo power amplifier with latest integrated circuitry... 10 W RMS per channel output... full short-circuit and overheat protection.

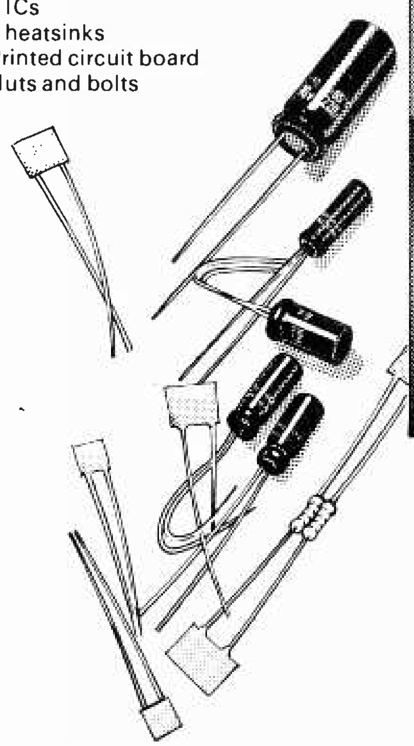
Latest from Sinclair – the brand new IC20 power amp. It incorporates state-of-the-art integrated circuits – 2 monolithic silicon chips each containing the equivalent of over 20 transistors ! These deliver 10 W per channel into 4 Ω speakers. And the IC20 has integral short-circuit protection and thermal cut-out – it's virtually indestructible !

How should I use the IC20?
Use the IC20 for converting your mono record player to stereo ... for upgrading your existing stereo ... for improving your car radio/tape player. The IC20 runs off a 9-24 V power supply. If you're running the IC20 off the mains, simply add a Sinclair PZ20 power supply (£4.95 plus VAT).

Using the IC20 to improve your car radio/tape player's quality and volume ? Run the IC20 off the car battery direct. You don't need a separate power supply, and you're reducing the drain on the player's dry batteries.







A complete kit!
6 resistors
15 capacitors
2 ICs
2 heatsinks
Printed circuit board
Nuts and bolts

Typical performance of the IC20 stereo amplifier
Supply voltage: absolute maximum 24 V, minimum 6 V.
Current consumption: *24 V, no signal* – 20 mA each channel.
18 V, 9 W into 4 Ω – 770 mA each channel.
Power output: *14 V supply, 4 Ω load, 10% distortion* – $5\frac{1}{2}$ W RMS per channel, *20 V supply, 4 Ω load, 10% distortion* – 10 W RMS per channel.
Total harmonic distortion: at *50 mW, 4 Ω load, 20 V supply* – less than 0.1%.
Input sensitivity: *for 9 W into 4 Ω* – 90 mV.
Frequency response: – 3 dB at 40 Hz and 16 KHz.
Load impedance: 4 Ω or 8 Ω, but device is safe with any load.

Improve your audio equipment – today

Both the IC20 and the PZ20 are covered by the Sinclair one-year, no-quibble guarantee – if absolutely any defect arises, Sinclair will replace the whole unit – unconditionally.

You can find both the IC20 and the PZ20 at stores like Laskys and Henry's. But if you have any difficulty, send us a cheque direct and we'll send you an IC20 and/or a PZ20 at once. 14-day money-back undertaking, naturally.

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An aerial rotator servo

by D. J. Telfer, A.R.I.C.

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This article describes a circuit for remotely adjusting angular displacements in a drive shaft, for use with 12–24V d.c. motors at continuous currents of up to 250mA. The system is well suited to a wide range of applications and has been very successfully employed as an automatic aerial rotator. The advantages of proportional control are available while preserving low cost and simplicity of design.

Sometimes there are applications in which the full potential of elaborate control equipment may not be fully exploited. In such instances, a less complex and more economical system could adequately perform the required operations. The control system to be described in this article is simple and yet has been found to be reliable in operation and particularly well suited for use in automatic aerial rotators. Although it was initially designed, while the author was with the Department of Physics, UMIST, for remote positioning of furnace charges, the circuit lends itself to many other possible applications, not least in the teaching laboratory as a technique for demonstrating the use of feedback systems and the principles of proportional control.

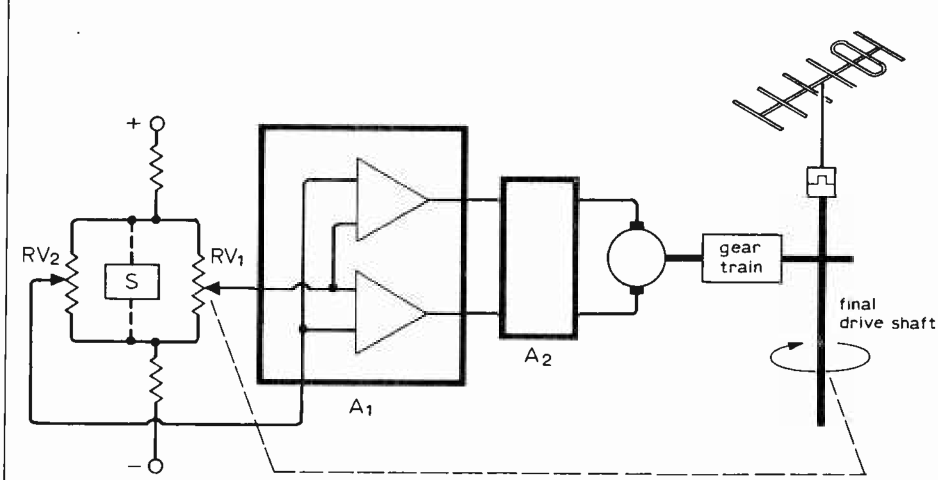


Fig. 1. Block schematic diagram of the proportional control system.

Proportional control system

A block schematic diagram is shown in Fig. 1. Use of a Wheatstone bridge to provide positive or negative error signals follows conventional practice. The spindle of one potentiometer RV_1 is mechanically coupled to the final drive (signified by the dotted line) and the other potentiometer RV_2 is the final drive position selector. A difference in the relative positions of the wiper arms of RV_1 and RV_2 produces an error signal which is amplified, firstly by the differential amplifier A_1 and then by an output stage A_2 connected to the motor, whose direction and speed depend on polarity and magnitude, respectively, of the voltage applied across its terminals. The final-drive shaft keeps turning until the wiper arm position at the motor-driven potentiometer catches up with the selected setting of the control potentiometer. The error signal is thereby continually reduced until the motor stops with the final-drive shaft in the desired position. In the author's design, operational amplifiers are used for A_1, and A_2 consists of two pairs of complementary emitter followers. An additional feature is the

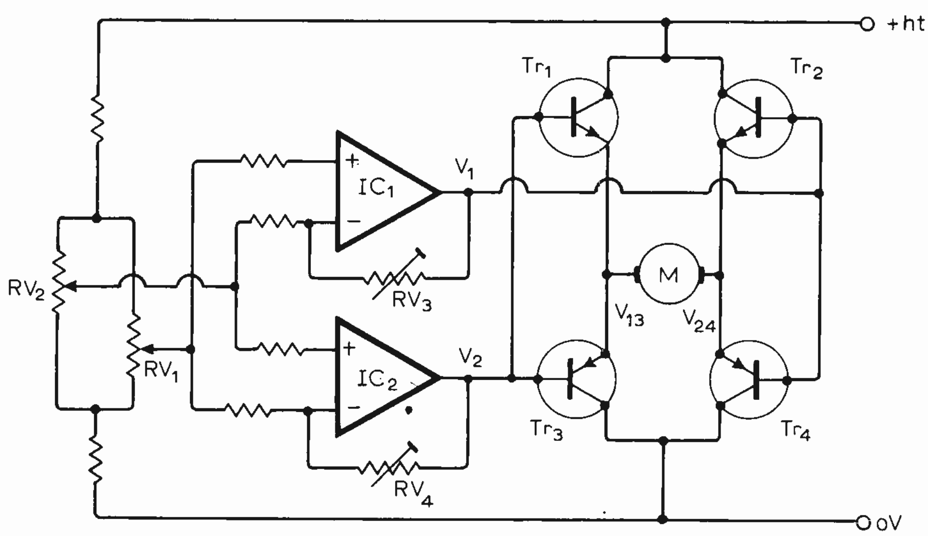


Fig. 2. The final drive shaft of motor M is coupled to the wiper arm of RV_1.

electronic bridge shunt S, which is activated at the final stage of operation to ensure that the motor is switched off.

Amplifier. In Fig. 2 the d.c. error voltage is taken to a pair of differential amplifiers IC_1 and IC_2, whose gain is adjusted with preset potentiometers RV_3 and RV_4 respectively. When the wiper arm of RV_2 is more positive than that of RV_1, the output of IC_1 goes negative and that of IC_2 goes positive. Under these conditions, Tr_2 and Tr_3 are turned off, while Tr_1 and Tr_4 are turned on, affording a low resistance path through which the motor is connected across the supply. If the wiper arm of RV_1 is more positive than that of RV_2, Tr_1 and Tr_4 are turned off and conduction is through Tr_2 and Tr_3, whereupon polarity of the voltage applied to the motor is reversed.

Proportional control. The mode of operation is conveniently described by assigning three states to the system. Fig. 3(a) shows how the output voltage of IC_1 (V_1) and of IC_2 (V_2) varies with angular displacement, θ, of the driven potentiometer spindle with respect to the setting chosen for RV_1, which is represented by $\theta = 0$ at A.

In region D–C, the input signal is large enough to saturate both amplifiers IC_1 and IC_2. Motor voltage, which depends upon the difference between V_1 and V_2, is held at a maximum value. The final-drive shaft rotates at a constant angular velocity, and the spindle of RV_2 is driven towards the selected rest position that it will eventually take up at A.

At an angle θ_2 from A, which is predetermined by the setting of RV_3, the error voltage falls below that level required to saturate IC_1, and V_1 steadily decreases. Passage through C represents the onset of proportional control.

In the region B–A, amplifier IC_2 is no longer held at saturation. However, the setting of RV_4 is such that it has greater gain than IC_1. Its proportional control bandwidth, given by $2\theta_1$, is correspondingly narrower than that of IC_1. The value of $V_1 - V_2$ continues to fall, ideally reaching zero at A. If these conditions are faithfully transmitted to the motor, there is no residual current in the windings and the final-drive shaft comes to rest with the spindle of RV_2 exactly in the position determined by RV_1. In practice, the motor may stop when an appreciable voltage is still being applied to its terminals. Since at B the value of $V_1 - V_2$ is just over half its maximum value at C, this event will be captured within the narrow region BA, provided that mechanical loading is not excessive and that the motor is not severely under-run. Although the author has experienced no difficulty on occasions when 24V motors were run using a 12V supply, it is recommended that the h.t. voltage should be at least 60% of the voltage rating for the motor.

The output voltages of IC_1 and IC_2 are not transmitted faithfully to the motor because of the emitter-base voltage drop incurred at the power transistors. In Fig. 3(b), the emitter voltages of transistor pairs Tr_1, Tr_3 (V_{13}) and of Tr_2, Tr_4 (V_{24}) converge to plateaux centred at A. The difference between V_{13} and V_{24} is therefore the voltage applied to the motor. However, the range of θ values over which the motor is stationary, SAS′, may be compressed by increasing the gain of IC_2. This will not affect the overall proportional control bandwidth of the system, which is given by $2\theta_2$, and is dependent on the gain of IC_1.

Protection of transistors. Quite low values of residual voltage across the motor can give rise to standing currents high enough to justify an automatic switching arrangement for protection of the conducting pair of output transistors, which will dissipate maximum power just before they become biased to cut-off, when the emitter-collector voltages approach their highest values. The motor may be made to cut out below a certain applied voltage, within the region BA of Fig. 3(b), by connecting a suitable relay across the motor. For example, a motor rated at 24V maximum was run with 20V on the h.t. rail of the circuit. Satisfactory action was obtained from a reed switch having a solenoid resistance of 800Ω, operating at 7V.

Any such cut-out device must come into operation before the motor has actually stopped, resulting in a dead zone about A in Fig. 3(b) which is greater than SAS′. This state of affairs may be avoided by introducing a time delay so that the motor can stop at its limiting voltage before being switched off.

An alternative switching method, incorporating a delay, is shown in Fig. 4. This solid-state approach, which the author has found to be very effective, uses a complementary pair of transistors shunted across the bridge potentiometers. Conductance of the transistor pair Tr_5 and Tr_6 is appreciable only when both base voltages are within a limited range centred on half h.t. potential. The state of this circuit may first be considered with the input diodes D_3 and D_4 disconnected from the output of IC_2.

The bases of Tr_5 and Tr_6 are connected by a resistor through which most of the mutual base current will flow, since D_3 and D_4 are reverse-biased by the small potential difference reflected across this resistor. Base bias is forward at both transistors, which conduct and act as emitter followers. Their mutual load is the bridge, across which the voltage falls to a value approaching the sum of the voltages across the interbase resistor and the emitter-base junctions. In practice this total amounts to about 2V.

Next the connexion of D_3 and D_4 to the output of IC_2 is restored, via a limiting resistor R. No significant change will occur at the bridge shunt until the small reverse bias voltage at either D_3 or D_4 is cancelled by a voltage swing at IC_2, transmitted through R. When the output of IC_2 goes sufficiently positive, conduction through Tr_6 is maintained but Tr_5 is cut off. Conversely, Tr_5 conducts and Tr_6 is turned off during negative excursions. The diodes D_1 and D_2 protect Tr_5 and Tr_6 from Zener breakdown of their base-emitter junctions under reverse biasing conditions.

Finally, the onset of shunting action is delayed by introducing a capacitor C between the input of the shunt circuit and ground. A suitable choice of time constant for RC is about one-fifth of the duration of the proportional control régime.

Practical circuit

The circuit diagram of a practical design for use with 24V d.c. motors appears in Fig. 5. An electronic bridge shunt is employed and the unit may be run from a 15 to 28V supply. Feedback capacitors are included to lower the a.c. gain of the operational amplifiers in order to reduce transient response and provide a safe-

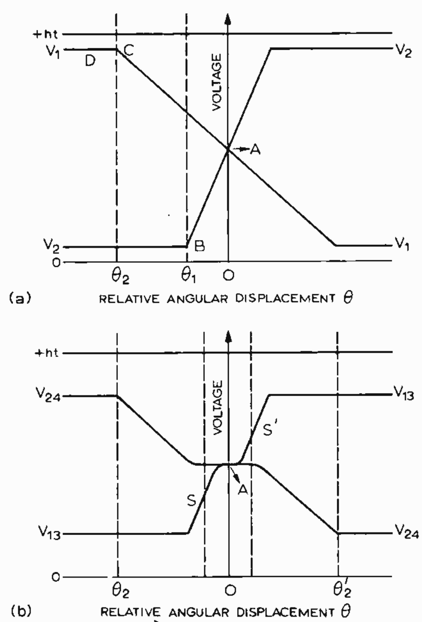


Fig. 3(a). Voltage at IC outputs plotted against θ; at (b) is shown the voltage at emitters of power transistors plotted against θ. Limiting voltage of the motor is reached at S and S′.

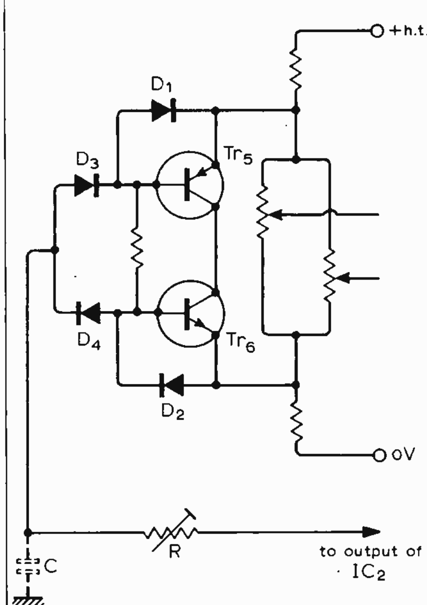


Fig. 4. Circuit diagram of bridge shunt.

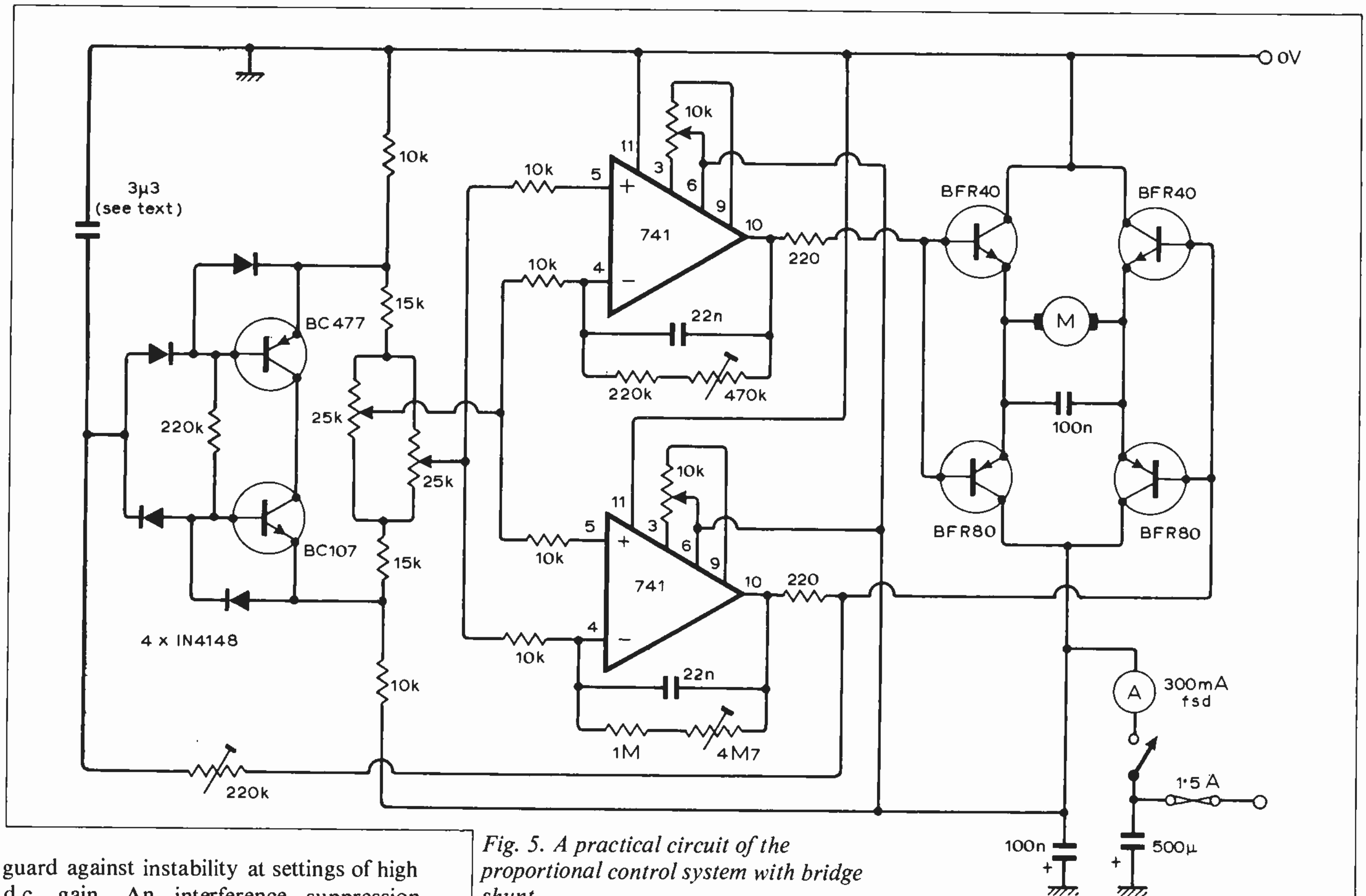


Fig. 5. A practical circuit of the proportional control system with bridge shunt.

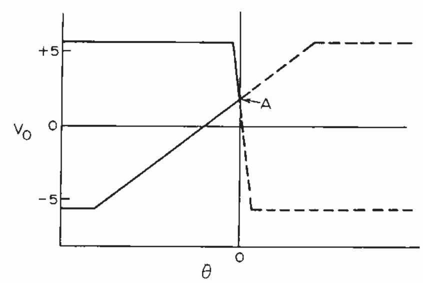


Fig. 6. Illustrating the effect of displaced crossover point A on the symmetry of the proportional control characteristics. Amplifier output voltage V_o has its zero of voltage reference at half h.t. potential. The zero axis of θ represents here the situation when both wiper arms are at the positive end of the bridge.

guard against instability at settings of high d.c. gain. An interference suppression capacitor is also connected across the motor terminals. Inclusion of offset null controls (the 10kΩ potentiometers) is recommended. Adjustments are carried out with the wiper arms of the bridge potentiometers brought to the centre of their tracks and then short circuited together. The offset null potentiometers are then set to give an output of exactly half h.t. potential at each operational amplifier.

A panel meter for monitoring the behaviour of the motor is a useful asset. Total current may be measured, as shown in Fig. 5, or, alternatively, motor voltage or current may be displayed, using a centre-zero instrument to follow directional changes.

The power supply should be capable of delivering 1A at the operating voltage and be well smoothed. Otherwise, requirements are not critical.

Performance. Operation with the bridge shunt is not critically dependent upon supply voltage, so long as the input capacitor value fulfils the time constant requirements mentioned above. Fine adjustments may be made with the 220kΩ preset potentiometer, which is normally set near mid-range. Efficacy of the shunt is improved if bridge resistance is high compared to the value of resistance presented by the shunt during its turn-on period. However, the values of bridge circuit resistors shown in Fig. 7 were found to be more than adequate and may be considered to represent an upper practical limit above which the performance of the differential amplifiers becomes adversely affected. This arises because of the differences in d.c. input resistance of the inverting and non-inverting inputs, and variation in amplifier gain with wiper arm position at the bridge potentiometers. The operational amplifiers see highest source resistance, and experience concomitant reduction in gain, when the wiper arms are near track centre. In this region, therefore, the proportional control bandwidth becomes relatively expanded.

Measurements of amplifier output voltage were made with the bridge wiper arms positioned at similar track intervals and then shorted together. Experimental conditions and data are summarized in Table 1 for an h.t. of 15V and feedback resistors of 680kΩ (IC_1) and 4.7MΩ (IC_2). The behaviour pattern shown in Fig. 6 represents the situation with the wiper arms at the positive end of the bridge. The crossover point did not deviate markedly from the $\theta = 0$ axis, but was displaced in voltage, being more positive than the half-h.t. potential axis, which is taken as the zero of voltage reference. At the negative end of the bridge, an approximately equal negative displacement relative to a centre offset potential of 0.25V was observed. The bridge shunt was removed during these measurements, which confirmed that the effective common mode gain of the amplifiers was near to unity. This tends to produce a degradation in symmetry of the proportional control characteristics, which change progressively from one end of the bridge to the other. Therefore, the ratio of voltage across the bridge to peak swing at the amplifier outputs should not exceed 0.15 if good symmetry is to be preserved.

	Deviation of output voltage from half-h.t. potential		
	positive end of track	centre	negative end of track
IC_1	1.9V	0.25V	−1.5V
IC_2	2.0V	0.25V	−1.5V

Voltage reflected across the bridge is directly proportional to the supply voltage whether or not the bridge shunt is used, so that proportional control bandwidth at given gain settings remains practically constant above 20V h.t. At lower h.t. voltages the discrepancy between peak output swing of the operational amplifiers and the supply voltage must be taken into account. During conduction, approximately 1.5mA base current flows at the power transistors. This loads the amplifiers sufficiently to produce a total discrepancy of about 1.5V. As the supply voltage is reduced, there is little change in this value, but its effect in decreasing the bandwidth becomes more noticeable.

In addition, the difference between h.t. and peak motor voltage amounts to approximately four volts, and this becomes an important consideration when using the circuit to drive motors at lower peak voltages.

Circuit properties are considered further in the light of other practical experiments. A small 24V d.c. motor (see Fig. 4) was connected to the circuit of Fig. 7, which was operated at 24V h.t. and with fixed feedback resistors; 330kΩ for IC_1 and 4.7MΩ for IC_2. Maximum potential across the bridge was 3V, falling to 0.7V at cut-off, when the motor current was reduced to less than one microamp.

An *xy* plot of motor voltage against amplifier input voltage V_i measured at the bridge wiper arms is presented in Fig. 7. Total proportional control bandwidth CC′ was 82 degrees, centred at mid-scale, for a driven potentiometer electrical rotation of 280 degrees. The bandwidth of IC_2 was seven degrees, giving a practical dead zone of ±2.5 degrees for a limiting motor voltage of 3V.

Potentiometer drive. There are various possible mechanical arrangements at the bridge potentiometers, and only the rotary type is considered. To cover rotation through a complete circle, a 360-degree potentiometer with 1:1 coupling is required at the final-drive shaft and also at the control box. Alternatively, the more usual pattern with electrical rotation in the region of 280 degrees may be used in conjunction with pulley, chain or gear coupling of the correct ratio. If the absence of a 90-degree sector from the rotation range can be tolerated, direct 1:1 coupling may be retained, as in the rotator.

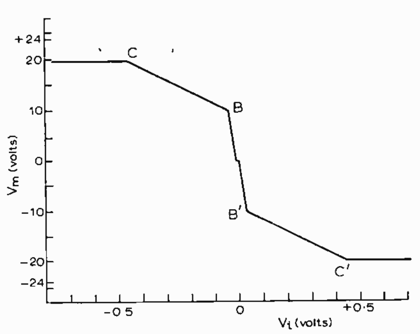


Fig. 7. XY recorder plot of motor voltage V_m against input voltage V_i.

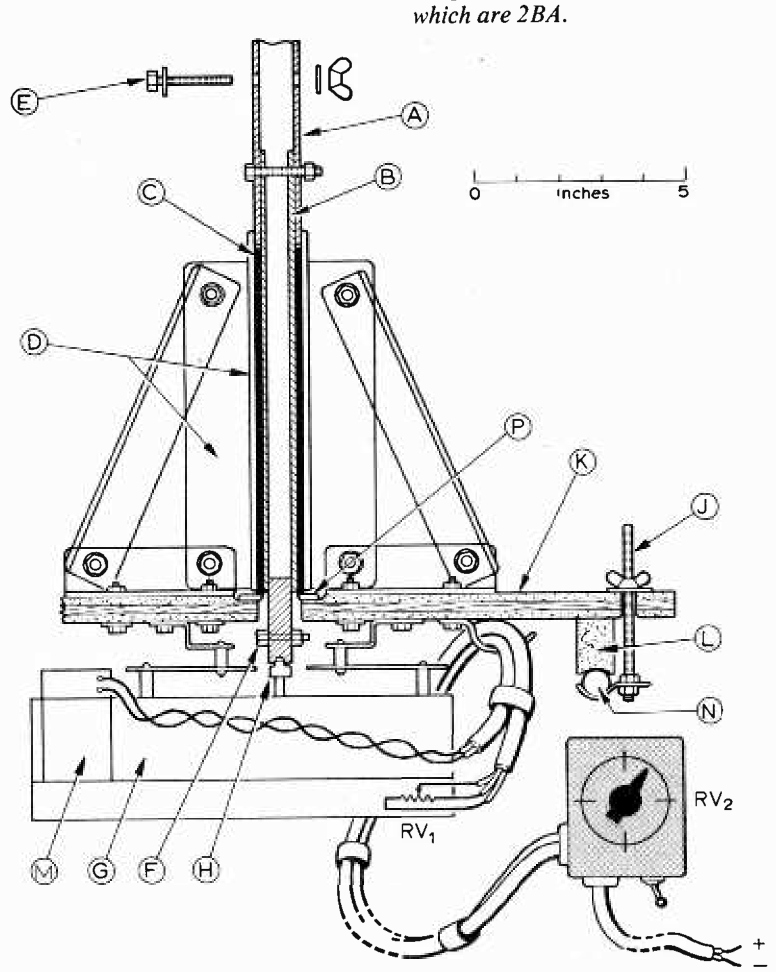


Fig. 8. Schematic diagram of portable aerial rotator. Material is mild steel unless otherwise specified. Tubing is of $\frac{1}{16}$-in wall thickness. Nuts and bolts are steel, $\frac{1}{4}$-in BSF, except those fastening the gearbox support bracket to the deck, which are 2BA.

Aerial rotator

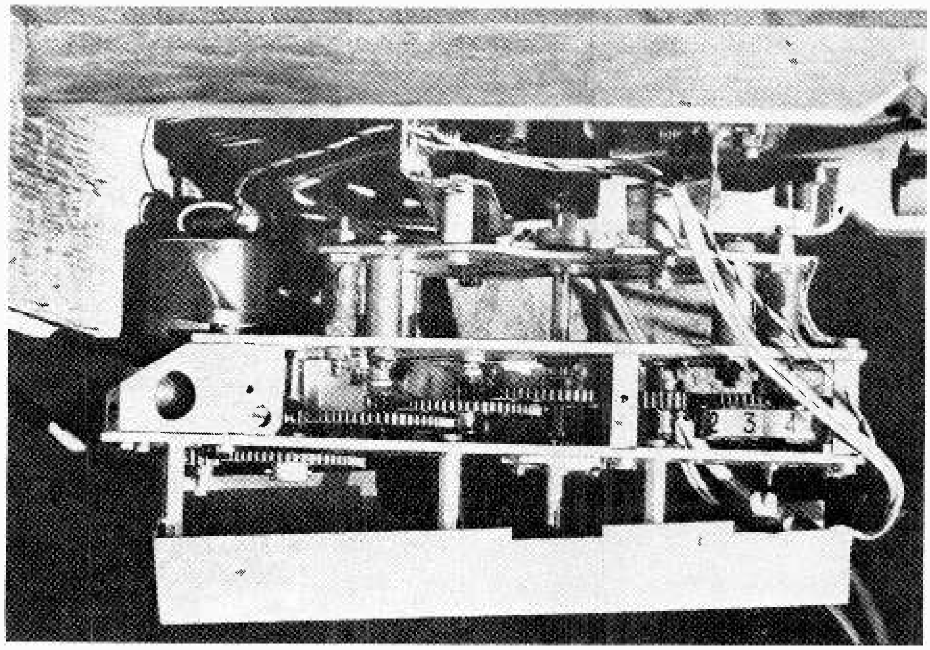
In point-to-point v.h.f. and u.h.f. communication, well-sited portable equipment incorporating a low-power transmitter can be capable of very encouraging results, particularly if a high-gain directional aerial is used, in conjunction with a reliable and accurate means of turning the mast. In aerial rotator applications the servo system may be used in conjunction with a variety of mechanical arrangements, depending on the requirements of the operator.

Basic construction of a portable aerial rotator for mounting on the roof-rack of a stationary vehicle is shown schematically in Fig. 8. The drive unit is readily demountable and an alternative type may be fitted if desired; Fig. 9 shows how the gearbox adapted by the author was installed. This was part of an ex-government switching unit having rubber mounting bushes and a 24V d.c. motor coupled to the final-drive shaft through 625:1 reduction gearing.

Removal of the lower cover plate exposed the switch wafers, which were then discarded to allow a feedback potentiometer to be coupled to the final-drive shaft through the 1:1 gearing as illustrated. Drive was transmitted to the mast through a simple dog clutch. A similar arrangement was employed at the potentiometer spindle, into which a slot was cut to accommodate a blade filed on the end of the coupling shaft. Although the potentiometer could have been mounted in a carefully positioned hole drilled in the lower cover plate, compactness was preserved by fixing the potentiometer case to the inside of the cover plate with soft solder, in the position shown. In order to mount the component in this way, the threaded part of the spindle collar was shortened. The spindle was of nylon to minimize damage in the event of accidental servo overruns at track limits.

Above the deck, short lengths of mild steel slotted angle were bolted together to act as a support for the vaned tube containing the aerial mast socket bush (Fig. 8). Grease was applied liberally to the mast socket bearing before fitting it to the bush. Positioning of the lower retention bolt allowed the mast socket assembly to be lifted just clear of the gearbox dog to permit easy and rapid alteration of the aerial reference direction by 180 degrees. An upper retention bolt was also fitted to secure the mast. Steel J-clamps were used to firmly fasten the rotator to a secure vehicle roof-rack (Fig. 10) and dimensions of the grooved mounting blocks were adjusted to suit the type of rack. Protection from the weather was afforded by fitting an aluminium cover over the gearbox and applying paint to external surfaces.

Upper torsional limits for the above



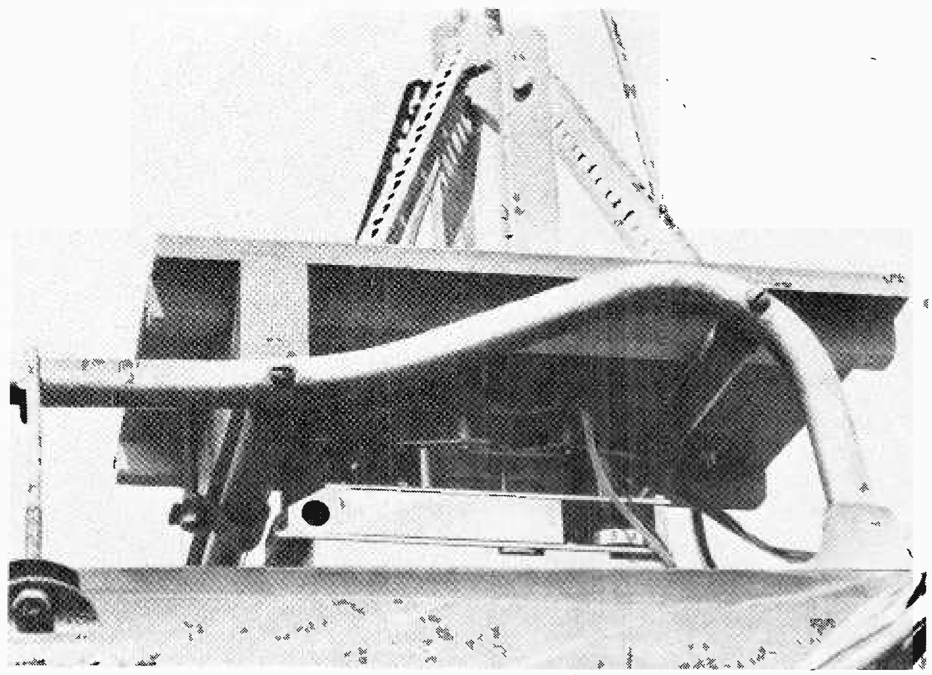


Fig. 9. Underside view of rotator showing adapted gearbox unit with lower cover plate detached to expose the feedback potentiometer (bottom right). Final drive shaft and dog clutch are in the centre, with the motor at left centre.

Fig. 10. Rotator secured to horizontal roof-rack bars.

gearbox were approached in normal weather conditions with an eight-element conventional Yagi array cut for the two-metre amateur band, which was supported at its centre of gravity on a five-foot mast. Aerials of greater physical size were not considered practicable on a free-standing mast fixed to this type of rotator.

Mechanical backlash in the blade and slot feedback potentiometer coupling has the effect of allowing the aerial to overrun its selected heading, but by judicious use of the relative sizes of blade and slot, can be made to correct any slight lag which may otherwise be present.

Feedback and control potentiometers should preferably have a linearity better than 2%, and the system be calibrated before operation.

In practice, the portable rotator has performed with consistent reliability in conjunction with the control unit described. Aerials have also included a 16-element aerial for the 70cm amateur band, using a five-foot mast.

When the portable rotator was used with the above proportional control unit, time taken for complete rotation of a 2m eight-element Yagi array was about 20s at 15V h.t.

