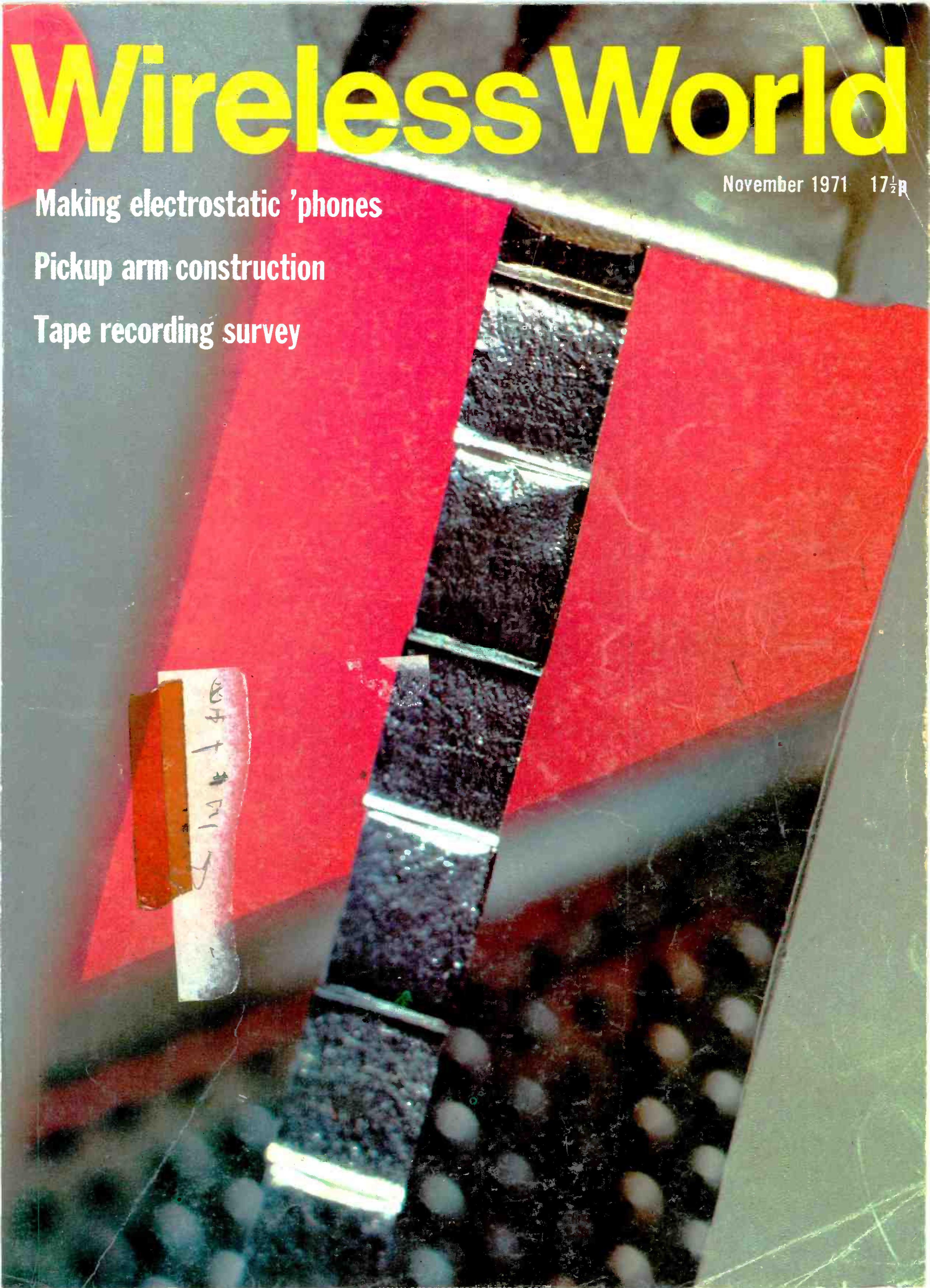
Wireless World

November 1971 17½p

Making electrostatic 'phones

Pickup arm construction

Tape recording survey

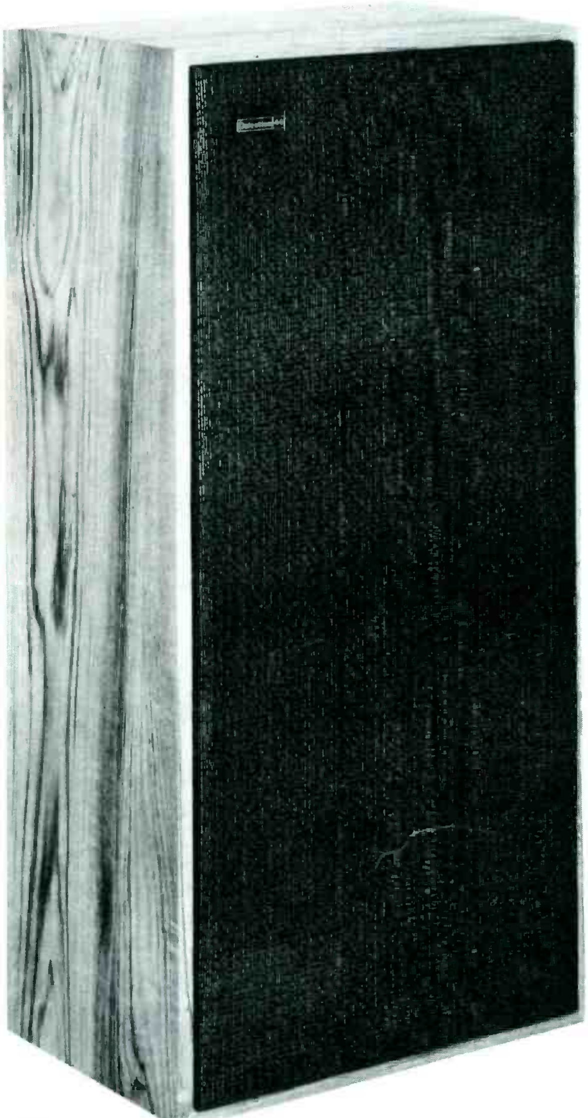


Celestion

Loudspeakers for the Perfectionist

Proudly present the Fabulous

Celestion DITTON 44 MONITOR



Dimensions:	30″ x 14½″ x 10″
Max Input:	44 Watts (D45.500)
Response:	30 Hz to 30 KHz
Impedance:	4 to 8 ohms
Crossover:	500 & 5,000 Hz
Treble:	HF2,000 (pressure)
Mid:	MF Super 5″
Bass:	LF Long drive 12″
Finish:	Natural Teak
R.R.P.	£54.00 each

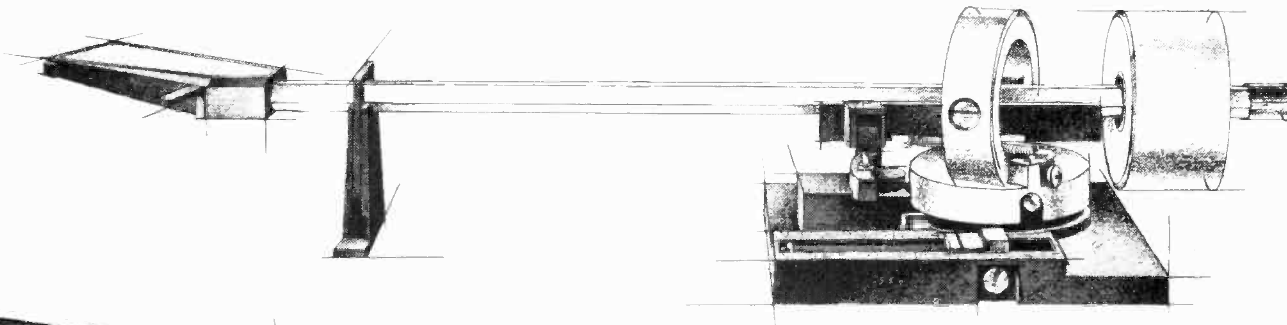
Plus full supporting cast!

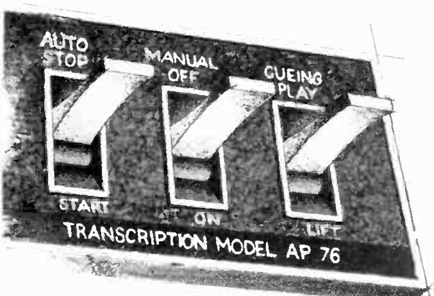
Left to Right: Ditton 10 Mark II, Ditton 120, Ditton 15, Ditton 44, Ditton 25.

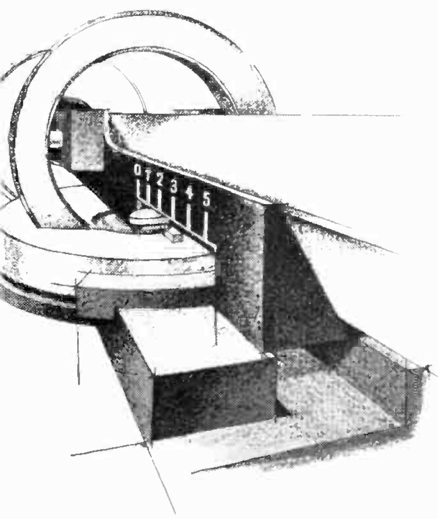
ROLA CELESTION LIMITED, DITTON WORKS, FOXHALL ROAD, IPSWICH, SUFFOLK, ENGLAND

WW—001 FOR FURTHER DETAILS

The Garrard AP76 transcription quality deck gives you a good deal to think about:







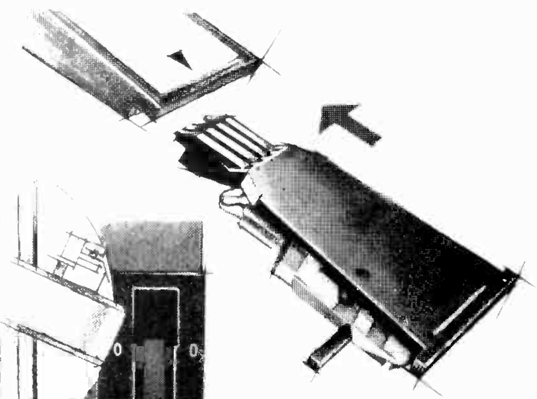
Forget the price for a moment, look at the features. ☐ Offers automatic play (start, stop and return) of single records at 33⅓, 45 and 78 rpm. ☐ Tab controls for viscous damped cue and pause, start/stop, manual/auto. ☐ Hexagonal, low resonance, aluminium pickup arm. ☐ Resiliently mounted counterbalance weight. ☐ Stylus force adjustment, calibrated 0 to 5 grams. ☐ Bias compensation calibrated for spherical and elliptical styli. ☐ Combined record speed and size selector. ☐ Slide-in cartridge carrier. ☐ 11½ inch non-magnetic turntable driven by 4-pole induction motor. ☐ Performance: wow and flutter better than 0.10% rms. Rumble (relative to 1.4 cm/sec at 100Hz) better than −49dB. This performance betters DIN 45-500 Hi-Fi standard. ☐ Black and silver finish as standard. Wooden base and rigid plastic cover available.

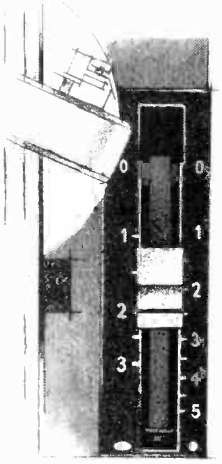
These are hard facts (and compare them with what the competition offers). Add in true quality engineering and the reliability based on 50 years' leadership in record players.

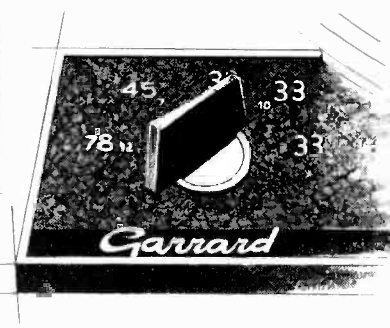
Now look at the price – recommended at £27.85. Fully £10 cheaper than the good competitive decks having the same features. Only Garrard can do it – by long experience and their comprehensive production programme across a whole range of quality players.

At £27.85 the AP76 gives you transcription quality.

Return the coupon below for full details of this and other Garrard decks – or ask your Hi-Fi dealer for a demonstration today.







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ADDRESS ____________________

WW 11

Garrard
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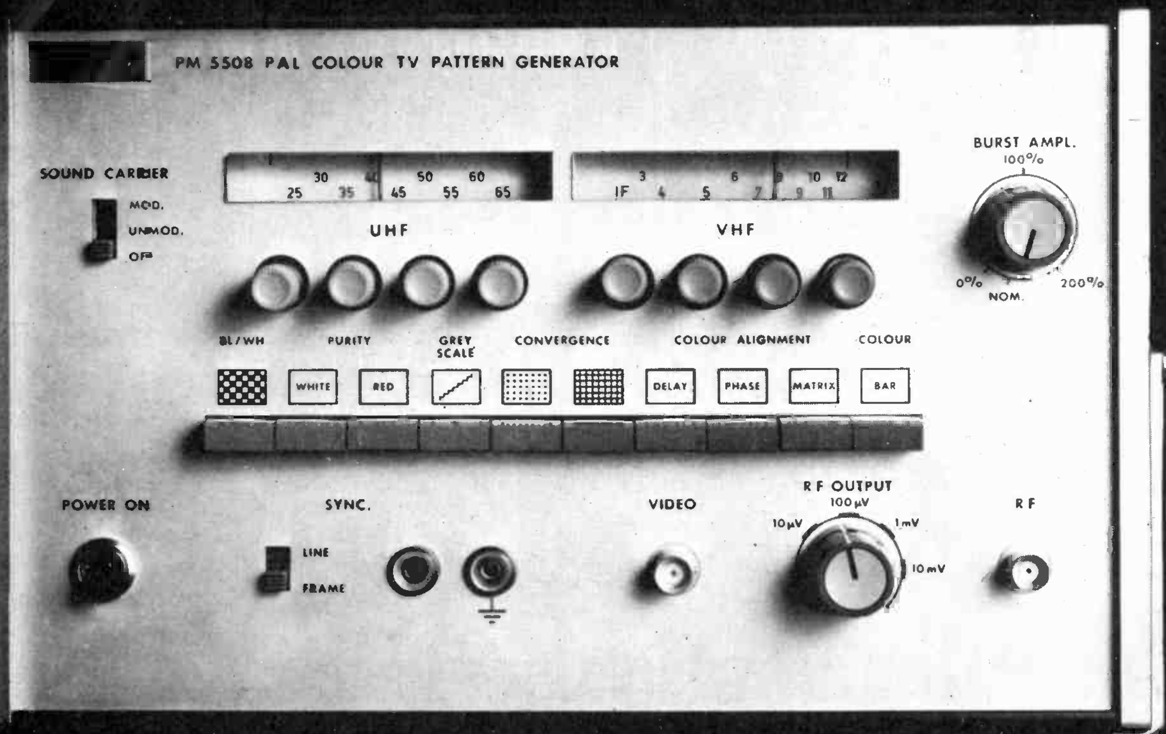
Garrard, Newcastle Street, Swindon, Wiltshire.

639 PLG

WW—003 FOR FURTHER DETAILS

PHILIPS



Philips for the best 'PAL' you could have

Colour television can win or lose you your friends – and your profits. Fast, efficient and reliable installation and after sales service will make sure you're on the winning side. Philips PM 5508 PAL Colour Pattern Generator provides your engineers with all the facilities for on-the-spot colour TV (and monochrome) service – for many adjustments you don't even need an oscilloscope; just use the receiver's picture tube instead.
Of course, though, a sensitive, 10 MHz double-beam oscilloscope, such as the Philips PM 3230, could increase your advantage further – even over the competition.
If you want to make friends and influence people just contact Pye Unicam straight away. Ask for a leaflet giving more information on the Philips PM 5508 PAL Colour TV Pattern Generator, the PM 3230 Oscilloscope and other radio and TV service equipment in the Philips range.

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WW—005 FOR FURTHER DETAILS

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The new distribution service that brings together six market leaders under one cover!

Now there's a faster more reliable way to get hold of electronic components. It's called BLUELINE. It covers almost all your everyday needs with a selective top quality range. And backs it with a service so efficient and friendly that BLUELINE quickly becomes an extension of your own purchasing department.

Six top manufacturers
BLUELINE is unique in its teaming together of the six market leaders in component manufacture. They give a quality concentration that enables you to meet most of your everyday needs for components.

In depth stocks
BLUELINE holds quantity stocks for every component. So it doesn't matter whether you need single items for a prototype or a batch for a production run. BLUELINE can cope with stocks off the shelf....or deliver to your scheduled requirement.

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The BLUELINE ICL 1903A computer forecasts demand and prints out a stock list daily – a feature that means orders can be confirmed immediately they're received and delivery on time guaranteed.

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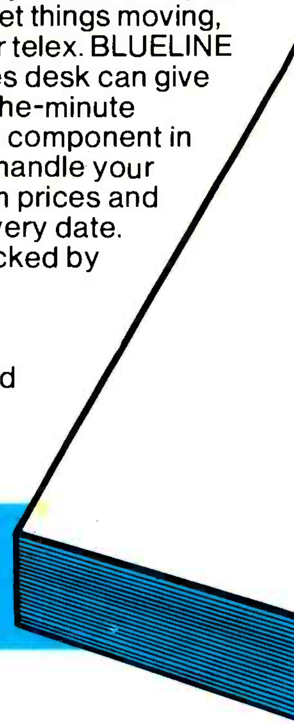
Order by post if you like. Or if you really want to get things moving, by telephone or telex. BLUELINE girls on the sales desk can give you the up-to-the-minute position on any component in the catalogue, handle your queries, confirm prices and give you a delivery date. And they're backed by five engineers throughout the country to help with queries and special orders on-the-spot.



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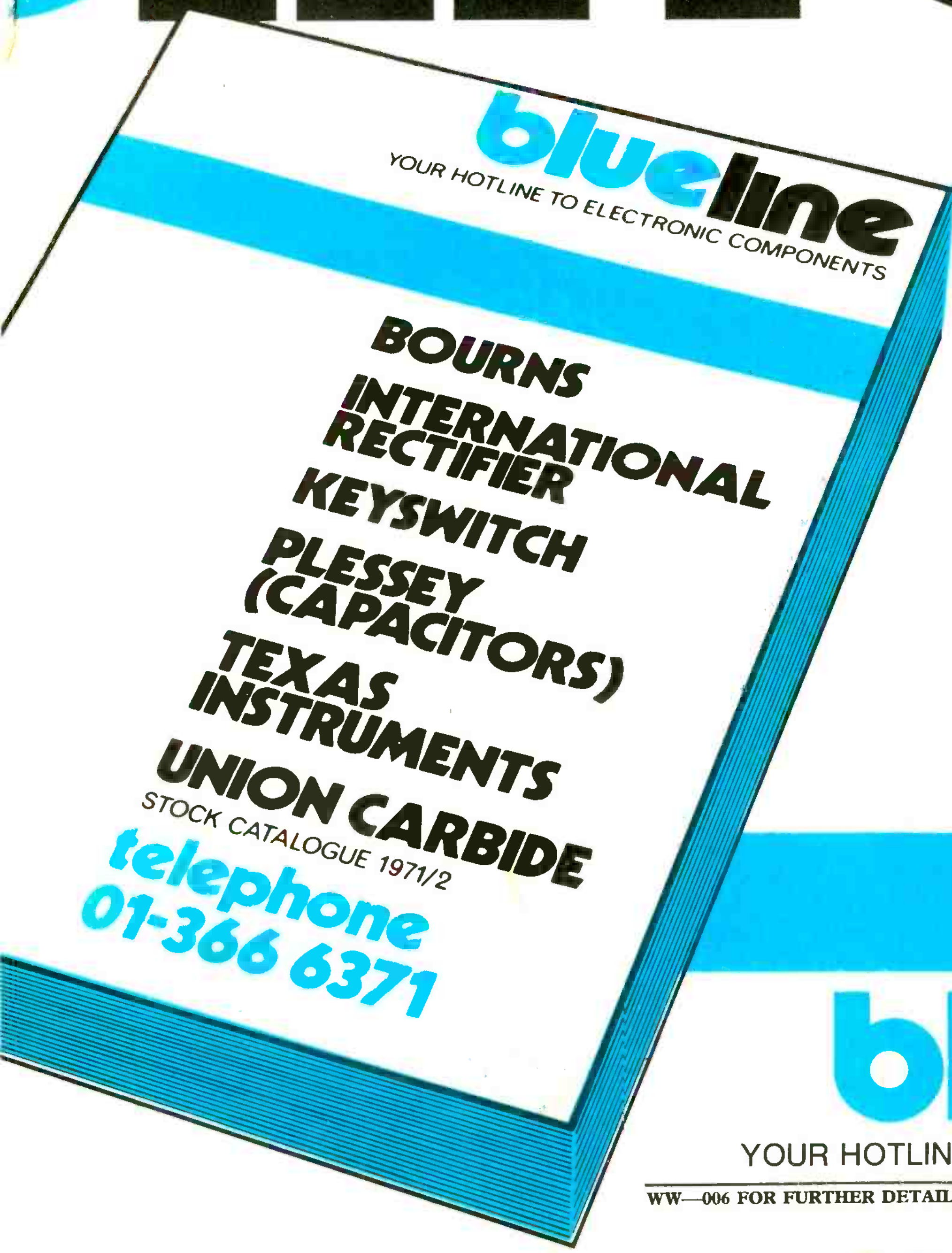

Compact, comprehensive catalogue
The complete BLUELINE range is covered in this catalogue. If you haven't yet received your copy, please write – or better still, phone 01-366 6371 and get a preview of the friendly way we make ourselves indispensable to your organisation.

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Tel: 01-366 6371 **Telex: 22196**

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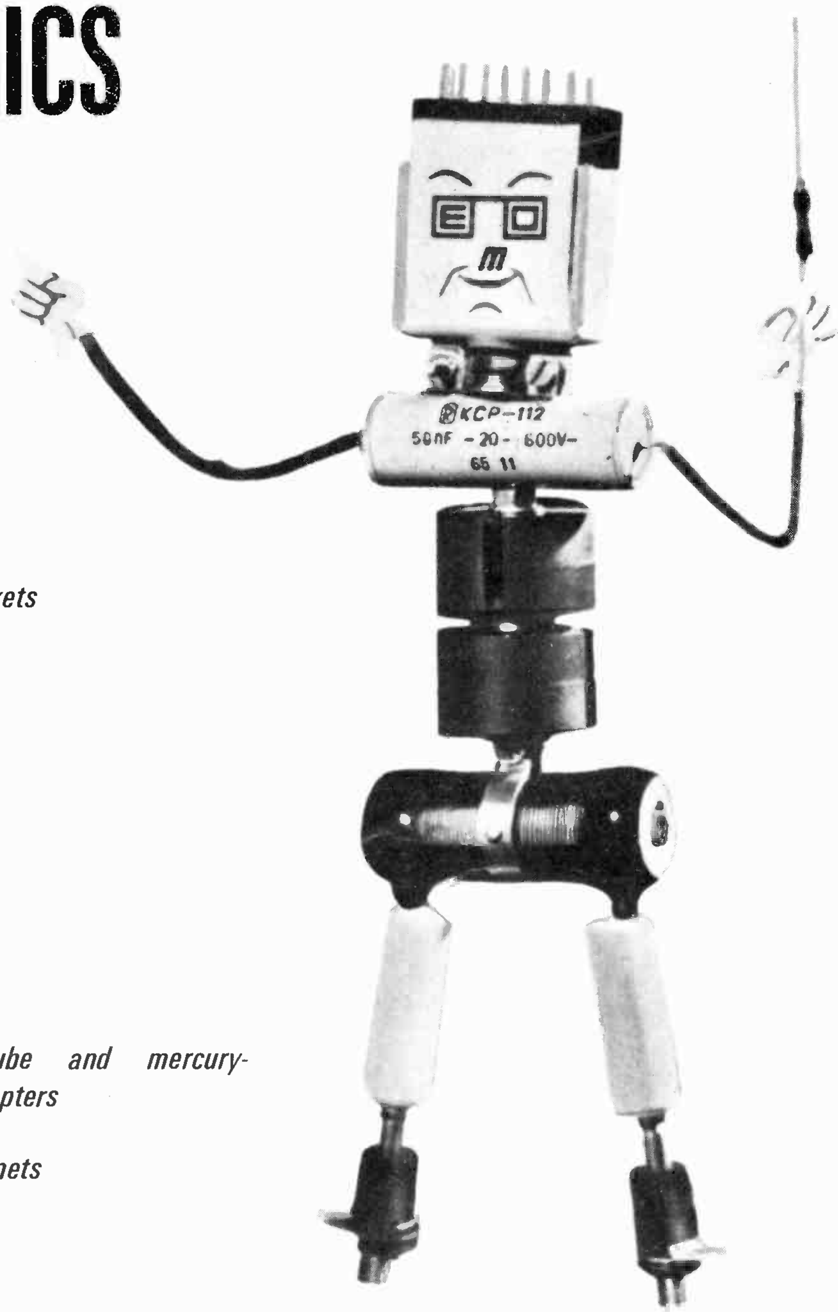
PARTS AND COMPONENTS FOR TELECOMMUNICATION ENGINEERING AND ELECTRONICS



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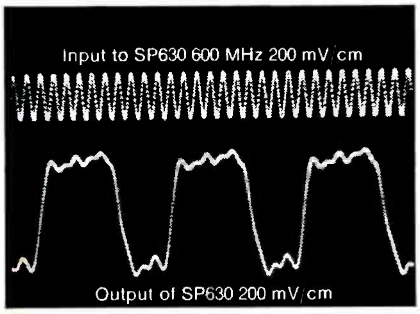
WW—007 FOR FURTHER DETAILS

Here are some outstanding ICs from the wide Plessey standard range.
As European leaders in MOS and Bipolar technology
Plessey also offers you the most experienced
custom/customer design service available —
proven by more than 400 successfully completed designs.

Ultra-High-Speed ECL Dividers



SP602 ÷2 500MHz
SP620 ÷5 400MHz
SP630 ÷10 600MHz

These three circuits form part of an expanding range of dividers.
Power consumption from only 60mW.
Operating temperature from −55°C to +125°C.
They are the only dividers available with full temperature range at this speed.
Commercial and military applications are already nearing production.

WW—250 for further details.

Unique LSI Computing Circuits

These DTL/TTL compatible circuits were initially developed for process control applications in ICI. Now generally available, they feature the following:

SP520 5-Bit Reversible Gray Code Counter

A 5-bit up-down counter with non-overflow facility with both Gray and binary outputs. The Gray code o/p's can be inhibited—effectively open-circuiting. This makes them ideal for 'addressed parallel highway wired-OR applications'. Reset to zero facility is also provided.

SP521 5-Bit Binary Rate Multiplier

Basically an arithmetic unit capable of multiplying together a frequency and a binary number. Has two-phase capability, is infinitely cascadable and eliminates the need for capacitors and other components, all as a result of internal Gray code operation.

SP522 Divider, Phase Lock and Comparator

Divides the master clock frequency (8F) by 8 giving two interlaced o/p's (1F). These can be used to clock the SP521. There is also an o/p at 2F. Locks the phase of any i/p signal to that of the master clock. Max. i/p frequency to phase lock circuit is 3.2F.
The comparator is a 5-bit up-down counter with reset facility to the central symmetrical state.

WW—251 for further details.

Quad decade complements MOS counter range

WW—252 for further details.

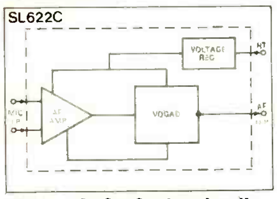
Device Number	Single or Quad Decade	Single or Dual Power Supply	BCD or Decimal Output	Current (I) or Voltage (V) Output	Carry Facility	Package
MP107B	S	S	BCD	V	✓	10 lead TO.5
MP108B	S	S	BCD	I	✓	10 lead TO.5
MP120B	Q	D	BCD	I	✓	16 lead DIL
MP123B	S	D	BCD	V		10 lead TO.5
MP124B	S	D	Decimal	V		16 lead DIL
MP125B	S	D	BCD	V	✓	14 lead DIL
MP126B	S	D	Decimal	I		16 lead DIL
MP127B	S	D	BCD	I	✓	14 lead DIL

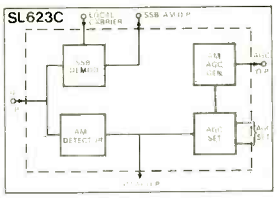
PLESSEY

Plessey Semiconductors
Cheney Manor, Swindon, Wiltshire
Telephone: Swindon (0793) 6251
Telex: 44375

Detectors, Demodulators & AGC Circuits

The SL622C, a microphone amplifier plus VOGAD and the SL623C, an SSB demodulator, low level AM detector and AM AGC generator are the latest additions to the successful range of SL600 communications circuits. This fully compatible series operates from a single power rail, has low power consumption, full AGC facilities and operates up to 140MHz.





WW—253 for further details.

1GHz Transistor Pair

The SL360 is a monolithic matched pair of transistors capable of being used at frequencies up to 1GHz. The particularly good low current betas make this device suitable for a wide range of applications.

Typical characteristics:

BV_{CEO}	15V	$(I_C = 10\mu A)$
h_{FE}	65	$(V_{CE} = 2V, I_E = 5mA)$
f_T	2.5 GHz	$(V_{CE} = 5V, I_E = 5mA)$
f_T	3.2 GHz	$(V_{CE} = 5V, I_E = 25mA)$
$V_{BE}(1) - V_{BE}(2)$	3mV	$(V_{CE} = 2V, I_E = 1mA)$
$h_{FE}(1)/h_{FE}(2)$	1.1	$(V_{CE} = 2V, I_E = 5mA)$
V_{CE} (Sat)	0.25V	$(I_E = 10mA, I_B = 1mA)$

These characteristics make the SL360 an ideal element for the design and manufacture of more complex UHF circuits.

WW—254 for further details.

Low Noise GaAs Microwave FET'S

Featuring high transconductance, low capacitance and operating frequency up to 4.5GHz.

GAT1	10dB gain at 1GHz	4dB noise figure
GAT2	8dB gain at 3GHz	5dB noise figure

Ideal for use in low noise front-end amplifiers.

WW—255 for further details.

Television and Audio Circuits

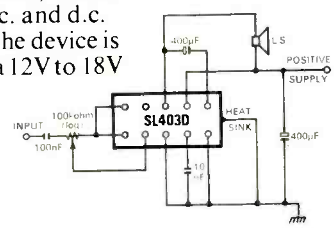
Colour TV on 2 Chips

The SL435C and SL436B combined form the complete colour signal processing section of a colour television receiver (PAL system).
The following functions are incorporated:

Chroma amplification • PAL switch • Colour killer
Gated burst amplifier with 45° switch
Internal stabilisation • Reference amplifier
Matrixing for red, green and blue outputs
R-Y, B-Y balanced demodulator

6W Audio Amplifier

The SL403D is a 6W (3W rms) audio amplifier incorporating a.c. and d.c. short-circuit protection. The device is designed to operate from a 12V to 18V supply into loads from 3Ω to 15Ω. Total harmonic distortion at full output is typically less than 0.3%.



WW—256 for further details.

OPTO Character Recognition

The OPT6 is a linear array of 72 integrating elements designed for OCR, code recognition and position sensing applications where high data rates and high definition are required.
The 72 elements operate in current recharge mode and integrate for one line period. Two clock pulses and one data input pulse are required for scanning the shift register which will operate typically in the range 10KHz to 7MHz.
The 0.2″ × 0.08″ chip is mounted in a ¾″ glass windowed flat pack and dissipates about 300mW at maximum bit rate.

WW—257 for further details.

Product Summary

If you would like details of the full range of Plessey IC's please ask for our Product Summary. This includes details of nearly 300 standard bipolar and MOS IC's, package diagrams, MOS logic diagrams and bipolar logic diagrams.

WW—258 for further details.

Phoned 13/12/72

Semiconductors

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Tel: (0532) 636311

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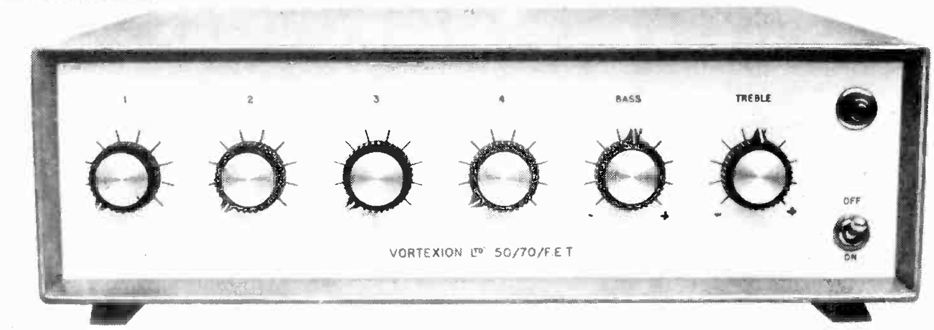
Vortexion

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough.

The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) gram stage with bass and treble controls plus the usual line or tape input. All the input stages are protected against overload by back to back low self capacity diodes and all use F.E.T's for low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8/16Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected.

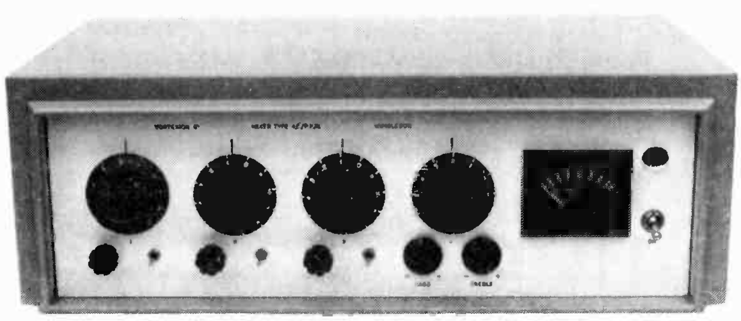
100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s–20 Kc/s ± 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100–120 V or 200–240 V. Additional matching transformers for other impedances are available.

F.E.T. MIXERS and PPM's



Since we have been supplying professional mixers for 25 years we have delayed the introduction of solid state units until they were at least as good as their valve counterparts. (Which will continue where required.)

The various sections of the FET mixers and BBC type PPM's have been performing successfully for several years in other equipments with complete reliability. The PPM also uses an FET in its time constant circuit so that polyester capacitors can be used. The response from the 600Ω output (25Ω source impedance) is level 20 Hz to over 30 kHz with very low intermodulation distortion to zero level +12dB. The input signal voltage range is over twice that of the valve unit and the noise at least halved.

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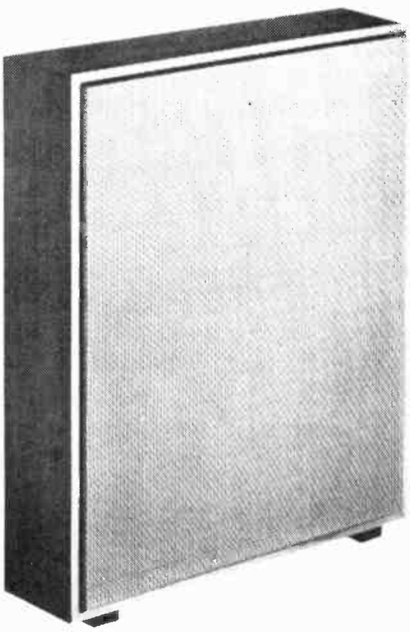
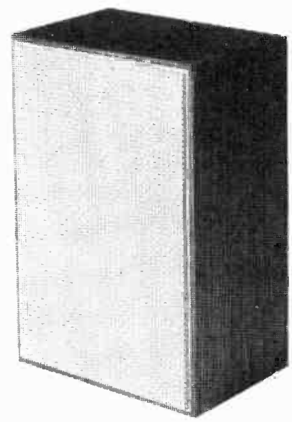


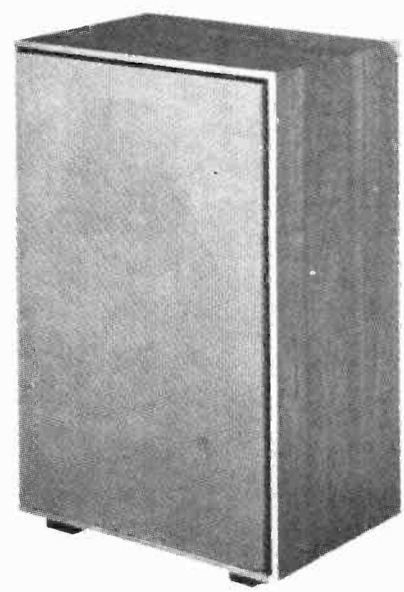


LC93

A 19″ x $12\frac{1}{2}$″ x $8\frac{1}{2}$″ completely enclosed acoustically loaded cabinet housing a 9″ graded melamine paper cone with siliconized cambric suspension giving a frequency response of 60Hz to 20KHz.

LC94

A $29\frac{1}{2}$″ x $23\frac{3}{4}$″ x $6\frac{1}{8}$″ acoustic Labyrinth enclosure fitted with acoustic resistance in the pipe, using the same highly efficient 9″ speaker unit used in the LC 93. Frequency response 45Hz to 20KHz.



LC95

The LC95 loudspeaker system is an acoustically loaded Bass Reflex cabinet, measuring $31\frac{1}{2}$″ x $20\frac{3}{4}$″ x $13\frac{1}{2}$″, fitted with two loudspeakers and a crossover network. The bass loudspeaker being used is a newly developed 12″ unit having a Melamine treated paper cone with a cambric surround. The middle and high frequency unit is a new 8″ loudspeaker having a Melamine treated paper ribbed cone and surround.

These products can be seen in our showrooms at 109 Kingsway, London WC2.

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Advance-
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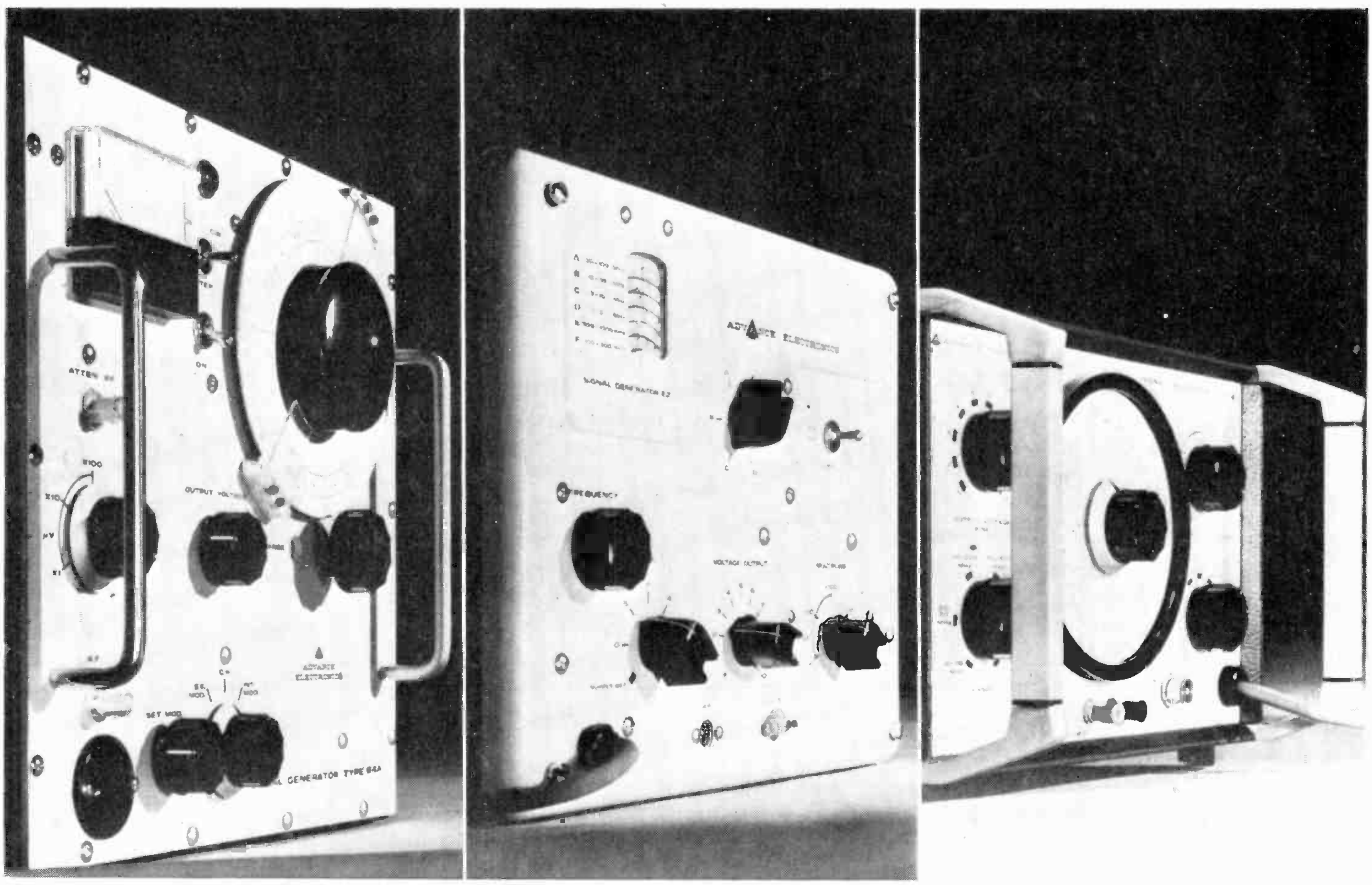

B4A7 100kHz— 80MHz
B4B7 30kHz— 30MHz
Price **£135**

E2 100kHz—100MHz
Price **£70**

SG62B 150kHz—220MHz
Price **£65**

The range of RF SIGNAL GENERATORS
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frequencies from 30kHz to 220MHz.

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INSTRUMENT DIVISION SALES OFFICE

WW—015 FOR FURTHER DETAILS

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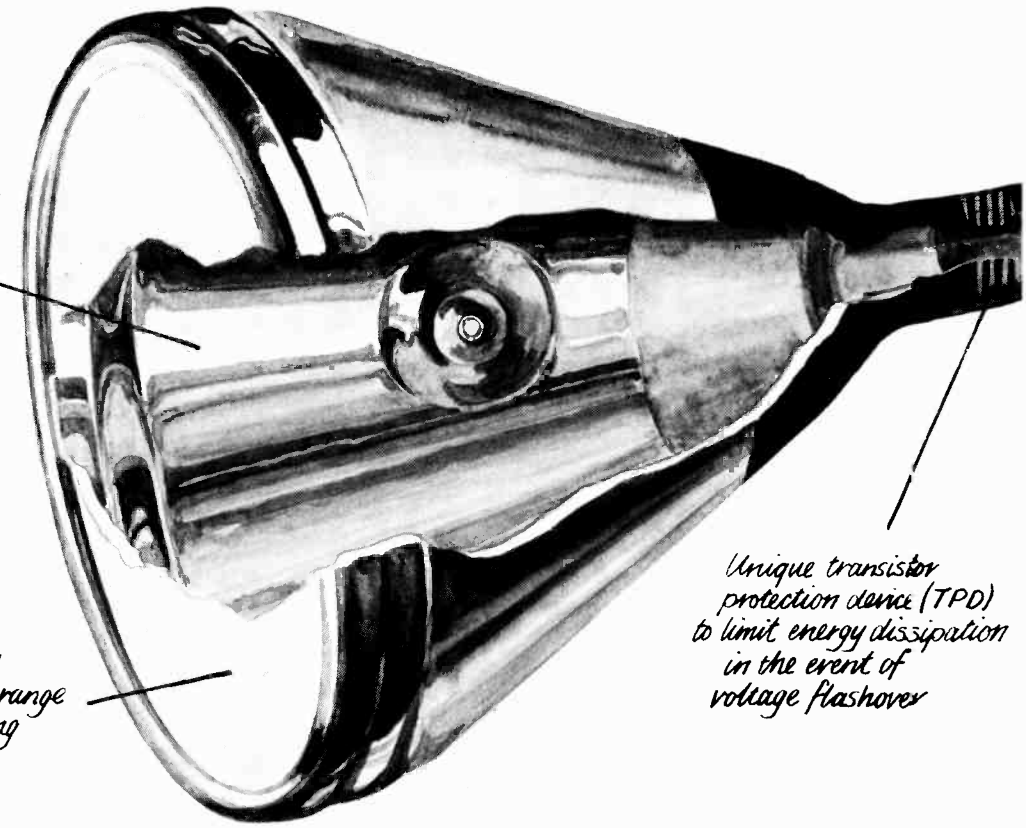

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YOU APPRECIATE low cost, a wide choice of instrument sizes, good delivery and service, inexpensive spares, British design and quality.

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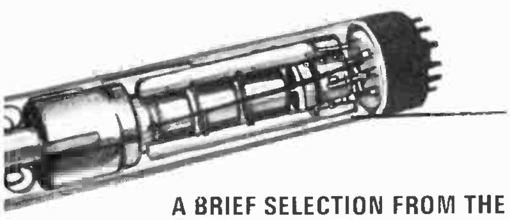
WW—016 FOR FURTHER DETAILS

Radar CRT business



Advanced gun design-precision alignment for crisp high brightness presentation

A BRIEF SELECTION FROM THE RADAR CRT RANGE

TYPE	SCREEN SIZE cm	FINAL ANODE VOLTAGE kV	FOCUS	DEFLECTION ANGLE degrees	LENGTH mm
700H	7	30	Magnetic	35	259
1400E	14 rectangular	15	Electrostatic	50	268
F16-10	16	14	Electrostatic	37	370
7ABP	18	7	Electrostatic	50	342·5
F21-10	21	14	Electrostatic	41	460
2200P	22	12	Electrostatic	58	408
3000M	31	15	Magnetic	50	520
3000Q/T957	31	12	Electrostatic	50	485
3000R	31	16	Electrostatic	40	572
T989	31	15	Magnetic	50	520
4100A/T958	41	12	Electrostatic	50	610
T983	41	15	Electrostatic	50	650
LD631*	41	10/15	Electrostatic	52	562

Round screens unless otherwise stated *Two-colour display tube

Business to M-OV means total commitment to quality. Our reputation for cathode ray tubes has been won purely and simply on specification and performance—advanced specification and unbeatable performance. Take our radar CRTs for example—who else can give you such a wide variety of specifications including commercial, BS 9000, CV and MIL? Who else can incorporate the unique transistor protection device? Who else but M-OV offers such a wide range of radar cathode ray tubes as standard.
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We'll fill the air with sound

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Goldring Manufacturing Company (Great Britain) Limited, 10 Bayford Street, Hackney, London E8 3SE. Phone 01-985 1152

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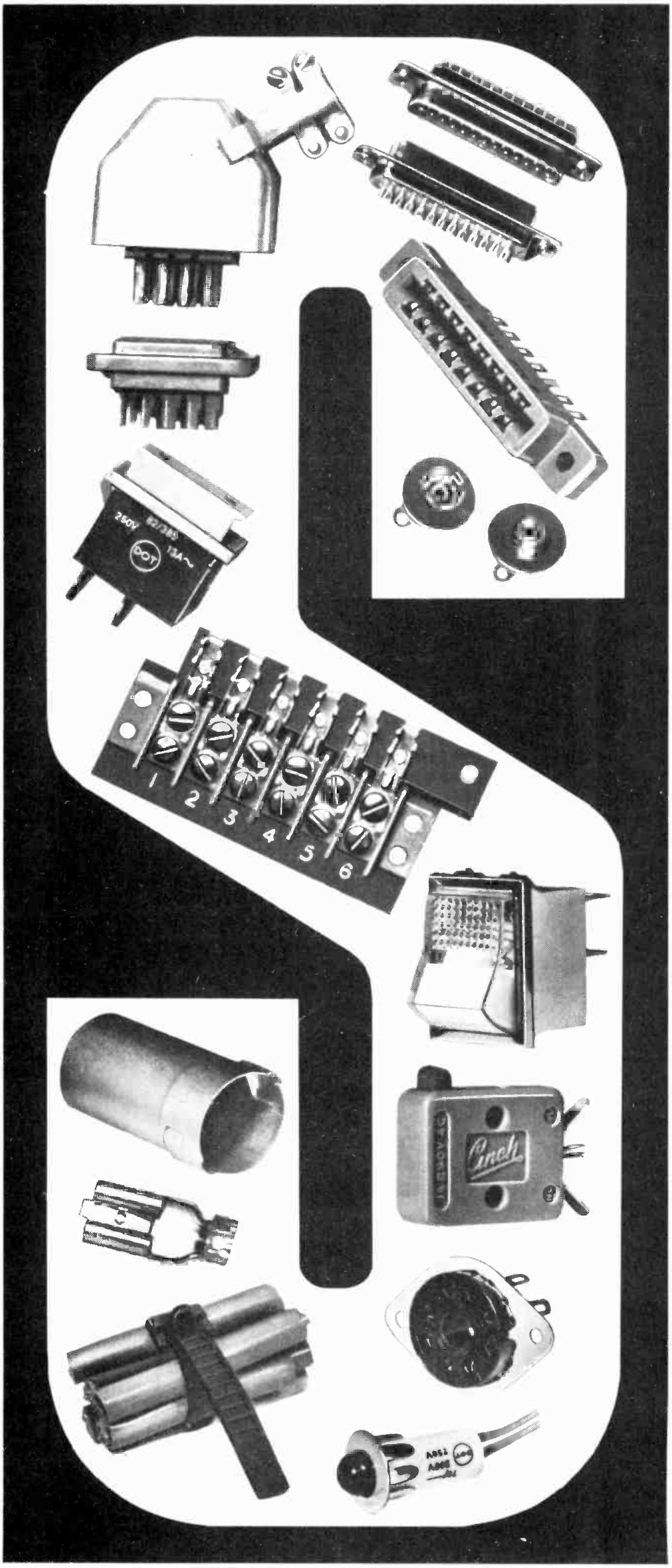
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Cinch

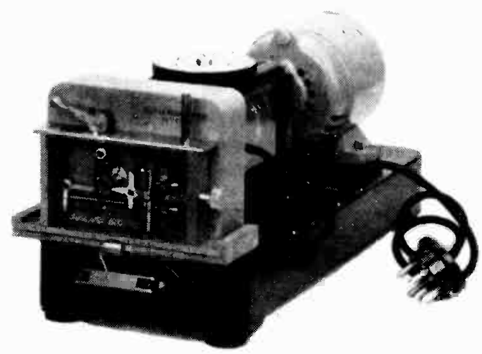
MORSE TRANSMISSION AND TRAINING SIMPLIFIED

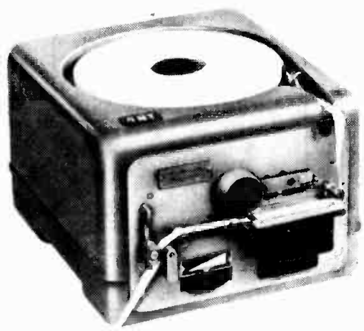
GNT Keyboard Perforator
MODEL 51

For preparing morse code tape for use in a transmitter. Maximum speed 750 o.p.m.

GNT Transmitter
MODEL 112

Morse transmitter capable of working direct to line with a speed range of 13-250 words per minute.



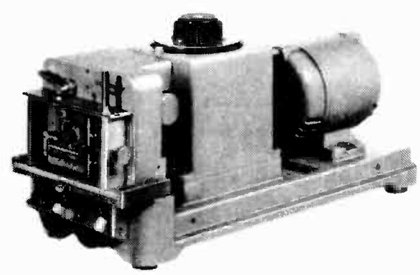


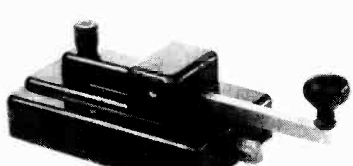
GNT Morseinker
MODEL 1532

Specially designed for training. Prints dots and dashes on tape with variable paper speed drive. Speed range 0-40 words per minute.

GNT Transmitter
MODEL 115

Specially designed for morse transmitting schools permitting the insertion of pauses between transmitted letters and words. Speed range 5-35 w.p.m.





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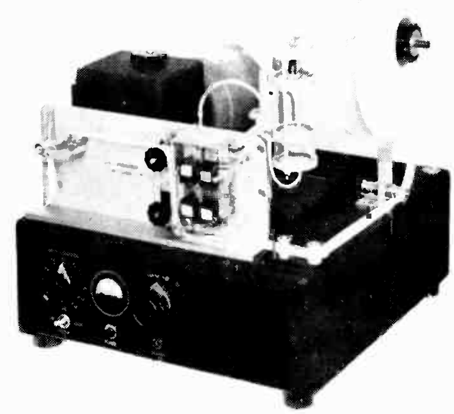
MODEL 605

A heavy duty key in a strong bakelite housing. All parts free of electrical potential available with platinum/iridium or silver contacts which are visible for inspection.

GNT Undulator
MODEL 311

Records WT signals up to 300 words per minute available in single or double pen versions with or without amplifiers with built-in tone filter for increased selectivity.



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2206	Converter No. 2 code to morse.
2201	Converter morse to No. 2 code.
3072	Line commutator.
451	Morse code reperforator, operating from 40-200 w.p.m.
3082	Student box.
3065	AF tone generator.

The GNT range of morse equipment for automatic transmission and morse code training schools is now manufactured in the U.K. by

Morse Equipment Limited

77 AKEMAN STREET, TRING, HERTS., U.K.

Telephone: Tring 3476/8 STD: 0442-82 Cables: MORSE TRING Telex: 82362 Ans. Back: Batey Tring

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The TM2
-a new a.c./d.c. millivoltmeter from Farnell

* 1mV-300V f.s.d.
* 10Hz-2MHz
* 10MΩ typical input impedance/resistance
* Low zero drift
* Mains or battery operated

The TM 2 is a general purpose instrument offering a wide frequency range of operation, a high input impedance/resistance and very low drift. It is basically mean rectified reading, the meter being calibrated to provide r.m.s. values for sine wave inputs in a range sequence of 1-3-10. A decibel scale from −10dB to + 2dB is also provided. The TM 2 has an integral power supply permitting operation from a.c. mains and may also be run on two internal batteries. Its U.K. price is £68.00.

For further details contact:-

Farnell

Farnell Instruments Limited, Sandbeck Way, Wetherby, LS22 4DH. Tel: 0937 3541/6.

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3 in 1

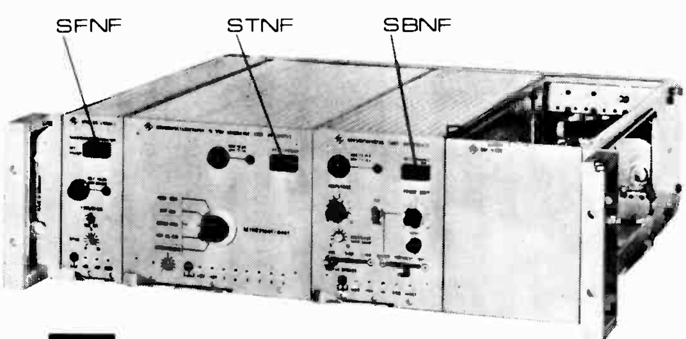
PLUG-IN CASSETTE ASSEMBLY

An entirely new cassette system the **Rohde & Schwarz Sync & Colour sub-carrier Generator Assembly Type SPSF** is made up of a rack adapter which complies with the 19" or DIN standard, and contains **three plug-in cassettes.**

The Colour Sub-carrier Generator Type **SFNF** has a highly stable oscillator circuit together with input facilities for an external colour sub-carrier for parallel operation.

The TV Sync Generator Type **STNF** has a built-in coupler for the colour sub-carrier and supplies digital pulses which include PAL and burst-flag.

The Burst Generator Type **SBNF** with internal pulse generation, has a facility for synchronization by composite video signal. Each cassette is separately available in a small cabinet. The TV Sync Generator has its own cabinet whilst the Colour-Sub-Carrier Generator and Burst Generator use a common cabinet as they are frequently used together, each cassette can however be operated independently.



- **Sync & Colour Sub-carrier Generator Assembly Type SPSF**
- **Cassette system for supplying pulses to TV servicing and measuring equipment**
- **Available for all TV standard systems with 625 and 525 lines.**
- **Suitable for the colour-TV systems NTSC, PAL and SECAM.**

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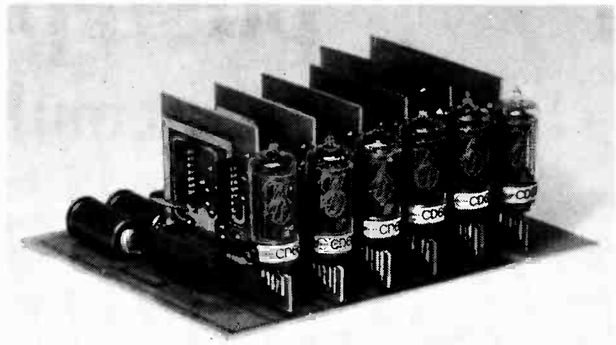

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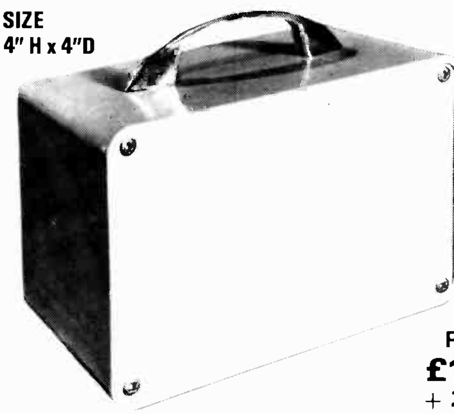

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PRICE £1.85

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Standard temp. 360°c at 23 watts.
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B 42 LL 3/16" — 4.75 mm CHISEL FACE
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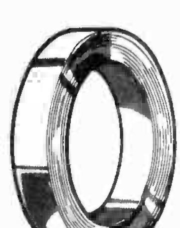
Soft magnetic alloys

TELCON OFFER THE WIDEST RANGE



Mumetal alloys

This is the best known and widest used Telcon group of high permeability alloys. They possess low hysteresis and total losses and are available in strip, rod, bar, wire and core form. Typical applications include: many types of transformers, bridge ratio arms, inductors, h.f. chokes, blocking oscillators, filter circuits, magnetic amplifiers, saturable reactors, modulators, flux gate magnometers, storage circuits, shift registers, transformers, logic switching circuits and a variety of magnetic shielding applications.

Radiometal alloys

Almost as well known as the Mumetal group, these high permeability alloys, with their high saturation induction and low electrical losses, are extensively used for transformers and chokes where the operating flux density is higher than is possible with Mumetal and where a higher permeability than that of silicon iron is required. The six grades have a variety of applications including: relay circuits, pulse and radar transformers, transductor and convertor cores, magnetic amplifiers and saturable reactors.

Permendur alloys

Permendur has the highest saturation ferric induction of all known alloys commercially available. It also has a correspondingly high incremental permeability at high inductions. It is extensively used for stator laminations, telephone diaphragms, magnetic circuits of loudspeakers and equipment operating at high temperatures. Its excellent magnetostrictive properties are frequently used in echo sounders and ultrasonic devices. A special grade of alloys, known as 'Rotelloys', which have superior mechanical properties have also been developed for use in high speed rotating equipment such as aircraft generators.