Circuit assembly. Components in the prototype were mounted on a $2\frac{1}{2}$in square piece of 0.1in matrix Veroboard, in a $4\frac{1}{2} \times 3\frac{1}{2} \times 2$in diecast box, with the control potentiometer and dial on the largest face. A five-cored cable from the motor and driven potentiometer was plugged into a DIN socket on the control box, allowing different motor units to be activated.

If the motor connections are reversed, an aerial rotator will become an automatic beam heading avoider. Care must be taken to connect the control and driven potentiometers in the correct sense, and to prevent mechanical damage to the latter component, operational checking should be carried out with both wiper arms near track centre.

Other applications

In common with other proportional control systems, the above design commends itself to a wide variety of possible functions. Simple modifications may greatly extend its range of capabilities.

By connecting a suitable amplifier (such as another 741) in place of the driven potentiometer, the system may be coupled to external probes or sensors. For instance, the e.m.f. across a thermocouple junction may be used for remote automatic positioning of a furnace charge. Position is manually pre-set with the control potentiometer.

If the driven potentiometer is mechanically disengaged from the motor, the unit becomes a manually adjustable reversible motor speed controller.

Law and insurance

It is of the utmost importance to ensure that, as a load attached to a vehicle roof-rack, the rotator and aerial conform to legal requirements.

There must be no danger to people inside or outside the vehicle. On a public highway the aerial and rotator also become illegal if any part extends beyond the front, rear or sides of the vehicle by more than 12in.

Any effect that the presence of the aerial and rotator may have on the vehicle's insurance should be ascertained.

The author has found that the authorities are very willing to help in these matters, and if the operator has any doubts about his position, he should not hesitate to seek advice from the Traffic Department of the local police.

Suppliers

Transistors and integrated circuits were obtained from Texas instruments. Minimum size of heat sinks for the power transistors will depend on circuit applications, and manufacturer's literature should be consulted. For the rotator, the TO-92 plastic encapsulation may be bonded to the diecast box with epoxy adhesive.

The surplus gearbox unit, and also separate d.c. motors, were obtained from North West Electrics, 769 Stockport Road, Manchester.

An extensive range of small gearboxes is manufactured and supplied by S. H. Muffet Limited, Mount Ephraim Works, Tunbridge Wells, Kent. For driving the rotator, the author recommends that a unit is chosen with an output ratio of 500–1,000 which is capable of delivering at least 30lb. in. continuous torque at the output shaft.

Recent loudspeaker developments

According to a recent article in the American journal *Audio*[1] it is possible to adjust separately the amplitude response of the upper range and bass frequencies of a single loudspeaker drive unit without one affecting the other, thus reducing the necessity for the motor (coil and magnet system) to be of an optimum strength for a system.

Consider the performance of a practical loudspeaker system in which the sealed volume of the enclosure, cone area and mass of the moving parts are kept constant. The results of changing the motor strength are plotted in Fig. 1. In the 70 to 500Hz range, if Bl (product of magnet strength B and coil winding length l) is increased output will increase, if it is decreased output will decrease. However, around resonance the reverse happens. Increasing Bl decreases output and decreasing Bl increases output. In other words efficiency or cone velocity for a given input at frequencies above resonance are directly proportional to Bl, while at frequencies around resonance these two factors are inversely proportional to Bl.

It can be seen from Fig. 1 that for a given loudspeaker system, and where a flat amplitude response is desired, the motor must be of the correct strength. If the motor is too small, efficiency is low and there is a bump in the bass. If it is too large, efficiency is high, but the bass response is down. This also shows that purchasing the speaker with the larger magnet could result in the use of a speaker with less than optimum bass response. By juggling motor parameters, there is apparently an inevitable trade-off between bass response and efficiency in the flat band. Restating the requirements, then, we need a large motor for high efficiency above resonance and a smaller motor for similar efficiency at bass frequencies.

Dual motors

The usual practice for adjusting the power output of the motor is to vary the magnet strength, B. To construct a speaker with two different magnetic field densities to drive the same cone would be both expensive and difficult to manufacture. Suppose instead it was possible in effect to make l vary with frequency in such a manner that a lower value of Bl in one frequency range would not affect a higher Bl product in another range and vice versa. Fig. 2 shows a simple method.

A second voice coil is wound over or under the conventional voice coil and is driven via a series LC resonant circuit adjusted to resonate at the same frequency as the fundamental mechanical/acoustical resonant frequency of the woofer. The LC circuit presents almost zero impedance at resonance and a sufficiently high impedance one octave either side of resonance to effectively remove voice coil 2 from the circuit. Thus l of voice coil 2 can be adjusted to eliminate the high value of motional induced back e.m.f. at the fundamental resonance, f_o. A lower impedance path is provided at f_o to maintain current flow and the bass response at f_o can be adjusted at will and independently of mid-range response above f_o. In effect a second motor is added that generates less back e.m.f. and offers a lower impedance to the amplifier at the tuned frequency.

A voice coil gap of twice the width is not required to accommodate the extra voice coil. The output and inner clearance spaces are the same as usual and since a single layer coil with a notch in the top plate for the return end of the coil has apparently proved satisfactory, the gap width need only be increased by 25%.

Summarizing, the design (it is claimed) "does not involve trade-offs in areas of performance, requires no additional amplifier power or equalizer, has the advantage of simplicity of construction and offers an improvement readily discernible on listening".

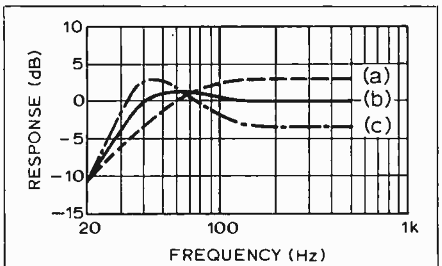


Fig. 1. Loudspeaker amplitude response for different values of motor strength (a) motor too large, (b) motor optimum, (c) motor too small.

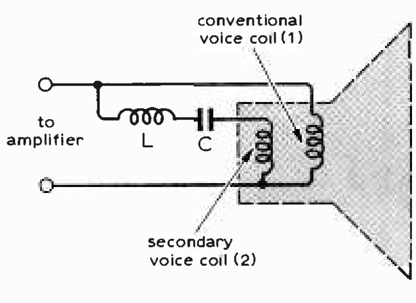


Fig. 2. Circuit for a dual motor woofer.

Soft speaker

Further to the item "Flexible speaker cone" (News of the Month, March issue), this system, under development in W. Germany by JWM Systems, has caused somewhat of a stir in the technical press, be it on an academic level of interest only. The flat diaphragm structure of this new loudspeaker is a flexible, highly viscous, elastic material. The diaphragm is driven at its centre by a conventional voice coil and magnet system. The area of radiation is inversely proportional to the radiated frequency.

To ensure that the radiation area is symmetrical around the centre point of the diaphragm, the voice coil is split into two, each section being fed with an offset current of opposite polarity. In similar manner to a differential input, like signals cancel so that the voice coil remains centred in the gap between magnet pole pieces. The system requires equalization to account for a 6dB per octave drop in response above 6kHz.

The new diaphragm[2] consists of a flexible bearing structure and a filling compound. A mesh of polyamide threads is used as a bearer, which is capable of stretching. In its manufacture, the diaphragm is radially pre-loaded (stretched) to a small degree and the visco-elastic filling compound is applied as a lacteal dispersion which dries like varnish and becomes interlaced in the polyamide.

The diaphragm is held at its circumference by the speaker basket frame and in addition there is a firm star-shaped support in the centre. In operation, amplitude is limited to a maximum of 3mm at the coupling point between voice coil and diaphragm. With the amplitude of vibration decreasing out from the centre, a smaller and smaller part of the diaphragm vibrates as frequency rises so that the large area required for moving a large air volume at bass levels and the low mass favourable for rapid movement at high levels is achieved with the single diaphragm. The prototype drive requires a continuous input of 3.2W for 96dB s.p.l. at 1m at 1kHz.

References

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Voltage-to-frequency converters

This article complements set 21 of Circards

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

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Voltage-controlled oscillators—astable multivibrators—waveform generators—frequency modulators: under each of these headings one finds circuits that have an important common property, that the output frequency is a function of some reference or control signal. Such circuits are multi-variable systems in which several parameters of the output waveform are controlled singly or in various combinations by other parameters at the input. Thus the same circuit can appear under different headings depending on which input/output relationship is of priority concern.

As an example, some recent integrated circuits have been designed as waveform generators with square/triangle/sine wave outputs. If the output waveform is of no particular concern, the fact that the frequency of each output is proportional to a direct control voltage assumes a greater importance. The circuit can then be called a voltage-controlled oscillator. Now assume that the control voltage is set to a particular quiescent value with a smaller alternating voltage superimposed. Then the output frequency is modulated by the a.c. input, with the carrier frequency corresponding to the quiescent value of control voltage. The label for this circuit is frequency modulator.

In set 21 of Circards the primary property of interest is the relationship between an input voltage or current and the frequency of the output, with much less importance being attached to the wave shape or amplitude. A particularly desirable property is that the voltage-to-frequency relationship be linear, and in extreme cases departures from linearity of as little as 0.01% may be desired. In the process of achieving this, the output pulse height and width may have to be equally well controlled but these are a means to the end and not an end in themselves. There are other cases where the frequency needs to be varied only over a limited range, demanding only a small linear region to the *V/f* characteristic. A good example is found in the design of v.c.os for high-frequency phase-locked loops. Restriction of the frequency range and of linearity is a compromise accepted more or less willingly in exchange for a speed capability that matches that of the associated digital circuits.

In nearly all of these examples, the basic timing mechanism is that of charging a capacitor from a control voltage or current. The voltage change across the capacitor is sensed by some level-detecting circuit which activates an electronic switch to discharge the capacitor and restart the cycle. Two categories of circuit can be clearly distinguished:

- where the discharge time of the capacitor is made short compared with the shortest charging time and need not be under the control of the input voltage, and
- where both charge and discharge times are controlled in common by the input. The first-mentioned circuits produce sawtooth waveforms across the capacitor and short duration output pulses, while the last-mentioned commonly develops a triangular wave across the capacitor, in association with a square wave at a separate output.

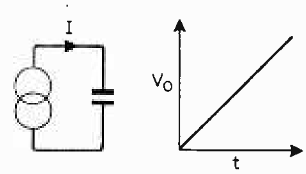

Fig. 1. Constant charging current allows repetition frequency to be made proportional to current.

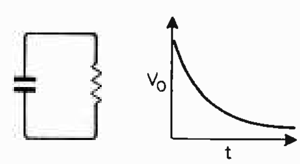

Fig. 2. To cause charging cycle to recommence, a low-value resistor is switched across the capacitor to discharge it quickly.

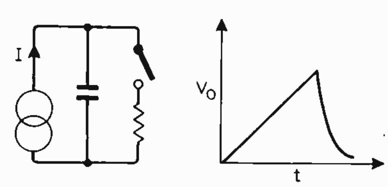

Fig. 3. If discharge time is made small enough the charging current can remain connected. Level of capacitor voltage is used to operate discharge switch.

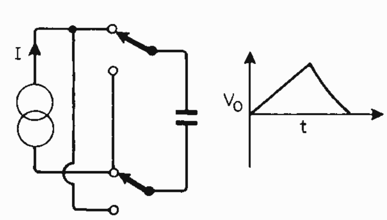

Fig. 4. Triangular waves with repetition frequency proportional to current are produced by reversing capacitor charging current.

These ideas are illustrated in Figs 1 to 4. In Fig. 1, constant current results in a constant rate-of-change of voltage across the capacitor, i.e. the time taken to charge to a given p.d, will be inverse to the charging current. If that level can be sensed and caused to end the cycle or half-cycle, then the repetition frequency (being inverse to the period of the waveform) will be proportional to the current and a linear *I/f* converter results. The simplest way of causing the cycle to recommence is to place a low-value resistor across the capacitor to discharge it in the shortest possible time. If the discharge current is large compared to the charging current, then it is immaterial whether the charging current is disabled or not and Fig. 3 represents the basic principle of many *V/f* converters, with the switch periodically closing at the instant when the p.d. across the capacitor reaches a defined value.

An alternative principle is shown in Fig. 4. The current generator is applied to the capacitor in the reverse direction giving an opposing slope to the ramp but of equal magnitude. The resulting waveform is triangular with the repetition frequency linearly related to the current if the points at which switching is initiated are defined. The provision of a purely electronic two-pole change-over switch is difficult, and the reversal of current direction is more often achieved by using a single-pole switch or its equivalent to control the current generator directly.

A second problem that often arises is that the changing p.d. across the capacitor affects the nominally constant current. This is obvious in terms of the non-linearity of the ramp, but may not affect the linearity of the

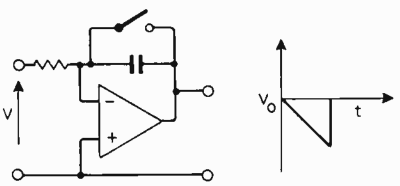

Fig. 5. Using the charging capacitor in an op-amp integrator ensures current is independent of capacitor p.d.

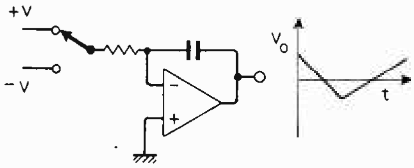

Fig. 6. Simple form of triangular-wave generator uses principle of Fig. 5.

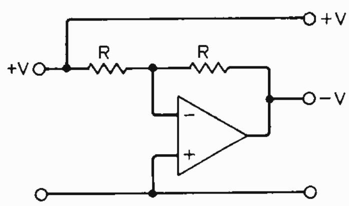

Fig. 7. Circuit provides equal $+V$ and $-V$ inputs for Fig. 6 with an op-amp of -1 gain.

V/f function provided the waveshape is well controlled, e.g. accurate V/f conversion is possible with simple R-C charge and discharge circuits though the wave shape is highly non-linear. Where waveshape is also of importance, the capacitor forms part of an operational amplifier integrator circuit, with the virtual earth action ensuring that the charging current is independent of the p.d. The discharge element now has no point connected to ground which can raise problems in activating it. (Fig. 5.)

This technique leads to a simple form of triangular-wave generator shown in Fig. 6 where both the $+V$ and $-V$ inputs have to vary together if the slopes are to remain of equal magnitude. By using both the input and the output of an amplifier with a voltage gain of -1 this is readily achieved (Fig. 7). Alternative methods include the design of amplifiers whose voltage gain is switched from $+1$ to -1, and of integrators in which the direction of capacitor current is reversed by a switch while the magnitude is controlled by a single input voltage.

In all of these circuits there remains the problem of the level sensing circuitry that is to determine the instant of switching; both switching speed and accuracy of level are important making the design of a fast, accurate V/f converter a difficult one.

The term charge-dispensing is a big one in the literature on precision V/f converters. A feedback system is set up in which the output pulses from a generator (basically monostable in form) are arranged to feed back a constant amount of charge for each output pulse. If these units of charge are combined at the input of the system with the control signal, and the overall feedback is negative, then the pulse rate will be proportional to the control signal.

In block-diagram form in Fig. 8, the principle is illustrated by a combination of V/f and an f/V converter. Assuming that the amplifier gain is high, and that the f/V convertor is very linear then the feedback overcomes any non-linearities in the V/f converter, i.e. $V_o = V$ to a high accuracy because of the feedback while $V_o \propto f$ ensuring that $f \propto V$ without reference to the linearity of the V/f converter. The f/V converter might be of the diode-pump variety which with suitable design can transfer a fixed charge into a load for each output pulse rate.

A level-sensing monostable gives an output pulse when the input level rises above a critical value. If the input then falls a second pulse is generated on the next excursion through the set level in the same sense. An important restriction is that the capacitor shall have been completely discharged prior to the second pulse—otherwise the time taken for recharging will be shortened and the output pulse-width reduced. The output of such a monostable would ideally be a train of constant-amplitude constant-width pulses, which could be smoothed and fed back to the input amplifier as in Fig. 9.

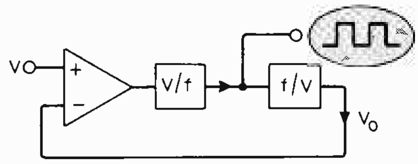

Fig. 8. In this "charge-dispersing" system, a constant amount of charge for each output pulse is fed back so that pulse rate can be proportional to the control signal.

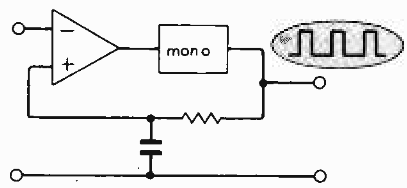

Fig. 9. Monostable circuit produces output pulse when input exceeds a certain level, in either sense.

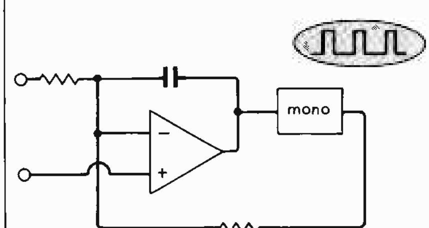

Fig. 10. An alternative arrangement is to dispense charge into a summing integrator. Output pulse rate is a linear function of control voltage or current.

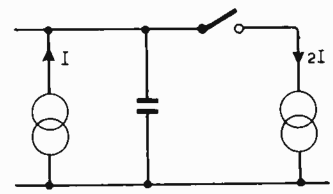

Fig. 11. Technique of using two current sources, but switching only the one having twice the value of the other, is used in some i.cs.

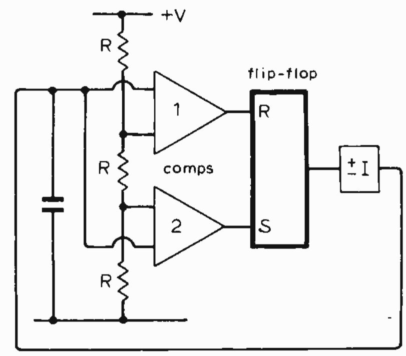

Fig. 12. Triangular wave generator using technique of Fig. 11. Comparator reference inputs are set to $2V/3$ and $V/3$, the capacitor voltage ranging between these limits.

A better arrangement dispenses these units of charge into a summing integrator—Fig. 10. For positive pulses a negative control voltage is required, the integrator output ramping up until a pulse is produced from the monostable. The charge dispensed into the summing junction causes the output of the integrator to fall, again rising slowly under the action of the control current. On average, the net charge inflow has to be zero, the charge dispensed per pulse is constant and hence the pulse-rate is a linear function of the control voltage/current.

Other recent i.cs revert to the separate constant current circuit for timing circuits and waveform generators, and the resulting I/f linearity can be accurate enough for many applications. One technique is to have two current sources one set by the external control voltage, the other of opposite polarity but of twice the magnitude—Fig. 11. Keeping the former permanently on and switching the latter on and off makes the net current in the capacitor change from $+I$ to $-I$. A circuit configuration to use this technique to produce a triangular-wave generator is shown in Fig. 12.

Two comparators sense the capacitor voltage, their reference inputs being set to $+V/3$ and $+2V/3$ by an internal potential divider. Assume the current at I; the capacitor charges until its p.d. reaches $+2V/3$. Comparator 1 changes its output and resets the flip-flop. This reverses the direction of current flow until the capacitor discharges to $+V/3$. The comparator 2 operates setting the flip-flop into its original state and restarting the cycle.

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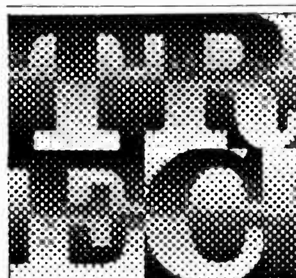

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Vision cassette and cartridge recorders

Facilities and performance of models on the UK market

In attempting to assess the current state of domestic, industrial and educational video activity, one is reminded of the sub-title of a recent article on the computer industry. It read: "Where are we now, and how did we get into this mess?". For it seems that commercial and political considerations dictate that each new development is attended by a flurry of alternative approaches—some only slightly different to each other—and that the eventual emergence of one or two practical solutions to the problem can take many years. It is all very wasteful, expensive and uncivilized, but nonetheless entertaining.

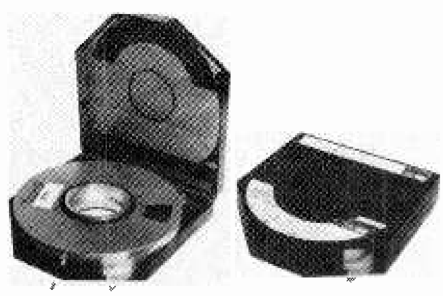
It seems likely that John Logie Baird, having worked out his system of seeing at a distance which, with fine impartiality he named "tele-vision", was the first to record a picture. There was, in 1927, nothing new needed to do this, as he simply used a 10-in, 78 r.p.m. record and called it "Phonovision". Magnetic recording was not well developed and it was not until the 1950s that an acceptable, recorded image was possible. In 1951, Crosby Enterprises were using a longitudinally-recorded tape at 100in/s for black-and-white pictures, in which the spectrum was separated in 10 bands, each being recorded separately, with two more tracks for control and sound. This was followed rapidly by RCA in 1953 with a longitudinal system capable of recording colour at 240in/s on three tracks for RGB and two more for sync and sound. The longitudinal method, wherein the video tracks were recorded along the length of the tape as in audio tape recorders, was wasteful of tape (high speeds of up to 360 in/s for adequate bandwidth) and caused problems of speed control, particularly in colour. Head-to-tape contact was difficult to ensure and even at high speeds, the theoretical maximum bandwidth of the tape recording process (10 octaves) is insufficient for the 20 or so octaves of a vision signal.

Ginsburg and Anderson, together with a man named Dolby, of Ampex, originated the modern approach to vision recording in 1956 with the transverse-track recorder, using frequency-modulated vision signals to avoid the bandwidth problem. In this principle, the tape is slowed to a canter and the tape-to-head speed is maintained by moving several heads across the tape, giving transverse tracks. Four heads were used by Ampex, and the term "quadruplex" was applied.

From then on, the transverse-scan recording method was to become standard throughout television broadcasting, using tape up to two inches wide and eventually producing a picture indistinguishable from the original. Much programme material is now transmitted from tape. Only the BBC continued the longitudinal method in "VERA" (1956), but soon acknowledged that this was not the way to do it.

All this time, the idea of the domestic and educational use of television recording was being pursued, albeit rather spasmodically. RCA had a $\frac{1}{4}$-in tape system for home use in 1956, and throughout the 50s and 60s one saw optimistic announcements from time to time that the ideal had been achieved, but they all sank without trace. Many systems have been tried, but the "electronic" kinds have now narrowed to several types of tape recorder and a few systems using discs, optical and electro-mechanical. Several manufacturers produce tape systems with open-reel tape handling, but our impression is that, for domestic and educational use, the open-reel machine has had its day and that the enclosed tape storage machine will reign supreme within two or three years. Seven thousand are said to be in use in the UK now.

The tape enclosures take three forms. A cassette, familiar in one form as the audio cassette, possesses two spools mounted either side-by-side as in the Sony machines



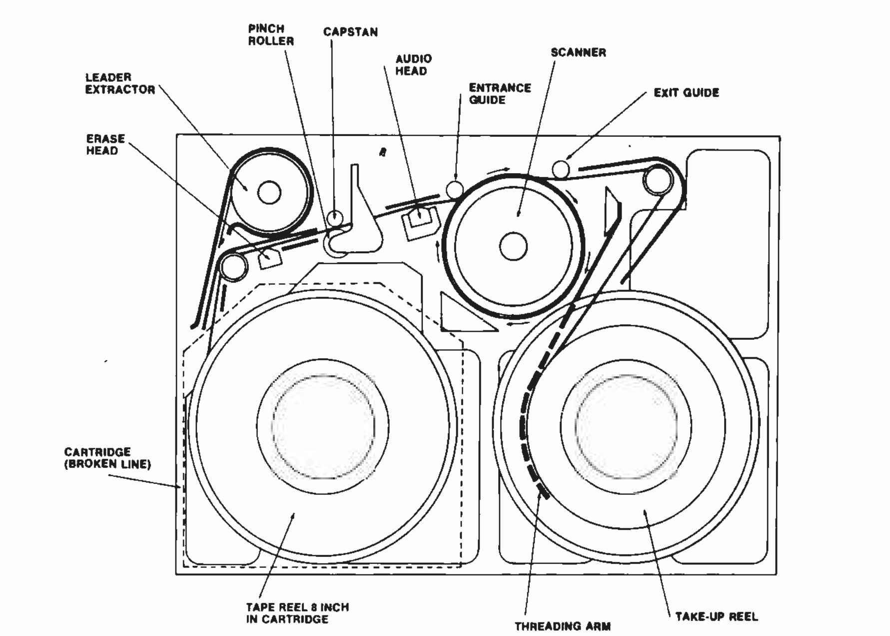


Fig. 1. The IVC cartridge of 1-in tape is shown at (a) and the tape path in the machine is at (b).

or one on top of the other, as in machines made to the Philips pattern. A further type of tape enclosure is the cartridge, which possesses only one spool and is analogous to the 35mm film cassette (we should, perhaps, have mentioned that it is all very confusing!) in which the tape is pulled out of the enclosure, past the heads and on to an external take-up spool contained in the machine. When the tape is used up, it is rewound into the cartridge and ejected, a process which points to one disadvantage of the cartridge—it cannot, unlike the cassette, be removed until the tape is rewound.

There is, as yet, very little standardization in the use of enclosed-tape machines. They differ in enclosure type, tape width, signal-processing, tape type and many smaller parameters. Sony and Philips are the leaders in their own fields, and there is standardization in machines using these two different systems as there is in another group, the EIAJ v.c.r. standard used by Matsushita and several others. Both types use helical scanning, which is a half-way stage between longitudinal and transverse scanning. The tape is pulled out of its enclosure and wrapped part of the way round a drum, rising or falling on the way round. The drum is provided with two, three or four heads, which revolve inside the drum about a vertical axis, "looking" at the tape through a circumferential slit in the drum. As the tape is slightly inclined, moving on a helical path round its part of the drum, and the head axis is precisely vertical, the tracks recorded on the tape are inclined at about 3° to the horizontal. As one head finishes its track, the next one starts the next track and the effect is as though there were one continuous track, recorded at high speed instead of the five or seven inches per second of the actual tape speed. In this way, a low tape speed provides bandwidth of up to 3.5MHz and a horizontal picture resolution of up to 360 lines. Either two audio tracks or one audio and a control track are recorded along the edges of the tape in the normal way.

Signal processing is rather more complicated than in the ordinary audio tape recorder, particularly when a colour signal is being handled. As transmitted, the broadcast colour signal consists of a vestigial-sideband luminance carrier with the upper sideband extending to 5.5MHz, and a chroma signal with a suppressed sub-carrier extending from 3MHz to 5.5MHz. Neither of these signals can be handled directly by the tape machine and must be turned into a recordable form.

The chroma signal is simply transposed to a centre frequency of 562.5kHz (in the Philips system) with a bandwidth of 650kHz and recorded in the normal way as a.m. The reduced bandwidth, and hence resolution, does not have as serious an effect on colour as it would on the luminance information which determines the sharpness of the picture. Luminance is not recorded directly but is remodulated as f.m. with a deviation of 3–4.4MHz, thereby avoiding the effects of imperfect head-to-tape contact and completely eliminating the need for tape bias, as the waveform is no longer important. Bias for the chroma signal is automatically provided by the luminance f.m. signal, the two being combined in the recording amplifier.

Problems are introduced by the transposition of the chroma signal to a different frequency and also by inevitable phase jitter in the tape transport. This would, of course, be disastrous for the chroma decoder and would also result in an increased amount of sub-carrier patterning on the screen due to the loss of interleaving of chroma sideband energy peaks between those due to time-base repetition rates. Circuitry is therefore needed to overcome this defect, and a description appeared in *Wireless World*, December 1972.

On playback, the luminance information is passed to an f.m. detector and the chroma is reinstated in its proper position at 4.43MHz, prior to being impressed as modulation on a u.h.f. carrier and passed to the aerial socket of the television receiver. Not every recorder possesses an r.f. output and if the output is at video frequencies, modifications to the receiver are needed. Many receivers will need modification for other reasons in order to be compatible with video recorders. For instance, the fly-wheel time-constant will need to be shorter to accommodate the "drop-out" time—the time between one head finishing a track and the next one starting. During the time when no signal is being played back, the flywheel will try to compensate unnecessarily, only to be caught on one leg by the arrival, on time, of the next set of information. The result will be "hooking" or bending of verticals at the top of the picture as the time-base slowly comes back into sync and this effect

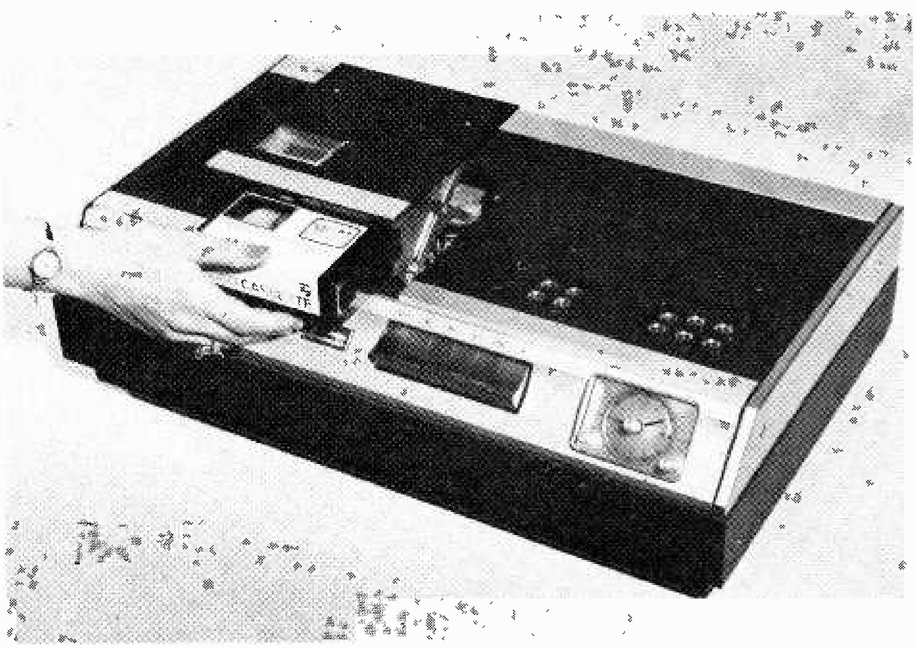


Fig. 2. Loading a Philips cassette. Lowering the cassette engages the pins behind the tape and takes it round the drum.

Fig. 3. A Sony cassette is loaded in roughly the same way as the Philips type.

Fig. 4. An IVC cartridge being loaded.

can, without modification, reach half-way down the screen. The time-constant must therefore be shortened so that the hooking occurs invisibly during the blanking time or during a small amount of over-scan. If, however, it is shortened too much, the object of having a flywheel is lost and noise again becomes a problem.

It seems possible that future television receivers will make some provision for the connexion of recorders, preferably in video form, thereby eliminating the cost of a u.h.f. modulator. There will then, of course, be the old question of live chassis, as manufacturers still have not found it necessary to use mains transformers. A. C. Smaal of Philips set out his views on this in *Wireless World* March 1975. On this question of compatibility, it should be pointed out that the different systems are mutually incompatible. The two cassette systems—Sony and Philips—are possibly the closest in conception, but are still incompatible because of the different tape width and cassette type. Compatibility between two machines of the same model is better than it initially was; control circuitry is improved and there does not appear to be an insuperable problem. Dealers have told us that they can choose any machine in stock and play any tape on it with every chance of success.

Some recorders possess their own u.h.f. tuner, which means that the recorder can receive and store information on one channel while the television receiver is displaying another. Others take a video feed from the receiver, necessitating yet another modification.

The feeling expressed fairly freely is that off-air recording is not going to be enough to make a success of these machines. A supply of programme material is essential if they are to enjoy the success of an audio system, but the number of competing formats must be drastically reduced before any programme supplier is likely to commit himself. There is also the question of copyright. It is, after all, an infringement of the Copyright Act of 1956 to record a broadcast programme. The Whitford Committee are unlikely to report for some time and this unenforceable law will continue to be broken daily, but it is an unsatisfactory situation.

The other source of "programmes" is to buy a monochrome television camera (colour is far too expensive a proposition) and to use the camera and recorder as a kind of up-market home movie system, but one would have to be very single-minded about immortalizing Dad and the kids on tape to go to such lengths.

The facility of stop motion or still frame is obtained by stopping the tape feed, while the heads continue to turn. As each track contains one field of information, the same field is scanned continuously. There is a slight problem in that the heads do not now cross the tape at precisely the same angle as when it is moving, so that they may start on one track, cross the guard band between tracks and finish on another. A drop-out then exists and it is necessary to ensure that this drop-out occurs in the blanking interval between frames. Most machines incorporate a drop-out compensator, the Philips type consisting of a drop-out detector which, when a defect is noted, substitutes for the line of information containing the drop-out a previous line, delayed by 64μs. The difference between the two is usually negligible and preferable to a total loss of information.

Our impression of the two "standard" machines is that the Philips, being smaller, cheaper and possessing a tuner and timer is better suited to the domestic scene than the Sony, but that Sony's performance is a little better and should be more at home with a camera input for education and training.

Other systems

Although this article is intended to cover methods of video recording using tape in "convenience" form, it is well to note that several other contenders exist which use discs—an area of activity on which we intend to report in detail in the near future. Most of these (Thomson-CSF, Zenith, Philips/MCA) use optical methods in either the transmission or reflection modes and have playing times of between 20 and 30 minutes. The records are thin plastic or glass discs and the information is encoded in the form of pits or holes, which tends to render them somewhat vulnerable to dust and grease. The recent Philips/MCA link would appear to give the VLP (video long player) a distinct advantage over others—MCA have a vast library of material and are to manufacture the discs.

The Telefunken-Decca system (TeD) uses what is effectively an up-rated audio record of 8-in diameter playing for ten minutes. Hill-and-dale recording is used. The disc systems were described in detail in *Wireless World*, November 1973.

A recently-announced development from BASF is the LVR (Longitudinal Video Recorder) which again employs a single-spool enclosure. As its name implies, longitudinal recording is used, but the extremely high rate of tape usage common to this method is avoided in the LVR by the 28-track format employed. Quarter-inch tape is used and playing time can be as long as 120 minutes using 6μm thick tape. Little is known of this machine at the time of writing, except than an unusual tape handling system is used. The cartridge opens to reveal the spool of tape, the leader being extracted by a large-diameter capstan, passed through the recording/playback station and again past the capstan onto the take-up spool. Feed spool, capstan and take-up spool are in continuous contact, leaving very little free tape. The extremely thin tape is therefore protected.

A speed of 3m/s is adopted, the reversing at the end of each of 28 passes taking 80ms. Colour recording is offered in conjunction with several audio tracks. Bandwidth is 3MHz. BASF claim that the area of tape used is less than a quarter of that used in the Sony system and even less than in the Philips method. The unit is not expected to make its appearance for at least two years.

A recent announcement is the MDR, developed by Erich Rabe. MDR is Magnetic Disc Recording and offers the facility of recording to the user—unlike the optical or stylus-pickup discs. An ordinary record turntable modified to run at 200-r.p.m. carries a disc whose inner section has a helical guidance groove which guides a stylus and, by a link, steers a magnetic head over the outer, magnetic, section of the record. All colour systems can be recorded and played for 15 minutes. Alternatively, the turntable can be slowed to 33r.p.m. and used to record up to 16 hours of audio.