T M **TELCON**

Telcon Metals Ltd.,
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(Crawley 28800)

WW—033 FOR FURTHER DETAILS

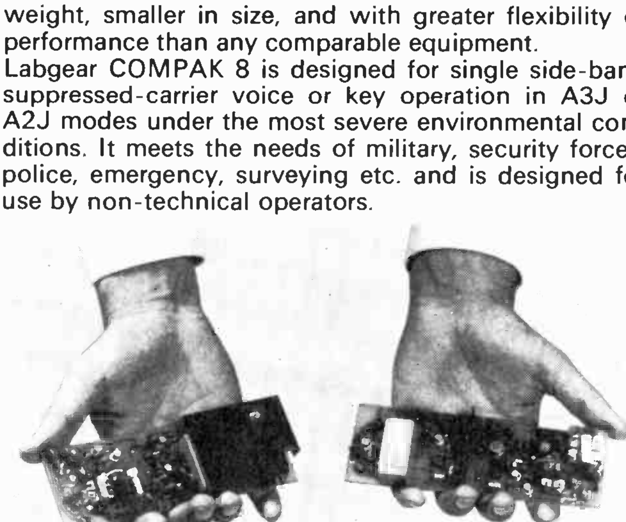
COMPAK 8 can be tuned in seconds —*by anyone!*

Labgear COMPAK 8
HF SSB PACKSET

10W p.e.p. speech over entire range 2-9 MHz. Unprecedented serviceability

- **Light, sturdy, inexpensive**
- **Externally-loaded Aerial for higher efficiency (Prov. Pat.)**
- **Plug-in Tx and Rx modules for instant replacement**
- **8 crystal controlled channels**
- **Fully submersible**

The forward looking COMPAK 8 Transceiver gives outstanding performance over the frequency range 2-9 MHz by making use of the very latest in integrated circuits, F.E.T. and wide band techniques.
Operating directly from a rechargeable battery it gives a power output of 10 watts p.e.p. on any of 8 channels in this H.F. band. The use of wide-band circuits eliminates the complexity of individual tuning and band switching with its time consuming channel alignment. The result is a completely self-contained back-pack SSB transceiver with a minimum of controls – lower in weight, smaller in size, and with greater flexibility of performance than any comparable equipment.
Labgear COMPAK 8 is designed for single side-band suppressed-carrier voice or key operation in A3J or A2J modes under the most severe environmental conditions. It meets the needs of military, security forces, police, emergency, surveying etc. and is designed for use by non-technical operators.



Transmitter and receiver use plug-in modules for ease of servicing. Low-noise high-gain receiver employs dual gate MOSFET RF devices in conjunction with fast attack, slow release AGC, to give exceptional immunity to blocking and cross modulation and performance approaching base station standards.

PYE LABGEAR

For full specification etc, please contact

CROMWELL ROAD, CAMBRIDGE CB1 3EL, ENGLAND

Telephone: 0223 47301. Telex: 81105 LAB. Telegrams: Labgear, Cambridge

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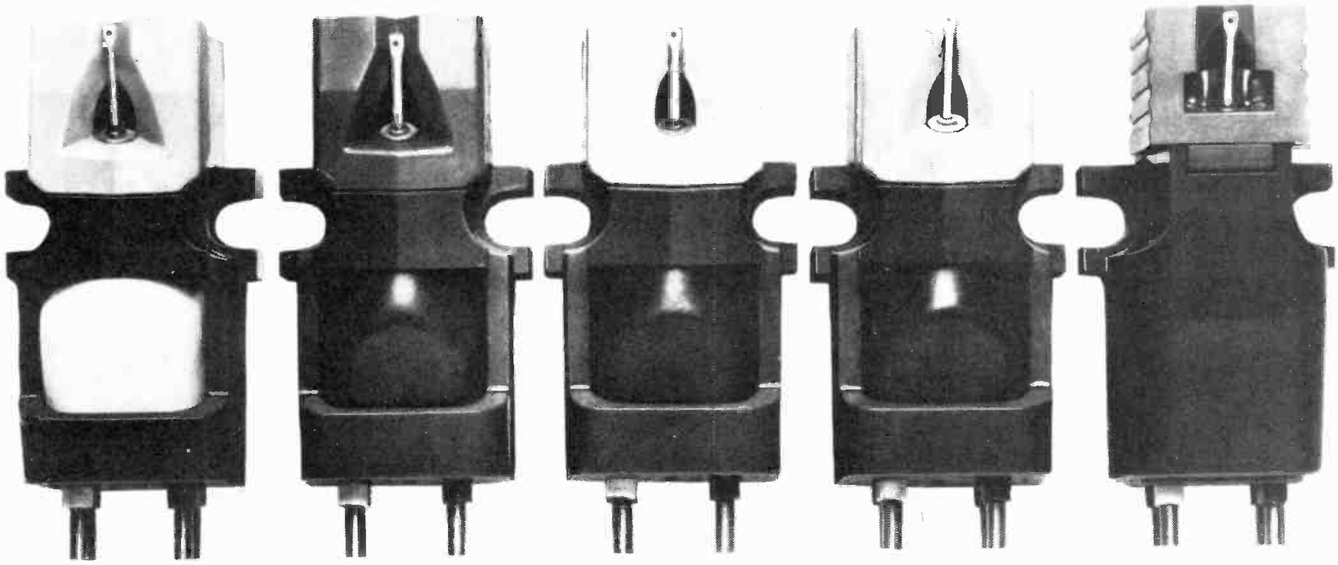
We're sensitive to everyone's needs.



Different people have very different requirements in Hi-Fi, so Goldring developed a comprehensive range of stereo magnetic cartridges that are superb in performance and realistic in price.

From the G800 Super E for those who seek perfection down to the G850 for systems on a budget, the Goldring range offers unsurpassed quality and value.

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Goldring Series 800

Stereo Magnetic Cartridges.

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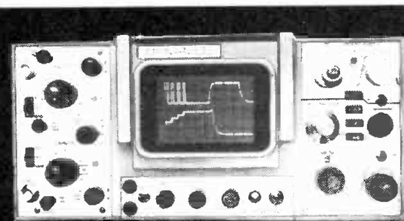
Three New Faces from DYNAMCO



NEW 72 SERIES
The On- Site commissioning/servicing scope.
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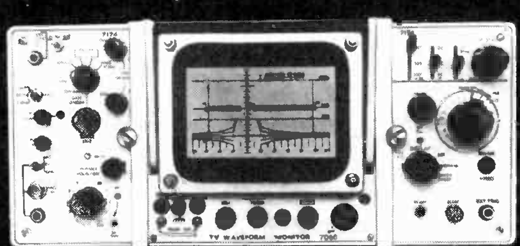
- Post Office Oscilloscope Type 14A.



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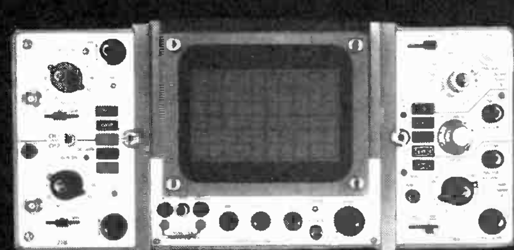
- Post Office TV test set Type 13B



NEW 7130
Wideband extension of 71 Series Oscilloscopes.
- 50 MHz Dual Channel plug – on amplifier.
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DYNAMCO
East Mains Industrial Estate,
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Telephone: Broxburn 2631 Telex: 72174

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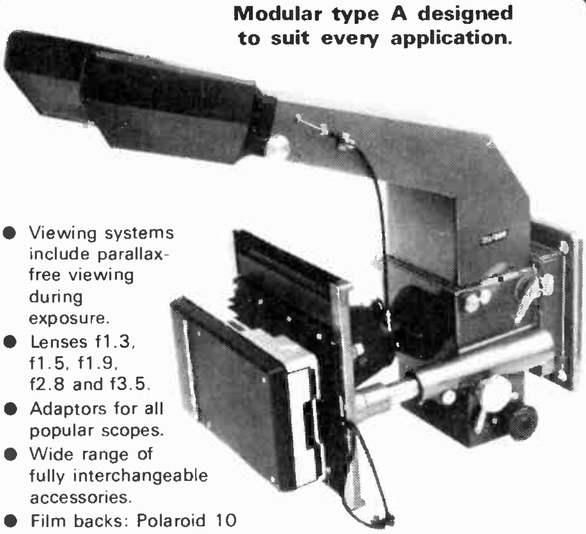
TELFORD RANGE OF Oscilloscope Cameras

Modular type A designed to suit every application.



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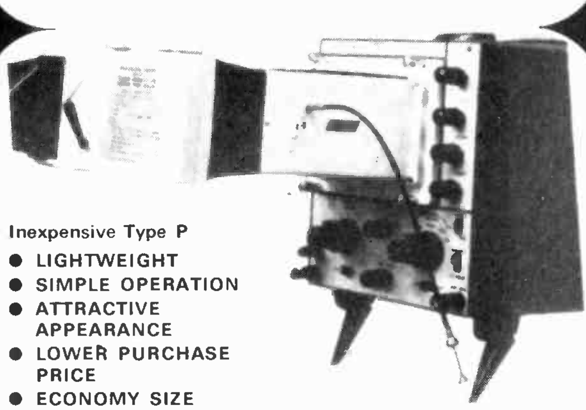

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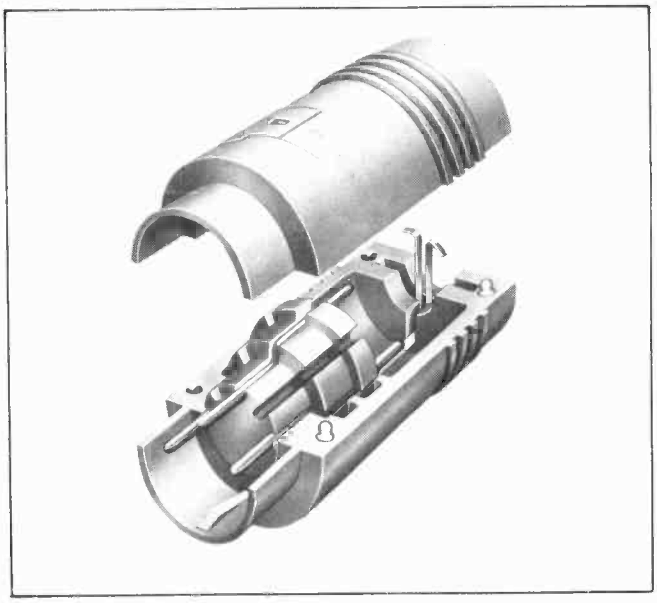
PD Connectors is **28p**



The System

This DIN 235A connector is one of a series of PD connectors. Cables which have been fitted with a PD universal terminal can be attached to any connector in the series. Complete compatibility between any PD audio connector is thereby achieved.

Method

The PD universal terminal is the heart of the system. These contacts are quickly and simply crimped to the cable without the use of any solder, special tools or screws. No part of the plug need be placed on the cable before the connections are made. The pins with the terminals attached are fitted into the centre bush in either 2 pin, 3 pin, or 5 pin stereo configuration.

Advantages

Facility for testing the output connections of a socket. Room allowed for attenuating resistors or other components. Manufactured in many colours for quick cable identification.

The PD connector is made in Britain by:

Parry Electronic Developments Ltd
28 Greville St London EC1N 8SU Tel: 242-1100

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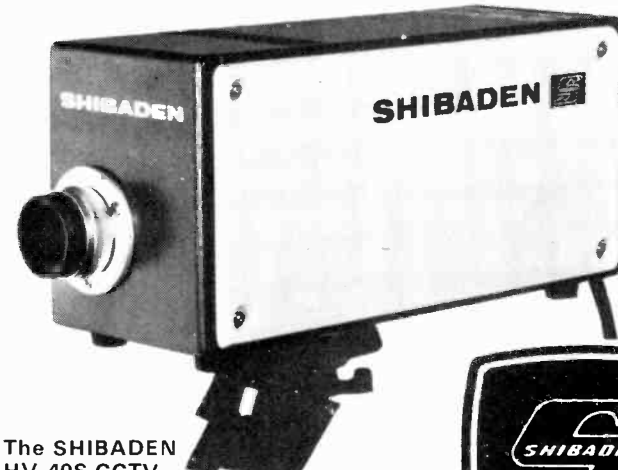

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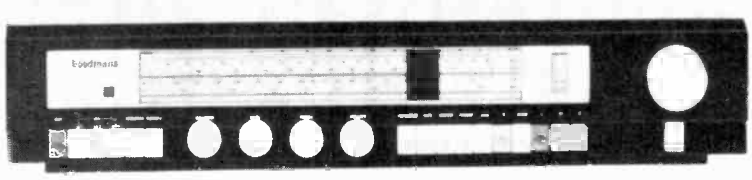

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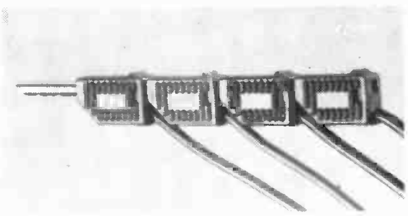

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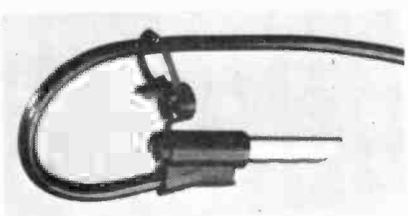

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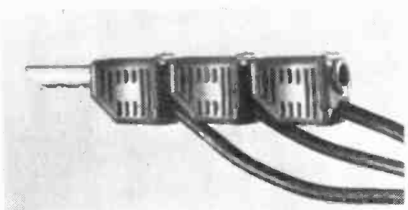

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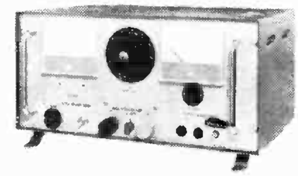

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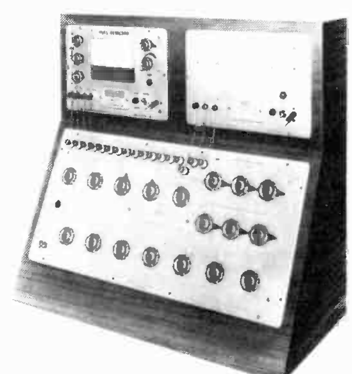

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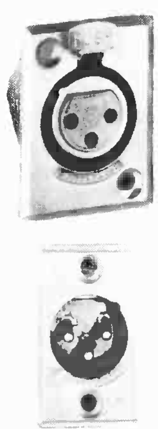

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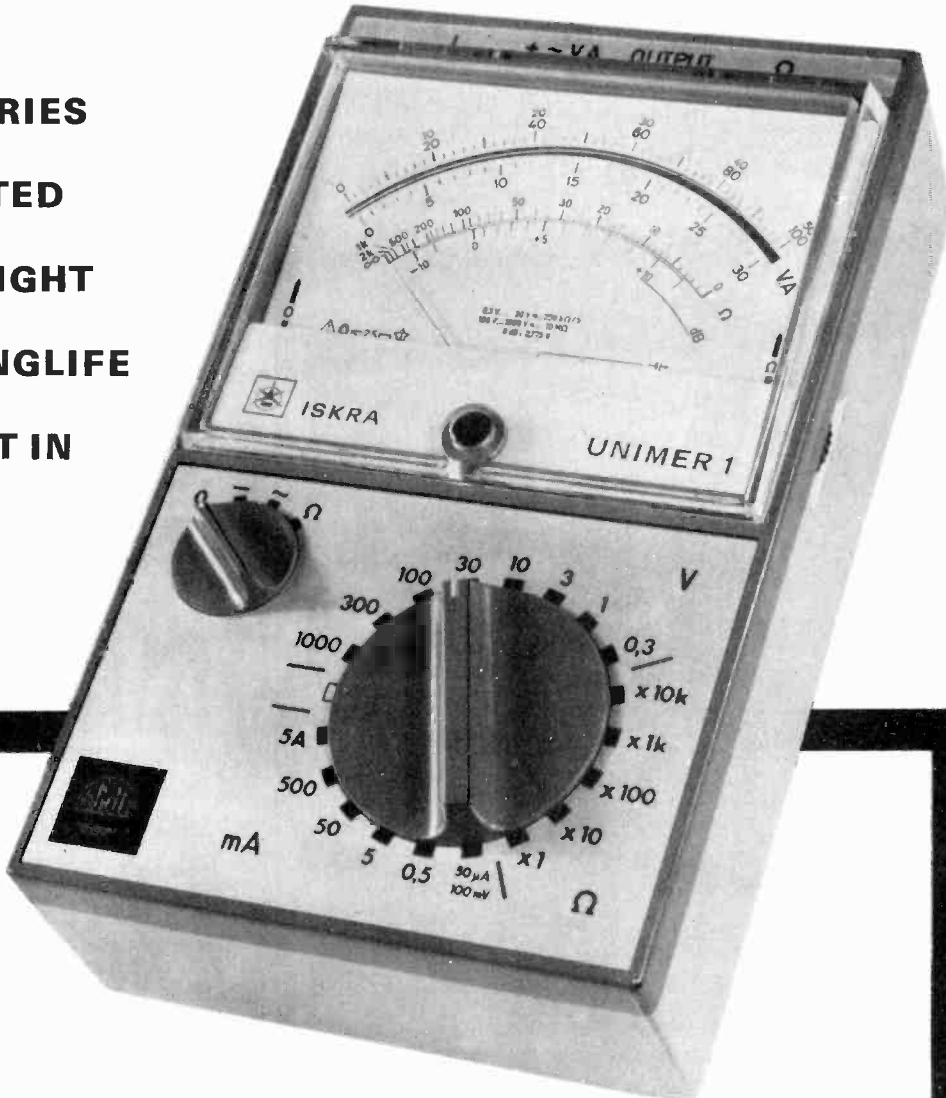

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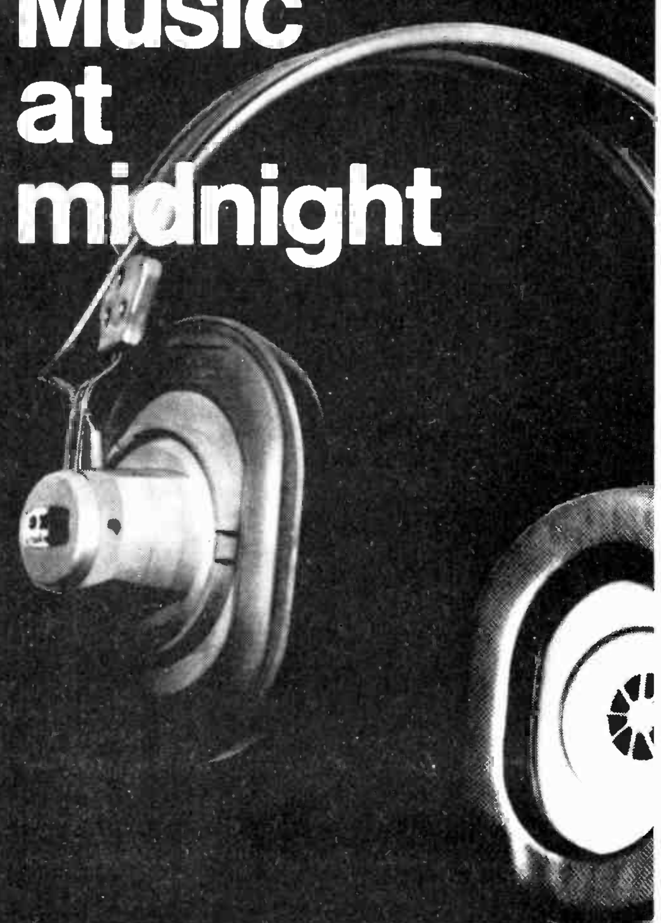

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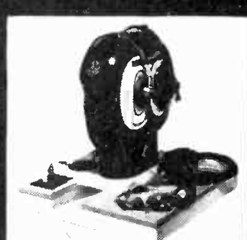

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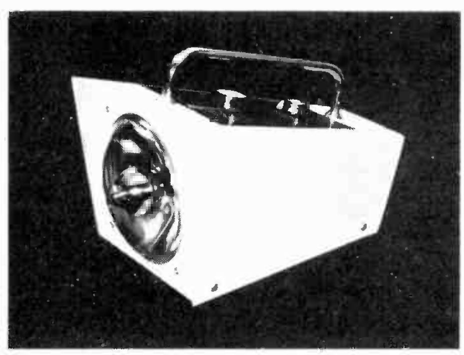

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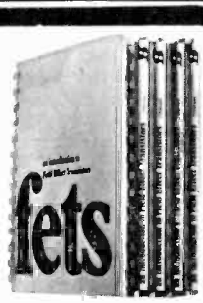

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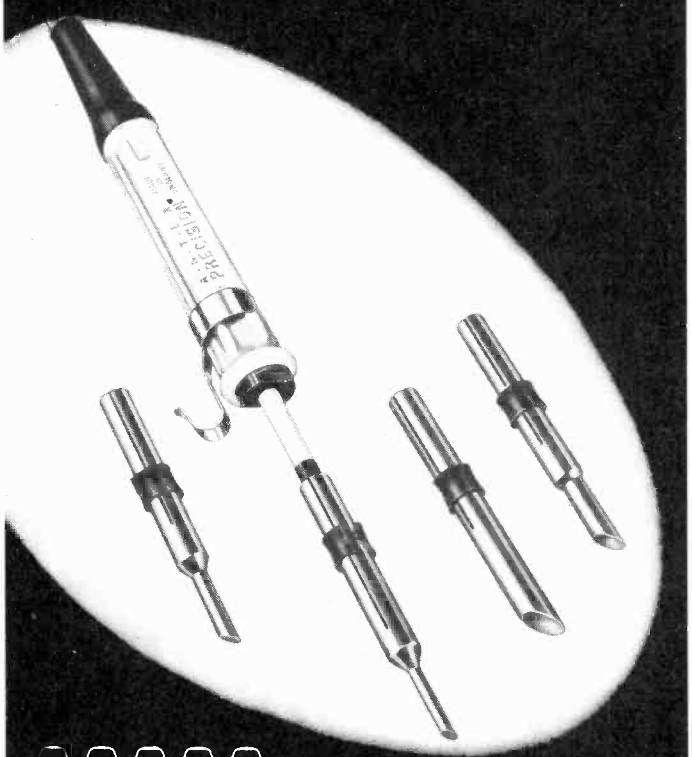

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Telephone: 0752-67377/8 Giro No: 2581000

WW11

WW—068 FOR FURTHER DETAILS

Trinity House Light Tower to replace the Light Ship off Beachy Head. The tower is 115 ft. high and it is equipped with a 36 ft. 4-section Beacon Aerial made by Bantex.

Bantex for Aerials

Bantex manufacture aerials
for land, sea and defence communications

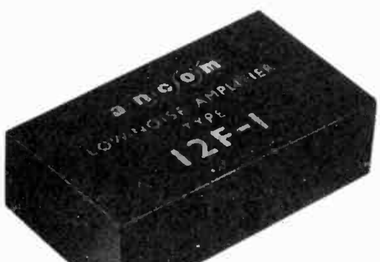
Bantex aerials combine good design and reliability
in all conditions

For enquiries or full catalogue please contact Ernest Gutman

Bantex Ltd. ABBEY RD., PARK ROYAL, LONDON N.W.10
Telephone: 01-965 0941 Telex: 82310

WW—074 FOR FURTHER DETAILS

PIEZO-ELECTRIC TRANSDUCER AMPLIFIER



The ANCOM F series is a range of AC INSTRUMENTATION amplifiers for use with Low Sensitivity Transducers.

AC or DC OUTPUT COUPLING
PIEZO-ELECTRIC ACCELEROMETER
MEGOHM RESISTIVE SOURCES

INPUT RESISTANCE	3000 M ohms typ.
INPUT CAPACITANCE	4 pf.
NPUT NOISE	1μV rms (12F-1a)
UNITY GAIN FREQUENCY	10 MHz
SMALL SIGNAL RESPONSE	2 Hz to 1 MHz
LOAD RESISTANCE	1 K ohm minimum
SUPPLY VOLTAGE	$\pm$ 10v to $\pm$ 15v

The 12F-1 comprises two internal amplifiers, one a fixed low noise pre-amplifier gain + 10 and a variable gain, 0·91 to 10, inverting amplifier.

MAXIMUM SIGNAL to pre-amp stage is 600mV p-p.
OUTPUT is dependent upon gain.

ancom limited devonshire street cheltenham 53861

WW—073 FOR FURTHER DETAILS

NEW from Eddystone

Eddystone

1830 Series

This is a range of solid-state, general purpose communication receivers with reception facilities for CW, AM and SSB in the band 120 kHz to 30MHz. Incremental facility with 1kHz readout.

10 Crystal controlled channels.

100kHz Calibrator.

Operation from standard AC supplies or powered directly from any 12V DC source.

Competitively priced receiver for general purpose communications: HF point to point: Re-broadcast: Monitoring purposes: Laboratory measurement: Mobile HF Reception.

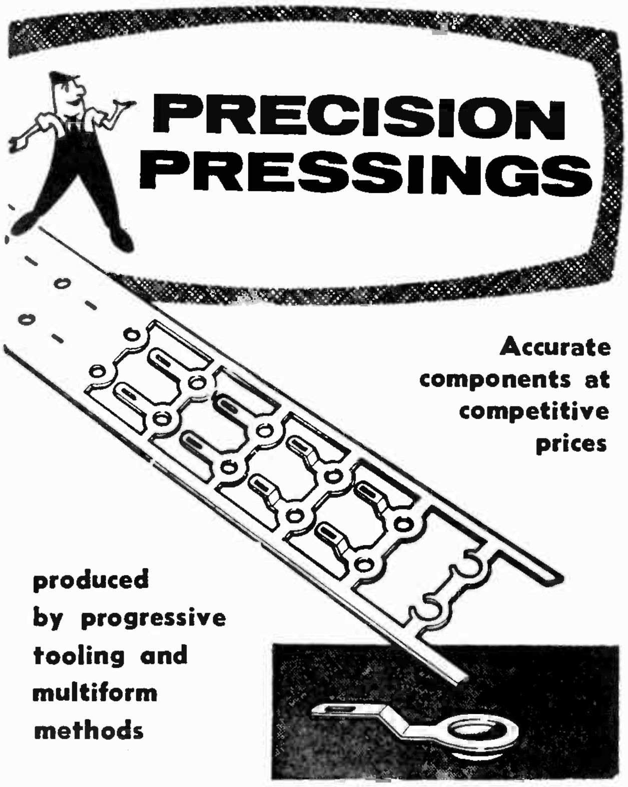
Illustrated brochure obtainable from:

Eddystone Radio Limited,
Alvechurch Road, Birmingham B31 3PP
Telephone: 021-475 2231 Telex: 337081

A member of Marconi Communication Systems Limited

LTD/ED87

WW—046 FOR FURTHER DETAILS



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Accurate components at competitive prices

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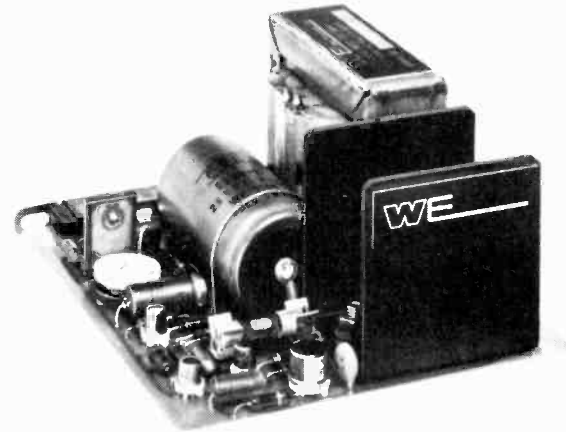
WW—075 FOR FURTHER DETAILS

Logic Power Supply



New, compact plug-in 5V power unit designed to supply IC logic such as DTL, TTL etc.
Mains input 110, 220, 240V 50-60 Hz
Regulation < 0·1% line and load, Ripple < 2·5mV p-p
Transient recovery time 40 μSec
Full short circuit protection – re-entrant current limit
Output spike clipper and optional overvoltage 'crowbar'
Dimensions 95 x 108 x 55mm 5V1A, 95 x 175 x 70mm 5V2A
Price 5V1A 1 off £14·00, 5 off £12·00, 50 off £10·00
Add £2 for 5V2A Add £2 for Crowbar
Add £2 for cased units Immediate Delivery

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Bognor Regis 5991 Grams Electron Bognor Regis

WW—076 FOR FURTHER DETAILS

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Coils, Induction
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Coils, Retardation
Cords, Handset
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Electrodes

Fuses
Fuse Mountings
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Indicator, Miniature

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Jacks, Instrument
Jacks, Lamp 10 & 20 way
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Jacks, Shelf
Jacks, Strips 10 & 20 way
Jacks, Test Relay Set
Jacks, Switchboard

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Keys, Miniature
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Keys, Plunger

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Lamp Strips
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Plugs, Instrument
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Plugs, Test

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We also stock unit assemblies for PAX, PABX, PUBLIC EXCHANGE, MULTIPHONE EQUIPMENT. TWO MOTION SELECTORS BPO. 2000 & 4000 TYPE. GROUP SELECTORS & FINAL SELECTORS. TRANSISTOR RINGING GENERATORS, ETC.

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low tool cost method for cylindrical coils and potting. Enquiries also for—

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Solenoid SRM.
7 lbs to 14 lbs at 1½"

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WW—078 FOR FURTHER DETAILS

MODEL K-30THD

SANWA MULTI TESTERS

USED THROUGHOUT THE WORLD, SANWA'S EXPERIENCE OF 30 YEARS ENSURES ACCURACY, RELIABILITY, VERSATILITY, UNSURPASSED TESTER PERFORMANCE COMES WITH EVERY SANWA

6 Months' Guarantee		Model K-30THD	£12.60
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Model 360-YTR	£8.25	Model 460-ED	£21.75
Model A1303TRD	£11.00	Model EM-700	£45.00
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Cases available with most meters
Please write for illustrated leaflets of these Sanwa meters

SOLE IMPORTERS IN U.K;
QUALITY ELECTRONICS LTD.
47-49 HIGH STREET, KINGSTON-UPON-THAMES, SURREY. Tel: 01-546 4585

WW—079 FOR FURTHER DETAILS

CHART RECORDERS

MOVING COIL

SINGLE PEN

ELLIOTT Portable AC/DC RECORDER
A versatile recorder producing a trace in a curvilinear chart 3½" wide. Fitted with alarm contacts which close when the current exceeds a pre-set value. Coil resistance: 1195 ohms. Sensitivity: 1mA f.s.d. DC. Built-in bridge rectifier for use on AC. Chart speeds: 1 and 6 ins. per hour. Chart drive: 230V 50 Hz synchronous motor. Dimensions: Ht. 11½", width 5¾", depth 9". Weight: 22 lbs. .... **£39·50**

RECORD 3" Graphic ACDC RECORDER
A small portable recorder designed to a rigid GPO specification. Fitted with alarm contacts which close when the current exceeds a pre-set value. Panel mounting and free standing models are available. Coil resistance: 1900 ohms. Sensitivity: 1mA f.s.d. DC. Built-in bridge rectifier for use on AC. Chart speeds: 1 and 6 ins. per hour. Chart drive: 230V 50 Hz synchronous motor. Chart width 3".
Panel mounting .... **£49·50**
Free standing .... **£55·00**

EVERSHED & VIGNOLES MURDAY SYSTEM RECORDING WATTMETER
A portable roll chart recorder mounted in a lockable wooden case. The chart is driven by an 8-day clockwork mechanism allowing the instrument to be used on site completely independently of a mains power supply. The pens are syphon fed from a trough having a large ink capacity. Range: 0–700 Watts. Max. Current: 38 amps. Max. voltage: 256 volts. Chart width: 4 ins. Chart speed: 1 in. per hour. Chart drive: Clockwork—8-day. Dimensions: Ht. 20", width 7¾", depth 8½". Weight: 22½ lbs. .... **£35·00**

EVERSHED & VIGNOLES MURDAY SYSTEM RECORDING AMMETER
A portable roll chart recorder incorporating oil damping. Range: 15–0–15mA. Chart width: 7 ins. Chart speed: 1 in. per hour. Chart drive: Clockwork—8-day. Dimensions: Ht. 19", width 10½", depth 8". Weight: 60 lbs. .... **£30·00**

ELLIOTT DC MILLIAMMETER RECORDER
A robust and well-tried instrument using the LINKSYN pen system which has very low pen to paper friction. The standard charts contain 65 ft. of chart which will last for one month. Range: 0–0·5mA. Coil resistance: 4,500 ohms. Chart width: 3½ ins. Chart speed: 1 and 6 ins. per hour. Chart drive: 200–250V 50 Hz synchronous motor. Dimensions: Ht. 21", width 13½", depth 8½" .... **£39·50**

ELLIOTT DC MILLIAMMETER RECORDER
A reliable clockwork-driven recorder using an ink trough and syphon pen. Range: 0–1mA DC. Coil resistance: 1050 ohms. Chart width: 3½ ins. Chart speed: 2 ins. per hour. Chart drive: Clockwork—14 days. Dimensions: Ht. 18½", width 12½", depth 8". Weight: 56 lbs. **£35·00**

ELLIOTT DC MILLIAMMETER RECORDER
Similar to 0–1mA above, but four chart speeds selected by movement of lever. Range: 0–2mA. Coil resistance: 2900 ohms. Chart width: 4½ ins. Chart speed: 1 and 6 ins. per hour; 1 and 6 ins. per minute. Chart drive: Clockwork—8-day. Dimensions: Ht. 17½", width 8½", depth 7½". Weight: 30 lbs. .... **£42·50**

ELLIOTT DC MILLIAMMETER RECORDER
Similar to Elliott recorders above, but with electric chart drive. Range: 0–1mA. Coil resistance: 1050 ohms. Chart width: 4½ ins. Chart drive: 230V 50 Hz synchronous motor. Chart speed: 3 ins. per hour. Dimensions: Ht. 18½", width 12½", depth 8". Weight: 56 lbs. **£35·00**

ELLIOTT MODEL 400 "EMREC" DC MILLIAMMETER RECORDER
A portable free-standing single-pen recorder designed for field use where a robust and reliable recorder is required. Fitted with miniature fluorescent strip light. Range: 0–1mA. Chart width: 4 ins. Chart speed: 1 in. per min. Chart drive: 240V 50 Hz synchronous motor. Dimensions: Ht. 7½", width 7½", depth 9". Weight: 20 lbs. .. **£75·00**

EVERSHED & VIGNOLES PORTABLE DC MILLIAMMETER RECORDER
A neat and compact instrument using a typewriter ribbon chopper marker on to a continuous strip chart. Range: 0·5–0–0·5mA. Coil resistance: 240 ohms. Chart width: 2 ins. Chart speed: 6 ins. per hour. Chart drive: 230V 50 Hz synchronous motor. Dimensions: Ht. 6½", width 4½", depth 8½". Weight: 7½ lbs. .... **£25·00**

KELVIN HUGHES Portable HIGH SPEED RECORDERS
A general purpose instrument providing a clear, instantaneous and permanent record on Teledeltos paper. Will respond to signals having a relatively high rate of change. The moving-coil galvanometers are fitted with a unique torsion strip suspension which protects the instrument from the effects of vibration, shock, etc. This recorder comes complete with a matched amplifier. Chart width: 1¾ in. Chart speed: 60 and 240 ins./min. Pens: Electric pens on Teledeltos paper. Chart drive: 230V 50 Hz synchronous motor. Dimensions: Ht. 5¾", width 7", depth 12½". Weight: 19 lbs. (recorder only) .... **£95·00** C/W Amplifier

Also available with 2 and 4 pens—see below.

TWO PENS

RECORD DUPLEX 3" GRAPHIC RECORDER
Similar to the Record 3" Graphic single pen recorder above, but incorporates two movements in a single case .... **£75·00**

ELLIOTT DC MILLIAMMETER RECORDER
Similar to Elliott single pen above. Range: 0–2mA. Coil resistance: 1687 ohms. Chart width: 6½ in. Chart speed: 1 in. per hour. Chart drive: Clockwork—8-day. Dimensions: Ht. 21", width 13½", depth 8½". Weight: 42 lbs. .... **£52·50**

KELVIN HUGHES PORTABLE HIGH SPEED RECORDERS
Similar to single pen above. Chart width: 3 ins. Chart speeds: ½, 1, 2, 4, 8, 16 cm. per sec. Chart drive: 230V 50 Hz synchronous motor. Pens: Electric pens on Teledeltos paper. Dimensions: Ht. 7½", width 10½", depth 11½" .... **£65·00** less amplifier

THREE PENS

EVERSHED & VIGNOLES ADMIRALTY RECORDER
Originally designed for services use for tested magslips but can be used as a normal 3-pen recorder. Range: 12–150V AC f.s.d. set by range selector switch. Chart width: 3·5 cm. per channel. Chart speed: 12 ins. per hour or 12 ins. per minute. Please state which is required. Chart drive: Synchronous motor. Power supply: 50/250V 50 Hz and 20/120V 400 and 1100 Hz .... **£42·50**

FOUR PENS

KELVIN HUGHES PORTABLE HIGH SPEED RECORDER
Similar to single pen above. Chart width: 3 ins. Chart speed: ½, 1, 2, 4, 8, 16 cm. per sec. Chart drive: 230V 50 Hz synchronous motor. Pens: Electric pens on Teledeltos paper. Dimensions: Ht. 8", width 10½", depth 22½" .... **£140·00** with amplifiers

POTENTIOMETRIC

SINGLE POINT

KENT INSTRUMENTS Mk. II CHART RECORDER
A general purpose slow response recorder suitable for recording quantities which have a relatively slow rate of change such as temperature, smoke density, etc. Sensitivity: 10mV. Response time: 33 secs for f.s.d. Chart width: 8 ins. Chart speed: ¼, 3, 6 ins. per hour. Power supply: 110V 50 Hz (autotransformer to 230V 50 Hz available). Dimensions: Ht. 16¾", width 19", depth 15½" .... **£59·50**

LEEDS & NORTHRUP STRIP CHART RECORDER
This well-known instrument is fitted with a Series 60 control unit servo amplifier101041 BR EQ. Range: 5·571 to 18·855. Ref junction 320F. Primary element: Pl. Pl. 13% RH JMC. Response time: 5 secs for f.s.d. Chart width: 7 ins. Chart speed: 1 in. per hour. Power supply: 120V 50 Hz (autotransformer available). Dimensions: Ht. 18", width 11", depth 12½". Weight: 51 lbs. .... **£175·00**

CAMBRIDGE STRIP CHART RECORDER WITH CONTROL UNIT
A general purpose recorder for recording temperature, moisture content, etc. Chart width: 8 ins. Chart speed: ⅛, ¼, ½, 1½, 3 and 6 ins. per min. Power supply: 240V 50 Hz .... **£52·50**

SIX POINTS

RUSSION STRIP CHART RECORDER
A very well-made recorder, fully tropicalised and ideally suited to use in an industrial environment, for recording temperature, humidity, etc. Range: 100–0–100mV. Response time: 8 secs for f.s.d. Accuracy: ±0·5%. Chart width: 6½ ins. Chart speed: 20 to 720 mm. per hour in 10 steps. Dimensions: Ht. 11½", width 13", depth 17" ..... **£79·50**

ELLIOTT STRIP CHART RECORDER
Range: 0–10mV. Chart width: 10 ins. Dimensions: Ht. 21", width 20", depth 19½". Further information available on request .. **£145·00**

TWELVE POINTS

KELVIN HUGHES MODEL HPR/A12 Mod 2 STRIP CHART RECORDER
Range: 0–100mV. Chart width: 11½ ins. Chart speed: ½ in. per min. Power supply: 240V 50 Hz .... **£195·00**

CIRCULAR CHART TYPES

FIELDEN Mk. II SERVOGRAPH TYPE RL41
Four Point. A very sensitive servo-operated circular chart recorder. The four point head enables four inputs to be recorded on the chart in four separate colours. Range: 0–50 microamps. Chart diameter: 11 ins. Chart speed: 1 rev per hour. Chart drive: Interchangeable synchronous motors. Power supply: 210/250V 50 Hz 35 Watts. Dimensions; Ht. 16", width 13¾", depth 7 5/16 ins. Weight: 22 lbs. **£45·00**

FIELDEN Mk. II SERVOGRAPH TYPE RB1
Similar to above except for following: Range: 0–60 microamps. Chart diameter: 11 ins. Chart speed 1 rev in 24 hours. Weight: 28 lbs. .... **£42·50**

CAMBRIDGE TEMPERATURE RECORDER (Single Pen)
These well-known reliable circular chart recorders operate on the bulb and capillary tube principle. Range: 50–300°C. Chart diameter: 10¾ ins. Chart speed: 1 rev in 24 hours. Chart drive: 230V 50 Hz synchronous motor. Dimensions: Diameter 13¾", depth 4½". Weight: 22 lbs. .... **£38·50** C/W bulb and 6 ft. tubing

NEGRETTI & ZAMBRA TEMPERATURE RECORDER (Two Pen)
Similar to above except has two pens and associated bulbs and tubing. Range: 0–200°C. Chart speed: 1 rev in 24 hours. Chart drive: 230V 50 Hz. Dimensions: Ht. 15½", width 13½", depth 4¾" .... **£45·00**
C/W two bulbs and 10 ft. of tubing

ULTRA VIOLET RECORDERS

HONEYWELL 1706 VISICORDER
6 channel. Chart width: 4½ ins. Chart speed: 6, 12, 25, 50, 100, 200, 400, 800 mm./sec. Timer internal: 1/10 sec, 1 sec. Provisions for external timer. Portable: 13"×11"×9". Mains supply ...... **£350·00**

HONEYWELL 906S VISICORDER
14 channel complete with 6 galvo's. Chart width: 6 ins. Chart speeds: 4·2, N, 17, 21, N, 8·3 ins./sec. Dimensions: 15"×9"×10"—portable. **£200·00**

NEW ELECTRONIC PRODUCTS TYPE 1000
6 channel complete with 6 galvo's. Chart width: 6 ins. Chart speed: 0·2, 0·6, 2, 6 ins./sec. Facilities for event marking and bright viewing. Footage counter. Overall dimensions: 14"×16"×10½". Mains supply. **£100·00**

NEW ELECTRONIC PRODUCTS TYPE 1160
12 channel. Chart width: 4½ ins. Chart speed: 2, 6, 20, 60 ins./sec. Two event markers. Rack mounting. Overall dimensions: 19"×12"×19" .... **£95·00**

NEW ELECTRONIC PRODUCTS TYPE 1185
12 channel. Chart width: 12 ins. Chart speed: 0·5, 1, 1·5, 2, 4, 6, 10, 20, 30, 40, 80, 120 ins./sec. +10 or ×1. Event marker and inching facilities. Overall dimensions: 21"×21"×19½" .... **£110·00**

Note: Galvo's are available to various specifications and a price will be quoted when the specification of the galvo's required is made known.

MISCELLANEOUS

EVERETT EDGCUMBE "INKWELL" RECORDING WATTMETER
This recorder uses the dynamometer principle to record power in watts. Range: 0–10 watts. Chart width: 4 ins. Chart speed: 12 ins. per min. Chart drive: Clockwork—8-day. Dimensions: Ht. 9¾", width 9½", depth 7". Weight: 28 lbs. .... **£25·00**

ETHER "XACTROL" SIX POINT RECORDER
Range: 0–600°C using Cr/ni AL Thermocouple. Chart width: 6 ins. Chart speed: 1 in. per hour. Power supply: 110V 50 Hz (autotransformer for 230V 50 Hz available). Dimensions: Ht. 10", width 11", depth 11½" .... **£165·00**

MUIRHEAD "MUFAX" Type 901, 9" FACSIMILE RECORDER/TRANSMITTER
Full specification and price available on request.

E
ELECTRONIC

X-Y PLOTTERS

ELECTRONIC ASSOCIATES VARIPLOTTER 1100E
X–Y plotter, suitable for recording analogue information. Table size 15 in. × 10 in.; slow speed 20 in./sec.; I/P sensitivity for f.s.d. 0–05–20V in 9 ranges. Basic I/P sensitivity. Arm 10mV/in. Pen 1V/in. Fully overhauled, tested, guaranteed and in new condition.
Price: **£350·00**

I. MOSELEY AUTOGRAF MODEL 2A
Table size: 11 in. × 17 in. Dimensions: W. 24 in., H. 9 in., D. 16 in. Wt.: 55 lbs. Power I/P: 115V 1 phase 100 w. Signal I/P: X Axis 0–7½, 15, 75, 150, 750mV; 0–1½, 7½, 15, 75, 150V. Y Axis 0–5, 10, 50, 100, 500mV; 0–1, 5, 10, 50, 100V. Sensitivity not less than 200 ohms/V. Accuracy: 0·25% FS on all ranges. Response speeds: 1 sec. for full scale. Supplied complete with copy of handbook. Carriage extra .... **£310·00**

EVENT RECORDERS

ELECTRONIC BROKERS 6-CHANNEL TIME & EVENT RECORDER
Specially made for us by a well-known manufacturer. Each of the six channels works independently by shorting inputs—no external voltage is required. Max. response rate: 10 impulses per second give 1/16 in. pen deflection. Chart speeds: 1, 5, 10, 20 and 30 ins. per min.; 6, 9, 12 and 18 ins. per hour. Please state speed required. Power supply: 220–240V 50 Hz or 110–115V 60 Hz. Dimensions: Ht. 9", width 15", depth 9½". Weight: 10 lbs. Instrument .... **£79·5**
Carrying case .... **£5·00** 19" rack mounting attachment **£5·00**

EVERETT EDGECUMBE OPERATION GRAPHER TIME & EVENT RECORDER 20 and 40 PENS
Pens operated by 24V DC. Chart width: 8½ ins. Chart speed: 1 in. per min. Power supply: 110V 50 Hz (autotransformer for 230V available). Dimensions: Ht. 13½", width 14½", depth 7" 20 pen .... **£95·00**
40 pen .... **£115·00**

All the above recorders have been fully refurbished by our own workshops and carry a 3 months' warranty.

As our stocks of recorders and other instruments is constantly changing, please enquire if you have a specific requirement.

RECORDER CHART ROLLS

We have large stocks of pen recorder chart rolls for most makes of recorder including Elliott, Kent, Honeywell, Record, Teledeltos, Rustrak, etc. Please let us know your exact requirements so that we may quote—our prices are often up to 50% below list.

ANALYSERS

1. AVO
Type CT446 TRANSISTOR ANALYSER for measuring parameters on PNP, NPN, and Point Contact Transistors .... **£30·00**

2. DAWE INSTRUMENTS
Type 1401 DX PORTABLE AF ANALYSER. Frequency range: 2·5Hz to 8kHz .... **£18·00**

3. DAWE INSTRUMENTS
Type 1401A PORTABLE OCTAVE BAND ANALYSER. Frequency range: 20Hz–10KHz .... **£18·00**

4. SOLATRON
AF ANALYSER. Frequency range: 2·5Hz–7·5kHz. Battery powered. **£25·00**

5. GENERAL RADIO
Type 760 AF ANALYSER. Frequency range: 2·5Hz–7·5kHz. Battery powered .... **£15·00**

6. FENLOW ELECTRONICS
Type SA2 I.F SPECTRUM ANALYSER. Frequency range: 0·3Hz–1kHz .... **£195·00**

7. DAWE INSTRUMENTS
Type 705B WAVE ANALYSER. Frequency range: 50Hz–16kHz. **£30·00**

8. MARCONI
Type TF455 D/1 WAVE ANALYSER. Frequency range: 20Hz–16kHz .... **£35·00**

9. MUIRHEAD
Type D–489–EM WAVE ANALYSER. Frequency range: 19Hz–21kHz .... **£75·00**

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ELECTRONIC BROKERS LTD

BROKERS

GENERATORS

SQUARE WAVE GENERATORS

1. SOLARTRON
Type GO-511 SQUARE WAVE GENERATOR. Range: 0–1MHz £65·00

TONE GENERATORS

2. B.E.M.E.
Type X9327 TONE GENERATOR Range: 3·2, 3·6, 4·0, 4·4, 4·8, 5·2, 5·6, 6·0, 6·4, 7·2kHz. 19 in. Rack mounting .... £45·00

VOLTAGE AND CURRENT GENERATORS

3. EKCO
Type 1482A DECADE VOLTAGE & CURRENT GENERATOR

This instrument is a self-contained unit for providing accurate voltages and currents which can be varied by small increments. Voltage ranges: 0–1V in 0·0001V steps; 0–10V in 0·0001V steps. Current ranges: On 1 volt range 10^{-5}; to 10^{-13}A; On 10 volt range 10^{-4} to 10^{-12}A. Voltage ranges; $+0·01$%. Current series resistors: 10^{-5}, 10^{6} ohms $\pm 0·1$%; 10^{7} ohms ± 5%; 10^{8}, 10^{9}, 10^{10}, 10^{11}, 10^{12} ohms ± 10% .... £45·00

NOISE GENERATORS

4. WAYNE KERR
NOISE GENERATOR CT410. A portable instrument for measuring the noise factor of radio receiving equipment, metric radar receivers and radar wide-band i.f. amplifiers in the band 15kHz–160MHz .... £75·00

400Hz GENERATORS

5. HATFIELD INSTRUMENTS
Type PUM16 400Hz GENERATOR. Provides 400Hz 1 ph and 3 ph power .... £145·00

6. HATFIELD INSTRUMENTS
Type PUM 16/1 133Hz GENERATOR. Similar to above only 133Hz .... £145·00

TEST GENERATORS

7. MARCONI
Type TF1167 TELEGRAPH TEST GENERATOR. This generator delivers high quality keyed RF signals at stable carrier frequencies of 3·1, 6·2, and 9·3MHz. On/off frequency-shift or frequency shift diplex (twinplex) keying can be selected, or the carrier can be sinewave amplitude modulation. Carrier Frequency: 3·1, 6·2, 9·3MHz. Frequency Stability: Better than $\pm 0·001$% for mains variation up to ± 10% over an ambient temperature range of 20 to 50°C .... £65·00

PULSE GENERATORS

8. COSSOR
Type CG200 MICROSECOND PULSE GENERATOR .... £15·00

9. FLEMMING RADIO
Type 1478A PULSE GENERATOR PRF 0·25 to 100K pps. Attenuator 1, 2, 4, 6, 10, 20, 40 db .... £35·00

10. KASAMA ELECTRONICS
Type 301A PULSE GENERATOR PRF 0–100K pps. Pulse width and delay facility .... £38·00

11. NAGARD
Type 5002 DOUBLE PULSE GENERATOR PRF 0·1–1M pps. Delay 0·2 sec. to 0·2 µsec. Pulse width: 0·2 sec. to 0·2µ sec. O/P 20mV–50V .... £65·00

SIGNAL GENERATORS
Audio Frequency

12. AIRMEC
Type 257 SIGNAL GENERATOR. Provides four phase related outputs of identical frequency. A unique feature of this instrument is that one output is continuously variable in phase relative to a reference. Frequency range: 0·03Hz to 30Hz O/P level; 50V peak unbalanced to earth O/P impedance: 10Kohm normal. FULL SPECIFICATION AVAILABLE ON REQUEST .... £95·00

13. ADVANCE
Type SG66 LF SIGNAL GENERATOR. Frequency range: 5Hz to 125kHz. Accuracy: ± (1% ±1Hz). O/P SINE WAVE: 0–30V rms into 600 ohms; 0–1W into 5 ohm. O/P SQUARE WAVE: 0–30V pk to pk; O/P impedance varies with O/P level. RISE & FALL TIMES: 0·75 µs max .... £49·50

RF SIGNAL GENERATORS

14. ADVANCE
Type C2. Spot frequencies selected by 12 push buttons marked A to L. Each spot frequency is tunable. Frequency range: 200kHz to 15mHz .... £15·00

15. SIGNAL GENERATOR
Type CT218. Frequency range: 85kHz–30MHz. Crystal calibrator at 200kHz and 2MHz .... £55·00

16. AIRMEC
Type 201 STANDARD SIGNAL GENERATOR. This instrument will provide accurate, stable sinusoidal signals of pure waveform from 30kHz to 30MHz. Output levels, which are stabilised by an amplified AGC system can be varied from 1µV to 1·1V rms (or 2·2V rms unmodulated). A high output of 5V (10V unmodulated) is also provided from a 300 ohm source impedance. The attenuators are very accurately calibrated and have a constant 75 ohm output impedance. Frequency range: 30kHz–30MHz in 7 bands. CRYSTAL CALIBRATION: A 500kHz crystal oscillator provides between 20 and 50 check points on each band. FULL SPECIFICATION AVAILABLE ON REQUEST .... £95·00

17. AIRMEC
Type 701 SIGNAL GENERATOR. Frequency range: 30kHz–30MHz in 7 bands .... £95·00

18. COSSOR
Type CT202 SIGNAL GENERATOR. Frequency range: 7–70MHz. Band width: Swept 1–10MHz .... £89·00

19. MARCONI
Type TF144H STANDARD SIGNAL GENERATOR. Frequency range: 10kHz–72MHz. Crystal check: 400kHz and 2MHz crystals. Stability: 0·002% in 10 minute interval. FULL SPECIFICATION AVAILABLE ON REQUEST .... £165·00

20. MARCONI
Type TF144G STANDARD SIGNAL GENERATOR. Frequency range: 85kHz–25MHz. Output voltage: 1µV–1V continuously variable. Output impedance: 1µV to 100mV 10 ohms; 100µV to 1V 52·5 ohms. FULL SPECIFICATION AVAILABLE ON REQUEST .... £85·00

21. MARCONI
Type TF517F/1 UHF SIGNAL GENERATOR. Frequency range: 0–300MHz Sine & Square wave .... £45·00

22. ADVANCE
Type D1/D SIGNAL GENERATOR. Frequency range: 10MHz–300MHz. O/P voltage: 1µV–10mV .... £45·00

23. ADVANCE
Type 71 SIGNAL GENERATOR. Frequency range: 0–320MHz .... £25·00

24. AVO
Type CT378 SIGNAL GENERATOR. Frequency range: 2MHz–500MHz. O/P voltage 1µV–25mV into 75 ohm. Internal modulation: 1kHz to 30%—sine or square .... £45·00

25. MARCONI
Type TF801A SIGNAL GENEROTOR. Frequency range: 10MHz to 310MHz. O/P voltage: 0–100 db relative to 200 mV into 75 ohm; 1V CW O/P available. Internal modulation: 400Hz, 1kHz and 5kHz to 80% sine or square .... £45·00

26. RCA
Type 710-A UHF SIGNAL GENERATOR. Frequency range: 370MHz–560MHz. Power supply: 117 volts 6Hz 50 Watts .... £25·00

27. EX-SERVICES
No. 16 SIGNAL GENERATOR. Frequency range: 0–11cm .... £15·00

28. MARCONI
Type TF1343/1 'X' BAND SIGNAL GENERATOR .... £65·00

29. MARCONI
Type TF1343/2 'X' BAND SIGNAL GENERATOR .... £65·00

30. SANDERS
Type SG480 'X' BAND SIGNAL GENERATOR. These high grade generators comprise a klystron oscillator in a coaxial cavity from a stable power source. Provision for applying sine wave or pulse modulation from either an internal or external source. Frequency range: 8–11·5kMHz .... £275·00

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Type SG478 'X' BAND SIGNAL GENERATOR. Frequency range: 1·3–4·2kMHz. Details as SG480 above .... £275·00

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1. MAKER NOT KNOWN
Type 248 INDICATOR UNIT. Range: 0–20,000MHz .... £10·00

2. MAKER NOT KNOWN
Type CTR103 INDICATOR CRO. Range: 0–10MHz. TB Speed: 10,000–20,000MHz .... £10·00

3. B.P.L.
Type LB320 BALANCE INDICATOR .... £15·00

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Type M9600B MAGNETIC FLOW DYNALOG INDICATOR. Range: 0–40 Litres/min .... £25·00

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Type 1T3–1 RATIOMETER INDICATOR. Range: 0–200°C .. £15·00

6. SANGAMO WESTON
Type 1T3–3 RATIOMETER INDICATOR. Range: —70°C to +30°C .... £15·00

7. SANGAMO WESTON
Type 63/4 RATIOMETER INDICATOR. Range: 250°C–350°C .... £15·00

8. SANGAMO WESTON
Type S63/5 RATIOMETER INDICATOR. Range: 50°C–350°C .... £15·00

9. SANGAMO WESTON
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7. 500V BRIDGE MEGGER SERIES 2 Ranges: Bridge 0·01–999, 990 ohms. Insulation: 0–100Mohms .... £29·50
8. 500V INSULATION TESTER SERIES 1. Range: 0–100Mohm–infinity .... £20·00
9. 500V INSULATION TESTER SERIES *. Range: 0–100Mohms–infinity .... £22·50
10. 1000V INSULATION TESTER SERIES 1. Range: 0–5000Mohm–infinity. Requires 1000V power supply .... £12·50
11. 100V VARLEY LOOP TEST BRIDGE MEGGER .... £25·00
12. 1000V BRIDGE MEGGER SERIES *. Ranges: Bridge 0·01–999, 990 ohms. Insulation: 0–200Mohms .... £25·00
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14. METROHM BATTERY INSULATION TESTER. Ranges: 0–0·00 ohms. 0·1–infinity ohms .... £15·00

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INTEGRATOR 6 digit counter read-out .... £25·00

2. NEW ELECTRONIC PRODUCTS
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The R.C.A. Speech Inverter is a device intended for use in radio-telephone installations where privacy is a prime consideration. The equipment when used in conjunction with the R.C.A. M1·7182 Hybrid Transformers enables parallel two-way conversations on a single telephone pair line at each terminal of the communications system. With inversion, speech fed into the transmitting inverter circuit will feed the radio transmitter with unintelligible signals. These signals will remain unintelligible until they pass through a receiving inverter circuit at the other end of the communication channel. (Used only under Licence in U.K.) .... £12·50

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2. BRADLEY (GEC)
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Type 44A PRECISION MULTI RANGE METER. An instrument of very high accuracy for use in laboratory, test-room, or factory. Ranges: Voltage: DC 0·2 to 1000V fsd. AC 1 to 1000V rms fsd. Current: DC/AC 1mA to 10 amp fsd. Resistance: 0·1Mohm in 3 ranges. Power: 0–4 watts. Sensitivity: 1000 ohms/volt .... £15·00

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Type 47A MILLOHMMETER. Designed for measurement of low and very low resistance. It is a transportable direct reading instrument with a clean linear scale and is very simple to use. Ranges: 1·2Mohm to 1200 ohms f.s.d. in 7 ranges. Accuracy: better than ±2% of full scale. Mains powered .... £35·00

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6. CAMBRIDGE INSTRUMENTS
Type L-134995 PL METER. Range: 0–12. Probes available from manufacturer at approx. £4·00 each. Complete with galvanometer .... £12·50

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Type 6A PL METER. Range: 0–14. In wooden box complete with electrode stand .... £30·00

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Type 11071 PL METER (PORTABLE) Range: 2–12 .... £39·00

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Type D729–BM PHASEMETER. Frequency range: 0–25Hz to 10kHz. Angle range: 0–360° .... £15·00

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Type K159 PHASEMETER. Range: 0–100° .... £25·00

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11. INDUSTRIAL PYROMETER
INDUSTRIAL PYROMETER. Range: 0–110°C .... £35·00
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12. FLEMING RADIO
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13. DAWE INSTRUMENTS
Type 1402C VIBRATION METER. Range: 2 to 10kHz. Complete with probe .... £25·00

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14. DYNAMCO
Type 2006 DIGITAL VOLTMETER. Ranges: 100mV–1KV fsd. Scale: 4 digits. Sensitivity: 10µV. Supplied with D2 module and calibration certificate .... £350·00

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16. GLOSTER INSTRUMENTS
Type GE(B1E2123) DIGITAL VOLTMETER .... £55·00

17. SOLARTRON
Type LM902·2 DIGITAL VOLTMETER. Ranges: 0·1V–1KV fsd 7 ranges. Scale: 4 digit. Accuracy: ±0·1% of fsd .... £49·00

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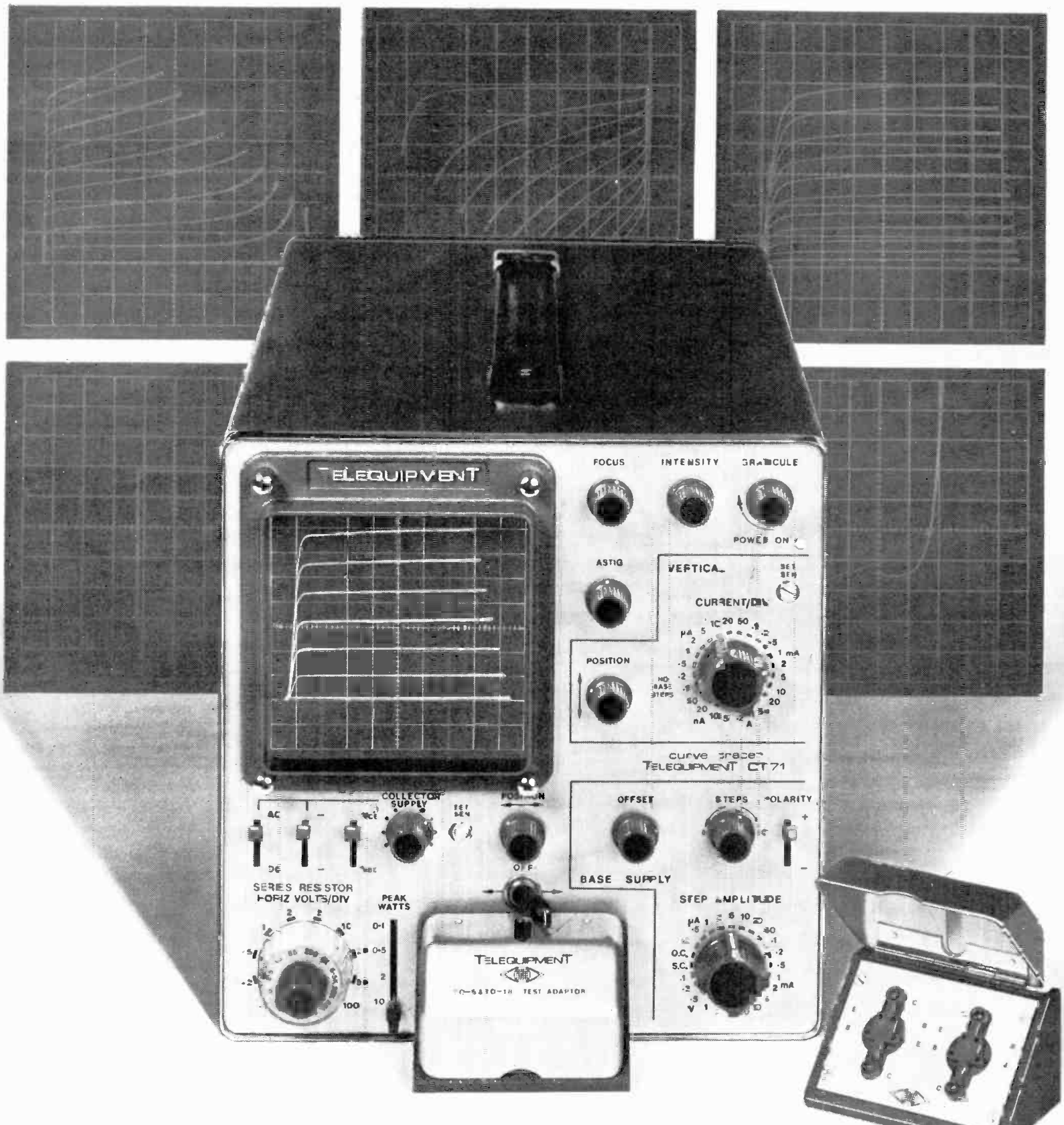
Type 612A TRUE RMS VALVE VOLTMETER. A sensitive electronic voltmeter for the measurement of true rms valves of complex wave forms. Range: 100 microvolt to 300V rms. Frequency: 5Hz–500kHz .... £55·00

20. MARCONI
Type TF 428B VALVE MILLI VOLTMETER. Ranges: 0·15V, 0·5V, 2V fsd .... £15·00

21. AVO
Type CT38 VALVE VOLTMETER .... £15·50

22. EX-SERVICE
Type ZD00121 VALVE VOLTMETER. Ranges: DC 0–3V; 1–10V; AC 0–1·5V; 0–5V; 0–15V .... £10·00

49-53 PANCRAS RD., LONDON, N.W.1. TEL.: 01-837 7781. TELEX 267307



NEW — LOW COST Transistor Curve Tracer

Once in a while, it *has* to happen. Something really new arrives. A development so far ahead that immediately it sets a standard of its own. That's why Telequipment are so often in the news. This time, it's a transistor curve tracer *at remarkably low cost* — the CT71. This is a dynamic semiconductor tester which allows display and measurement of characteristics of transistors, FET's and diodes. Two different transistor characteristics may be displayed, including the collector family in common emitter configuration. In addition to the transistor curves the CT71 may be used to display dynamic characteristics of a wide range of semiconductor devices. It enables diode characteristics to be displayed at forward currents up to 2A, reverse currents down to 5nA and reverse voltages up to 1kV. Two test fixtures are provided, one with 1 pair of TO-18's in a source-drain-gate configuration, 1 pair of TO-18's in an emitter-base-collector configuration, 1 pair of TO-15's in an emitter-base-collector configuration and 2 sets of 3 terminals in the emitter-base-collector configuration. The other provides two pairs of power transistor sockets (a pair of TO-66's and a pair of TO-3's) both pairs in an emitter-base-collector configuration. By producing such an instrument at only £195, Telequipment have again demonstrated their expertise in the design and manufacture of completely reliable equipment at a realistic cost. For further details write, telephone or telex: Telequipment, 313 Chase Road, Southgate, London, N14 6JJ. Telephone: 01-882 1166. Telex: 262004. A division of Tektronix U.K. Ltd.

WW—085 FOR FURTHER DETAILS

Wireless World

Electronics, Television, Radio, Audio

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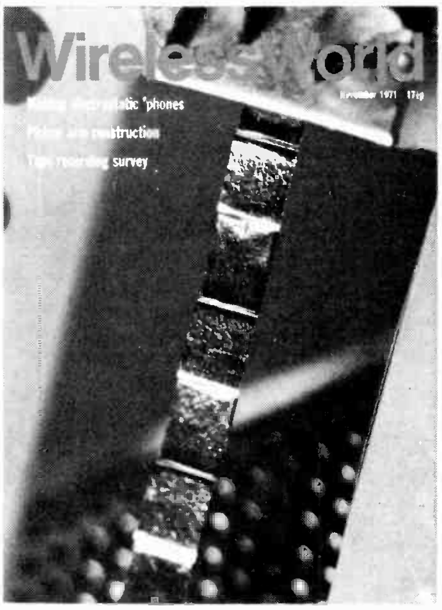

The **cover picture** of the ribbon of a Reslo-sound UD4 microphone typifies the audio bias of this issue. *Photographer—Paul Brierley.*

Contents

IN OUR NEXT ISSUE

The Japanese **Trinitron colour television tube**, which has vertical striped phosphors and an aperture grille, is described and compared with the shadowmask tube with its triad dot structure.

A novel **wow and flutter meter** using a phase-locked loop is described by the designer of the pickup arm in this issue.

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Wireless World

The Environment of Invention

It has been so often said that nowadays there is no place for the lone inventor that we are in danger of accepting it as an incontrovertible truth. First of all let it be known that there are plenty of electronics inventors around–whether they are experimenters working at home or professionals earning their living by electronics is not really important. Probably what is behind the cliché is the thought that an inventor cannot achieve much nowadays without being a member of a team with large resources at its command. What we should consider about this is whether a true inventor, a person with a divergent mind, can in fact achieve anything really original within such a team. How many inventions have been lost–still-born or not even conceived–because of the necessities and disciplines of the team's orderly march towards its pre-determined goal?

The inventor needs materials, tools and time–but above all time. He will get the first two by being an employee of an industrial organization, but time only up to a certain limit. In an efficiently run R & D department the time allowable for any given line of enquiry is strictly determined. Someone, such as a research director, has to make the decision at some point that enough time has been spent on the project; that further work is unlikely to bring worthwhile benefits. This is an extremely difficult decision to make. How can he be sure there is not something really important that a few more weeks will bring to light, perhaps even by accident? It would be interesting to know if any such administrative soul-searching went on at Bell Telephone Laboratories when Shockley, Bardeen and Brattain were working towards the 'three-electrode germanium crystal contact device' which was to revolutionize the electronics industry. We know the official story, but we do not know what was the pattern and interaction of the purely human factors–euphoria, pessimism, hopes, doubts and obsessions–that moved the whole project.

Time, above all, is needed by the individual inventor because what drives him forward is often a completely irrational confidence, a feeling 'in his bones', in spite of all the setbacks, that his idea is going to work. The classic case of this is, of course, the 19th century American, Charles Goodyear, a non-scientist with no chemical knowledge, who experimented for years, impoverishing himself in the process, even to the point of selling his son's schoolbooks, in his determination to discover how to harden rubber (or vulcanize it, as we now say). In the end, after several spells in prison for debt, he succeeded. Is there a need for such heroic sacrifice nowadays? Perhaps not; but people, being people, will continue to have brain children which they will nurture obsessively against all discouragement, and some of these ideas, given time, can become powerful realities.

It is all too easy to look back on the 'progress of technology' as some impersonal force which has caused inventors to pop up at just the right moment to put another brick on the wall at a place where it was obviously needed. If Shockley, Bardeen and Brattain had not invented the transistor when they did, somebody else would have done it sooner or later. Those who think this should try viewing the 'progress' as it rolls into the future and attempt to predict what will be the most important electronic inventions by, say, the year 2000 A.D. They will be shocked at the paucity of their ideas.

Pickup Arm Design for Home Construction

by R. Ockleshaw

The pickup arm described is designed to accompany the turntable detailed in our last issue. It includes an optional bias compensator and lift mechanism. Mechanical resonance is damped by a flexible coupling between counterweight and arm. A further article will describe how to check performance of the turntable using a test record and novel wow and flutter meter.

Design of pickup arms has been well described. The articles* published in *Wireless World* May and June 1966 contain all the information required to design an arm for minimum distortion due to lateral tracking errors. In the present design, note has also been taken of the opinions of J. Walton on pickup-arm design.†

Briefly, one should try to avoid a system reproducing frequencies generally below the limits of audibility, because they may produce a disturbing Doppler effect on some loudspeaker systems whose acoustic impedance at these frequencies is low.

*J. K. Stevenson, 'Pickup arm design', *Wireless World* vol. 72 1966 pp. 214-8 and 314-20.
†J. Walton, 'Turntable rumble and pickup arm design', *Wireless World* vol. 68 1962 pp. 435-7.

Also, vibrations of the turntable and pickup-arm suspension should not cause excitation of the pickup arm, however damped.

A pickup arm has a natural period of oscillation of $T = 2^{\pi}(MC)$ where M is the effective mass of the pickup arm and C is the compliance of the pickup cartridge. Mechanical impedance moves from a low to a high value around the resonant frequency peak—Fig. 1. Below the resonant frequency, because the mechanical impedance of the arm is low in comparison with the mechanical impedance of the pickup cartridge armature, the output from the pickup will be severely attenuated. Thus the arm acts like a high-pass filter, rejecting frequencies in the rumble range. The cut-off can be quite sharp but its value as an active part of a system is lost if different cartridges of varying compliance are fitted. Consequently my approach is that it is always better to ensure that rumble is reduced as much as possible at source and not rely entirely on the impedance characteristics of the arm. Damping the resonant peak is important too as the coincidence of some discrete vibration with the high-impedance resonant peak of an undamped arm may

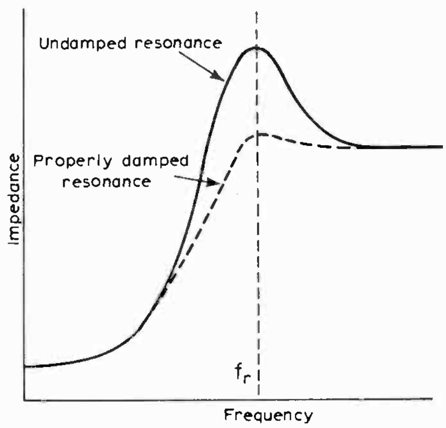


Fig. 1. Pickup arm resonance must be damped to allow for different cartridges. In this design damping is achieved with plastic 'decoupling' between balance weight and arm.

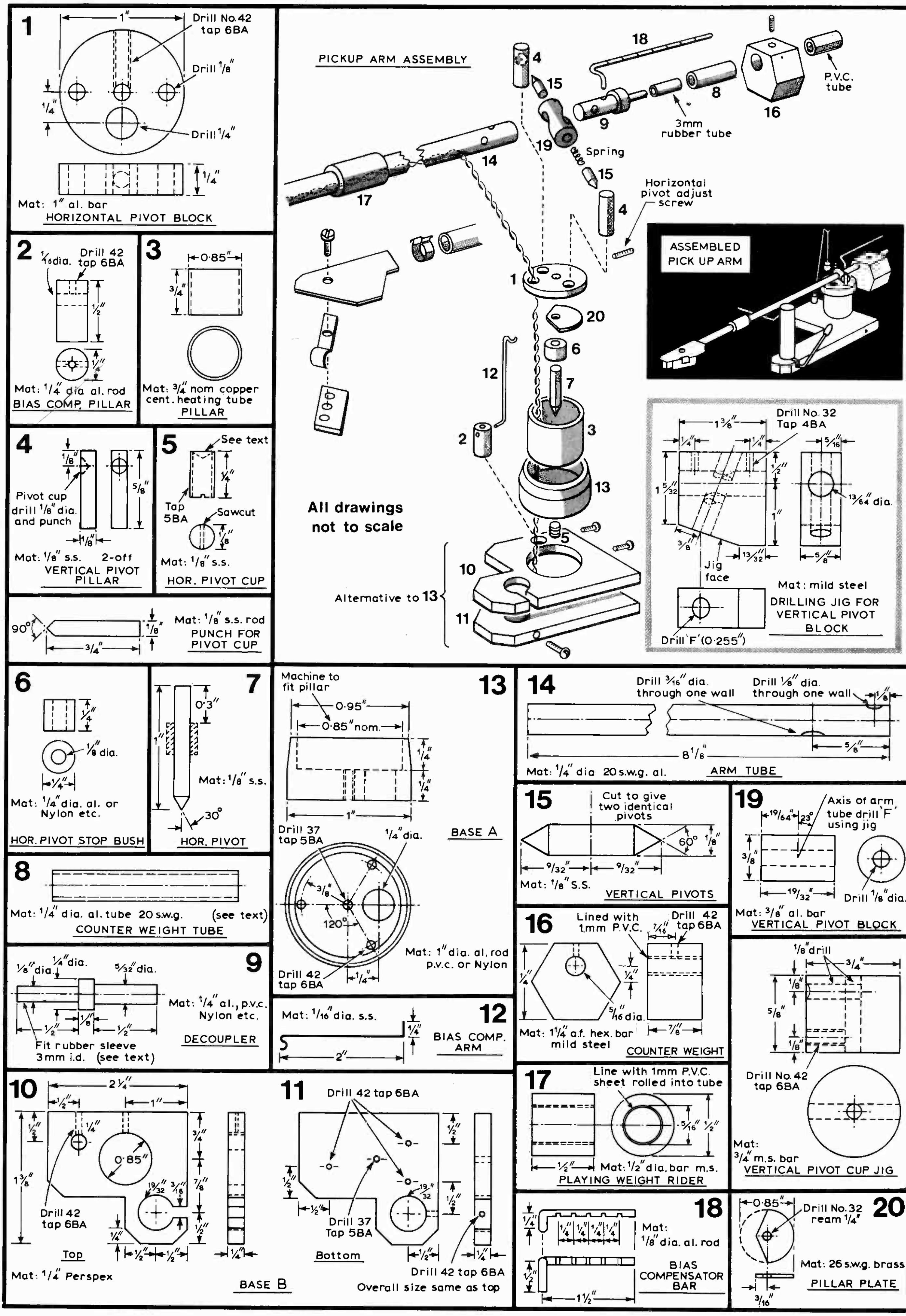
cause excitement which could damage the disc groove. This design is damped by ensuring that the counterweight is flexibly coupled to the arm. This effectively spoils any modes of mechanical resonance.

Record warp causes large vertical pickup-arm movements and it is important that the stylus remains normal to the record surface. Making the vertical pivot axis normal to the axial line of the cartridge, as in this design, gives a better approximation to correct movement than making the axis normal to the whole arm.

Construction is described in the drawings and in the supplementary notes which follow. The material for the counterweight is steel, but this can be replaced by any high-density material such as brass—though the dimensions may have to be changed to maintain the correct weight. When making the decoupler, which fits into the counterweight tube, ensure the wide end is a comfortable push fit into the arm tube. Fit a 3-mm internal dia. rubber sleeve over the smaller end and push into the counterweight tube, checking that the tube does not touch the decoupler.

The vertical pivot block is drilled at an angle to accept the arm tube. This is a difficult operation in practice without the aid of a jig and so a suitable design is shown. The material required is a 1-in length of $\frac{3}{4}$-in dia. aluminium bar which is inserted

In this photograph, the pickup arm has a different shell to that shown in the diagrams. A drawing showing how to make this version — heavier, though possibly aesthetically more acceptable — is available from the editorial offices.


1
Drill No.42 tap 6BA
Drill 1/8"
Drill 1/4"
Mat: 1" al. bar
HORIZONTAL PIVOT BLOCK
2
1/16 dia.
Drill 42 tap 6BA
Mat: 1/4" dia al. rod
BIAS COMP. PILLAR
3
0·85"
Mat: 3/4" nom copper cent. heating tube
PILLAR
4
Pivot cup drill 1/8" dia. and punch
Mat: 1/8" s.s. 2-off
VERTICAL PIVOT PILLAR
5
See text
Tap 5BA
Sawcut
Mat: 1/8" s.s.
HOR. PIVOT CUP
Mat: 1/8" s.s. rod
PUNCH FOR PIVOT CUP
PICKUP ARM ASSEMBLY
P.V.C. tube
3mm rubber tube
Spring
Horizontal pivot adjust screw
ASSEMBLED PICK UP ARM
All drawings not to scale
Alternative to 13
Drill No. 32 Tap 4BA
13/64" dia.
Jig face
Mat: mild steel
DRILLING JIG FOR VERTICAL PIVOT BLOCK
Drill 'F'(0·255")
6
1/8" dia.
Mat: 1/4" dia. al. or Nylon etc.
HOR. PIVOT STOP BUSH
7
Mat: 1/8" s.s.
HOR. PIVOT
13
Machine to fit pillar
0·95"
0·85" nom.
BASE A
Drill 37 tap 5BA
1/4" dia.
Drill 42 tap 6BA
Mat: 1" dia. al. rod p.v.c. or Nylon
14
Drill 3/16" dia. through one wall
Drill 1/8" dia. through one wall
Mat: 1/4" dia 20 s.w.g. al.
ARM TUBE
8
Mat: 1/4" dia. al. tube 20 s.w.g. (see text)
COUNTER WEIGHT TUBE
9
1/8" dia.
1/4" dia.
5/32" dia.
Mat: 1/4" al., p.v.c. Nylon etc.
Fit rubber sleeve 3mm i.d. (see text)
DECOUPLER
12
Mat: 1/16" dia. s.s.
BIAS COMP. ARM
15
Cut to give two identical pivots
Mat: 1/8" S.S.
VERTICAL PIVOTS
19
Axis of arm tube drill 'F' using jig
Drill 1/8" dia.
Mat: 3/8" al. bar
VERTICAL PIVOT BLOCK
16
Lined with 1mm P.V.C.
Drill 42 tap 6BA
Mat: 1 1/4" a.f. hex. bar mild steel
COUNTER WEIGHT
1/8" drill
Drill No. 42 tap 6BA
Mat: 3/4" m.s. bar
VERTICAL PIVOT CUP JIG
10
Drill 42 tap 6BA
Top
Mat: 1/4" Perspex
BASE B
11
Drill 42 tap 6BA
Drill 37 Tap 5BA
Bottom
Drill 42 tap 6BA
Overall size same as top
17
Line with 1mm P.V.C. sheet rolled into tube
Mat: 1/2" dia. bar m.s.
PLAYING WEIGHT RIDER
18
Mat: 1/8" dia. al. rod
BIAS COMPENSATOR BAR
20
Drill No. 32 ream 1/4"
Mat: 26 s.w.g. brass
PILLAR PLATE

into the jig. Lock it into position by two 4BA screws. Using an F(0.255in) drill, pierce the aluminium bar by inserting the drill into the hole in the jig face with the jig held in a vice. After piercing, shorten the pivot block to the dimensions given.

A jig is also used to make the vertical pivot pillars. Hold the pillar in the jig while preforming the cup with a $\frac{1}{8}$-in dia. drill. The pillar should not be removed from the jig, however, before the pivot cup is formed using the punch shown. Heat the punch to cherry red, quench and polish. After punching, likewise harden the pivot cups. Form the horizontal pivot cup in the same way, harden both pivot and cup, and finally polish the pivot.

Two versions of pillar base are shown. Use version A—best made on a lathe—if the lift mechanism is not required. Base B accepts both the lift mechanism and bias compensator pillar. Bond the two parts of base B after they have been made with Evostik and spray if desired.

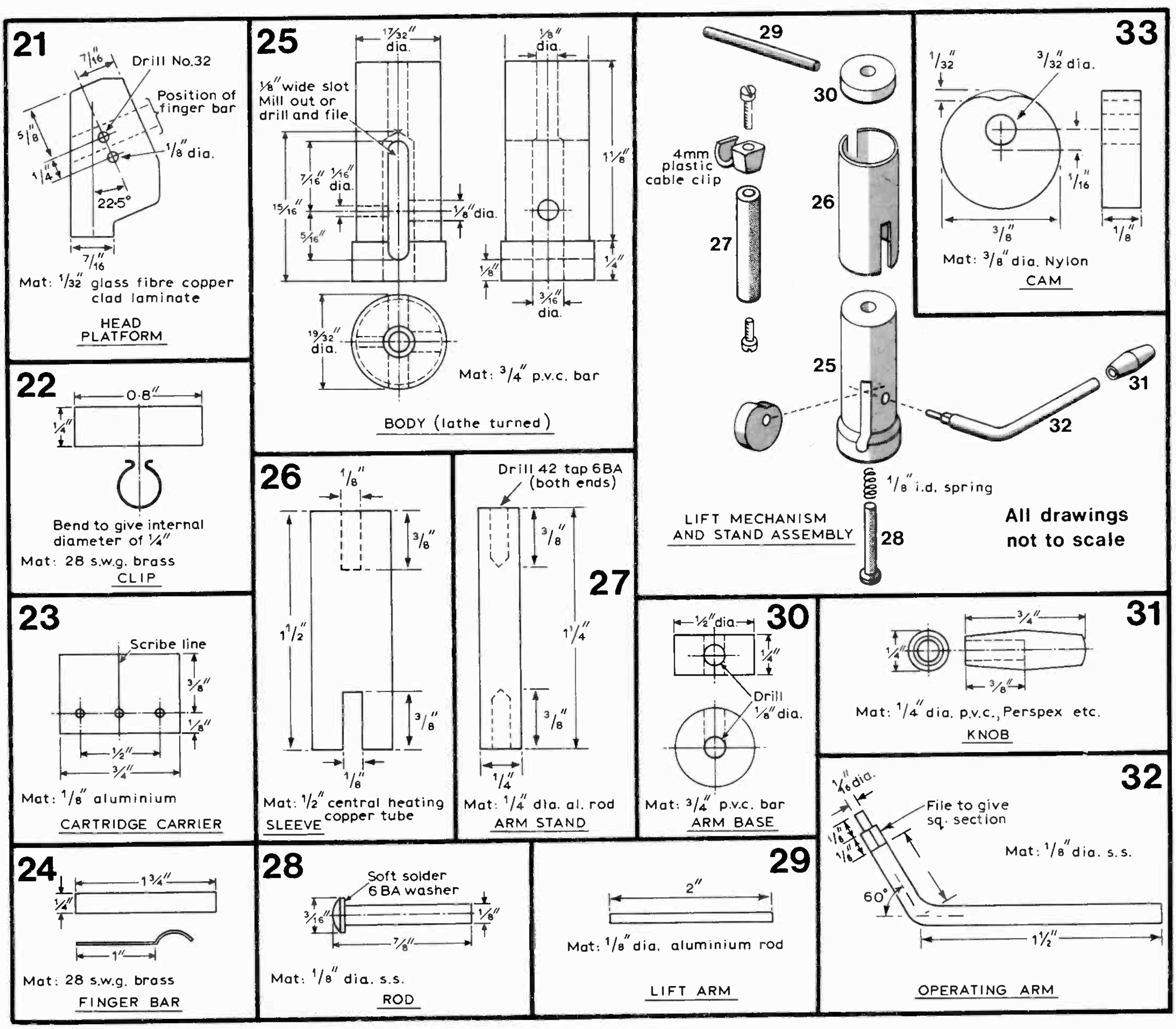
Assembly

Once the vertical pivot block and decoupler are assembled on and in the arm tube

Parts list

All turntable and pickup arm parts are available from Longdendale Technological Products, Hadfield, Hyde, Cheshire.

part	description/material
arm tube	$\frac{1}{4}$-in dia. × 20 s.w.g. Al tube (12-in)
vertical block	$\frac{3}{8}$-in dia. × $1\frac{1}{2}$-in Al bar
decoupler	$\frac{1}{4}$-in dia. × 1-in Al bar
bias compensator bar	$\frac{1}{8}$-in dia. × 3-in Al bar
horizontal pivot block & base A	1-in dia. Al bar (2-in)
horizontal pivot stop	$\frac{1}{4}$-in dia. Al bar
horizontal pivot and cup, vertical pivot & pillar	$\frac{1}{8}$-in dia. silver steel (13-in)
pillar plate, finger bar & clip	28 s.w.g. brass or copper
pillar	$\frac{3}{4}$-in dia. nom. copper central-heating tube (2-in)
head platform	$\frac{1}{16}$-in copper-clad laminate
base B	$\frac{1}{4}$-in Perspex sheet
counterweight	$1\frac{1}{4}$-in a.f. mild steel hex. bar (1-in)
cartridge carrier	$\frac{1}{8}$-in Al
playing weight rider	$\frac{3}{4}$-in mild steel bar
vertical pivot loading spring	from Longdendale Technological Products
bias compensator pillar	$\frac{1}{4}$-in dia. Al rod
bias compensator arm	$\frac{1}{16}$-in dia. s.s. (13-in)
socket-head grub screw	6BA × $\frac{1}{4}$-in (6 off)
pickup-arm wire nylon thread	about 18-in
bias compensator weights	appropriate lengths of $\frac{1}{4}$-in dia. brass rod
lift mechanism	
body & arm base	2-in × $\frac{3}{4}$-in p.v.c. bar
lift and operating arm & rod	$\frac{1}{8}$-in silver steel (7-in)
cam	$\frac{3}{8}$-in nylon
sleeve	$\frac{1}{2}$-in nom. copper central heating tube ($1\frac{1}{2}$-in)
spring	$\frac{1}{8}$-in i.d. × $\frac{1}{4}$-in long from Longdendale Technological Products
knob	$\frac{1}{4}$-in dia. p.v.c., Perspex etc. (1-in)



respectively, use the vertical pivot block as a jig to complete the $\frac{1}{8}$-in dia. axial hole through the arm tube and decoupler. A small amount of Araldite or Evostik ensures a permanent assembly. Now insert the spring and two pivots into the axial hole of the pivot block as shown.

Bond the vertical pivot pillars into the pivot holder with Araldite with the cups accurately aligned inwards. After setting, insert the vertical pivot block between the pillars by squeezing the pivot loading spring in the pivot block over the pivots. This is a tricky operation requiring a little patience and, hopefully, only one spring! The resulting pivot should be completely free from sticking and quite stable.

Bond the horizontal pivot-stop bush to the horizontal pivot after it has been hardened and polished. Insert the square-cut end through the $\frac{1}{8}$-in hole in the pillar plate. Assemble the base to the pillar.

Fix the vertical pivot pillar holder on to the horizontal pivot by the grub screw. Screw the horizontal pivot cup to the pillar base until the bush tightens against the top of the pillar. Slacken off $\frac{1}{4}$ turn and lock with cellulose paint. Adjust the vertical

measured as the distance the stylus overhangs the centre of the turntable. Using the adjusting screw on the head, adjust offset angle to give zero tracking angle—i.e. angle of stylus to groove at a distance of 2.4in (2.375) from the turntable centre and then at a distance of 4.6in (4.606) from the turntable centre. There should be very little difference in tracking angle. If it is discernible check the positioning of the arm base, the effective length and overhang.

Calibration

The playing weight rider can be omitted, in which case the playing weight must be set up each time using a suitable balance. If the rider is used the arm can be calibrated against either a 'pressure' gauge or a set of weights. In either case stick a piece of plasticine to the cartridge platform. Its weight is not important but it should be roughly equal to the weight of a cartridge—say 6 or 7g.

If you use a pressure gauge, adjust the counterweight to balance the arm with the rider as close to the pivots as possible. Moving the rider away from the pivots will

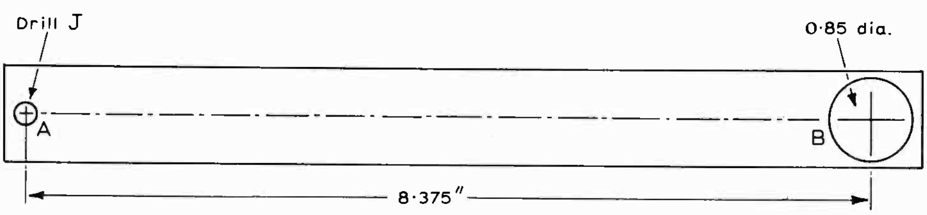


Fig. 2. When turntable and pickup arm are assembled place hole A over spindle and hole B over pickup arm pillar. Draw round the base to mark selected position.

pivot block to give a clearance of about 0.025in.

Wiring should present no problem if it is done before the arm is fitted to the pickup-arm board. Remember to mark one of the wires at both ends for identification. It may help if a piece of stiffer wire is threaded first so it can be used to pull both of the coaxial wires through at once. The two wires can be terminated on a small tagboard underneath the pickup-arm board or on to a plinth-mounted socket.

Performance of the arm is improved by using the bias compensator. Possibly the best way of setting up the compensator, for a spherically-tipped stylus at least, is with an unmodulated disc. But be prepared for some experimentation.

Setting up the arm

A jig for assembling the arm to the pickup-arm board is shown in Fig. 2. It should be used with the turntable in place, the small hole being placed over the spindle. The other end should be slipped over the pickup-arm pillar. The arm's position should then be selected and marked.

Effective arm length should be nine inches — i.e. the distance from stylus tip to centre line of vertical pivots. To do this slide the head of the arm either forward or backward along the arm tube. The overhang is designed to be 0.625in and is

unbalance the arm and increase the playing weight. Relate distance from the pivots to playing weight using the pressure gauge.

If you use weight, stick four 1-g weights to the plasticine (assuming a maximum playing weight of 4g). Adjust the counterweight to balance with the rider close to the pivots. Remove one of the weights and move rider away from pivots to rebalance. Mark the arm. Repeat this procedure removing one weight at a time until all have been removed. Half-gram markings can be inserted by interpolation as the scale will be linear.

A third article will describe a wow and flutter meter and how to check turntable performance.

Wide-stage stereo

Some readers of E. J. Jordan's article 'Loudspeaker Stereo Techniques' (*Wireless World* Feb. 1971) may like to know that the author has developed a practical design based on the 'reflector delay-line system', which can be adapted to suit individual requirements. Readers interested in having such a system built should write direct to E. J. Jordan, 22 Hyde Green, Marlow, Bucks.

Announcements

An equipment contract worth over £10M for Europe's largest international telephone exchange, has been awarded by the British Post Office to Plessey Telecommunications. The equipment is for part of the first unit at Mondial House — the new international telephone exchange under construction on a $2\frac{1}{2}$ acre site adjacent to Cannon Street Station, London. Apart from the massive switching complex, Plessey will design, develop and install International Accounting and Traffic Analysis Equipment. The heart of the I.A.T.A.E. is an on-line computer which will provide information on a call duration/route/destination basis for the clearing of international charges.

Blueline Electronic Components, a new distributor company at Refuge House, River Front, Enfield, Middx, (Tel. 01-366 6371), has been set up by ITT Components. It is completely independent of ITT Electronic Services and has been formed as a franchised distributor — 'not to sell ITT lines'. Blueline has six franchises: Texas Instruments; Bourns; Plessey capacitors; Union Carbide solid tantalum capacitors; International Rectifiers; and Keyswitch Relays.

The BBC has placed an order with Pye TVT for **'sound-in-sync' equipment** comprising 40 encoder and 61 decoder units. The system enables both sound and vision signals to be transmitted over a single land line in place of the current two-line system.

British Communications Corporation Ltd. of Wembley, have been awarded a contract by the Ministry of Defence covering the pre-production aspects leading to the supply of **v.h.f./f.m. manpacks** for the 'Clansman' military communication project.

Computer Automation Inc., of California, designers and manufacturers of minicomputers and associated equipment, have formed a **U.K. subsidiary company** called CAI Ltd. at 95a High Street, Rickmansworth, Herts.

Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey CR4 7JA, have signed an agreement to market in the United Kingdom the **semiconductor and thin film** products manufactured by A. S. Akers Electronics, of Norway.

Granger Associates Ltd, of Weybridge, has been appointed exclusive sales representative for Jampro Antenna Company, of California, manufacturers of **broadcast aerials** for v.h.f. and u.h.f. applications and associated equipment.

The McMurdo Instrument Co., Rodney Road, Portsmouth PO4 8SG, in conjunction with Alliance Technique Industrielle, of France, are marketing a range of **miniature connectors** built to the French CCTU 0811 specification.

Data Devices Ltd, Abbey House, Farnborough Road, Farnborough, Hants, has been appointed exclusive U.K. agent for the range of data terminals, modems and input/output devices manufactured by **Terminal Equipment Corporation,** of New Jersey, U.S.A.

Euro Electronic Instruments, Shirley House, 27 Camden Road, London N.W.1, has been appointed sole agent in the U.K. for **Electro Optical Industries Inc.,** of Santa Barbara, California, makers of wave analysers, digital voltmeters, amplifiers and noise measuring equipment.

News of the Month

A step in the right direction

Farnell Electronic Components Ltd, component distributors, are to be congratulated for their latest policy on prices. They have just published a new catalogue and they have given an undertaking not to increase any of their published prices before 31st March 1972. Any manufacturers' price increases will be absorbed by Farnell and will not be passed on to customers.

Conferences by television

Groups of people in five large cities can now converse and see each other by means of Confravision, the conferences-by-television service just introduced by the British Post Office. Special studios have been built in London, Birmingham, Manchester, Glasgow and Bristol, and are designed so that they can be operated by the users themselves. Each studio has a vidicon camera, with a remotely controlled two-turret lens which will take in either five people or the central three of them in close-up; two 24-inch monitor screens, allowing each group to see themselves as well as the other group; an overhead vertically mounted camera for transmitting documents; and microphones and a tape-recorder. There are two sets of duplicate push-button controls, one for use by the chairman of the group and the other, at a side desk out of view, for use by a secretary. Small pairs of monitors are provided for both the secretary and the document display operator.

Video signals, which are on the normal 625-line monochrome 5MHz bandwidth standard, are sent from the studio's equipment room by coaxial cable to the nearest network switching centre (e.g. in London the Post Office Tower), and thence over the Post Office's microwave radio network on a standard television channel as used by the broadcasting organizations. (It is understood that these channels are in fact television standby channels originally provided for broadcasting signal distribution but seldom if ever used as such.) Sound is carried over music quality lines, but there is a possibility that sometime in the future it could be sent with the video signal by the 'sound-in-sync' technique. *Wireless World's* reporter, in London, took part in a discussion with a group in Bristol and found the system easy to get used to. The only minor drawback is that with five people displayed on the monitor it is difficult to see immediately which person is speaking. Some method of visual indication would be helpful. The pictures as seen at the demonstration did not appear to be up to the normal broadcast standard of clarity, and the sound, considering that it came over a music line, was somewhat distorted and muffled.

The cost of using the service? £120 per hour for up to 125 miles (e.g. London-Birmingham) and £180 per hour over 125 miles (e.g. Glasgow-Bristol).

Taxi 'mayday'

Members of an independent taxi association in New York are to use an RCA radio system to alert their headquarters in case of a robbery or other emergency. By operating a concealed switch, a driver will be able to signal, without a passenger's knowledge, that an emergency exists. A controller, after consulting a log of the cab's earlier movements to determine its general location, can summon help by calling the police or contacting other cabs near the one in distress.

The alarm is part of a two-way radio system which relays messages in number code as well as by voice. Automatic equipment in dispatch headquarters prints out a log showing the taxicab's identifying number, the time the message was received, and sounds a bell. Aside from emergencies, the RCA mobile radio will be used to advise the dispatcher via a coded message that a cab is available to pick up a passenger. The system automatically transmits a return signal from the dispatcher that lights an 'acknowledge' lamp on the cab's dashboard to indicate the driver's message was received. The entire transaction takes a little more than a second. The digital system is expected to find other applications in the trucking and related industries.

Data for the individual

A. Marshall & Son (London) Ltd, 28 Cricklewood Broadway, London N.W.2, are offering a mailing service to the general public which gives information and prices on the range of components stocked and will enable them to publicize small quantities of parts. Subscribers will be provided with a loose-leaf binder in which to collate all the information. A charge will be made of £1 per annum for the service and subscribers will be entitled to certain preferential discounts.

Radio controlled clocks

The 170 town clocks of Vienna have been modified so that they are now controlled by means of radio impulses. Until recently the clocks were controlled over telephone lines, and they often showed incorrect time because the same lines were used for fire alarm purposes. An alarm could result in one or several impulses being lost, which in turn caused the town clocks scattered over the city to show different times. The radio-controlled system, which was designed by the municipal engineers of Vienna in collaboration with Storno engineers, employs two crystal-controlled main clocks which in turn are controlled by the observatory of Vienna. The maximum error that can occur is now 20ms.

Complex hybrids

A small West German company called Microelectronic has introduced a high packing density system for thick-film hybrid circuits. Lewicki, the designer, claims to be able to achieve four times the packing density of conventional hybrids at only twice the cost.

The new hybrid consists of two ceramic substrates held slightly apart by small soldered risers. The space between them is sufficient to allow chips to be attached to all four substrate-surfaces thus providing the equivalent of four hybrid circuits in each device. In this way, using 25 × 12mm substrates, up to 80 components can be attached. Interconnections between opposite sides of each substrate are made around the substrate edges. This eliminates the need for punching holes and reduces cost. In addition to holding the substrates apart, the risers provide interconnections between each substrate and form the external leads for the dual-in-line package.

Churches television centre

Just outside Watford, there is a country house which has just had a large, six-camera, television studio added. The building is the headquarters of the Churches Television Centre whose object is to spread the Christian message using television. The centre has an outside broadcast unit and gives training in television and sound broadcasting techniques in an effort to make maximum use of modern ways of spreading information. Television programmes made at the centre, and recorded on video tape, are copied on to 16mm film for distribution throughout the country.

Marine simulator

A digital marine radar simulator is to be designed and produced by Marconi Space and Defence Systems for a nautical college currently being built at Hull. The simulator will help to train students to tackle the hazardous and crowded shipping situations which will become an accepted part of their daily lives. The simulator mimics a ship's bridge, including radar display, helm controls, echo sounder, radio direction finder, and other instruments. A student can navigate his 'ship' through any exercise conditions which the instructor sets. The situations to which he has to respond might range from collision avoidance action in busy seaways to navigating along fog-bound shores. The 'ship's' manoeuvring reactions are preset in the simulator's computer, and can be varied to represent any size of ship, from supertankers to small trawlers. Provision is made in the trainer for the special fishery training requirements of the Hull and Grimsby trawler fleets, and for research into ship and port control situations.

The trouble with ATS-3 and receiving it in the U.K.

A jammed aerial control system in the satellite ATS-3 recently caused the almost four-year-old experimental satellite to stop transmitting weather pictures as well as other data.

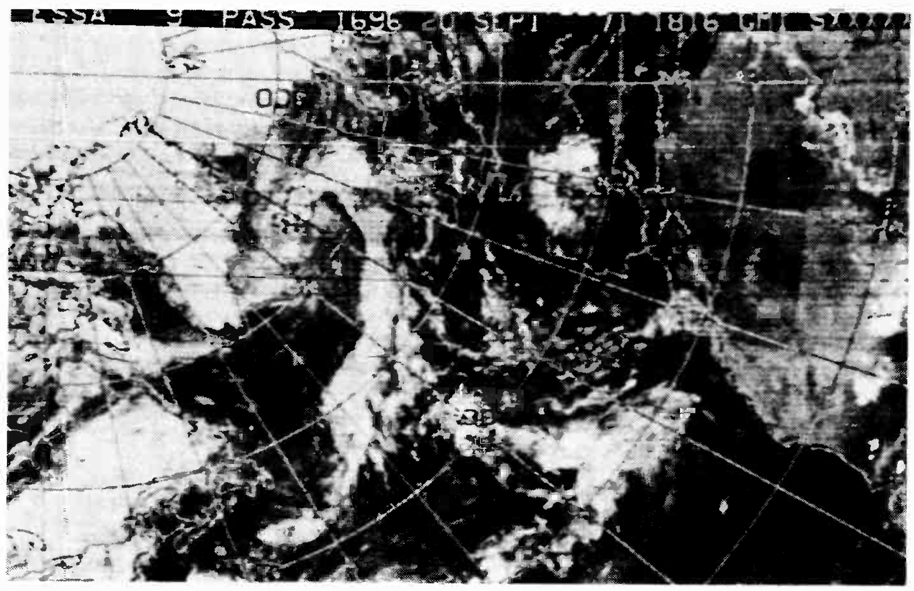
N.A.S.A. officials believe the spacecraft gets heated up when the sun is north of the equator in the summer—and, as the aerial is located on the top and north side of the spacecraft, it probably overheats the drive system causing it to stop spinning.

The spacecraft spins at 100 revolutions per minute and the aerial spins in the opposite direction at almost the same speed which, when coupled with the motion of the satellite in its orbit, keeps the aerial pointed toward Earth.

About mid-July officials at N.A.S.A's Goddard Space Flight Center, had trouble making the aerial drive at the necessary speed. A few days later it cleared up and worked well. Then in early August the problem began again only this time the aerial spin rate went to zero.

The sun has now moved farther south and, as in previous years, ATS-3 is on the air again and is being used in an automatic weather picture experiment. The object is to prove that a geo-stationary satellite can transmit weather data to a wide area as indeed it can as shown by the photograph received by Westminster school, using the equipment described in this and last month's issues of *Wireless World*, direct from ATS-3.

The picture was taken by the satellite ESSA-9 (which does not use the normal automatic picture transmission system) and was transmitted on command to an American ground station. The picture was then sent to Mojave in California where the grid and coastline were added. The modified picture was then transmitted in normal a.p.t. form to ATS-3 whose internal transponder re-transmitted it at 135.6MHz. ATS-3 is stationed at longitude 70°W over Colombia which means that the Westminster school aerial had to be positioned with a bearing of 255° and an elevation of only 3°. The range was about 22,000 miles — quite an achievement for home-made equipment. Incidentally, readers who wish to receive ATS-3 are warned that interference can be expected from aircraft transmitters which use adjacent channels.



Applying 'Bosworth' in radio and radar instruction

As a result of the university/industry liaison recommended by the Bosworth* report to start courses in product technology, a compromise has been worked out between industry's need for staff-release periods which are not too long and universities' pleas for adequate lecturing time.

The Electronic Engineering Association and the University of Birmingham have organized a Bosworth M.Sc. course in radio-communications and radar technology consisting of nine sessions. Each session lasts from one to three weeks and is a course in itself in a particular subject. The sessions are designed to allow engineers to attend only those lectures which are of interest to them. Experience gained during 1970/71 showed that it was desirable to arrange all the lectures for three days of any one week allowing short-course students to return to their firms for the remaining two working days.

Under the chairmanship of Mr. G. S. Bosworth a working group set up to examine the education and training requirements of industry issued two reports: an introductory one, 'A review of the scope and problems of scientific and technological manpower policy', H.M.S.O. Oct. 1965, and 'Education and training requirements for the electrical and mechanical manufacturing industries'. H.M.S.O. 1966.

Progress in Acoustics

Seventh International Congress on Acoustics, Budapest

by N. F. Spring, B.Sc., A.R.C.S., M.Inst.P.*

It is now well past the time that acoustics could be referred to as the 'Cinderella of the sciences'. More than 700 papers were presented at this year's international acoustics congress, so this report is more than usually selective. The selection problem is eased by my total ignorance of large sections of acoustics. For example, I feel singularly unqualified to comment on voiced/voiceless probabilities of Serbo-Croatian speech sounds, and *Wireless World* readers hoping for a discussion of the acoustical features and perceptual cues of the four tones of standard colloquial Chinese will be disappointed.

Electro-acoustics

One of the most widely used devices for the production of artificial reverberation in broadcasting and recording is the reverberation plate. The decay of flexural vibrations in a carefully made steel sheet, $2m^2$ in area and 0.5mm thick, simulates the reverberation of a room remarkably well. For some time now the inventor of the reverberation plate, W.Kuhl (I.R.T., Hamburg) has been developing a smaller version, hoping to make it small enough to fit into the boot of a car and also to eliminate the slight residual metallic colouration of the existing plate. Dr. Kuhl's written work on the new plate has been tantalizingly sparse so far and it was not surprising that his Budapest paper "Eine Kleine Nachhallplatte" was extremely well attended.

* B.B.C. Research Department

Fig. 1 shows the reverberation time/frequency characteristics of the existing large plate and of an experimental plate having an area of $0.1m^2$ and a thickness of 0.02mm. To maintain the eigentone density, a reduction of surface area of the plate must be accompanied by a proportional reduction in thickness; the difficulties in making a successful mini-plate arise from this fact. The lower surface density of the new plate (more properly described as a foil) means that the various sources of unwanted damping are much more effective and it is difficult to maintain the required reverberation time at high frequencies. There are also difficulties with the transducers, whose mass cannot be permitted to be more than a few milligrams if attached to the foil. Kuhl's paper gave a very clear summary of the problems but was less informative about solutions. One hopes that it will not be too long before a commercial version of the mini-plate is available.

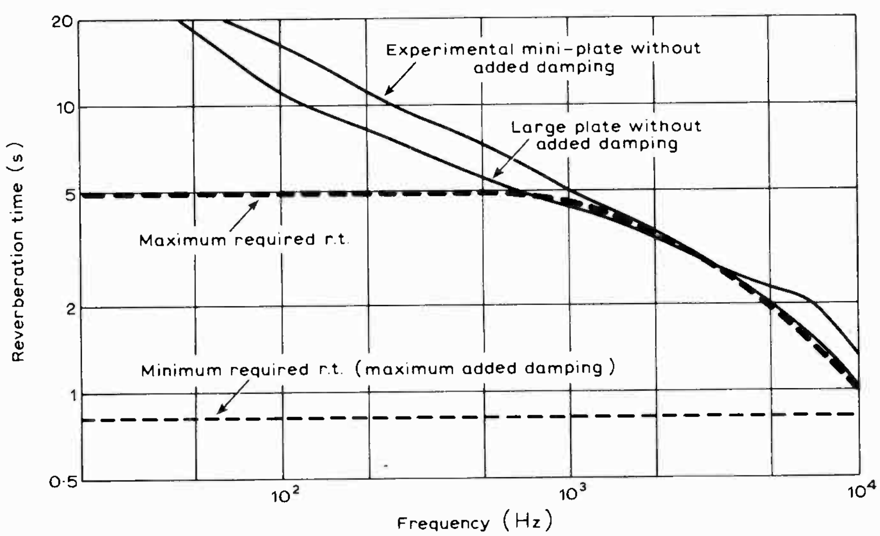


Fig. 1. Reverberation time/frequency characteristic of experimental reverberation plate only $0.1m^2$ in area, compared with a standardized plate.

Barát and Viczián (Hungary) produced some fascinating colour pictures illustrating their technique for displaying sound field contours. Five differently coloured lamps are fixed onto a microphone and each lamp is arranged to switch on when the sound pressure level at the microphone falls within one of five different narrow ranges. To trace out a contour of constant sound pressure level, one merely moves the microphone so that one lamp stays switched on. An open-shutter camera in front of the sound source will then record a set of isobars of different colours. A set of colour slides showing the patterns in front of a bass-reflex loudspeaker at different frequencies was very instructive, and a 'picture' of sound leaking through a door indicated that the technique might be useful for investigations in the field as well as in the laboratory.

Open-loop high-frequency cut-off in audio power amplifiers can result in momentary 100% intermodulation distortion according to M. Otala (University of Oula, Finland). Transient clipping occurs when a rapidly rising voltage is applied to the input terminals. If the open-loop cut-off frequency is not very high, then the negative feedback does not act quickly enough to reduce the amplified input signal and overload occurs. Otala's contribution has been to present a theory of this type of distortion which enables the duration of the distortion to be calculated. In practical terms the results indicate that an amplifier can be blocked off for 1ms by quite small transients. Measurements on three popular commercial amplifiers were presented. One, a Danish amplifier, employed judicious local feedback and gave no sign of distortion. The worst of the other two, a nominally 20-watt amplifier, had a distortionless output power of only 0.15W, which went below 10mW when the tone control was set for maximum treble boost. The next step required is the acquisition of data on the subjective importance of this type of distortion.

The pioneers of the electret microphone, G. M. Sessler and J. E. West (Bell Telephone, U.S.A.), gave some examples of the latest work on electret transducers. The dielectric polarization in an electret is almost completely attributable to charge displacement and very little to dipole

This 1/8-scale model of a studio has been used by the B.B.C. in listening tests to determine how the acoustics of the real studio might be improved.

alignment. Work over the past two or three years has shown that the most rapid and consistent method of producing a uniform charge distribution at the surface of the electret is simply to fire an electron beam at it. The high capacitance per unit area of the foil-electret microphone and the fact that there is virtually no physical limitation on size means that large units having a high capacitance can be made. One such unit, when fed into a high input resistance amplifier, had a frequency response ranging from 1mHz to 10kHz and was used to record infrasonic radiation from Apollo 10. A more down-to-earth application is for a touch-dial for telephones (Fig. 2). Touching the metallized-foil electret through one of the holes displaces it and generates a voltage pulse across a resistor wired between the metallizing and the underlying backplate.

A. Boleslav (Czechoslovakia) described a method of measuring the frequency response of a woofer without the use of a free-field room. A pressure gradient microphone is placed in the centre of the mouth of the loudspeaker, close to the diaphragm. Provided certain conditions are met, the results are close to those obtained in a free-field room.

Room acoustics

There were several papers on acoustic modelling of one sort or another. Of the theoretical models, Strøm (Norway) described an investigation on room shapes by use of a computer model, using ray-tracing techniques. Although the method involved gross over-simplifications, some interesting tentative results have been obtained. Rectangular halls typical of the 19th century, possessing a high rating according to Beranek's scale, showed a relatively even spatial distribution of the impinging energy and there seemed to be a certain concentration of reflected energy in the time interval 50 to 100ms. Highly rated modern halls also gave similar results, except that the concentration of energy was found to be in the 20 to 50ms time interval. In contrast, modern halls having a low rating showed an uneven distribution of impinging energy both in space and time; also the directional distribution of reflections did not seem to be so uniform.

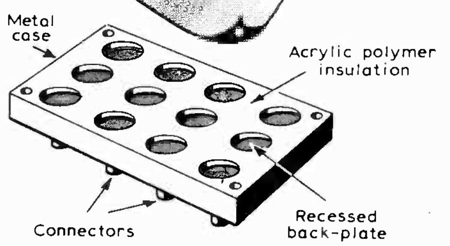


Fig. 2. Touching the metallized foil electret through one of the holes displaces it, producing a voltage pulse across a resistor connected between electret and backplate.

A. N. Burd described the continuing work on the BBC's $\frac{1}{8}$-scale model of a large orchestral studio. In spite of formidable engineering difficulties, recordings can now be made in the model having a weighted signal-to-noise ratio better than 52dB and with colourations from the transducers at a level sufficiently low so as not to mask the acoustical characteristics of the model. Demonstration recordings were played to show the similarity between music reproduced in the model and that reproduced in the real studio. Listening tests on a number of simple modifications to the model have suggested ways in which the acoustics of the real studio might be improved.

Gilford and Gibbs (University of Aston), are concerned with the use of $\frac{1}{4}$-scale models to investigate the characteristics of sound transmission in building structures. Whether such models are valid or not depends partly on the way in which the internal losses of the modelled materials vary with frequency and amplitude. The authors' measurements show that internal losses are not a large factor in transmission loss along structural elements of a building for the common building materials in use today. The losses could, however, affect the airborne transmission of sound through panels and walls to a significant extent. These losses are therefore a potential source of error in models attempting to scale airborne transmission.

The assisted-resonance system installed in the Royal Festival Hall has been very successful, notwithstanding the fact that no satisfactory theory of its detailed behaviour has yet been devised. G. Dodd (Southampton) has been studying the characteristics of peaks in the transmission response of rooms, and in his paper he concludes that the room behaves like a simple damped oscillator in the vicinity of well-defined peaks. The well-defined peaks are those which are chosen for assisted-resonance channels. Dodd's results suggest that a theory of assisted resonance simpler than those proposed hitherto might be possible.

Anyone contemplating planning the expensive facility of a free-field room or anechoic chamber, would do well to read the paper by Delany and Bazley (N.P.L.). They have produced a satisfactory method of predicting the performance of such rooms having an absorbent lining of plane sheets. They also reported progress towards predicting the performance of wedge-lined rooms at middle and high frequencies. Already the authors have produced some interesting results. The usual figure of merit of a free-field room is obtained by measuring the variation in sound pressure as a microphone is moved away from a point source of sound. In free space the pressure would vary inversely as the distance, so the figure of merit in a free-field room is obtained by considering departures from this inverse pressure-distance law. What Delany and Bazley found was that the mean deviation of the field from the true law varies only slowly as the frequency is increased in wedge-lined rooms; this behaviour is rather different from that observed with plane absorbent treatment where the performance improves significantly towards higher frequencies. They also found that for a given frequency in a wedge-lined room the r.m.s. deviation increases with increasing separation between the source and the microphone, and their final conclusion was that the presence of even small reflecting objects within the enclosure has a profoundly deleterious effect on the overall performance of a wedge-lined room.

A round-table discussion on subjective evaluation in room acoustics was opened by F. Kolmer (Czechoslovakia). Kolmer reminded us that in spite of its well-known shortcomings, the reverberation criterion is still the only generally accepted objective criterion which corresponds with subjective evaluation of the acoustics of a room. After reviewing the recent work on improvements to objective measurements and attempts to establish subjective evaluations, Kolmer concluded that the connection between the subjective perception and the objective description of the acoustic field is the missing link in room acoustics. The discussion from the floor was conducted very energetically. The fact that it was held almost entirely in German emphasized the difficulties of the concepts involved, especially if they are to be discussed internationally. British workers in this field have encountered considerable difficulties in applying names to the subjective qualities being evaluated. Terms like bloom, sheen, brilliance, and so on are bad enough, but what are we to make of Räumlichkeit, Halligkeit, Raumeindruck and Durchsichtigkeit? (Incidentally it seems that the recent British work in this field—e.g. Hawke's work at University College, London—was not widely known.)

New objective measurements in room acoustics are still being vigorously pursued, especially those concerned with the impulse response of rooms. R. Kürer, in his introduction to a round-table discussion on the subject, focused attention on recently proposed parameters such as early decay time and early reverberation, including Kürer's own parameter Schwerpunktzeit (a sort of centre of gravity of the envelope of the decay curve).

Acoustic surface-wave devices

Developments in acoustic surface-wave (a.s.w.) devices were the subject of an invited paper by E. G. S. Paige (R.R.E., Malvern). Progress in the past five years has been impressive and it is now possible to make the front-end of a television receiver including r.f. amplifier, local oscillator, mixer, channel selector, i.f. filter and i.f. amplifier using these devices. The planar structure means that their fabrication is compatible with that of microelectronic circuits.

The basically simple structure of a surface-wave delay line having interdigital transducers is shown in Fig. 3. The system resonates when the wavelength equals the spacing between the fingers, and the bandwidth is given simply by the resonant angular frequency divided by the number of finger pairs.

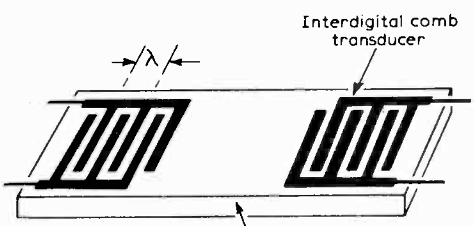


Fig. 3. In acoustic surface-wave devices the system resonates when the wavelength equals the finger spacing. Bandwidth is inversely proportional to the number of finger pairs.

Many other a.s.w. substitutes for electronic devices are possible, such as matched filters for pulse-compression systems, directional couplers, tapped delay lines and decoding filters. Even the non-linearities have been exploited recently in an a.s.w. convolver.

An interesting feature of an a.s.w. filter is that the arrangement of the fingers in the transducer looks like the impulse response of the filter, with the weighting corresponding to the degree of finger overlap. Dr Paige foresees the possibility that, with the development of many combinations of a.s.w. components in the future, large sections of electronics will be done without electrons.

Computers and acoustics

At the exhibition held at the time of the congress it was notable that all the major acoustical instrument manufacturers were offering measurement systems incorporating real-time frequency analysers and small laboratory computers to reduce the data from the analysers to a more digestible form. This development was also reflected in a number of the papers which discussed the use of such systems in, for example, sound power measurement, perceived noise level determinations and computer-controlled transmission loss measurement.

Other applications of computers were also evident and a round-table conference on the use of computers in acoustics was introduced by M. R. Schroeder (Göttingen University, formerly at Bell Telephone) with later support by Denes, Mathews and Risset (Bell Telephone). This might well have been called the Bell Labs Show. Professor Schroeder gave us a breathless and breathtaking account of the applications of computers to acoustical problems. Among the remarkable demonstrations was one on noise stripping. A recording of speech in the presence of noise so intense that the speech was unintelligible was processed so as to be virtually noiseless. The technique relied on computed estimates of the noise spectrum still remaining good estimates during the periods of speech, so that an accurate subtraction of the noise could be made.

The effectiveness of the predictive coding of speech was also demonstrated. The inherent redundancies in speech are utilized to predict the current sample of a speech signal from its past values. The difference between the true and predicted values is then coded. Even with only one-bit coding, the quality was remarkably good.

The next international acoustic congress is to be held for the first time in London, in July 1974.

Further reading

Proceedings of the seventh international acoustics congress are published in four volumes (2750 pages: abstracts only, 255 pages) by Akademiai Kiado, Budapest.

Otala, M. 'Transient distortion in transistorized audio power amplifiers' *I.E.E.E. Trans.* vol. AU-18, 1970, pp.234-9.

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Harwood, H. D. & Burd, A. N. 'Acoustic modelling of studios and concert halls'. International Broadcasting Convention 1970 (I.E.E. conference publication 69). See also *Wireless World* October 1970 p.484.

Marshall, F. G. & Paige, E. G. S. 'Novel acoustic surface-wave directional coupler with diverse applications'. *Electronics Letters* vol. 7, 1971, pp.460-2.

Mathews, M. V. 'The technology of computer music'. MIT Press, 1969.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Helical v.h.f. aerials

Mr. Monser's article on helical v.h.f. aerials in the September issue leads us to repeat our warning given in a letter in *Wireless World*, January 1969, which referred to the use of helical aerials for u.h.f. reception.

The argument still holds for Bands I and III where the planning of television v.h.f. stations in this country has been based on the use of mixed polarization to reduce interference between co-channel stations. It has been established by experiment, and is recognized internationally, that v.h.f. signal polarization is sufficiently well preserved even over long interference paths for an additional 10dB protection at 90% of locations against interference transmissions to be readily achievable with vertical and horizontal transmissions and the corresponding types of receiving aerial.

In Band II (f.m. sound) the use of mixed polarized transmission was not adopted because sufficient channels were available to obtain a good coverage without having to resort to this stratagem. The use of a helical aerial in Band II may have some advantage but the claimed advantage in respect of multipath propagation is not in general valid. Since it is agreed that reflections would have a greater tendency to change polarization than the direct signal, it would always be of some advantage, other things being equal, to match the receiving aerial polarization to that of the wanted transmission.

J. L. EATON &
L. F. TAGHOLM,
BBC Research Department,
Kingswood Warren,
Surrey.

Television sound quality

I hope Mr. Sear's recent experience ('Letters', October issue) has not discouraged him. There are two ways of improving television sound, which is of very good quality when transmitted.

At the risk of nullifying the maker's guarantee, the first thing to do is to find out if there is, in the set, any sound signal worth using. To do this, a 200W mains isolating transformer (NOT a Variac) should be connected between mains and the set. Next the detector output should be found and connected to a good amplifier (radio input). The TV set should be earthed at the amplifier input, and the connection on the chassis should be as near as possible to the detector diode load. If the sound thus obtained is satisfactory, the isolating transformer should be connected to the set using a 2-pin connector which is not compatible with the mains connectors. This will prevent accidents! If, with this (easy) modification, the quality is still not satisfactory, then a separate tuner will be necessary.