The RCA Selectavision Magtape, not yet available here, uses a new type of tape handling and head format. Four heads are used, a layout which, amongst other benefits, allows all the tape to remain in the two (side-by-side) reel cassette, as only 90° of the drum must be wrapped. The drum protrudes into the cassette to achieve this amount of wrap. Cassette size is $9 \times 6\frac{1}{4} \times 1\frac{1}{2}$in.

In the following section, the machines mentioned are the ones we have found to be available in the UK. There are many more, but they are not obtainable here and so have been omitted.

Philips
N1500 VCR

Cassette-loading (vertically-stacked spools)
Record/playback of colour and monochrome
Tuner for off-air recording
U.h.f. modulator output
PAL standard 625/50
Two heads
$\frac{1}{2}$-in tape
Automatic tape threading
Cassette size: 12.7 × 14.6 × 4.1cm
Recording time: 30, 45 or 60min
Bandwidth: 2.7MHz
Tape speed: 14.29cm/s
Dimensions: 56 × 33 × 16cm (with cassette lid up)
Sound is on two tracks on tape edges
Mains supply: 110–245V ± 10% at 50Hz ± 1%. Any frequency drift must be slow to remain tolerable
Price: £462.84 (plus v.a.t.) (1500) cassettes: £11, £14.50 and £17.00 (1500/15M): £537.04 (plus v.a.t.)

This is one of the group leaders in these machines. It provides an acceptably sharp picture but not, perhaps, as finely resolved as in some others. It must be said that most dealers tend to demonstrate Philips machines on large-screen receivers, whereas other systems seem to be shown on small Trinitron sets—a procedure which does emphasize the difference. Controls are provided for tracking, audio record level auto/manual, the usual function controls and a timer for use when recording a programme in one's absence. Cassettes are available for 30, 45 or 60 minute playing times; the cassette holder is raised, the cassette inserted and the whole lowered, thereby engaging pins which pull out a loop of tape and wrap it round the scanning drum. The 1500/15M is similar, but the input and output are at video frequencies for direct connexion of colour or monochrome camera and monitor. The 1520, at £820, is a semi-professional machine with no timer or tuner, having assemble and insert editing provision, and facility for sound dubbing on two sound channels. It has an extended bandwidth (3.2MHz) for monochrome, and is intended for a video input from a camera. Stop motion is possible, and the output can be either video or u.h.f. Head life on this range of machines is up to 500 hours with chrome tape, and replacement during the first year is free; after this the cost of new heads is £35–£40. The N1500 and 1500/15M are handled by Philips Electrical Ltd, Century House, Shaftesbury Avenue, London WC2H 8AS, and the N1520 by Pye Business Communications Ltd, Cromwell Road, Cambridge CB1 3HE.

Radio Rentals

Model 8200

This is based on the Philips N1500. The performance and appearance are the same essentially, but the programme timer and u.h.f. tuner are not included. The 8200 can be bought or rented (not privately) from Radio Rentals Contracts Ltd, 1/15 Clyde Road, Tottenham, London N15.

Sony

VO-1810UK

Cassette: (Sony U-matic, spools side-by-side)
Record/playback colour and mono-chrome
U.h.f. output modulator/video input
PAL standard on 625/50
Two heads
$\frac{3}{4}$-in tape
Auto tape threading
Cassette size: 3.3 × 22.1 × 14cm
Recording time: 20, 30 or 60min
Resolution: 300 lines monochrome, 240 lines colour
Tape speed: 9.53cm/s
Dimensions: 67.6 × 23.8 × 46.6cm
Two sound channels
Mains supply: 110–240V ±5% at 50Hz ±0.5%
Price: £765 (plus v.a.t.)
Cassettes: £8.20, £9.80 or £14.50

The leader of the U-matic group of recorders, that being a Sony trade mark. The operation of the two types of machine is broadly similar in all external essentials. The VO-1810UK uses chrome tape and possesses a tape winding memory feature, which enables continuous repeat of a full tape or part of a tape, starting and finishing points being pre-set by the operator. Sound dubbing on one channel is provided for. A u.h.f. tuner, type TU1000B is available for off-air recording at £99.

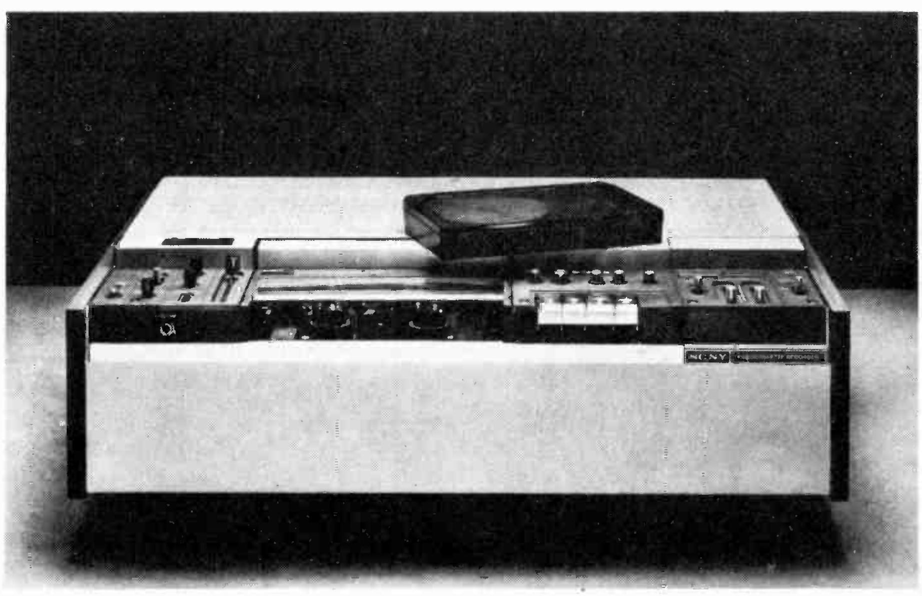
VO-1210

A similar machine to the VO-1810UK but intended solely for play-back of recorded cassettes.

VO-2850 U-matic is a semi-professional machine in the cassette format with assemble and insert editing facilities and sound dubbing. Stop-motion is offered. Price is £2,500.
Sony (UK) Ltd, Pyrene House, Sunbury-on-Thames, Middx.

Philips N1500

Radio Rentals 8200



Sony VO-1810UK

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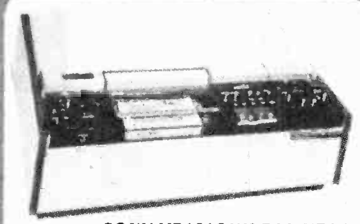
SONY



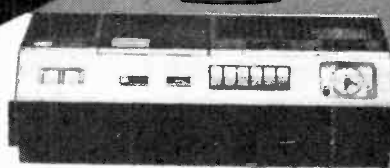
VO1810UK
PAL NTSC UMATIC' RECORDER PLAYER
Giving high resolution colour, auto repeat pause, 2 audio tracks. R/F output.

£765

SONY VP1210UK PAL NTSC PLAYER ONLY £645

PHILIPS

VCR



N1500 VCR
A simple low cost video cassette recorder. Records up to 1 hour. Built-in tuner for all stations with time clock. Uses normal type TV. **£447**

VIDEO CASSETTES: VC30 mins. £11. VC45 mins. £14.50. VC60 mins. £17. PHILIPS/SCOTCH/BASF.

N1500/M VIDEO VERSION **£537**

N1520 VIDEO WITH EDIT **£850**

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All of the equipment on this page plus most other top makes are available on our economic leasing terms. For example £1,000 worth of the very latest equipment costs £20/30 approx per month to lease. Please ask us to quote on any item or system.

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We hire, by the day or week, cameras, VTR's, monitors, large screen TV projection units with and without operators. We also offer outside broadcast and studio facilities for production work, editing etc., in colour or monochrome. Other facilities include tape dubbing, film to tape transfer and editing. Please contact us for assistance in your sales conference or presentation. For advice or a quotation without obligation contact Phil Knight, Production/Hire Manager.

TELETAPE VIDEO, THE LONDON VIDEO CASSETTE CENTRE
76 BREWER STREET, LONDON, W.1. Telephone: 01-734 1319/434 1267
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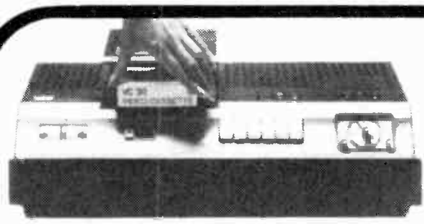
London W1V 1DB
Phone 01-734 7465/7
Midlands Representatives:
Foxall & Chapman,
51 North Street,
Cheetham, Manchester.
Phone 061-834 5786

You can always get it at REW

At the London Video Cassette Centre at Centrepoint



PHILIPS N1500 VCR

Low cost video cassette recorder for up to 1 hour recording time. With built-in tuner and time clock. Available from stock. SPECIAL OFFER £425 plus VAT

N1500/M VIDEO INPUT AND OUTPUT VERSION. Available from stock. £539 plus VAT

N1520 ELECTRONIC EDIT VCR
Complete with electronic editing facility with insert and assemble modes • 2 audio tracks • extended band width • stop/motion facility. Available from stock. £850 plus VAT

AKAI

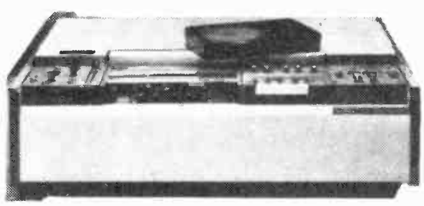
GREAT SAVING!

For one month only we are able to offer the Akai VTS-110 DX complete ¼" mono kit for an amazing £525 + V.A.T. This is a saving of £150 on the normal price.

Incredibly versatile, the kit comprises portable video tape recorder, video camera, portable monitor and adaptor.

Power source is no problem. You operate from built-in battery, mains, or a car battery. High quality pictures can be relayed from camera, "off air" or other VTR equipment, and can be played back through clip-on monitor, VTR monitor, or any UHF receiver.

With added benefits of still framing and sound dubbing, the Akai VTS-110 DX is excellent value at any time. At our price it's almost a give-away!



SONY VO1810 UK

PAL NTSC U-MATIC RECORDER PLAYER
High resolution colour, auto repeat and memory facilities, 2 audio tracks and R/F output. Available from stock. £765 plus VAT

SONY VP1210 UK PAL NTSC PLAYER ONLY
Available from stock. £645 plus VAT

Video Tapes

We offer highly competitive prices on all makes of ½ in., 1 in., VCR and U-Matic Video Tapes including Sony, Scotch, Ampex, BASF, Philips and Memorex. Next time you are ordering tapes, ring our Sales office at Colliers Wood and let us quote you. You'll be surprised.

REW have been in the Video Industry for over 10 years and their accumulated wealth of experience offers you the finest Video service in the country. All the equipment you need is always available from stock and at their London Video Cassette Centre at Centrepoint in London you can view and compare all the latest equipment. REW also offer first class studio and production facilities. Why not contact us when you want to talk video – REW know better than most.

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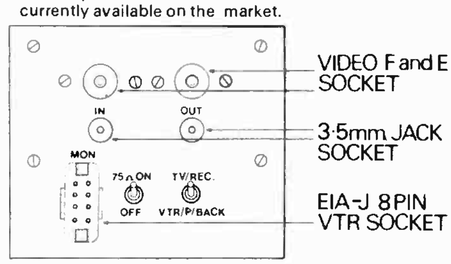
This high quality monitor is compatible with most video tape recorders and video Cassette recorders currently available on the market.



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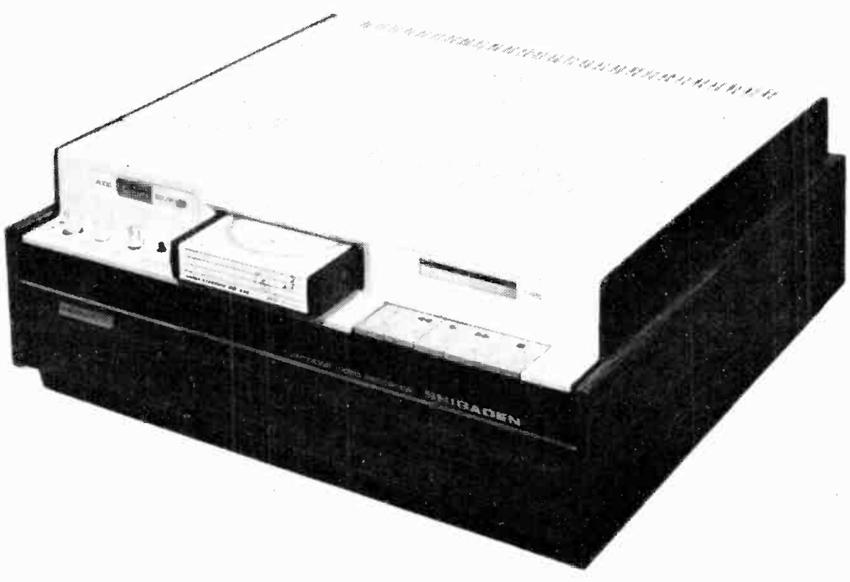
Telephone: 01-540 9684 (6 Lines) Ask for Mike Jarvis, Richard Murray or Roy Haines.

WW—209 FOR FURTHER DETAILS

National NV-5120A-B

JVC CR-6000E



Hitachi Shibaden SV-630E(K)

National (Matsushita)

NV-5120A-B

Cartridge loading (one reel—one in machine)
Record/playback of colour and monochrome
U.h.f. output converter as optional extra
PAL standard 625/50
Two heads
$\frac{1}{2}$-in tape
Automatic tape threading
Cartridge size: 12.8 × 13 × 2.9cm
Recording time: 36min
Bandwidth: 4MHz (−20dB) monochrome resolution 240 lines, 3MHz (−20dB) colour (resolution 260 lines)
Tape speed: 16.322cm/s
Dimensions: 48.5 × 38.8 × 20.8cm
Mains supply: 240V 50Hz
Price: £595 (plus v.a.t.)
Tape: £8.50 for 36 mins (National tape)

A cartridge recorder which conforms to the only "standard" in existence, if one defines a standard as a specification arrived at by agreement rather than by *force majeure*. The A-matic cartridge uses a single reel, the tape having a stiffened leader which is automatically pulled past the heads onto the tape-up reel. A programmer for repeated playing of selected parts of the tape (search) is provided and there is provision for stop-motion. Controls are solenoid-operated. A timer is obtainable as an extra, as is a remote-control unit. Sound can be dubbed.

A point to note about the EIAJ $\frac{1}{2}$-inch cartridge is that it can be loaded by the user with $\frac{1}{2}$-inch tape, so that tape recorded on an open-reel machine can be used in cartridge form.

Collett Dickinson, Pearce & Partners Ltd, Howhand House, 18 Howhand Street, London W1P 6AT.

JVC

CR-6000 E

Uses the U-matic $\frac{3}{4}$-inch cassette and is compatible with other U-matic equipment. Records and plays back in colour or monochrome with an r.f. or video input and video output (u.h.f. converter as an extra). It possesses the "search" facility, solenoid-operated controls, audio dubbing and two sound channels. A remote-control unit is an accessory. Playing time is up to 60 minutes. Price £749 plus v.a.t.

Bell and Howell, Alperton House, Bridgwater Road, Wembley, Middlesex.

Hitachi Shibaden

SV-630E(K)

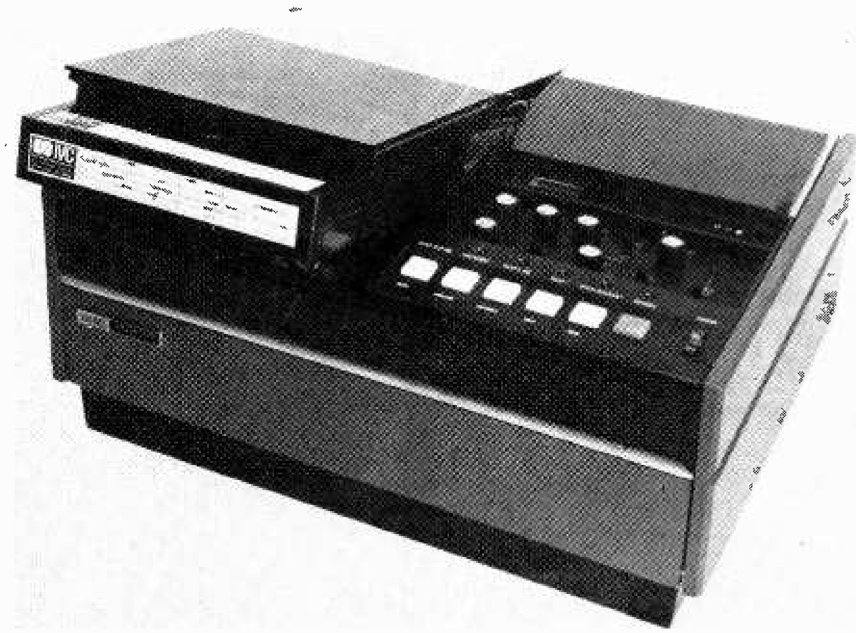
A cartridge machine conforming to the A-matic (EIAJ) $\frac{1}{2}$-inch standard of the National NV-5120A-B, with a similar specification and range of facilities. A sound-dubbing facility is provided, as is automatic re-wind. The price is £580 plus v.a.t. The price of tape is £12 for 36 minutes (Shibaden tape).

Shibaden (UK) Ltd, Lodge House, Lodge Road, Hendon, London NW4.

Loewe-Opta

Optocord 700

Basically similar to the Philips 1500/15M but with r.f. and video in and out. Auto tracking is provided, as is drop-out compensation and a colour killer which operates on playback only, thereby avoiding the possibility of recording colour in black and white. A seven-selector r.f. tuner is included, and a timer, and the machine offers stop-motion operation. Price £744.17 plus v.a.t. and the Optocord 700 uses the same type of cassette as the Philips machines. Hokushin Audio Visual Ltd, 2 Ambleside Avenue, London SW16 6AD.



IVC VCR-101C

IVC
VCR-101C

Cartridge loading (one spool)
Record/playback in colour
Video input and output
PAL on 625/50
One head (tape completely encircles drum)
1-in tape
Automatic threading
NAB 8-in reel mounted in cartridge
Recording time: 60min
Bandwidth: 3.2MHz luminance, 1.4MHz colour
Tape speed: 17.1cm/s
Dimensions: 18 × 13.5 × 8.5in
Two sound channels
Mains supply
Price £1812 plus v.a.t.
Tape around £21.00 per hour

Yet another cartridge machine, this time using a standard 8-in NAB reel of 1-in tape, with obvious compatibility with open-reel machines. Stop-motion is provided and the instruments (this is one of a range) are fitted with audio amplifiers and speakers. The machines are available in monochrome or PAL versions, and are controllable electrically by t.t.l.-compatible voltage levels. The scanning mechanism is direct-driven, having its own printed-circuit motor. Head life is claimed to be 2000 hours.
Bell and Howell, Alperton House, Bridgwater Road, Wembley, Middlesex.

Literature Received

A booklet entitled "Photocouplers" is now available from Mullard, describing the characteristics, operation and application of these devices. Requests for copies, on headed notepaper, should be sent to Computer Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

EQUIPMENT

A leaflet describing a deglitched d.a.c. system, the DMC Digisweep, which takes in digital data and drives c.r.t. deflection amplifiers to draw vectors and write alpha-numerics, is available from Amplicon Electronics Ltd, Lion Mews, Hove BN3 5RA WW411

A publication is available illustrating and giving technical data on radiotelephones types M202 (v.h.f.) and M212 (u.h.f.). Pye Telecommunications Ltd, Cambridge CB5 8PD WW412

A basic guide to data communications is the subject of a new brochure relating to computer installations where remote control terminals are connected by telephone lines to a control computer. SE Labs (EMI) Ltd, Spur Road, Feltham, Middlesex WW413

A catalogue from Burns describes a range of equipment intended for the amateur radio market, including a frequency standard, wavemeter, test oscillator and many modules for building into other equipment. Burns Electronics, 43a Chipstead Valley Road, Coulsdon, Surrey CR3 2RB WW414

The Spellman range of high-voltage power supplies is shown in a catalogue 7400 from Hartley. Solid-state, regulated and unregulated, miniature, rack-mounted and modular units are described. Hartley Measurements Ltd, HML House, London Road, Hartley Wintney, Basingstoke, Hants. WW415

We have received a leaflet on the lightweight v.h.f./f.m. marine radiotelephone, Model RF-440, made by Harris. Complete performance details and facilities provided are described, as are several accessories. Harris Corporation, RF Communications Division, 1680 University Avenue, Rochester, New York 14610, U.S.A. WW416

Tally have sent us a leaflet on their latest range of paper tape peripheral equipment, which is designed for use with the PDP11, Nova and Digico 16V minicomputers on a plug-in basis. The leaflet describes a reader and two punches for low and high speeds. Tally Ltd, 7 Cremyll Road, Reading RG1 8NQ WW417

Farnell have produced a leaflet on the PG5000 series of five pulse generators. Types 5111 to 5222 provide between them, dual channel output with delay or positive or negative-going pulses. Repetition frequency is up to 5MHz. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH WW418

We have received a leaflet describing a loudspeaking intercommunication using mains-borne f.m. or a.m. and made by the NOA Corporation. The unit is the Model FN-113S and the leaflet is obtainable from Hadley Sales Services, 112 Gilbert Road, Smethwick, Birmingham WW419

The latest Heathkit catalogue is now available. New equipment this time includes a digital clock/radio, a scientific calculator, a car clock, a 15MHz oscilloscope and a function generator. Heath (Gloucester) Ltd, Gloucester GL2 6EE WW420

A leaflet describing the Digipet electronic weighing machine for top-loading is available from Transducers (CEL). The weighers are by Shinko-Denshi, provide a digital indication and automatically select ranges of 0–19.99g or 0–199.9g. Transducers (CEL) Ltd, Trafford Road, Reading RG1 8JH WW421

The recent informative advertisements for Wayne Kerr have been reprinted in booklet form entitled "Some Notes on Bridge Measurement". The publication is obtainable free from The Wayne Kerr Company Ltd, Durban Road, South Bersted, Bognor Regis, Sussex PO22 9RL WW422

Peerless loudspeaker kits and drive units are described and pictured in a leaflet from Ross Electronics, 32 Rathbone Place, London W1P 1AD WW423

A description and specification of the Philips time division multiplexer type 3TR 1500 is given in a brochure from Philips' Telecommunicatie Industrie BV, PO Box 32, Hilversum, The Netherlands WW424

MATERIALS

Data sheets describing the applications for and properties of four new silicone resins specially developed for use in the electrical and electronics industries are available. The resins M15 and P22 can be used for binding high-temperature-resistant impregnating varnishes, while PO5 and P15 are additives for use in the manufacture of base cements for electric bulbs. TH Goldschmidt Ltd, York House, Station Road, Harrow, Middlesex .. WW425

A booklet from DuPont describes the company's range of products for the manufacture of micro-circuits, optoelectronics, and potentiometers, together with basic information on thick-film compositions. R. G. Paterson, DuPont Information Service, DuPont (UK) Ltd, 18 Bream's Buildings, Fetter Lane, London EC4A 1HT WW426

In a new leaflet, EGM Solders give full details of their ranges of solders, fluxes and chemicals. (EGM is the amalgamation of Enthoven, Grey and Morton and McKechnie.) EGM Solders Ltd, Wolseley Road, Mitcham, Surrey CR4 4JQ WW427

Transistor-aided ignition

A simple solid-state switch for ignition coils

by G. F. Nudd

The contact breaker is, in the author's opinion, the bugbear of a modern car. Many vehicles require the contact breaker to be adjusted, if not replaced, every three months or so. In a recent survey by the Automobile Association one in 15 breakdowns was found to be caused by points failure. Various types of electronic ignition have been designed to overcome the drawbacks of standard systems, notably the capacitor discharge method. However, in the case of mass-produced cars, these systems could be considered overdesigned as they are generally costly, usually requiring a special transformer. Also, in some cases, electronic revolution counters cease to operate correctly.

As a car works perfectly well when the points are in good condition and correctly adjusted all that is needed is an electronic switch to isolate the points from the heavy current and high-voltage backswing of the ignition coil. Until recently transistors capable of the 300V or so needed were not readily available. Now one can obtain the so-called "triple diffused device" that not only offers high-voltage operation but a much better second breakdown region because of its higher switching speed. The author has used the Texas BUY23/23A which, when operated with ten ohms between base and emitter, is capable of withstanding 600V. Some designs have used a high-voltage, high-power zener diode across the transistor for protection. This, however, has been found unnecessary with the author's circuit.

Concerning the driver circuitry, normal amplifying stages have been used in some designs. This, however, gives rise to excessive power dissipations in components when a worst-case circuit is designed for operation between 7 and 15V limits. To overcome this problem, a constant-current driver is used, which results in quite reasonable dissipations, and the design is suitable for all cars using a 12V ignition system. If the car does not have a ballast resistor system, R_2 can be increased from 1.2 ohms to 2.2 ohms, giving less dissipation in the driver transistor. When using the positive-ground version, the ignition coil is connected to ground instead of battery voltage. The capacitor C can be a 600V, electronic type or alternatively a "points" capacitor as normally used in the car, the normal capacitor being left *in situ* to facilitate disconnecting the unit. The capacitor should be soldered into the i.a. unit because if, for example, it became disconnected through a faulty slide connector, the ensuing high voltage might damage the transistor. Diodes D_4 and D_5 are protection measures for the transistors against voltage transients.

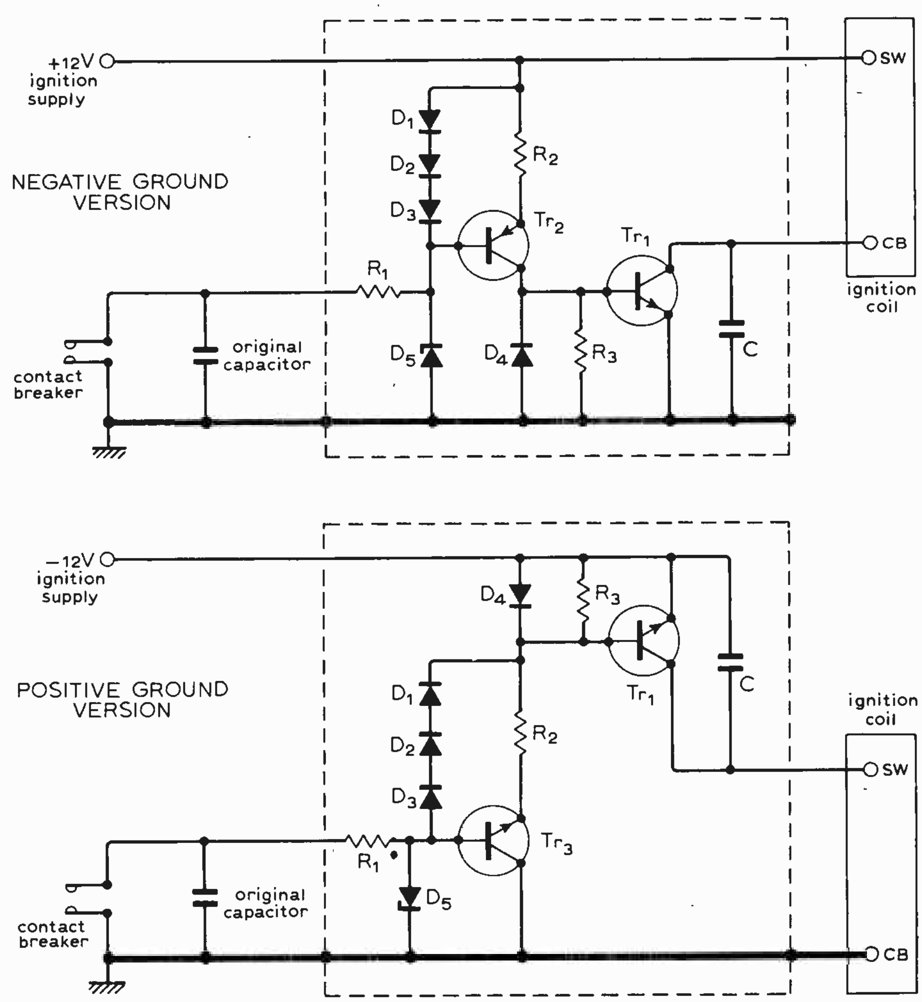
The i.a. unit may be built on a piece of aluminium and attached to the car body under the bonnet for heat dissipation. In the case of glassfibre cars the chassis must be used. Also modern aluminium oxide insulating washers for the power transistors should be used.

The points should be replaced and the engine timed accurately when the unit is fitted. The sparking plugs should be replaced or regapped as normal. It has been remarked that when electronic ignition is fitted there is no need to check the ignition system. This may, in fact, be true with an older type of car but with a more modern one the engine timing must be within a couple of degrees accuracy to obtain optimum power output.

The unit has been functioning in two cars for many months with no troubles. The points themselves wear slowly, both parts receiving slight indentations which causes the unused outer surfaces to gradually be used leaving the engine timing unaltered. The fibre surface of the points which rubs on the cam also wears to the extent of one or two thou at the points-gap in a year.

Components list

Tr_1	BUY23A/BUY23 Texas Instruments or BDY96/97/98 Mullard	
Tr_2	2N3789/90/91/92	
Tr_3	2N3055	
$D_{1,2,3,4}$	1N4001	
D_5	18V zener diode 400mW	
R_1	56Ω 2W	
R_2	1.2Ω 2W or 2.2Ω 2W, see text	
R_3	10Ω 0.5W	
C	600V d.c. working, same capacitance as the points capacitor, see text.	
Aluminium oxide TO3 thermal insulating washers:		
2 off for negative earth		A26-2004
1 off for positive earth		Jermyn Industries



Complete circuit diagrams for positive- and negative-ground systems.

PROJECT

National Electronics Council Link Scheme

The NEC Link scheme has just entered its second year of successful operation. It is an organization devoted to linking schools wanting to start electronics projects with advisers based in industry and commerce. A good example of a successful link is described in their newsletter and which is reproduced below with their kind permission. Those wishing to contact Link should write to The Organiser, Peter Noakes, Link Scheme, Department of Electrical Engineering Science, University of Essex, Colchester CO4 3SQ.

A link in operation

In October 1973, having received an offer of help from Mr Short, an engineer at Recording Designs (E.M.I.) Limited, Link Scheme put him in touch with Mr Ellerker, a teacher at the Robert Haining School, Surrey. Both were obvious electronics enthusiasts and after the initial introduction we retired to await the outcome. Following initial discussions concerning what each side expected to get from the link, it was decided to develop an introductory electronics course for 12 year olds. After considerable thought, careful design and preparation the course has now been introduced, and I was pleased to receive from the individuals involved in this link the following report. If you are interested in receiving more information, please contact directly any of the individuals mentioned at the end of the report.

Electronics at the Robert Haining School. The lives of most of us today are increasingly influenced by technological development; because of this we have organised a series of courses for our 12 year olds which expose them to a variety of technologies. The basic courses are intended to act as a stimulus, creating interest and enthusiasm.

Introduction to electronic work units. In the case of electronics a set of six work units offers the pupils the opportunity to gain familiarity *with* and confidence *in* handling components, plus intrigue and excitement through seeing and using their completed projects. They very soon show their newly gained knowledge through their ability to select resistors, capacitors, diodes and transistors with confidence.

In designing the units we had to look for efficient ways of producing attractive software which would involve the young pupils at all stages. A short introduction describing the project and its possible uses is followed by an "items sheet" which involves the selection of components and the placing of them alongside their respective symbols on the sheet. On the next sheet is drawn a 1 cm square grid depicting the component positions as they appear on the actual circuit board and numbered and lettered to correspond with the items sheet. The pupils transfer the components from the items sheet to the grid. It is now a simple matter to transfer the components from the grid to identical positions on the circuit board.

The circuit board is made from white faced hardboard marked with a 1cm square grid and numbered to assist in the transfer of the components. The components are held to the board by tension springs, mounted vertically, which may be stretched upwards to allow the component leads to be slipped between the coils of the spring. This technique is shown in diagrammatic form and is studied before the transfer takes place. A sheet of step-by-step instructions ensures that each component is placed correctly on the circuit board.

When the project is satisfactorily completed the pupils are required to fill in a questionnaire which is designed to test their understanding of the project.

Selection of projects. Selecting suitable projects for the six units of work was not a simple task. The choice was constrained by a number of factors, some dictated by the objectives of the course and others by practical considerations.

The most important objective is that the child should enjoy the work unit and this implies that each project should have a degree of novelty, such that when complete it is fun to use. A further implication of the "fun factor" is that the completed project must be guaranteed to work, provided the components are not faulty and are inserted in the correct positions. Many youngsters have been turned away from electronics as a pastime due to the repeated experience of building projects described in some of the many electronic magazines and finding they cannot make them work. To avoid this pitfall the circuits must be designed to tolerate wide variations in transistor gain, poor tolerance components and a variation in supply voltage consistent with battery operation. Also, because battery supplies are used, current economy must be considered at the design stage.

A further objective of the course is to demonstrate a range of tasks to which electronics can be applied. However, certain categories of projects were not considered. For example, the obvious applications of electronics in radios and audio amplifiers were deliberately avoided. As 12 year olds do not own cars, electronic gadgets for cars were not included. Also, electronic test instruments were excluded because they have no appeal unless their purpose is understood. In all cases the theory of operation was not considered.

The projects finally selected were as follows:

1. Moisture detector
2. Simple electronic organ
3. Light beam burglar alarm
4. Sound operated switch
5. Two-way intercom
6. Reaction time tester

Future work. In order to provide continuity of work as the present group of 12 year olds moves up through the school, further courses will be developed. At present, consideration is being given to a set of work units based on circuit blocks such as multivibrators, amplifiers, level detectors etc. The object will be to demonstrate how a wide variety of tasks may be tackled by various arrangements of a small number of basic circuit blocks. At some stage it will be necessary to change from the "spring terminal" method of construction to the more conventional technique of soldering. To this end a work unit entitled "An Introduction to Soldering" is being produced, including a video tape presentation demonstrating the technique.

Anyone who would like further details of this work is welcome to contact either:

Ted Ellerker or Brian Burtsell,
Technical Studies Department,
Robert Haining School,
Mytchett Place Road,
Mytchett, Surrey
or
Lawrence Short,
Recording Designs (EMI) Ltd.,
Victoria Avenue,
Camberley, Surrey.

World of Amateur Radio

Proposed changes to American licences

The long-awaited FCC proposals for the major "restructuring" of amateur licence conditions in the United States have now been outlined in a 29-page document, Docket 20282. Among the many changes suggested is a 2000-watt p.e.p. *output* power limit for those holding an "Advanced Class" permit, thus effectively doubling the already very high powers permitted in the USA. Amateurs with h.f. licences would be restricted to operation below 29.0 MHz until they obtain an "Experimenter" licence. "Novice" licensees would be able to use up to 250 watts d.c. input (for c.w.-only operation) instead of 75 watts, and these licences would be renewable in five-year terms. A new "Communicator" class of licence would not require a Morse code test and would permit use of all amateur frequencies above 144MHz but restricted to frequency-modulation (F3). "Extra" class licences for h.f. and v.h.f. would require a 20 w.p.m. Morse test but no further theoretical examination. Extra facilities on 50 and 144MHz would be given to "Technician" class licensees.

Generally it seems that the FCC wants to make entry into the hobby easier and to give newcomers more facilities, including new Morse-free licences, but would retain the existing "incentive" structure by providing progressively more operating privileges. The FCC has invited comment by June 16, 1975, so it will be some time before these proposals become effective—and of course they may yet be modified.