The cheapest way to provide one is to obtain an old valve television set which has a turret tuner. (Many dealers will gladly give them away.) This set should have everything unnecessary removed from it— the e.h.t. supply, vision circuits and c.r.t. Apart from enabling a smaller box to be used, this will reduce the h.t. load and hence improve the smoothing, and will eliminate those circuits as local sources of interference. The valve heaters which have been removed should be replaced by a suitable dropper resistor to enable the chain to operate from 240V. Next the sound i.f. strip should be tuned up to give maximum sound, consistent with acceptable vision buzz from the adjacent signal, and the output taken from the detector to the high-quality amplifier. For a transistor amplifier, it will probably be necessary to use a cathode follower between the detector and the output. The audio amplifier valve can most easily be utilized for this. To keep hum down, the common on the set from a point as near as possible to the detector should be earthed at the amplifier input, and nowhere else.

PETER SMALL,
Cavendish Laboratory,
Cambridge.

The following are extracts from a few of the many letters on this subject.

I chanced to come across an advertisement referring to an "Audio adaptor unit" which was exactly what I (and obviously Mr. Sear) was looking for.

It comprises a small compact unit, with a built-in isolating transformer, and comes complete in a teak box of only $3\frac{1}{2}$in cubic dimensions.

This unit, which feeds the audio output of the TV set to an external loudspeaker or amplifier, is obtainable from M.A.C. Electronic Co., Ripley, Surrey, under the reference AAU-TV, and costs about £8.

Finally, regarding TV (u.h.f.) tuners, there are to my knowledge two on the market, one made by Lowther Manufacturing Co., of Bromley, Kent, and the other by Motion Electronics of Addlestead Farm, Tonbridge Road, East Peckham, Kent. The latter firm also make v.h.f. television tuners.

M. TOOGOOD,
North Baddesley,
Southampton.

Upon purchasing a new portable television set, a Teleton TH14, I noticed that an earphone socket was provided. I have been in contact with the set manufacturers who have no criticism whatsoever with the piping of sound from this socket through an amplifier to loudspeakers, providing a far higher standard of reproduction.

C. E. HAYHURST,
Putney,
London S.W.15.

There must be a niche, somewhere along the spectrum between £60 rubbish and £300 luxury, for a set or range of television sets which will give improved performance and be reliable. Perhaps, like some tape recorders, we could have TV units with no sound amplifiers or speakers of their own but, having fully isolated chassis, are to be linked to the domestic hi-fi equipment. But manufacturers will not provide them if there is no demand; and there will be no demand if they do not make them.

T. R. MAHONEY,
London W6 8HE.

I have for some time been using a converter fitted to my Eddystone EB35 Mk 11/S which provides me with BBC-2 sound. This I feed into my high-quality amplifier and with the loudspeakers set around the television receiver, the improvement in sound quality is truly remarkable. Of course one could suggest that the programme planners get together so that we could enjoy in stereophony on the Radio 3 transmitters some of the excellent musical programmes of BBC-2. The Corporation could also, possibly, save some programme costs as the BBC-2 concerts are very acceptable in sound only.

R. M. CARROLL,
Stratford upon Avon

For the past year I have been using a Bang and Olufsen 24-inch monochrome receiver. While the sound quality from this is not exactly high fidelity it does deliver about $2\frac{1}{2}$W at fairly low distortion into a 9in × 5in speaker.

If true high-fidelity sound is required an outlet is provided direct from the demodulator which can be fed to an external amplifier.

Most people who buy black and white television sets do so, I believe, because they can't afford colour; if they have any money available above the cost of a monochrome receiver they would rather spend it on colour than on improving the sound quality.

B. DARLING,
Winchmore Hill,
London N.21.

People who complain about television sound are probably also those who are quite happy to pay £500 for a high-fidelity audio set up, and therefore would not object to paying £50 for the one-off modifications to the receiver.

One method is to construct a special receiver which is fed from the intercarrier output of the i.f. amplifier. Interconnection is made on the hot side of the ratio discriminator coil or, in the case of an i.c. discriminator and amplifier combined, on some pin found by experiment to contain some signal voltage. (For example, the quadrature coil.) A design for such a receiver, not too difficult to construct, has been published.

A somewhat cheaper alternative might be open to the enthusiast daring enough to cut into his f.m. tuner to provide a 10.7MHz signal i.f. input to the existing strip. A frequency changer could then be constructed to convert the 6MHz to 10.7MHz and feed it to the tuner.

JOHN DE RIVAZ,
Barnet,
Herts.

'These tell-tale women . . .'

Tsk! Tsk! What *is* 'Vector' saying? (October issue). Does he think no further than the end of his quill pen? While agreeing with him regarding the proliferation of obscure acronyms for the various exhibitions, seminars, etc., etc., I must point out the danger with which one of his alternatives is fraught. Can you imagine the reaction of our ever-loving wives when they accidentally turn over the pages of our diaries, and for sometime in May find the following entry:—'London—Frieda' (or Janice, or Laureen)?

D. JONES,
Newbury,
Berks.

Correction

'Incremental indicator': The Comark instrument described in 'New Products' in September (p.461) has a resolution better than 10μV and provides 30 ranges of 1mV f.s.d.

Breakthrough in Integrated Circuits

Ferranti plump for collector diffusion isolation

A simple bipolar integrated circuit process which allows low-cost production with most of the advantages of m.o.s. i.cs is announced by Ferranti. Devices are made by the collector diffusion isolation technique first investigated* at Bell Telephone Labs about 3½ years ago. The technique did not make much impact when announced, no doubt because of the low 3-V breakdown voltage of devices. But after looking at various production processes for i.cs, like the tri-mask, base diffusion isolation and silicon gate techniques, Ferranti recognized the potential of c.d.i. and spent two years developing the process to increase the breakdown potential to allow circuits to be used with 5-volt supplies — directly compatible with conventional bipolar digital i.cs. Not that c.d.i. devices are confined to digital electronics — in fact both linear and digital circuits can be combined on the same chip. Ferranti have designed a series of c.d.i. functional building blocks and are developing circuits for application to automotive systems, battery desk calculators, consumer durables, telecommunications and custom logic arrays. Among devices already in production are a high-speed random access memory and a 1024-bit shift register. They expect most of their custom designed i.cs to c.d.i. in two to three years.

Conventional bipolar devices suffer from high-power dissipation, large chip area and the production process involves nine steps. Unipolar (m.o.s.) devices in contrast have low power dissipation, small area per function and only five masking steps. But they are severely limited in speed, they pose handling problems unless protective circuitry is included, and have a higher packaging cost. The c.d.i. bipolar technique allows circuits to be produced in only five steps instead of nine, with high complexity, high speed, low propagation delay-dissipation product, and low chip size (see Table 1).

Characteristics of a typical device are shown in Table 2. High f_T and low series resistance give the high-speed capability of the devices. Current gain is maintained at a higher level than in ordinary bipolars at both high and low collector currents.

Because the devices do not rely on surface properties of semiconductors—as in m.o.s.—they are less susceptible to ionic contamination and have the high stability and ruggedness of conventional bipolar devices. The masking steps in the production process follow a five-step sequence of: buried n⁺ diffusion, isolation diffusion, emitter diffusion, contact holes and

Table 1. Comparison between conventional bipolar, m.o.s. and c.d.i. bipolar gates

	c.d.i. bipolar	m.o.s.	bipolar
chip area (static gate)	20	30	100 ($10^{-3}in^2$)
dissipation	2	1	10mW
propagation delay (for above diss.)	5	100	10ms
delay-dissipation product	10	100	100pJ

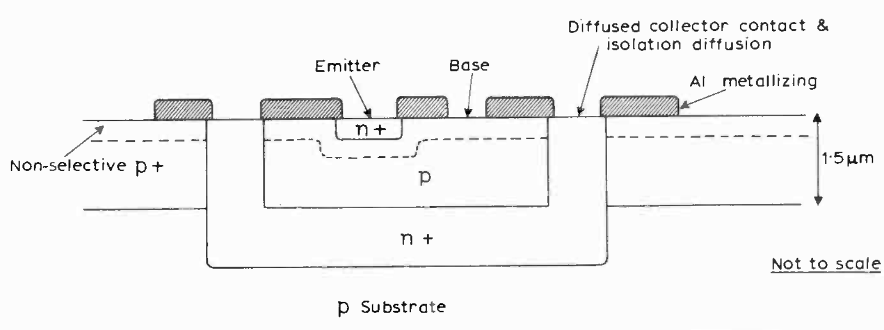
Table 2. Typical c.d.i. device characteristics

BV_{CBO}	7.5V	V_{offset}	5mV
h_{fe}	60 typ	I_{CBO}	1pA
f_T	1GHz	h_{fe} inverse	20
R_{sat}	10Ω	C_{ob}	0.3pF

interconnections. The low thickness of the player (1.5μm as opposed to 5μm for t.t.l. and 10μ for m.o.s. — normally n-type in conventional devices) and the passivation technique used results in only shallow oxide steps on the surface make metallizing easier. Ferranti are not disclosing precise process details at present but they say the increase in collector-base breakdown voltage is a result of changing the sheet resistivity of the non-selective p⁺ layer and changing the epitaxial layer thickness and resistivity. The problem of storage delay — usually circumvented by gold doping or with Schottky diodes — caused by hole storage in the collector does not arise. (The n-type layer in a conventional device is now an p-type layer, see diagram) and storage that occurs in the *base* is reduced by wiring an additional emitter to the base. This dual emitter facility means that devices can be produced with or without delays, as dictated by the circuit, with virtually no difference in cost.

A potentially competitive process is Fairchild Isoplanar† using isolation by oxidation and etching, but Ferranti say c.d.i. is better because it involves less etching, and less time (by an order of magnitude) in the furnace for oxidation (isolation by diffusion is much quicker), greatly reducing the possibility of building up stresses in the silicon.

*Murphy, B.T., *et al*, 'Collector diffusion isolation' *Proc. I.E.E.E.* vol. 57 1969 pp. 1523-7.
†Deltzer, D & Herndon, W, 'Isolation method shrinks bipolar cells . . .' *Electronics* vol. 44 1971 pp. 52-5.



Electrostatic Headphone Design

Instructions for making a simple and inexpensive high-quality unit

by Philip D. Harvey, B.Sc.

The design described below, like that published in 1968[1], is based on the constant charge push-pull principle schematically illustrated in Fig. 1. The constant charge is derived by feeding the diaphragm from a high resistance *R*, and relying on the capacitance of the earphone to store the charge.

Basic requirements in construction are that:

1. the fixed plates be rigid, acoustically transparent, and both flat and conducting on the inner surface;
2. the spacers be flat, of uniform thickness and, above all, insulating; and that
3. the diaphragm be flexible and light.

In all, three models were constructed. In producing fixed plates for the final model the electro-mechanical analogy described in Appendix B was used.

Stroboscopic examination of an earphone had shown that the diaphragm behaves as an elliptical vibrating piston with major and minor axes set by the spacers. These dimensions were set at 75×45 mm to cover the ear. A short transmission "tunnel" is employed to improve low-frequency coupling with the ear. This extension is lined to reduce resonances.

The fixed plates are of single-sided copper-plated fibre-glass. Hole area is 30%—sufficient to ensure acoustical transparency without sacrificing rigidity. The holes must be deburred after drilling.

To remove the risk of charge leakage at the edges of the board and at the connecting bolt holes (due perhaps to tearing of the diaphragm and consequent shorting) about 2 mm of copper is removed from the edges of the board round the connecting bolt holes (see Figs 2 and 3) to prevent charge leakage should the diaphragm tear at the edges.

The spacers, made of polyvinyl acetate, are cut in one piece from a sheet to avoid poorly insulating joints. These are drilled, using the fixed plates as templates, and deburred.

To make a safe connection of high voltage leads, two methods can be employed for the outer plates:

(a) Alternate unrounded corners of each fixed plate are removed to allow a connection to be made to the other fixed plate. Plasticine can be used for insulating the connection. The principle is illustrated in Figs 4 and 5.

(b) A small hole may be drilled in one corner of the fixed plate, and the copper side of the board slightly countersunk. The insulation of the signal wire is then stripped off, the inner being tinned and fed through the hole, as shown in Fig. 6. The well, created by countersinking, is now filled with solder which makes good contact with both the wire and copper plating. By grinding this surface flat we have a good safe connection.

To insulate the diaphragm connection it was decided to utilize the insulating properties of both the fixed plates and the transmission tunnel. The connection was brought to the surface of one fixed plate by a brass bush as shown in Fig. 7. The connection was then made harmlessly between the tunnel and board.

The film for the diaphragm is prepared by taping it crease free over a wooden frame of inside dimensions 200×250 mm. The frame, with the film now flat and under tension on its upper surface, was placed over a sheet of glass 240×190 mm of slightly greater thickness than the frame. Under these conditions it was easier to rub Aquadag on and off the film. This should be continuous until surface resistivity is $10^8\,\Omega$. The prepared film is next mounted on one spacer using double-sided Sellotape with the resistive side exposed, and laid on to the other spacer and a fixed plate with the brass bush inserted. The brass bush

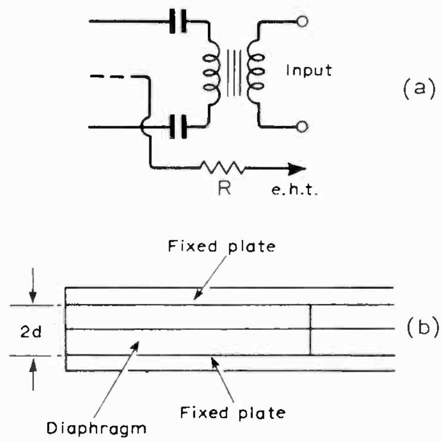


Fig. 1. Push-pull electrostatic sound generator.

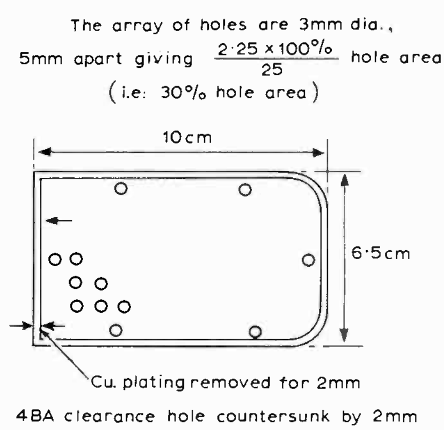


Fig. 2. Plan view of fixed plate.

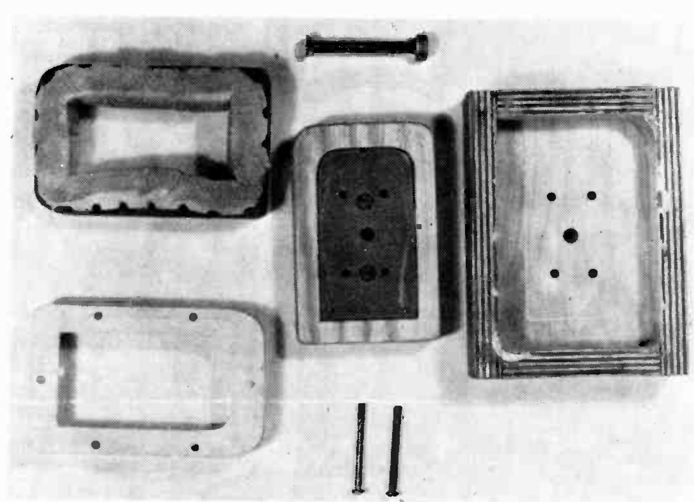


Fig. 3. Mould used for the transmission tunnel, and typical results achieved.

[1] 'High-quality Electrostatic Headphones' by J. P. Wilson, *Wireless World*, Dec. 1968.

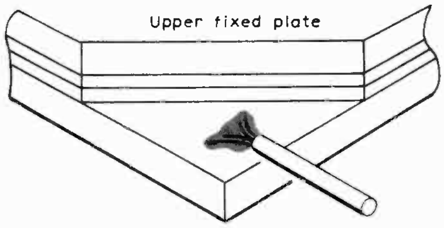


Fig. 4. One corner of final model.

now contacts the resistive coating, although it might be necessary to use some Aquadag on the contacting surfaces. The other fixed plate is laid on the assembly, followed by the transmission tunnel ready drilled, enabling the parts to be fastened together with nylon nuts and bolts. The components are shown in Fig. 5.

Before testing, the earphone is heated by warm air to tighten the diaphragm and remove any slight creases in it.

Transmission tunnel details

The transmission tunnel must be light and strong, and transmit the sound produced by the earphone to the ear. The simplest shape to do this is shown in Fig. 9. The only readily available group of materials to fulfil the above conditions is the plastics. These also have an advantage of damping incident sound, whereas metals tend to 'ring'.

The idea of casting the tunnel from polystyrene was investigated. Experiments led to the use of a wooden mould. It was found that if the mould was left overwaxed, then the excess wax was melted during the ensuing catalytic process, and this enabled the polystyrene to be removed from the mould whilst it was still pliable. Provided it was well supported whilst setting fully, the result was quite acceptable. Both the mould used (made of two parts for easier positive removal) and a typical positive are shown in Fig. 3.

Tunnels of both clear and coloured polystyrene were made, and it seems that the colouring material used gave the tunnel added strength.

It was found that latex foam rubber, used for lining the tunnel because of its excellent sound absorbing properties, was best cut on the bandsaw.

Variation of the other component elements

Under given conditions of signal and bias voltages, the two components affecting the earphone's performance are:

(a) The spacers—the thickness of which determine E and hence sound output. Spacer thicknesses of 0·18, 0·25, 0·37, 0·62 and 1 mm were tried. Decreasing the spacer thickness did not alter the frequency response but raised the sound level. Construction difficulties increased as spacer thickness decreased due to the slight and unavoidable warping of the fixed plates. This did not become too bad until ionization of the air was also a problem (see below).

Silicon resin bonded paper, paxolin, and dry paper were also tried as spacer materials. No difference was observed in the performance and it is concluded that any material having a resistivity greater than $10^{10}\,\Omega$ cm would be satisfactory.

(b) The diaphragm—through which no appreciable current should flow in less than half the time period of the lowest frequency to be reproduced. This ensures constant charge conditions. If one assumes the diaphragm to be perfectly conducting and the earphones to have capacitance C farads, and further that the lower limit of audibility is 27 Hz, then the diaphragm must be fed via a resistance R ohms, such that;

$$RC > \frac{1}{2 \times 27}\text{(approx.)}.$$

C is calculated as 330 pF from $C = \dfrac{\epsilon A}{d}$

$$\text{whence } R > \frac{1 \times 10^{12}}{54 \times 330} \text{ i.e. } R > 6 \times 10^7\,\Omega.$$

Due to the high value of this resistance it is easier to make the diaphragm resistive than feed it through an external resistance. Experiments were made with sheets of $10^7\,\Omega$ surface resistivity and greater. As expected the bass response improves as the resistance increases. The high-frequency

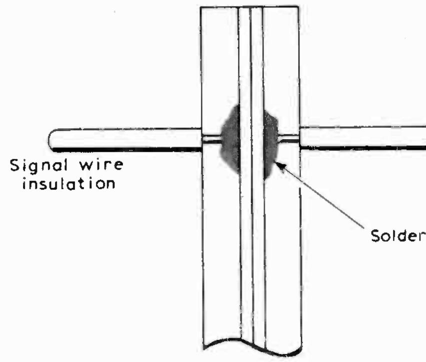


Fig. 6. Cross-section of alternative final model.

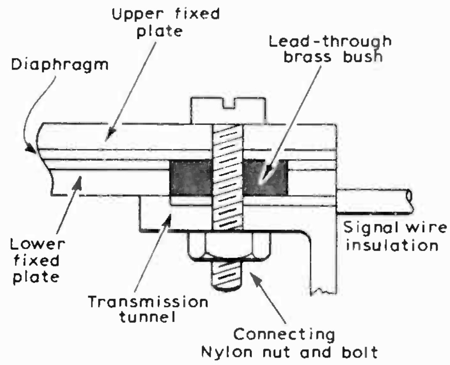


Fig. 7. Cross-section through connection to diaphragm.

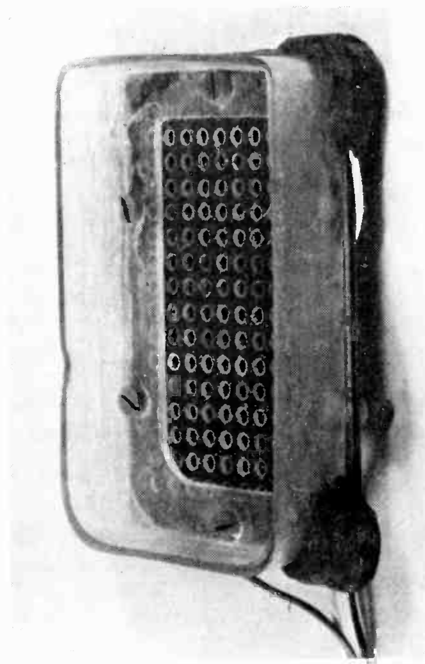


Fig. 8. The completed final earphone.

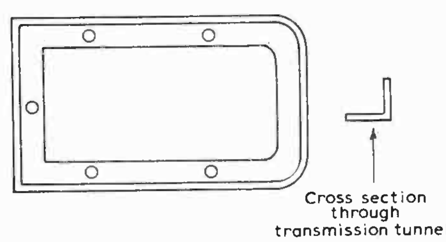


Fig. 9. Basic transmission-tunnel shape.

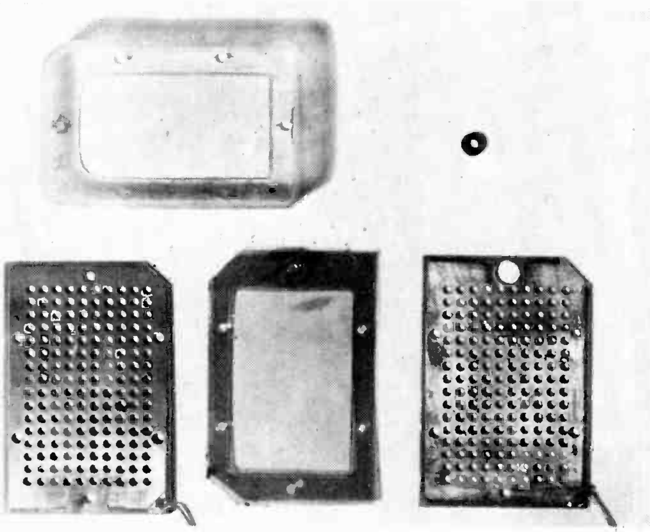


Fig. 5. Component parts of the final model.

response also improves, due presumably to the lower mass resulting from less graphite on the film. As some charging current must flow on to the diaphragm there is some limit to how high the resistance can be. Best results were obtained at the limit of measurability, i.e. a surface resistivity of approximately $10^9\,\Omega$.

Hospital anti-static polythene was tried and though it worked, the type available was thick and heavy, with a surface resistivity of only $10^5\,\Omega$. Hence both high and low frequencies suffered.

Various materials of the same type (Vitafilm) were obtained from local supermarkets. These were analysed spectroscopically and found to be the same material with the exception of that supplied by Sainsbury's. Microscopic analysis then showed that Vitafilm because of its porosity was not very suitable. The film made by The Borden Chemical Company was judged to be best closely followed by that made by Filmco in Durham.

Further tests to discover how best to apply homogenous resistive coating to the film were made on Borden's film. The use of evaporation techniques were first studied, but these posed three problems. In the conventional evaporator the film surface exposed was not large enough for an even film to be deposited over a sufficiently large area. Also at the low temperature required (not to destroy the film) oxidation of the depositing metal occurred. Finally when a film was deposited the metal permeated the plastic, altering its properties such that it became brittle and unusable.

Dry graphite powder rubbed into the surface did not alter its resistivity, presumably because the particles did not interlink and form molecule chains.

Finally a method was considered whereby a conducting medium could be sprayed as a solution in a liquid that would attack the film and hence give a permanently resistive surface. Graphite does not readily dissolve in any p.v.c. solvent, and so could not be used. A solution of silver in methyl acetate (Silver Dag) was sprayed on to a film, soaped to lower surface tension. The results were encouraging but a less active solvent would have to be used. Before pursuing this method, diluted Aquadag was substituted for Silver Dag and found to leave a completely uniform layer of graphite on the film when dry. Although this coating could be made fairly thick its resistivity remained immeasurably high until it was rubbed. Experience soon showed the amount that had to be sprayed for the required resistivity.

Drive circuits

Provisional model

The circuit shown in Fig. 10 employs the output stage of a commercial valve amplifier. The surface resistivity of the diaphragm must be greater than $10^8\,\Omega$ and hence the $10^7\,\Omega$ resistor in the feed line to the diaphragm is not necessary, but an added safety precaution.

It was found that the 0·01 μF isolating capacitors were sufficiently leaky to allow the outer plates to attain a high voltage, and the diaphragm could be earthed as an alternative form of bias. This makes the diaphragm an effective negative charge. This is not desirable because a steady high voltage on the outer conducting plates could be dangerous.

With the earphones in the circuit as shown, distortion was apparent, even at low acoustic levels. This was thought to be due to the output transformer. This amplifier was not designed to operate at maximum output continuously, and under these conditions inter-modulation distortion sets in. The earphones require a high voltage signal, but very little current. With this in mind an amplifier to deliver a distortion free signal was designed.

Designed valve amplifier

With a spacing of 0·37 mm (which changed by only 10% at full bass output) the maximum permissible voltage between the diaphragm and either fixed plate, to avoid ionization of the air between them, is 1000 V. With 300 V on the diaphragm this means that the maximum peak-to-peak voltage level on one plate can be 500 V. This leaves a large margin of safety for humid days or signal surges. The circuit of Fig. 11 was used giving only 400 V peak signal, as the valves and components were readily available. It gave no distortion observable on an oscilloscope, even without negative feedback, due presumably to the light loading on the amplifier.

Its use gave immediately discernible improvement in output level and fidelity.

Designed transistor amplifier

40 V rails are commonly available on transistor amplifiers and the circuit of Fig. 12 was built giving 32 V peak signal. Using 300 V rectified mains on the diaphragm gave a barely audible output.

The circuit of Fig. 13 was designed to give 300 V peak output. Any n-p-n silicon transistor with a $h_{fe}>50$ at 1 mA and a

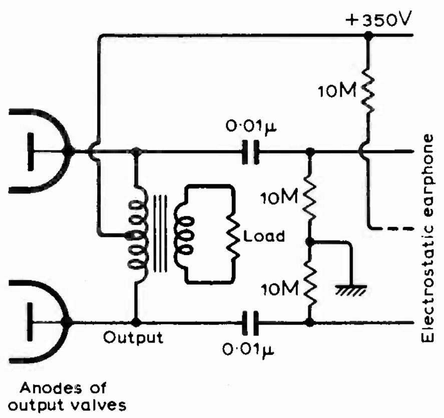


Fig. 10. Modified output of a commercial valve amplifier.

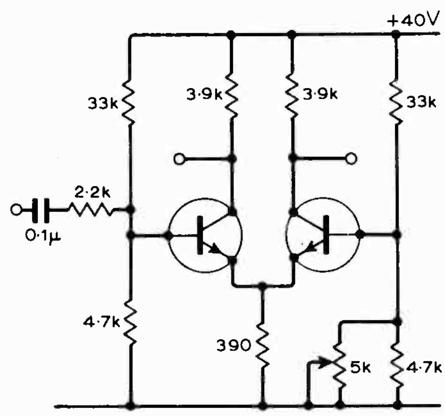


Fig. 12. Differential amplifier providing 32 V output.

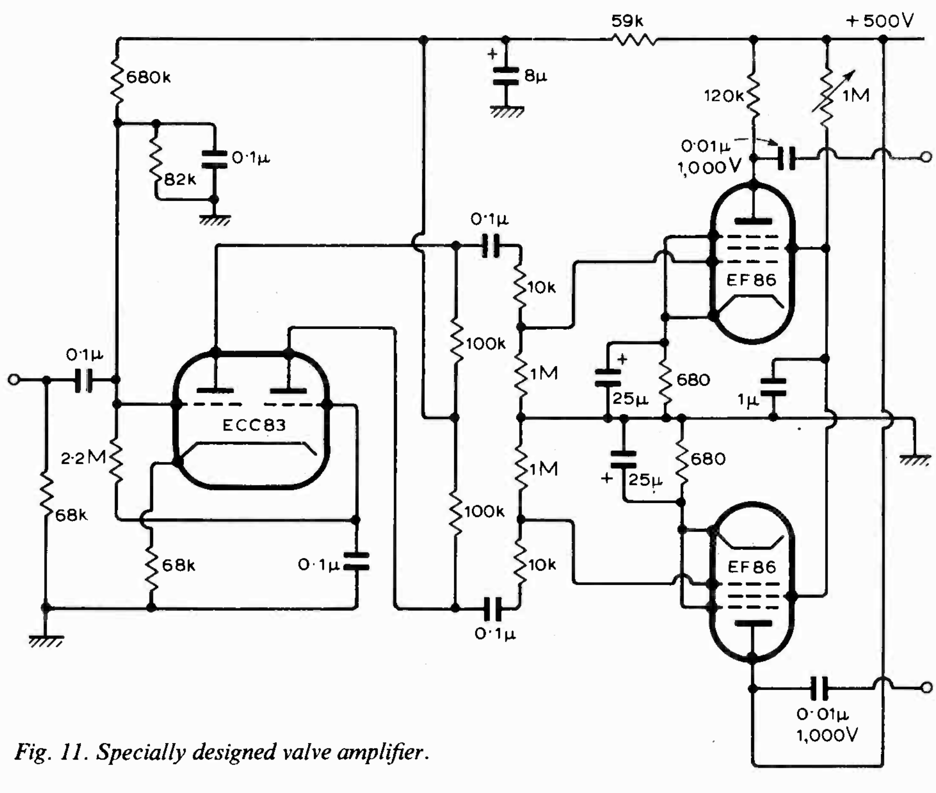


Fig. 11. Specially designed valve amplifier.

$V_{ce} > 35$ V will do for the first stage. The transistors in the differential stage should preferably be matched.

Three potentiometers are included to set up the amplifier to its optimum performance. First use R_1 to match the base voltages of Tr_1 and Tr_2; then adjust R_3 to make the average collector voltage of Tr_3 and Tr_4 115 V. Finally, using R_2, balance these collector voltages; repeat this procedure until both Tr_3 and Tr_4 collectors are at 155 V.

Measurement and analysis

From the section below and Appendix A the optimum of all the variables may be found. Although the thinner the spacers used the more the acoustic output obtained, it was found with the thinner ones (0·18 and 0·25 mm) that the air ionized on more humid days. This was apparent as a clicking noise, varying in repetition rate from one to ten hertz. It arose because constructionally the fixed plates are never equidistant from the diaphragm, and the air between the diaphragm and closest plate ionizes first. This allows attraction to the other plate increasing E, so that air here ionizes while the other reconstitutes itself. This effect is eliminated by reducing the voltage on the centre plate, but this necessarily reduces sensitivity.

The 0·37 mm spacers were therefore chosen and a plot of output versus central electrode potential revealed a levelling off at about 600 V. This is unexplained, but below this value the measured output is very near to the calculated value.

Many listeners were satisfied with volume and fidelity using 350 V on the diaphragm and the designed valve amplifier. There were many comments on the "depth" of the sound, which is due to the fact that plane waves are arriving at the ear, and these are normally associated with a distant source by the hearing mechanisms. When in use on a stereo system this effect makes it easier to identify the direction from which the sound appears to come.

Results achieved

Traces of the frequency responses are given with markings of 10 dB intervals and at the frequencies 20 Hz, 100 Hz, 200 Hz, 1 kHz, 2 kHz, 10 kHz and 20 kHz.

Fig. 14 gives the responses with different input signal voltages. The effect of increasing this voltage should be the same as decreasing spacer thickness. The relative graphs show this to be true, though the relative amplitudes differ.

Fig. 15 displays the difference made by altering the potential on the centre electrode.

Fig. 16 displays the difference in characteristic responses when plotted in the open air, and when plotted in the artificial ear.

Fig. 17 shows the best response achieved and corresponds to all the variables being optimised. The component specification for this is:

spacers—polyvinyl acetate 0·37 mm thick;

diaphragm—Borden Chemical's plasti-

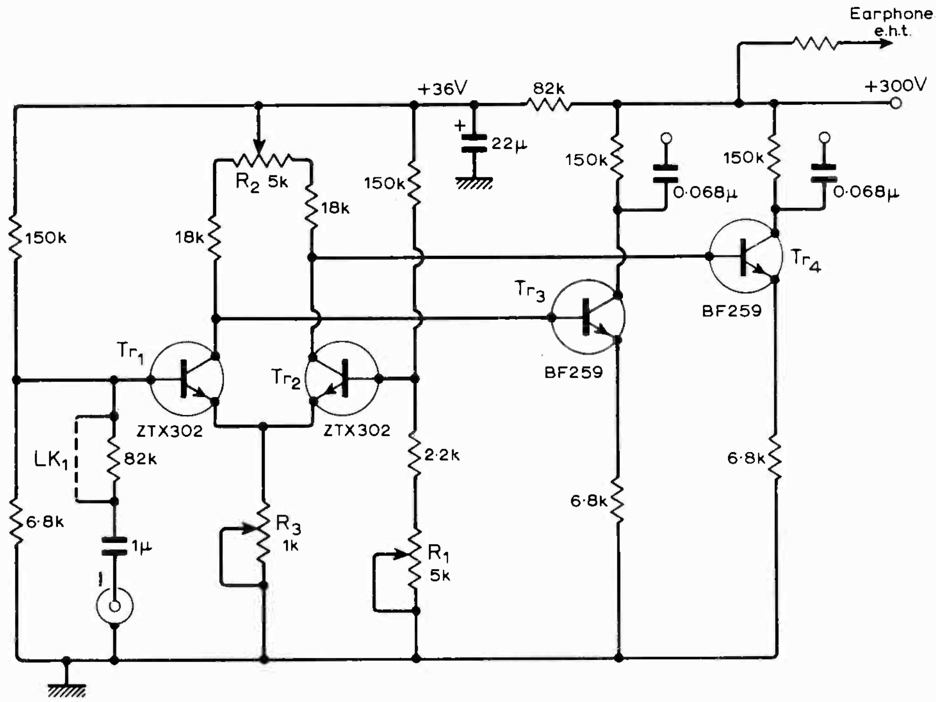


Fig. 13. Suitable transistor drive amplifier providing 300 V peak output.

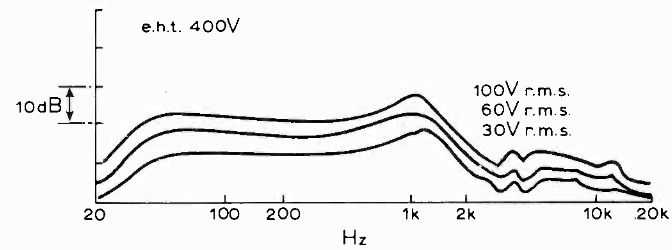


Fig. 14. Response for different signal-voltage levels.

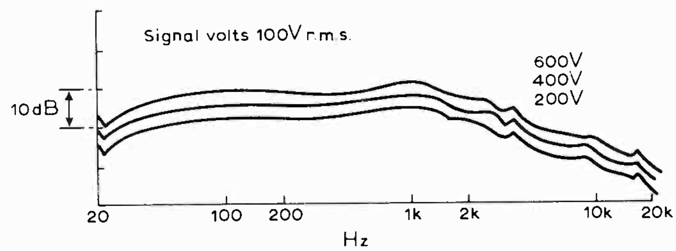


Fig. 15. Response for different diaphragm voltages.

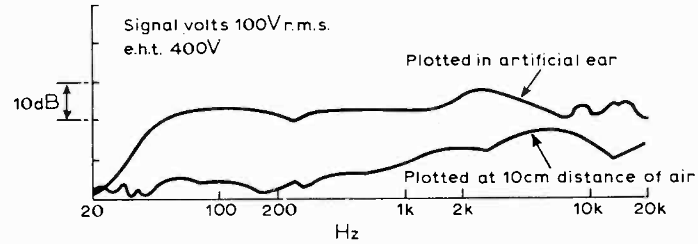


Fig. 16. Comparison of response in open air to that in artificial ear.

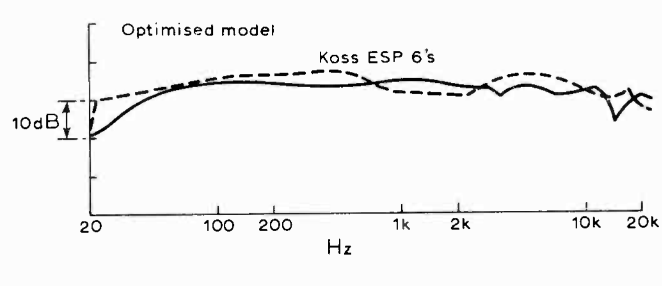


Fig. 17. Comparison of best earphone constructed with the published response of a Koss ESP6 unit.

cized p.v.c. sheeting 15 μ in thick, sheet resistivity $10^9\,\Omega$.

Safety

There are no uninsulated connections carrying high voltage near to the ear. Provided the connections at the signal generator are also well insulated, there is no danger of a fatal shock. There is always the danger of the diaphragm splitting, but even if it were to lacerate and protrude from a fixed plate, it would come up against the polyurethane foam the earphone is lined with. (This avoids cavity resonances in the sound conveyed to the ear, as well as insulating the ear.) If the diaphragm managed to touch the ear, then in the worst case at least $10^8\,\Omega$ on the film would allow only 3.5 μA to flow through the body, even assuming the body to be a dead short!

Suggested improvements

In order to achieve a broad frequency response it is essential to have slack suspension, and a low mass radiator. The first has been achieved by the use of a diaphragm which can be under quite high stress on its own plane, whilst a relatively low force can cause deflection in a transverse direction. In this design the mass of the radiator is no more than that of a layer of adjacent air a few millimetres in thickness. This could further be reduced by using a film resistive by manufacture.

The effect of resonances in this particular shape of diaphragm has not been investigated as the response curve does not indicate trouble of this kind. Three final points are worth making:

(a) The behaviour of the charge on the film is still largely unexplained as is the levelling off of the response with greater than 600 V on the diaphragm;

(b) Double-sided boards which prevent warping, along with more sophisticated construction techniques, should yield a system of adequate acoustic output using much smaller signal and bias voltages; and

(c) The quantities of different types of distortion present could be measured. Results obtained and listening tests indicate their virtual absence at low sound levels.

APPENDIX A

Measuring the response of the earphone on the ear

Without elaborate equipment, such as a probe microphone, this is difficult to do. Furthermore the earphones under test were not always safe to wear. For these reasons the ear was simulated for the tests. Artificial ears are readily available, and commonly have a volume of 6 cubic centimetres. The volume enclosed by the transmission tunnel is nearly twenty times this, and the addition of the ear's volume makes little difference to its response. The B & K microphone used for the tests was one inch in diameter, about the same as the opening to the ear. The flat wooden plate used for holding the microphone was lined with polyurethane foam, to simulate the coefficient of reflection of the skin.

The conventional B & K frequency plotting apparatus was then set up, and a constant peak-voltage sine-wave output fed to one plate with the other earthed. The inner electrode is maintained at, say 400 V by an h.t. supply. The frequency is swept continuously throughout the audio range 20–20,000 Hz, synchronized to a chart recorder into which the output of the microphone amplifier is fed.

Measuring diaphragm surface resistivity

Apply 250 V d.c. across two electrodes one inch long and one inch apart. The current flow is measured. Sufficient accuracy was obtained by quoting the result as $P \times 10^N\,\Omega$, where both P and N are integers.

APPENDIX B

The electro-mechanical analogy

This is employed to determine the output expected from the earphones, and the frequency response expected. The calculations performed assume values either already determined for the final model or values of the materials readily available.

Fig. 18 gives the equivalent mechanical circuits of the earphones, where the mass m is the mass per unit area of the diaphragm. The spring S is the suspension of the diaphragm in the transverse direction. The damping, $2R_m$ in the centre frequency band, is due to the impedance of the air. F_o is the peak force per unit area on the diaphragm.

Employing the electrical analogy of this circuit gives us Fig. 19. The mass per unit area becomes an inductance of M henries. The suspension becomes a capacitance of S^{-1} farads. The damping becomes a resistance of $2R_m\,\Omega$, and the force a voltage of $F_o \sin \omega t$ V.

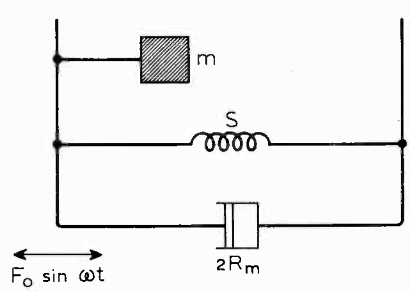


Fig. 18. Equivalent mechanical circuit of earphone.

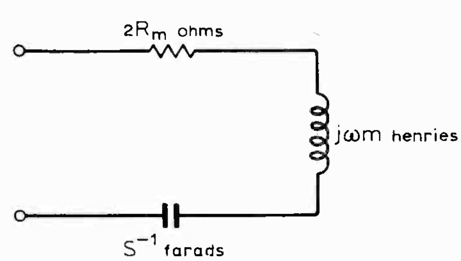


Fig. 19. Circuit given by the electro-mechanical analogy.

We know that:

$$M = 2{\cdot}4 \times 10^{-2}\ \text{kg}\ m^{-2}\ \text{(Vitafilm)}$$
$$2R_m = 2\rho c$$
$$= 820\ \text{Rayl in the mid-frequency band.}$$

S cannot be easily measured *in situ*, but a comparison with a conventional 4 inch loudspeaker indicated the same order of magnitude. It is calculated accurately knowing the free resonance to be at 55 Hz.

From Fig. 19 we know:

$$I = \frac{F_o \cos \omega t}{\left(2{\cdot}4 \times 10^{-2} j\omega + \dfrac{S}{j\omega} + 820\right)}\ \text{amps,}$$

and that at resonance I is real.

Hence
$$2{\cdot}4 \times 10^{-2} j\omega = \frac{S}{j\omega},$$

giving $S = 2{\cdot}4 \times 10^3$ newtons per metre. Because power $\propto$ current^2, the -6 dB points are given by

$$\frac{S}{\omega_L} = 820 \qquad \therefore \omega_L = 3$$
$$\omega_h m = 820 \qquad \therefore \omega_h = 35{,}000.$$

Therefore the -6 dB points are expected to be at ·5 Hz and 6000 Hz. In the region between these two points the movement of the plate is opposed only by the resistance of the air, so that the device is almost 100% efficient.

A light, thin material, such as that from the Borden Chemical Company considerably extends the flat response.

In order to determine the expected output, the equation $F_o = qE_o$ is utilised. The charge per unit area, q, is determined from the expression:

$$q = \frac{C \times V_{dc}}{\text{area}} = \frac{2\epsilon_o V_{dc}}{d},$$

where V_{dc} is the voltage applied to the diaphragm, and d is the thickness of the spacers:

Hence

$$F_o = \frac{2\epsilon_o V_{dc}}{\text{area}} \times \frac{v_o}{2d}$$
$$= 1{\cdot}95 \times 10^{-2}\, v_o\ \text{newtons per metre}^2$$

A loudness of 100 dBm is considered adequate, whence $F_o = 2$ newtons per metre^2.

This is achieved by signal voltages V_o of the order of 100 V in the region 6 kHz to 10 kHz. This is not a signal voltage sufficient to cause ionization of the air with 350 V on the diaphragm.

A suitable amount of the recommended plastic film, made by the Borden Chemical Company, will be sent from the *Wireless World* editorial department to any reader on receipt of *two* 2½p postage stamps.

Aquadag can be obtained in 75g jars, from stockists of the Acheson Colloids Co. products. It costs 22p (+ 10p packing and postage) from Ferguson and Timpson Ltd, 7–9 Sebert Road, Forest Gate, London E.7.

Circuit Ideas

Zero hysteresis trigger circuit

Where it is necessary to generate a fast rise-time square wave from a slowly varying input, the Schmitt trigger type of circuit is normally employed. However, the regenerative switching action usually results in considerable hysteresis. This means that the mark-to-space ratio will vary with the input signal amplitude. Further, the fundamental component of the square wave output will be phase delayed with respect to the input.

The circuit shown can give both zero hysteresis and an equal mark-space ratio provided the input frequency is known approximately. Multiple triggering due to high-frequency noise is also effectively eliminated. Tr_1 serves as a constant current source to the differential pair Tr_2, Tr_3. Regenerative feedback between the collector of Tr_2 and the base of Tr_3 is provided by R_1 and C_2. Switching occurs when the base voltages of these two transistors become approximately equal. During switching, the base voltage of Tr_3 changes by ± 5V. This inhibits further operation of the stage until the capacitor C_2 has discharged according to the approximate time constant C_2R_3. Provided this discharge is nearly completed during a half cycle of the input waveform the remaining hysteresis may be reduced to zero by adjusting R_1. Subsequent adjustment of R_2 then ensures an equal mark-space ratio at the output.

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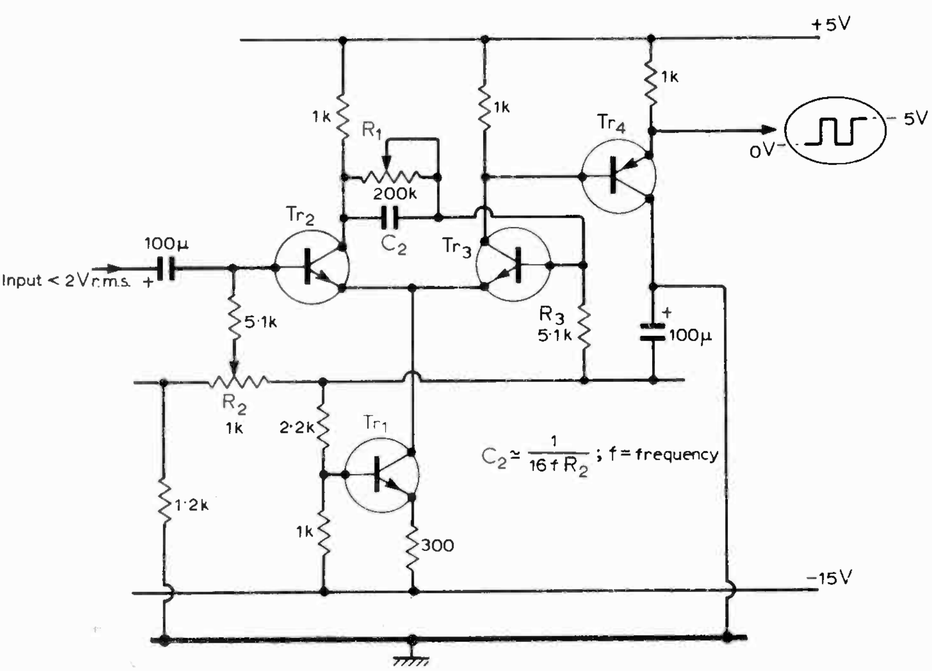
University College of Swansea.



Digital method of obtaining frequency difference

In developing the readout for an exclusively t.t.l. digital system it became necessary to extract, aperiodically with reasonable precision, the difference frequency between two square waves. The D-type flip-flop used (the SN7474) has the feature that, as the clock pulse goes to one (the positive clock edge) the D signal is transferred to the Q output, the transfer occurring in the 20-or-so nanoseconds characteristic of t.t.l.

Typically, a fixed clock frequency (f_c) of 50kHz was used and an equal mark-space ratio, variable frequency (f_d) applied to the D input. The Q output will reverse as the signals go in and out of synchronism, one cycle of output will occur every n cycles of the clock when n is the cycles between synchronism.

Thus $nf_c=(n+1)f_d$

hence $f_c-f_d=f_d/n$

The output pulse durations must be integers of the clock period. Thus there will be variations in individual durations of $\pm$ one clock period. The error is not cumulative, and typically if the sampling time is one second the frequency recorded will be the true difference frequency with the usual $\pm$ one digit uncertainty.

This method has been found to be a convenient and very advantageous way of obtaining a readout of difference frequency, being completely aperiodic, exclusively t.t.l., applicable over a wide frequency range and avoiding, the expensive incorporation of a reversible counter.

The case where the frequency difference is large is of practical interest. If $f_d=mf_c$ where m is an integer, the output will be unchanged (zero frequency) as the D signal is effective only at the instant of the clock edge. Similarly if $f_d=(m+\frac{1}{2})f_c$ the output will be f_c. Consideration will show that as f_d increases the output frequency will move linearity between the limits of zero and f_c to the ultimate performance of the device. Direct measurement has established that the performance expected from the analysis given is achieved in practice.

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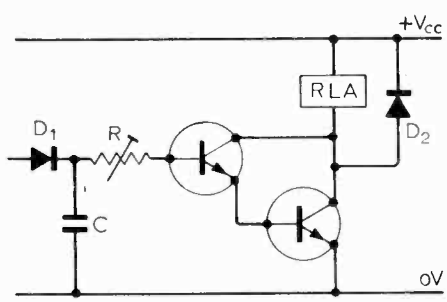
University of Aston.

Simple relay monostable

This circuit was evolved to enable a signal to switch a relay on very quickly and to have a variable drop-out time. Another important requirement was that of 'signal storage' so that the delay would be effective as from the last signal which for my purposes were pulses of constant height but varying widths. Fairly consistent



delay times can be achieved dependent upon the voltage fed to C, and to the high impedance of the switching pair. In my application C was 330μF tantalum, R 22kΩ, and D_1 a silicon diode with a fairly large I_R characteristic. The pulses were about 4V in amplitude.

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London S.W.10.

Dual-trace Oscilloscope Unit

4. Attenuators and switching circuits

by W. T. Cocking, F.I.E.E.*

In Part 3 we dealt in considerable detail with the design of an amplifier using bipolar transistors. The effect of component tolerances was treated in detail as well as the precautions needed to prevent the accidental application of a high voltage to the input from damaging the amplifier. Two amplifiers are needed, of course, one for each signal channel. These are identical except that only one carries the common collector resistance for the two output stages.

The circuit of the amplifier given in Part 3 is, of course, only the bare bones of it. It was found experimentally that the emitter followers tended to generate high-frequency oscillations and that collector resistors, with a by-pass capacitor across V_{CC} were needed to prevent this. A capacitor to earth from the base of Tr_6 was also required, and various other by-pass capacitors. These are matters which depend very much on layout and cannot be predicted.

The amplifiers have individual, continuous-gain controls with a minimum range of 3.33:1. Further control of signal level is by switched attenuators preceding the amplifiers, and attenuating probes at the input ends of the cables. As explained in Part 1 a probe is necessary primarily to reduce the effective input capacitance, which is provided mainly by the cable.

Attenuators

In Part 1 we envisaged the use of a dual-range probe which, with an internal switch, would provide two basic signal ranges of 1 V and 3 V input for 1 V output from the amplifier. This would require merely the addition of a 10:1 attenuator section to give 10 V and 30 V ranges. The advantage of this scheme was that it permitted the use of an amplifier gain of only 3.33, and at the start of the development we did not know if we could obtain a gain of 10 times reasonably easily.

The main disadvantage of the scheme was the practical difficulty of constructing the probe to be reasonably small yet employ standard components. It was also a disadvantage to have two switches widely separated in space to control the gain. Further, it was undesirable that there should be a change of input impedance on operating the probe switch.

*Editor-in-chief, *Wireless World*

However, it turned out, as explained in Part 3, that a gain of 10 times was readily obtained. The probe, therefore, now contains merely a 900-kΩ resistor shunted by a trimmer capacitor to give, with the amplifier input resistance of 100 kΩ, an attenuation of 10:1. The amplifier gain of 10 times makes up for this and the overall gain is unity. A 3-ft length of coaxial cable has a capacitance of about 60 pF. The amplifier will probably add at least 10 pF and the safety diodes (Part 3) account for the bulk of this. The input impedance of the probe will be 1 MΩ by about 7 to 10 pF.

For input voltages greater than 1 V attenuators are needed, to enable ranges of 3 V, 10 V and 30 V to be obtained. For the 3-V range, attenuation of 3:1 is needed; for the 10-V range it must be 10:1; and for the 30-V range, the two can be used in cascade. For this to work, each attenuator section must have an input impedance equal to that of the amplifier, when it is terminated by that same impedance.

The simplest attenuator section is shown in Fig. 1 with the termination R_0C_0. Let α be the reciprocal of the attenuation (i.e., 3 for a 3:1 section; 10 for a 10:1 section) then

$$R_1 = R_0\frac{\alpha-1}{\alpha} \text{ and } R_2 = \frac{R_0}{\alpha-1}$$

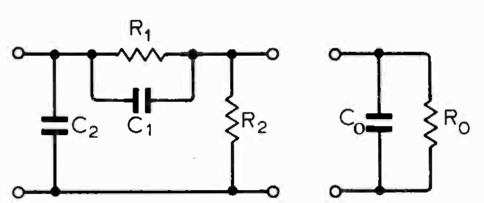


Fig. 1: Basic attenuator section.

Thus for 3:1, and $R_0 = 100\,\text{k}\Omega$, $R_1 = 66.6\,\text{k}\Omega$ and $R_2 = 50\,\text{k}\Omega$, while for a 10:1 section $R_1 = 90\,\text{k}\Omega$ and $R_2 = 11.1\,\text{k}\Omega$.

For correct frequency compensation, we must have $C_1R_1 = C_0(R_0\|R_2)$, which means $C_1 = C_0/(\alpha-1)$ when the foregoing resistance requirements are met. Since the cable precedes these attenuators, the value of C_0 is not about 70 pF as it is for the probe, but nearer 10 pF. Thus, in the two cases, C_1 will be about 5 pF and 1.1 pF respectively. The input capacitance excluding C_2 will be C_0/α, or 3.3 pF and 1 pF, and so C_2 must be C_0 less this figure.

In practice, one cannot have C_1 less than about 3 pF because of the minimum capacitance of the trimmer and other strays. This means that it may be necessary to increase C_0 by adding capacitance to it. If C_0 itself is increased, the probe capacitance will have to be increased also and so the input capacitance will also increase which is undesirable. An alternative is to shunt R_2 by a fixed capacitor.

If C_0 is 10 pF, and we connect 22 pF across R_2 of a 10:1 section, the effective C_0 is 32 pF and so C_1 must be 32/9 = 3.55 pF, which is more reasonable. The input capacitance is then 3.2 pF, so C_2 must be 10 − 3.2 = 6.8 pF for the normal 10 pF input capacitance.

For a 3:1 section, C_1 is 5 pF without added capacitance and C_2 will be 6.7 pF.

Exact calculation is impracticable, because no capacitance is known accurately enough. What we do in practice is to set up the amplifier with the probe only and feed the probe with a square wave. We adjust the probe trimmer for the optimum waveform. If the minimum capacitance of the trimmer is too large, we add capacitance to C_0. This is unlikely because of the cable. If the maximum is too small, we add, perhaps, 10 pF, across the probe trimmer.

We now insert an attenuator and apply the square wave directly to its input, not via the probe. Now C_1 of the attenuator is adjusted; if its minimum is too large we add a fixed capacitor across R_2, trying various values until we find one which will enable a definite optimum setting for C_1 to be obtained. Having done this we apply the square wave to the attenuator through the probe and we now adjust C_2 only. Again if the maximum capacitance of this trimmer is too small, we try various fixed capacitors in shunt, until we find one which enables a definite optimum setting for C_2 to be obtained. This brings the input capacitance to the proper value to suit the probe and as this was previously adjusted to suit C_0, it brings the input capacitance to C_0.

The same procedure is adopted for the second attenuator. There are no further adjustments when the two sections are used in cascade. The correct response should automatically be obtained. In practice, it may not be. The main cause of any such trouble is stray coupling between input and output. Stray capacitance between the input of one section and the output of the other has a serious effect and it need be only a fraction of 1 pF. Careful screening is essential.

It is possible to use a 3-pole 4-way rotary switch to give the ranges of 0, 3:1, 10:1, and 30:1. With a single wafer this is unsatisfactory because stray capacitance causes violent overshoots when both sections are in cascade. Separate wafers must be used with screening. It is considered preferable, however, to use separate d.p.d.t. switches and the arrangement is shown in Fig. 2. Two coupling capacitors C_1 and C_2 are included; the first is desirable to prevent any d.c. loading of the circuit under test, the second is needed to prevent operation of the switches from affecting the bias on the input stage of the amplifier. For a reasonable low-frequency response C_1 can be 0.22 μF because it is in a 1 MΩ circuit, but C_2 must be 2 μF since the resistance level is about 100 kΩ. C_1 must be 350 V rating to be safe for overloads, but C_2 can be of quite a low-voltage rating. It is essential that these capacitors be completely screened to prevent hum pick-up.

The resistors needed have values of 90, 66.6, 50 and 11.1 kΩ. None is a preferred value. High-stability types of $\pm 1\%$ tolerance should be used to give a $\pm 2\%$ tolerance on the attenuation ratio. The required values can be obtained from combinations of preferred values; thus two 180 kΩ resistors in parallel give 90 kΩ (and in the probe two 1.8 MΩ give 900 kΩ), two 100 kΩ give 50 kΩ, and two 22 kΩ give 11 kΩ. The value of 66.6 kΩ can be achieved by 120 kΩ in parallel with 150 kΩ. Alternatively, the required values can often be picked out from a largish selection of resistors, but an accurate bridge is needed to do this.

Switching circuits

To effect the switching between one channel and the other, the transistors Tr_9 in the two amplifiers require to be driven by square waves in opposite phase. These are best produced by a bistable driven by some form of pulse generator. The conventional bistable of Fig. 3 produces square waves of opposite phase at its two collectors, so these can be connected through limiting resistors to the bases of the two Tr_9 transistors.

When one transistor in Fig. 3 is ON it is saturated and its collector is at about 0.2 V: the other is then OFF and passes no

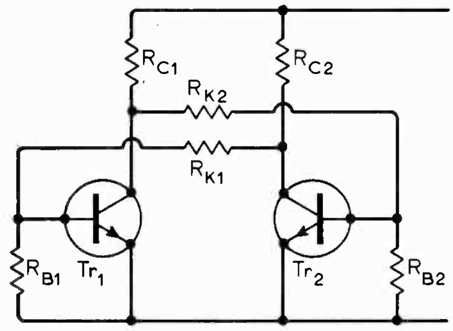


Fig. 3. Basic bistable circuit.

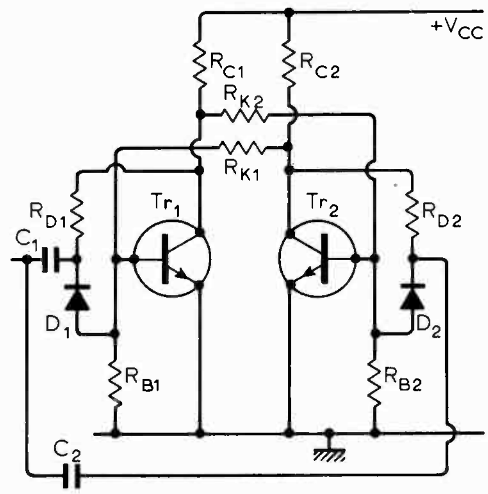


Fig. 4. Bistable with steering diodes D_1 and D_2 added.

collector current, so that its collector is at

$$V_{CC}\frac{R_B+R_K}{R_B+R_K+R_C}$$

For a 12-V supply a square-wave amplitude of about 10 V peak-to-peak is obtainable. Circuit values are far from critical.

To change the state of the bistable a negative trigger pulse is needed on the ON transistor. This is where most of the problems arise. It is necessary to incorporate steering diodes to ensure that a succession of trigger pulses are routed alternately to the two transistors, since each pulse must be fed only to an ON transistor. The arrangement is shown in Fig. 4 and the steering action depends largely upon the capacitors C_1 and C_2.

Consider a stable state with Tr_1 ON and Tr_2 OFF. If this has persisted for long enough, analysis is easy. The collector of Tr_1 is at 0.2 V or thereabouts while the base is around 0.7 V; Tr_1 is saturated. (Incidentally, all figures quoted here are very rough ones; we say this to avoid having to say "about" everytime!). The diode D_1 then has 0.5 V forward voltage across it and is near, if not actually in, conduction. The potential of the right-hand plate of C_1 (on the diagram) is 0.2 V.