The r.t.t.y. facilities at ZS3B

Interest in radio-teleprinting continues to grow and many well-equipped stations are using this mode. But surely one of the most elaborate installations must be that of Gerhard Schlorf, ZS3B, in what used to be known as South-west Africa. The following description of his station appeared recently in *Radio ZS*: "The station operates auto start on 14075kHz and offers a number of facilities. In response to a code contained in the incoming 45 baud, 170Hz shift signal a message generator responds: 'ZS3B attended' or unattended, whichever is the case, or 'ZS3B printing'. In response to a different incoming coded signal, a stored message can be activated. Another form of coded input signal records the incoming signal which, if ended appropriately, would by using a memory, switch on the transmitter, switch off the receiver and retransmit the incoming signal to another address.

"Another feature permits an incoming 7MHz signal to be retransmitted at the same time on 14MHz, and vice versa, to allow retransmission to another area.

"The installation includes two teleprinters and the whole station is operative 24 hours of the day with any incoming signal printed, with those signals addressed specifically to ZS3B printed on one teleprinter, so that the operator need not wade through reams of paper to see if anything has come in for him.

"The 14075kHz frequency is crystal controlled and maintained to within ±30Hz. The station forms part of a world wide amateur network."

Good winter for "Top Band"

The low sunspot levels of activity which have restricted operation on 14MHz (and above) fairly strictly to the hours of daylight this winter have brought compensating benefits to the considerable number of "Top Band" (1.8MHz) dx enthusiasts, to judge by the latest Bulletin from Stewart Perry, W1BB. He reports that many amateurs have this season completed the by-no-means-easy feat of achieving "worked all continents" on this band (KV4FZ even completed a WAC in a space of eight hours!). Much sought after have been VS6DO in Hong Kong and a growing string of stations in South and Central America. Helena de Kertesz, YV5CKR, after a visit to Europe and the United States returned to Caracas, Venezuela, to become possibly the only "young lady" operator currently active on 1.8MHz dx, and has made many long-distance c.w. contacts. One of the new countries to appear on the band this winter was ST2AY in the Sudan, operated by Roger Crofts, G3UPK. The "first-timers" tests were handicapped by rather poor conditions, but the ARRL 1.8MHz tests in December provided many excellent contacts particularly on the second night. Stew Perry, W1BB, has this season worked 150 dx stations in 46 countries compared with 116 stations in 37 countries in the equivalent season of 1973–74.

50 years of REF

This month, French amateurs are marking the 50th anniversary of the formation of the Reseau des Emetteurs Français in April 1925. This society—long-established as the French national society for radio amateurs—was by no means the first radio society to be formed in France; for example, in 1914 there was the "Groupe Français des amateurs de TSF" and others in the early 1920s included the rather sinisterly named "Club des 8". But in 1925, Jack Lefebvre, F8GL, invited licensed amateurs to join an association that would be concerned exclusively with amateur radio activities and promised to eschew the intrigues that were plaguing some of the other groups that were attempting to embrace also broadcast listeners. Some 50 amateurs responded and Jack Lefebvre became founder-president.

Although amateur activity has always been on a fairly modest scale in France (currently there are about 5000 French amateurs) at least two of Europe's most successful pioneers of h.f. were located there: Leon Deloy, F8AB of Nice and Pierre Louis, F8BF.

The South African Radio League similarly reaches it 50th anniversary in May.

From all quarters

A suggested "facsimile standard" for British amateurs is put forward in *CQ-TV* by J. J. Wilcox, G8GGU: drum speed 3Hz; drum size 70mm diameter by 70mm long for 1:1 aspect ratio; scan rate 64 or 96 lines/inch; co-operation index 264 or 176; sync/phasing 15 second period, 4% white pulse in black level at start of line; scan direction left to right; modulation a.f.s.k. to A4, F4 or A4J; tones carrier 1700Hz, white 1300Hz, black 2100Hz, stop 1100Hz with picture inversion available.

The Radio Amateurs Old Timers Association (open to amateurs who have held a licence for 25 years) is holding its 1975 annual reunion on Friday, May 16 at the Bonnington Hotel, London WC1 (details Miss M. Gadsden, 79 New River Crescent, London N13 5RQ). Its official "net" is at 1100 hours on the first Thursday of each month on 3740kHz.

Following representations from the RSGB, the Home Office has agreed to a simplication of log-keeping for mobile operation. Logs will now have to show only time of the start and finish of the journey; starting and finishing points of the journey; and frequency bands used during the journey.

The Sunday-morning GB2RS news stations on v.h.f. are now all using the same frequency of 144.5MHz.

In Brief

Letters reaching me from the RSGB are usually franked with the slogan "Radio Society of Great Britain guards the interest of the radio amateur"—but recently the Post Office substituted the rather perverse message: "Collect stamps a great hobby" . . . To counter overcharging of the Oscar 6 battery amateurs can now make use of the morning "descending" orbits on Mondays, Wednesdays and Saturdays . . . Allan Mears, G8SM, has been elected as President of the Thames Valley Amateur Radio Transmitters Society, now in its 42nd year . . . The Amateur Radio Mobile Society's 1975 rally will be on Sunday, May 18 at The Clinical Research Centre, Northwick Park Hospital, Watford Road, Harrow, Middx (near Northwick Park underground station).

PAT HAWKER, G3VA

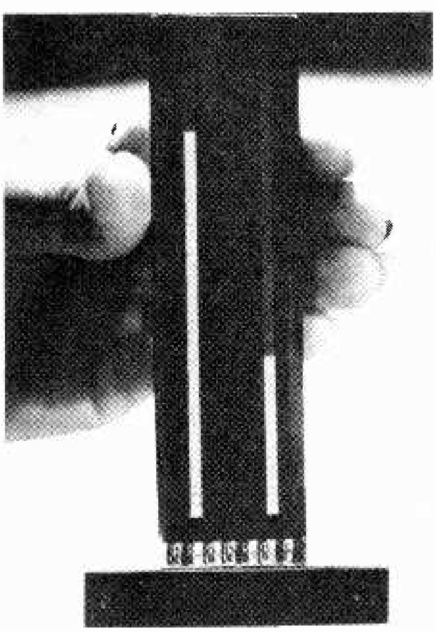
New Products

Column indicator

This indicator consists of two columns of light, the lengths of which represent an analogue quantity. Two separate analogue values can be displayed on the columns which are formed by 100 elements, each being illuminated in turn to form a continuous column of light up to 126mm long and 2.54mm wide. The indicator is manufactured by Burroughs and available from Walmore Electronics Ltd, 11–15 Betterton St, London WC2H 9BS.
WW300 for further details

Temperature detector

The "thermafilm" temperature detector is a thick-film unit which matches the BS1904 and DIN43760 specifications and can therefore replace conventional wire-wound platinum resistance detectors. Response time of the device is claimed to be half that of platinum detectors. Thermafilm can be used over a temperature range of −50 to +600°C. Matthey Printed Products Ltd, William Clowes Street, Burslem, Stoke-on-Trent, Staffs.
WW303 for further details



WW300

Microwave filters

Models TYG-100 and TYG-400 are continuously-tunable bandpass filters having bandwidths from 1 to 20GHz and 4 to 18GHz respectively. These filters are YIG types offering an error of less than 1% and a resolution on the frequency dial of 10MHz. Maximum average r.f. power from the instrument, which measures $4\frac{1}{2} \times 4\frac{1}{2} \times 3$in, is 100mW. Telonic Industries UK, 2 Castle Hill Terrace, Maidenhead, Berks.
WW313 for further details

Heat-sinks

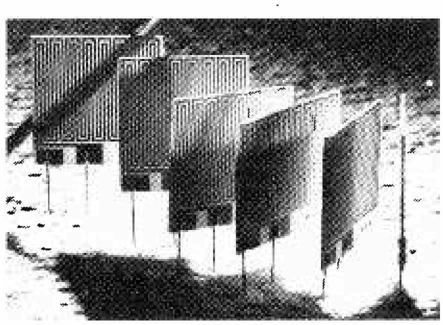
A range of black-anodized heat-sinks for TO-5 and TO-100 packages have thermal resistances from 30°C/W and are manufactured from copper-based alloys. Dau UK Ltd, 42A Main Road, Barnham, Sussex PO22 0ES.
WW327 for further details

Vacuum relays

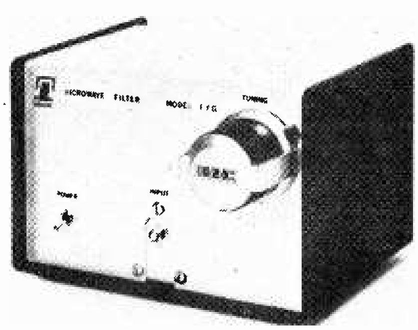
Latest additions to the Kilovac Corporation range of vacuum relays are the KC-3 rated at 8kV, the KC-10 and H-26 both rated at 15kV, and the KC-20 rated at 28kV. The relays offer a dielectric strength of around 1000V/mil when operating, which permits closer contact spacing and low-bounce mechanisms. Walmore Electronics Ltd, 11 Betterton Street, Drury Lane, London WC2H 9BS.
WW320 for further details

Frequency synthesizer

The Rockland model 5100 programmable frequency synthesizer uses digital techniques to provide outputs in 0.001Hz steps from d.c. to 2MHz. Programming is accomplished through t.t.l.-compatible circuits or contact-closures to ground. Either a binary or 8.4.2.1 b.c.d. format can be used, with up to 46 parallel bits or four 12-bit bytes. Output amplitude of the instrument is variable continuously and in 1dB steps to 85dB from a maximum of 10V pk-pk with 50Ω source impedance. Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QP.
WW315 for further details



WW303



WW313

Contactless keyboard

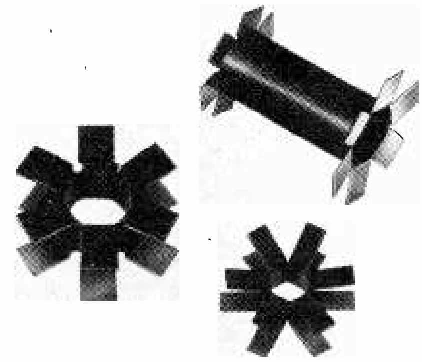
Plessey Keyboards have announced a contactless electronic keyboard—the PCK 2000. The unit, which has been produced primarily for the professional computer market, features capacitance coupled keyswitches. These switches operate into encoding logic based on an l.s.i. r.o.m. which provides various design options. The options can be selected on the basis of specification or cost requirements. Plessey Keyboards, Wood Burcote Way, Towcester, Northants NN12 7JN.
WW316 for further details

Opto-isolated switches

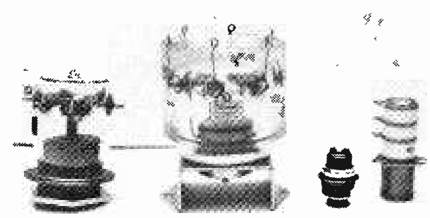
Two new solid-state switches consist of a low-level voltage switching control, suitable for direct drive from logic pulses, and optical isolation between input and output circuits. The input voltage range is from 3 to 32V d.c., which will switch an alternating current of 10A r.m.s. at a voltage of either 120 or 240V. Hamlin Electronics Ltd, 14 New Road, Southampton.
WW317 for further details

Thick-film amplifiers

A 12W class A power amplifier, type TF008, requires an input of 0.5V for full rated output and a claimed distortion figure of 0.05%. The supply voltage range is from ±12 to ±20V, and the frequency response is 10Hz to 30kHz. Type TF009 is a 25W class B design requiring a supply voltage of between ±17 and ±25V at 2A maximum. Frequency response is



WW327



WW320

20Hz to 60kHz with a typical harmonic distortion figure of 0.2%. Both units require external power transistors, and measure 1.35×1×0.25in. Guest Distribution Ltd, Redlands, Coulsdon, Surrey CR3 2HT.
WW318 for further details

Phasor meter

The model STD10,000 phase-sensitive multimeter will give direct readings, of in-phase and quadrature components of voltage or current, on two separate meters. Five voltage/current ranges from 500mV to 500V and 1mA to 10A f.s.d. are provided on the instrument, which operates at 50/60Hz or 12 to 2400Hz with the aid of an adaptor. J. J. Lloyd Instruments Ltd, 1 Brook Lane, Warsash, Southampton, Hants.
WW305 for further details

Digital multimeter

A multimeter offering a voltage range from 1μV to 1000V, a resistance range from 1mΩ to 2000MΩ, and a current range from 10pA to 2A has been introduced by Keithley Instruments. Other features of the model 160B are a 1200V floating capability, a 0.2μV/°C stability, and several options/accessories including a b.c.d. output, a r.f. probe, and a 50A shunt. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks.
WW325 for further details

Load simulator

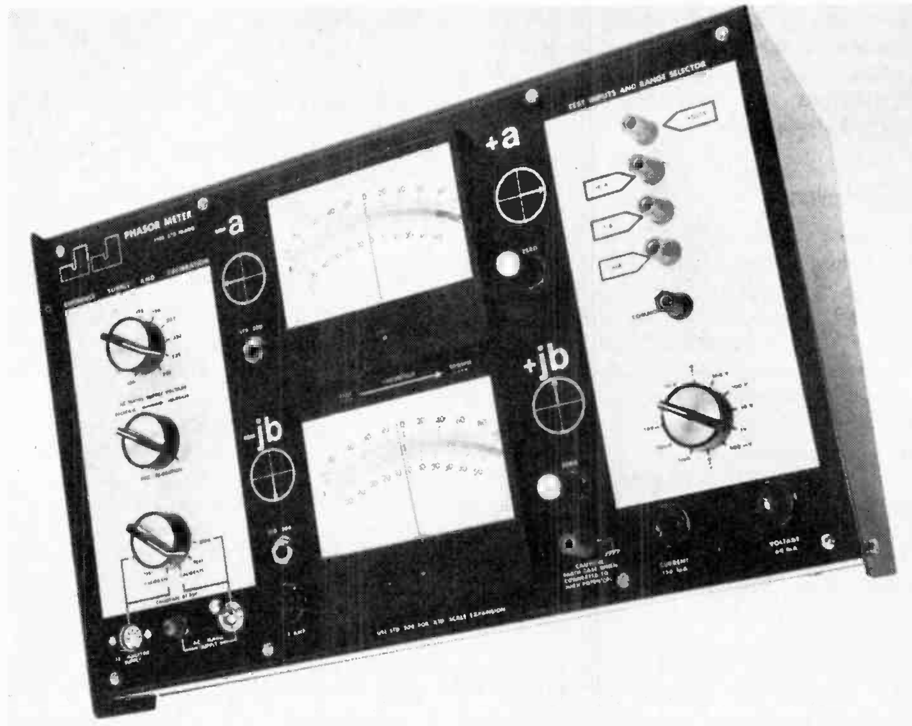
The model EL750 is a portable d.c. power tester suitable for checking power supplies. The unit will dissipate up to 750W d.c. and will operate in a constant-resistance or constant-current mode, selected manually in steps by push buttons. Load-current programming can be accomplished by applying an external direct voltage through a connector on the rear panel. Data Technology Corporation, Sherwood House, High Street, Crowthorne, Berks.
WW308 for further details

Silk-screen service

Circuitape Ltd have introduced a made-to-order service for silk-screen printed aluminium panels. The panels can be produced in any shape and size with punched holes to specific requirements. Silk-screening can be in any colour with legends in any language. Delivery is normally around five weeks, but a special rapid service is also available. Circuitape Ltd, New Street, Aylesbury, Bucks.
WW306 for further details

Elapse timers

A custom range of elapse timers from Longmore Systems enable time periods between 1ms and 99990s to be measured. Five-decade selection is provided but different ranges may be specified. Control is by voltage-trigger and push-button start-stop with separate reset. Instrument read-



WW305

WW325

WW308

out is on a four-digit display which is accurate to within 10 p.p.m. Longmore Systems Ltd, Environment House, 875 Sidcup Road, London SE9 3PP.
WW307 for further details

YIG counter

The model 331 microwave counter will automatically measure frequencies from 825MHz to 18GHz. The centre frequency of signals with up to 200MHz f.m. deviation can be measured directly and an optional plug-in circuit permits the measurement of signals as low as −25dBm. Remote programming, b.c.d. output and rear input options are also available for system's application, where up to 80 readings a second can be made. Dana Electronics Ltd, Collingdon Street, Luton, Beds.
WW329 for further details

Function generator

The Hewlett-Packard model 3312A function generator contains two independent generators in one case. The main generator has a frequency range from 0.1Hz to 13MHz in eight ranges while the modulator generator delivers signals from 0.01Hz to 10kHz. Both generators provide sine, triangle, square, pulse and positive/negative ramps. By combining the generators, sweep, a.m., f.m. and tone bursts can be created with an output, from the main generator, of 10V pk-pk into 50Ω. A four-position attenuator with variable control adjusts the output over a 60dB range. Hewlett Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.
WW326 for further details

36 position switch

A single-pole, 35-way switch rated at 2A continuous with a breaking figure of 50mA at 300V a.c./d.c. has been added to the N.S.F. range of rotary wafer switches. Both 10° and 20° indexing versions are available from N.S.F. Ltd, Keighley, Yorkshire DD21 5EF.
WW302 for further details

Plastic pots?

Two ranges of conductive plastic potentiometers designated P4100/4200 and P4400, the latter being a low cast version of the former, are now available in the UK. The precision range is rated at 1.8W and offers a resolution of 0.003% with 352° angle of rotation, a linearity within 0.2% and an operating torque of 0.2 cm.g. Both models are manufactured in servo size 13 and can be supplied with up to ten ganged tracks. Variohm Components, The Barn, Wood Burcote, Towcester, Northants NN12 7JR.
WW311 for further details

Active filter

The UAF31 is a two-pole active filter in which, with the addition of three or four external resistors, the Q-factor, resonant frequency and gain can be controlled. Three separate outputs provide low, high and band-pass transfer function—by summing the high and low pass outputs a band-reject transfer function can be obtained. Frequency accuracy is within 1% and the Q range is from 0.5 to 500. Burr-Brown International Ltd, 25A King Street, Watford, Herts WD1 8BT.
WW310 for further details

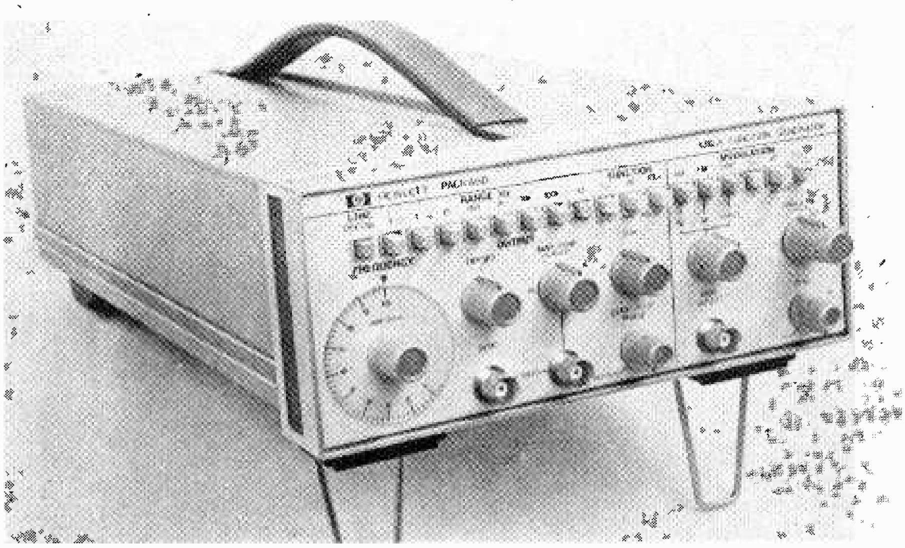
Pyrometer

The Litesold pyrometer has been designed for measuring soldering-iron bit temperatures. A fine thermocouple tip, which causes negligible cooling, is placed on the bit and temperature is read off a meter calibrated to 500°C f.s.d. Light Soldering Developments Ltd, 97 Gloucester Road, Croydon, Surrey.
WW332 for further details

Conductive plastics

3M have announced a conductive plastic called Velostat. This product is available as a material or as a variety of manufactured items. For the benefit of any organic-chemists that may be reading the material is a carbon-loaded polyolefin

WW329



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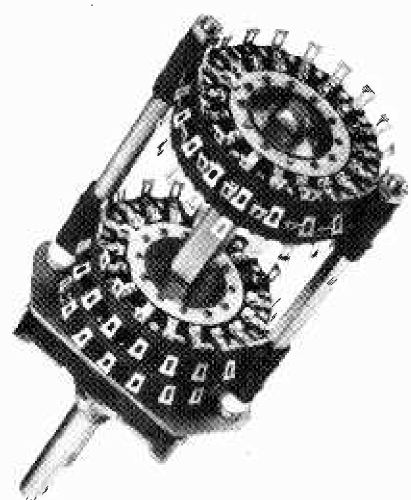

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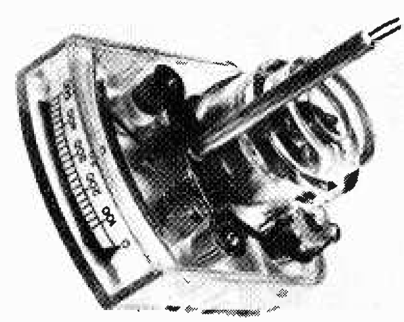

WW332

plastic which is conductive throughout its volume. 3M UK Ltd, 3M House, Wigmore Street, London W1A 1ET.
WW330 for further details

Logic panel meter

This panel meter has a six-digit display and can be used for frequency counting, time, and period measurements. The unit, which occupies 3.3×1.4in of panel space, consists of three modules—a six digit decimal counting and display section, a pre-scaler and timing generator module, a clock and offset module which consists of an internal 500kHz crystal oscillator and a programmable divider. Power requirements are ±5V at 800mA. Tony Chapman Electronics Ltd, 80A High Street, Epping, Essex CM16 4AE.
WW331 for further details

Circuit tester

A pocket-sized tester that will check voltage, polarity and continuity is now available in the UK. The instrument has a l.e.d. indicator which glows when either a voltage between 3 and 600V a.c./d.c. is present, continuity in a circuit exists, or the polarity of a circuit/component is correct with respect to the coloured probes. British Central Electrical Co Ltd, Ringwood, Hants.
WW321 for further details

Variable transformers

Cherishaw Ltd have introduced a new range of single- and three-phase variable transformers with current ratings from 2 to 28A. Each model is manufactured in either an open form for panel mounting or enclosed for bench use and all versions are designed for a 240V supply. Cherishaw Ltd, 103 Mount Pleasant, Tunbridge Wells, Kent.
WW322 for further details

Inductors

The 1537 series of moulded r.f. inductors will operate in the temperature range −55° to +125°C and are available in inductances from 0.15 to 240μH. Maximum current ratings range from 115mA, for the 240μH device, to 2.74A for a 0.15μH type. The components measure 0.155in dia × 0.375in and are manufactured by Amphenol Ltd, Thanet Way, Whitstable, Kent CT5 3TF.
WW323 for further details

P.r.o.m. eraser

An ultra-violet power source designed for erasing p.r.o.ms has a built-in timer, variable from 0–30 minutes, and can erase up to six memories in a single run. The unit is manufactured by Stolz A.G. of Switzerland and is available in the UK from Memec Ltd, The Firs, Whitchurch, Aylesbury, Bucks.
WW324 for further details

Sinewave oscillators

A series of low-distortion, amplitude-stable signal sources manufactured by Frequency Devices Inc., provide a single, specified frequency in the range 100Hz to 10kHz. Features include a stability of 0.02% per °C, amplitude stability of 0.1dB, adjustable output from 1 to 20V p-p. Distortion of the device is 0.1% and the impedance is less than 10Ω. The oscillators are short-circuit protected, measure 1.5×2.0×0.4in and are available from Lyons Instruments Ltd, Hoddesdon, Herts.
WW304 for further details

Solid State Devices

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

Photodiodes

The TIXL471 gallium-arsenide l.e.d. and the TIXL451 silicon avalanche photodiode are both high-speed diodes for use in fibre optic application. The devices will connect directly and self-align with Corning T-19H optical waveguide terminations.
WW350 for further details Texas

Regulators

Fixed-voltage regulators for both positive and negative supplies are available with outputs from 5 to 24V and current ratings up to 1.5A. The regulators are supplied in either a plastic package or TO-3 encapsulation.
WW351 for further details GDS

Switching transistor

A triple diffused n-p-n- power transistor, type SCA100-120, appears as only a 0.002Ω resistance with a 100A collector current. Saturation voltage at the maximum-rated I_C is 1.7V and the maximum voltage is 120V.
WW352 for further details Impectron

Microprocessor

The Mostek eight-bit parallel microprocessor, type MK5065 is a 40-pin single chip-device. It offers 51 basic instructions or 81 with modifications, and has t.t.l. compatible inputs and outputs.
WW353 for further details Lock

Miniature bridges

A new range of 1.5A silicon full-wave rectifiers comprises seven devices—the MDA100 to 110 designed for voltages between 50 and 1000V. These bridges will operate over a junction-temperature range from −55 to 150°C and will withstand a 45A surge for one cycle of operation.
WW354 for further details Motorola

Alarm i.cs

A range of i.cs designed for alarm application are now available in the U.K. Devices in the range include the 3010 tone alarm which compares an input signal to an adjustable reference voltage if the reference voltage is exceeded a pulsating or constant tone for driving an external loudspeaker is generated. The 3020 tri-stage alert/alarm has three l.e.d. drivers. Each of the three drivers has two t.t.l. compatible inputs. The 3030 temperature alarm activates both a steady t.t.l. compatible output and a tone output if the temperature of the i.c. package exceeds a preset level.
WW355 for further details
Adrian Electronics

A/d system

A low-cost a/d system can be realized by using the MC14435 d.v.m. i.c. and the MC1505L dual-ramp generator and comparator i.c. One external capacitor and two potentiometers are required to complete the circuit.
WW356 for further details Semicomps

TV-sound i.c.

The TDA1190 is capable of carrying out all the functions of a television sound channel. These functions include an i.f. amplifier/limiter, an active low-pass filter, f.m. detector, a d.c. volume control and a power amplifier.
WW357 for further details SGS-Ates

Zener diodes

A new range of zener diodes are plastic package types with a power dissipation capability of 1.32W and a zener voltage range from 3.3 to 200V.
WW358 for further details Siemens

C.m.o.s. a/d converter

Analog Devices Ltd have announced what is claimed to be the world's first microprocessor-compatible i.c. analogue-to-digital converter to provide up to 10-bit accuracy. The device, designated AD7570, uses c.m.o.s. construction and is designed specifically to interface with microprocessors, and is fully t.t.l./d.t.l./c.m.o.s. compatible. The AD7570 features a conversion time of 20μs and a throughput rate of 50kHz.
WW359 for further details
Analog Devices

Texas Instruments Ltd, Manton Lane, Bedford.
GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
Impectron Ltd, 23 King Street, London W3 9LH.
Lock Distribution, Neville Street, Middleton Road, Oldham, Lancs OL9 6LF.
Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middx.
Adrian Electronics Ltd, 28 High Street, Winslow, Buckingham MK18 3HF.
Semicomps Ltd, Northfield Industrial Estate, Beresford Avenue, Wembley, Middx HA0 1SD.
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Real and Imaginary

by "Vector"

The Second Book of Vector

There dwelt in the land of Brit certain high priests who served in the temples of Elektron, which is an invisible god who darteth around in ever-decreasing circles but never into his own nucleus. And the priests of Elektron were devout men, serving no other god but he. And Elektron looked with favour upon them and rewarded them each according to his worth with divers strange gifts. To some he gave power to converse with those from afar off and to others he brought visions of strange happenings in distant lands; yea, even of the United States cavalry in glorious Technicolor.

And to certain other of his high priests Elektron gave powers of levitation, so that they walked with their feet ever-so-slightly off the ground; these dwelt in glass temples called, in the native tongue, Researchlabs or Funnifarms, which were set apart from the common people and to which entrance was denied to all, saving only those having scrips of authority from the chief priest. And these priests were called by the common people Egbonces which meaneth he who knoweth the square root of minus one. And the Egbonces were cunning at fashioning curious devices from boot-latchets and wax so that the populace were astonied and continually cried out, saying, Behold, these are great wonders but of what use be they?

Yet other high priests of Elektron were followers of the prophet Babbage and these were set in authority over divers machines that brought much benefit to the common people; some computed the numbers of the tribes and the taxes that each man should pay; others controlled the *paycheks* of those that laboured, so that each man received less than his hire, while others suggested that the inter-city chariots were tardy in arrival. And Elektron taught the high priests to feed the engines with curious symbols engraven upon tablets that they might print out likenesses of the sex-goddess Bardot devoid of her apparel, which gave satisfaction to many. And these priests likewise withdrew the hems of their garments from the common populace and, by conversing in the alien tongues of Fortran and Algol, preserved their mysteries jealously.

At this time the skies were filled with heavier-than-air machines of many nations which flew with the noise of emasculated hornets and carried the peoples to and fro, even unto the ends of the earth. These machines were under the auspices of the god Hijak. And certain of the nations had air machines which could drop unpleasantness on the land beneath to discomfort the people; but certain other nations who were poor and backward and, as the saying goeth, not with it, did not possess these amenities. Thus it came to pass that the acquisition of such machines was regarded by all as an outward and visible sign that the possessor nation was emerging from savage practices and an ensample to others.

And certain rich merchants searched diligently and redeemed many heavier-than-air machines; some from the knacker's yard; some which fell from the back of an hangar and yet others which were dislodged privily from the Science Museum. And they purposed to sell these to the heathen for many shekels of gold and at great profit. So it came to pass that the merchants sent envoys to a far country, even to the kingdom of Tsetse-Tsetse.

And the envoys said unto the king of Tsetse-Tsetse, O king live for ever but put not thy money upon it. And the king answered saying, What meanest thou? Then did the envoys reply saying, Surely thou knowest that thy neighbour the king of Beri-Beri hath cast covetous eyes upon thy lands and thy maidens? If only thou hadst an Air Force it would cause thine adversary to wind his neck in. Then did the king beat his breast crying, Woe is me! And the envoys made reply saying Not so, O king, for it so happeneth that we can supply thee with a squadron of Bleriot Mk.Is. And thus it came to pass that the king bought from the envoys for much fine gold and slept peacefully with his wives that night.

Then did the envoys depart and journeyed to the neighbouring land that is called Beri-Beri. And they said to the king of Beri-Beri, O king live for ever but begin not the reading of any long novels. And the king said What meanest thou? Whereupon the envoys replied saying, Knowest thou not that thy neighbour the king of Tsetse-Tsetse hath secretly purchased war-birds and purposeth to ravage thy country? At this the king went as pale as was possible and the end of the matter was that he became Commodore of a squadron of Cabbage White Mk. VIIs.

And it came to pass that in Brit the god Elektron gave unto his high priests the power to fashion magick bowls which could divine the presence and movements of heavier-than-air machines even at great distances. Yea, and not only this, for, by gazing into the bowl, vessels having their business in great waters could be made to broach each other with greater certainty. And on land its magick powers enabled the Fuzz to put the finger upon all charioteers who, like their forebear Jehu, drove furiously. And the name of this new wonder was radar, which, being translated, meaneth That which worketh by suction and mirrors.

And the rich merchants came unto the high priests of radar and said unto them, Lo, we have heard much of the wonders that thy god Elektron hath taught thee and it seemeth that we can do a deal with profit to all. Make for us great numbers of these magick bowls, we pray thee, that we may sell them to the nations for their greater safety. Do this and we will pay thee many shekels of gold; moreover, we will pull down thy temples which are but potting sheds and in their stead we will raise mighty glass temples to the greater glory of Elektron, wherein thou shalt find all the instruments that thy heart desirest. And we will clothe thee in white raiment and give thee charge over many. What sayest thou?

And the high priests conferred privily and agreed among themselves that they were on to a good thing. So it came to pass that the merchants caused mighty temples to be built wherein the god Elektron might be served, both by day and night; and the high priests, for their part, devised magick bowls with ever greater cunning and these the merchants sold to whoever was in the market place. Thus it came about that both the king of Tsetse-Tsetse and the king of Beri-Beri were persuaded to buy the magick bowls with which to keep vigil each upon the other. Yea, both primary and secondary radar had they in plenty and certain inhabitants of the two countries were trained to interpret the signs and portents which appeared upon these bowls whenever an heavier-than-air machine was drawing nigh.

And behold, it came to pass that upon a certain night there was a watchman in the kingdom of Tsetse-Tsetse who was an exceeding dim lamp; moreover, when interpreting the symbols on the magick bowl, he was, as the saying is, unable to tell Squawk from Clutter. And this watchman, fearful of what he supposed he saw upon the face of the bowl, said unto himself The enemy is upon us, and thereupon smote the Panick Button. Whereupon the Bleriot Mk.Is rose (all excepting one which had broken its elastick band) and brought destruction to the sleeping land of Beri-Beri. But the Cabbage Whites, being forewarned by their magick bowls, were already riding the heavens and bringing affliction upon their neighbours. And, by morning, both countries were bathed in blood.

And in the temples of Elektron there was great commotion, for the hot lines were glowing red and the artificial moons which the high priests had raised were overburdened with coloured images of the slaughter, for the delectation of the common people. And when all was accomplished, overseers from the United Nations came and wagged their heads and voted Tsetse-Tsetse and Beri-Beri into their assemblies in recognition of their emergence.

Sanyo Video Tape Recorder Systems

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VTR 1100SLR
½" 4-head monochrome solid-state VTR offering four different viewing motions: standard, slow, still and frame-by-frame. Features include: rotating 4-head ferrite magnetic helical scanning system for perfect slow motion, independent audio erasure and re-recording for voice-over, video editing, ALC, digital counter for instant location of material, auto shut-off.

VCA 200 E Video camera kit with built-in viewfinder, microphone, zoom lens and tripod. For use with the VTR 1100SLR and VTR 2000. 3" electronic viewfinder can also be used as a playback monitor.

VM 4120 (K)
11¾" monitor with R/F. Off-air portable video monitor/receiver with high resolution 12" CRT. Ideal for educational purposes. Can be used as conventional TV.

VM 4155 (K) Robust 16" industrial video monitor with sound channel.

VTR 2000
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VM 4092 (K) 9" industrial video monitor. Robust metal case. High resolution 10" CRT. For use in stores, hospitals, etc.

VC 1120 Surveillance video camera with R/F. Covers all light conditions from extra-low 20 lux 2ft-candles to outdoor brightness with ALC. Takes all lenses, including wide angle, zoom, close-up and telephoto.

VC 1150
General purpose video camera with switchable internal/external sync. and ALC. For use with the VTR 1100 SLR and VTR 2000.

VCS 3000 Low light level video camera. Operates at very low light levels for security purposes. Also for use with infra-red lighting.

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For further information please apply to VTR Manager, Sanyo Marubeni (UK) Limited, Sanyo House, Bushey Mill Lane, Watford, WD2 4UQ. Telephone: Watford 30421.

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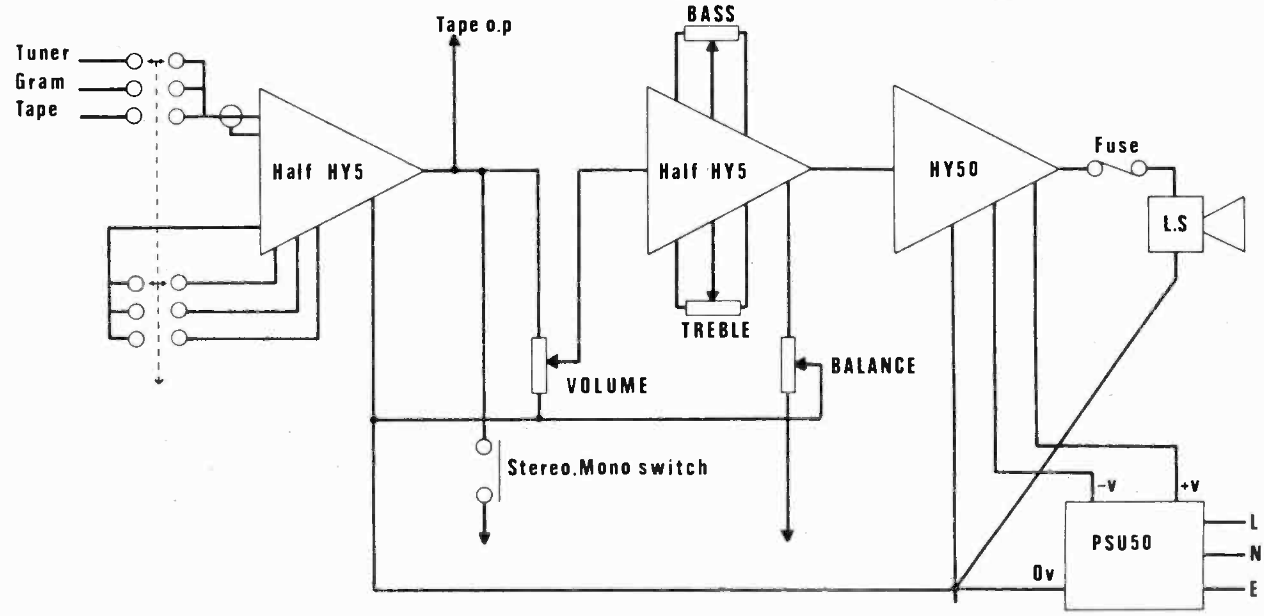
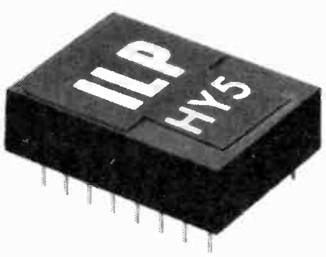
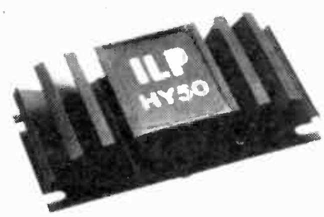
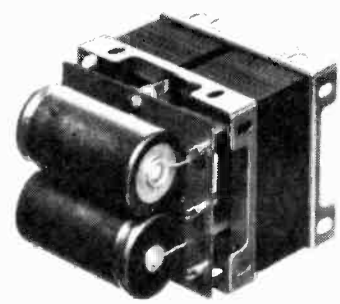


Mono electrical circuit diagram with interconnections for stereo shown







The HY5 is a complete mono hybrid preamplifier, ideally suited for both mono and stereo applications. Internally the device consists of two high quality amplifiers—the first contains frequency equalisation and gain correction, while the second caters for tone control and balance.

TECHNICAL SPECIFICATION

Inputs

Magnetic Pick-up	3mV.RIAA
Ceramic Pick-up	30mV
Microphone	10mV
Tuner	100mV
Auxillary	3-100mV
Input impedance	47kΩ at 1kHz

Outputs

Tape	100mV
Main output	Odb (0.775 volts RMS)

Active Tone Controls

Treble	±12db at 10kHz
Bass	±12db at 100Hz

Distortion 0.05% at 1kHz
Signal/Noise Ratio 68db
Overload Capability 40db on most sensitive input
Supply Voltage ±16—25 volts.

PRICE £4.50 + 0.36 V.A.T. P & P free.

The HY50 is a complete solid state hybrid Hi-Fi amplifier incorporating its own high conductivity heatsink hermetically sealed in black epoxy resin. Only five connections are provided: input, output, power lines and earth.

TECHNICAL SPECIFICATION

Output Power 25 watts RMS into 8Ω
Load Impedance 4—16Ω
Input Sensitivity Odb (0.775 volts RMS)
Input Impedance 47kΩ
Distortion Less than 0.1% at 25 watts typically 0.05%
Signal/Noise Ratio Better than 75db
Frequency Response 10Hz—50kHz ± 3db
Supply Voltage ± 25 volts
Size 105 x 50 x 25 mm.

PRICE £5.98 + 0.48 V.A.T. P & P free.

The PSU50 incorporated a specially designed transformer and can be used for either mono or stereo systems.

TECHNICAL SPECIFICATIONS

Output voltage	50 volts (25–0–25)
Input voltage	210–240 volts
Size	L.70. D.90. H.60 mm.

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AMPLIFIER KITS OF *Distinction*

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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)

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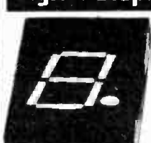

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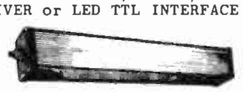

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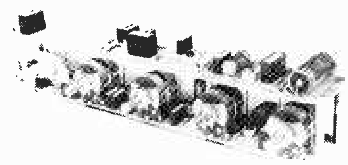

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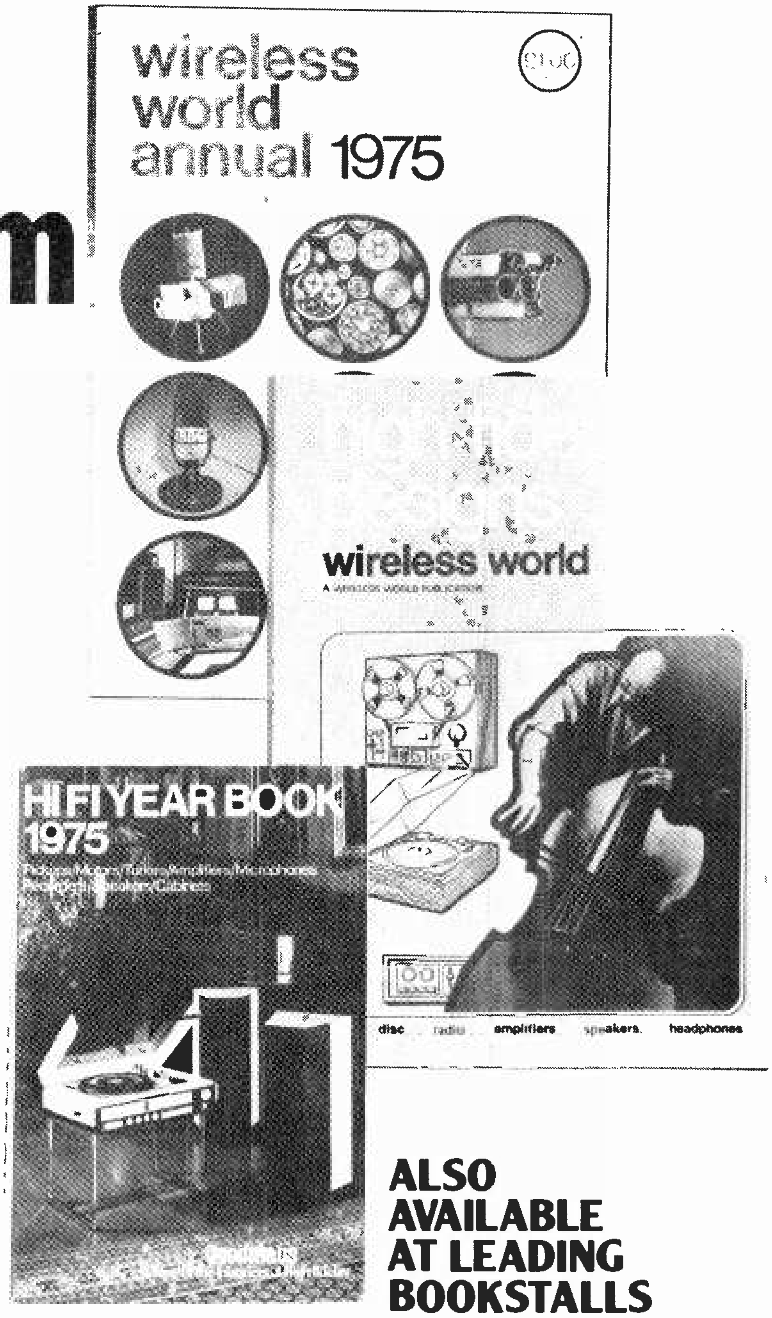

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4·0	—	Securex 5000
7·0	Inst.	Westingh. 550
7·0	4	Heinemann (60c.) AM12
8·0	Inst.	Westingh. 550
8·0	—	Securex 5000
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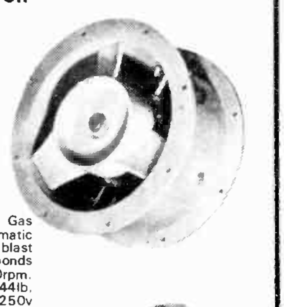

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2N1306	0.31	2N5294	0.48	BC14BB	0.15	8F195	0.12	TIP34A	1.51
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2N214B	0.94	2N6027	0.45	8C168B	0.15	BF257	0.47	TIP3055	0.50
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2N2646	0.55	40406	0.44	8C184L	0.13	BFX29	0.30	1N914	0.07
2N2904	0.22	40407	0.35	BC212A	0.16	8FX30	0.27	1N3754	0.15
2N2905	0.25	40408	0.50	8C212LA	0.16	BFX84	0.24	1N4007	0.10
2N2906	0.19	40409	0.52	8C213LA	0.15	BFX85	0.30	1N4148	0.07
2N2907	0.22	40410	0.52	BC214LB	0.18	BFX88	0.25	1N5404	0.22
2N2924	0.20	40411	2.00	BC237B	0.16	BFY50	0.225	1N540B	0.30
2N2926G	0.12	40594	0.74	BC238C	0.15	BFY51	0.23	AA119	0.08
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2N3054	0.60	40636	1.10	BC257A	0.16	BRY39	0.48	BA145	0.18
2N3055	0.75	40673	0.73	BC258B	0.16	ME0402	0.20	BA154	0.12
2N3391	0.28	AC126	0.20	BC259B	0.17	ME0412	0.18	BA155	0.12
2N3392	0.15	AC127	0.20	BC301	0.34	ME4102	0.11	BB103B	0.23
2N3393	0.15	AC128	0.20	BC307B	0.17	MJ480	0.95	BB104B	0.45
2N3440	0.59	AC151	0.27	BC308A	0.15	MJ481	1.20	BY126	0.12
2N3442	1.40	AC152	0.49	BC309C	0.20	MJ490	1.05	BY127	0.15
2N3638	0.15	AC153	0.35	BC327	0.23	MJ491	1.45	BYZ11	0.51
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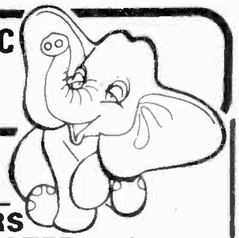

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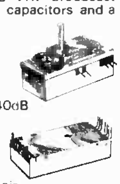

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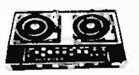

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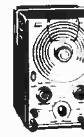
(carr/packing 35p)



U4324 20KΩV with case	£9.85
U4311 Laboratory meter	£52.00
U4312 20KΩv with case	£10.75
U4315 20KΩv with case	£10.00
U4317 20KΩv with case	£17.00
U4313 20KΩV with steel case	£13.80
U4317 20KΩV with case	£17.00
U4341 33KΩV plus transistor tester steel case	£11.00
U4323 20KΩV plus 1KHz 465KHz OSC with case	£8.00
ITI-2 20KΩV slim type	£5.95
THL33D (L33DX) 2KΩV robust	£7.50
TP5SN 20KΩV (Case £2.00)	£10.75
TPS10S 2KΩV	£8.50
TW20S 20KΩV	£13.00
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S100TR 100KΩV plus transistor tester	£22.50
New Revolutionary Supertester 680R Multitester	£18.50
† TE40 AC multivoltmeter	£19.75
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† TE65 28 range valve voltmeter	£22.50
† TE20D RF generator 120KHz–500MHz	£18.95
† Tk22D AF generator 20Hz–200KHz	£19.95
* HM350 In circuit transistor tester	£19.50
* TT145 Compact transistor tester	£14.75
† G3-36 R/C osc 20Hz–200KHz	£19.75
* C3042 SWR Meter	£5.75
* SE350A De-luxe signal tracer	£12.95
* SE400 Mini-lab all in one tester	£15.50
C1-5 Scope 500,000KHz (carr £1.00)	£44.00
Radio activity counter 0–10r (carr £1)	£9.97
Mains unit for above (carr 50p)	£3.75

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Marriot XRPS/17 ¼-track high	£2.50
Marriot XRPS/18 ¼-track med	£3.50
Marriot XRPS/36 ¼-track med	£5.00
Marriot XRPS/63 ¼-track high	£1.75
Marriot ½-tr. Erase 13X12E 343	£0.75
Marriot erase heads for XRPS 17/18/36 (XESII)	£0.75
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Bogen type UL290 erase	£1.50
Miniature stereo-cassette rec/play	£2.25

pp 15p

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150R	6v	2 p.c.o.
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1250R	12/55	2 p.c.o.
1700R	18/24v2	p.c.o.
1800R	24v	4 p.c.o.
2500R	18/24v2	p.c.o.
4000R	24v	2 p.c.o.

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A high stability signal generator using the low distortion Wien bridge principle. Covering 10Hz to 100KHz in four ranges. Adjustable output from 1mV to 1v. Sine and Square wave output. **£34.00**

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MODEL 42 WIDE RANGE RF SIGNAL GENERATOR
Covering 150KHz to 300MHz in eight ranges. Highest range in harmonic. Built-in AF mod. Output up to 50mV. Circular scale. **£24.50**

MODEL 43 RC BRIDGE
Null indicating bridge for resistors and capacitors. Resistance range 10R to 10M ±2% at Centre Scale. Capacity range 10pF to 10pF ±2% Centre Scale except 1pF to 10pF Range ±5%. Power Factor Measurement 0–70% **£23.50**

MODEL 44 INDUCTANCE BRIDGE
Measures 1μH to 100H in four ranges ±5% accuracy. Q measurement from 0.1–1,000 +10%. **£34.00**

MODEL 45 DIRECT READING FREQUENCY METER
10Hz to 100KHz in four ranges. Input from 10mV to 5v **£36.00**

All models except Model 35 are internally powered from 9v battery (extra). Carriage and packing all models 37p.

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Type	1	25	100+
SN7400	0.15	0.14	0.13
SN7401	0.15	0.14	0.13
SN7402	0.15	0.14	0.13
SN7403	0.15	0.14	0.13
SN7404	0.15	0.14	0.13
SN7405	0.15	0.14	0.13
SN7406	0.39	0.34	0.31
SN7407	0.39	0.34	0.31
SN7408	0.25	0.24	0.23
SN7409	0.25	0.24	0.23
SN7410	0.15	0.14	0.13
SN7411	0.25	0.24	0.23
SN7412	0.28	0.27	0.26
SN7413	0.32	0.31	0.30
SN7416	0.30	0.29	0.28
SN7417	0.30	0.29	0.28
SN7420	0.15	0.14	0.13
SN7422	0.30	0.29	0.28
SN7423	0.40	0.39	0.38
SN7425	0.40	0.39	0.38
SN7426	0.40	0.38	0.36
SN7427	0.40	0.38	0.36
SN7428	0.45	0.42	0.40
SN7430	0.15	0.14	0.13
SN7432	0.40	0.38	0.36
SN7433	0.42	0.40	0.38
SN7437	0.35	0.32	0.30
SN7438	0.35	0.32	0.30
SN7440	0.15	0.14	0.13
SN7441	0.74	0.71	0.64
SN7442	0.74	0.71	0.64
SN7443	£1.20	£1.15	£1.10
SN7444	£1.20	£1.15	£1.10
SN7445	£1.60	£1.55	£1.50
SN7446	£1.20	£1.15	£1.10
SN7447	£1.10	£1.07	£1.05
SN7448	£1.10	£1.07	£1.05
SN7450	0.15	0.14	0.13
SN7451	0.15	0.14	0.13

Type	1	25	100+
SN7453	0.15	0.14	0.13
SN7454	0.15	0.14	0.13
SN7460	0.15	0.14	0.13
SN7470	0.32	0.29	0.27
SN7472	0.32	0.29	0.27
SN7473	0.41	0.39	0.35
SN7474	0.41	0.39	0.35
SN7475	0.60	0.58	0.56
SN7476	0.44	0.43	0.42
SN7480	0.60	0.58	0.55
SN7481	£1.10	£1.05	£1.00
SN7482	0.90	0.85	0.80
SN7483	£1.20	£1.15	£1.05
SN7484	£1.00	0.97	0.95
SN7485	£1.60	£1.55	£1.50
SN7486	0.35	0.34	0.33
SN7489	£4.00	£3.75	£3.50
SN7490	0.65	0.63	0.60
SN7491	£1.10	£1.05	£1.00
SN7492	0.74	0.71	0.64
SN7493	0.74	0.71	0.64
SN7494	0.85	0.82	0.75
SN7495	0.85	0.82	0.75
SN7496	0.96	0.93	0.86
SN74100	£1.50	£1.45	£1.40
SN74104	0.60	0.58	0.55
SN74105	0.60	0.58	0.55
SN74107	0.44	0.42	0.40
SN74110	0.60	0.55	0.50
SN74111	0.90	0.88	0.85
SN74118	£1.00	0.95	0.90
SN74119	£1.50	£1.40	£1.30
SN74121	0.50	0.48	0.45
SN74122	0.70	0.68	0.65
SN74123	0.75	0.73	0.70
SN74141	0.85	0.82	0.79
SN74145	£1.30	£1.25	£1.20
SN74150	£1.50	£1.40	£1.30
SN74151	£1.10	£1.05	£1.00

Type	1	25	100+
SN74153	£1.00	0.95	0.90
SN74154	£1.70	£1.65	£1.60
SN74155	£1.20	£1.15	£1.10
SN74156	£1.20	£1.15	£1.10
SN74157	£1.00	0.95	0.90
SN74160	£1.40	£1.35	£1.30
SN74161	£1.40	£1.35	£1.30
SN74162	£1.40	£1.35	£1.30
SN74163	£1.40	£1.35	£1.30
SN74164	£1.80	£1.75	£1.70
SN74165	£1.80	£1.75	£1.70
SN74166	£1.60	£1.55	£1.50
SN74174	£1.60	£1.55	£1.50
SN74175	£1.10	£1.05	£1.00
SN74176	£1.25	£1.20	£1.15
SN74177	£1.25	£1.20	£1.15
SN74180	£1.25	£1.20	£1.15
SN74181	£3.95	£3.85	£3.75
SN74182	£1.25	£1.20	£1.15
SN74184	£1.80	£1.75	£1.70
SN74190	£1.95	£1.90	£1.85
SN74191	£1.95	£1.90	£1.85
SN74192	£1.95	£1.90	£1.85
SN74193	£1.95	£1.90	£1.85
SN74194	£1.30	£1.25	£1.20
SN74195	£1.10	£1.05	£1.00
SN74196	£1.20	£1.15	£1.10
SN74197	£1.20	£1.15	£1.10
SN74198	£2.75	£2.70	£2.65
SN74199	£2.50	£2.40	£2.30

Devices may be mixed to qualify for quantity price. (TTL 74 Series only) data is available for the above series of I.C.'s in booklet form. Price 35p.

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price
UIC00=12×7400	0.54
UIC01=12×7401	0.54
UIC02=12×7402	0.54
UIC03=12×7403	0.54
UIC04=12×7404	0.54
UIC05=12×7405	0.54
UIC06=8×7406	0.54
UIC07=8×7407	0.54
UIC10=12×7410	0.54
UIC20=12×7420	0.54
UIC30=12×7430	0.54
UIC40=12×7440	0.54
UIC41=5×7441	0.54
UIC42=5×7442	0.54
UIC43=5×7443	0.54
UIC44=5×7444	0.54
UIC45=5×7445	0.54
UIC46=5×7446	0.54
UIC48=5×7448	0.54
UIC50=12×7450	0.54
U1351=12×7451	0.54
UIC53=12×7453	0.54
UIC54=12×7454	0.54
UIC60=12×7460	0.54
UIC70=8×7470	0.54
UIC72=8×7472	0.54
UIC73=8×7473	0.54
UIC74=8×7474	0.54
UIC76=8×7476	0.54
UIC80=5×7480	0.54
UIC81=5×7481	0.54
UIC82=5×7482	0.54
UIC83=5×7483	0.54
UIC86=5×7486	0.54
UIC90=5×7490	0.54
UIC91=5×7491	0.54
UIC92=5×7492	0.54
UIC93=5×7493	0.54
UIC94=5×7494	0.54
UIC95=5×7495	0.54
UIC96=5×7496	0.54
UIC100=5×74100	0.54
UIC121=5×74121	0.54
UIC141=5×74141	0.54
UIC151=5×74151	0.54
UIC154=5×74154	0.54
UIC193=5×74193	0.54
UIC199=5×74199	0.54
UICX1=25 Assorted 74's	1.65

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

LINEAR I.C.'s—FULL SPEC.

Type No.	1	25	100+
72702	0.50	0.48	0.45
72709	0.25	0.23	0.20
72709P	0.20	0.19	0.18
72710	0.35	0.33	0.30
72741	0.30	0.29	0.28
72741C	0.28	0.27	0.26
72741P	0.30	0.29	0.28
72747	0.85	0.80	0.75
72748P	0.38	0.36	0.34
SL201C	0.59	0.45	0.40
SL701C	0.50	0.45	0.40
SL702C	0.50	0.45	0.40
TAA263	0.80	0.70	0.60
TAA293	£1.00	0.95	0.90
TAA350A	£1.85	£1.80	£1.70
μA703C	0.28	0.26	0.24
μA709C	0.20	0.19	0.18
μA711	0.35	0.33	0.30
μA712	0.35	0.33	0.30
TBA800	£1.50	£1.45	£1.40
76003	£1.50	£1.45	£1.40
76023	£1.50	£1.45	£1.40
76660	0.95	0.93	0.90
LM380	£1.00	0.97	0.95
NE555	0.65	0.63	0.60
NE556	0.95	0.93	0.90

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0·15	0·14	0·13
BP932	0·16	0·15	0·14
BP933	0·16	0·15	0·14
BP935	0·16	0·15	0·14
BP936	0·16	0·15	0·14
BP944	0·16	0·15	0·14
BP945	0·30	0·28	0·25
BP946	0·15	0·14	0·13
BP948	0·30	0·28	0·25
BP951	0·70	0·65	0·60
BP962	0·15	0·14	0·13
BP9093	0·45	0·43	0·40
BP9094	0·45	0·43	0·40
BP9097	0·45	0·43	0·40
BP9099	0·45	0·43	0·40

BI-PAK 1975
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DUAL-IN-LINE SOCKETS

14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1-24	25-99	100up
TSO 14 pin type	33p	30p	27p
TSO 16 „ „	38p	35p	32p
TSO 24 „ „	75p	70p	68p
LOW COST No.			
BPS 14 „ „	16p	14p	12p
BPS 16 „ „	17p	15p	13p
BPS 8 pin type	15p	13p	11p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron	£1.50
MAN 3M.	L.E.D. 7-segment 0-127"	£1.90

All indicators 0.9 + Decimal point. All side viewing. Full data for all types available on request.

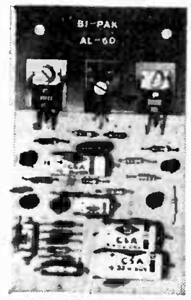
SHP80 STEREO HEADPHONES. 4-16 ohms impedance. Frequency response 20 to 20.000Hz. Stereo/mono switch and volume controls. £4.95

EDSR 3166 TRIPLE 66 BIT DYNAMIC SHIFT REGISTER TTL Compatible. Low Clock Capacitance. High Speed Diode Protected Inputs Wired 'OR' Capability SPECIFICATION SHEET AVAILABLE £1 each

TEAK VENEERED CABINET for: STEREO 20
TC 20. £3.95 p&p 45p

E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers. Rec. retail price £45.50 per pr. OUR SPECIAL PRICE £30 per pair P. & P. £3. ONLY WHILE STOCKS LAST!

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £4.25



- Max Heat Sink temp. 90°C.
- Frequency Response 20Hz to 100KHz
- Distortion better than 0.1% at 1KHz
- Supply voltage 15-50 volts
- Thermal Feedback
- Latest Design Improvements
- Load—3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm × 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

FULLY BUILT—TESTED and GUARANTEED

STABILISED POWER MODULE SPM80 £3·25

SPm80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BmT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available. 10p.

TRANSFORMER BMT80 £2.75 p. & p. 40p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	3·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	75mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	3mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292×82×35 mm

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

only £14.25

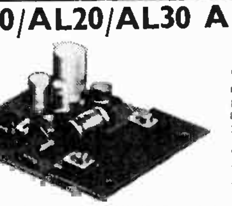
MK 60 AUDIO KIT

Comprising: 2× AL60, 1× SPM80, 1× BTM80, 1× PA 100, 1 front panel. 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Prices: £29.75 plus 45p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16½"×11⅛"×3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit price: £9.95 plus 45p postage.

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power device has resulted in a range of output powers from 3 to 10 watts R.M.S.

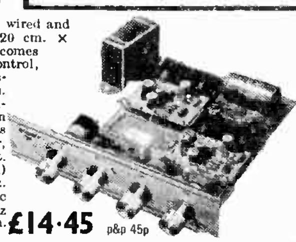
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po=3 WATTS f=1KHz	0·25%
LOAD IMPEDANCE	—	8–16Ω
INPUT IMPEDANCE	f=1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po=2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3"×2½"×1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL=8Ω f=1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2.50	£2.85	£3.20

The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. × 14 cm. × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

£14·45 p&p 45p

3 TERMINAL POSITIVE VOLTAGE REGULATORS

TO.3 Plastic Encapsulation

μA7805/L129 5V (Equv. to MVR5)	£1.35
μA7812/L130 12V (Equv. to MVR12V)	£1.35
μA7815/L131 15V (Equv. to MVR15V)	£1.35
μA7818 18V	£1.35

TRANSFORMERS

T461 (Use with AL10) £1.60 P. & P. 22p.
T538 (Use with AL20 & AL30) £2.30 P. & P. 22p.
BMT80 (Use with AL60) £2.75 P. & P. 40p.

POWER SUPPLIES

PS 12. (Use with AL10, AL20 & AL30) 95p
SPM 80. (Use with AL60) £3.25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with •Ceramic cartridge while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm

PRICE £4·35

Frequency response—
20Hz–50KHz (—3dB
Bass control—
± 12dB at 60H
Treble control—
±14dB at 14KHz
•Input 1. Impedance
1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance
30 K ohms
Sensitivity 4mV

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B12H	3.00	ECL86	0.50	GZ34	0.70
CY31	0.50	EF36	0.65	GZ37	1.00
DAF96	0.50	EF37A	1.20	KT66	2.50
DF96	0.55	EF40	0.75	KT88	3.00
DK96	0.55	EF41	0.65	MH4	0.75
DL92	0.40	EF80	0.30	ML6	0.65
DL96	0.60	EF83	1.25	OA2	0.45
DY86/87	0.40	EF85	0.35	OB2	0.45
DY802	0.45	EF86	0.35	PABC80	0.40
E88CC/01	1.20	EF89	0.30	PC97	0.50
E180CC	0.70	EF91	0.45	PC900	0.50
E182CC	1.25	EF92	0.50	PCC84	0.40
EA50	0.40	EF95	0.40	PCC85	0.40
EABC80	0.40	EF183	0.35	PCC88	0.60
EAF42	0.75	EF184	0.35	PCC89	0.50
EB91	0.30	EFL200	0.75	PCC189	0.60
EBC33	1.00	EL33	2.50	PCF80	0.40
EBC41	0.75	EL34	0.70	PCF82	0.40
EBF80	0.40	EL36	0.60	PCF84	0.60
EBF83	0.50	EL41	0.80	PCF86	0.60
EBF89	0.40	EL81	0.60	PCF200	0.75
EC52	0.35	EL82	0.55	PCF201	0.75
ECC81	0.40	EL84	0.30	PCF801	0.55
ECC82	0.35	EL85	0.60	PCF802	0.50
ECC83	0.35	EL86	0.45	PCF805	0.90
ECC84	0.35	EL90	0.45	PCF806	0.75
ECC85	0.40	EL504	0.80	PCF808	0.90
ECC86	0.90	EM31	0.60	PCH200	0.80
ECC88	0.50	EM80	0.55	PCL81	0.55
ECC189	0.70	EM84	0.40	PCL82	0.40
ECF80	0.40	EM87	1.00	PCL83	0.65
ECF82	0.40	EY51	0.45	PCL84	0.45
ECF801	0.75	EY81	0.45	PCL86	0.50
ECH42	0.80	EY86	0.40	PCL805	0.80
ECH81	0.35	EY88	0.50	PFL200	0.70
ECH83	0.45	EZ40	0.70	PFL200	0.70
ECH84	0.45	EZ41	0.75	PL36	0.60
				PL81	0.50
				PL82	0.45
				PL83	0.45
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PY80	0.40	UAF42	0.65
PY81	0.40	UBC41	0.60
PY82	0.40	UBF80	0.40
PY83	0.40	UBF89	0.40
PY88	0.45	UBL1	1.00
PY500	1.00	UBL21	0.70
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PY801	0.50	UCF80	0.75
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QQVO6-40A	8.00	UCH81	0.45
QVO3-12	1.10	UCL82	0.45
R19	0.60	UCL83	0.65
SC1/400	3.00	UF41	0.70
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SP61	0.75	UF85	0.45
TT21	5.00	UF89	0.50
U25	0.85	UL41	0.70
U26	0.75	UL84	0.40
U27	0.65	UY41	0.45
		UY85	0.40
		VR105/30	0.45

	£		£
VR150/30	0.45	3D6	0.40
X66	0.65	3S4	0.40
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1R5	0.40	5Y3GT	0.55
1S4	0.30	5Z3	0.80
1T4	0.30	5Z4	0.80
1X2A	0.60	5Z4TG	0.55
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2D21	0.50	6AC7	0.60
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	£		£		£
6AK5	0.40	6C6	0.50	6L6G	0.40
6AK8	0.40	6CB6	0.50	6L7G	0.40
6AL5	0.30	6CH6	1.45	6SA7	0.50
6AL5 W	0.55	6CL6	0.75	6SA7GT	0.40
6AM6	0.45	6D6	0.55	6SC7GT	0.40
6AN8	0.45	6EA8	0.85	6SG7	0.50
6AQ5	0.45	6F7	1.10	6SJ7	0.55
6AQ5W	0.70	6F8G	0.75	6SJ7GT	0.35
6AS6	0.80	6F23	0.90	6SK7	0.55
6AT6	0.45	6F32	0.75	6SL7GT	0.50
6AU6	0.40	6F33	3.50	6SN7GT	0.50
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6BE6	0.40	6J7	0.60	6X5GT	0.50
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6BJ6	0.65	6K6GT	0.80	6Z4	0.65
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				12BE6	0.50
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AC128	ASY26	BFY52	OA5	OC45	1N23A	2N2989
AC176	ASY27	BFY90	OA47	OC70	1N25	2N3053
ACY18	ASY28	BSY27	OA70	OC73	1N32A	2N3054
ACY19	BC108	BSY38	OA71	OC78	1N38A	2N3055
ACY20	BC118	BSY95A	OA73	OC78D	1N43	2N3390
ACY28	BC119	BYZ16	OA79	OC81	1N70	2N3391
ACY39	BC136	CRS1/10	OA91	OC82	1N277	2N3730
ACY40	BC137	CRS1/20	OA200	OC82D	1N415C	2N3731
AD149	BC148A	CRS1/30	OA202	OC82DM	1N4148	2N3819
AD161	BC172	CRS1/40	OAZ200	OC83	2N456A	2N4038
AD162	BC172A	CRS3/10	OC22	OC139	2N708	2N4058
ADZ11	BC212A	CRS3/20	OC23	OC140	2N918	2N4061
ADZ12	BCY31	CRS3/30	OC26	OC170	2N1304	2N4785
AF114	BCY33	CRS3/40	OC28	OC172	2N1305	2N5295
AF115	BCY72	CRS25/025	OC29	OC200	2N1307	3N128
AF116	BF115	GET115	OC39	OC206	2N1309	3N154
AF117						3N159
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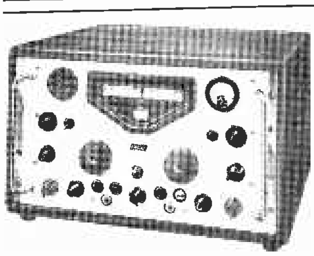

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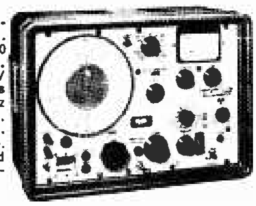

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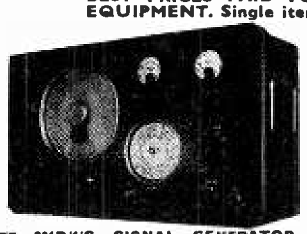

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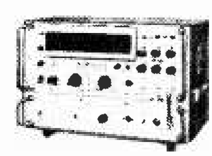

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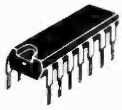

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7409	£0·15	£0·125	£0·10
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7427	£0·27	£0·225	£0·18
7430	£0·15	£0·125	£0·10
7432	£0·25	£0·225	£0·18
7437	£0·27	£0·225	£0·18
7438	£0·27	£0·225	£0·18
7440	£0·15	£0·125	£0·10
7441A	£0·825	£0·687	£0·55

	1/99	100/499	500/1000
7442	£0·645	£0·537	£0·43
7443	£1·275	£1·062	£0·85
7445	£0·855	£0·712	£0·57
7446	£1·05	£0·875	£0·70
7446A	£1·05	£0·875	£0·70
7447	£1·05	£0·875	£0·70
7447A	£1·05	£0·875	£0·70
7448	£0·855	£0·712	£0·57
7450	£0·15	£0·125	£0·10
7451	£0·15	£0·125	£0·10
7453	£0·15	£0·125	£0·10
7454	£0·15	£0·125	£0·10
7460	£0·15	£0·125	£0·10
7472	£0·255	£0·212	£0·17
7473	£0·153	£0·262	£0·21
7474	£0·315	£0·262	£0·21
7475	£0·465	£0·387	£0·31
7476	£0·315	£0·262	£0·21
7480	£0·435	£0·362	£0·29
7482	£0·75	£0·625	£0·50
7483	£0·825	£0·687	£0·55
7485	£1·275	£1·062	£0·85
7486	£0·315	£0·262	£0·21
7490	£0·465	£0·387	£0·31
7492	£0·465	£0·387	£0·31
7493	£0·465	£0·387	£0·31

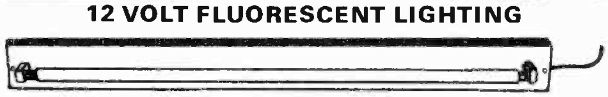
	1/99	100/499	500/1000
7494	£0·495	£0·412	£0·33
7495	£0·63	£0·525	£0·42
7496	£0·72	£0·60	£0·48
74104	£0·315	£0·262	£0·21
74105	£0·315	£0·262	£0·21
74107	£0·315	£0·262	£0·21
74121	£0·315	£0·262	£0·21
74122	£0·45	£0·375	£0·30
74123	£0·63	£0·525	£0·42
74141	£0·75	£0·625	£0·50
74151	£0·69	£0·575	£0·46
74153	£0·69	£0·575	£0·46
74155	£0·69	£0·575	£0·46
74156	£0·69	£0·575	£0·46
74160	£1·005	£0·837	£0·67
74161	£1·005	£0·837	£0·67
74162	£1·005	£0·837	£0·67
74163	£1·005	£0·837	£0·67
74166	£1·425	£1·187	£0·95
74174	£1·20	£1·00	£0·80
74175	£0·975	£0·812	£0·65
74192	£1·275	£1·062	£0·85
74193	£1·275	£1·062	£0·85
74198	£2·10	£1·75	£1·40
74199	£2·10	£1·75	£1·40

To secure the above prices, all orders for these devices must exceed £10 in total value. Price rating is established by TOTAL NUMBER OF DEVICES ORDERED. Any mix may be made. For special quotations for large orders ring 021-327 2339 NOW!!!