As its base is at earth and its collector at 10 V Tr_2 is non-conducting and D_2 has 10 V reverse bias, and the right-hand plate of C_2 is at 10 V. A negative trigger pulse of, say, 4V amplitude is applied to the left-hand plates of both capacitors, and appears also on the right-hand plates. This drops the voltage across D_2 from 10 V to 6 V, but the diode is still cut off and the voltage is not applied to the base of Tr_2. If the source of pulses is of low impedance, D_1 conducts and pulls the base of Tr_1 negative by the pulse amplitude and so cuts off Tr_1. If the source is not of low impedance the pulse amplitude is reduced by the low input resistance of Tr_1 while it is conducting.

Assuming that Tr_1 is cut-off, its collector voltage rises and drives Tr_2 into conduction. The action is cumulative around a closed positive feedback loop. The speed of transition is governed by the circuit resistances and stray capacitances. At the end, the initial conditions are reversed with Tr_1 OFF and Tr_2 ON. The charges on C_1 and C_2 are unaltered, however; C_1 is still at 0.2 V with the collector of Tr_1 at 10 V and C_2 is at 10 V with the collector of Tr_2 at 0.2 V.

The capacitors now charge and discharge through R_{D1} and R_{D2} until C_1 is at 10 V and C_2 is at 0.2 V. In each case there is 9.8 V acting and the time required for this change to occur is approximately $3CR_D$. Common values are $C = 0.001$ μF and $R_D = 22$ kΩ, so the time is 66 μs.

If three signal cycles are to be displayed on each oscilloscope trace, the signal period for this condition is 22 μs, so its frequency is 45 kHz.

It is not necessary that the interval between successive trigger pulses should be as long as $3CR_D$. If it is shorter, the charging and discharging will be less complete and the difference between the voltages on the two capacitors will be smaller. Eventually the difference will be too small for the steering diodes to function properly and the bistable will refuse to change state. It is usually reasonable to work with a trigger pulse interval equal to the time constant, which is 22 μs for the foregoing values. This will enable three cycles of signals up to 135 kHz to be displayed.

In practice, it has proved difficult to generate a square wave having a shorter half-cycle period than 25 μs, even with changes to the steering circuit time constant. This corresponds to a trigger pulse repetition frequency of 40 kHz and, if the circuit is triggered by the oscilloscope timebase, to the timebase frequency. At lower frequencies, triggering remains good without change of time constant. Thus, for a three-cycle display, oscilloscope triggering can be used only for signal frequencies up to 120 kHz. For higher signal frequencies, either more cycles must be displayed or unsynchronized triggering employed, as

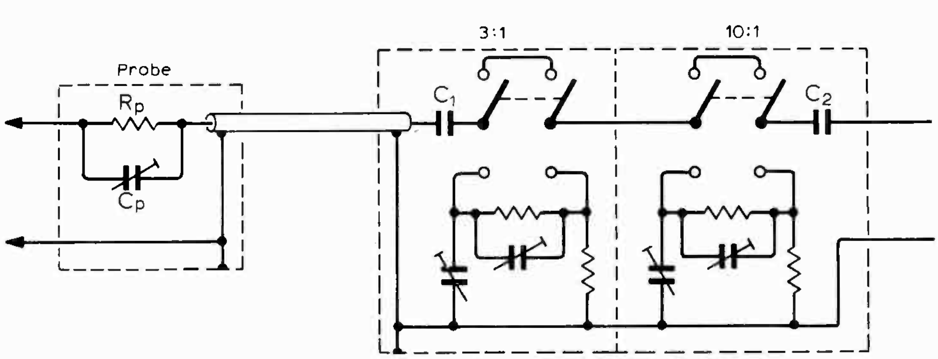


Fig. 2. Circuit of probe and attenuator sections.

described in Part 1. The pulse generator for this is still limited to 40 kHz maximum.

To display three cycles of a 50 Hz signal, the timebase frequency must be 16.66 Hz. Flicker will inevitably occur. It will be prohibitive with dual traces because the repetition frequency of each will be only 8.33 Hz. This is covered by using an unsynchronized condition with a switching frequency much higher than the signal frequency. A good display will result with a ratio of about 100:1, which makes the lowest pulse generator frequency about 500 Hz. However, it is advisable to extend the range down to about 100 Hz for cases where it is impracticable to trigger the switch from the c.r.o. timebase.

The range of frequencies needed is thus 400:1, which can easily be achieved in three ranges.

Before we consider the pulse generator, however, there is one other matter to be dealt with. It is necessary to have a square-wave generator to adjust the trimmer capacitors of the probes and attenuators. It cannot easily be done without it. Rather a good waveform is needed. As the equipment needs a square-wave generator for switching, the obvious thing to do is to arrange for it to be usable also for the attenuator adjustments. This means that the square wave must be freer from minor blemishes than is necessary for switching and there must be outputs at the proper voltage levels.

The positive half-cycles are usually somewhat marred by the charging currents of the steering capacitors. The simplest remedy is to add a pair of clamping diodes, as shown by D_3 and D_4 in Fig. 5. These are returned to a voltage lower than V_{CC} which is stabilized by the zener diode D_5. As long as a collector voltage is below V_Z the associated diode plays no part, but when it rises to about V_Z, the diode conducts and clamps the collector voltage to V_Z. There is then a low impedance path for charging currents. In addition, the square-wave amplitude is now closely defined by V_Z and is independent of V_{CC}. This makes it easier to prevent any dangerous condition occurring on Tr_9.

The second requirement of various output levels is easily met by dividing R_C of one transistor into several resistors in series, at the junction of which the various outputs will appear. With a 4.7 V zener diode, the square-wave amplitude will be nominally 4.5 V, plus the clamping diode drop, which is around 0.6 V, or 5.1 V total.

With only the probe in use an amplitude of around 0.45 V is about right. With the input to the amplifier itself and the 10:1 attenuator in use, the same amplitude is needed. With the 3:1 attenuator only 0.135 V is required. Using the probe and the 3:1 attenuator, we want 1.35 V, and with the 10:1 attenuator, 4.5 V. When the probe and both attenuators are in circuit, and we apply 4.5 V we shall get only 0.15 V on the oscilloscope. There are no adjustments on this range, and although the amplitude is rather small, it is sufficient to check that nothing serious is wrong.

The voltage ratios required are 1:1, 3.33:1, 10:1 and 33.3:1, so the resistance ratios needed are 0, 2.33:1, 9:1 and 32.3:1. We cannot hope to get these exactly and it is not necessary, for any voltage will do as long as it is roughly right. A string of resistors 68 Ω, 180 Ω, 680 Ω and 1.2 kΩ totals 2.128 kΩ and is reasonably matched by 2.2 kΩ for the other transistor. This gives 5.1 V, 2.12 V, 0.569 V and 0.155 V with a tolerance of ±10% using 5% resistors and an extra ±5% for the zener tolerance. Experimentally, we obtained 5.2 V, 2.5 V, 0.66 V and 0.18 V in a particular case. Experimentally, with a basic capacitance of 150 pF plus strays, and a total resistance of 22 to 250 kΩ the square-wave frequency (to one-half of the sawtooth frequency) was 7.95–71.5 kHz. Adding 0.001 μF gave 920 Hz to 9 kHz, and adding 0.01 μF gave 120–1430 Hz.

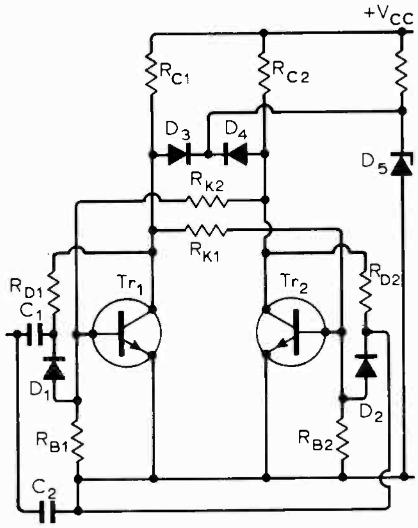


Fig. 5. Bistable elaborated to include clamping diodes D_3 and D_4.

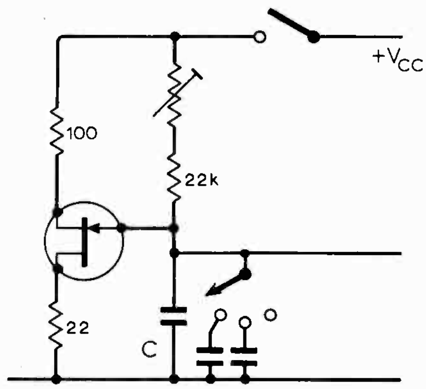


Fig. 6. Sawtooth generator with unijunction transistor.

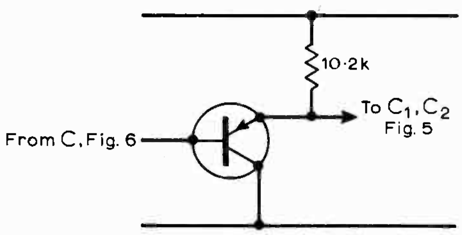


Fig. 7. Emitter follower to isolate the sawtooth generator from the bistable.

Turning now to the pulse generator, the simplest is a unijunction and the circuit is shown in Fig. 6. Three capacitors and a selector switch provide the three frequency ranges and the variable resistor enables the frequency to be set at any required value. A switch in the supply line enables the generator to be disabled when triggering by the oscilloscope timebase is required.

A positive-going sawtooth appears across the capitance, a positive pulse across the 22 Ω resistor and a negative pulse across the 100 Ω. Neither pulse unfortunately is suitable for triggering the bistable. It triggers best from the negative-going flyback of the sawtooth. If an attempt is made to trigger directly, by connecting C_1 and C_2 of Fig. 5 to the capacitor of Fig. 6, trouble can arise. The charging currents of C_1 and C_2 affect the charging current in Fig. 6 and differently on successive cycles. Successive sawteeth have different amplitudes and durations, and the final square wave no longer has a 1:1 mark-space ratio. A buffer stage is, therefore, needed to separate the two. This must have a high input impedance (> 1 MΩ) and a low output impedance.

For operation from the oscilloscope timebase a sawtooth output is needed and this can be either positive or negative going. With the Marconi Instruments model which we used it is about 8 V negative-going. Thus, phase reversal is needed.

We found experimentally that a TIS 43 p-n unijunction produced a sawtooth of 6.2 V amplitude, the peak being 7.5 V above earth. Thus the capacitance is discharged to 0.7 V. An emitter follower with a load of 10 kΩ should give an input resistance of over 1 MΩ. A p-n-p transistor is better than an n-p-n here because it is the negative-going edge of the sawtooth which we want for triggering. The p-n-p transistor can turn on plenty of current to supply a capacitive load, or more likely, the low impedance of the ON transistor being triggered. An n-p-n transistor on a negative-going edge is likely to cut-off in this condition. All that we need as a buffer between the circuits of Figs 5 and 6 is the simple arrangement of Fig. 7. This takes a mean current of 0.35 mA.

The requirements for triggering the bistable from the timebase of the oscilloscope are rather different and will depend upon the particular instrument used. If a positive-going sawtooth is available or can be readily obtained, it can be reduced to 6 V amplitude by a potential divider. In most cases it can then be fed directly to C_1 and C_2 of Fig. 5.

If the only sawtooth available is negative-going, as in the case of the Marconi Instruments oscilloscope which we used, a phase reversal is needed. The sawtooth is of 8 V amplitude and comes at low impedance from a cathode follower.

It is tempting to use the circuit of Fig. 7 with a collector resistor, both inputs and outputs being switched. This will not work, however, for the stage would then have to give a total output of 12 V and would require a supply of at least 14 V, whereas we may have only 10.5 V, and less if decoupling is needed. Further, the bias condition would have to be changed. The switching would get involved and it is

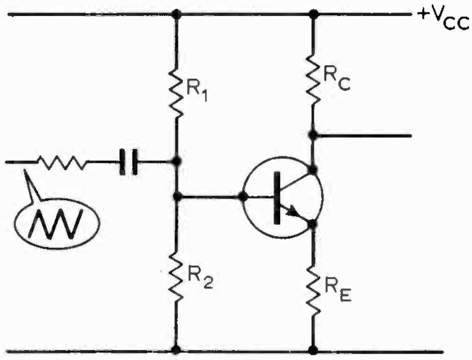


Fig. 8. Phase reverser for use with negative-going sawtooth.

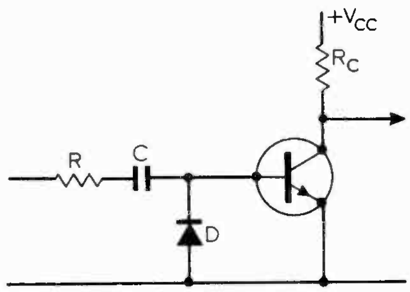


Fig. 9. Practical phase reverser.

simpler and cheaper to use a separate transistor.

The sawtooth, since it is taken from the oscilloscope, is likely to be a good one and so its mean value will be nearly one-half of its peak-to-peak amplitude. Mid-point biasing of the transistor will be needed with a capacitance input coupling.

For phase-reversal an earthed-emitter stage is needed and the obvious thing to do is to use the simple arrangement of Fig. 8. However, it does not work! The d.c. conditions in the presence of a signal are very different from the truly static ones. There is a d.c. restoration effect at the base which causes this.

As will be seen next month, a protective diode is needed across R_2 with its anode earthed and it turns out that the simplest arrangement is the one shown in Fig. 9. Here C is the coupling capacitor and R is chosen to suit the particular oscilloscope used; D is the protective diode to guard against excessive negative inputs. This diode and the base-emitter path of the transistor form two diodes back-to-back. Unless the input is very small, they conduct alternately and their d.c. restoring tendencies act in opposition and tend to cancel. The circuit acts as a crude slicer and an output from the transistor is obtained whenever it conducts. In spite of its simplicity, the circuit works admirably.

The unijunction sawtooth generator with its emitter follower, and this phase reverser for c.r.o. triggering, are shown together in Fig. 10 with the necessary switching.

Correction

In Part 2, September p. 423, middle column, the numerator of the fraction in the expression for R_{in} should be $R_L + R_C/(1+y)$.

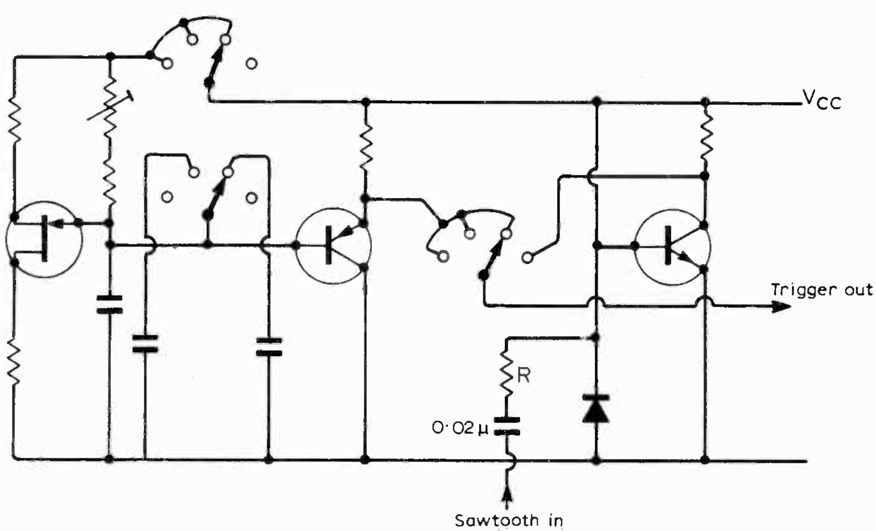
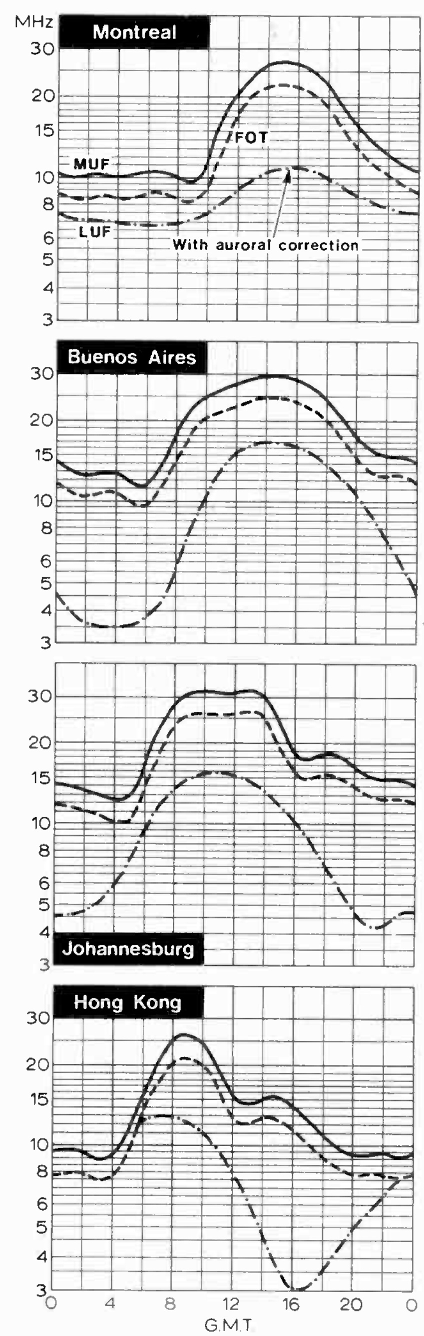


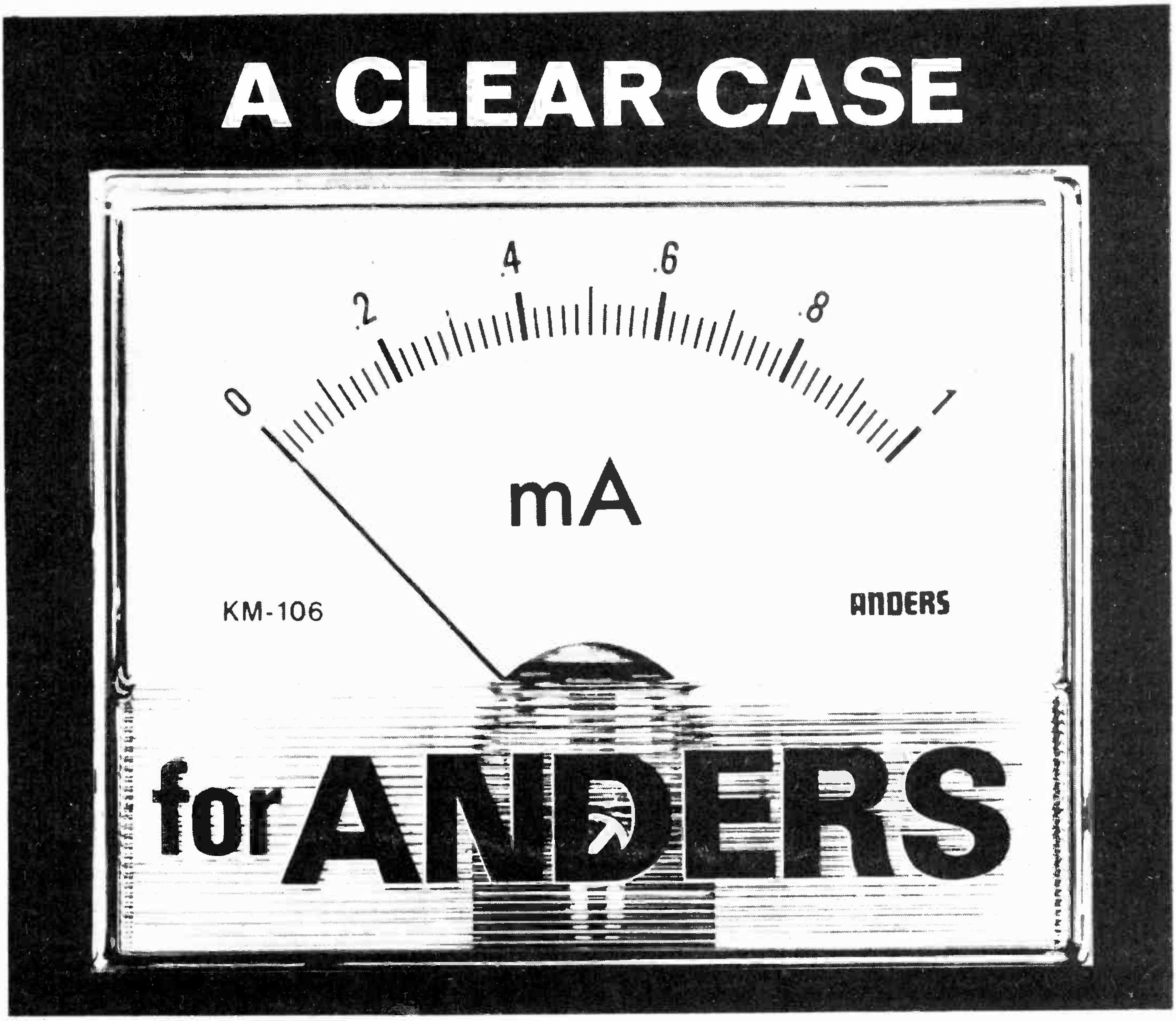
Fig. 10. Sawtooth generator, emitter follower and phase-reverser for c.r.o. sync showing switching.

H.F. Predictions—November

Despite decreasing solar activity the MUF for South America exceeds 30MHz for several hours so the 26MHz broadcast and 28MHz amateur bands should be open between 08.00 and 14.00 G.M.T. throughout the month. These two frequency bands will also be available to South America but not quite so consistently and to North America for very short periods only, if at all.

Prospects for the Far East are not good. The high rate of MUF change during 06.00 to 18.00 G.M.T. indicates that several working frequencies are required for a continuous commercial service. A steady MUF for the remaining period is offset by LUF exceeding FOT which means poor signal-to-noise or fade out.





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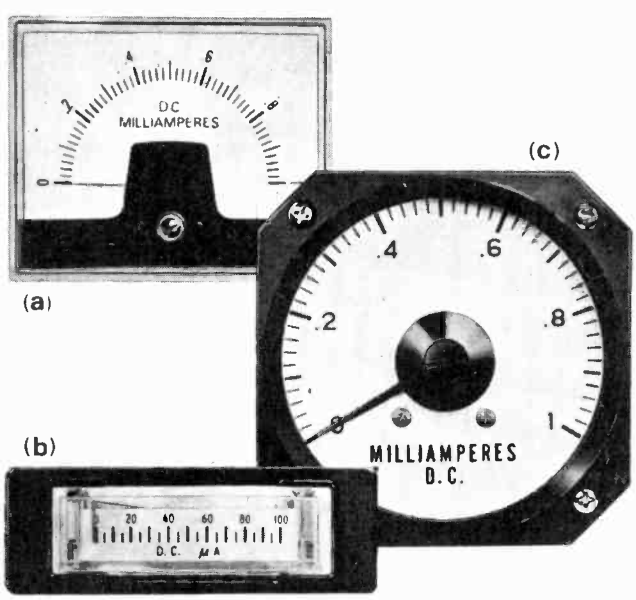

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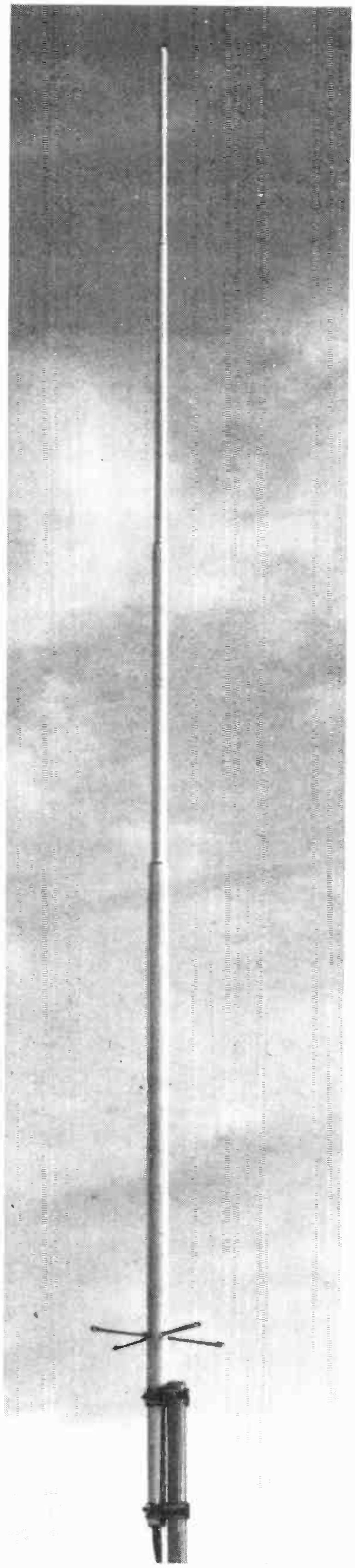

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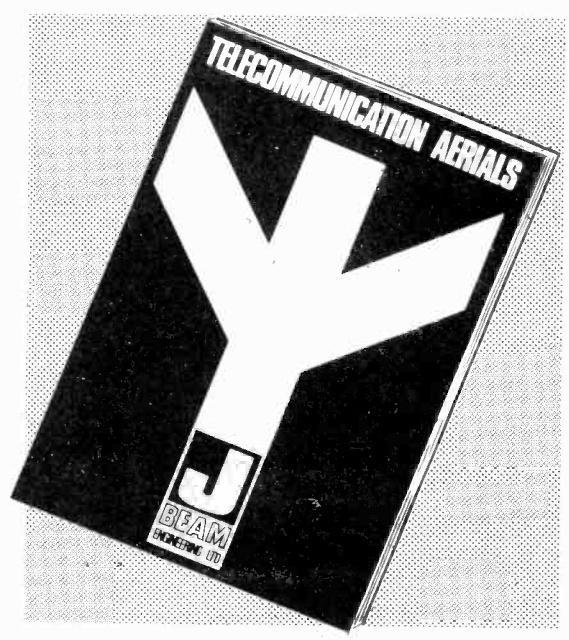

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Receiving Weather Satellite Pictures

2: A more complex station which provides better quality pictures

*by J. M. Osborne**

Last month I described a very simple system for receiving weather satellite pictures and now I would like to describe the more complex arrangement which we use at Westminster School. I am not suggesting that readers should try to copy this because it would probably prove impossible to obtain many of the surplus components we employed in the construction. However my object is to provide a little food for thought and show the sort of steps which are necessary if last month's simple system is to be improved.

As mentioned last month a picture taken by a satellite is broadcast at four lines per second in the 137MHz band; each picture taking around three minutes to send. Successive pictures overlap geographically and one can receive, in U.K., three pictures covering North Africa to Iceland in a single satellite transit. The carrier from the satellite's transmitter is frequency modulated with a 2.4kHz sub-carrier which is in turn amplitude modulated with the picture information as shown in Fig. 15 (a). There is no line synchronizing signal so that the user has to provide his own sync pulses at 4Hz. Each picture is preceded by a train of pulses (see Fig. 15 (b)). The gaps in the sub-carrier correspond to the start of a line of picture information and are used to initiate pulses at 4Hz generated by the circuit given in Fig. 11 last month.

*Westminster School, London.

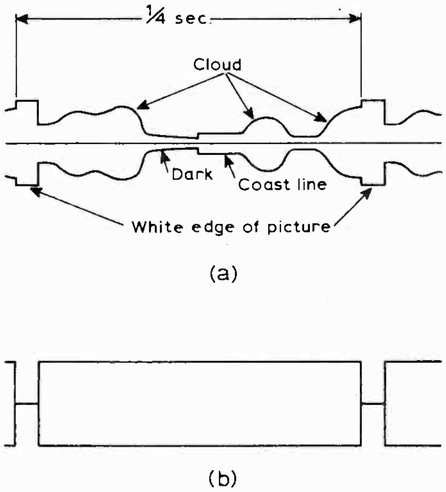

Fig. 15. (a) Sub-carrier envelope for one line of picture information. (b) Sync pulse train preceding the picture. The gaps are at 4Hz.

A block diagram of the complete ground station we use is shown in Fig. 16. The 2.4kHz audio sub-carrier emerges from the receiver and, after demodulation, is used to control the spot brightness of a c.r.t. The spot is made to scan in a normal TV type raster by two timebases; the line running at 4Hz and the frame sweeping once in 200 seconds for an 800 line picture. The raster is photographed by setting up a camera in front of the c.r.t. as described last month.

A stereo tape recorder can record from points A and B and subsequently play back into the circuit at the same points. This enables the picture making process to be separated from the reception of the satellite's signal and is a great help in the building and testing stages.

Signal chain

The aerial is a crossed Yagi made by J-Beam Ltd, of Northampton. It is type 2/1OXY cut for 137MHz. The mounting is very crude but has operated without trouble for over two years. A short mast was fixed to railings on the roof but the clamps left a little slack. A short rod was clamped to the mast horizontally, acting as a handle to rotate the mast about a vertical axis. Another short rod was clamped but not tightened horizontally near the top of the mast about ten feet above the ground. The Yagi was tightly clamped to one end of this rod at right

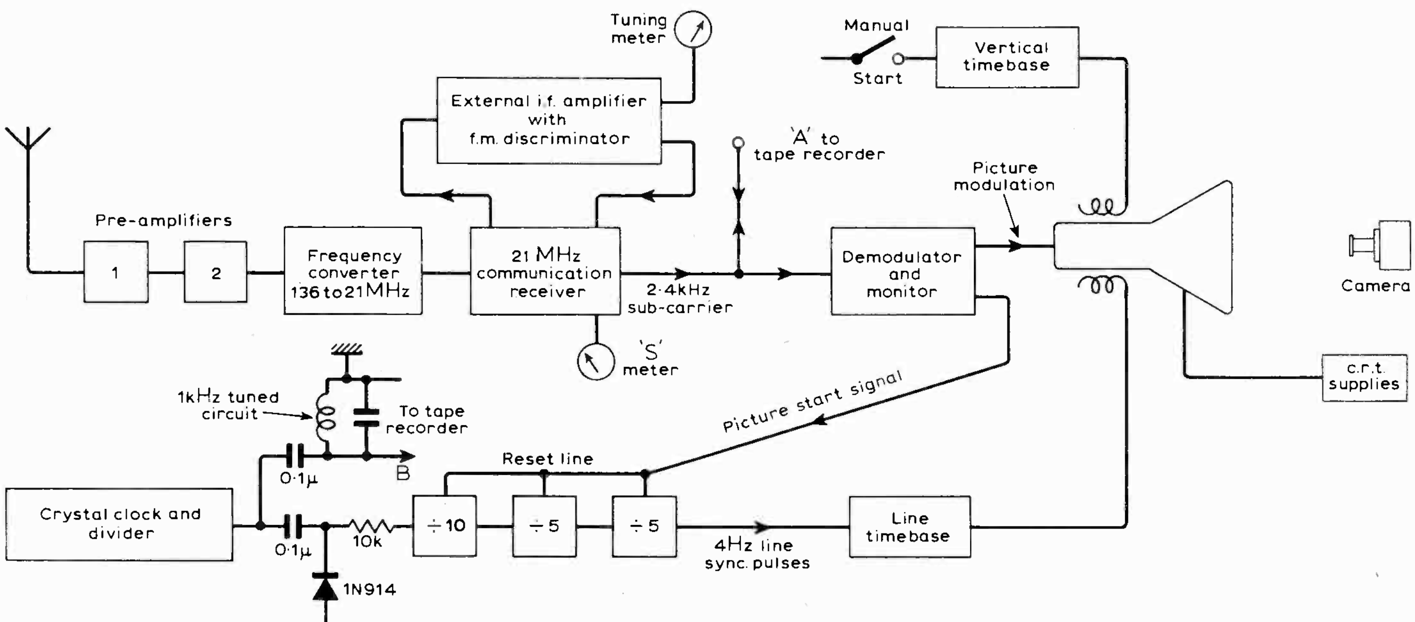

Fig. 16. Westminster School's satellite station.

angles to it. Another short rod was tightly clamped to the other end, also at right angles parallel to the Yagi boom. This rod is the handle for setting the elevation of the aerial. Greasing proved a mistake as the wind tended to take over the steering. All the parts are standard TV aerial components supplied by J-Beam.

The aerial feed goes via two f.e.t. v.h.f. pre-amplifiers to the frequency converter. The pre-amplifiers are useful but are by no means essential because of the high signal strength of present satellites. The frequency converter is a standard 2m amateur band type made by Solid State Modules of Huddersfield and aligned by them for 137MHz. This gives, with an internal crystal oscillator, a first i.f. of 21MHz which is connected by a coaxial cable to the aerial terminal of an Eddystone EC10 communication receiver tuned to the 21MHz band. For example a satellite on 137.5MHz appears at 21.5MHz on the receiver's dial and satellites transmitting at 137.62MHz appear at 21.62MHz on the dial. The EC10 is an a.m. receiver so the 465kHz i.f. output from the frequency changer is connected via a screened lead and a small capacitor to an external i.f. amplifier with a frequency discriminator. The i.f. amplifier we used came from a Pye Cambridge mobile receiver. Its bandwidth was rather below the required 50kHz but in practice it gave adequate results. The audio output of the external i.f. amplifier's discriminator was fed back to the a.f. stages of the EC10. A 50-0-50 μA meter in series with a 30kΩ resistor was connected to the discriminator to serve as an f.m. tuning meter. The internal i.f. of the EC10 remains live but the diode detector is disconnected from the a.f. amplifier and drives a signal strength meter instead. This is a large scale 100 μA meter in series with a 20kΩ resistor on a long extension lead so that it can be placed in sight of the aerial operator as a tracking aid. The audio output of the f.m. discriminator does not indicate signal strength and it is, of course, just this property which makes it possible to obtain consistent pictures over a wide range of signal strengths.

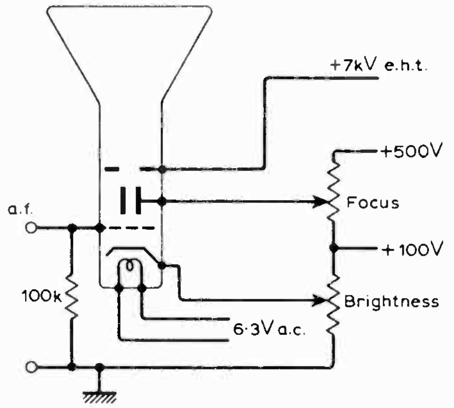

Fig. 17. Circuitry around the c.r.t.

Tape recording pictures

If one wishes to record the pictures a high-quality stereo tape recorder is worthwhile. The Brenell STB2 we employ gives good results. Tape deteriorates noticeably after several runs and only new high grade tape can be relied on for perfect results. However, any tape in any tape recorder will give results adequate for testing the rest of the apparatus, provided imperfections of the tape and recorder are recognized for what they are. The 1kHz timing signal from point B Fig. 16 is recorded on one track while at the same time the picture is recorded on the other track from point A. Thus synchronizing is affected by tape speed changes, wow or flutter. It is possible to add an extra record/playback head to some mono tape recorders (four track recorders may have the wiring to one head available for external use). The 1kHz can be recorded without bias and retrieved without other modification to the recorder.

The circuit of the crystal sync pulse divider unit was given last month. The only modification required for using a tape recorder is shown in Fig. 16.

The 1kHz square wave now goes through an *LC* filter tuned to 1kHz to provide a sine wave for the recorder. The filter is not essential but cleans up the input to the tape by removing harmonics from the square wave. On play-back the same filter provides a good clean signal with no noise to produce false triggering. The filter 'rings' at its 1kHz resonant frequency, attenuating all other frequencies. Tape recordings are made, and played back into points A and B.

Cathode-ray tube

In order to resolve an 800 line picture, the c.r.t. spot size must not be more than one thousandth of the tube diameter. Suitable

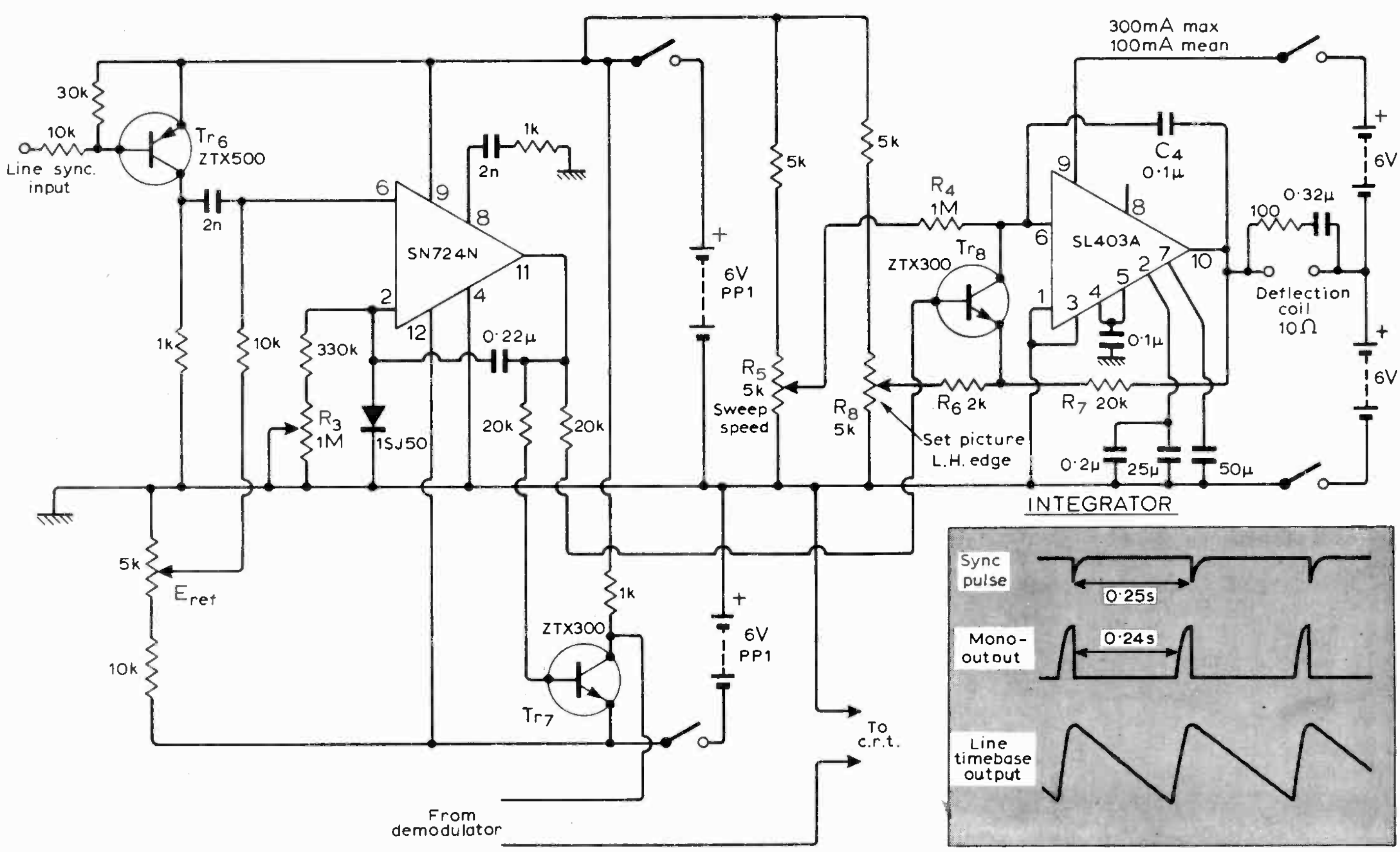

Fig. 18. Line timebase and waveforms.

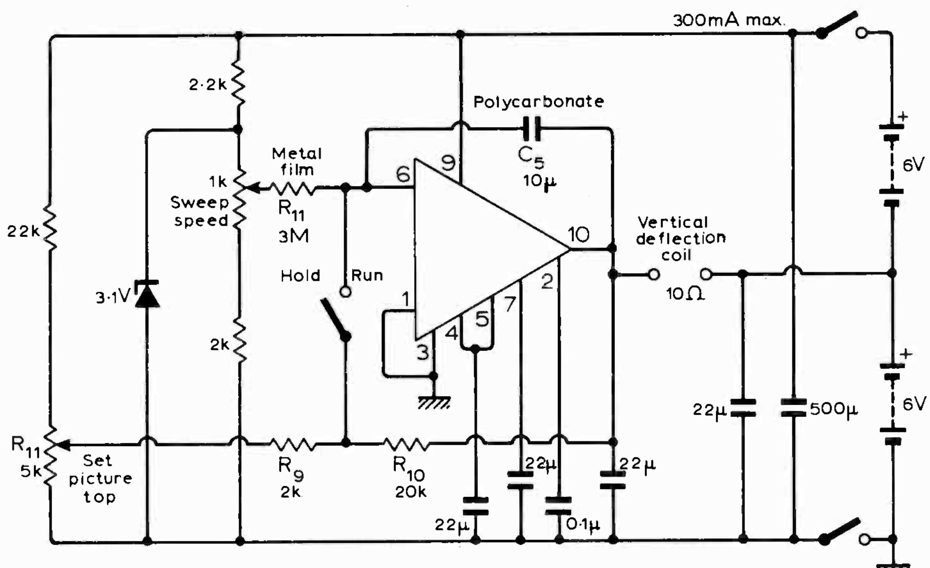

Fig. 19. Vertical timebase.

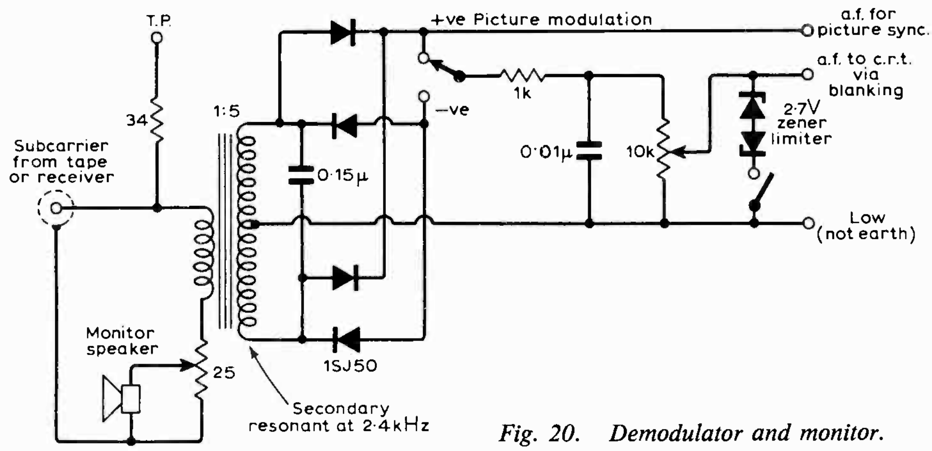

Fig. 20. Demodulator and monitor.

tubes with electrostatic deflection do not appear to be available but TV type tubes obviously meet the required specification. We obtained an obsolete Pye monitor type 2780 which contained an excellent tube. The monitor cabinet was a convenient housing for the tube but none of the original electronics except the scan coils proved of any value. Fig. 17 gives the circuitry associated with the c.r.t.

Line timebase

The scan coils in the monitor had a resistance of about 10Ω and it was found that i.c. audio amplifiers, capable of driving a loudspeaker direct, were ideal for driving the scan coils. The final version of the line timebase is shown in Fig. 18. The SN724N is wired as a monostable with a period of about 0.24s as determined by R_3. The diode connected across R_3 greatly speeds the recovery time, enabling the monostable to operate every 0.25s. A negative going edge, from the 4Hz sync generator circuit described last month, applied to the base of Tr_6 drives the monostable to negative saturation. Transistors Tr_7 and Tr_8 are switched off: Tr_7 allows the picture signal to reach the tube and Tr_8 starts the integrator formed by the SL403A. At the end of the integrator's timing period the monostable goes back to positive saturation, switching on Tr_7 thereby blanking the c.r.t. spot and resetting the integrator by switching on Tr_8.

It is now fairly obvious how the sweep operates. The current through the deflector coil is determined by the voltage between the output of the SL403A and the mid-point of the batteries. The output voltage, when Tr_8 is on, is set by the potentiometer R_8. When a sync pulse arrives Tr_8 switches off and C_4 starts to charge through R_4 at a rate determined by potentiometer R_5. As the input remains at 'virtual earth' the output voltage goes down causing the spot to sweep the tube. Assuming that the sweep speed has been set correctly the spot reaches the end of the sweep just as the monostable period ends and flyback occurs.

Vertical timebase

The vertical timebase uses the same integrator circuit (Fig. 19) as the horizontal timebase, except that Tr_8 is replaced by a switch as only one sweep per picture is needed. The sweep speed is variable over a wide range and can easily be set to 200s but high quality components are needed to give reliable and consistent performance. This applies particularly to C_5. R_{12} and the switch.

In the simple vertical timebase circuit described last month the capacitor was shown in Fig.5 as being 1µF and in Fig.12 as 1mF. Fig.12 is correct, e.g. one millifarad or 1,000µF.

Demodulator and monitor

The 2.4 kHz signal from either the receiver or tape recorder drives the monitor speaker and the primary of a step-up transformer (Fig. 20). The ratio is about 1:5 and the secondary is tuned by a capacitor to resonate at 2.4kHz giving a useful improvement in the signal-to-noise ratio. The secondary is centre tapped to allow full wave rectification of the sub-carrier. The polarity of the modulation can be switched so that either a positive or negative picture can be taken. Thus the film in the camera can give either a negative for normal printing or a positive for a slide projector. The demodulated a.f. picture signal is fed to a potentiometer which adjusts the contrast. The zener diodes act as limiters and stop interference spikes from reaching the c.r.t. The full demodulated output is taken to a separate terminal for the picture sync.

Power supplies

The supplies for all units except the c.r.t. come from batteries which means that each unit is self contained and is free from mains earth with the batteries inside the box. This eliminates problems due to hum and coupling of units through common supplies is avoided. In view of the light intermittent load, the cost is probably less than mains power supplies even over a period of years. Nife cells for the time bases can be left on trickle charge though even these can be replaced with Ever Ready Lattern Cells type 996.

60 Years Ago

November 1911. Perhaps the most exciting story in this issue of the *Marconigraph* came under the heading 'Experiences of the first Marconi airship officer'. Jack Irwin was the wireless operator in question and he described the part wireless played in the unsuccessful attempt of the airship *America* to reach Europe. It appears that after being blown far off course and after sustaining damage a ship was sighted. Irwin says "I immediately called C.Q.D. and S.O.S., but received no response. So, seizing an electric torch, I commenced calling in Morse fashion. After some little delay I was answered by the steamer. I conveyed to them by lamp the fact that we were equipped with wireless, and in a few minutes the most welcome signals I ever heard came hammering in my 'phones".

The *America* was brought down in the sea and the crew were taken off by the steamer, which was the Royal Mail *S.S. Trent*.

Electronic Building Bricks

17. Alternating current and voltage

by James Franklin

Most people are familiar with the term 'a.c.' in reference to the electricity mains, but even those who know that it means 'alternating current' may not be quite sure of *what* is alternating. It is, in fact, the direction of the electron flow (current) in a circuit. The electrons flow first in one direction round the circuit, then in the opposite direction, then in the first direction again . . . and so on, rather like the balance-wheel of a clock.

Figs. 1 and 2 use the electronic circuit ideas introduced in Part 5 to demonstrate the nature of alternating current. In Fig. 1 (a) the e.m.f. source drives electrons round the circuit in the direction shown by the arrow. The value of the current is determined by the resistor *R* (see Part 7). A time-graph of this uni-directional current (switched) is shown at (b).

In Fig. 2 (a) we have the same circuit, but the e.m.f. source has been taken out and put back with the + and − terminals in the reverse positions. When the switch is closed the current direction is now reversed. The value of the uni-directional current, however, is still determined by *R* and is the same as in Fig. 1.

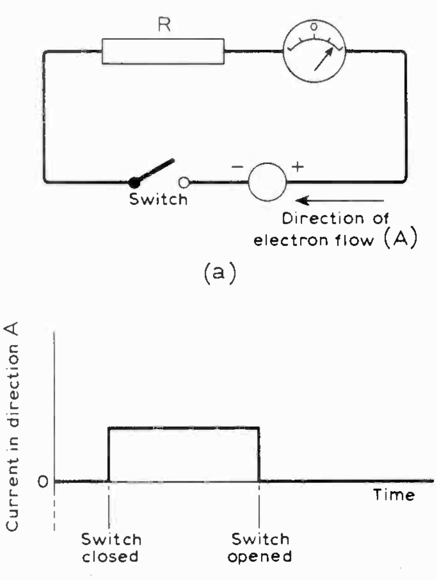

Fig. 1. Uni-directional current in circuit (a) when the switch is closed and opened is plotted in (b). The meter is a centre-zero type.

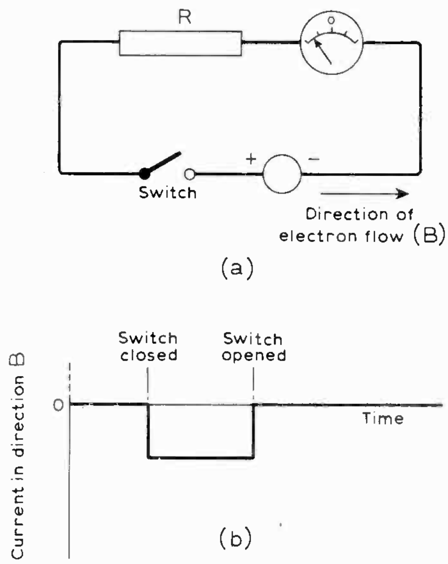

Fig. 2. Same circuit as in Fig. 1 but with the e.m.f.-source connections reversed so electron flow direction is reversed.

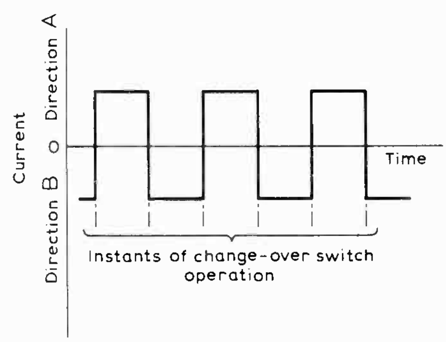

Fig. 3. Use of a change-over switch in circuit enables us to combine two uni-directional currents into an alternating current.

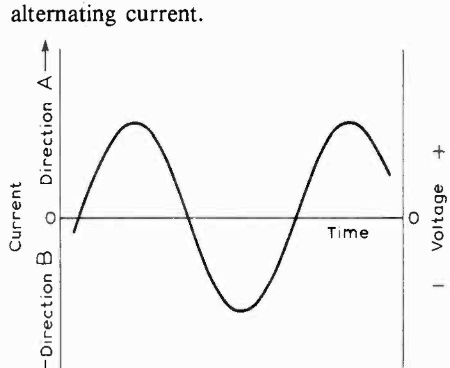

Fig. 4. Graph of alternating current of voltage having a sinusoidal waveform.

In the graphs we use in electronics there is a convention that electrical variables of opposite direction are plotted on opposite sides of a central zero on the vertical axis — analogous to degrees of latitude north or south of the equator. Which current direction we show as 'going up' from zero and which 'going down' doesn't really matter as long as we make the situation clear by labelling the vertical axis of the graph. So, since the current direction in Fig. 2 (a) is opposite to that in Fig. 1 (a) we plot the current in the Fig. 2 (a) circuit as in Fig. 2 (b).

If now we repeatedly reverse the ± position of the e.m.f. source—which we could do conveniently by removing the ordinary switch and putting in a change-over switch — we would repeatedly reverse the direction of the current in the circuit. Following the convention, the resulting graph of current would be as in Fig. 3. Note that at each change-over of the switch the current flowing in one direction falls to zero (switch going 'off') and immediately rises to the maximum value in the opposite direction (switch going 'on'). The resulting time graph, or waveform, is a representation of an alternating current.

The waveform of the alternating current graph is obviously determined by the instants we choose to operate the change-over switch, and in Fig. 3 it can be seen that we have chosen to operate the switch not randomly but in a strictly regular fashion. As a result this waveform is a constant repetition of a fixed cycle of current values and directions. It is, in fact, an oscillation (see Part 10). As such it could be generated by an electronic square-wave generator instead of the manually operated switch used for Fig. 3.

Thus a periodic alternating current is an oscillation. It can have any waveform (e.g. square, triangular) but the most widely used shape is the sine wave, described in Part 10. This is the waveform that is produced by power-station generators for the electricity mains and by electronic oscillators for the various uses described in Part 13. As a reminder, the sine-wave oscillation shown in Part 10 is repeated here in Fig. 4 as an alternating current.

What about the e.m.f., or voltage, that causes the current to flow? An alternating current in a circuit is created by an e.m.f. varying in a corresponding way and alternating on the principle of the ± ∓ change-over switching used for Fig. 3. In the generator or oscillator, this repetitive change of *polarity*, as it is called, occurs automatically. When plotting a graph of sinusoidal (or other waveform) alternating voltage we adopt the convention shown on the right hand vertical axis of Fig. 4. The upward direction is for values of positive (+) electrical potential (as given by the + terminal of a battery if the − terminal is considered as zero potential); and the downward direction is for values of negative (−) potential (as given by the − terminal of the battery if the + terminal is considered as zero potential).

Wien Oscillators

Properties of RC oscillators using Wien and related networks

*by P. Williams**

This article discusses the properties required of both active and passive sections of a range of *RC* oscillators. The passive networks include that due to Wien and other networks using the same *CR* values to give the same frequency for which the phase-shift is zero. Minimum realizations of suitable controlled sources are indicated and a series of practical circuits described. These include well-known circuits together with some new variants. Some have the advantage of low component count and the possibility of operation at low voltages and currents. Two other approaches to the design of *RC* oscillators—negative-impedance convertors and balanced-bridged circuits—are shown to be alternative descriptions for many known circuits, and a series of variants is described, together with their practical advantages. The nullor representation is, as with active circuit theory, a useful concept in helping to unify the three approaches.

Oscillators based on *RC* networks have been variously designed in terms of controlled sources,[1] impedance convertors[2] and balanced bridge circuits.[3,4] Of these *RC* networks, that due to Wien[5] is the most usual at low frequencies, and it is considered together with related networks using identical components and giving the same frequency of zero phase shift. The properties required of the associated controlled sources are discussed and transistor realizations outlined.

The basic forms of the Wien-bridge oscillator are considered and related to controlled source oscillators having external negative feedback networks. Oscillators can also be realized by the application of a negative impedance converter (n.i.c.) to the arms of the Wien network. Such a use of some known n.i.cs is described, and the resulting oscillators are also shown in bridge form. The discussion is limited for simplicity to the case of two equal capacitors and two equal resistors (with one noted exception).

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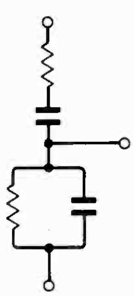


Fig. 1. In the Wien network there is a single frequency for which phase shift is zero, at which voltage transfer function attains its maximum value of 1/3. (Equal resistances and equal capacitances are assumed throughout this article unless shown otherwise.)

Wien's network

The basis of most sinusoidal oscillators designed for the 1 Hz to 1 MHz frequency range is Wien's network—Fig. 1. In its simplest form it uses pairs of identical resistors and capacitors as this allows continuous tuning over wide frequency ranges. There is a single frequency for which the phase shift between input and output is zero, and at that frequency the voltage transfer function (T_v) attains its maximum magnitude of one third.

The network input and output can be interchanged, when the new current transfer function (T_i) is identical with the previous value of T_v

$$\text{forward } T_v^{-1} = \frac{v_i}{v_o} = 1+Z_1Y_2$$

$$\text{reverse } T_i^{-1} = \frac{i_i}{i_o} = 1+Z_1Y_2$$

$$1+Z_1Y_2 = 3+\mathrm{j}[\omega CR-(\omega CR)^{-1}]$$

The circuit configurations for these well-known oscillators are indicated in Fig. 2.

There are several related networks of the same resistors and capacitors with transfer functions which peak at the identical frequency of zero phase shift if properly terminated. These are shown in Fig. 3 and the defined transfer functions are indicated for the two directions and identified separately. Thus the first network will be given as I or II according to the direction of signal flow. The basic properties of the networks are summarized in Fig. 3.

Controlled-source oscillators

A series of oscillators can be constructed by combining each network with the appropriate controlled source. Networks I, III and V require an ideal voltage amplifier, or, adopting the nomenclature of Mitra,[7] a voltage-to-voltage transducer (v.v.t). The required voltage gain is then +3. Similarly networks II, IV and VI require a current-to-current transducer (c.c.t.) of current gain +3. The basic oscillator circuits for III and IV are shown in Fig. 4. Similar circuits can be drawn for each of the other networks.

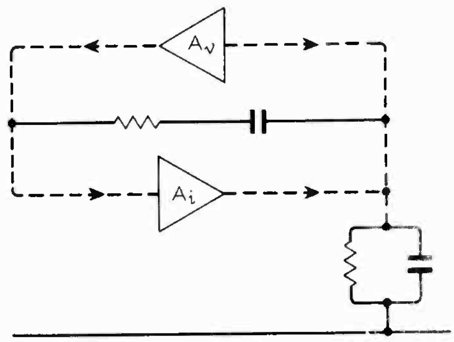


Fig. 2. Oscillators can use either a voltage amplifier with high input and low output resistances or a current amplifier with low input and high output resistances.

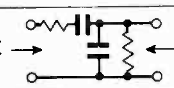
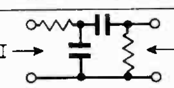
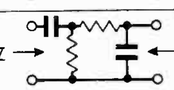
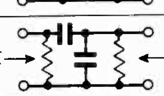
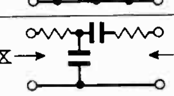
Network		Optimum source resistance	Optimum load resistance	Transfer function at frequency of zero shift
I →  ← II	I	0	∞	$T_v = \frac{1}{3}$
	II	∞	0	$T_i = \frac{1}{3}$
III →  ← IV	III	0	∞	$T_v = \frac{1}{3}$
	IV	∞	0	$T_i = \frac{1}{3}$
V →  ← VI	V	0	∞	$T_v = \frac{1}{3}$
	VI	∞	0	$T_i = \frac{1}{3}$
VII →  ← VIII	VII	∞	∞	$T_z = \frac{R}{3}\Omega$
	VIII	∞	∞	$T_z = \frac{R}{3}\Omega$
IX →  ← X	IX	0	0	$T_y = \frac{1}{3R}$ S
	X	0	0	$T_y = \frac{1}{3R}$ S

Fig. 3. Networks related to Wien's network and having the same frequency of zero phase-shift for equal component values.

Realizations of the amplifiers used in the above network should ideally meet the constraints (a) that the output is in phase with the input, (b) that the transfer function is the inverse of that of the network at the frequency of zero phase shift, and (c) that the input and output impedances should be separately zero or infinite as required by the network. This last condition is equivalent to the requirement that for a defined value of T_v, T_i, T_z or T_y that the value of the corresponding T_i, T_v, T_y or T_z should be infinite. None of the available active devices can meet the last condition, but used in the inverting mode (common cathode, emitter or source) the errors due to finite transfer functions can be small.

In the other modes though the phase relationship is correct, either the current gain or the voltage gain is less than, or equal to, unity. Thus a minimum of two active devices must be used and Fig. 5 shows the five combinations of two identical transistors that meet the first constraint. Only the first three of these can approximate to satisfying the third constraint. Combining each of these three with each of the ten *CR* networks above would generate 30 oscillator circuits, but there is considerable mismatch with some combinations. For example network VII requiring current drive and open-circuit load would match ill with amplifier C the input and output impedances of which are both low. The resulting oscillator, which for brevity will be referred to as VIIC, would have a frequency of oscillation markedly different from the natural frequency of the properly terminated network.

When an optimum combination of network and amplifier has been chosen it is likely that the available gain will be greatly in excess of that needed just to sustain oscillation. The loop gain can be reduced simply by attenuation of the signal at some point in the loop, or a resistive network can be introduced which simultaneously modifies the effective impedances presented by the amplifier to the network. This minimizes loading errors and leads in some cases to oscillators which are more usually considered as bridge oscillators. The following series of circuits indicate some of the combinations that can be used.

In each case an attempt has been made to minimize component count to expose the essential elements of the oscillator. To this end advantage has been taken of the ability of bipolar transistor to operate with collector forward-biased with respect to base by a few hundred millivolts on the peaks of the output waveforms. Naturally these circuits would benefit from additional bias networks for larger outputs at lower distortion, but some of the suggested circuits have the advantage of very low power consumption. Simpler circuits may result if the power supply is a constant-current rather than a constant-voltage type.