MICROWAVE DEVICES

CL8300	Gunn effect oscillator	9·4GHz	£40
CL8370	ditto	9·5GHz	£10
CL8380	ditto	10·5GHz	£10
CL8390	ditto	11·5GHz	£10
CL8430	ditto	9·35GHz	£40
CL8450	ditto	9·35GHz	£40
CL8470	ditto	9·35GHz	£40
BXY27	Varacter Diode. "S" Band. Cut-off	70GHz	£1
BXY28	Varacter Diode. Cut-off	100GHz	£1
BXY32	Frequency Multiplier. "X" Band	150GHz	£1
BXY35A/C	ditto	25GHz	£1
BXY36C/D	ditto	75GHz	£1
BXY37C/D	ditto	100GHz	£1
BXY38C/E	ditto	120GHz	£1
BXY39C/D	ditto	150GHz	£1
BXY40D/E	ditto	180GHz	£1
BXY41C/D/E	ditto	200GHz	£1

12 VOLT FLUORESCENT LIGHTING



Inverter transformers 13/15W (circuit included)		70p
"Current economy" transistor (600 ma.)		50p
"Maximum light" transistor (1·3A)		50p
Resistors/capacitors to suit		15p
Lampholders (long lead) (needed with cases)	Pair	30p
(short lead)	Pair	20p
White enamel case 21in (postage 30p)		70p
Tube, 21in–13W		45p

(Note: tube only supplied if case ordered, to prevent postal damage).
13W fitting ready built and tested—including tube (postage 30p) **£3·75**
Post/packing, 25p per order except where shown.

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.
Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray **£1·00** plus postage
Developer and Etchant **50p** plus postage

Single-sided Copper-clad Fibreglass Board **75p** sq. ft.
Double-sided Copper-clad Fibreglass Board **£1·00** sq. ft.
Boards cut to any multiple of 6". Max. size 3' × 4'.

1,000,000 POTENTIOMETERS

We have bought a huge assortment of volume controls.

Pre-sets, sliders, etc. All are in manufacturer's original packing.

Manufacturing quantities of some types available.

Write or phone for details.

Sample bag
100 mixed £2·50

ELECTROLYTIC CAPACITORS

Several thousand of each of the following types. Silly price to clear!

ALL NEW STOCK

5µf 10V	**35p** dozen
10µf 10V	**35p** dozen
50µf 10V	**35p** dozen
100µf 10V	**35p** dozen
330µf 16V	**45p** dozen
330µf 25V	**60p** dozen
330µf 35V	**80p** dozen
2200µf 16V	**£1** dozen
15000µf 25V	**50p** each

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BRAN TUB !!!

- ★ **Resistors, Wire-wound and Carbon**
- ★ **Capacitors, Silver-mica, Paper, Ceramic, Polyester and Electrolytic**
- ★ **Controls, Volume, Pre-set, Carbon, Wire**
- ★ **Diodes, Silicon, Germanium, Zener**
- ★ **Transistors, Silicon, Germanium**

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We have made up packs of 2lb gross weight, all are different in content, and contain a mixture of components from the above list. This is a fantastic, unrepeatable offer that will enable you to get a good stock of spares at a tiny fraction of normal price!
To make things even more interesting—TWENTY OF THESE BAGS ALSO CONTAIN A POUND NOTE! TWENTY CUSTOMERS WILL BE VERY PLEASED INDEED!
And the price that we are asking? Only **£1·50** including both postage and VAT!
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£1 — **100 ¼ ½ WATT RESISTORS, 100 CERAMIC CAPACITORS, 100 OIOOES**
POSTAGE **25p** — PACK No. 1

£1 — **100 RESISTORS, 100 CERAMIC CAPACITORS, 100 POLYSTYRENE CAPACITORS**
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£1 — **100 RESISTORS, 100 CERAMIC CAPACITORS, 50 MULLARO POLYESTER CAPACITORS**
POSTAGE **25p** — PACK No. 4

£1 — **20 ASSORTEO UNUSEO MARKEO, TESTEO TRANSISTORS BC108 ETC.**
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£1 — **1 TRANSISTORISEO SIGNAL TRACER KIT, 1 TRANSISTORISEO SIGNAL INJECTOR KIT**
POSTAGE **25p** — PACK No. 6

£1 — **100 RESISTORS, 100 CAPACITORS (ASSORTED TYPES)**
POSTAGE **25p** — PACK No. 8

REMEMBER! ALL GOODS PLUS 8% V.A.T.

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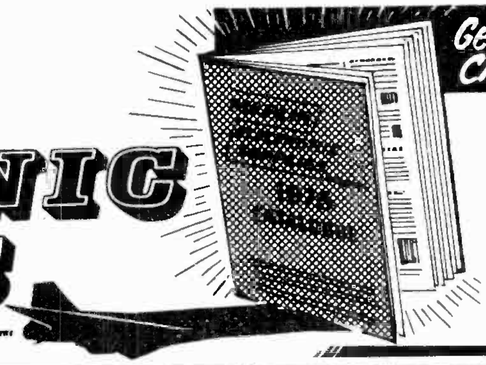

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CARBON FILM
¼W 1Ω to 1M : 5%, IM2 to 10M : 10% E12
⅓W 1Ω to 10Ω : 5%, IM2 to 10M : 10% E12
11Ω to 910k : 5% E12 & E24 **1p** each.

METAL OXIDE
½W 10Ω to 1M : 2% E12 & E24 **4p** each

WIREWOUND
3W 0.22Ω, 0.27Ω, 0.33Ω, 0.47Ω : 10%
1Ω:5% **17p** each
1.2Ω to 270Ω:5% E12 **13p** each

Other ranges stocked. See our catalogue for details.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and decades.
E24: 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and decades.

● POTENTIOMETERS

Rotary miniature carbon track ¼" spindle. Values available: 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1M, 2M.
Log. signle-gang **16p.** Lin. single-gang (+1k) **16p**
Log. or Lin. single-gang with switch **33p**
Log. or Lin. dual-gang without switch **49p**
Slider 60mm track. Metal-cased: overall length 86.15mm less knob (7p extra).
Log. or Lin. 1k, 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1M, 2M. Single-gang **36p**; Dual-gang **45p**
Presets: 0.1W Vertical or Horizontal.
100Ω, 220Ω, 470Ω, 1k, 2k2, 4k7, 10k, 22k, 47k, 100k, 220k, 470k, 1M **7p** each.

● CAPACITORS

Sub-miniature
Axial lead electrolytic

Mfd	V	Price	Mfd	V	Price	Mfd	V	Price
1	63	6p	68	6.3	6p			
1.5	63	6p	68	16	6p			
2.2	63	6p	68	63	14p			
3.3	63	6p	100	4	6p			
4.7	63	6p	100	10	6p	470	6.3	6p
6.8	40	6p	100	25	6p	470	10	14p
6.8	63	6p	100	40	6p	470	25	16p
10	25	6p	100	63	16p	470	40	25p
10	63	6p	150	6.3	6p	680	6.3	14p
15	16	6p	150	16	6p	680	16	16p
15	40	6p	150	25	6p	680	25	25p
15	63	6p	150	40	14p	680	40	28p
22	10	6p	150	63	16p	1000	4	14p
22	25	6p	220	4	6p	1000	10	16p
22	63	6p	220	10	6p	1000	16	25p
33	6.3	6p	220	16	6p	1000	25	28p
33	16	6p	220	25	14p	1500	6.3	16p
33	40	6p	220	40	16p	1500	10	25p
47	4	6p	220	63	25p	1500	16	28p
47	10	6p	330	4	6p	2200	6.3	25p
47	25	6p	330	10	6p	2200	10	28p
47	40	6p	330	16	14p	3300	6.3	28p
47	63	6p	330	63	28p	4700	4	28p

● SWITCHES

Rotary adjustable stop. 1 pole. 2 to 12 way; 2 pole. 2 to 6 way; 3 pole. 2 to 4 way; 4 pole. 2 or 3 way **36p** each.
Slide Sub-min. DPDT **9p**
Slide min. DPDT **13p**
Push to make non-locking SPST **14p**
Push-on. push-off locking DPDT 250V 4A **36p**
Rocker white DPST 250V 10A **40p**
Rotary mains DPST 250V 2A **24p**
Toggle with ON/OFF plate DPDT 250V 1.5A **25p**

BCD OUTPUT SLIDE SWITCH
Marks the end of the old-fashioned thumb-wheel switch. With 7-segment type read-out. Full details in our catalogue **£1.38**

● TRANSISTORS & DIODES

AC127	18p	BFY52	20p
AC128	18p	BY126	13p
AC176	17p	BY127	13p
AD161/		BY164	49p
162MP	93p	BZY88	
BA100	9p	series	13p
BA145	22p	MPF102	36p
BC107	11p	OA91	6p
BC108	10p	OA200	7p
BC109	13p	OC71	20p
BC109C	15p	SC146D	88p
BC142	23p	T1S43	28p
BC143	26p	WO05	30p
BC147	10p	WO4	33p
BC148	10p	1N914	4p
BC149	12p	1N4001	6p
BC168C	12p	1N4002	6½p
BC169C	12p	1N4003	7p
BC178	17p	1N4004	7½p
BC182L	10p	1N4005	8p
BC183L	12p	1N4006	8½p
BC184L	12p	1N4007	9p
BC212L	14p	1N4148	4p
BC213L	15p	2N1302	20p
BC214L	18p	2N1303	20p
BCY71	22p	2N1304	30p
BD131	45p	2N1711	24p
BD132	54p	2N2219	25p
BD131/		2N2646	45p
BD132MP		2N2905	33p
	£1.20	2N2926 Ye	12p
BD135	36p	Gn	13p
BD139	49p	2N3053	18p
BD140	69p	2N3055	49p
BF258	35p	2N3819	22p
BF259	25p	2N5459	51p
BFX29	30p	7400	16p
BFX30	33p	7413	39p
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BFX85	36p	7473	54p
BFX87	30p	7474	45p
BFX88	25p	7490	82p
BFY50	20p	7493	82p
BFY51	22p	74121	39p

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2mcd ¼" **15p**
Panel mtg. clip **5p**
(Other colours and 7-seg. displays in our catalogue.)

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LHOO42CH (TO99) **£4.25**
MC1310P (14-pin DIL) **£2.50**
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MFC4000B **59p**
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NE555V (8-pin DIL) **65p**
SG1495 (14-pin DIL) **£2.70**
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µA741C (8-pin DIL) **36p**
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µA748C (8-pin DIL) **39p**
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µA7805 5V 1.5A (TO3) **£1.75**
µA7815 15V 1.5A (TO3) **£1.75**
MVR 5V, 12V, 15V 500mA (TO3) **£1.60**
µA78M05 5V 500mA (Plastic power) **£1.05**
µA78M15 15V 500mA (Plastic power) **£1.05**
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DIN	PLUG	CHASSIS SOCKET
2-pin	8p	6p
3-pin	9p	7p
4-pin	10p	7p
5-pin A(180°)	10p	7p
5-pin B(240°)	10p	7p
6-pin	10p	9p
7-pin	10p	8p

JACK PLUGS

2.5mm plastic barrel **9p**
2.5mm metal barrel **15p**
3.5mm plastic barrel **9p**
3.5mm metal barrel **15p**
¼in. std. mono plastic barrel **13p**
¼in. std. mono metal barrel **24p**
¼in. std. stereo plastic barrel **18p**
¼in. std. stereo metal barrel **30p**

JACK CHASSIS SOCKETS

2.5mm open-type metal **9p**
3.5mm open-type metal **9p**
¼in. std. mono open-type metal **13p**
¼in. std. mono moulded with 2 break contacts **14p**
¼in. std. stereo open-type metal **15p**
¼in. std. stereo moulded with 3 break contacts **21p**
In-line sockets also stocked: see catalogue

PHONO

Plastic-topped plug **5p**
Screened plug **12p**
Chassis socket single **5p**
Chassis socket twin **7p**

● MAINS CONNECTORS

P360 3-pin 1.5A chassis plug with line socket **33p**
SA2190 3-pin 5A chassis plug **25p**
SA1862 Line socket for SA2190 **28p**
P437 3-pin 5A chassis socket with line plug **66p**

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LT700 min. output. Pri. 1k2: Sec. 5Ω 200mW **50p**
Sub-min mains 6–0–6V 100mA **95p**
12–0–12V 50mA **95p**
(Size both approx. 30×27×25mm)
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A Full-Scale Electronic Organ that you can build to your own specification.

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Leaflet MES 51: price **15p**, describes a fully polyphonic basic organ which can later be used as the basis of a large sophisticated instrument.
Leaflet MES 52: price **15p**, continues the description of the MES 50 series organs and shows you how to add a second keyboard with lots more stops.
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DMO2T includes built-in variable depth and rate frequency shift tremulant.
DMO2 **£12.25** DMO2T **£14.25**
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Keyboards high quality, fully sprung.
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*Reverberation driver module **£5.34**
*S.a.e. please, for full details: leaflet MES 24.
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Palladium earth bar **15p** per octave length
Contact blocks 2-make (GB2) **22p**
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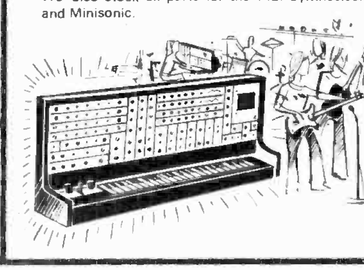

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with 21 separate function keys. Housed in slimline diecast case. Transistorised.

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CLEARANCE LISTS AVAILABLE. S.A.E.

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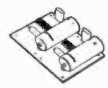

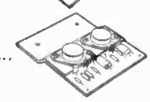

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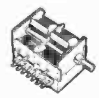

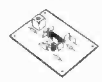

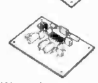

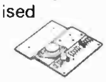

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TRANSFORMERS

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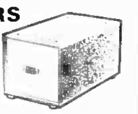

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100	150	8·22	0·80	4·60	0·52
200	151	10·20	0·80	7·40	0·52
250	152	11·68	0·80	8·88	0.65
350	153	14·10	0·80	10·80	0·80
500	154	15·68	0·80	12·38	1·00
750	155	24·63	1·00	18·72	1·20
1000	156	32·19	1·00	26·50	1·20
1500	157	38·18	1·00	30·34	0.A
2000	158	45·20	2·40	34·68	0.A
3000	159	66·50	2·40	53·35	0.A

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS Sec. 1	Sec. 2	MILLIAMPS Sec. 1	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	1·95	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	1·75	0·22
0-8-9	0-8-9	1000	1000	208	2·30	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	2·47	0·38
0-20	0-20	300	300	214	1·72	0·22
0-20	—	3500	No Screen	1116	3·00	0·40
20-12-0-12-20	—	700 (D.C.)	—	221	2·31	0·30
0-15-20	0-15-20	1000	1000	206	3·22	0·38
0-15-27	0-15-27	500	500	203	2·73	0·38
0-15-27	0-15-27	1000	1000	204	3·52	0·38

12 and 24 VOLTS PRIMARY 200-240 Volts.

AMPS 12V	24V	TYPE No.	PRICE £	Post £
0·3	0·15	242	1·34	0·22
0·5	0·25	111	1·38	0·22
1	0·5	213	1·58	0·22
2	1	71	2·09	0·22
4	2	18	2·58	0·38
6	3	70	3·80	0·42
8	4	108	4·20	0·52
10	5	72	4·80	0·52
12	6	116	5·01	0·52
16	8	17	6·22	0·52
20	10	115	9·47	0·69
30	15	187	11·95	0·97
40	20	232	13·26	1·00
60	30	226	15·30	1·10

30 VOLTS

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

AMPS	Ref. No.	Price £	Post £
0.5	112	1·72	0·22
1	79	2·21	0·38
2	3	3·26	0·38
3	20	4·10	0·42
4	21	4·68	0·52
5	51	5·80	0·52
6	117	6·50	0·52
8	88	8·50	0·67
10	89	8·47	0·67

50 VOLTS

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

AMPS	Ref.	Price	Post
0·5	102	2·33	0·30
1	103	3·00	0·38
2	104	4·57	0·42
3	105	5·20	0·52
4	106	6·89	0·52
6	107	11·17	0·67
8	118	14·19	0·97
10	119	15·47	0·97

60 VOLTS

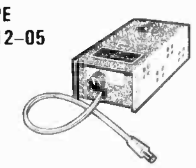
PRIMARY 200/240V.
SECONDARY 24, 30, 48, 60V.

AMPS	Ref.	Price	Post
0·5	124	2·08	0·38
1	126	2·96	0·38
2	127	4·63	0·42
3	125	6·84	0·52
4	123	7·94	0·67
5	40	8·86	0·67
6	120	10·15	0·82
8	121	13·58	1·00
10	122	18·15	1·00
12	189	16·00	1·10

BRIDGE RECTIFIERS

	Price
ONE AMP	
50 P.I.V.	0·25
100 P.I.V.	0·25
200 P.I.V.	0·28
600 P.I.V.	0·30
FOUR AMP	
100 P.I.V.	0·55
200 P.I.V.	0·59
400 P.I.V.	0·65
600 P.I.V.	0·75
TWO AMP	
50 P.I.V.	0·35
100 P.I.V.	0·40
200 P.I.V.	0·45
400 P.I.V.	0·50
SIX AMP	
50 P.I.V.	0·65
100 P.I.V.	0·70
200 P.I.V.	0·08
400 P.I.V.	0·90

POWER UNIT TYPE CC12–05



Output switched 3, 4·5, 6, 7·5, 9 and 12 Volts at 500 mA D.C. Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players etc. Size 7·5 × 5·0 × 14·0 cm. Price **£3·95**. Post 25p.

AUTO TRANSFORMERS

VA (Watts)	Ref No.	PRICE Cased £	PRICE Plugs 2 & 3 pin £	PRICE Open £	Post £
Tapped at 115, 220, 240 Volts					
20	113	3·00	0·15	1·55	0·30
Tapped at 115, 200, 220, 240 Volts					
150	4	5·80	0·15	3·98	0·39
200	65	6·40	0·15	4·50	0·40
300	66	7·27	0·15	5·28	0·52
500	67	9·99	0·15	8·29	0·67
750	83	12·56	0·75	9·76	0·82
1000	84	15·70	0·75	12·40	0·82
1500	93	19·88	0·75	16·58	1·50
2000	95	30·10	1·44	22·05	1·50
3000	73	43·58	1·90	32·00	1·90

NEW! 2″ AND 4″ PANEL METERS

2″: SIZE: 60mm Wide × 45mm High × 40mm Deep.
4″: SIZE: 110mm Wide × 82mm High × 43mm Deep.

2″ Movement	I.R. Ohms	4″ Movement	I.R. Ohms
0–50 micro A.	1250	0–50 micro A.	1400
0–100 micro A	580	0–100 micro A.	730
0–500 micro A.	170	0–500 micro A.	200
0–1 mA	170	0–1 mA	200
0–5 mA	170	0–5 mA	200
0–10 mA	6	0–10 mA	6
0–50 mA	0·5	0–50 mA	0·5
0–100 mA	0·5	0–100 mA	0·5
0–500 mA	0·5	0–500 mA	0·5
0–1 AMP	0·5	0–1 AMP	0·5
0–2 AMP	0·5	0–2 AMP	0·5
0–25 Volt	15K	0–25 Volt	15K
0–50 Volt	50K	0–50 Volt	50K
0–300 Volt	300K	0–300 Volt	300K
"g" Meter	170	"g" Meter	200
VU Meter	5250	VU Meter	5250

VU Meters are complete with detectors. Modern wide view. Price 2″ **£3·15** Post 10p. Price 4″ **£3·95** Post 10p. Lamps **55p** per set.

C1000 MULTI-METER

Compact General Purpose Mini Multimeter
Input Resistance 1000 ohms per volt.
Ranges: AC Volts 0–15 50 250 1000 Volts
DC Volts 0–10 50 250 1000 Volts
DC Current 0–1 mA 0–100 mA
Resistance 0–150K ohms
Size 60 × 24 × 90 mm
Complete with: Batteries, Test Prods, Instructions.
Special price **£3.25** Post 20p.

¼-WATT CARBON FILM RESISTORS

also available ¼ watt at 70°C E 12 range 10Ω–1MΩ. 5% tol. above 470KΩ 10% tol. at **95p** per 100.

MINIATURE NEONS

6mm dia., 12mm length leads length approx. 20mm. Recommended ballast resistor 150K ohms for 240 Volt operation. Price: Packet of 10 for **50p**. Postage 10p.

PLEASE ADD 8% FOR VAT

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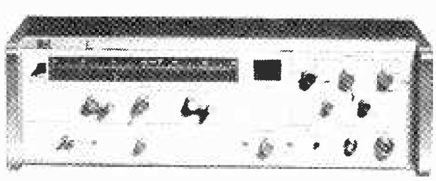
FANTASTIC INSTRUMENT BARGAINS

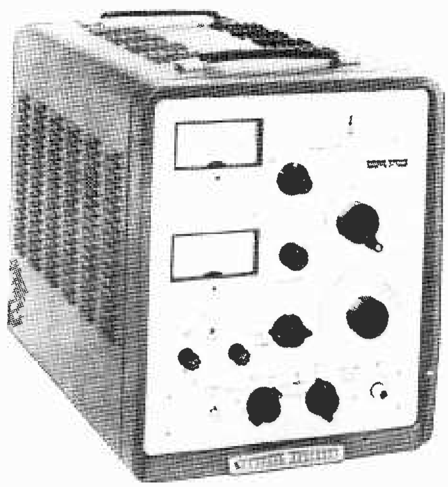
In this updated list of high-quality equipment which is surplus to our present requirements we have included two excellent laboratory digital voltmeters and a limited number of DC Power Supplies. You will notice also that there are substantial price reductions.
Please check the availability of instruments and ask for a quotation by telephone or telex. Equipment may be viewed by prior appointment.
Calibration to BSC release may be arranged if required. Please ask for a quotation.
Delivery to any destination can be arranged.

	Sale Price Range £
AUDIO (Professional)	
Crown	
Stereo Recorders	384.00–500.00
BRIDGES etc	
Wayne Kerr	
601Z. LCR Bridge. Wide frequency range	192.00
SR268. Source & Detector	288.00
CALCULATORS	
Canon	
Briefcase size with charger and printer	20.00
COUNTERS & TIMERS	
Hewlett Packard	
5216 12MHz. 7 Digits	320.00
5246 50MHz. 6 Digit Counters	180.00–270.00
5252A 350MHz. Pre-Scaler plug-ins	96.00–115.00
5253B 512MHz. Converter plug-ins	96.00–182.00
Marconi	
TF1417/2. 0–15MHz. 6 Digits	86.00
TF2401. Main Frames	On Application
TM7558. Plug-ins	On Application
TM8094/1.0.3–2.5GHz. Plug-ins	On Application
DEVIATION METERS	
Marconi	
TF91D. 4–1024MHz	182.00–220.00
DIGITAL VOLTMETERS	
Dana	
3800A Digital Multimeter 0.1%. Max RDG 1999	98.00–140.00



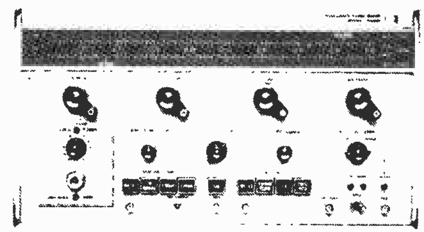
5230 DVM. 0.02% 10µV Max RDG 119999	360.00–450.00
5330 DVM. 0.02% 1µV Max RDG 119999	590.00–640.00
Dynamco	
DM2022. DV. 0.02% 10µV resolution—2kV	130.00–290.00
DM2140/A1/B1. Mean AC. Converters	192.00
DM2140/A1/B3. RMS AC. Converters	61.00
Hewlett Packard	
3440 and Range of plug-ins (complete)	576.00
Solartron	
LM1420. 2. DC. 0.05% 2.5µV resolution to 1kV	96.00–190.00
LM1420. 2. BA–DC and RMS/Mean AC	330.00–400.00

	Sale Price Range £
OSCILLOSCOPES	
Cossor	
CDU150. DC–35MHz. 5mV–50V/DIV dual trace	380.00
Telequipment	
D53S with 2 × 'A' amps. Storage. Dual Trace	290.00
A. DC–15MHz. Single Trace Amplifier plug-ins	10.00–20.00
POWER SUPPLIES	
Farnell	
30/10/5.0–30V. 10A. Pre-set	40.00–50.00
SSE. 0–15V. 1A. Pre-set	22.00–40.00
Roband	
30/10. 0–30V. 10A	35.00–45.00
RECORDERS	
Bell & Howell	
5–124 Ultra Violet Light Beam. 18 Channels (Galvos to 13kHz available at extra charge)	60.00
6–127. As above with 12 Channels	180.00
SIGNAL SOURCES	
Advance	
SG70. Audio Oscillator. 600 Ohms. 4 Watts	100.00–180.00



General Radio		
1362. UHF Oscillator	(both need a	80.00
1363. UHF Oscillator	power supply)	90.00
Hewlett Packard		
200CD. Audio Oscillator		30.00–60.00
612A.0.45–1.23GHz. Internal or External Amplitude Modulation		300.00

	Sale Price Range £
Marconi	
TF144H/4. 10kHz–72MHz. Xtal check Int/Ext. AM. 50 Ohms	290.00–320.00
TF801D/1. 10MHz–470MHz. Int/Ext. AM and Pulse modulation	320.00
TF2005. 20Hz–20kHz. Twin Oscillators	220.00–290.00
Wayne Kerr	
0.22D. 10kHz–10MHz. Video Oscillator	160.00
SPECTRUM ANALYSERS	
Hewlett Packard	
8551B/851B. 10MHz–12GHz	2,310.00
SWEEP GENERATORS	
Hewlett Packard	
8690B with 8693B. 3–7.8GHz plug-ins	660.00–750.00
TELEPHONE TV AND MICROWAVE	
Hewlett Packard	



423A. 12.6GHz Crystal Detectors	28.00
3701/02/03. Microwave Link Analyser	2,420.00
Marconi	
OA 2090A. White Noise Test Set (Filters also available at extra charge)	712.00
TF2909 TV Test Set. Grey Scale 625 lines	Price to be advised
Richmond Hill	
TSP. TV Studio Precision Signal Generator Sin 2 P & B. Window. Staircase (Requires all drives)	310.00
Siemens	
REL3K53. Contact Fault Locators. 1MHz Test signal variable levels. High sensitivity	95.00
STC	
74166. Milliwatt Test Sets	36.00–45.00
74184B. Selective Measuring Sets	132.00
74216. Noise Generator. 20Hz–4kHz	90.00–180.00
74306B. Oscillators 10kHz–20MHz	80.00–110.00
74600. RF Attenuators. 10 steps each unit total Att: 0.9; 9.0; 90.0dB	15.00
74832B. Selective Level Measuring Set	80.00–100.00
Wandel & Golterman	
TFPS75. 1.3MHz. Selective Oscillators	140.00
TFPM43. 14MHz. Selective Meters	225.00
VZM1 Differential Phase Meters (TV) VZMG1 Sampling Attachments (complete)	318.00
WAVE ANALYSERS	
Airmec/Racal	
248A. 5–300MHz. Harmonic Analysers	132.00
ASSOCIATED EQUIPMENT	
Hewlett Packard	
412A. DC Electronic Multimeter	20.00
Marconi	
TFB93 Audio Power Meter 20µW–10W	90.00
TF2606 Differential Voltmeter. 0–1000V	120.00
Radiometer	
RV24. DC Electronic Multimeter	60.00
Siemens	
Multizet. RF Voltmeter 0–100V	5.00*

*Uncalibrated.

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MARCONI TF867 STANDARD SIGNAL GENERATOR

Carrier Frequency. Range: 15Kc/s—30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Output Voltage: 0.4µV–4V. Impedance: 75 ohms nominal for outputs from 2–4V 75 ohms for outputs from 4µV–2V. 13 ohms for outputs from 0.4µV–0.4V. Accuracy: below 3Mc/s ± 0.25dB to ± 0.1µV. 3–10Mc/s ± 0.5dB or 00.2µV. 10–30Mc/s ± 1.0dB or ± 0.5µV. Power Supply: 100–125V, 200–250V. 40–100c/s. Dimensions: 18 in. high x 21in. wide x $14\frac{1}{2}$in. deep.

£139.50

OSCILLOSCOPE CT 436

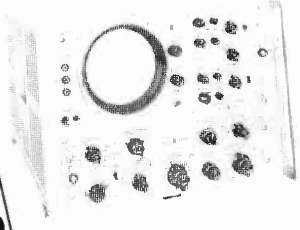
Commercial Designation Solartron CD1014

General Purpose Dual Beam DC 6MHz flat faced double gun cathode ray tube operating at 1.6kV. The time base velocity is continuously variable between 1cm/usec. and 1cm/sec. TIME BASE Free running or triggered from positive or negative pulses. Sweep speed 1cm/usec to 1cm/sec.

Synchronisation: positive or negative going internal from either channel or external continuous waves. Internal 3mm P/P. External 100mVP/P. Sensitivity 100mV/cm; maximum on Y2 amplifier 1mV/cm. Size $9\frac{1}{2}''$ × $11\frac{1}{2}''$ × 15". Wt. 25 lb. PRICE: **£79.50.** Solartron 1014 .2 & 3 **£85.** Tektronix Sampling Scope 661 **£295.**

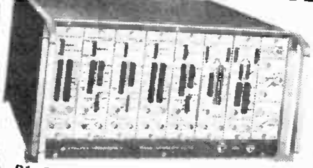
ADD 8% VAT TO ALL PRICES

HEWLETT Packard 50MHz Oscilloscope



Dual Beam
Max Sensitivity
50mV/cm
Timebase
0.1 µsec/cm
to 5 sec/cm
Delay Sweep
2µsec/cm
to 1 sec/cm
Also available
4-channel vert.
amplifier 1754A

MODULAR PULSE GENERATOR PG52



P1 Clock Gen, P2 Width or Delay, PL, P2, P3, P3 Outputs, P5 Variable Slope. Complete Modular Construction. Clock 0.1Hz to 30MHz in switched decade steps. Delay 25nS to 1S in switched decade steps. Output-up to 20V in 500 Ohms. Variable slope-rise and fall rates 1nS/V to 100mS/V independently adjustable over 10:1 range. Double pulse output. Short circuit protection. **PRICE £275**

ADVANCE PG 56 DOUBLE PULSE GENERATOR

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PRICE £120

Advance T.V. Dot and Cross Hatch Generator SG73

Output in form of modulated signal at VHF and UHF at level suitable for aerial sockets of receiver. Two ranges. Band III on fundamental (MOD). Band IV & V On Harmonics (—MOD). Modulation 405 Lines or 625 Lines.

Ex-Demonstration, Brand New

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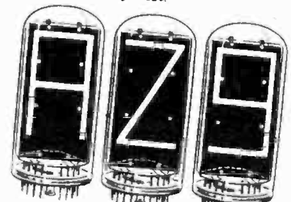
ALPHANUMERIC NIXIE TUBES B7971

The Alphanumeric NIXIE tube has the ability to display all the letters of the alphabet, numerals 0 thru 9 and special characters in a single tube.

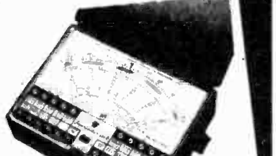


From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including
★ 170V–21mA ★ All DC operation
★ Uniform, continuous line characters of equal height
★ Memory with simple solid state drive circuits
★ Readability in high ambient light ... 200 footlamberts brightness ★ Long life with no loss of brightness
★ Character height $2\frac{1}{2}$ ins.

Price only 99p each plus 16p
Bases for above 60p each
DISCOUNT GIVEN FOR QUANTITY ORDER

JUST ARRIVED!! NUMERIC INDICATOR TUBES ultra-long life, high quality, 0–9 and 2 independent decimal points. Supply voltage 200V D.C. Current 14mA. Pulse duration 100µs. Characture height 0.51, overall size 1.4. Brand new, guaranteed. Surplus to manufacturers requirements. Type B5853st. Price 1–25 **£1.00**. 25+ **90p**. 100+ **80p**. 1000+ price on application.

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 Ohms per Volt sensitivity ● Fully screened against external magnetic fields ● Scale width and small case dimensions (128 × 95 × 32mm) ● Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading ● Simplicity and ease of use and readability ● Full range of accessories ● 1,000 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–5 mA–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 5000Hz. 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

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

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For measuring magnetic field strengths **£11.95**

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For transistors and diodes. **£11·95**

Electronic Voltmeter

Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£24.00**

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

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

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

OTHER ACCESSORIES AVAILABLE: **LIGHT METER £11.95. RESISTOR MULTIPLIER £5.95. 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.**

FANTASTIC NEW MICROTEST 80

MEASURES ONLY 90×70×18 mm
AMAZING VALUE
at **£11.95**

8 fields of measurement and 40 ranges

● 20,000 ohm per volt sensitivity ● 1000 times overload (on the ohmetric ranges only) ● Scale width and small case dimensions ● Printed circuit board is removable without soldering ● Fully screened against external magnetic fields ● Full ranges of accessories ● Accuracy and stability of indicated reading <2% in A.C.-D.C.> ● Simplicity and ease of use and readibility **Volts D.C. 6 ranges**: 100mV–2V.–10V.–50V.–200V.–1000V. (20kΩ/V). **Volts A.C. 5 ranges**: 1.5V.–10V.–50V.–250V.–1000V. (4kΩ/V). **Amp. D.C. 6 ranges**: 50µA–500µA–5mA–50mA–500mA–5A. **Amp. A.C. 5 ranges**: 250µA–2.5mA–250mA–2.5A. **Ohms 4 ranges**: LowΩ–Ω×1–Ω×10–Ω×100 (da 1/10 di Ω fino a 5 Mega Ω). **V Output 5 ranges**: 1.5V.–10V.–50V.–250V.–1000V. **Decibels 5 ranges**: +6dB, +22dB, +36-dB, +50dB, +62dB. **Capacity 4 ranges**: 25µF–250µF–2500µF–25,000µF.

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VZM1 Measuring set for measuring phase and amplitude modulation distortion for Colour T.V. Sub carrier (PAL Systems)

£495.00

VZM2 Measuring set for measuring phase and amplitude modulation distortion for Multichannel FM radio systems with base bands up to 12 Mc/s.

£295.00

VZM83 Generator and Receiver used to measure transmission distortion on FM radio link systems. Superimposed signal 52/304/556kHz.

£275.00

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 × 50 **£29.** 20 × 11 **£15.**

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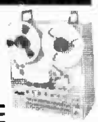
Stop Press



AMPEX SP-300 FM/DIRECT RECORDER/REPRODUCER 4 Channels. Speed $1\frac{1}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$ 15 ips. Flutter 0.15% at 151 ips. Frequency Response: Instrumentation 50Hz to 40Hz at 15 ips. Audio 50Hz to 18Khz at 15 ips. **£1950**

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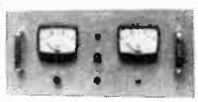

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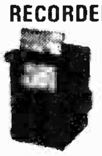
Advances DC197
6V 7.5Amp. 6V 11Amp. 28V 9Amp. PRICE **£35**

BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK Model 88



This recorder indicates the magnitude of applied currents of voltages by a continuous distortion free line on pressure sensitive paper. Moving coil movement scale calibrated 1 milliamp D.C. internal resistance 100 ohms. Chart Drive motor 240V 50Hz.
Chart speeds 90" per hour **£39**
1" per hour **£45** or 6" or 12".

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3" chart sensitivity 1 milliamp chart speed 1 and 6" per hr. Size 8" × 11" × 6". Offered complete with pen assembly. Listed at over £120—this month's special price due to bulk purchase.

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

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Potentiometers

TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
50		Beckman	AR/S	£2.25
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
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7218	£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
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

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100/100 Beckman Type C £3·00

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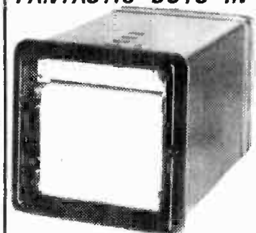

10 CHANNEL EVENT RECORDER
Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160 × 160 × 255mm. Weight 9 lbs. Price complete with accessories.

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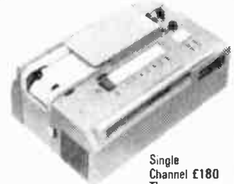
HIGH SPEED PEN RECORDER
Chart length 175 ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by push buttons) 1.2-6-12-30-60-120-300-600-3000mm per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms Dimensions 320×340×175mm. Weight 35 lbs. Price complete with accessories.



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Three Channel £310

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Fitted with separate zero-marking pen. Accuracy 1.5% DC. 2.5% AC. Measurements ranges—AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Price complete with accessories

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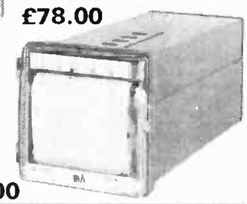

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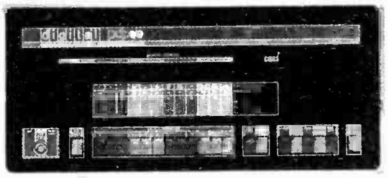

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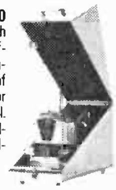

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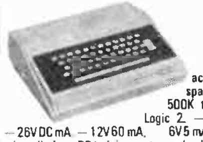

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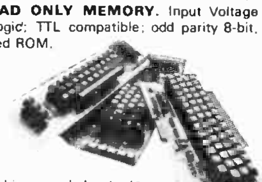

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½	CF	22–IM	1	0·75	0·60	0·55	5·5 × 16
⅛	MF	10–2M7	2	1·54	1·32	1·1	3 × 7
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4·7μF 63V	6½p	150μF 16V	6½p
6·8μF 63V	6½p	150μF 63V	15p
8·0μF 40V	6½p	220μF 6·4V	6½p
10μF 16V	6½p	220μF 10V	6½p
10μF 25V	6½p	220μF 16V	8p
10μF 63V	6½p	220μF 63V	21p
15μF 16V	6½p	330μF 16V	12p
15μF 63V	6½p	330μF 63V	25p
16μF 40V	6½p	470μF 6·4V	9p
22μF 25V	6½p	470μF 40V	20p
22μF 63V	6½p	680μF 16V	15p
32μF 10V	6½p	680μF 40V	25p
33μF 16V	6½p	1000μF 16V	20p
33μF 40V	6½p	1000μF 25V	25p
32μF 63V	6½p	1500μF 6·4V	15p
47μF 10V	6½p	1500μF 16V	25p
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IN914	1p
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OA5	42p
OA47	9p
OA81	11p
OA200	8p

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Oin 2 Pin	10p
3 Pin	10p
5 Pin 180°	12p
Std. Jack	15p
2·5mm Jack	13p
Phono	6p

ELECTROLYTIC CAPACITORS. Tubular and Large Cans
(μF/V): 1/25, 2/25, 4/25, 4·7/10, 5/25, 8/25, 10/10, 10/50, 16/25, 22/63, 25/25, 25/50, 32/25, 50/25, 100/10, 100/25, 6½p. 50/50, 8p. 100/50, 200/25, 11p. 250/50, 18p. 500/10, 11p. 500/25, 15p. 500/50, 18p. 1000/10, 15p. 1000/25, 22p. 1000/50, 40p. 2000/10, 20p. 1000/100, 88p. 2000/25, 30p. 2000/100, 93p. 2500/25, 38p. 2500/50, 61p. 5000/25, 65p. 5000/50, £1·08.

HI-VOLT: 4/350, 14p. 8/350, 19p. 100/100, 20p. 16/350, 22p. 16/450, 23p. 32/350, 33p. 50/250, 20p. 100/250, 30p.

METALLISED PAPER CAPACITORS
250V: 0·05μF, 0·1μF, 6p. 0·25, 6p. 0·5μF, 7½p. 1μf, 9p. 500V: 0·025, 0·05, 6p. 0·1, 6p. 0·25, 7½p. 0·5, 9p. 1000V: 0·01, 11p. 0·022, 13p. 0·047, 0·1, 15p. 0·22, 23p. 0·47, 34p.

PLEASE NOTE OUR NEW ADDRESS.
Our New Electronics Centre is now open in Leighton Buzzard and all callers are welcome. As well as our normal stock of over 2,000 products, we have a large range of surplus bargains and calculators, etc. Open six days. 9–12.30, 1.30–5 p.m.

NEW KIT
5E12 ½W Metal Film. 5 each value 10Ω–1M, total of 305 £3·25

MULTIMETER U435

32 ranges. High sensitivity. 20.000Ω/Volt.
Vdc—75mV—1000V in 8 ranges.
Vdc—2·5—1000V in 7 ranges.
Idc—0·001—2·5A in 6 ranges.
Iac—0·005—2·5A in 5 ranges.
Resistance—3-300K in 3 ranges.
Capacitance scales 0–0·5μF.
Accuracy—dc and R—2½% of F.S.D.
ac and C—4% of F.S.D.
Size—205 × 110 × 84mm.
Complete with steel carrying case, test leads and battery.
PRICE £9.45 net P. & P. 25p.

CALCULATORS

Sinclair Scientific	£21.55
Sinclair Cambridge	£13.98
Sinclair Cambridge Memory	£19.39
CBM MM6	£8.75
CBM 8850 Percentage	£16.25
CBM 7840	£10.75
CBM 987R Memory	£21.55

MULTIMETER U4323

22 Ranges plus AF/IF Oscillator
20.000Ω/Volt
Vdc—0·5—1000V in 7 ranges
Vac—2·5—1000V in 6 ranges
Idc—0·05—500mA in 5 ranges
Resistance—5Ω—1M Ω in 4 ranges.
Accuracy—5% of F.S.D.
OSCILLATOR—1KHz and 465KHz (A. M.) at approx. 1 Volt.
Size—160 × 97 × 40mm.
Supplied complete with carrying case, test leads and battery. PRICE £8·30 net P. & P. 25p. U4323

MULTIMETER U4341

27 Ranges plus Transistor Tester.
16,700Ω/Volt. Overload protected.
Vdc—0·3—900V in 8 ranges.
Vac—1·5—750V in 6 ranges.
Idc—0·06—600mA in 5 ranges.
Iac—0·3—300mA in 4 ranges.
Resistance—2KΩ—2MΩ in 4 ranges. Accuracy—dc—2½%.
ac—4% of F.S.D.
hfe—10—350 in 2 ranges.
Size—115 × 215 × 90mm.
Complete with steel carrying case, test leads, and battery. PRICE £11·30 net P.&P. 30p. U4341

NEW CAPACITOR KITS

C280 Kit—PC Mounting polyester 250V. 5 of each value: 0·01, 0·022, 0·047, 0·1, 0·22μF. 2 of 0·47, 1μF. £1·30 net.
C296 Kit—Tubular polyester. 400V. 5 of each value: 0·01, 0·022, 0·047, 0·1, 0·22μF. 2 of 0·47μF. £1·30 net.
Ceramic Kit—square plaquette 50V. 5 of each value: 22, 33, 47, 100, 220, 330, 470, 1000pF, 2200, 4700pF, 0·1μF. £1·30 net.
250V Paper Kit—Tubular metal case. 3 of each value: 0·05, 0·1, 0·25, 0·5, 1μF. 90p net.
500V Paper Kit—Tubular metal case. 3 of each value: 0·025, 0·05, 0·1, 0·025, 0·5μF. 90p net.
1000V Paper Kit—Tubular metal case. 3 of each value: 0·01, 0·025, 0·05, 0·1μF. £1·10 net.

S-DeC

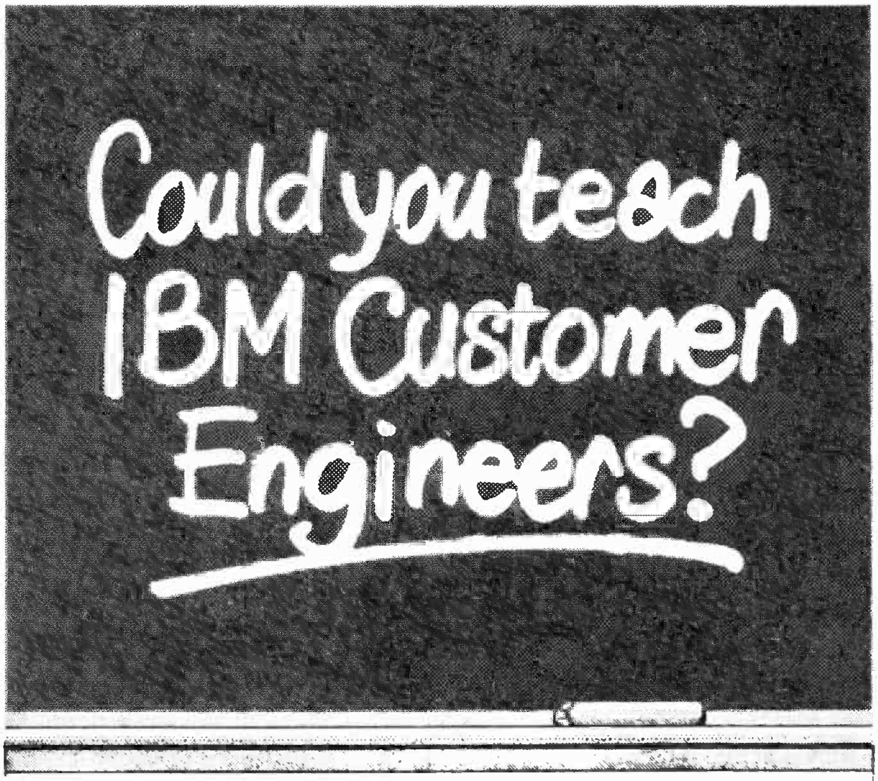
S-DeC	£2·14
T-DeC	£3.92
μDeC "A"	£4.30
μDeC "B"	£7.53
2 DeC	£4.72
ANTEX	
CCN240	£2.43
CN240	£2.01
X25	£2.01

CATALOGUE NO. 4
Bigger than ever—contains 68 pages, fully illustrated. Covering approx. 2,500 product lines. Many new components and test meters, and many standard lines have been expanded.
20p post free

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT: £6.08 per single col. centimetre (min. 3cm).
LINE advertisements (run on): 86p per line (approx. 7 words), minimum three lines.
BOX NUMBERS: 35p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU).
PHONE: Allan Petters on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Advertisements accepted up to 12 noon Thursday, March 27th, for the May issue subject to space being available.



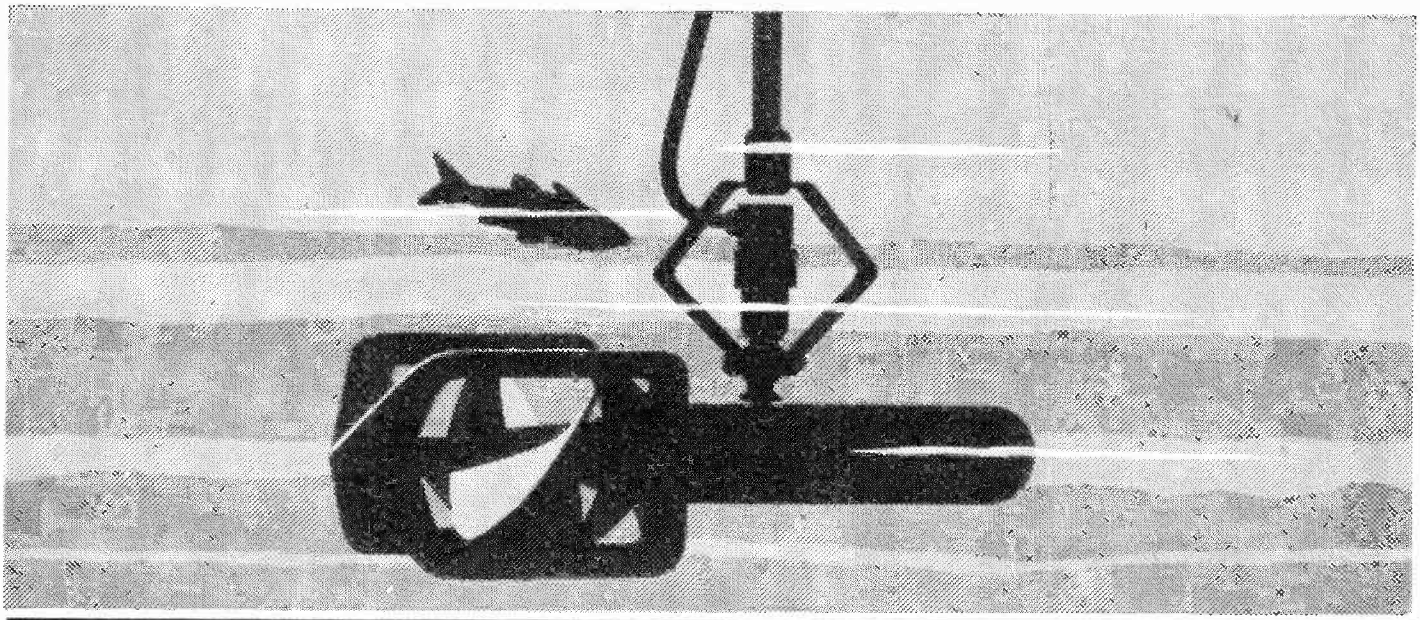
We have a number of opportunities for instructors to train our customer engineers to service and maintain data processing equipment including the latest 370 Systems and Software.

If you're an experienced or potential instructor with a background in software and/or electronics, educated to HNC, C & G standard or perhaps you've had similar service experience – now's the chance to find out more about these secure, well paid positions, based in NW London. Salaries start from £3000 and career development prospects and training are excellent.

If you are interested please write to:
Anne Dare, IBM United Kingdom Limited,
389 Chiswick High Road, London W4 4AL.
Quoting ref: WW/92418.

IBM

4338



DRAUGHTSMEN/ILLUSTRATORS and TECHNICAL AUTHORS

Marine Electronics **West Country**

The Plessey Marine Research Unit is engaged in a broad range of research and development in the field of electronics and underwater acoustics. New projects are now creating a number of openings for Draughtsmen/Illustrators and Technical Authors. They will be assisting in the preparation of Admiralty Handbooks describing advanced sonar systems. The equipments contain the most modern digital circuitry employing TTL Logic, ROM's, RAM's and thin film techniques. The research and design laboratories are situated on a country estate at Templecombe, Somerset. Good educational and housing facilities are available in nearby towns like Yeovil, Sherborne and Wincanton, while the Dorset coast is less than an hour away.

Principal Draughtsman/Illustrator

An experienced Draughtsman/Illustrator is required to take charge of the Illustration Section in a new Technical Publications Department.
The successful candidate must be capable of liaison with customers on technical matters relating to drawings and illustrations. He should be familiar with circuit diagram presentation to BS3939.
It will be an advantage if the candidate has been concerned with technical publications produced to Admiralty Specification NWS 1/70 REF.DI.50

Senior Draughtsmen/Illustrators

This is an ideal opportunity for illustrators to join an enthusiastic team in a new department engaged in the preparation of MOD(N) Handbooks.
They will work in liaison with the Technical Authors and ideally have had a minimum of five years' relevant experience, with a sound knowledge of circuit diagram presentation to BS 3939. An understanding of reprographics is desirable. REF.DI.100

Draughtsmen/Illustrators

They should have had a minimum of three years' experience as illustrators in the Electronic industry, but draughtsmen with a leaning to illustrative work and the ability to prepare good quality diagrams for photographic reproduction should apply. An understanding of reprographics is desirable. REF.DI.200

Technical Authors

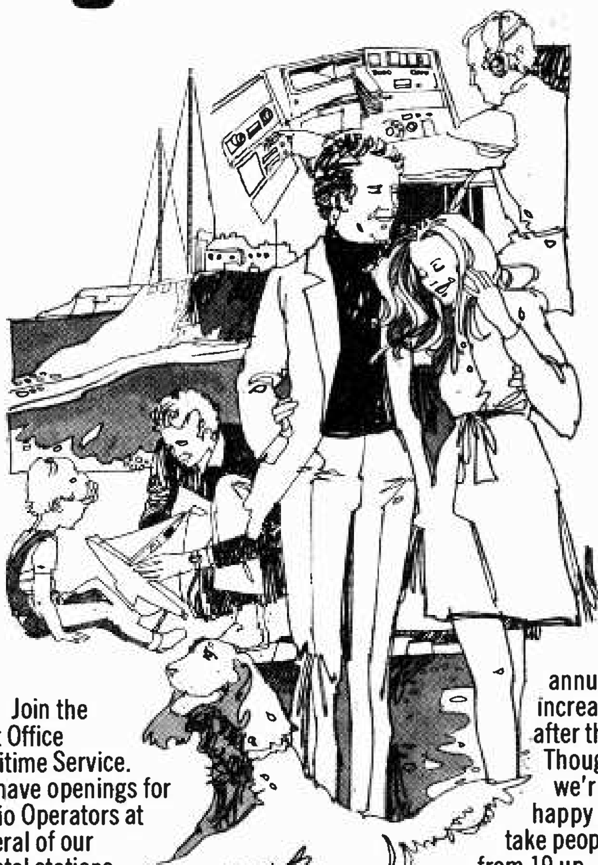
To prepare original material for publication, originate draft text illustrations; prepare final copy after approval; read and correct camera copy and printers' proofs. Would work largely on own initiative under limited supervision. Should be educated to O.N.C. standard in electrical engineering or equivalent standard in appropriate subjects coupled with an engineering apprenticeship or service in HM Forces, or other practical experience. REF.TA.516

Plessey Marine employs in the region of 1,700 people divided between locations' in Somerset, Newport, S. Wales, and Ilford, Essex. Highly competitive salaries and excellent conditions of employment are offered. Generous holiday entitlement. Pension/Life Assurance scheme. Relocation expenses will be paid.
For further information please telephone, or write giving details of age, qualifications and experience, to The Personnel Manager, Plessey Marine Research Unit, Wilkinthroop House, Templecombe, Somerset. Tel: Templecombe (0963 7) 551.

4541

PLESSEY

Radio Operators. How to see more of your wife without losing sight of the sea.



Join the Post Office Maritime Service. We have openings for Radio Operators at several of our coastal stations.

The work is just as interesting, just as rewarding as aboard ship, but you get home to see your wife and family more often. You need a United Kingdom General or First Class Certificate in Radiocommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay for a man of 25 or over is £2,270, plus cost of living allowance with further annual increases after that. Though we're happy to take people from 19 up.

In addition to your basic salary, you'll get an average allowance of £450 a year for shift duties and there are opportunities for overtime.

Other benefits include a good pension scheme, sick pay and prospects of promotion to Senior Management.

For more information, write to: ETE Maritime Radio Services Division (L533), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AS.

Post Office Telecommunications

(93

RADIO OFFICERS

Do you have PMG I, PMG II, MPT 2 years operating experience?

Possession of one of these qualifies you for consideration for a Radio Officer post with composite signals organisation.

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £3,096 pa; commencing salary according to age—25 years and over £2,276 pa. During training salary also by age, 25 years and over £1,724 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer,
Government Communications Headquarters,
Room A/1105, Priors Road, Oakley,
Cheltenham, Glos GL52 5AJ
Telephone Cheltenham 21491 Ext 2270

(92

STAFF REQUIREMENT

SAMUELSON FILM SERVICE LIMITED

require

TV TECHNICIAN

to develop their SAMCINEVISION Department.

The position calls for an enterprising, inventive and reliable technician who thoroughly understands CCTV and can maintain the range of equipment and TV viewfinder systems operating with Motion Picture Cameras. A certain amount of location work with film units will be involved and there will be a requirement to instruct others on the use of the Samcinevision TV Viewfinder Systems.

Further development and design possibilities will be part of the responsibility of the successful applicant.

Salary is negotiable, non-contributory pension scheme.

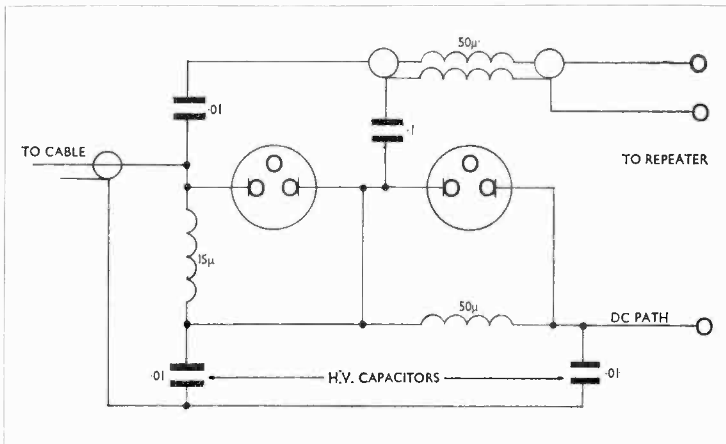
Please send written application, stating experience and salary expected, in confidence, to:

DAVID SAMUELSON,
Samuelson Film Service Limited,
303, Cricklewood Broadway,
London, N.W.2.

(4526

Electronic Engineers

This can work from 1 to 45 MHz -can you?



The above power separating filter is only one example of the sort of work that our engineers do in the design and development laboratories of the Submarine Systems Division of S.T.C.

We are looking for graduate or similarly qualified engineers with experience of a year or more in electronic design and development. An analogue background will be preferred.

This is what we have to offer :–

A Secure Future:

We are the world's largest supplier of repeatered submarine telephone cable systems. Most of our product is exported and our order books are healthy. We are also the technological leaders in our field and through our design and development teams we are continuously improving on our fine record of innovation and reliability.

Benefits:

Excellent starting salary. Your salary progression will be determined by your performance, responsibilities and potential. First class large company benefits include 4 weeks, 2 days holiday. Generous relocation expenses will be paid where appropriate.

A Satisfying Job:

Working in an area of advanced technology, you will design and develop wideband analogue amplifiers, filter networks (using C.A.D.), repeater supervisory circuits, terminal transmission equipment or advanced test gear. You will be designing a product of supreme quality, for once laid a system must operate for 25 years without fault or maintainance.

Training:

We shall offer training to those whose experience of analogue circuitry is limited. Encouragement is given to engineers who wish to obtain corporate membership of the I.E.E.

Career Development:

You will be given every opportunity to develop and take responsibility. There is much scope for advancement in the Engineering Department and other functions of the company. Promotion is given on the basis of merit.

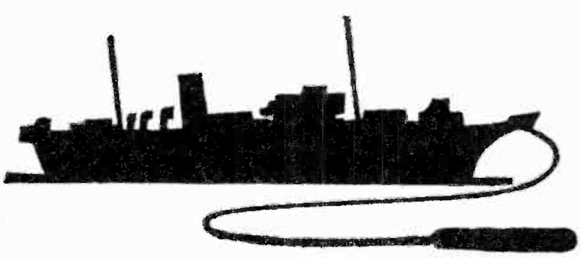
Travel:

Opportunities may exist for you to spend periods abroad on cable laying and commissioning operations. In 1975 this might take you to Spain, Italy, the Greek Islands, Australia, New Zealand or New Guinea.

Interested?

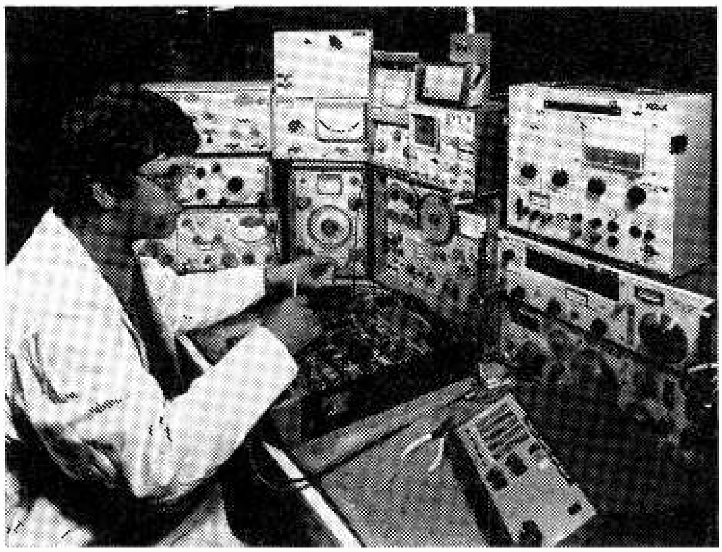
If you would like our special information pack 'phone David Stenhouse on 01-476 1401, or write to him at :–

Standard Telephones and Cables Limited,
Submarine Systems Division,
Henley Road, North Woolwich, London, E.16



Standard Telephones and Cables Limited
A British Company of ITT

Electronics Test Engineers: career openings that affect all sorts of people...



. . . you most of all, naturally. Mainly because, by joining the world's largest exporter of radio-telephone equipment you will inevitably open up for yourself career advantages that very few companies can provide. Pye Telecom is growing at an ever-increasing rate – and the potential for its products has as yet been only fractionally utilised.

But the work you do will also be vital to an incredible number of others. Very frequently, life itself depends on the efficiency of the UHF and VHF equipment you'll be working on. Police, firemen and ambulance staff are a small sample of the extensive range of users. Which explains the exacting specifications of the test procedures in operation – and why previous fault-finding and testing experience is an essential requirement. If it relates to communications equipment, so much the better, but this is not absolutely essential. More important is practical proficiency, which may well have been gained in the armed forces.

Find out more right now by phoning or writing to Mrs Audrey Darkin at:

Pye Telecommunications Ltd
Cambridge Works, Elizabeth Way,
Cambridge CB4 1DW. Tel: Cambridge 58985

A member of the Pye of Cambridge Group 4496

THE OPEN UNIVERSITY OPERATIONS AREA SENIOR MAINTENANCE TECHNICIAN

A vacancy exists in the Audio-Visual Department of the Operations Area of the Open University for a Senior Maintenance Technician.

The person appointed will supervise the Audio-Visual Workshop which handles repair and maintenance of video-tape equipment, television cameras, film projectors, professional broadcasting sound recording equipment, slide and overhead projectors and all equipment housed in the Lecture Theatre of the University. The operation of such equipment will also be necessary from time to time.

A lively interest in the audio-visual field is necessary to keep up to date on new developments and to modify and adapt equipment and methods as required.

The successful candidate should have either HNC/HND (Electronics) plus an electrical/electronics apprenticeship, and a minimum of 7 years relevant experience in inspection testing, maintenance of audio-visual equipment, or Science degree (Electronics) and a minimum of 3 years relevant experience.

Salary within scale Technican Grade 6: £2844—£3,450 per annum.

Further particulars and application forms are available from the Personnel Manager (OT4). The Open University, P.O. Box 75, Walton Hall, Milton Keynes, MK7 6AL. Applications should be returned as soon as possible. [4510

MAJOR RECORD COMPANY IN WEST-END

requires

AUDIO ENGINEER

with Electronic and Mechanical experience for their Studios Technical Department.

For further details ring
SUE CAMBRAY
on: 01-262 5495

[4524

R.F. Engineer

Leading Manufacturers of Audio equipment have a vacancy on their development team at King's Lynn for an experienced R.F. Engineer who will be engaged in the development of their high quality products.

Good salary commensurate with experience.

Applicants write giving details of experience to:
Mr. D. J. Chesney
Personnel Manager,
Dynatron Radio Ltd.,
Hansa Road,
Hardwick Industrial Estate,
King's Lynn, Norfolk.

[4516

DYNATRON

WIRELESS TECHNICIANS

There are vacancies at Home Office Wireless Depots throughout England and Wales for Wireless Technicians to assist with the installation and maintenance of VHF and UHF Systems. Ability to drive a car and possession of a current driving licence is desirable.

Salary

is £1530 (at 17), £1865 (at 21) and £2210 (at 25) rising to £2575 a year plus a cost of living supplement of £19.14 a month.

A London Weighting Allowance of up to £410 a year is also payable for staff employed in London.

A Secure Future

with a good pension scheme, good prospects of promotion and a generous leave allowance.

Qualifications

Candidates should have good experience in Telecommunications and preferably hold a City and Guilds Intermediate Telecommunications Certificate or equivalent.

Interested?

Then write or telephone for further details and application form to Mr C B Constable, Directorate of Telecommunications, Home Office, 60 Rochester Row, London SW1P 1JX. Telephone 01-828 9848 Extension 734.

4522

Home Office

B&W manufacturers of Monitor Loudspeakers

B & W of Worthing is a fast-growing independent company manufacturing high-fidelity loudspeakers —acknowledged to be among the world's finest. Due to further planned development we are looking for a:

DESIGN ENGINEER

This new opening is a unique opportunity for a senior engineer (age 30–40) to join our research team, where laboratory facilities are probably better than any in the UK hi-fi industry.

Applicants should have good academic qualifications, preferably with a post-graduate degree to Ph.D. standard, and be capable of original thinking.

Salary will meet the requirements of the right man.

Please write with fullest details to the Managing Director.

B&W electronics
Meadow Road Worthing BN11 2RX

1973

4558

TV Systems Commissioning Engineer to lead teams overseas.

The growth of Pye TVT, international manufacturer of TV broadcast systems and equipment, has created a vacancy for a Senior Installation and Commissioning Engineer to work on either studio or transmitter systems.

The man we want will be a self-reliant and fully-experienced broadcast engineer capable of leading a small installation team. He will have to spend up to six months a year working overseas, mainly outside Europe.

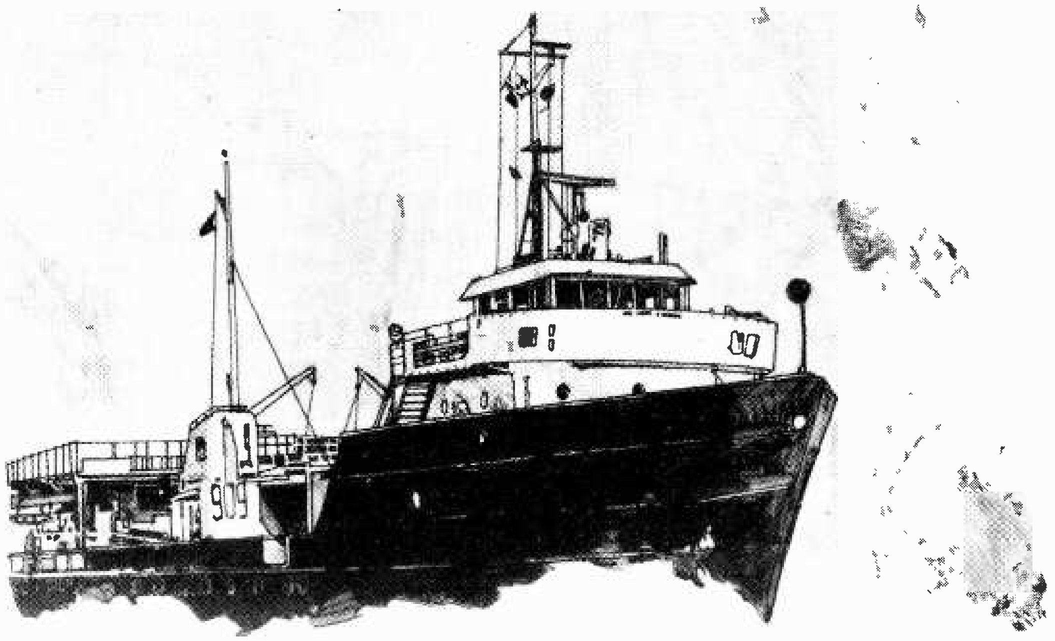
We recognise the responsibilities of this position in the salary and generous overseas allowances we offer. Other company benefits include re-location expenses to Cambridge where applicable.

Please write, with brief details of qualifications and career so far, to:

Mrs J. A. Macnab, Personnel Manager

4562

Pye TVT Limited
P O Box 41 Coldhams Lane
Cambridge CB1 3JU



Oil Exploration

G.S.I. Ltd, a subsidiary of Texas Instruments requires technicians with approximately four years experience in maintenance and repair of digital and analogue electronic equipment and qualified to ONC/HNC or City & Guilds (F.T.C.).

The openings available are in overseas marine seismic operations and are based on a 26 month contract with opportunities for home leave during this period.

The type of people we are looking for are single men who want a career that involves travel, work on shipboard Texas Instruments navigation and seismic digital recording equipment but will still be prepared to get their hands dirty.

If you feel that you fit the qualifications listed and are looking for a job that is not "9 a.m. to 5 p.m." contact David Kennedy, Personnel Department, G.S.I. Ltd, Canterbury House, Sydenham Road, Croydon, Surrey. Tel: 01-686 6511, ext 257.

Geophysical Service International Ltd.

4560

VISUAL AND AURAL AIDS TECHNICIAN

Applications are invited from suitably qualified persons to maintain and repair a range of Audio and Video equipment including T.V. Receivers in schools and other Education Establishments.

Average weekly earnings including bonus up to £50 per 40 hour week.

CROYDON

Applications to (or further particulars may be obtained from) The Superintendent, Croydon Education Committee, Service Centre, Princess Road, Croydon, CR0 2QZ. Tel: 01-684 9393. [4506

THE MOTOR INDUSTRY RESEARCH ASSOCIATION

ELECTRONICS ENGINEER

Required

To work with a small team in the design, development and commissioning of a wide range of specialised instrumentation and test equipment. Practical experience should include the designand construction of equipment using analogue and digital integrated circuits.

Preference will be given to graduate engineers, but applications are also invited from candidates with equivalent qualifications and relevant experience.

Apply in writing to the Personnel Manager, The Motor Industry Research Association, Watling Street, Nuneaton, Warwickshire CV10 0TU, giving age, experience, qualifications and current salary, and quoting CHGM. [4530

HER MAJESTY'S GOVERNMENT COMMUNICATIONS CENTRE

HANSLOPE PARK MILTON KEYNES MK19 7BH

has vacancies in the following fields of R & D work:

(a) HF Communications
(b) VHF/UHF Communications
(c) Communication Field Trials
(d) Acoustics
(e) Optics including Infra-Red
(f) Microwave
(g) General Circuit Design—Analogue, Digital
(h) Statistics/Operational Analysis/Systems Analysis

Most posts will be at Hanslope Park but some will be in London.