The circuits shown in Figs 6(a) and 7(a)

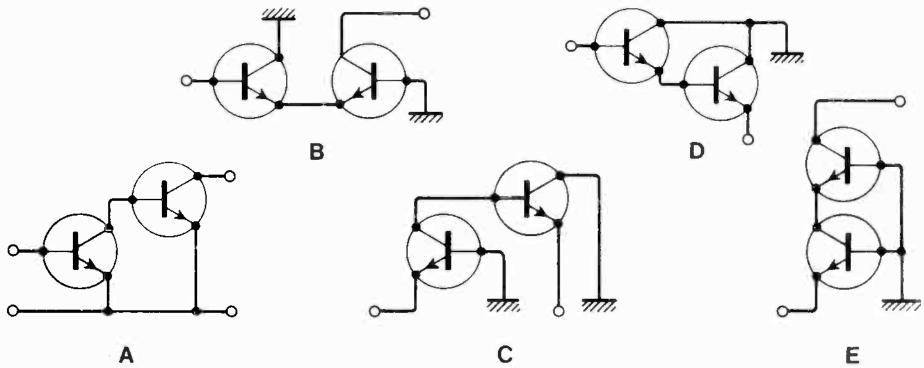


Fig. 5. Of the five combinations of two identical transistors that produce non-inverting amplifiers, only the first three have appropriate input and output impedances. Combining these with the CR networks would provide 30 oscillator circuits–though there would be mismatches in some, affecting frequency of oscillation.

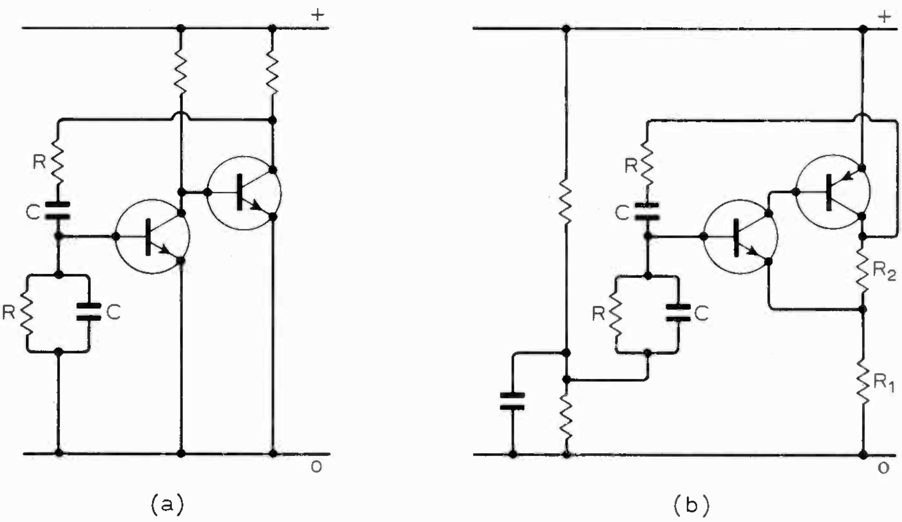


Fig. 6. To get loop gain just in excess of that needed to sustain oscillation, a resistive attenuator is included—a type IA circuit is shown (a)—which at the same time reduces loading errors (b). Network I can be replaced with III or IV of Fig. 3.

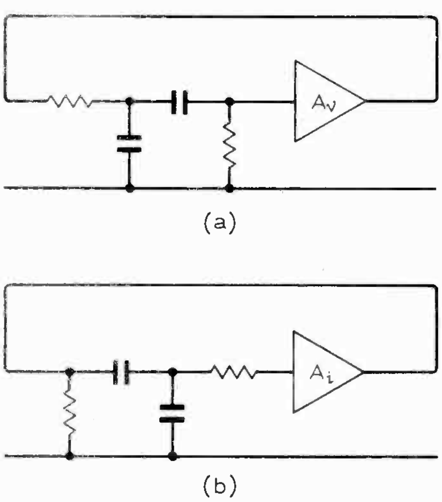


Fig. 4. Series of oscillators can be made using each of the networks of Fig. 3 with the appropriate controlled source. Basic circuits for types III and IV are shown. See Fig. 5 for amplifier configurations.

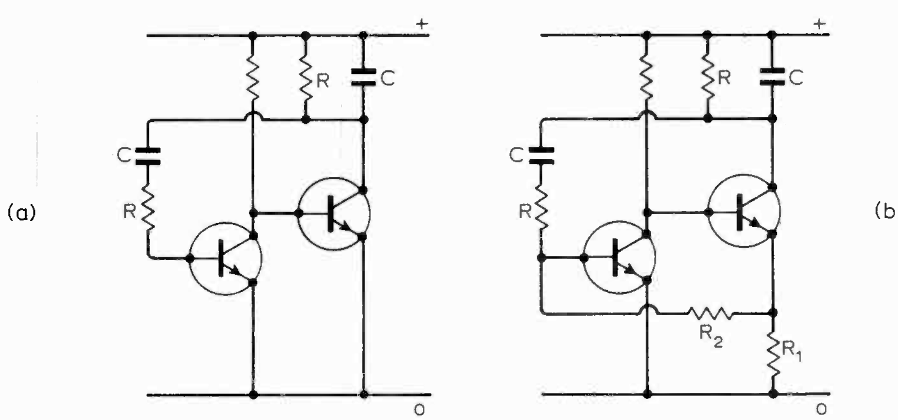


Fig. 7. Type IIA circuit (a), with practical version (b) including resistive attenuator to reduce loading errors. Network II can be replaced with IV or VI of Fig. 3. These simple circuits may need more elaborate bias networks for large outputs but have very low power consumption.

are the usual forms of voltage-[8] and current-fed[9] Wien networks and can be classified as types IA and IIA respectively. Biasing methods are indicated in Figs 6(b) and 7(b). In each case R_1 and R_2 define the transfer function of the amplifier while minimizing the loading effects on the network. Network I may be replaced by III or V, and network II by IV or VI. The input and output impedances differ but, provided loading effects have been minimized, the behaviour is comparable. The Wien network together with these resistors also constitute an almost-balanced bridge at the frequency of oscillation and such circuits have been regularly described in the literature.[4,10] Other variants on the bridge oscillator are given in the following section.

Variants of normal Wien oscillators

Amplifier B of Fig. 5 has high input and output impedances and of the three it is the nearest approximation to a voltage-to-current transducer (v.c.t.). As such it matches best to networks VII and VIII. For simplicity only network VIII is shown in the following circuits. That of Fig. 8 uses a long-tailed pair with Tr_2 tapped onto the resistor of the CR network. This is the simplest way of limiting the amplitude of oscillation, but the finite input impedance of Tr_2 does load the network. If the loop gain is high enough, the base is loading only a small part of R, with reduced effect on the frequency of oscillation.

Clearly a better method is to use negative feedback in the emitters of Tr_1 and Tr_2 raising the input and output impedances of the amplifier and allowing it to approach more closely to the ideal v.c.t. A complementary form of the circuit is shown in Fig. 9(a). Direct coupling of the emitters of a pair of complementary bipolar transistors makes for a simple circuit requiring only a single-ended power supply. The effective source impedance of the supply should approach zero at the frequency of oscillation, but biasing would be both critical and strongly temperature-sensitive if a direct voltage source were used. A direct-current source adequately bypassed solves this problem as indicated in Fig. 9(b), though such a source can be provided by a limiting resistor to a direct voltage source.

Other forms of type B oscillators can be designed to take advantage of the characteristics of f.e.ts. The loading effects of the gate circuits will be negligible, and direct voltage supplies are suitable. Two complementary circuits are shown in Figs 10(a) and 10(b). The required supply voltage clearly depends on the pinch-off voltages of the transistors.

These f.e.t. circuits share a problem not encountered with the bipolar versions. The transconductance (g_m) is much lower than for bipolar transistors operated at comparable currents, e.g. ~ 1 mA/V as compared with ~ 40 mA/V at currents in the region of 1 mA. Thus unless the effective load presented by the network is high enough, the circuit will not oscillate. As indicated in the Appendix, the solution is to operate the f.e.ts close to pinch-off. To a first-order approximation the maximum possible p.d. across the drain resistor of Tr_1 is constant, but as the device approaches pinch-off g_m falls more slowly than does the drain current I_d. As the loop gain depends on the product $g_m R$ and R may vary inversely with I_d the loop gain continues to rise as the current falls. The value of R may become impractically high with some f.e.ts but the limitation can be removed by the addition of separate bias networks. Mixed circuits using one bipolar transistor and one f.e.t. can also be used as in Fig. 10(c).

The networks most suited to amplifier C are IX and X. These ideally require zero

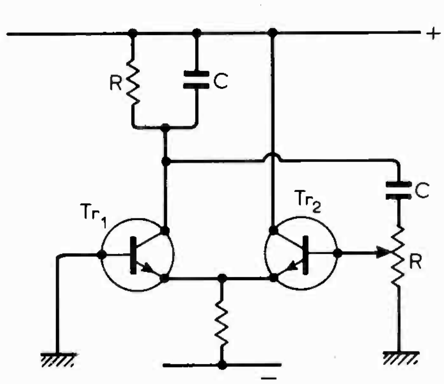


Fig. 8. Amplifier B of Fig. 5 approximates a voltage-to-current transducer because of its high input and output impedances and best matches networks VII and VIII. This circuit—using VIII—uses a long-tailed pair with one R tapped to give amplitude limiting while reducing the loading effect of Tr_2 base.

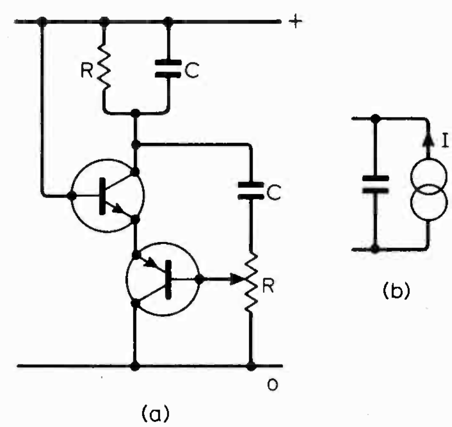


Fig. 9. This complementary form of Fig. 8 circuit uses negative feedback in the emitters to raise input and output impedances. A bypassed current source (b) avoids the problem of critical and temperature-sensitive bias with direct voltage source.

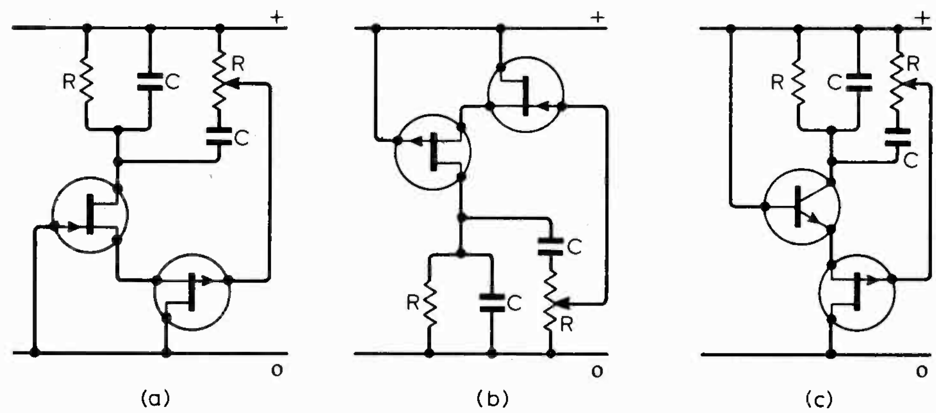


Fig. 10. The two complementary f.e.t. circuits (a) and (b) feature negligible loading by the gate circuit and allow direct voltage supplies. Low g_m of the f.e.ts—which may prevent oscillation—is avoided by using one bipolar transistor (c).

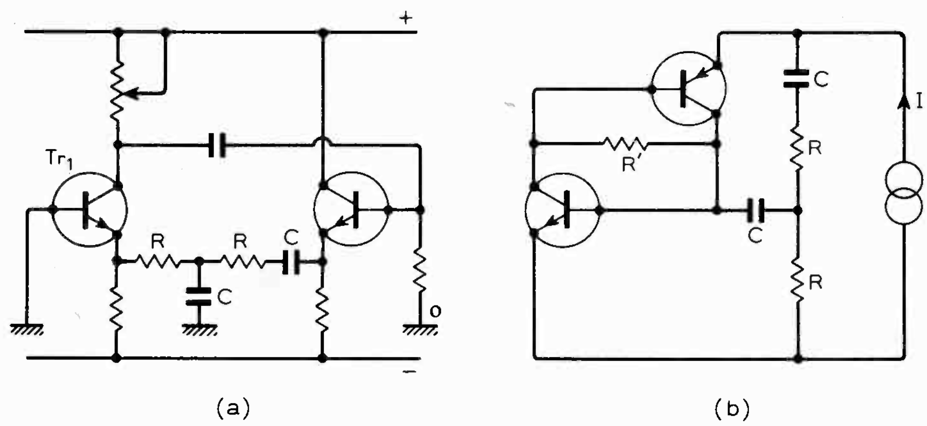


Fig. 11. Amplifier C of Fig. 5 best approximates to a voltage-to-current transducer with zero source and load impedances and is best suited to networks IX and X. Circuit (a)—showing network X—has variable loop gain and needs a dual supply. Complementary version (b) uses a single-ended constant-current supply, unbypassed. (With transistors replaced by nullors the oscillatory condition is $R' = 3R$.)

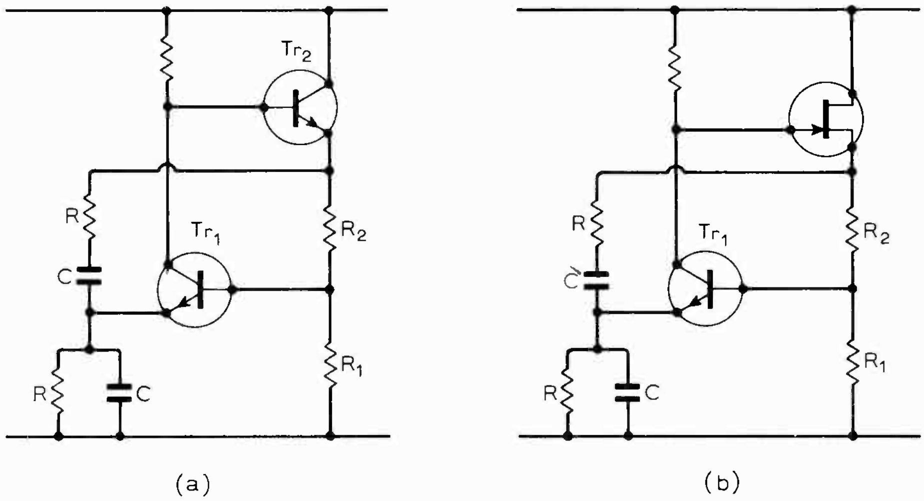


Fig. 12. Oscillator (a)—a modified version of Fig. 6(b)—is produced with network I and amplifier C but feedback increases input impedance and makes it similar to type IA. Loading of the network is reduced by reducing current in Tr_2, requiring an f.e.t. for the second stage.

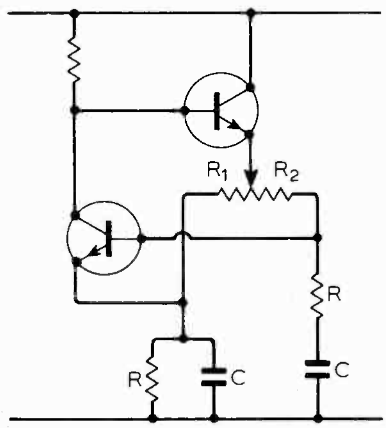


Fig. 13. This version of the Fig. 12(a) circuit—produced from Fig. 12(a) by transposing bridge elements—indicates that bridge drive and output points can be interchanged. In this version either the two capacitors or the two resistors in the bridge have a common point.

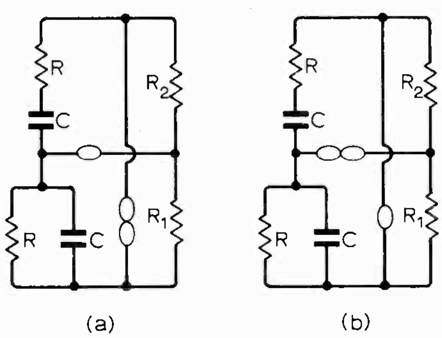


Fig. 14. Wien-bridge oscillators using nullor representations—the combination of nullator and norator and equivalent to any controlled source of infinite gain. Circuits (a) and (b) have nullator and norator transposed, with (a) equivalent to Figs 6 and 12 and (b) equivalent to Figs 7 and 13.

source and load impedances and amplifier C approximates to a current-to-voltage transducer (c.v.t.). Two practical versions are shown in Fig. 11(a) and (b). The first has two identical transistors separately biased with network X (or IX) coupled between the emitters. The loop gain is varied by a resistor in the collector of Tr_1. The complementary version in Fig. 11(b) is particularly simple in that beyond the active devices and the Wien network it uses but a single additional resistor—again to bring the circuit just into the oscillatory condition. In this case the constant-current supply should not be bypassed as the signal is transmitted through the network via the emitters. Similar realizations of type IXC are possible and the introduction of f.e.ts allows some variety in the choice of supplies.

Bridge oscillators

Some self-biasing bridge oscillators can be produced by a simple modification to the circuit of Fig. 6(b). The combination of network I with amplifier C seems less than ideal as the amplifier approximates to a c.v.t., i.e. with low input impedance. The loading effect of this input impedance on the network can be mitigated by the series application of negative feedback. The resulting circuit is shown in Fig. 12(a) and is unusual in that the feedback is to the base of Tr_1. Ideally the emitter current of Tr_1 should be vanishingly small, which places a similar constraint on the base current of Tr_2. If both are silicon transistors and Tr_2 has a high current gain the ratio $R_2:R_1$ approaches that for a balanced Wien bridge. The mean output voltage is then a reasonably defined multiple of the base-emitter p.d. of Tr_1 and no other bias elements are required. The method may be extended by replacing Tr_2 by a junction field-effect transistor of low pinch-off voltage. The gate current is negligible, the collector load of Tr_1 may be very high and the loading effect of Tr_1 emitter current on the Wien network is minimal.

The oscillators of Fig. 12 are basically type IC but the feedback makes the behaviour similar to type IA. Isolating the section of the circuit consisting of network I with the feedback resistors R_1 and R_2, leads to the alternative interpretation of the oscillator. It is a bridge, almost at balance at the critical frequency with the amplified unbalance being just sufficient to provide the appropriate drive voltage. Such an approach further indicates that bridge drive and output points can be interchanged as shown in Fig. 13. This version of the circuit has the advantage that either the two resistors or the two capacitors of the Wien network have a common point to one side of the supply. Remote control of frequency is thereby facilitated.

Nullor representation

Two one-port networks—the nullator (characterized by $V = I = 0$) and the norator[11] (in which voltage and current are independent)—have been used very successfully in the analysis and synthesis of such active networks as the negative-impedance convertor[12] and the gyrator.[13] Combined as the nullor[14] these one-port networks have been shown to be equivalent to any controlled source of infinite gain, e.g. the ideal operational amplifier.[15] If the bridge network is isolated then the active devices together with any bias components may be replaced by one or more nullors. In the circuit of Fig. 14(a) a single nullator/norator pair is sufficient to determine the conditions of oscillation. The nullator imposes the constraint of zero p.d. between one opposite pair of bridge points without drawing current, while the norator establishes an arbitrary p.d. between the other pair. This is possible only if the bridge is precisely balanced.

The nullor concept gives no information on the operations of the circuit with finite controlled sources but allows other forms of oscillator to be generated. The circuit of Fig. 14(a) is equivalent to those of Figs 6 and 12. If nullator and norator are interchanged as in Fig. 14(b) the same constraints apply and the circuit is equivalent to those of Figs 7 and 13. The equivalence can be established by replacing each individual transistor by a nullor in which nullator and norator have a common point. If in the circuit any nullator/norator pair appears directly in series it places no constraint on the p.d. between the output points of the pair and draws no current. In each of the circuits of Figs 6, 7, 12 and 13 there remains one effective nullor in which the nullator and norator are floating.

A better approximation to the nullor is to be found in the many operational amplifiers obtainable in both discrete and monolithic forms. The gains, though finite, are sufficiently high that the departure from the behaviour predicted on the basis of the nullor is small. It seems then that two distinct forms of Wien-bridge oscillator are possible with such amplifiers. A further practical sub-division arises because, though the input floats with respect to output, one side of the output is common to a supply line for most commercially available circuits. Four realizations then result as in Fig. 15, depending on which bridge vertex is

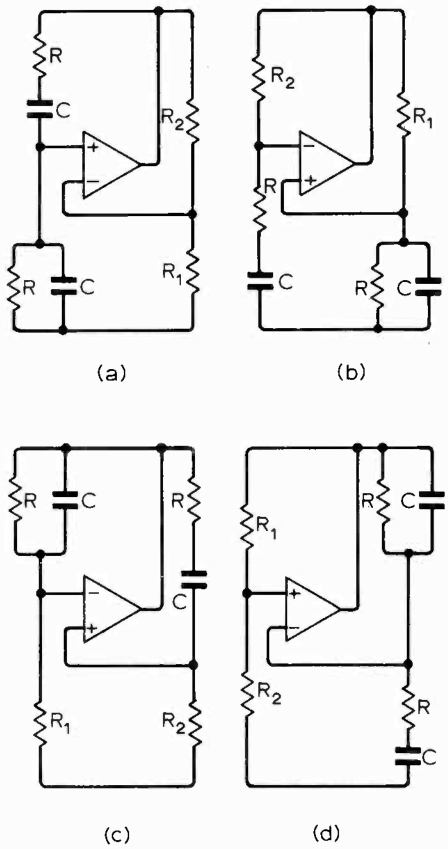


Fig. 15. Using operational amplifiers as an approximation to the nullor, four different forms of the Wien-bridge oscillator are possible.

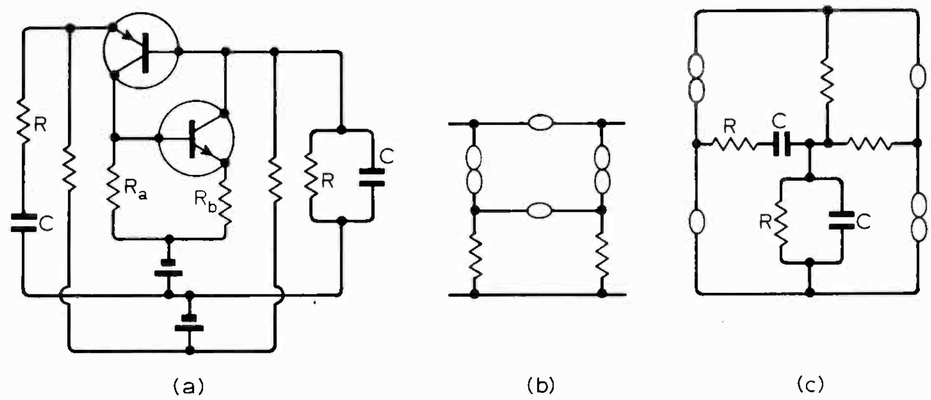


Fig. 17. Oscillator proposed by Pasupathy (a) corresponding to Braun type IIIB n.i.c. (b) and bridge at (c).

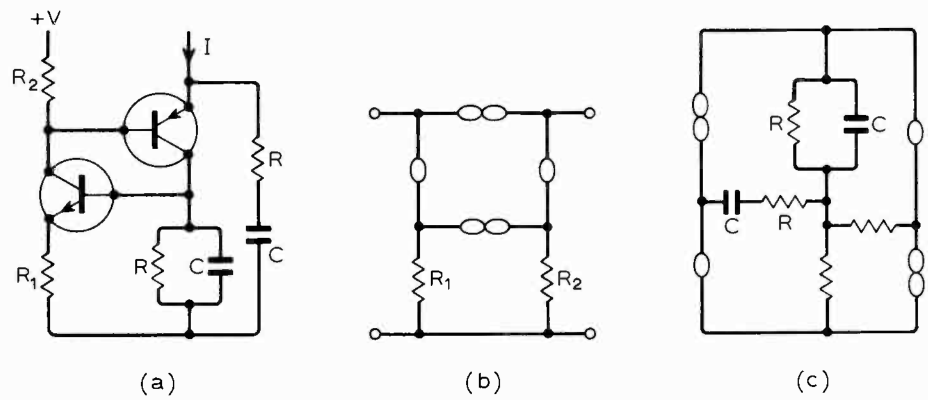


Fig. 18. Practical circuit (a) will oscillate with supplies of 1V and 70 μA. It is produced by nullator/norator interchange on Fig. 17. Corresponding n.i.c. Braun IIA is at (b) and bridge representation is at (c).

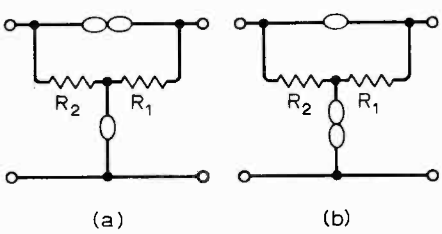


Fig. 16. Comparing the oscillators of Fig. 14 with negative impedance converter acting on the frequency-dependent section, they can be redrawn, (a) corresponding to Braun type IVA and (b) corresponding to IVB.

connected to that output point which is common with a supply line—generally the the common point of a dual-polarity supply.[16]

From a nullor standpoint versions (a) and (c) are identical as are (b) and (d). The differences arise where the oscillator is coupled into other active circuits sharing the same supply. Circuit (c) has the disadvantage that the amplifier inputs are subjected to a higher common-mode signal as compared to that of circuit (a), assuming equal C, R values in the network and equal signal amplitude at the amplifier output. Where voltage-controlled tuning is required it is an advantage if the elements controlling the frequency have a common point at the common potential of the system. This property is present in circuits (b) and (d) as it is in Fig. 13.

Another feature of these last circuits is that an output is available from either side of the nullator to the common supply point which differs in phase from that at the usual output point. The impedance at these points is high and any loading must be light but the phase may be adjusted by varying R_1 and R_2 while maintaining their ratio. If instead the value of the capacitors is changed together, the frequency is varied while the relative phase between the two outputs is retained.

It may sometimes be advantageous to operate such circuits with high values of R_1, R_2 so that high output voltages are possible with small common-mode signals at the inputs. This would also allow the use of capacitors of low voltage rating where maximum capacitance in a given volume is important. Two-transistor circuits corresponding to those of Fig. 15(c) and (d) are equally feasible and the discussion of the circuits of Figs 12 and 13 is applicable.

N.I.C. oscillators

Many oscillators have been classified as negative-resistance oscillators including the transitron and tunnel-diode types. In others an amplifier port may present an equivalent negative resistance to a tuned circuit because of some feedback path to that port. Similarly Wien-bridge oscillators can be interpreted in terms of negative-impedance convertors. Pasupathy[2] has argued that the Wien-bridge oscillator should be considered as a special case of the negative-impedance oscillator and proposed the circuit shown in Fig. 17(a). Resistors R_a and R_b define the conversion factor for the circuit just as resistors R_1 and R_2 define the transfer function of the controlled source in the circuit of Fig. 6(b), or as the corresponding resistors define the bridge balance conditions in Figs 12 to 15.

However, the simplicity of Pasupathy's oscillator stems from the choice of active circuit and not as suggested from the advantages of an n.i.c. approach. Thus in each of the circuits of Figs 12 to 15, the amplifier, together with the resistive arms, can be interpreted as performing impedance conversion on one frequency-dependent arm in presenting to the other. Comparing these circuits with the n.i.cs as classified by Braun,[12] Fig. 14(a) and (b) can be redrawn as in Fig. 16. They correspond to Braun IVA and IVB respectively. Similarly Pasupathy's oscillator corresponds to Braun IIIB—Fig. 17(b).

Another n.i.c. listed by Braun as IIA is shown in Fig. 18(b), while Fig. 18(a) gives one realization of an oscillator using it. The oscillator requires separate voltage and current supplies but the operating voltages can be very low. For example, it will oscillate with $V = 1\text{V} \pm 10\%$ and $I = 70\,\mu\text{A}$. Under these conditions and with R_2 adjusted to produce a 50 mV r.m.s. output at the emitter of Tr_2, the peak p.d. between this point and ground is $\sim 1{\cdot}2$ V.

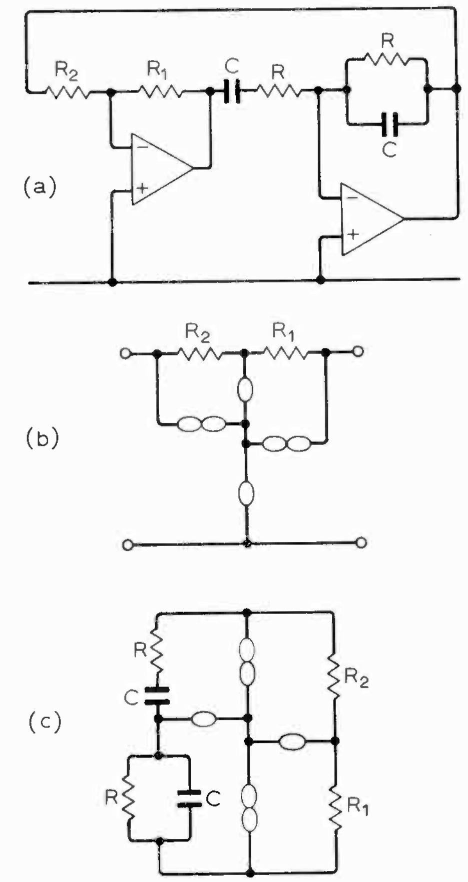


Fig. 19. Baxandall's oscillator with two antiphase low-impedance outputs (a) corresponds to Braun IIA (b) and to the bridge oscillator (c) activated by two nullors with a common point to both nullators and both norators.

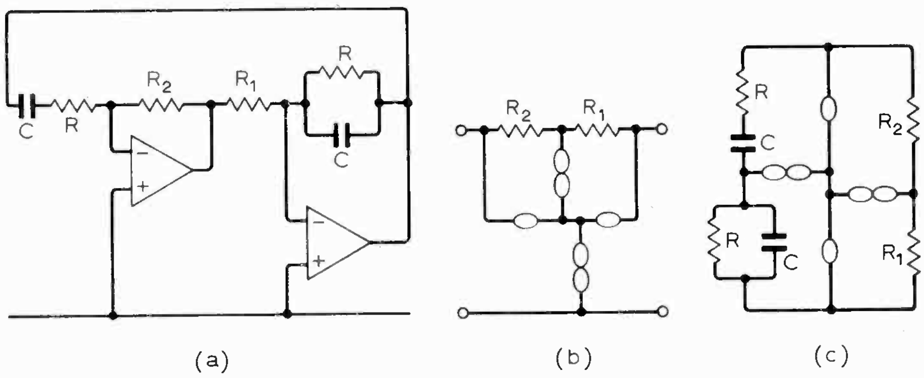


Fig. 20. Interchanging nullator and norator in Fig. 19 provides a new circuit (a) corresponding to Braun IIB (b). Bridge equivalent is at (c).

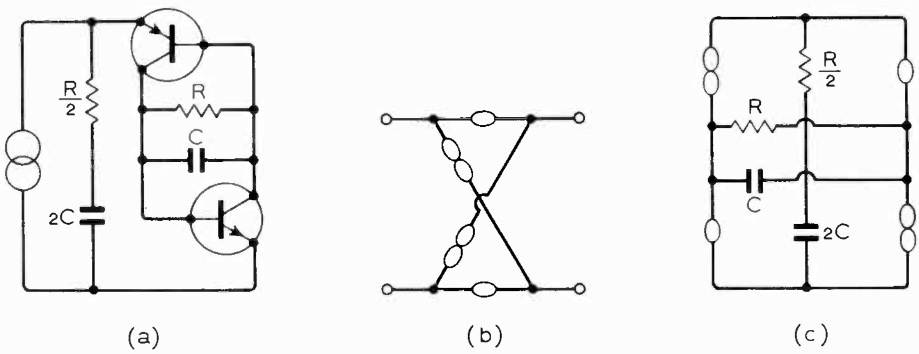


Fig. 21. Circuit at (a) works from a current source of 10 μA at 1V. Corresponding n.i.c., Braun I, is at (b) and bridge is at (c).

An oscillator due to Baxandall requires two inverting amplifiers and has two antiphase low-impedance outputs—Fig. 19(a). The equivalent circuit—Fig. 19(b)—shows that it corresponds to Braun IIIA. Equally it may be seen as a bridge oscillator activated by two nullors with a common point to both nullators and both norators. This is convenient as this common point can be the common supply line and the circuit is well-suited to realization with operational amplifiers. Just as two distinct forms of bridge oscillator were obtained by interchanging nullator and norator in Fig. 14, so too Fig. 20 shows a new oscillator related to that of Baxandall and corresponding to Braun IIB. The two low-impedance outputs can be adjusted in phase by choice of R_1 and R_2 while the appropriate ratio is maintained. The frequency can be varied by changing both capacitors without upsetting this phase relationship.

Other n.i.cs can be used with Wien's network to produce oscillators. A particularly interesting oscillator is possible using Braun I. The conversion factor is identically unity with ideal transistors and the circuit and its realization are shown in Fig. 21(a) and (b). The restriction imposed on the Wien network is that the elements of the series arm may no longer be identical with those of the parallel arm. In practice the finite gains of the transistors means that the impedance of the series arm must be further reduced. The power supply required is an unbypassed current source of as little as 10 μA with a circuit p.d. of less than 1 V. This oscillator is of interest for micropower operation and where minimum component count is important.

Appendix

In the circuit of Fig. 10(a) a condition can be derived for the minimum transconductance of the f.e.ts to sustain oscillation. For simplicity the f.e.ts are assumed to be separately described by the equation

$$I_D = I_{DSS}\left(1-\frac{V_{gs}}{V_P}\right)^2 \qquad (1)$$

with equal values of $|I_{DSS}|$ and $|V_P|$. (I_{DSS} is that value of I_D the drain current for $V_{gs} = 0$. V_P is that value of V_{gs} for which I_D is zero.) For the oscillatory condition, the loop gain has to be unity and

$$\text{loop gain} = \frac{g_m}{2}\cdot\frac{1}{3}\cdot R \quad \text{i.e. } (g_m R)_{osc} = 6$$

If both devices are operating in the pinch-off region, the value of gate-source voltage for the n-channel f.e.t. is as shown.

$$V_{gs} = -\frac{V_S}{2}$$

Maximum loop gain at any operating current is obtained for R such that the n-channel f.e.t. is just pinched-off i.e.

$$V_{gd} = V_P$$

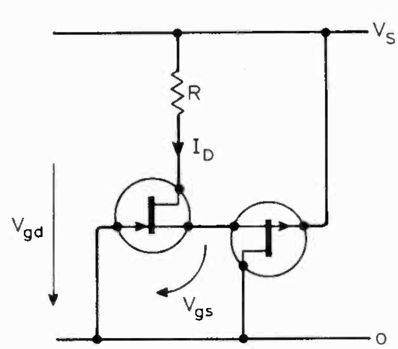
$$I_D R = V_S - V_{dg} = V_S + V_P \qquad (2)$$

From equations 1 and 2

$$R = \frac{V_P - 2V_{gs}}{I_D} = \frac{V_P\left[1-2+2\left(\frac{I_D}{I_{DSS}}\right)^{\frac{1}{2}}\right]}{I_D} \qquad (3)$$

Differentiating I_D with respect to V_{gs} in equation 1

$$g_m = -\frac{2I_{DSS}}{V_P}\left(\frac{I_D}{I_{DSS}}\right)^{\frac{1}{2}} \qquad (4)$$



Multiplying equations 3 and 4

$$g_m R = -\frac{2I_{DSS}}{V_P}\left(\frac{I_D}{I_{DSS}}\right)^{\frac{1}{2}} \cdot \frac{V_P}{I_D}\left[2\left(\frac{I_D}{I_{DSS}}\right)^{\frac{1}{2}} - 1\right]$$

$$= 2\left[\left(\frac{I_{DSS}}{I_D}\right)^{\frac{1}{2}} - 2\right]$$

For oscillatory condition

$$6 = 2\left[\left(\frac{I_{DSS}}{I_D}\right)^{\frac{1}{2}} - 2\right]$$

$$I_D = \frac{I_{DSS}}{25}$$

Thus for a pair of complementary f.e.ts having equal magnitudes of I_{DSS} and V_P and operating in the pinch-off region oscillation can only commence if the drain current is reduced to 4% of the zero-bias on-current.

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'United States of Earth'

Fifty-four nations recently signed an agreement in which they pledged to co-operate in developing communications satellites. Arthur C. Clarke, who was the first to describe the feasibility of geo-stationary communications satellites in his 1945 *Wireless World* article 'Extra-terrestrial Relays', was a guest of honour at the proceedings.

Arthur Clarke said at the signing "Whenever I peer into my cloudy crystal ball and try to visualize the future of communications satellites, I remember an incident that occurred in England almost a hundred years ago.

"The very alarming news had just been received from the United States that a certain Mr. Edison had invented an electric light. This, of course, was very disturbing to the manufacturers of gas, oil and candles. So as we British do in an emergency, we called a Parliamentary Commission. It listened to the evidence of expert witnesses, who gave the reassuring news that nothing further would be heard of this impractical Yankee invention . . . .

"Among the witnesses called was the chief engineer of the British Post Office. Someone on the Commission said to him: 'We understand that the Americans have invented a machine that can transmit human speech. Do you think that this — telephone — will be of any use in Great Britain?' The chief engineer of the Post Office thereupon replied: 'No, Sir. The Americans have need of the telephone — but we do not. *We* have plenty of messenger boys.'

"This very able man totally failed to see the possibilities of the telephone — and who can blame him? Could anyone, back in 1880 have imagined that the time would come when every home would have a telephone, and business and social life would depend upon it almost completely?

"I submit, ladies and gentlemen, that the eventual impact of the communications satellite upon the whole human race will be at least as great as that of the telephone upon the so called developed societies.

"In fact, as far as real communications are concerned, there are yet no developed societies; we are all in the semaphore and smoke signal stage. And we are now about to witness an interesting situation in which many countries — particularly in Asia and Africa — are going to leapfrog a whole era of communications technology and go straight into the space age. They may never know the vast networks of cables and microwave links that this continent has built at such enormous cost, both in money and natural resources. Satellites can do far more, at far less expense to the environment.

"Intelsat, of course, is concerned primarily with point-to-point communications involving large ground stations. It provides the first reliable, high quality, wide bandwidth links between all the nations that wish to join, and the importance of this cannot be underestimated. Yet it is only a beginning, and I would like to look a little further into the future. . . .

"Two years from now, N.A.S.A. will launch the first satellite — ATS-F — which will have sufficient power for its signals to be picked up by an ordinary domestic television set, plus about two hundred dollars worth of additional equipment. In 1974 this satellite will be stationed over India and, if all goes well, the first experiment in the use of space communications for mass education will begin. I have just come from India, where I have been making a TV film on the promise of space. We erected, in a village outside Delhi, the prototype antenna — a simple umbrella shaped wire mesh affair, three meters across. Anyone can put it together in a few hours; it needs only one per village to start a social and economic revolution.

"The engineering problems of bringing education, literacy, improved hygiene and agricultural techniques to every human being on this planet have now been solved. The cost would be of the order of a dollar per person per year. The benefits in health, happiness and wealth would be immeasurable.

"But, of course, the technical problem is an easy one. Do we have the imagination — the statesmanship — to use this new tool for the benefit of all mankind? Or will it be used merely to peddle detergents and propaganda?

"I am an optimist; anyone interested in the future *has* to be. I believe that communications satellites can unite mankind. Let me remind you that whatever the history books say, this great country was created little more than a hundred years ago by two inventions. Without them the United States was impossible; with them, it was inevitable. Those inventions of course were the railroad and the electric telegraph.

"Today we are seeing, on a global scale, an almost exact parallel to that situation. What the railroads and the telegraph did here a century ago, the jets and the communications satellites are doing now — to all the world.

"I hope you will remember this analogy in the years ahead. For today, my friends, whether you intend to or not, whether you wish to or not — you have signed far more than yet another intergovernmental agreement.

"You have just signed the first draft of the articles of federation of the United States of Earth."

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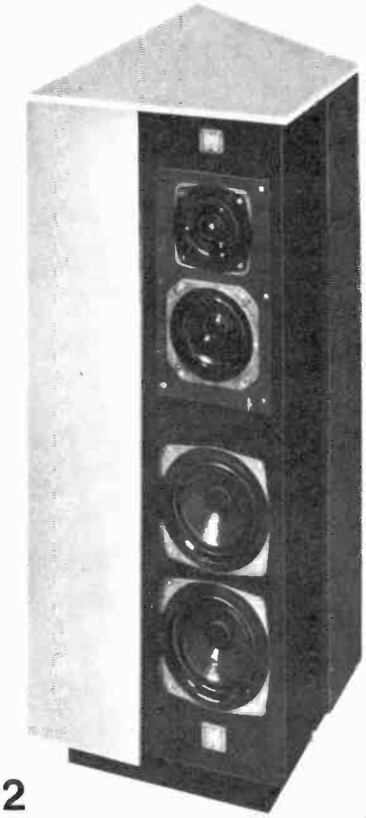
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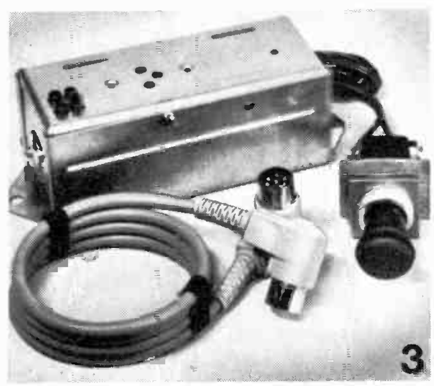
Focal Points at Berlin

Pressure on space prevented us from including these photographs in our report of the Berlin international radio and television exhibition (pages 486-8, October issue). **1.** Concurrent with CBS announcing their SQ (stereo/quadraphonic) disc and matrix technique, Sony — the first CBS licensee — showed their SQ1000 decoder, which will be available in Europe, early next year (see last issue). **2.** Goodmans Dimension 8 loudspeaker unit which, by virtue of the smaller angle one set of loudspeaker axes make with the wall behind, claims to give a larger area of stereo effect, as well as a "Raumeffekt" due to reflections from the other set of loudspeakers. **3.** Blaupunkt ARI (information by radio for car travellers) decoder which switches off the normal car radio programme for 3min when a 2.35-kHz signal, frequency modulated with a 12-Hz tone, is received to allow reception of traffic information. **4.** Typical touch type of television tuner (Graetz). **5.** Philips VCR video cassette recorder with built-in u.h.f. receiver. **6.** Pickup (stylus to the left) of the Teldec (Telefunken-Decca) colour video disc system (see last issue).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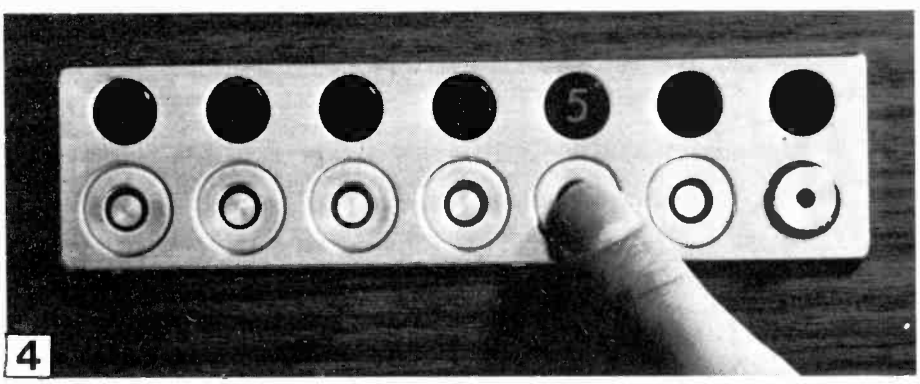

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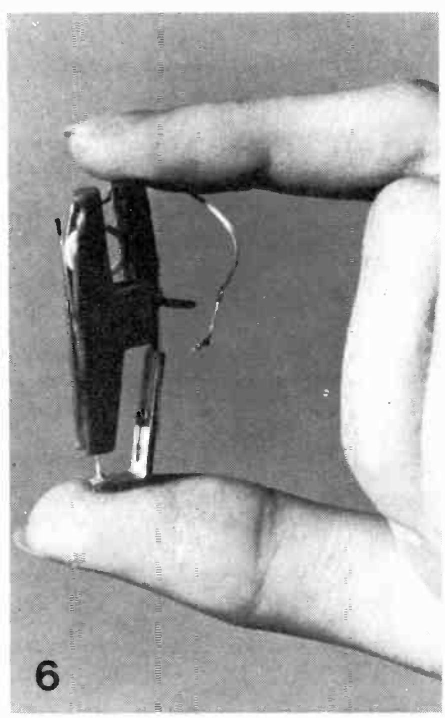
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Thank you gentlemen.

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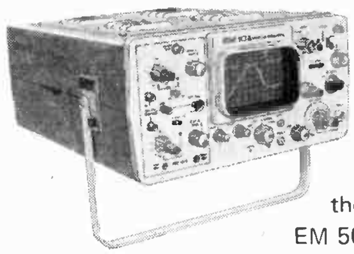

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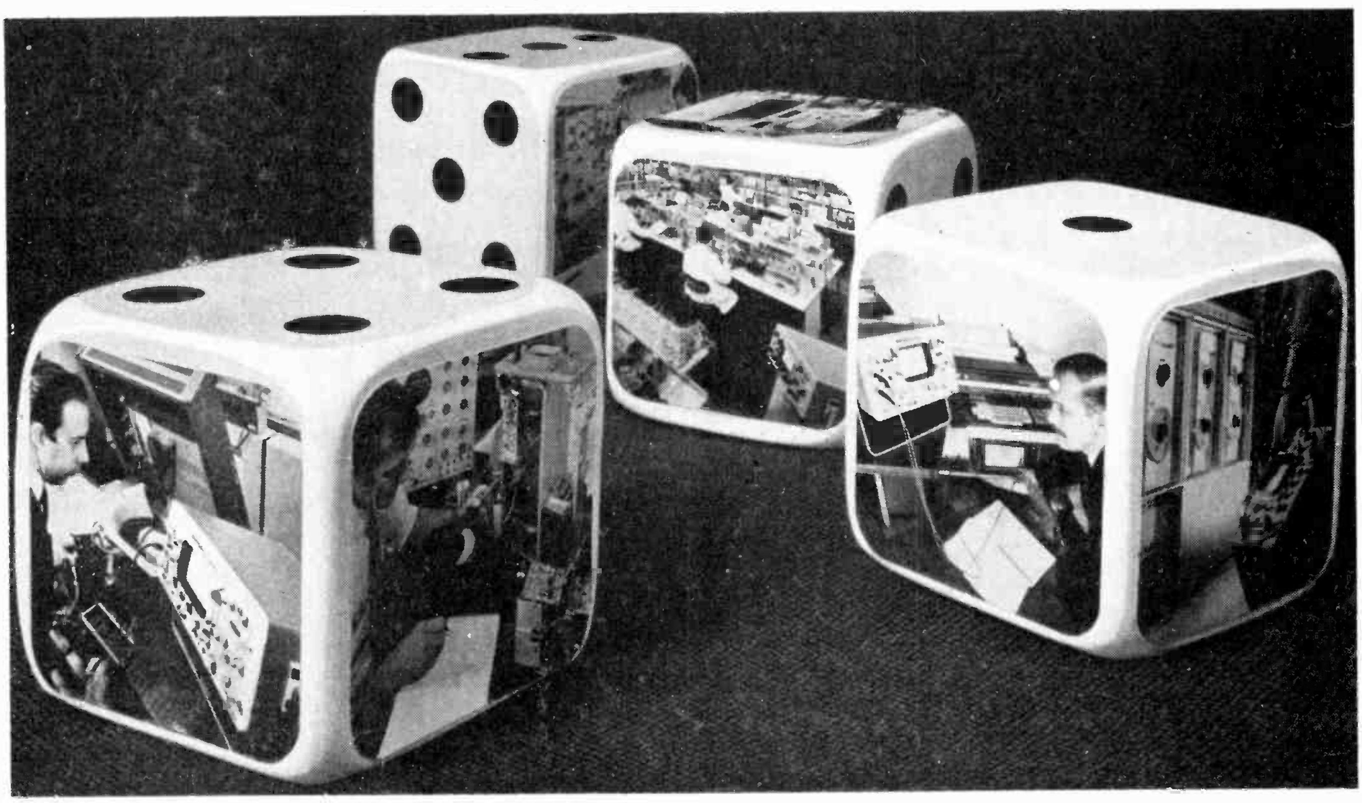


WW—090 FOR FURTHER DETAILS

The Drum Major

A hand-operated frequency response measuring instrument

by H. J. N. Riddle

The instrument described here is a hand-operated device for rapid plotting of response/frequency characteristics of audio equipment. It does the same sort of job as a swept-frequency a.f. oscillator and chart recorder, but the test frequency is varied and the chart is moved by hand—simultaneously at whatever speed one likes—and at the same time the response is traced on the chart by hand, using a fine felt-tipped pen. The response of the equipment being tested is measured by an a.c. voltmeter; this consists of an amplifier driving a reflecting voltmeter movement, the light spot from which falls on the chart. Thus as the frequency is varied the light spot makes a path on the moving chart, and if the pen tip is held on to it, always following the spot, this path is traced as a visible line—the frequency response. Fig. 1 shows the general principle of operation.

The name "Drum Major" derives from the fact that the chart on which the frequency response is traced is wrapped round a drum, as can be seen in Fig. 2 and the photographs. This drum is manually rotated, using the left hand, by means of a wheel. On the wheel is marked a logarithmic frequency scale (0 to 20kHz), which moves past a stationary 'cursor' as the wheel is rotated. This scale is in alignment with a corresponding logarithmic frequency scale marked on the chart. The charts are home-made—photocopies taken from a pen-and-ink master—and are of a length which almost encircles the $3\frac{1}{2}$-inch diameter drum (about 30cm). A fresh chart is attached to the drum at one end by a folded tongue in the paper strip, which fits into a slot cut in the drum, and at the other end by adhesive tape. In addition to the frequency scale the charts carry a response scale in decibels (voltage or current ratios), with lines at 0, 1, 5, 15, 20 and 25dB; these, of course, are seen as circumferential lines when the charts are attached to the drum.

Mechanically coupled to the drum and hand-wheel is a variable capacitor, which is part of a variable oscillator in a heterodyne circuit generating the test frequency. It is this capacitor which varies the test frequency as the wheel and drum are rotated by hand. A heterodyne oscillator, as distinct from some other type of oscillator using range switching, is, of

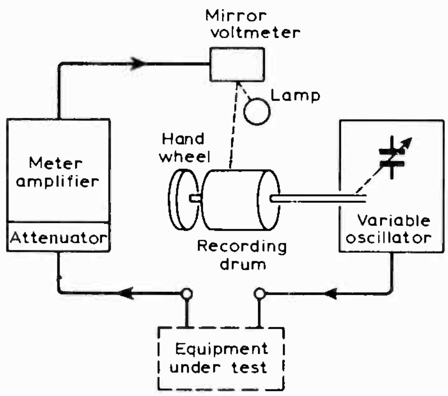


Fig.1. Schematic showing the principle of operation of the instrument.

course, necessary, because an essential of the whole instrument is to provide a frequency sweep of 0 to 20kHz with a single turn (actually 350°) of the drum. In this heterodyne oscillator the fixed frequency part works at 280kHz while the variable oscillator can be varied from 280kHz to 260kHz by the capacitor, and it is the difference frequency resulting from heterodyning these two outputs which provides the 0-20kHz sweep.

To obtain a chart with suitable scales—logarithmic frequency scale and decibel response scale—two non-linear relationships have to be introduced into the system in Fig. 1. First, in the variable oscillator, there has to be a non-linear relationship between the rotation (angular displacement) of the drum and the capacitance of the variable capacitor. This is provided partly by the law of the variable capacitor itself and partly by a cam through which the drum spindle drives the capacitor spindle (see Fig. 2). Secondly, in the a.c. voltmeter, the normally linear response of the amplifier and meter movement has to be modified to give a decibel response scale. This is given

Editor's note. This article is not presented as a repeatable constructional project, as we think many readers may be deterred by the mechanical construction work involved, but we hope sufficient information is given to help and guide experimenters who may wish to try building something similar.

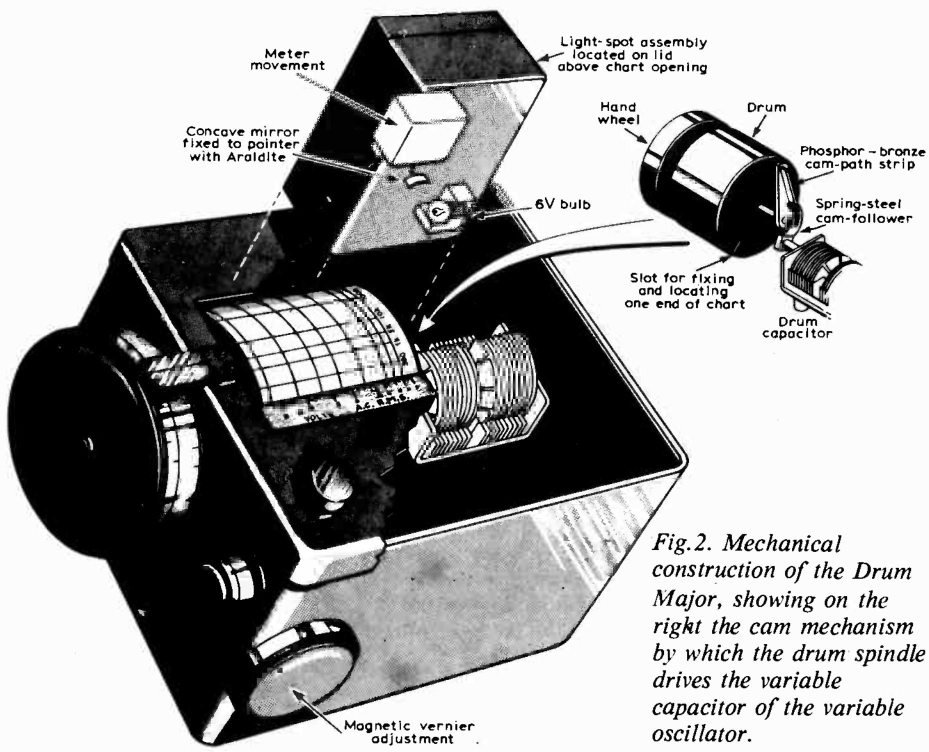


Fig.2. Mechanical construction of the Drum Major, showing on the right the cam mechanism by which the drum spindle drives the variable capacitor of the variable oscillator.

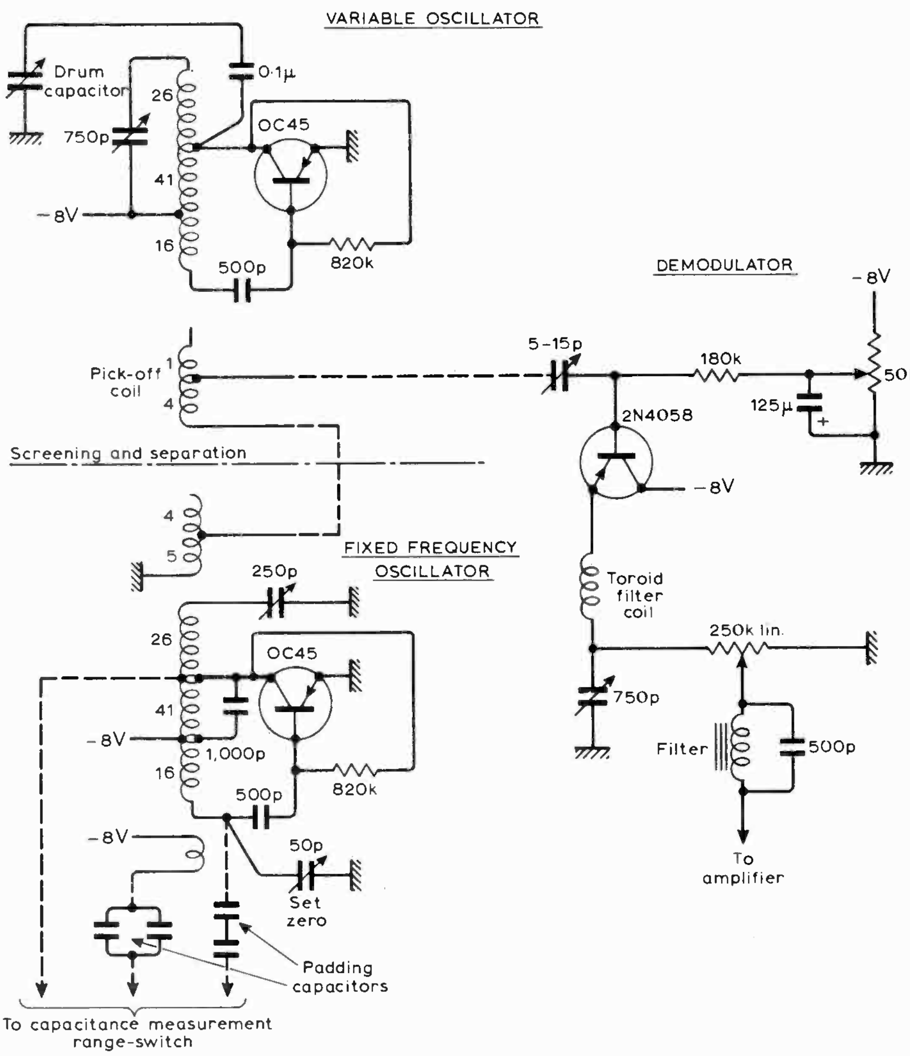
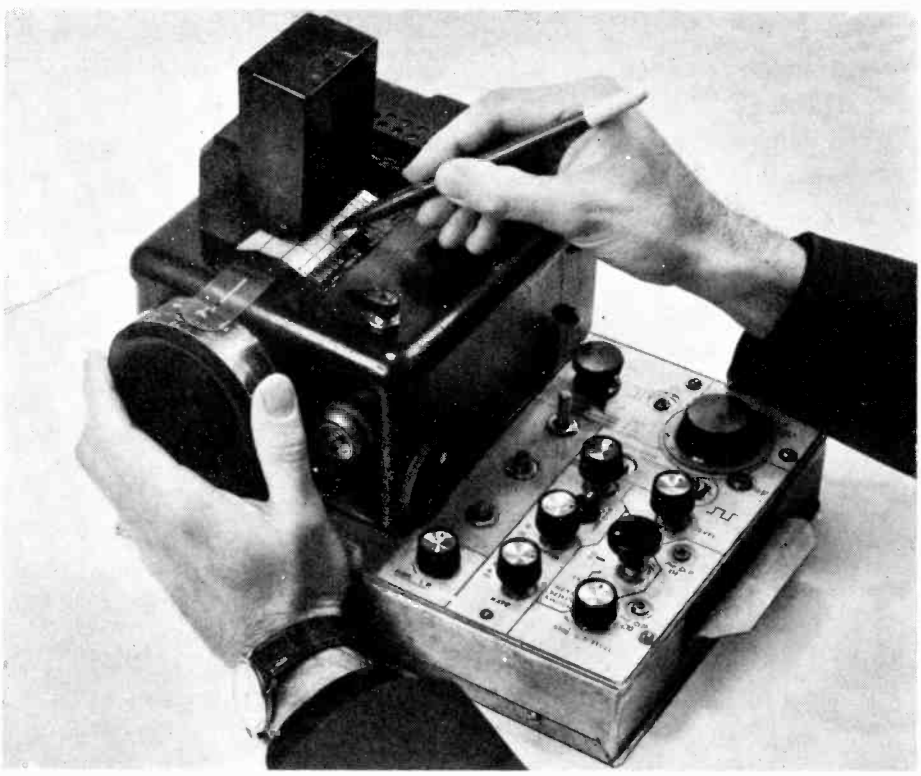


Fig.3. Circuits of the three sections of the heterodyne oscillator: variable oscillator, fixed oscillator and demodulator. Pick-off coil tappings are found by experiment.



The Drum Major in use. While rotating the drum by the hand wheel (left) the operator follows the movements of the light spot across the drum chart with a fine felt-tipped pen.

by the mechanical characteristics of the reflecting voltmeter movement.