Candidates for post (h) should be experienced scientists/engineers who have specialised later in one of the required fields. An ability to deal with non-technical people is essential.

Appointments will be made within the grades of Higher Scientific Officer except for (e), (f) and (h) where appointments may also be made within the Senior Scientific Officer grade. In addition to the salary scales quoted, all posts attract the Threshold Agreement Payment (£229 p.a.) and a non-contributory pension.

HIGHER SCIENTIFIC OFFICER

Applicants should be under 30 years of age but this requirement may be waived if special qualification or experience can be offered. They should have one of the following qualifications:

(a) A degree in a scientific or engineering subject
(b) Degree-standard membership of a Professional Institution
(c) A Higher National Certificate or Higher National Diploma in a scientific or engineering subject
(d) A qualification equivalent to (c) above

In addition the following relevant experience is required:

(a) Applicants with 1st or 2nd class honours degrees—at least 2 years post-graduate experience.
(b) Applicants with other qualifications—at least 5 years post qualification experience.

Salary Scale: £2,461—£3,371 with entry point dependent upon experience beyond the minimum required.

SENIOR SCIENTIFIC OFFICER

Applicants should be at least 25 and under 32 years of age, although the upper age limit may be waived if experience of special value can be offered.

Applicants should have obtained a 1st or 2nd class honours degree and have had a minimum of four years appropriate post-graduate experience.

Salary Scale: £3,157—£4,441. Entry will normally be at the minimum of the scale but applicants with experience of special value may be entered above the minimum.

Applications, stating the field of work and grade required, should be made to

Administration Officer
HM Government Communications Centre
Hanslope Park
Hanslope
MILTON KEYNES MK19 7BH

[4478

PROJECT DEVELOPMENT ENGINEER

To consolidate and further develop an established product and also look after the engineering and test requirements of the product in production. H.N.C. in Electrical/Electronic Engineering, with some years electro-mechanical experience would be required.

Applications giving full career details should be sent in confidence to:

Mrs. J. I. Standfield,
Personnel Officer,
GEC Medical Equipment Limited,
East Lane,
North Wembley,
Middlesex.

GEC
Medical

[4518

OMAN

DHOFAR REGION TELEVISION SERVICE

We are recruiting on renewable one-year contracts

Staff—Engineers—Management

for the complete maintenance and operation of the television service.

If you work in television please apply for further information:

MANAGEMENT
PROGRAMME STAFF
ENGINEERS (STUDIO, TX & M/W & O.B.)
OPERATIONS STAFF/ENGINEERS
ACCOUNTS & ADMINISTRATION
OFFICE STAFF
LIGHTING
ELECTRICIANS
NEWSCASTING etc.

Let us discuss with you your abilities for these interesting and important positions.

Phone: Tony Owers 01-573 7352 for more information.

★ VERY GOOD SALARY
★ FREE FAMILY PASSAGE
★ NO INCOME TAX PAYABLE IN OMAN
★ FREE FURNISHED ACCOMMODATION
★ SPECIAL END-OF-CONTRACT BONUS
★ WE PAY *LOCAL* EDUCATION FEES
★ COMPREHENSIVE FREE INSURANCE, HEALTH, DENTAL, ETC.
★ HARD WORK IS NECESSARY

P & E LTD

PERSONNEL & ELECTRONICS LTD.

4557

GOVERNMENT OF BOTSWANA

EXECUTIVE ENGINEER

Required by the Department of Posts and Telecommunications to be responsible to the Assistant Director of Telecommunications for (a) co-ordination of planning, installation and maintenance of all telecommunications equipment, (b) supervision of Senior Assistant Engineers, (c) expenditure control, (d) preparation of annual estimates and (e) short term planning for network extension.

Candidates, between 40–55 years of age, must possess a recognised degree in Telecommunications Engineering and have at least 5 years' professional experience.

Starting salary up to maximum of £4,610 in scale £2,800 to £5,350 according to qualifications and experience, which includes an allowance normally tax-free in scale £660 to £1,752.

Engagement is for one tour of 24–36 months in the first instance. Gratuity 25% of total basic salary. Generous leave. Subsidised accommodation. Family passages. Children's education allowances and holiday visit passages. Interest-free car loan and tax-free Appointment Grant payable in certain circumstances.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Ministry of Overseas Development.

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/740818/WF.

4545

crown agents

Technical Officer
(Components)

British Airways Group Management Services has a vacancy for a Technical Officer to organise and supervise the Central Technical Stores of the Telecommunications Engineering Department.

He will be expected to maintain a close liaison with manufacturers and distributors and keep abreast of rapidly changing technology in the compartment field. He will also work closely with the Accounts and Purchasing sections of Group Management Services.

The responsibilities also include arranging for the shipping and transport of equipment and components to UK and overseas stations, clearing equipment through Customs as required, meeting the requirements of maintenance terms for the supply of components, advising of suitable alternatives where appropriate and providing a technical advisory service on components and accessories.

Applicants should have at least five years' experience in an electronics design or maintenance environment, and preferably an HNC or equivalent certificate in electronics or communications. Experience in purchasing and components supply would be an advantage.

The job is based at Heathrow Airport and carries a starting salary of £3,341 which includes a London Weighting Allowance of £200.

Additional benefits include an excellent contributory pension scheme, a first-class sports and social club and opportunities for concessional holiday air travel worldwide.

Please write, giving details of age and experience, quoting reference 458/WW/MA, to:

Manager Selection Services, British Airways, PO Box 10, Heathrow Airport—London. Hounslow TW6 2JA.

British airways

4556

Applications are invited from

Marine Electronic/ Communications Engineers

with a minimum of five years experience. The positions are available with a rapidly expanding Middle East Company and call for a wide background in the maintenance and servicing of Marine Electronics, Radar and Communications equipment. Applicants should show evidence of having recognised and qualified experience in any three of the following fields:

1. Low and medium Power MF/HF Transmitters and Receivers.
2. Low Power Solid State SSB Transceivers.
3. Marine VHF Radio Telephone Equipments.
4. Marine navigating Radar equipments and other navigational aids.
5. Gyro Compass and ship steering Servo Systems.

Successful applicants, following interviews in London will be engaged on a contract basis in the Arabian Gulf. Initial salary will be in the region of £3,500-£4,000 p.a. plus fringe benefits and bachelor status accommodation, one month's overseas leave, return air passage paid annually, plus earned gratuity. Possibilities would be available for married status after proving ability in this area. Replies only will be sent to engineers actively servicing equipments at this time in a similar senior position. Reply in confidence to:

The Managing Director,
P.O. Box 1788.
Dubai,
United Arab Emirates.

4565

UNIVERSITY OF NEWCASTLE UPON TYNE
Department of Photography and Teaching Aids Laboratory

Colour Television Engineer

To be responsible to the Head of the Film and Television Section for the operation of an off-air colour recording, playback and transcription service. He will begin to assist in the immediate planning of a new colour system to be commissioned in 1976 for the new Dental School and Medical School and for the subsequent phased development of colour CCTV throughout the rest of the University.

Applicants should have several years' experience of colour programme origination and video tape recording, and preferably some experience of administration and television planning. He must be familiar with colour and monochrome studio equipment of all types, and capable of establishing and maintaining professional standards.

Salary at a suitable point on the scale £1,683-£2,931 plus a threshold payment of £229.68 per annum, according to age, qualifications and experience. For an exceptionally well qualified and experienced candidate the appointment may be made on the higher scale £2,757-£4,341 (plus threshold) (scales are under review). Membership of an appropriate University superannuation scheme will be required.

Further particulars may be obtained from the Registrar, The University, Newcastle upon Tyne, NE1 7RU, with whom applications (three copies) stating age, education, job experience, availability for interview and names of two referees, should be lodged not later than 30th April 1975. Please quote reference W.W. 4568

Audio experts wanting a new deal

Come to Pye Limited Audio Products, where we offer a great deal in our new deal for 1975. Leading makers of stereo equipment, car radios, radiograms, etc., we have increased our already high rates of pay.
To maintain our reputation for quality which makes our growth and prosperity possible, we need more:

Audio and RF Fault Finders

Men aged 21+ to strengthen our Test/Diagnosis Department. You should ideally be capable of working with a minimum of supervision and have—or be studying for—a C & G qualification in Electronic/Radio Servicing. Alternatively you should have at least two years in similar work.

Production Engineers

For production methods and measurement, and assisting with direct labour analysis. Preferably applicants should have an ONC or MLWSP and practical experience of consumer electronics.
We can offer, besides the new rates, excellent career prospects and a number of company benefits which include a subsidised canteen and discounts on the products we make.
For further details, please write or ring:
The Personnel Department,

4553

Pye Limited
Audio Products
Caxton Way Stevenage
Tel: Stevenage (0438) 50241

Storno *LIMITED,*

Manufacturers of modern FM radio communication systems for all branches of industry, transport and Public Authorities require additional

TEST TECHNICIANS

based in Camberley to assist in the final testing of personal and mobile radio equipment and sophisticated control systems.

Knowledge of RF, digital and thick film techniques desirable with academic levels to ONC or C. & G. Final, but for an applicant with exceptional experience and knowledge these qualifications may be waived.

Pleasant working conditions, good salary and overtime. Opportunities for further study and training.

Hours: Monday–Thursday:
8.15 am–1.00 pm. 1.30 pm–4.45 pm.
Friday:
8.15 am–1.00 pm. 1.30 pm–3.30 pm.

Apply: The Personnel Officer,
Storno
LIMITED,
Frimley Road,
Camberley. Telephone: 0276 29131

Storno *SERVES THE NATION...*

[4555

M E R C U R Y

PROJECT ENGINEERS BROADCAST TELEVISION

To cover and extend our increasing international commitments, we are seeking to further expand our team of engineers working on broadcast television systems design and installation.

This work involves both static studio installations and Outside Broadcast vehicle construction, and may be located at Uxbridge or Westbury, Wiltshire.

The potential ability and confidence to assume total responsibility for the planning and execution of complete broadcast systems is an essential requirement, together with the personality to deal with a wide variety of people in the course of this work.

The engineers we are looking for will have formal qualifications to at least HNC level or equivalent, with detailed knowledge of one or more aspects of broadcast television. Experience of operational work within this sphere will be particularly useful. Overseas travel, occasionally for extended periods will be involved.

In return, we can offer you a varied, demanding and rewarding career with a young, vigorous company which is rapidly expanding and establishing a considerable reputation for itself in a highly competitive field.

Please write giving FULL details of your qualifications and experience or phone for an application form to:—

UXBRIDGE 39876/39613
MERCURY ELECTRONICS,
6 ROCKINGHAM WHARF,
ROCKINGHAM ROAD,
UXBRIDGE, MIDDLESEX

[4547

ENGINEER
(With TV Service Experience)

RS

R.S. Components Limited, Britain's biggest distributor of electronic components, requires an experienced Engineer or Service Manager who is currently employed on TV service work. Ideally, he should be between 25–45 and possess a good academic background.

This is a new post and an exciting opportunity for an engineer who is eager to further his experience by becoming our technical adviser on component requirements in the field of TV and Audio Equipment servicing.

Duties will include component evaluation, specification and assisting in answering customers' telephoned enquiries. Additionally, the candidate will be expected to maintain a close liaison with the service industry and manufacturers.

We can guarantee an interesting career which may occasionally involve travel in the U.K.

This new important post commands a good salary commensurate with ability and there is every opportunity for advancement. Excellent working conditions, generous holiday entitlement and pension scheme.

Write giving brief résumé of your career to date or ring for an application form to

Chief Engineer
R.S. Components Limited
13–17 Epworth Street, London
EC2P 2HA. Tel: 01-253 1222

An Electrocomponents Group Company

4559

TV Systems: Senior Installation and Commissioning Engineers

Help Pye TVT continue to grow as a leading international designer and manufacturer of TV broadcasting systems and equipment.
We want Senior Installation and Commissioning Engineers, self-reliant and able to lead small teams of engineers on projects involving modern generation, colour television, transmitter (VHF and UHF) and professional broadcast studio equipment. They will have several years' practical experience in broadcasting and hold qualifications involving or leading to membership of the I.E.R.E. or I.E.E.
Since many of our projects are overseas, usually outside Europe, they will be required to spend considerable periods abroad, for which generous overseas allowances will be paid in addition to basic salary and adequate subsistence expenses, Appointments are based in Cambridge and relocation expenses will be paid where applicable.
Please apply, with brief details of experience, to:
Mrs. J. A. Macnab, Personnel Manager,

Pye TVT Limited
P O Box 41 Coldhams Lane
Cambridge CB1 3JU

4566

CENTRAL BIRMINGHAM
HEALTH DISTRICT

ELECTRONICS TECHNICIAN

(M.P.T. II)

A vacancy exists in the electronics section of the Medical Physics and Biomedical Engineering Department for an experienced Technician with H.N.C. or equivalent, competent to take responsibility for the servicing and development of biomedical electronic equipment throughout the Teaching District and to act as Deputy Head of the section. Experience of medical electronics advantageous, but good general electronic experience essential.

Salary: £2,601—£3,390 per annum, plus Threshold.

Further particulars and application form from the

PERSONNEL OFFICER,
QUEEN ELIZABETH MEDICAL CENTRE,
EDGBASTON,
BIRMINGHAM B15 2TH.

[4542

TONGA

SUPERVISING BROADCASTING TECHNICIAN

required by the Tonga Broadcasting Commission to be responsible for the operation and maintenance of the Commission's two 10 Kilowatt sound transmitters, to install and maintain studio equipment, to run a radio retail store involving technical supervision in purchasing, selling and repairing of receivers and other equipment.
Candidates, under 55 years of age, MUST have a City and Guilds Telecommunications Technician Final Certificate Course 271 or equivalent with 10 years' experience in the operation of studio and transmitter equipment as well as in all aspects of a small broadcasting station with particular emphasis on sound transmitters.
Salary in scale £2,125 to £3,400 pa which includes an allowance normally tax free in scale £504 to £1,404 pa and 20% cost of living allowance. Gratuity 20% of Local salary. Tour of 2 years.
Benefits include free passages, Government housing at moderate rental. Holiday visit passages and generous paid leave. An appointment grant of £300 and car loan of £600 may be payable.
The post described is partly financed by Britain's programme of aid to the developing countries administered by the Ministry of Overseas Development.
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/740928/WF.

4508

crown agents

Opportunities in the
ELECTRONICS FIELD

Men with analogue or digital qualifications/experience seeking higher paid posts in: TEST – SERVICE – DESIGN – SALES. Phone Mike Gernat. Ref. WW.

NEWMAN APPOINTMENTS
360 Oxford St. W1
01-629 7306

[94

ST. HELIER HOSPITAL
Carshalton, Surrey

MEDICAL PHYSICS TECHNICIAN GRADE II

required for District Medical Physics Department.

Salary scale from £2,601 to £3,390 p.a. plus £312 London Weighting Allowance. Further details can be obtained from Chief Technical Officer — 01-644 4343

[4529

CITY OF LONDON POLYTECHNIC

SENIOR ELECTRONICS TECHNICIAN

(GRADE 5)

required immediately in the Department of Biological Sciences for the maintenance, design and operation of electronic and other instruments, especially those used in Neurophysiology. The successful candidate must possess the relevant qualifications at HND/HNC or CGLI level, together with at least seven years relevant experience (including training period). Salary £2,439—£2,895 plus £411 London Weighting (starting point dependent on qualifications and experience).
Apply, in writing, giving full details of qualification, experience, etc. and including the names and addresses of two referees, to the Laboratory Superintendent, Biological Sciences, Calcutta House Precinct, Old Castle Street, London E1 7NT.

[4554

University of Surrey
Audio Visual Aids Unit

TECHNICIANS

(T4 £2247-£2628)
(T2B £1860-£2187)

The AVA Unit is responsible for projection and allied services in 26 Central Lecture Theatres, and also provides services of photography, film and television for teaching and research throughout the University.

These new posts are for skilled technicians who will be responsible for installation, maintenance and repair of a wide range of Audio Visual equipment ranging from slide projectors to television. The Unit is well equipped for electronic and mechanical servicing, and instrument making and repair work.

For the Grade 2B post experience in one or more of these fields is essential, although training in specific techniques will be given where necessary.

For the Grade 4 post experience in electronic servicing is essential and candidates should hold an ONC or equivalent qualification.

Applications immediately on forms available from: Assistant Secretary (Personnel), University of Surrey, Guildford, or Tel: Guildford 71281 Ext. 452

[4543

SERVICE ENGINEER

We are the distributors of World renowned Tandberg Products and are looking for a Service Engineer who has had experience in the Service and Repair of domestic Hi-Fi Equipment. Up to date Service Facilities and good working conditions, 5 day week with 3 weeks Annual Holiday. Wages up to £2,500 per annum depending on experience.

Please apply in writing with details of Career to date to Mr. D. D. Hamilton, London Manager, Farnell-Tandberg Ltd, 167, Hermitage Road, London N4 1LZ. [4578

Electronics Engineer

Our Research Function carries out innovative research through a number of project groups supported by certain essential specialised services. We are seeking an Electronics Engineer to join the Laboratory Services group in trouble shooting, maintenance and some development work.

Responsible to the Laboratory Manager, he will provide a service to all of the departments in our new research laboratories where the electronic equipment includes infra-red, ultra-violet, NMR and mass spectrometers as well as chromatographic equipment, calculators and recorders. There is also a Fourier transform NMR instrument incorporating a small computer.

The man we are looking for will be in his late twenties or thirties, qualified to HNC or possible degree level and he will have had some experience of service and development work preferably in a multi-disciplinary academic or industrial research laboratory. Specific experience in the field of NMR electronics would be an advantage. The person we appoint will be working largely without direct supervision and he should therefore be capable of accepting this degree of responsibility.

Roche Products Limited is part of one of the world's largest and most successful pharmaceutical companies and is itself one of the leading companies in the U.K. Working conditions are excellent and the Conditions of Service include some valuable fringe benefits.

Please apply in writing, quoting reference R50 to the Personnel Manager.

ROCHE

Roche Products Limited,
PO Box 8, Welwyn Garden City, Herts AL7 3AY

[4534

Service Area Planning Engineers

£2488 - £3019

The Independent Broadcasting Authority requires two Junior Engineers to assist Engineers in charge of field teams with the planning and execution of the UHF television service area surveys, RBL tests and other field work. The people appointed to the posts will also assist with the general UHF television and independent local radio planning work of the section.

Candidates should preferably be qualified to HNC or equivalent level and should have some basic knowledge of radio wave propagation and television principles, plus experience of radio frequency measurement.

The posts are based at Crawley Court, near Winchester, Hampshire, however a considerable amount of travelling throughout the UK will be involved for which appropriate allowances will be payable. Candidates should have a current driving licence and should preferably have the ability to climb aerial support structures up to about 150 feet.

IBA INDEPENDENT BROADCASTING AUTHORITY

Please write or telephone for an application form quoting Ref. DT/2670 to:– Miss Vanessa Aldred, Independent Broadcasting Authority, Crawley Court, Winchester, Hants. SO21 2QA. Tel: Winchester 822327.

[4561

Radio Technology

TELECOMMUNICATIONS OFFICERS

International Radio Monitoring Station,

Baldock, Herts

. . . concerned with the installation and maintenance of electronic equipment such as radio receivers, spectrum analysers, and direction finding equipment and will include the use of a wide range of test equipment.

Radio Interference Branch,

Stanmore, Middx

. . . duties include: the development of equipment for detection, location, measurement and suppression of radio interference; the technical control and inspection of amateur radio stations, the tracing of illicit radio transmitters and the development of methods of detecting unlicensed television receivers.

Mobile Services Branch,

Central London (2 posts)

. . . responsible for technical advice in connection with Maritime Mobile Services and Land Mobile and Fixed services between 30–1000MHz. The work also covers the preparation of specifications for equipments for these services and the type-approval testing of such equipment; the assignment of frequencies and application of computer techniques to frequency assignment problems.

Candidates (aged at least 23) must have ONC in Engineering (with a pass in Electrical Engineering 'A') or in Applied Rhysics, or an equivalent qualification. In addition, they should normally have had at least 5 years' relevant experience.

Salary starting between £2,800 and £3,300 (according to age) and rising to £3,500. Central London salaries quoted; less elsewhere. Prospects of promotion. Non-contributory pension scheme.

For full details and an application form (to be returned by 10 April, 1975), write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone BASINGSTOKE 29222 ext 500 (or, for 24 hour answering service, LONDON 01-839 1992). Please quote reference T/8921.

HOME OFFICE

4537

ELECTRONICS TECHNICIAN JUNIOR ENGINEER

Systems Company requires 20/30 years old Engineer for development, Commissioning and Maintenance of mini-computer based remote batch terminals.

Good opportunity for either an experienced Man to establish himself in a fast growing and friendly Company or for a Young Man to acquire experience of the latest technology in mini computers and peripherals.

Full training will be given. Some travel U.K. Salary range £1,800—£2,600 p.a. Write or phone: Peter Rogers or Steve Clifford.

TASK TERMINALS LTD.
117, Cleveland Street,
London, W.1.
01-637 4516

[4521

SIEMENS
MEDICAL ENGINEERING

Service and Sales Engineering

Service and Sales Engineers required for Electro-Medical Department, to work in the London area. Previous experience in this field an advantage, but knowledge of electronics essential.

Applications to:

SIEREX LTD.,
Heron House, 109 Wembley Hill Road,
Wembley, Middlesex, HA9 8BZ.

[4570

ELECTRONIC CRAFTSMEN

Is your present job routine and uninteresting?

We are a research establishment and our craftsmen are engaged on a wide variety of work in the fields of prototype and small batch wiring and assembly, test and inspection, maintenance fault finding and repair. Why not join us and enjoy working in first class conditions in the country.

You can expect gross earnings including overtime of £45 per week, and we can offer good housing at low rental (for applicants who reside outside the radius of our Assisted Travel Area) together with 3 weeks paid holiday with holiday bonus, free pension and excellent sick benefit scheme.

Applicants who should have served a recognised apprenticeship or have had equivalent training together with experience in one of the fields detailed should 'phone Tadley 4111 (STD 073 56 4111) Ext. 5230, or write to:

INDUSTRIAL RECRUITMENT OFFICER
(PA/79/WW) PROCUREMENT EXECUTIVE
MINISTRY OF DEFENCE
AWRE ALDERMASTON
READING, BERKS.
RG7 4PR.

[4316

HARINGEY

Education Services

Full-time

Laboratory Technician

required at Stationers' Company's School, Mayfield Road, N.8, to work 35 hours per week x 52 weeks per annum.

Salary rising to £2,677 per annum including threshold payments. Commencing salary according to qualifications and experience.

Minimum Qualifications: Ordinary National Certificate or Ordinary National Diploma; City and Guilds Laboratory Technicians Certificate; 4 G.C.E. passes with 2 at 'A' Level in appropriate subjects; Membership of Institute of Science Technology OR an equivalent suitable qualification OR 5 years suitable experience. Qualifications in Electronics would be an advantage.

Candidates will be responsible for the maintenance of the Language Laboratory and will be required to assist in the upkeep of Audio Visual aids throughout the school and help monitor a computer link-line.

The post is ideal for a candidate who wishes to gain experience in the maintenance of a fairly wide range of equipment.

Application forms obtainable from Chief Education Officer, Somerset Road, N.17, to be returnable 7th March, 1975.

[4536

APPOINTMENTS

BRUNEI

TELEVISION ENGINEER

- **Posting Bandar Seri Begawan**
- **Engagement for three years initially**
- **Gratuity 25% of total salary drawn**
- **Free family passages**
- **Furnished quarters at reasonable rental**
- **Children's education allowances and holiday visit passages**
- **Interest free car loan**
- **There is *no income tax payable* in Brunei at present**

The Brunei Television Service require a Supervisory Engineer (Transmitters) to be responsible to the Superintending Engineer for the efficient operation and maintenance of all transmitting equipment; also routine inspection and maintenance of aerials and feeders on towers 400/450 ft. high and to undertake the training of local staff. Candidates, preferably under 55 years of age, *must* hold a recognised qualification in colour television engineering, and have spent at least 5 years in a supervisory position in a PAL colour television transmitting station. Experience should include parallel operation of Band III transmitters of 5KW and higher output towers and the installation, operation and maintenance of microwave link equipment. Salary, according to qualifications and experience in the scale £3,166 to £5,750 approximately.

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/740804/WF.

crown agents

4509

Aerial Maintenance Engineer

£3238-£3928

We require an experienced Aerial Engineer in the Station Operations and Maintenance Department to be responsible for the maintenance of UHF, VHF and SHF Transmitting and Receiving Aerial Systems.

The post is based at the Authority's North Regional Office in Leeds and the duties will mainly be confined to stations within the North of England, although duties throughout the UK may from time to time be required.

The work will require the successful applicant to travel extensively in the fulfillment of his duties (a car will be provided). In addition, because of the nature of the broadcasting service, duties outside 'normal office hours' will be required.

A minimum of three years' experience in the microwave transmission field on work involving aerial arrays and coaxial line assemblies and filters used in broadcasting bands is essential.

Applicants should preferably be qualified to HNC level or equivalent and/or should be able to demonstrate a sound theoretical understanding of aerial and transmission line systems.

Applicants should possess a current driving licence and should be prepared to climb masts up to 1250 feet in height.

The commencing salary will be within the above range, depending upon qualifications and experience.

IBA INDEPENDENT BROADCASTING AUTHORITY

Please write or telephone for an application form quoting reference number 2596 to: Vanessa Aldred, Independent Broadcasting Authority, Crawley Court, Winchester, Hants. Telephone: Winchester 822599.

4567

GUY'S HOSPITAL

MEDICAL PHYSICS TECHNICIAN GRADE II AND ELECTRONICS TECHNICIAN/ ENGINEER GRADE III

Department of Clinical Physics and Bioengineering

The Grade II Technician is a member of a team of physicists and technicians engaged in a variety of clinical instrumentation projects. ONC, HNC or higher qualification required together with 2 years electronics experience in Technician III Grade or other relevant technical experience. Basic salary from £2,601—£3,390, starting point according to experience.

The Grade III Technician post is for an Electronics Technician/Engineer engaged upon maintenance, repair and calibration of a wide range of electromedical equipment. ONC/HNC in electronics required plus at least 3 years electronic instrument maintenance experience. Basic Salaryy from £2,190—£2,817.

Apply to Personnel, Guy's Hospital, London SE1 9RT. Telephone 01-407 3662 Ext. 68.

[4514

RADIO TECHNICIAN FOR CENTRAL AMERICA

Needed to work in Guatemala with the Radio Schools Movement, training a team of Guatemalans in the maintenance and repair of station equipment. A British Volunteer Programme post.

Information:

Paddy Coulter, Overseas Volunteers/CIIR, 41 Holland Park, London W.11. [4577

KILLINGBECK HOSPITAL, YORK ROAD, LEEDS 14

AN

ELECTRONIC TECHNICIAN

(MEDICAL PHYSICS TECHNICIAN III)

is required for the Cardiovascular Unit. The hospital is the Regional Cardiothoracic Centre.

The work involves the servicing of patient monitoring and biochemical analysis equipment.

Basic qualifications required: ONC, HNC or HND. Experience in repair of audio-amplifiers or TV servicing would be an advantage.

Salary Scale:—£2,190—£2,817 per annum, plus current cost of living allowance.

Application form and job description from Personnel Officer, Seacroft Hospital, York Road, Leeds LS14 6UH. Telephone 648164 Ext. 253.

[4533

Classifieds continued on page 97

Articles for Sale—Continued

COLOUR. UHF and TV SPARES. Colour and UHF lists available on request. 625 TV. If unit, suitable for Hi-Fi amp or tape recording, £6.75, P/P 35p. Television construction cross hatch kit, £3.85, P/P 15p. Bush CTV 25. New convergence panels plus yoke and blue lat., £3.85, P/P 40p. New Philips single standard convergence panels complete, incl. 16 controls, coils, P.B. switches, leads and yoke £5.00, P/P 40p. 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 35p. Mullard or Plessey Blue Laterals, 75p P/P 20p. BRC 3000 type Scan Coils, £2.00 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 35p. EHT Colour Tripler ITT TH25/1TH suitable most sets. £2.00 P/P 25p. KB CVC1 Dual Stand, convergence panels complete incl. 22 controls £2.75, P/P 35p. CR1 Base panel, 75p. P/P 15p. Makers Colour surplus/salvaged Philips G8 panels part complete; Decoder, £2.50, IF incl. 5 modules, £2.25. T. Base, £1.00, P/P 25p. CRT base, 75p, P/P 15p. GEC 2040 panels, Decoder, £3.50. T. Base £1.00, P/P 35p. CRT Base 75p, P/P 20p. 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 transistorised, £4.95. All tuners P/P 35p. 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. 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, 75p P/P 35p. PHILIPS 625 IF amplifier panel incl. cct., 75p. 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, £1.00. A.B. miniature with UHF injection suitable K.B. Baird, Ferguson, 75p. New fireball tuners Ferguson, HMV, Marconi, £1.80 P/P all tuners 30p. Mullard 110° mono scan coils, new suitable all standard Philips, Stella, Pye, Ekco, Ferranti, Invicta, £2.00, P/P 35p. Large selection LOPTs. FOPTs available for most popular makes. 200+200+100 Microfarad 350v Electrolytic, £1.00 P/P 20p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6. Shop premises, callers welcome. (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.

LOW COST IC MOUNTING. Use Soldercon IC socket pins for 8 to 40 pin DIL's. 70p (plus 5p VAT) for strip of 100 pins, £1.50 (plus 12p VAT) for 3 strips of 100, £4 (plus 32p VAT) for 1,000. Instructions supplied. Send for sample. SINTEL, 53c Aston Street, Oxford. Tel: 0865 43203. [67

OLD COPIES, Wireless World, April 1913-14 (No. 1 Vol. Bound), January 1929—June 1932 (Bound), July 1932—December 1938 (Loose). Offers: J. Greaves, 82, Hodge Hill Common, Birmingham B36 8AG. [4525

P.D.P. 8 MINICOMPUTER with ASR33 Interface; but without peripherals, £425. P.D.P. 8/S in rack cabinet, c/w A.S.R. 33 & stats. software, £850. I.C.L. 1901/2 processor with K.S.R. 33 typewriter, £650. I.C.L. 2501 cassette tape unit, £225 Monroe Model 1210 'Monrobot', small desk COMPUTER incorporating A.S.R. 33 on stand & mag. memory drum, £225. A.S.R. 33 Teletype in A.S.C.I.I., £225. Elliott tape punch & reader with handlers, £32. Friden tape reader, £9. FLEXOWRITERS: Model 2 c/w desk etc., £385. Model 1, £125. Model 1 (upper case), £45. Singer PROGRAMMABLE PRINTING CALCULATOR, 30 step, 5 memory, £48. Singer Calculator displaying 'stack' on C.R.T., £28. (These calculators are D.T.L./T.T.L. & offer interesting potential. Ferranti mag. memory DRUM, £29. S Band Travelling Wave Tube Amplifier, c/w T.W.T., £45. ITEL AUTOMATIC 'GOLFBALL' TYPEWRITERS and ITEL TERMINALS from £250 s/hand, and £700 NEW. Descriptive Stock List, 25p (refundable). COMPUTER APPRECIATION, Castle St., Bletchingley, Surrey RH1 4NX. Godstone 3106. [4571

PYE VHF mobile AM10 Boot mount multi channel Radio C/ with controls cables cradle accessories and Aerial just over-hauled as new, £50. Phone 01-464 8417 evenings. [4550

THYRISTORS BT106 Branded Product 95p each. Tantalum Bead Capacitors 1mfd 35V 22mfd 16V. All at 10p each. Prices are exclusive of VAT. CWO plus p. & p. 10p. Pace Electronics Ltd., 138 Glebe Road, Deanshanger, Milton Keynes. MK19 6NB. [4497

TRIO Model 9R-59DS Receiver very little use, £25. Griffiths, Eymore House, Trimpley, Bewdley, Worcs. Tel. Arley 449. [4511

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

VALVES AND TRANSISTORS—Valves 1930—1975, 2,000 types stocked, many obsolete. List 15p. Transistors list 15p. Cox Radio (Sussex) Ltd., The Parade, East Wittering. Tel: West Wittering 2023. [4520

BRENT AND HARROW AREA HEALTH AUTHORITY
NORTHWICK PARK HOSPITAL,
Watford Road, Harrow, Middx. HA1 3UJ Tel: 01-864 5311

ELECTRONICS TECHNICIAN
(GRADE II)

Required to supervise the work of 4 Technicians and to provide a maintenance service to the Harrow Health District. The successful applicant would also be expected to develop a full range of services in the medical engineering field. Previous health service experience an asset but not essential.

Salary: £2,406—£3,141 plus £312 London Weighting plus £228 Threshold payments.

If interested please contact Miss P. Knight, Personnel Department, Ext. 2001.

[4523

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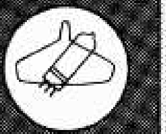

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BC108	10
BC109	14
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BC135	15
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BC138	26
BC142	23
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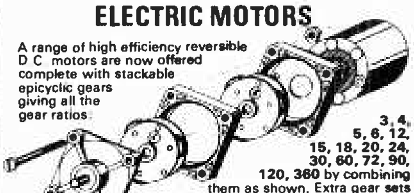

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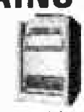

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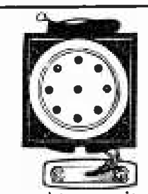

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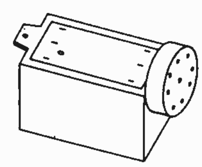

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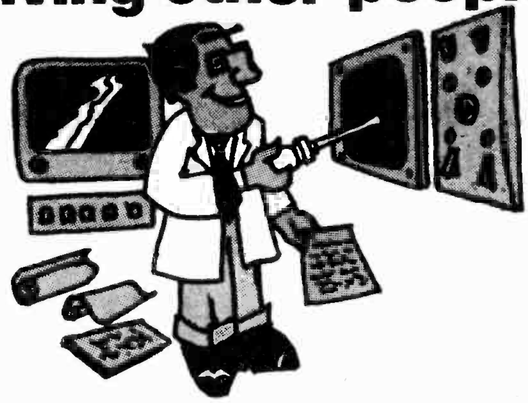

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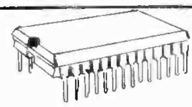

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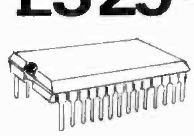

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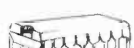

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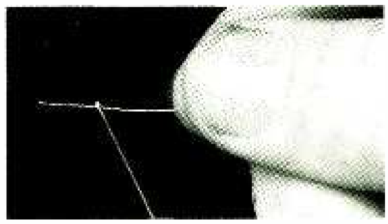

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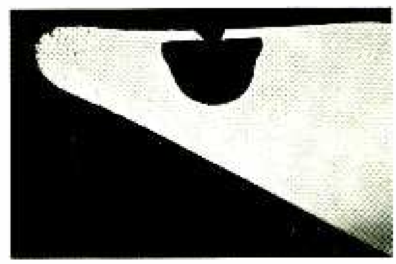

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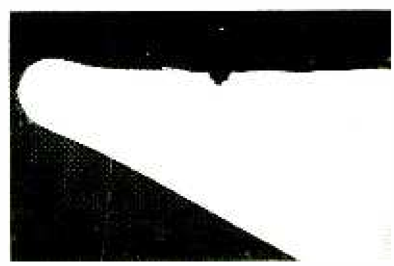

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