In addition to response/frequency measurements by the method described, several other facilities are provided by the instrument. It can be used as a signal generator (0-20kHz), as an a.c. voltmeter (ranges: 0-35mV, 0-350mV, 0-3.5V, 0-35V) and as a capacitance meter (1pF to 1μF). There is a square-wave test signal output, derived from the sinewave oscillation; and a chopper, consisting of a multivibrator and an electromechanical relay, by which both the square-wave and sinewave outputs may be interrupted at various rates.

Heterodyne oscillator

The circuit of the heterodyne oscillator is shown Fig. 3. It consists of two Hartley type transistor oscillators, one fixed and the other variable, two pick-off coils to enable the oscillations to be heterodyned, and a demodulator circuit which extracts the difference frequency and filters out the unwanted high-frequency components. The output of the demodulator passes into an amplifier (Fig. 4) which provides the final test signal; this has an amplitude variable from 0 to2.0 volts r.m.s.

In each of the 280-kHz oscillators the transistor collector circuit feeds power into a tapping on a tank circuit, consisting of a 67-turn ferrite-coil coil tuned by a capacitor; and feedback is provided by a 16-turn coil, coupled to the tank circuit, which is connected via a 500pF d.c. isolating capacitor to the base of the transistor. The base is d.c. biased through an 820kΩ resistor connected to the collector of the transistor. The frequency of the variable oscillator in Fig. 3 is determined by the 365pF square-law variable capacitor (one section of Henrys Radio type 0) which is driven through the cam system by the drum.

If there is any magnetic or electrical coupling between two oscillators there is a tendency for them to "pull" into the same frequency of oscillation. This tendency increases as the oscillation frequency of one approaches that of the other. Even with the oscillator coils wound in pot-cores a considerable external field exists, and to reduce magnetic coupling the two oscillator units are mounted as far apart as possible and at right angles. Even so, electrostatic coupling between the wiring and components of each oscillator is sufficient to cause "pulling" unless care is taken in the layout of the wiring.

The very fact that some of the high-frequency output of each oscillator is to be mixed in a common circuit is itself a source of coupling. For this reason the pick-off windings are designed with as few turns as possible and with very thin wire (to reduce capacitive coupling). Further, the load imposed by the demodulator on the output impedance of these windings is kept as low as possible. Even if the oscillators do not "pull" together completely, the output waveform of the whole heterodyne oscillator will be considerably distorted.

Several factors in the circuit design of each oscillator influenced the extent to which the oscillator is affected by "pulling" in the presence of unwanted coupling: ratio of inductance to capacitance of the tuning components, ratio of turns between tapping on the windings, phase of feedback current, characteristics of the transistor, and degree of decoupling of d.c. supplies. The component values in Fig. 3 take account of these factors and were found by experiment.

In general the frequency at which "pulling" becomes serious is related to the frequency of the fixed oscillator. For example, other things being equal, oscillators operating at 200kHz may pull seriously when the difference is reduced to 20Hz, while oscillators designed for 2MHz could be expected to be similarly affected when the difference frequency is as high as 200Hz. As the aim is to produce audio frequencies to below 50Hz, the lower the frequencies of the individual oscillators the better. However, as the frequency at the upper end of the audio range is to be 20kHz, difficulties in eliminating the high-frequency components from the demodulator output increase as the individual oscillator frequencies are reduced. The matter inevitably has an element of compromise about it, and other considerations enter in too: (a) interference with, or by, broadcasting or other radio channels—in particular, any strong local transmitters; (b) the desirability that the modulated product of the two oscillations should have a constant amplitude over the range of the instrument; and (c) the necessity for a good sinusoidal waveform in each oscillator. Various frequencies were in fact tried before the final choice of 280kHz for the fixed oscillator was made.

As can be seen, the two pick-off coils are connected in series and their combined output is fed to the demodulator circuit. Difficulties were feared with the elimination of 280kHz energy from the final output (the 260kHz as well, when generating 20kHz) and experiments proved the fears to be well founded. Attempts to overcome the trouble by providing by-pass capacitors in the demodulator, or at one or more stages in the following amplifier, inevitably resulted in a fall-off of output amplitude (voltage) as the output frequency increased.

Finally, the filtering arrangement shown was adopted to remove the bulk of the unwanted components, but further cleaning-up was achieved with by-pass capacitors in the amplifier (Fig. 4). One of the two filters is a series acceptor circuit, tuned to remove frequencies of 270kHz ± 10kHz connected between the emitter of the 2N4058 and earth; the other is a rejector circuit, similarly tuned, connected between the demodulator output and the amplifier. Fixed capacitors of 200pF and 500pF in the amplifier deal with any small amounts of h.f. components which do get through.

One advantage of the heterodyne method over other methods of signal generation is that, in general, any change in the frequency of one oscillator, due to temperature changes or mains voltage variations, is likely to take place also in the other oscillator, thus cancelling errors from these causes in the audio frequency output.

In practice the Drum Major operates in ambient temperatures of below 5°C to 30°C and requires only a few minutes to stabilize after first switching-on before it is ready for use. The 50pF zero-set variable capacitor in the fixed oscillator is used to ensure accurate accordance of the output audio frequency with chart position. With the chart on the drum set to zero frequency, this capacitor is adjusted until the light spot plunges down and remains stationary on the 0dB line of the chart.

A further, vernier, adjustment of zero setting is provided by a circular rotatable magnet mounted on a spindle passing through the case, as shown in the drawing and photographs. This is a convenient, if crude, way of making minute alterations to oscillator frequency, utilizing the fact that the oscillator coils have ferrite pot cores.

The a.c. voltmeter

Fig. 5 shows the circuit of the a.c. voltmeter which is basically a transistor amplifier with an input attenuator and with a rectifier circuit at the output to feed the d.c. meter. The first stage is an emitter follower (to secure high input

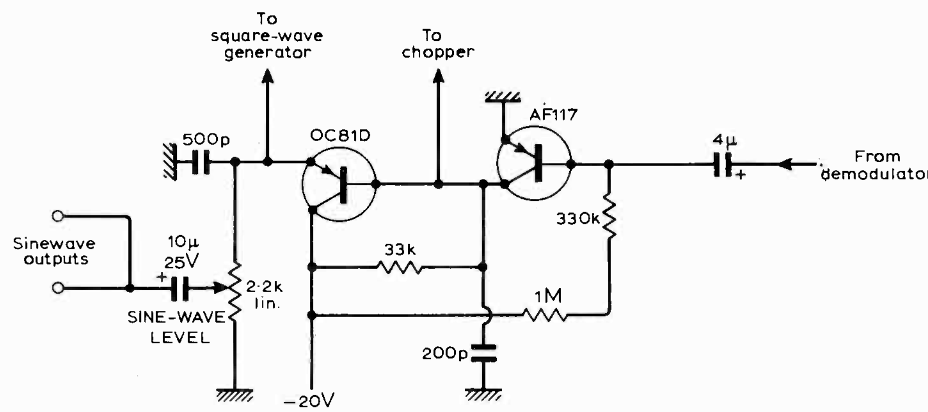


Fig.4. Amplifier for output from demodulator of heterodyne oscillator (Fig.3).

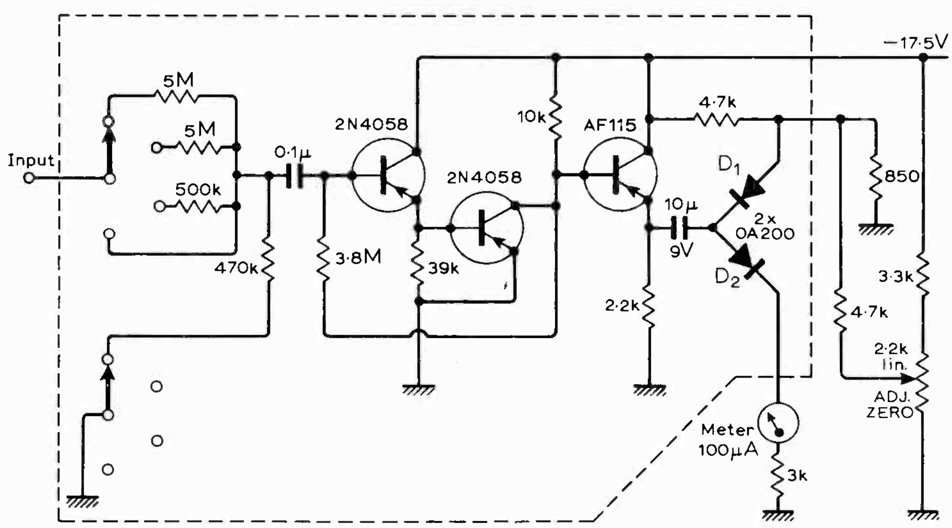


Fig.5. Circuit of the a.c. voltmeter, showing the 100µA reflecting meter movement at the bottom right.

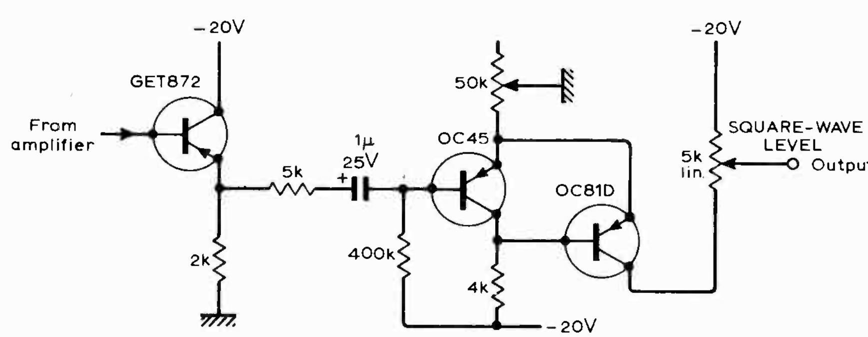
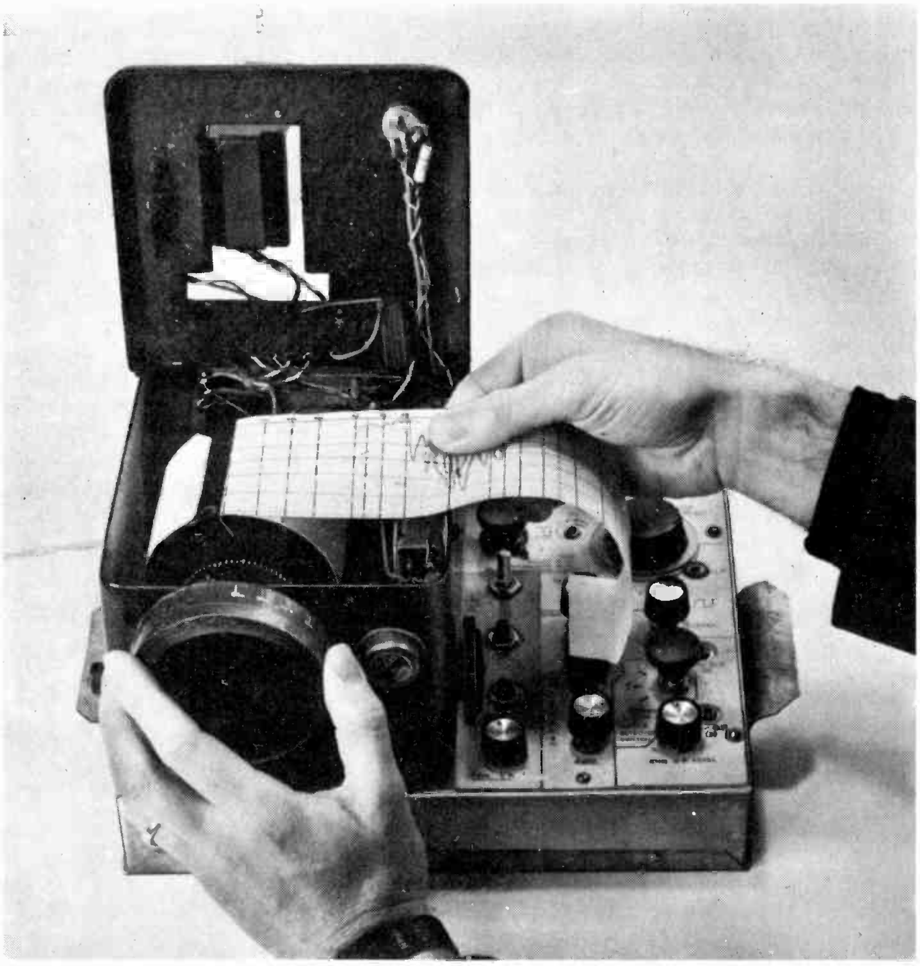


Fig.6. Square-wave generator, driven by sinewave from oscillator amplifier (Fig.4).



Showing how the chart is attached, by a folded tongue in the paper fitted into a slot in the drum.

impedance), the second a grounded emitter voltage amplifying stage, and the third an emitter follower. This arrangement allows the collector of the second transistor to remain almost unaffected by the cycle of changes which occurs as the rectifying circuit goes through its phases of operations, thereby keeping the feedback power to the input constant. The rectifying circuit, consisting of a 10μF capacitor and silicon diodes D_1 and D_2, operates as follows: During each negative-going half-cycle of the emitter of the AF115 emitter-follower the capacitor becomes charged, its right-hand plate going positive as current flows through D_1. During each positive-going half-cycle of the emitter the capacitor discharges through D_2 and the meter moving-coil. To overcome the relatively high pedestal voltage of the silicon diodes a "priming" circuit is provided in the shape of the 2.2kΩ potentiometer and associated 3.3kΩ and 4.7kΩ resistors. This circuit largely, but not entirely, overcomes the cramping of the low-reading end of the scale, and also provides a convenient "zero set" control which overcomes the effects from the temperature sensitivity of the diodes.

The combination of linear amplifier, rectifiers and moving-coil meter would normally produce a linear scale on the meter and recording chart. What is required of this combination is a logarithmic amplitude response, in order to produce a linear decibel scale on the meter and chart. The necessary correction is obtained by two mechanical expedients: (1) the moving-coil meter chosen for the job, a tuning indicator MH25B, 100μA, (Henrys Radio), has an in-built tendency to non-linearity — equal increments of current producing greater deflection at the lower end of the scale than at the top; (2) this tendency is augmented by an added gravitational effect which, acting vertically, has little or no effect in the zero position of the moving mirror, but offers an increasing return force as the mirror is deflected. It is purposely not counterbalanced.

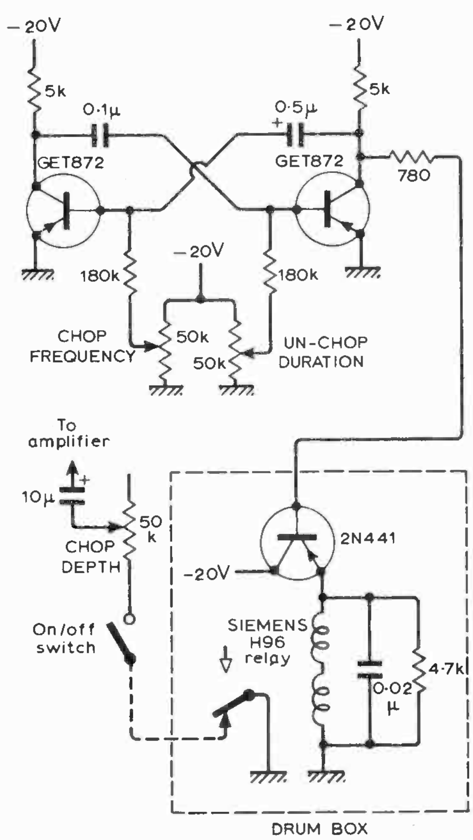


Fig. 7. Circuit of chopper for periodic interruption of sinewave and square-wave test signals.

The amplifier, diodes and variable attenuator are completely screened, being housed in a cylindrical canister within the chassis. This prevents leakage into the voltmeter of h.f. fields from the high and audio frequency generating sections of the instruments.

The multi-position rotary switch of the attenuator, of course, forms the range switch of the a.c. voltmeter and the four positions are marked ÷ 1 (−0dB), ÷ 10 (−20dB), ÷ 100 (−40dB) and ÷ 1000 (−60dB).

Reflecting voltmeter

The reflecting voltmeter is a tuning indicator meter movement (see above) with the pointer cut down to a short stub, to which a small concave mirror is cemented. The concave mirror was made by smashing one of the thin glass globes used for decorating Christmas trees and then selecting by experiment a piece of glass of suitable size and concavity. This was simply a matter of finding a piece of mirror glass which gave a sufficiently sharp spot of light on the chart. The reflecting voltmeter thus made is mounted, together with a spot-filament lamp, in a separate housing fixed immediately above the drum (see photos), so that the light spot movement is parallel with the drum axis and dB scale on the chart.

The sensitivity, resistance and other characteristics of the meter movement affect the whole design of the meter amplifier. Much depends on the importance one attaches to the accuracy of the logarithmic form of the light-spot scale.

Other facilities

Square-wave output. Although of little use with the drum charts, a square-wave generator is included for general test purposes. Shown in Fig 6, this is a circuit which receives a sinewave output from the amplifier of the heterodyne oscillator (Fig 4) and converts it into a square wave of the same frequency.

Chopper. Both the sinewave and square-wave outputs may be interrupted at rates up to 100 per minute and to different degrees, by a chopper circuit. This, shown in Fig. 7, is a multivibrator, of variable frequency, driving an electro-mechanical relay. Contacts of this relay, by earthing an inter-stage coupling in the heterodyne oscillator amplifier (Fig. 4), interrupt the sinewave and square-wave outputs. A "Depth" control, provided by inserting an adjustable amount of resistance into this short-circuiting, enables a partially chopped output to be obtained from the sinewave outlet. The on/off ratio of the chopper may be adjusted as required.

Capacitance measurement.

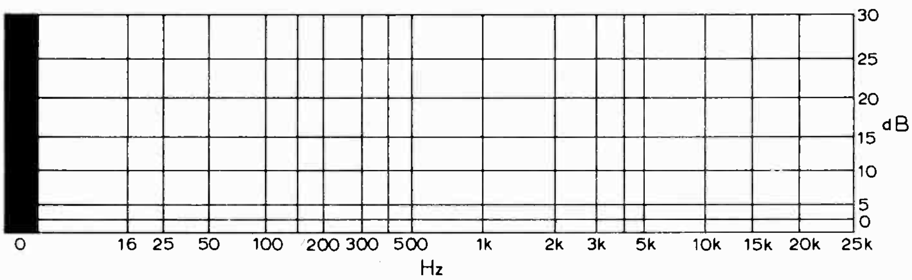
Capacitance from 1pF to 1μF can be measured on the principle of using the unknown capacitance to alter the frequency of the fixed oscillator in the heterodyne pair, then measuring the change by means of the variable oscillator. First, the variable oscillator is adjusted to the same frequency as the fixed oscillator to give zero beat frequency — indicated either by the light spot falling to zero on the drum or by an earphone connected to the sinewave or square-wave output. Then the unknown capacitance is connected through a range switch to the tuned circuit of the fixed oscillator at the points shown in Fig. 3. This changes the oscillator's frequency and results in a beat frequency. The hand-wheel is then rotated until the frequency of the variable oscillator equals that of the fixed oscillator and there is zero beat frequency once more. The amount of rotation is proportional to the unknown capacitance and this value is indicated by a calibrated capacitance scale on the rim of the hand-wheel. The large range of the capacitance measurement (a million to one) is made possible by connecting the unknown capacitance to different tappings on the fixed oscillator's coil through a range switch. There are in fact three ranges: 1.0 to 200pF; 10pF to 0.1μF; and 0.002μF to 1.0μF.

The "padding capacitors" shown in Fig. 3 are necessary for bringing the capacitance scales on the hand-wheel to convenient positions and providing overlap between scales.

Voltage checking. The a.c. voltmeter in the Drum Major can, of course, be used for measuring voltages at various points in a test setup; for example, the output of the demodulator, the output of the amplifier which follows it, or the voltage from the equipment under test. For this purpose a "meter select" switch is provided (though not shown in the diagrams).

Construction

As far as possible separate functional units have been assembled on separate, small Veroboards, although the demodulator circuitry was mounted in situ, partly in the wiring and partly on the control potentiometers. The filter coils were fixed with cement to the underside of the chassis. The chassis is, of course, a common positive conductor. For the power supplies (Fig. 8) transformers and rectifiers are housed in the drum box. Where the d.c. supplies are to be used by voltage-sensitive circuits (e.g. the oscillators) separate decoupling and stabilization by zener diodes is provided, with the components mounted under the chassis.



Scale layout of chart for plotting response/frequency characteristics on the drum.

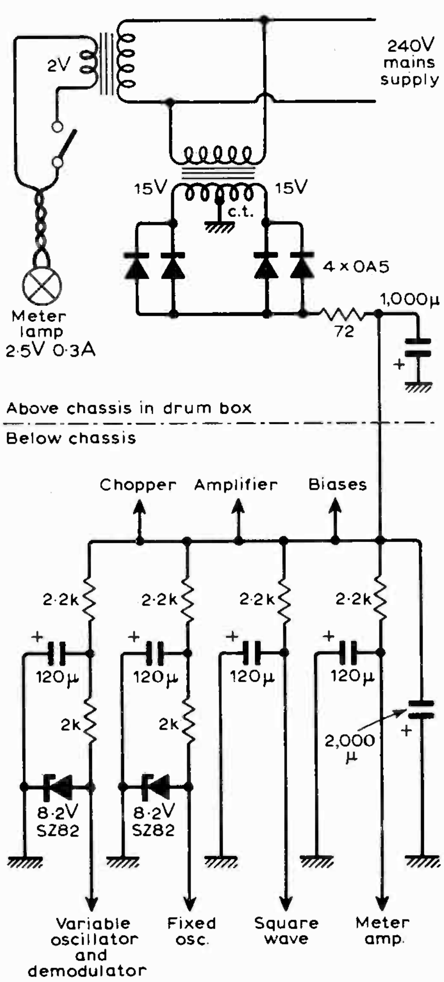


Fig. 8. Power supplies for the instrument.

Details of the reflecting meter movement and spot-filament lamp below it in their housing (cover removed).

Conferences and Exhibitions

GATESHEAD
Nov. 23-25 Five Bridges Hotel
Electronic Instruments Exhibition
(Industrial Exhibitions Ltd., 9 Argyll St, London W1V 2HA)

MANCHESTER
Nov. 15-19 Belle Vue
Low Cost Automation Exhibition
(Exhibitions for Industry Ltd. 157 Station Rd East, Oxted, Surrey)

OVERSEAS
Oct. 31-Nov. 4 Las Vegas
Engineering in Medicine and Biology Conference
(I.E.E.E., 345 East 47th St, New York, N.Y.10017)
Nov. 2 & 3 Boston
Electronics Packaging Conference
(I.E.E.E., 345 East 47th St, New York, N.Y.10017)
Nov. 24-27 Karaikudi
Electrochemistry Seminar
(Dr C. V. Suryanarayana, Central Electrochemical Research Institute, Karaikudi-3, (Tamil Nadu), India)
Nov. 29-Dec. 3 Pretoria
Biotelemetry Symposium
(South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria)

Personalities

J. A. Powell, M.A., D.Phil., has joined EMI Ltd as group technical director. Dr. Powell, who is 47, has been managing director of Texas Instruments Ltd since 1963 and assistant vice-president of its American parent company for the past three years. In 1940 he undertook a two-year instrumentation apprenticeship with the R.A.F. In 1943 he was invalided out of the Service and went to Oxford University. He was awarded a post-doctorate research fellowship by the National Research Council in Ottawa in 1952 and returned to Britain in 1954 to become leader of a research team at Marconi's Great Baddow Laboratories in Essex. Dr. Powell, who joined Texas Instruments in 1957 as a product engineer, is chairman of the Electronic Valve and Semiconductor Manufacturers' Association (VASCA), and a member of the Electronic Components Board.

Frank Caplin, B.Sc. (Eng), F.I.E.E., who joined British Communications Corporation Ltd in 1956 as technical director, has retired but will continue to act as technical advisor to the company. In the late 1940s and early 1950s Mr. Caplin was in the Signals Research and Development Establishment (S.R.D.E.) where he was in charge of the development of the Larkspur Range of Army combat radio equipment.

T. G. Clark, F.I.E.R.E., has joined Mullard Ltd as technical manager of the Communications Division following an academic year with the School of Management Studies at Portsmouth Polytechnic. Mr. Clark was previously with Decca Radar, Astaron-Bird and The Plessey Co. Ltd.

L. Calvert has been appointed sales manager of the Marine Division of Redifon Ltd. He was previously the Marine Division's Northern Area Manager. After war service with the R.A.F. as a radio observer, Mr. Calvert qualified as a marine radio officer joining Redifon in 1953, as a marine service engineer at Hull. He subsequently took charge of the company's worldwide marine service network, operated from London.

Elizabeth Laverick, B.Sc., Ph.D., F.I.E.E., who was the fifth woman to achieve full membership of the Institution of Electrical Engineers (that was in 1964), has been appointed deputy secretary of the institution in succession to **F. Jervis-Smith** who has retired. Dr. Laverick studied physics and radio at the University of Durham where she received her doctorate in 1950. She joined Elliott Bros. in 1953 and in 1959 became head of the company's Radar and Communications Research Laboratory. Latterly she has been technical director of Elliott-Automation Radar Systems now part of GEC-Marconi Electronics.

Harry Sellers, managing director of Tektronix U.K. Ltd since its formation in 1963, has retired. Mr. Sellers was commercial director of Livingston Laboratories, who handled the U.K. marketing of Tektronix prior to the setting up of the U.K. company in Harpenden.

John Elliott, B.Sc., has joined The McMurdo Instrument Co., at Portsmouth, as manufacturing director. Mr. Elliott, who is 41 and graduated in engineering from London University, has been with Dubilier for the past 17 years, latterly as general manager.

The appointment of three senior sales engineers was recently announced by Siemens (U.K.) Ltd, of Brentford, Middx. They are **A. Joyce** (semiconductors), **M. Bennett** (ferrite and passive components) and **J. M. Silvester** (electro-mechanical components). Mr. Joyce, who began his career with the Post Office Research Laboratories at Dollis Hill, has worked for the Atomic Weapons Research Establishment, and several companies, latterly Microwave Ltd. Mr. Bennett has been with M.E.L. and Mullard Ltd, and Mr. Silvester, who was originally employed on valve and microwave device development with Mullard, was latterly with I.T.T. Also announced by Siemens is the appointment of **R. K. D. Fowler** as their specialist on radio interference suppression. He joins the company from Timeon Electronics Ltd where he was marketing manager. He previously spent five years with the Solartron Electronic Group.

T. B. "Jock" Henderson, commercial director of British Radio Corporation, has retired on medical advice. He served in the Radar Branch of the R.A.F. and in 1957 was appointed sales promotion manager for HMV and Marconiphone brands, and two years later became sales director of Philco (Great Britain) Ltd. When in 1965, British Radio Corporation Ltd was organized to bring together the Ferguson, HMV, Marconiphone and Ultra activities of the company into one operating division of Thorn, Mr. Henderson was appointed commercial director. He is to reside in Cyprus but will retain his connections with B.R.C. as a consultant.

Francis Oakes, F.I.E.E., F.I.E.R.E., until recently executive director of research and engineering of Thorn Bendix Ltd, is setting up as an engineering and management consultant. His connection with Thorn Electrical Industries, with which he has been associated for 18 years, will, however, not be severed as he will act as a consultant to the company. Born in Austria in 1919 he came to England in 1939 and became a British subject in 1947. After a period of free-lance technical writing and consulting he joined Thorn Electrical Industries in 1953. In 1961 he became chief engineer of the Ferguson Electronics Division and, successively, chief engineer, director and general manager of Thorn Electronics (Laboratories) Ltd., and since 1967, executive director of research and engineering, Thorn Bendix Ltd.

Ronald F. Russ, F.I.E.E., has been appointed managing director of Electro Mechanisms Ltd, of Slough. Mr. Russ, who is 45, was formerly founder managing director of Consolidated Electrodynamics Division of Bell & Howell Ltd, and more recently international vice-president of the Electronics & Instruments Group, Bell & Howell, California, U.S.A.

Keith G. Johnson has been appointed video projects manager for Ampex International, of Reading, Berks, where he will be responsible for broadcast video systems business throughout Europe, Africa and the Middle East. Mr. Johnson was previously with the B.B.C. He worked on the first transatlantic transmissions made by Telstar and Early Bird satellites and later joined the studio planning department where he co-ordinated the outside broadcast engineering for the 1966 World Cup programmes. He was latterly manager for video outside broadcast planning and design.

R. W. Garrett, B.Sc., F.I.E.E., has joined Dynamco as general manager of their factory at Broxburn, near Edinburgh. Mr. Garrett, who is 41, had been director of production with Crosfield Electronics, London, for the past four years. Prior to that he had spent over four years with Elliott's, latterly as manager of the manufacturing division of Elliott Electronic Tubes Ltd. Dynamco have also announced the appointment of **W. J. Trevelyan** as marketing manager, analogue products. Mr. Trevelyan, who is 33, has been with Dynamco since November 1968 when he joined as an area sales engineer. He served his apprenticeship in the electronics laboratory of Venner Ltd.

Three new directors have been appointed to the board of Pye Telecommunications Ltd. They are **William F. Hawes, Patrick B. Holden** and **Edward J. Scotcher.** Mr. Hawes, aged 50, is the general manager for marketing and has been with the company for 23 years. Mr. Holden (34) joined Pye Telecoms two years ago as central services manager and is now overseas marketing manager. Mr. Scotcher (45), who joined the company two years ago from G.E.C., is manufacturing manager.

OBITUARY

Sir Alan Dudley, K.B.E., C.M.G., director of the Electronic Components Board since 1968, died at the age of 64 on September 13th. Sir Alan had a distinguished career in the Civil Service from 1930, latterly as deputy secretary at the Ministry of Overseas Development (1964-68), before joining the Electronic Components Board. Under his wise guidance the three associations B.V.A., VASCA, and R.E.C.M.F. joined together to form the E.C.B.

Hubert Barker, C.B.E., director of network planning at the Post Office, died on September 19th while on holiday in Syracuse. He was 61. He joined the Post Office in 1928 and was seconded to the Air Ministry in 1938 to help plan the communications system for operations control of the R.A.F. He was later commissioned in the R.A.F. and became deputy chief signals officer in the 2nd Tactical Air Force. He returned to the Post Office after the war but in 1951 was again temporarily seconded to the Air Ministry on special duties.

Experience with the Karnaugh Map Display

The writer discusses the problems he met when constructing the display and describes its value in teaching

*by G. T. Lawrence**

The Training Centre of Automatic Control Engineering Limited sets out to give students, who vary from instrument mechanics to qualified engineers, an insight into the principles of electronics in a short period of time. To facilitate this end a system of experiment boards was evolved, each board being related to an experiment guide sheet. On the digital side it is possible to cover from simple pulse forming, multivibrator switching through to counting circuits. It is not easy for a student to quickly analyse basic logic devices. Therefore, when the article on the Karnaugh map display unit appeared in the April 1971 *Wireless World* we quickly saw the possibilities it offered, both to the student, using the above mentioned system, and for demonstration purposes on the shorter, higher pressure, appreciation courses.

Having decided to build the unit we presented it to a student engineer as a project and work was started on this basis. I do feel that, while it was not intended to be within the scope of the article, we would have been helped by some constructional guidance, to avoid the pitfalls that are irresistible to the student. It was decided to use modular construction and to employ a mains power supply unit. Due to delay in the provisioning of certain components the p.s.u. and oscillators were ready for testing before the logic module was complete. When testing the oscillators the clock generator performed exactly as predicted in the article. However, the phase shift oscillator then performed as expected, but inspection of voltages and a look at the diagram revealed the reason. The transistor collector was saturating at the level of bias chosen. The easy way out was taken and a 3.3kΩ resistor was fitted in the collector instead of 6.8kΩ (R_7). The oscillator then performed as expected, but without reasonable control of the gain with the trimmer resistance, and thus with a sine wave something less than perfect. This was still being thought about but was not considered desperate.

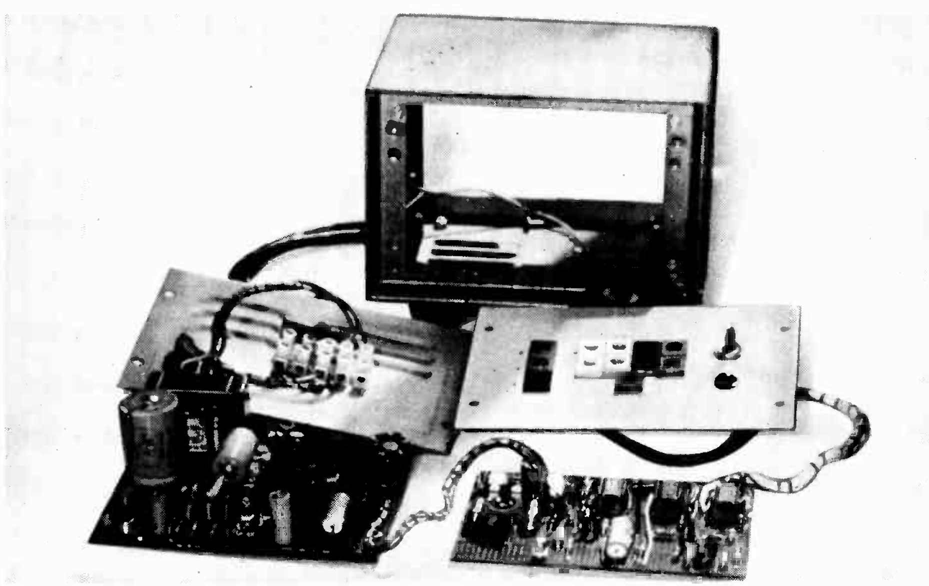
The next stage was to test the complete device before putting it into its box. Once the logic was connected it was found necessary to replace the original collector load in the oscillator and to change the bias level, as there was insufficient gain to make it 'go' under load. The 56kΩ bias resistor (R_6) was replaced by a 100kΩ and the 470Ω fixed emitter resistor (R_5) replaced by a 470Ω trimmer. This produced a satisfactory result.

The ladder networks performed well (once a dry joint on one of the pins had been found), but the 0's were all leaning drunkenly backwards. A check of the oscillator showed that the 90° signal was one lag displaced. Correcting this cured the problem, and it was a simple matter on the Telequipment oscilloscope to get all 1s or all 0s. However, the output from the X amplifier was too high for the oscilloscope gain control to cope with, and to get the matrix nicely in the screen area it was necessary to put variable gain in the unit's X amplifier feedback path. The 10kΩ resistor (R_{37}) was replaced by a 4.7kΩ fixed and 4.7kΩ variable resistor in series. Having been successfully tested this far, the unit was put into its box, and made a very pleasing instrument.

An i.c. NAND gate was linked to the unit and the display examined. From the display it was clear that D and $\overline{D}$ were out of place and either the student had failed to make the amendment called for in the May *Wireless World* or else the amendment was unnecessary. Reversal of the connections gave a true display. Apart from this the whole was quite satisfactory.

The real test came when the unit was linked to the 14in display oscilloscope, (dubiously, because of the lower input impedance and longer persistence screen of the big oscilloscope). However, all went well except that the 0s had mysteriously become narrower than on the small oscilloscope without changing the aspect ratio of the matrix and fly-back was accentuated due to the large screen and its persistence but this was not disconcerting.

Fortunately at this point there was a ready-made set of 'guinea pigs', in the form of a senior appreciation electronics course. Having dealt with the principles of analogue electronics, digital circuits and a little logic theory, the action of plugging in an 'instant truth table' produced quite a marked response. The ability to reverse the logic was the thing that completed the picture and tied a number of loose ends nicely together. The class felt that it really was happening, even though two days previously an electron was something to be feared. All things considered the task was well worth while and will serve the purpose for which it was designed, together with one or two side benefits not originally apparent.



The unit before final assembly.

*Automatic Control Engineering Ltd.

World of Amateur Radio

Truth and fiction

Seldom can amateur radio have received so many front-page headlines as in connection with the now-famous Baker Street bank raid of September 11th-12th. At the time, one gained the impression in amateur circles that there was considerable relief when it finally emerged that the 27.15 MHz 'citizen's band' transmissions stemmed from a genuine raid and were not part of some elaborate hoax which might have provoked public criticism or derision of the hobby. It was fascinating to hear on Independent Television News the tapes made by the short-wave-listener, Mr Robert Rowlands. He was using an AR88 receiver.

But for those who may be contemplating using the incident as the basis of the script for a TV play or film—a word of warning. They will find that they have been largely pre-empted by a recent Columbia Pictures film called 'The Anderson Tapes'. It is expected that this film, already shown in the United States, will be released in the U.K. early next year. With Sean Connery and Dean Martin in the leading roles, the film tells how a master robbery is foiled at the last moment by a young invalid amateur radio operator. Amateurs who have seen the film claim that, unlike so many earlier films touching on amateur radio, this one does not violate technical feasibility. It also provides glimpses of Canal Street, New York, a well-known centre of electronic surplus and surveillance equipment of which perhaps our nearest equivalent in London is Lisle Street.

A factual film on amateur radio called 'The Ham's Wide World', produced for A.R.R.L. by Dave Bell, W6BVN, has been shown more than 225 times by American television stations to an estimated audience of over 9 million.

Top-band super-DX

Some extremely significant results achieved during the past few years in the reception of low-power British and European 1.8 MHz amateur signals in Western Australia have been reported in *Radio Communication*. The listener, Mr G. Allen, shows convincingly that the optimum period for such remarkable propagation conditions — which have led not only to reception but also to quite large numbers of two-way contacts — is around the December solstice, almost invariably occurring for only short periods around the time of local dawn (roughly 21.00 to 21.15 G.M.T.). Curiously enough no comparable results appear possible — at least to anything like the same extent — in other parts of Australia, or around the June solstice. Although Mr Allen notes that the fading characteristics of the European signals are far more akin to F-layer than E-layer propagation, he does not himself offer the suggestion, which one might deduce from his results, that the transmissions may be reaching Western Australia by means of some form of chordal hop or layer entrapment mode; such modes have previously been felt to account for some of the quite common 3.5 MHz contacts between European and Australian amateurs.

The possibility of further investigation into this super-DX working is offered by the activity on this band of VK9GN and the prospect that VR1AA will soon be using 1.8 MHz.

Another series of 1.8 MHz transatlantic tests has been organized by Stewart Perry, W1BB, for November 28th, December 26th, January 9th and 23rd and February 13th (05.00 to 07.30 G.M.T.). The North American stations will use 1800-1810 kHz, European 1823-1830 kHz with alternate five-minute periods (U.S. and Canadian stations to lead off each hour). These tests thus span the 50th anniversary of the famous transatlantic tests of December 1921 organized in Britain by *Wireless World*. These were the tests which led to the first reception in Britain of numbers of North American amateur stations.

Proud of "home-built"?

The criticism is sometimes made by outsiders that amateur operation in these days of compact s.s.b. factory-built transceivers is all rather haphazard and as though the Post Office offered facilities for making random telephone calls to unknown subscribers (the cynics will say they already do this unintentionally). What is forgotten is that, in practice, a quite substantial proportion of amateur communication is with specific stations — members of local nets, regular "skeds" (scheduled times) with old friends or as part of long-term propagation studies and the like. There is also evidence that home-construction often continues alongside the use of factory-built s.s.b. equipments. A recent letter from Dr Michael Eccles, G3PPE/W6, now resident in California, mentions that many amateurs in the United States are now using commercial s.s.b. transceivers for home or mobile use almost as a form of telephone to keep in touch with other amateurs while continuing their home-building interests on v.h.f. equipment.

A man of many interests

It is sad to report the death of yet another well-known amateur. Within a few hours of taking part in the V.H.F. Field Day in September, Ernie Dedman, G2NH, died. Although perhaps best known as the co-founder, with N. H. R. Munday, G5MA, in the late 1920s, of the Quartz Crystal Company, he was for over forty years an enthusiast in developing and popularizing amateur techniques, including much early work in v.h.f. and s.s.b. (and even home-built computers), yet turning up from time to time on c.w. during h.f. contests.

In brief

At the I.A.R.U. Region III meeting in Tokyo, mainland China and Albania were named as countries permitting major 'intrusion' into the exclusive amateur frequency allocations in the 7 MHz band (Albania but not China is a member of the International Telecommunications Union). The Japanese society has produced detailed spectrum photographs underlining the current prolific interference in this band . . . . In the twelve months to July 31st, 1971 there was an increase of 311 in the British Class A amateur licences, 548 in Class B (both these figures are marginally down on the corresponding figures for July 1970). The total number of licensed amateurs in Britain now exceeds 16,500. . . . New prefix for Swaziland is 3D6 with 3D6AX reported active on 7 MHz at weekends . . . . The prefix OM instead of OK is again available to Czech amateurs until December 31st . . . . The next Radio Amateurs' Examination is on Monday, December 6th — the R.S.G.B. is organizing an examination centre at the University of London (applications, before October 31st, to R.S.G.B., 35 Doughty Street, London W.C.1) . . . . The 1972 president of R.S.G.B. will be R. G. Hughes, G3GVV . . . . 144 MHz enthusiasts are being urged to use more c.w. on the band. With modern equipment this mode can provide reliable long-haul contacts at times when the range of a.m. and f.m. 'phone is limited . . . . Philip West, junior, whose father holds the call G3JPN, has passed the Post Office morse test at the age of nine — believed the youngest candidate ever in Britain. His eight-year-old sister, Pauline, can also copy morse.

PAT HAWKER, G3VA

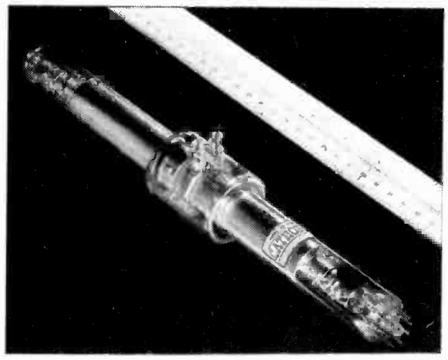
New Products

M.O.S. high speed shift register

A silicon nitride m.o.s. static shift register fabricated using the SGS-patented Planox process can be clocked up to 2MHz. The M134 is a register of 16 + 16 + 32 bits. Clock and data inputs and outputs are compatible with t.t.l. integrated circuits. Supply voltages are +5V, −5V and −12V. Encapsulation is TO−100 metal can. Operating temperature range is 0 to 70°C. SGS (United Kingdom) Ltd, Planar House, Walton Street, Aylesbury, Bucks.
WW301 for further details

Signal storage tube

A range of image storage tubes, the C996 family from Cathodeon, will record a single short exposure and then display the image for up to 30 minutes. Where only a weak signal is available, the desired image may be integrated over a period of time. The range can be used for radar scan conversion to television display, with storage for up to 100 hours and prolonged read-out of up to 30 minutes, and for the integration of weak signals. The tubes incorporate a dielectric storage target scanned by two opposing electron beams. The input beam can be amplitude modulated with any desired signal information, and this information is statically stored on the target. The reading beam can then be used to extract the stored information for long periods of time. Either beam can be used finally to erase the stored information. Writing, reading and erasure can be area selective and also adjustable in time for a particular type of tube. The full range of storage characteristics is obtained by making available a number of types with different targets. The tubes have a circular target and are magnetically focused and



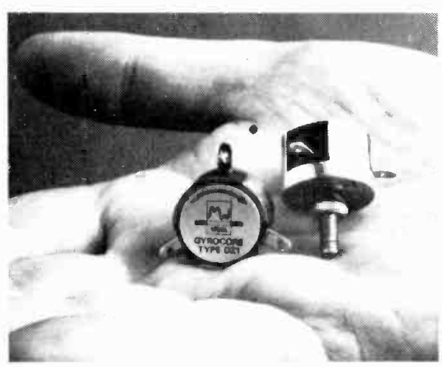
scanned. Length approximately 300mm, diameter 40mm. Weight 130g without coils. Cathodeon Ltd, Trinity Hall Farm Estate, Nuffield Road, Cambridge.
WW332 for further details

Specification of storage tube

writing speed	150μs to 2ms (depending on target diameter)
resolution	500 points per target diameter (50% amplitude)
Integration time . . .	2s to 20 min
passive storage time .	(signal retention without read-out) up to 100 hours
active storage time .	(signal retention with read-out) 1 second to 30 minutes
erasure time	50ms to 2s

Gyrotropic ferrite circulator

Microwave and Electronic Systems has developed the Gyrocore—a non-reciprocal junction device. It consists of three lumped inductors placed between two ferrite discs.



An integral permanent magnet provides a magnetic field to couple the inductors by the gyrotropic action of the ferrite material. It is, in effect, a conventional circulator giving low-loss transmission between two adjacent ports when the third port is decoupled. Line impedance can be matched by including suitable capacitance networks at each port. Four models are available to cover a frequency range of 50 to 1000MHz with a power rating of 10W mean and 1kW peak. Isolation is better than 20dB and insertion loss is about 1 or 2dB. An isolator-only version, known as the Isocore, is also available. This is a Gyrocore with one port terminated with a matched load. External tuning circuits can be included at the other two ports and adjusted for minimum forward loss and maximum isolation at the operating frequency. Microwave and Electronic Systems Ltd, Lochend Industrial Estate, Newbridge, Midlothian.
WW302 for further details

Calculator i.c.

All the electronic logic required for a digital calculator, performing addition, subtraction, multiplication and division, is contained in a 28-pin, single-chip m.o.s. integrated circuit, the TMS 1802NC, just introduced by Texas Instruments. The only additional components required to construct a complete calculator are a keyboard, a numerical display (e.g. light-emitting diode array) and display driver circuits. Texas say that it should enable a calculator to be manufactured at a cost of £20 ex works, the i.c. itself costing less than £10 (in quantity). A laboratory-made specimen calculator was demonstrated to *Wireless World.*

The i.c. contains an eight-digit b.c.d. arithmetic logic unit; a three-register 182-bit random access store; a 3520-bit read-only memory for holding the programme; and timing, output, and control decoders. Floating-point or fixed-point operation calculations can be performed and there is automatic round-off of numbers and leading-zero suppression. Arithmetic and control operations are based on a 4μs single-phase clock system.

Electrically the i.c. requires a substrate supply, V_{SS}, of 7.2V nominal and a gate supply, V_{GG}, of −7.2V. The substrate current, I_{SS}, is typically 25mA while the power dissipation of the whole chip is 250mW.

The manufacturers state that they can supply integrated circuit display drivers and light-emitting diode displays suitable for working with the TMS 1802NC. Texas Instruments Ltd, Manton Lane, Bedford.
WW314 for further details

Wideband high-power oscillator

Using eight plug-in heads, model 445 power oscillator from Microdot—available from Texscan Instruments—covers the range 10kHz to 2500MHz. Six plug-in units cover the range 10kHz to 1000 MHz providing output up to 50W. The two ranges 1000–2000MHz and 2000-

2500MHz have outputs variable up to 25 and 15W respectively. Each plug-in unit can be amplitude or frequency modulated. Modulation can be applied externally or from an internal 1kHz square-wave generator. After stabilization, frequency stability is given as ±0.002% for a ten minute period and power output constant to within ±0.2dB/h. The unit is protected from mismatch and loss of load. The front-panel meter indicates forward or reflected power. Texscan Instruments Ltd, Lord Alexander House, Hemel Hempstead, Herts.

WW322 for further details

Plastic power transistors for audio

Four transistors for use in medium-power audio equipment, announced by the Philips group at the Paris Components Show (page 229, May issue), are now available from Mullard. Designated BD201-4 they are inexpensive plastic-encapsulated devices that can give an output of 20W into loads of four or eight ohms. The BD201 and BD202 form a complementary pair, as do the BD203 and BD204, the odd numbers being n-p-n transistors. Brief details are:

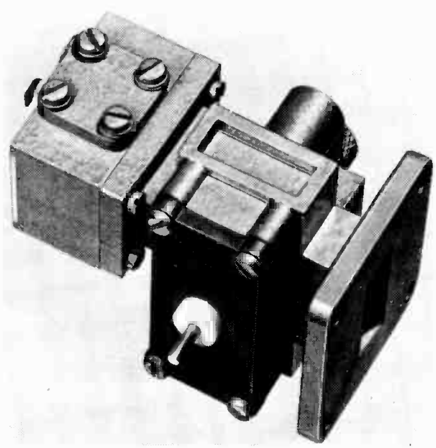
	BD 201	BD 202	BD 203	BD 204
V_{CBO} max (V)	60	−60	60	−60
V_{CEO} max (V)	45	−45	60	−60
I_C max (A)	8	−8	8	—
P_{tot} max (W) $T_{amb} \leq 25°C$	55	55	55	55
T_j max (°C)	150	150	150	150
h_{FE} min (I_C= 3A, V_{CE}=2V)	30	30	—	—
h_{FE} min (I_C= 2A, V_{CE}=2V)	—	—	30	30
f_{hfe} min (kHz) (I_C=0.3A, V_{CE}= 3V)	25	25	25	25

High-voltage versions of the 2N3055 that have high-power handling capability are also announced. They are 2N3442 and 2N4347 and are particularly suitable for use in a.f. amplifiers, converters, voltage regulators and power supply units. Type 2N3442 has a current rating of 15A and a power rating of 117W. With a V_{CE} of 80V it will pass 1.4A d.c. The 2N4347 has a current rating of 10A and a power rating of 100W. It will pass 1.4A at V_{CE} = 70V. Case is TO-3 style. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

WW 323 for further details (BD types)
WW324 for further details (2N types)

Single-cast mixer/local oscillator

A combined high quality waveguide balanced mixer and local oscillator source have been designed as a one-piece cast by Micro Metalsmiths. Designated the type MM16B 3G1 the unit operates from 9.3 to 9.5GHz in WG 16 size, and uses Mullard

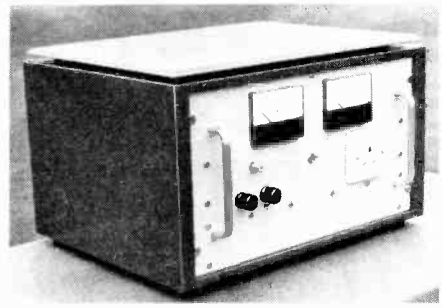


crystals and Gunn diode. This bias voltage can be varied ±0.3V to give a tuning range of ±10MHz. Signal v.s.w.r. is 1.7. The units can be produced in brass or aluminium and bandwidths altered to meet requirements. Micro Metalsmiths Ltd, Kirby Moorside, York.

WW327 for further details

Static inverter

An inverter designed to provide a 50Hz supply at 240V from a nominal 24V d.c. supply is available from R. Gilfillan & Co. The main application of the unit, type 24/360/50R, is as an emergency supply for mains operated equipment. The output voltage is maintained within ±6% for battery supply voltages of 22 to 28V and for loadings from below 0.5A to the full nominal 1.5A. The inverter is protected against reversal of input polarity and against overload. Frequency stability is ±1%, but a crystal-controlled master oscillator can be provided or provision can be made for locking to an external 100Hz source. Distortion over the practical working range is below 10%, and is very much less at 24V input and 1A load current. If a lower distortion figure is required because



of the special nature of the application an additional network element-pair may be incorporated. It is not needed for most applications. Meters are provided for both input and output voltages. Connections in the standard version are terminals for the battery and a 3-pin socket for the 240V output. Alternative types of connectors may be fitted if required. The efficiency under nominal working conditions (24V supply, 360VA resistive load) is 75%. Variants for 60Hz or 40Hz working are available. R. Gilfillan & Co. Ltd, Southdownview Road, Broadwater Trading Estate, Worthing, Sussex.

WW320 for further details

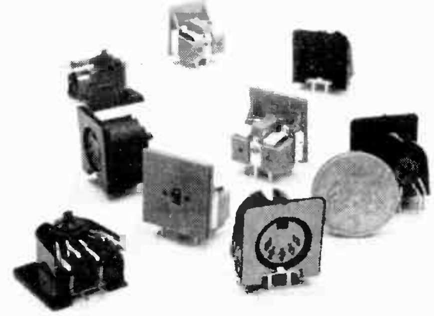
Slide sync recorder

A mono two-track $1\frac{7}{8}$ in/sec cassette recorder and player with built-in speaker combined with a pulsing and synchronizing facility is available from Sigmatron. Amplifier output is 5W (an extension speaker can be used). An audio input socket with separate control and level indicator are fitted. Playback frequency response is 100Hz—8kHz. The deck is fitted with a pause control. Other facilities provide for pulsing on one track while the audio signal is being monitored from the other track, and for a control signal to be introduced to stop the programme at predetermined points, the programme then being re-started by push button. When the tape finally ends, the tape unit ejects the cassette and stops. The unit is called the Magister and costs £99. Sigmatron Ltd, Woodman Works, Durnsford Road, Wimbledon, London S.W.19.

WW310 for further details

Board-mounting DIN sockets

Rigid mounting direct to printed circuit boards, with overlap support for adjacent pairs or multiples, is possible with new DIN



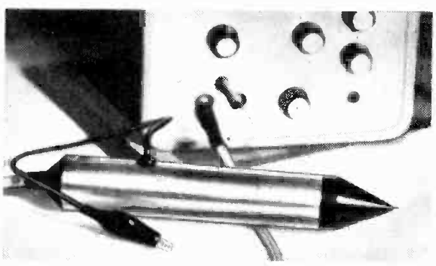
EEV know how to cool a mag

CRC 24

in a polypropylene case 20cm long. The transmitter power of the PL201 is 1W. The battery lasts for a day and can be replaced quickly and recharged. Chargers are available. Rank Precision Industries Ltd, Watton Road, Ware, Herts.
WW328 for further details

High impedance oscilloscope probe

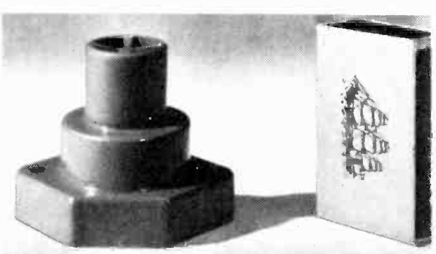
Active probe type POA 155 from Meteronic presents an input impedance of 10MHz on all ranges. Bandwidth is 2Hz–12MHz and switchable for × 10 and



÷ 10. The probe draws 11mA from a 24V supply. The output connector is miniature coax or B.N.C. Price £12. Meteronic, 114/116 Shipbourne Road, Tonbridge, Kent.
WW326 for further details

Transistor alarm-signal generator

A transistor operated 'buzzer', encapsulated for protection against humidity, and compensated for changes in air pressure, is



available from UMED. The output frequency is 3000Hz modulated by 300Hz, and peak sound pressure level 84dB at just over 1 metre. It is available for 12 or 24V d.c. operation, but will work directly from a.c. when the sound will be modulated by the supply frequency. Current consumption is about 30mA at 12V. Price £1.75. U.M. Electrical Distributors Ltd, Beaumont Road, Banbury, Oxon.
WW315 for further details

Resin-coated capacitors

The Sky Cap range of capacitors made by Aerovox and now available from G. E. Electronics (London) extends from 2.2pF to 4.7μF (tolerances $\pm$5%, $\pm$10%, $\pm$20% or +80, −20%). Three working voltages are provided for—50, 100 and 200V d.c., with a dissipation factor from 0.1 to 2.5%. Case sizes extend from 0.1 to 0.5 sq.in with thicknesses of only 0.1 to 0.2in max. The leads are solder-coated copper. G. E. Electronics (London) Ltd, Eardley House, 182/184 Campden Hill Road, Kensington, London W8 7AS.
WW311 for further details

Precision wirewound resistor

Supplied in standard resistance values from 10Ω to 1MΩ, Econistors from Guest International have resistance tolerances of 0.005%, 0.01%, 0.025% or 0.1%. The temperature coefficient is $\pm$3 p.p.m./ deg C max. from −55 to 125°C. Long-term stability is $\pm$25 p.p.m. per year and less than 50 p.p.m. per year after three years operation under normal conditions. Windings are multiple pi and balanced to minimize the effect of capacitive reactance. Encapsulation is epoxy resin. The body size is 13 × 7mm with tinned copper axial leads. The resistors are also available in non-standard values up to 1.1MΩ. Industrial Components Division, Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey.
WW309 for further details

Electrochemical capacitors

The Gould Ionics Energy Storage Device (ESD) is an electrochemical capacitor with exceptionally high capacitance density and charge retention. It provides capacitance of 160F/cu.in, with leakage resistance greater than 10,000MΩ. A 50F capacitor occupies less than 1/3 cu.in. and can store up to 25 coulombs at 0.5V, with greater than 97% charge retention after 16 months storage. Using the electrochemical properties of rubidium silver iodide, the ESD can provide values from 50F down to 0.01F (10,000μF) as individual units, and down to 500μF formed on an i.c. substrate. Applications include long-time ramp generators and timing circuits (up to about a month with reasonable charging currents), standby power for computer memories, and production of pulse power even months after charge. Prototype ESDs with values from 0.01F to 50F are priced at £19.20 each (minimum order is three of any one value). Large production quantity prices are expected to be in the £0.60-£1.80 range. Lyons Instruments Ltd, Hoddesdon, Herts.
WW331 for further details

Sound-level meter calibrator

The Rohde & Schwarz ELEB sound-level meter calibrator, available from Aveley Electric, provides a coupler opening into which a meter's microphone is inserted. The calibrator can then be switched on to provide a standard level at 1000Hz. At this frequency the calibration level is independent of the weighting filters used. Calibration error is kept within $\pm$0.25dB at 25°C (within $\pm$0.5dB between 0 and 50°C) by internal compensation. Aveley Electric Ltd, Arisdale Avenue, South Ockendon, Essex.
WW317 for further details

Mobile radiotelephone

A medium-power solid-state v.h.f. f.m. radiotelephone, type BE385 from Burndept, is available with up to ten channels. Operation is from the 12V vehicle

accumulator using either positive or negative earth. Operation is at 160MHz or 80MHz with 12.5kHz channel spacing. Burndept Electronics (E.R.) Ltd, St. Fidelis Road, Erith, Kent.
WW330 for further details

Panel meter

A panel mounting meter with a scale length of 57mm is available from Taylor Electrical Instruments. This meter, model 330, uses the Taylor centre-pole move-

ment. It can be mounted vertically or horizontally. Taylor Electrical Instruments Ltd, Archcliffe Road, Dover.
WW318 for further details

November meetings

LONDON

3rd. IERE — "The effectiveness of modern visual communications systems" by B. Stapley at 18.00 at Engineering Lecture Theatre, University College, Gower St., W.C.1.

4th. IEE — "The pulsars", seventh Appleton lecture by Prof. F. G. Smith at 17.30 at Savoy Pl., W.C.2.

4th. RTS — "Satellite broadcasting" Pt.3: Space broadcasting by Dr. G. Phillips at 19.00 at I.T.A., 70 Brompton Rd., S.W.3.

5th. IEE — "Computer controlled frequency response measurement" by A. J. Ley and A. J. Martin at 17.30 at Savoy Pl., W.C.2.

9th. IEE — "Trinitron: its history and future" by S. Miyaoka at 17.30 at Savoy Pl., W.C.2.

9th. SERT — "Thyristors and semiconductor devices in domestic appliances and television" by J. B. Ruming at 19.00 at Mullard House, Torrington Pl., W.C.1.

9th. AES — "A variety of approaches to audio power amplifier design" by David Rees at 19.15 at the Mechanical Engineering Dept., Imperial College, Exhibition Rd., S.W.7.

10th. IEE — "Piezo-electric devices" by P. Ellis at 17.30 at Savoy Pl., W.C.2.

10th. IEE — "Cable television and the wired city" by R. P. Gabriel at 17.30 at Savoy Pl., W.C.2.

11th. IEE/I.Phys. — Colloquium on "Semiconductor memories" at 17.30 at Savoy Pl., W.C.2.

11th. RTS — "Satellite broadcasting" Pt. 4: Applications and implications of satellites by T. Singleton and Economics of satellite broadcasting by A. L. Witham at 19.00 at I.T.A., 70 Brompton Rd., S.W.3.

15th. IEETE — "World electronics scene" by Dr. Frank Jones at 18.00 at the IEE, Savoy Pl., W.C.2.

16th. IEE/IERE — Colloquium on "Computer applications to design, simulation and testing of logic circuits and systems" at 10.00 at Savoy Pl., WC2.

17th. I.Navigation — "Onboard systems for monitoring marine traffic" by M. O'Hagan at 17.00 at the Royal Institution for Naval Architects, 10 Upper Belgrave St, S.W.1.

17th. IERE — "Solid state microwave sources for radar application" by Dr. B. Taylor and J. M. Skinner at 18.00 at Engineering Lecture Theatre, University College, Gower St., W.C.1.

18th. RTS — Discussion: "The poor relation — television sound" at 19.00 at I.T.A., 70 Brompton Rd., S.W.3.

19th. IEE/I.Measurement Control — "Measurement and control in oceanography" discussion at 17.30 at Savoy Pl., W.C.2.

22nd. IEE — Colloquium on "British activities in satellite technology" at 10.30 at Savoy Pl., W.C.2.

23rd. IEE — "Electronics in the '70s — training for management opportunities" by Dr. F. E. Jones at 17.30 at Savoy Pl., W.C.2.

24th. IERE — "Recognition and encouragement of innovation" by K. Benjamin at 18.00 at Engineering Lecture Theatre, University College, Gower St., W.1.

25th. IERE — Symposium on "Correlation" at 10.30 at Mullard House, Torrington Pl., W.C.1.

ABERDEEN

9th. IERE — "Recent development in oscilloscope design" by W. N. A. Tatton at 19.30 at Robert Gordon's Institute of Technology, Physics Dept., St. Andrews St.

AYLESBURY

22nd. IEE — "Long distance millimetric waveguide systems" by R. W. White at 19.30 at the College of Further Education.

BIRMINGHAM

17th. RTS — "The technical future of television" by Stuart Sansom at 19.00 at A.T.V. Centre, Broad Street.

BOURNEMOUTH

2nd. IERE — "Electronic performance testing of motor vehicles" by C. D. Freeman at 19.00 at the Technical College.

BRIGHTON

23rd. IERE — "Closed circuit television on cable — two standard video schemes" by J. A. Sharp and R. W. Wooten at 18.30 at the Technical College.

BRISTOL

9th. IEETE — "ITV colour — challenge and achievement" by A. James at 19.30 at Cabot Room, Royal Hotel, College Green.

18th. SERT — "Satellite communications" by Group Capt. F. C. Padfield and Sq. Ldr. Holtby at 19.30 at Room C1.1, Cabot House, Bristol Polytechnic, Ashley Down Rd.

24th. IERE — "Hi-fidelity sound reproduction" by R. L. West at 18.00 at Queens Building, The University.

CAMBRIDGE

25th. IERE/IEE — "Thoughts on world communication" by Prof. C. Cherry at 18.30 at University of Cambridge Engineering Laboratories, Trumpington St.

CARDIFF

10th. IERE — "Trends in integrated circuits" by R. G. Hibberd at 18.30 at the University of Wales Institute of Science and Technology.

CHATHAM

25th. IERE — "Operational research" by W. H. Simmonds at 19.00 at the Medway College of Technology.

CHELTENHAM

11th. IERE — "V. L. F. communications" by Dr. I. E. E. Bain at 19.00 at Government Communications Headquarters.

COLCHESTER

3rd. IEE — "The ionosphere and radio engineering" by G. Millington at 19.00 at the University of Essex, Wivenhoe Park.

9th. IERE — "Printed circuit boards for microelectronics" by J. A. Scarlett at 18.30 at the University of Essex, Wivenhoe Park.

11th. SERT — "Decoders and c.d. as in Pye television receivers" by L. Briggs at 19.30 at the North East Essex Technical College, Sheepen Road.

EDINBURGH

10th. IERE — "Recent development in oscilloscope design" by W. N. A. Tatton at 19.00 at Napier College of Science and Technology, Colinton Rd.

FARNBOROUGH

25th. IERE — "Concorde flight control and landing systems" by R. George at 19.00 at the Technical College.

GLASGOW

11th. IERE — "Recent development in oscilloscope design" by W. N. A. Tatton at 18.00 at The Institution of Engineers and Shipbuilders, Rankine House, 183 Bath St.

19th. SERT — "Holography and its applications" by Dr. Sayce at 19.30 at Birniehill Lecture Theatre, N.E.L., East Kilbride.

HUDDERSFIELD

8th SERT — "Video tape recorders" by R. Maude at 19.30 at Room E43, Engineering Tower, The Polytechnic, Queensgate.

LEICESTER

9th. RTS — "The Philips cassette video recorder" by C. Mitchell and C. I. Reid at 19.30 at the Bennitt Building, lecture room 4, University Rd.

16th. IERE — "The application of phase-locked loop to stereo decoders" by A. J. Haywood and M. J. Portus at 19.00 at the Physics Department, The University.

LIVERPOOL

10th. IERE — "The bipolar coagulator" by N. J. Davies at 19.00 at Dept. of Electrical Engineering and Electronics, University.

MANCHESTER

11th. IERE — "Modern oscilloscopes" by M. Thistlethwaite at 18.15 at University Institute of Science and Technology, Renold Building.

MIDDLESBROUGH

30th. SERT — "R.F. measurement techniques" at 19.30 at the Cleveland Scientific Institution.

NEWCASTLE-UPON-TYNE

10th. IERE — "Digital instrumentation" by A. R. Owens at 18.00 at the Main Lecture Theatre, Ellison Building, The Polytechnic.

PLYMOUTH

18th. IERE — "Optical communication systems" by M. M. Ramsey at 19.00 at The Polytechnic.

PORTSMOUTH

17th. IERE — "Micro-wave integrated circuits" by S. V. Judd at 18.30 at the Polytechnic.

SOUTHAMPTON

16th. IEETE — "Police communications" by Chief Inspector G. W. Baker and G. H. T. Evans at 19.30 at Polygon Hotel.

STONE

1st. IERE — "Radio astronomy" by R. S. Booth at 19.00 at Post Office Technical Training College, Duncan Hall.

SWINDON

2nd. IERE — "Thyristor applications" by Dr. M. James at 18.15 at The College.

WAKEFIELD

11th. IERE — "Electronics in policework" by A. Thompson at 19.00 at Technical and Art College, Margaret Street.

YORK

3rd. SERT — "Electronic applications in hospitals" by D. Barnard at 19.30 at the College of Further Education, Dringhouses.

Literature Received

For further information on any item include the appropriate WW number on the reader reply card

ACTIVE DEVICES

Integrated Photomatrix Ltd, The Grove Trading Estate, Dorchester, Dorset, have produced a short-form catalogue — which doubles as a wall chart — on their optoelectronic components . . . WW401

A Motorola wall chart devoted to m.e.c.l. (Motorola emitter coupled logic) is available from GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Rd, Slough, Bucks WW402

An 'All products short-form catalogue' covering standard and custom designed m.o.s. i.cs, diodes, connectors and capacitors has been produced by Emihus Microcomponents Ltd, Clive House, 12-18 Queens Rd, Weybridge, Surrey WW403

A catalogue which lists rectifier, zener and microwave diodes, diode assemblies, thyristors and transistors manufactured in America by a company called Unitrode can be obtained from G. E. Electronics (London) Ltd, Eardley House, 182/4 Campden Hill Rd, Kensington, London W.8 . . . . . WW404

PASSIVE COMPONENTS

We have received the following literature from the components division of Pye TMC Ltd, Roper Rd, Canterbury, Kent:

- Subminiature relay (contacts 2 c.o., 15W or 0.5A; sensitivity 35mW) WW405
- Sensitive reed relays (n.o., n.c., or latching) WW406
- Latching relay type 21 (contact s.p.c.o., 3A, 28Vd.c; sensitivity 176mW) WW407
- Small power relays type PHP (various coils; 4 p.c.o. contacts rated at 3A at 30V d.c.) . . WW408
- 'Moduprint' panel mounted paper tape printers available in a variety of configurations WW409
- 'Proximity initiators and proximity switches WW410
- Snap-action switch, d.p.d.t WW411
- 'Diode-lites'. GaAs light emitters . . . WW412
- GaAs numerical readout assembly . . WW413
- Single GaAs numerical readouts . . . WW414

The 'Hugger' adjustable clamp is an adjustable cable and harness clamp of a new design which is available in screw mounting and self-adhesive forms. It is described in a leaflet. Thomas & Betts International Inc., Greenhill House, 90-93 Cowcross St, London EC1M 6JR WW415

The D-T-V Group (126 Hamilton Rd, London SE27 9SG) have produced another 'Swift Service' components catalogue. It lists a large number of both passive and active devices WW416

Fast response 'patch thermocouples' (types P1 and P2) which can be stuck to any suitable surface to provide a permanent temperature monitor point are described in a leaflet. Comark Electronics Ltd, Brookside Ave, Rustington, Littlehampton, Sussex . WW417

A catalogue, called 'Section-K' covers a range of banana plugs and patch cords. Radiall Microwave Components Ltd, Romer House, The Causeway, Staines, Middx WW418

Details of mechanical counters in all shapes and sizes are given in a short-form catalogue from English Numbering Machines, Queensway, Enfield, Middlesex WW419

Rank Bush Murphy, Drayton Rd, Boreham Wood, Herts., have produced a second edition of their electronic components catalogue WW420

Tantalum capacitors stocked by ITT Electronic Services, Edinburgh Way, Harlow, Essex, are listed in a publication 'Tantalum Capacitor Finder'. Other manufacturers' equivalent type numbers and N.A.T.O. numbers are given WW421

APPLICATION NOTES

We have received the following literature from Integrated Photomatrix Ltd, The Grove Trading Estate, Dorchester, Dorset:

- Information sheet PX129. 'Analogue Photodetector family' WW422
- 201. 'The facts of light' WW423
- 202. 'An optical speech link' WW424
- 203. 'Image scanning with IPL 7000 series photo arrays' WW425

Application note 935 from Hewlett Packard Ltd, Components Group, 224 Bath Rd, Slough, Bucks. SL1 4DS, is called 'Microwave power generation and amplification using Impatt diodes' WW426

EQUIPMENT

A tape recorder designed for educational purposes (VR47) is described in a leaflet. Van der Molen Ltd, 1 Mildmay Rd, Romford, Essex RM7 7DA WW427

We have received the following literature from Aveley Electric Ltd, Arisdale Ave, South Ockendon, Essex RM15 5SR.

- Dumont Oscilloscope model 1062 . . WW428
- Pacific Measurements Inc. (U.S.A.) log./lin. r.f. power meter model 1009 (10MHz-12.4GHz, 1µW-10mW) WW429
- Rhode & Schwarz Literature
- Supplement to communication equipment catalogue WW430
- Supplement to measuring instruments catalogue WW431
- HFV. Field-strength meter, v.h.f. (130dB range) WW432
- USU1. Selective microvoltmeter, 30-1000MHz WW433
- USU2. Test receiver, u.h.f., 30-1000MHz WW434
- PBO. Octave filter, 45 to 22, 400 Hz . WW435

Leaflet P.1030 from Adretta Ltd, Station Approach, Fleet, Hampshire, describes a precison tuning fork oscillator designed for operation from a 5V supply, 600-4,000Hz WW436

Motorized selector switches for switching low-level devices such as thermocouples, resistance thermometers, etc are described in a leaflet from the Croydon Precision Instrument Co, Hampton Rd, Croydon WW437

A 13-page catalogue is devoted entirely to Hewlett Packard's (224 Bath Rd, Slough, Bucks) very large range of pulse generators WW438

The type 830 medium power (15W peak) X-band pulsed signal source is the subject of a leaflet from Microtest Ltd, 28 Walker Lines, Industrial Estate, Bodmin, Cornwall WW439

A set of leaflets describe the audio-visual equipment used to produce the 'Heroes' display at Madame Tussaud's exhibition. Electrosonic Ltd, Electronic Control and Audio Systems, 47 Old Woolwich Rd, London S.E.10 . . . . WW440

Various size transparent grids, a numerically controlled X-Y photo-construction equipment and a 20-inch measuring microscope, all for printed circuit master board fabrication, are mentioned in a leaflet from P. T. Barclay & Partners Ltd, Ullswater Industrial Estate, Coulsdon, Surrey . . . WW441

We have received the following literature from Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey

- Mullard mosaic printer. (Prints a variety of characters based on a 5 x 7 matrix on paper) WW442
- 700 series analogue to digital conversion systems WW443
- Biomotion (U.S.A.) transient recorder model 610 (d.c. to 2.5MHz). WW444
- Biomotion transient recorder model 8D2 (d.c. 500kHz) WW445

Smiths Industries, Industrial Instrument Division, Kelvin House, Wembley Park Drive, Wembley, Middx. HA9 0NU, have sent us a series of data sheets describing a range of very small chart recorders 96mm (3.78in) square at the face and 210mm (8.27in) deep:

- D/Tem. Thermocouple input chart recorders with ranges from −60—1,600°C . . . WW446
- D & Z series: Miniature chart recorders with f.s.ds of 6mV or 10µA upwards . . . WW447
- Type Z. Miniature ten-channel chart recorders WW448

A brochure describes a solderability tester manufactured by Electrothermal Engineering Ltd, 270 Neville Rd, London E.7 . . . . WW449

Scientific Audio Electronics, P.O. Box 2361, Santa Ana, California 92707, U.S.A., have supplied us with the data on the following items:

- Programme equalizer WW451
- Stereo octave equalizer WW452
- Power amplifiers WW453
- F.M. stereo tuner (Mk 6) with digital frequency readout and a 3 inch oscilloscope tuning display ($950 in U.S.) WW454

GENERAL INFORMATION

The following information sheets may be obtained from the Engineering Information Department, B.B.C., Broadcasting House, London W1A 1AA.

- 1936(2). B.B.C. radio Manchester v.h.f. service details
- 1926(5). B.B.C. radio Merseyside v.h.f. service details
- 1034(17). Radio transmitting stations (v.h.f.)
- 1607(1). Stereophony, questions and answers
- 1924(7). Stereophonic transmissions radio 3
- 4937(2). Angus 625-line colour television services

The services offered by Siraid, South Hill, Chislehurst, Kent BR7 5EH, in adhesive bonding, instrumentation and control and automation equipment, is described in a leaflet called 'of course'

The following BS publications may be obtained from the Sales Branch, British Standards Institution, 101 Pentonville Rd, London N1 9ND.

Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms. Part 3. Terms particular to telecommunications and electronics.

- Group 01: General telecommunications and electronics terminology . . . . price £1.40
- Group 02: Telephony terminology price £1.20
- Group 03: Telegraphy, including facsimile terminology . . . . price £1
- Group 04: Broadcasting radio and television terminology . . . . price 80p
- Group 05: Propagation and media terminology . . . . price 80p
- Group 06: Radio location and navigation terminology . . . . price £1
- Group 07: Radiocommunication terminology . . . . price £1.20

BS3939: Supplement No.3 (1971) Graphical symbols. Additions and alterations to sections 1-22 . . . . price £1

BS9000: Part 1. General description and basic rules . . . . price £1.20

BS9361: 1971. Rules for the preparation of detail specifications for semiconductor devices of assessed quality: high frequency low power transistors . . . . price 95p

Industry Services International Ltd, Griffin House, High St, Bracknell RG12 1LF have prepared a brochure which describes the services it can offer in product support, maintenance improvement, quality control and technical communication . . WW455

Progress in Tape Recording

by Basil Lane

Since its origin in 1898, the progress of magnetic recording has been marked by fits and starts of inventiveness, and a slow acceleration of interest by the general public. Modern plastic tapes first appeared in 1944, but it took until the early 1950s for domestic tape machines to become popular in the home.

Even at that stage quality was still far from being high and the initial enthusiasm gave way to euphoria in which many well known manufacturing names went to the wall. In the long run it was almost certainly the continuing professional interest which restored the commercial popularity of the tape recorder, until in this past year the general sales figures have shown a satisfying upward trend that has encouraged the formation of many a new company.

In this review we take a brief look at developments which over the past year or so have represented a serious contribution to the state of the art of tape recording. Many of the limitations of modern techniques rest with the tape itself and so it is logical that the first section of this article should be devoted to this subject.

Tape technology

Essentially, magnetic recording tape consists of a plastic base material coated with a magnetically retentive surface. As the most readily available and tractable material for this active element is iron, most development effort up until around 1965 concentrated on producing compounds of this substance for use in coatings.

Certain oxides of iron show good magnetic properties, but one in particular is ideal for the purpose, having high retentivity, low coercivity and being cheap to manufacture. This is gamma ferric oxide which does not occur in nature and has to be derived by a fairly exhaustive process from the non-magnetic alpha ferric oxide. The final physical form of the oxide is a fine needle shaped particle the dimensions of which are required to be held within fairly tight tolerances, since this has a bearing on the final characteristics of the tape.

Since a carefully controlled layer of these particles needs to be applied to the plastic base material some adhesive and dispersive properties are required and these are added to the oxide in the form of a binder, solvent and lubricant. This mixture or 'dope' is then carefully applied to the base material in thicknesses and dispersion to suit the properties required of the final product.

The factors in the coating and its associated process which affect the magnetic properties can be stated in a simplified form as follows. The proportions of oxide, binder and solvent are determined by the necessity to keep oxide shedding to a minimum. Many of the so called 'white box tapes' suffer terribly from this problem, thus clogging up the recorders on which they are used.

Oxide thickness determines the maximum output possible from the tape — the thicker the magnetic material the greater is the recording current required for saturation. Greater thickness also reduces the distortion at normal recording levels but requires increased levels of bias. The absolute noise level of the tape is affected by oxide thickness since this is related to the bulk of active material in the replay head gap field at any one time. Modulation, or d.c., noise is related to the density, evenness of dispersion and thickness, and regularity of particle size — the latter also affecting sesitivity and print through. Particle size and dispersion also have an important bearing on the short wavelength performance and the noise spectrum.

Surprisingly, the base material also plays a major part in some of the final properties of the tape. Most modern products have a p.v.c. or polyester base material with a later trend towards polyester. This is immensely strong even when thin and resists stretch, shrinkage and reasonable punishment from water and heat. The thickness chosen is a complex function dependent on the acceptable limits of print through (though oxide properties have some bearing on this) and the mechanical details of fitting a specific length of tape onto a certain reel size or the degree of wrap round on record and replay heads required by different types of recorder. Naturally the geometry of the heads plays no mean part in this and this does help to explain one of the many reasons for the diversity of base thicknesses available. Another consideration which comes to mind is the final use to which the tape is put — for example, educational recorded material tends to undergo extensive and often rough treatment and for this, a heavy grade of base material could prove to be most suitable. The poor degree of wrap round oh the tape heads would be of minor consequence since the degree of fidelity does not often have to be high.

In cassettes the base thickness is more usually dictated by the need to squeeze a specific amount of tape into fixed dimensions. For this reason, triple play would be used for C60 cassettes and quad play for the longer C90 versions. Thus it is usual where a manufacturer produces a complete range of tapes, for up to five thicknesses of base material to be utilized. Some tapes are put to work in cartridges and other endless loop devices, where long lengths have to slide over each other and to assist this graphite is added to the base material to provide lubrication. Polyester, in common with most other plastics can build up static, which affects the way in which tape winds on or off a reel. This can be partly overcome in some base materials by making the reverse a matt finish to help prevent the tape from slipping sideways as it beds on to the reel. However, as will be seen, some manufacturers have gone to the root of the problem and produced a solution which could prove to be more satisfactory.

All these points add up to a large number of independent variables which can be permutated and combined to produce a range of tapes from which selection has to be made to suit circumstances.

For convenience, tapes can be grouped under generic headings dependent upon their magnetic properties — low noise, low noise and high output, high output, and low print. Bearing in mind that there are only a limited number of physical factors involved, it can be seen that trading of one advantage for another is inevitable, so now we go on to look at the way in which the modern generation of tapes has evolved.

Modern developments in tape

The latest range of magnetic tapes based upon the use of ferric oxide as the recording medium has probably reached the ultimate in development. Much of the progress has been led by BASF who were the first to produce a viable magnetic tape. The latest achievement in the domestic range of tapes can be said to be a spin off from the demanding requirements made of the professional range where most manufacturers have made efforts to produce the difficult combination of low noise with high output. For example, where quality reproduction is required in domestic machines with 4-track heads or $\frac{1}{4}$-track stereo heads BASF's LP35LH probably represents a good example of the latest generation. However, such a tape would be suitable for use only with the more modern machines where the bias — an important factor many fail to appreciate — has been optimized for that particular product. In the case of earlier machines BASF DP26 would be preferred, since the machine biasing would produce a more acceptable high-frequency performance and a more satisfactory subjective signal-to-noise ratio.

Generally speaking, professional machines working at 38cm/sec are better off with single-play tapes where the additional base thickness assures the best signal-to-print ratio and a good measure of mechanical stability. Here two new developments by BASF have been announced recently. Advantage has been taken, in one instance, of the professional Dolby 'A' system (of which more later) to introduce a tape with an incredibly good low noise performance coupled with excellent short wavelength characteristics. However, considering the base thickness (50μm) the print through is slightly inferior to the standard LGS52. Fortunately, since the Dolby system deals with this problem rather well this is of minor consequence. The tape type is known as SP50M and represents a step which should assist studios to improve the quality of new masters and duplicating copies quite considerably.

The second and most recent addition to the professional range of tapes is one which carries the same oxide as LP35LH but has a matt backing to assist in even spooling. This can be a most important requirement for several reasons. Any tape edges protruding from the bulk of the reel of tape are easily damaged; this has a significant effect upon the signal level produced by the replay head. Also, unequal stresses are held in the tape causing distortion of the base material. This line of thinking is also evident in the new types produced by Zonal Tapes. Known as the Spectrum range not only are they available with matt back finish (in the low noise version) but also the base material has been given anti-static treatment which helps to prevent uneven spooling, and reduces the possibility of small dust particles adhering to the tape. In both versions a high output performance has been achieved, but some evidence of the trade off principle is shown in that one tape provides low noise with high output, and another low print-through with high output. Although the Spectrum range was designed principally with the professional in mind, the extended-play versions would probably work very well on modern high quailty domestic machines.

EMI have chosen to produce an interesting group of tapes under the name of AFONIC. These consist of different base thicknesses with identical oxides and oxide thicknesses. The result is that apart from a deteriorating signal-to-print ratio with the reduction of base thickness, all tapes have identical magnetic properties and no change of biasing is necessary when moving from one tape to another.

Over the past year, cassettes have proved to be the area of greatest growth and signs of this are reflected in the number of developments and innovations that have taken place. Since the cassette machine is a sensitive animal, the cassette design is of considerable importance in ensuring a low wow and flutter performance. In all cases the degree of tape/head contact depends upon a constant and steady back tension from the feed spool and most cassettes have failed to provide this. The main reason for this is irregularities in rewind tension causing the tape to scatter or throw sideways and come into contact with the inner cheeks of the cassettes; in addition, sufficient tension builds up in the tape itself to cause temporary tape stretch. Unfortunately this is not relaxed during the normal passage of the tape across the head, and tape weave occurs reducing channel separation and aggravating the wow and flutter problem. Other problems relate to a small bulk of oxide present in the record and replay head gap field creating low levels of tape saturation with accompanying poor low-frequency distortion characteristics.

These difficulties caused a considerable flurry of development activity involving about three years hard research. There has also been a spin-off from the computer and video recording fields where the demands for low dropout coupled with excellent short wavelength characteristics have engendered research into the use of other magnetic materials beyond ferric oxide.

A considerable amount of this work has centered on the use of oxides of nickel, cobalt and chromium — all of which have magnetic properties of the right type. Du Pont de Nemours, of America, were the first to make the break, by marketing a cassette tape carrying chromium dioxide as the magnetic medium. The advantages said to be gained from this were improved signal-to-noise ratio coupled with a superior ability to accept a higher level of signal at high frequencies. However, this was not strictly true, for the absolute noise level was higher, and although a higher level of flux could be recorded on to the tape, if advantage of the better high-frequency record characteristics of the tape were taken by adjustment of equalization and pre-emphasis the resultant subjective noise level deteriorated taking the situation almost back to square one. Although Du Pont holds the patents on this type of tape, three other firms have now produced their own versions of this type of oxide. The first of these to appear in Europe was from Agfa who produced review samples in the UK earlier this year. From tests conducted on this tape, two things became immediately obvious, first that the oxide had a higher coercivity requiring a greater level of bias current, and a higher retentivity making it almost impossible to erase using the average cassette recorder. Other factors, such as an inferior modulation noise, became evident and a rather abrasive surface which wore the soft record/replay heads on cassette machinery at a rather alarming rate. Clearly, these two new tapes did not represent the advance first imagined, but they did bring a marginal improvement. Finally, BASF had been seeking a way of producing a chromium dioxide tape without falling foul of the Du Pont patent and came up with a series of pre-production samples first appearing from the beginning of this year, and showing a steady improvement with each appearance. September saw the launch of the product and testing shows that many of the earlier deficiencies of the oxide have been overcome.

Biasing for BASF chrome cassettes needs up to twice as much head current as conventional oxides, and a high-frequency (70μsec) replay equalization. Unfortunately the DIN Committee has settled to retain the low frequency 1590μsec characteristic used with ferric oxide tapes which reduces the overload margin at low frequencies quite considerably. This is currently causing one of the biggest headaches for cassette enthusiasts. However, signal-to-noise ratio and high-frequency performance has been improved and a better surface structure has eliminated the original head wear objections. This cassette will be appearing on the market from the end of October at a rather higher price than its ferric oxide counterparts. The need for a change of bias and equalization implies the necessity for some additional circuitry in cassette machines and this is now appearing on some models. It is interesting to note that all versions of the cassette have the same thickness base material making the C120 a much more reliable product than its forebears. I understand, although I have not received any literature on the subject, that the Japanese firm of TDK are also marketing a chromium dioxide tape around this time, extending the choice to a C30 length.

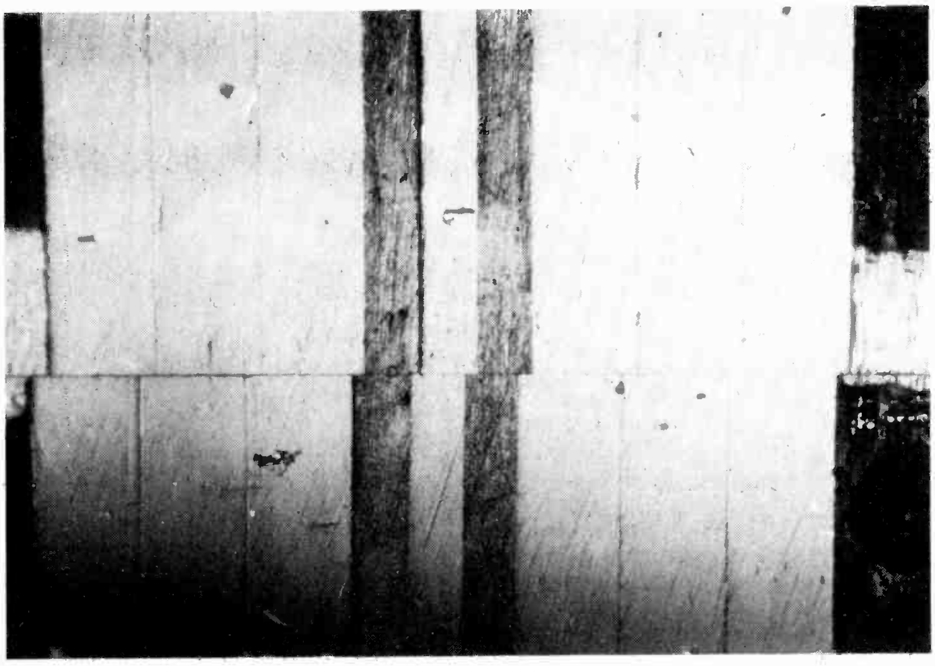
The principal disadvantage of such an oxide is the need to alter the bias and equalization, and this has occasioned some research into oxide materials having superior qualities to ferric oxide but requiring little or no change in any of the machine parameters. The 3M Company Magnetic Division have come up with a tape making use of a cobalt oxide which is said to bring improvements in signal-to-noise ratio by permitting greater levels of signal to be impressed upon the tape. Ampex have also been working along these lines but with the addition of mixing the coating in two layers with ferric oxide. This brings several advantages. Since cobalt oxides have a lower retentivity and coercivity the danger of print through is increased (the 3M's product suffers rather badly in this respect), and so mixing ferric oxide with the cobalt oxide can give the superior print characteristics of ferric oxide whilst adding the sensitivity of the cobalt. Whether this will work out in practice, remains to be seen, but it is rumoured that something will soon appear from Ampex.

As mentioned earlier, the cassette itself is a major influence in determining the performance of the machine and to this end efforts have been made by all manufacturers to improve the tape wind and eliminate jamming or increased friction. Some interesting research by the 3M company shows that wow and flutter on conventional tapes increases sharply after about 50 passes through the machine. This is a result of an accumulation of winding errors and internal stresses building up in the base material to permit the tape to touch the cassette cheeks thus creating an irregular back tension. They have overcome the problem by making the base material highly conductive to eliminate static.

Ampex and Philips are attacking the problem from a mechanical standpoint by improving the bearings of the spool centres, which contribute a considerable amount of friction. The first version produced by Philips was intended for computer purposes in data logging. The most fascinating feature of this data cassette is that it is made of metal, thus improving accuracy and reliability.

The new chrome cassette produced by BASF also displays some unique features to improve the mechanical performance. Pivoted, hard plastic guides give an even wind, help to remove dust particles, and also peel the tape layers apart in the event of static causing one layer to stick to the next. Developments are occurring so fast in this sector of the tape world that much might have happened between the writing of this article and its appearance on the bookstall.

So far, little has been said about cartridges, these employing an endless loop of ¼in tape. Some developments have occurred here with improvements in tape oxides similar to that enjoyed by the reel-to-reel recorder, but in particular the peculiar requirements for low friction where tape layers move one against the other have created the need for newer improved lubricants and heavier gauges of base material. Molybdenum disulphide has come to the rescue and the BASF cartridge tape base material is now impregnated with this chemical.



Misalignment of the pole pieces in a cassette record/replay head.

Progress in tape recorders

From the foregoing, one might be forgiven for assuming that all the major developments of the past two years have been with the tape manufacturers, but this is not really so, although in most instances the new machines have been the result of a steady improvement, rather than startling innovation. On the mechanical side considerable effort has gone into improving the reliability and mechanical performance so that wow and flutter figures of well below 0.15% have become quite common. At the high-priced end of the scale it is getting difficult to differentiate between domestic and professional — a fact that many over-enthusiastic advertising departments take unfair advantage of when labelling their machines as professional or semi-professional (whatever it is!) when they meet few of the criteria demanded by the professional recordist.

H.M. Government does have some say in the definition of a professional recorder (for tax purposes) but the requirements of the studios and broadcast organizations tend to be more basic and down to earth. Obviously the highest possible mechanical and electrical performance is required. The demands made of a machine that is to produce master or duplicating material are very high indeed, but in addition to this there are other features which are not only desirable but have become obligatory. Such features as being able to accept NAB or cine centred 10½in spools; being fitted with either XLR connectors; P.O. jack plugs or locking DIN plugs; being capable of operation at tape speeds of 19.5cm/s and 38cm/s; having accessible bias, pre-emphasis and equalization controls — all these have become regular features that delineate the professional area. In addition there are a number of important electrical requirements that have to be met, such as balanced line input and outputs (usually 600 ohms, although one studio at least has adopted a lower impedance) variable speed spooling and interchangeable head blocks.

Tape heads

Record and replay heads naturally present themselves next for discussion. Essentially, all that a recorder head consists of, is a ring-shaped electromagnet with a very fine gap between the pole pieces. Three types of material are now used for the poles in this area.

The earliest and still most popular structure is laminated magnetically soft iron. The very thin pieces of metal are stamped out, clamped together, wound with fine enamelled copper wire, and finally either moulded into a plastic block or fixed firmly inside a metal extrusion. The manufacturing tolerances involved are very close and this is why it is only in the very top-quality machines that consistency of performance is found from head to head. The principal factors involved are the gap dimensions which affect the wavelength performance of the head, alignment of the gap vertically since azimuth errors can cause serious reductions in level across the tape by phase cancellation at high frequencies, and vertical alignment of the pole pieces which can affect inter-track crosstalk and signal output.

As an example of the sort of errors which can occur, we reproduce a highly-magnified picture of a cassette record/replay head that suffers from several inaccuracies in this respect. The gap between the pole pieces is extremely small (about 1 micron) and severely limits the usable flux output. For this reason on multi-head machines it is usual to obtain a good flux at the record head by keeping a fairly wide gap, anything up to 12μm for reel-to-reel heads, and a very narrow gap at the replay head for good high-frequency performance.

The shape of the pole piece in contact with the tape is of some considerable importance. At low frequencies, where the recorded wavelength approaches the dimensions of the core width, comparatively large fluctuations of output level can occur. Normally these would be

The Dolby System: A Progress Report

Following world-wide acceptance of the professional A-System, more than thirty manufacturers will soon offer advanced new consumer products incorporating the Dolby B-System.

The Dolby A-System is the professional noise reduction system. Nearly 5,000 processors are now being used by record companies, motion picture studios, broadcasting stations and communication authorities throughout the world. The A-System has achieved virtually universal acceptance among professionals because it is precise and consistent in operation, simple to use, and has no effect upon the music or other signals being recorded or transmitted.

The Dolby System is a complementary noise reduction system. Unlike playback-only devices, which even in their most sophisticated form must alter the characteristics of the material, the Dolby System is used before and after the recording or transmission channel. The process selects the quietest signals during recording, where noise might be heard by a listener, and subtly increases their level automatically. Loud signals are not processed in any way. During playback, the low-level components are reduced by an exactly complementary amount, thus re-establishing exactly the original signal dynamics, and at the same time eliminating most of the noise introduced during the recording process.

The Dolby A-System provides wide-band noise reduction. With the Dolby A-System, this low-level compression-expansion technique is applied in four separate frequency bands covering the entire audio spectrum. Consequently cross-talk, modulation noise, print-through, and hum are all reduced, in addition to tape hiss. In communications applications, cross-talk, dialling pulses, and other mid-range noises such as monkey chatter are all effectively attenuated.

The Dolby B-System is the compatible high fidelity noise reduction system for consumer applications. Using the same basic compression-expansion technique as the A-System, but employing a single high-frequency band, the B-System is intended for consumer applications where hiss is the predominantly encountered noise. The single band operation is much simpler and lower in cost than its professional counterpart. Dolby Laboratories makes only professional products, but licenses the B-System to manufacturers of consumer tape recorders, receivers and Dolby adapters. More than 30 companies will soon be making products incorporating the B-System, and others are joining the list each week.

ADVENT	HARMAN-KARDON	RANK WHARFEDALE
A.G.S.	HIGHGATE (ALPHA)	REVOX
ALLIED RADIO SHACK	HITACHI	SANSUI
AMPEX	JANSZEN	SILVER
BELL & HOWELL	KELLAR	SINGER
BENJAMIN	KENWOOD (TRIO)	SONAB
BIGSTON	K.L.H.	STANDARD RADIO
CONCORD	LAFAYETTE	TEAC
CROWN RADIO	LENCO	TELETON
EMERSON	MITSUBISHI	TELEX/VIKING
FERROGRAPH	NAKAMICHI	3M/WOLLENSAK
FISHER	PLANET	

The Dolby B-System has been used in FM broadcasting with excellent results. FCC rules permit broadcasting of Dolby-encoded signals in the U.S.; experiments of this kind are taking place in other countries as well. The reduction in noise given by the system can more than double the area in which high-fidelity listening is possible, with no increase needed in transmitter power. Later this year Fisher and Harman-Kardon will be the first to offer receivers with the Dolby System built in.

Hundreds of different commercially recorded Dolby cassettes will be available by the end of the year. Many are already being released regularly by Columbia, Ampex, London/Decca, Vox, Musical Heritage Society, RCA (U.K.), and Pye/Precision (U.K.). Twenty other companies have obtained the professional B-Type encoders needed for duplicating such cassettes. There is no royalty payment to Dolby for these recordings. Listeners and dealers everywhere agree that Dolby cassettes are perfectly playable on any cassette recorder, and usually sound better even on non-Dolby equipment.

The Dolby B-System and new tape formulations (such as chromium dioxide) work very well together. Although their noise reduction effect is much less than that of the Dolby System, some of the new tapes provide a useful extension of high-frequency response. Used with the Dolby System, they provide striking evidence of the cassette's real capability. Although chromium dioxide tape is not compatible with the vast majority of cassette recorders in the field and on dealers' shelves, more and more manufacturers are providing new machines with the necessary circuitry, along with the Dolby System.

Integrated-circuit versions of the Dolby B-System will be available next year. An IC is being developed jointly by Signetics and Dolby Laboratories; the technology will be made available to IC manufacturers everywhere, to insure industry standardization and lowest cost to consumers, as well as reliable supply to manufacturers. Ultimately, the increased retail cost incurred by adding the Dolby System to a tape recorder should be $10 to $20.

The cost of licensing the Dolby System has been reduced considerably because of rapid industry acceptance of the system. Manufacturers now pay on a simple per-unit basis, with royalties as low as ten cents per channel. The licensing agreement also entitles a manufacturer to sustained technical support from Dolby Laboratories in noise reduction applications. Dolby employs a staff of more than 100 at its London facility, and maintains offices in New York and Tokyo, all devoted exclusively to noise reduction system development, manufacture, sale and licensing. To date, 80 patent applications have been filed in 17 countries to cover the Dolby System; 19 patents have already been issued in 10 countries, including the United States.

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WW—095 FOR FURTHER DETAILS

with a low revolution rate, the inertia of the flywheel is also reduced thus permitting variations in spooling or back tensions to adversely affect wow and flutter performance. Speed control on most modern mains driven machines is either governed by taking advantage of synchronous motors or using an electronic servo system such as is to be found on the Revox. An additional advantage of the servo system is to permit a direct drive capstan from the motor spindle, where the accuracy of the servo system overcomes the disadvantages of the low angular speed of the motor.

Battery-powered machines can suffer from supply voltage variations due to battery exhaustion and it is normal in these to stabilize the supply in some way.

An example of the success of combining these two features is to be found in the fascinating new addition to the Nagra range — the SN miniature tape recorder. Here the supply for transport and electronics is derived from two dry cells giving a total of 3V, this is then converted to 5V and stabilized for use by the motor and circuitry. In addition a servo system holds speed constant and because the capstan and motor spindle are in one, wow can be held to a minimum by the same system.

Flutter can occur as a direct result of small variations in the intimacy of tape contact with the head. In most early machines this was kept under control by the use of pressure pads, still a feature of the Ferrograph Series 7 machines. Part of the reason for employing such a system was because of the difficulties in maintaining a steady back tension from the feed spool which was mechanically braked to avoid overrun. Over the past few years an increasing tendency has been to use three motors one to drive the capstan and the others to rewind and control the 'play' mode tape tension. This has eliminated the necessity for pressure pads, but still leaves tape/head contact at the mercy of small vibrations caused by tape sticking as it leaves the feed spool or slow variations in reel motor torque as the diameter of the tape spool changes. Various systems have been evolved to combat the problem, many having been passed on to domestic machines from the professional range. Typical of such an evolution is the use of flutter rollers between the feed spool and head block in the Akai GX365. The Tandberg 6000X shows a vestige of the old pressure pad system with the use of a pressure pad pressing the tape against a metal plate to the left of the erase head thus providing good control of the tape as it passes across the head assembly.

Philips have introduced an interesting feature in their machine to be released in November. The capstan drive motor is a d.c. brushless type where a Hall effect device is used to sense the armature position and appropriately switch a transistor circuit controlling the polarity of the motor supply. It seems a pity that having gone to all this trouble the Philips N4450 is incapable of turning out a better wow-and-flutter figure than 0.15% at 19cm/s (the best speed) and a speed constancy of $\pm 1\%$. As an example of the sort of figures claimed for a professional *portable*, the Tandberg Model 11P used with their unique Farnell Tandberg film sync system has a wow and flutter of 0.14% at 19cm/s and speed constancy of 0.5%. Better results are, of course, obtained by the Nagra IVD (at three times the price); typical figures at 19cm/s being 0.05% wow and flutter and 0.1% speed stability. The need for additional gimmicks on domestic machines has brought a rash of very high priced machines, mostly from Japan, which include the facility of playing $\frac{1}{4}$-track tapes in the reverse direction and either adjusting the position of the playback head (Akai GX365) or using additional replay heads (Pioneer) switched to the alternative track positions. In conjunction with such facilities these machines and others with similar systems, such as the Philips N4550, have automatic timing devices which will permit a continuous cycling between any preselected two points on the tape.

In cassette machines, the problems associated with tape transport are those of a reel-to-reel machine, but amplified considerably by the need for miniaturization and the slow tape speed. Since the cassette principle started as a low-cost low-quality replay system, the urgency for improving the quality of the transport has not been great—until the last two years which saw the introduction of the Dolby 'B' system to be described later in this article. Again the impetus came from Japan where Nakamichi Inc. produced prototype machines capable of a performance limited only by the cassettes available at that time. These improvements were built into the current generation of high-quality decks where experience has shown that poor cassette mechanics can even reduce the standards of this type of machine to unacceptable limits.

Further improvements are being made all the time which represent a movement towards high-fidelity reproduction. So far the best wow and flutter available from such machines is around 0.15% found in the unique double capstan Sony TC160. Here tape tension is held constant across the head by placing a capstan each side, the one nearest the feed spool rotating at a slightly lower speed than the main drive capstan. An alternative, used by National in the U.K. marketed RS-275US, is to direct drive the capstan which also forms the motor spindle. With such a small capstan and a low tape speed, the rotational velocity of the motor armature is extremely low and controlled by a servo system to achieve a claimed wow and flutter performance of 0.1%; which incidentally is also the *claimed* figure for the Sony TC160. Extensive use has been made of solenoid operated controls in the National deck which make it a delight to operate but incredibly complex looking inside.

Generally speaking cassette mechanisms can be divided into two broad groups those where the cassette moves up to the head and pinch wheel assembly, and those where the cassette is held in a fixed position and the head assembly moves. The latter is based upon the original Philips system and derivatives representing developments of one sort or another are the Nakamichi, Sony, Wollensak and others. The first system, known as the Staar mechanism, has a brand new derivative in the Goldring Lenco deck, having two capstans (one used for playing in reverse), a four-track record/replay head, and two erase heads. Automation plays an important part in this mechanism since it will play through the cassette in one direction, sense the end and commence playing back in the opposite direction, finally ejecting the cassette at the end of the cycle.

There is no doubt that the cassette mechanism is going to get better. Already very high performance is possible under laboratory conditions, equalling the best domestic reel-to-reel machines and so it should not be too long before production techniques permit the realization of such high standards in domestic machines. The best in this respect can be confidently said to be the Wollensak, a traditionally designed machine, manufactured in America, and capable of consistently high standards. Advent have incorporated this mechanism into the latest generation of their Dolby cassette machines, the result being a virtual 'Rolls-Royce' of cassette decks. Regrettably these machines are not as yet available in the U.K.

The advances in electronics have perhaps not been quite so obvious as those previously discussed, but are nonetheless of great value.

The earliest Grundig recorders employing transistors, in common with other good domestic machines of the period, were very elemental and contained hardly any more transistors than the last of the valve models. Five or six transistors fulfilled all electronic functions at that time. Now with a reduction in the cost of transistors, advantage can be taken of using more devices to improve performance such that the latest comparable machine uses around 14 transistors. In addition functions such as automatic record level control are to be found on these and other machines such as the Tandberg and Sony range.

Low-noise devices have helped to improve the performance of reel-to-reel machines and to a lesser extent that of cassette machines where the noise limitations are more with tape than the electronics.

Miniaturization of components helps in the production of the small portable and cassette machines where electronic circuits are not only used to deal with the audio signals but also to serve many of the control functions.

Amplifier design has been simplified in some machines by the introduction of integrated circuits, a trend that will be becoming increasingly popular, if only to hold down production costs.

Several manufacturers have produced new machines which either represent a step into an area they had not served before, or have completely modernized well established designs. Good examples of the latter are the new series of machines from Brenell, the top of the range being the industrial Type 19 tape deck which employs many of the features described previously in this article. With a wow and flutter performance of 0.05% at 38cm/s, rack mount facility and solenoid operation, it is worthy of the title professional.

Sony have entered the world of professional machines with their new TC-850-2 with all the usual facilities expected of such a machine, plus a few such as sound-on-sound and echo.

Telefunken have introduced a range of professional portables under the generic coding of M28. It is interesting to note that these machines are available with the head block arranged in the fashion popular in studios on the Continent, where the tape oxide faces outwards from the reel and cannot come into contact with guides until its arrival at the head. This helps to reduce oxide wear and the accompanying scatter of oxide particles over the working surfaces.

Both Ferrograph and Revox have revamped their current range of recorders to include a new one containing the Dolby 'B' noise reduction system.

In a similar range to the Akai GX365 comes the Sansui SD7000, which is a high-priced domestic machine having a great variety of automatic facilities including an automatic rewind which is triggered by the presence of a 20Hz signal on the tape. At a retail price of over £400, including purchase tax, one cannot help wondering if they are not being a little more than optimistic.

The interests of the amateur movie maker are more than adequately looked after by the Tandberg Model 11-2 with its associated oscillator and indicator unit. Here a similar system to that employed by the professional Leevers Rich equipment has been produced to enable the production — with amateur cine equipment — of perfectly synchronized sound, and even to transfer this sound on to a stripe on the film after editing has been effected.

Most recently BASF added a surprising feature to their range of products by marketing two cassette recorders in the medium price range. One of them is very representative of current thought by Japanese manufacturers in that it incorporates an f.m./a.m. tuner.

Noise reduction

A principal problem in tape recording is the limitation set on dynamic range by the level of noise and the overload margin of the tape. Even with the new sophisticated ranges of tape available the demands of high-quality mastering require even lower levels of noise, thus giving room to accommodate a better dynamic range. Tape duplicating adds its own set of problems with the increase of noise which accompanies each stage of the copying process. For many years experiments were conducted with a view to producing an effective noise reducer which would not be noticeable in operation.

One such system has met with considerable success in this area, to the extent that it has become available in a domestic form in several cassette recorders, where the need for noise reduction is at its greatest, as well as in some reel-to-reel machines. The system is known as the Dolby 'A' noise reducing process for professional applications and the Dolby 'B' for domestic applications.

The professional processor was developed before the domestic version, but it is interesting to begin by examining the elements of the system by first taking a look at one of the earlier 'B' processor circuits, examining the circuit operation and then describing its philosophy. In this way we take an easy step to examining the principles of the more complex 'A' system. Fig. 1 shows one of the 'B' system circuits used as an integral part of a cassette recorder.

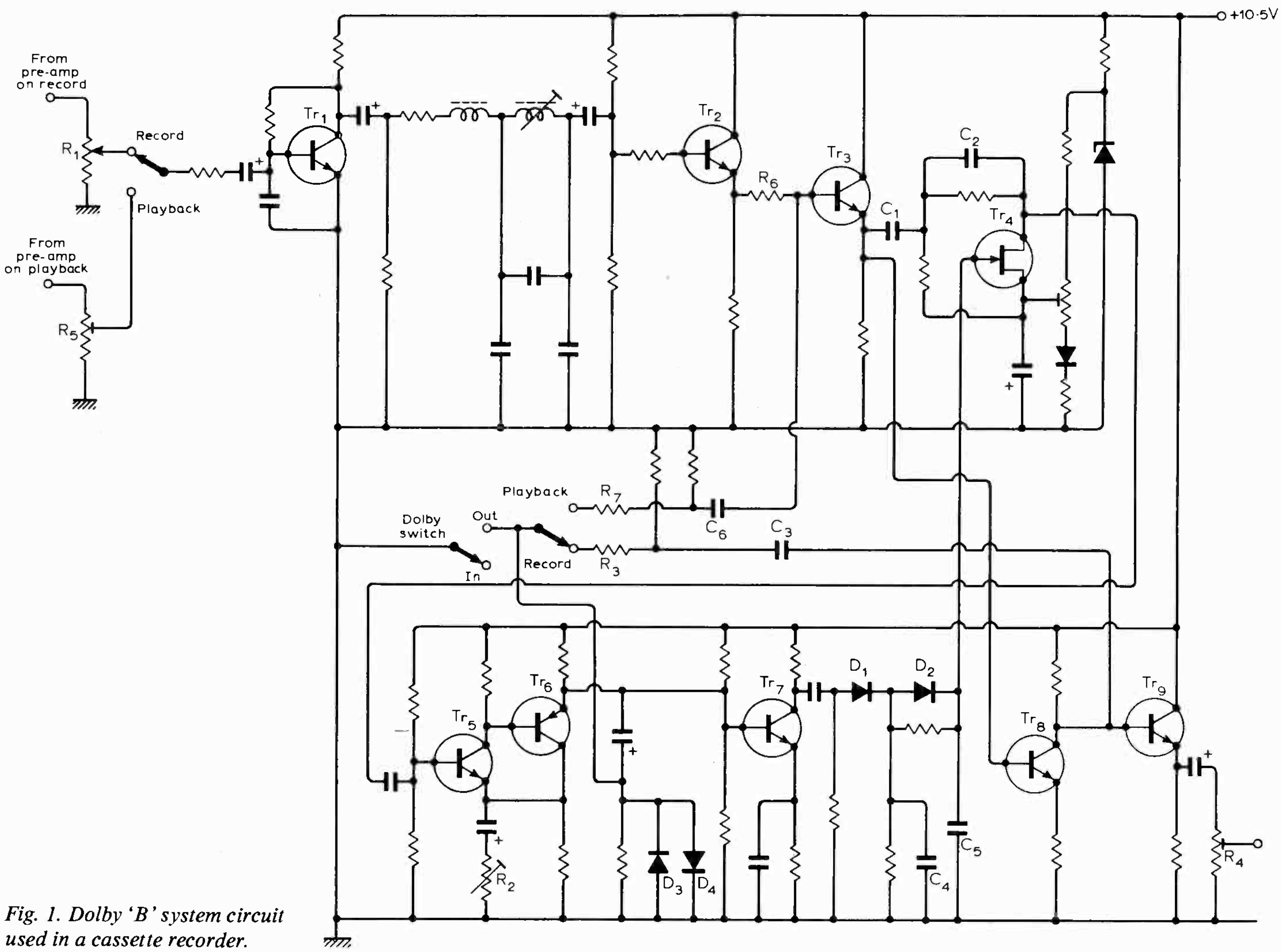

Fig. 1. Dolby 'B' system circuit used in a cassette recorder.

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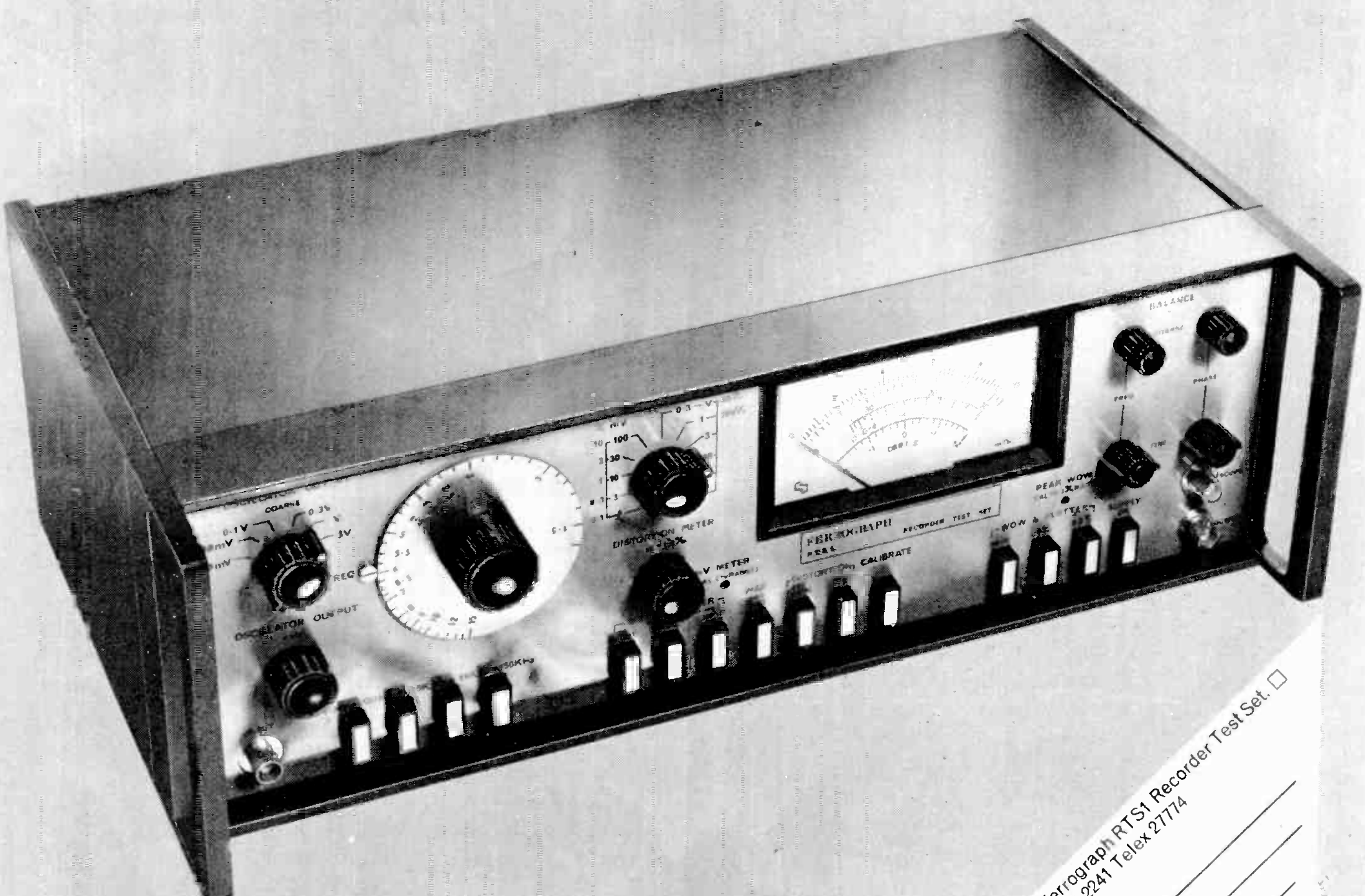

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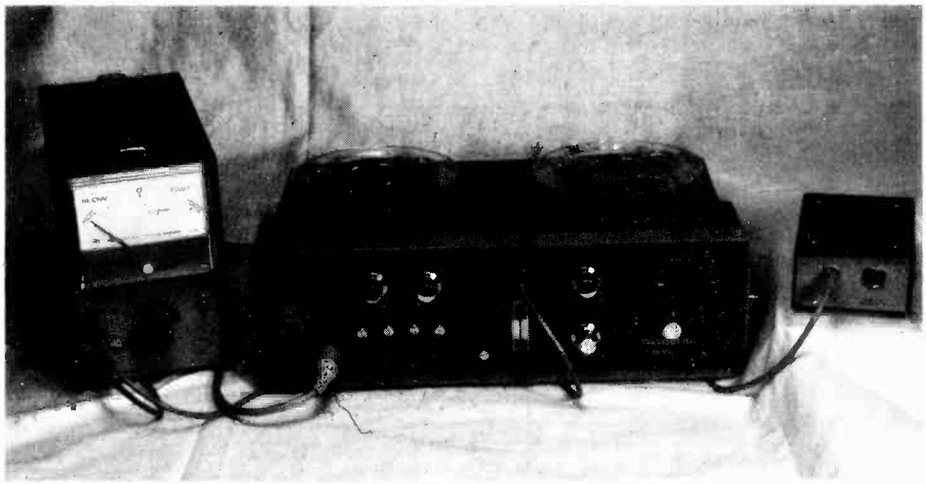
On record, the input signal passes via the recorder input level control R_1 and the bias/multiplex filter to emitter follower Tr_2 The filter is required to remove supersonic noise, including the f.m. stereo pilot tone, which would otherwise upset the operation of the noise reduction circuit. Transistor Tr_3 provides a high-impedance point on its base for summing on replay and a low impedance drive for a filter from which the noise reduction signal is derived. The filter consists of two elements — a fixed high-pass network consisting of capacitor C_1 and a resistor and a variable high-pass network formed by capacitor C_2 and the drain-to-source resistance of the Tr_4. The resistance of the f.e.t. is dependent on its gate-to-source voltage, which is derived from the non-linear rectifier stage driven by the transistor Tr_7. The impedance of the f.e.t. channel falls with a rise in its gate voltage. The output of the filter is amplified by the inverting stage, Tr_5 and Tr_6, the gain of which is adjusted by R_2 during manufacture and determines the maximum amount of noise reduction signal available from the circuit. The noise-reduced signal appears at the emitter of Tr_6. The main signal is taken from the emitter of Tr_3 into the inverting unity-gain amplifier Tr_8 to the collector of which is fed the noise reduction signal via C_3. The two signals are in phase and so they add, the resulting boosted record signal being fed via emitter follower Tr_9 and the record preset calibration control R_4 to the head driver amplifer. The noise reduction signal is also used to derive the control signal for the variable section of the filter. The signal is amplified by Tr_7, rectified by D_1 and initially integrated by capacitor C_4. The CR network in the emitter of Tr_7 increases the gain of the stage at high frequencies, which in turn gives the characteristic turn down in the record response at medium levels (about -30dB) thus avoiding the possibility of overloading the tape. The second part of the integrator, capacitor C_5, is charged during slow increases of side-chain signal level, but if the voltage drop across the series resistor becomes sufficient to forward-bias D_2, charging of the capacitor takes place much quicker. It is this non-linear nature of the rectifier stage and the resulting control voltage which enables the noise reduction circuit to remain inconspicuous in action. For small changes in signal level, the control signal changes slowly and its action remains undetectable, for large transients, the control signal changes quickly, enabling the circuit to cope with the new signal conditions almost instantly, the effect of the transient in the *control signal* being masked, as far as the ear is concerned, by the transient in the signal. By the time that the ear has recovered from the effect of the signal transient, the control transient has passed. The maximum level of the noise reduction signal voltage under transient conditions is limited by diodes D_3 and D_4. If actually clipping, the noise reduction signal may seem rather alarming, but it does not sound so because the condition lasts for less time than the ear takes to recover from the transient.



Farnell-Tandberg sound sync system provides a high quality sound recording facility for 8mm movie film.

The switchable Dolby circuitry being described uses the same elements, rearranged somewhat, to produce the inverse characteristics of the system in its record mode to restore the signal to its original condition. The signal from the replay preamplifier comes via the replay preset calibration control R_5 and the bias/multiplex filter to the emitter of Tr_2. Here it is fed via R_6 to the base of Tr_3 where it is mixed with the noise-reduction signal coming from the emitter of Tr_6 via C_6 and R_7. The mixed signal feeds the filter stage (C_1 etc.) and the inverting amplifier Tr_8. The action of the filter, noise-reduction signal amplifier, rectifier driver and rectifier stages is identical to that in record. It should be noted that the phase of the noise-reduction signal is the inverse of that of the input signal at the emitter of Tr_2 resulting in a subtraction of the noise-reduction signal from the input signal, thus giving the noise-reduction action.

When the block diagram of the Dolby system is discussed later, it will become apparent that the signal appearing at the emitter of Tr_3 will be identical with that fed into the input of the record processor. It will also become obvious why the filter stage is fed with this signal and not the replay input signal (i.e. that on the emitter of Tr_2). The signal is then fed to the replay output amplifier.

Noise and dynamic range

Having discussed how the circuitry of one version of the basic Dolby idea works. it would now be worth while to consider *why* it should follow the dictated characteristics. All information, transmission and storage systems introduce extra information to that fed into the input. The unwanted information is generally called 'noise'. In a tape system, there are two basic sources of noise. These are the electronics involved in the transfer of the signal on and off the tape and the tape itself. Both these sources of noise have theoretical minimum values below which, at normal 'people compatible, temperatures at least, it is not possible to go. The effect of noise is that it manifests itself as being similar to the wanted signal but at a level somewhat below it. Noise gives rise to practical difficulties when the information to be recorded has a wide dynamic range, as has music. The magnetic properties of the tape limit the maximum signal that may be recorded on the tape without excessive distortion, and this means that if the dynamic range of the music is greater than the difference between the maximum signal allowable on the tape and the noise on the tape, then the quieter passages of the music will be lost amongst the noise. In order to reduce the effects of noise it is necessary to decrease the noise, increase the maximum allowable signal or to devise a way of modifying the signal on record so that the full dynamic range of the music is squashed to fit in the range allowed by the tape, and then to expand the range back to normal on replay.

You have already seen how the efforts of the tape manufacturers have improved the capability of their products, but this alone is not enough, especially if one bears in mind the trend, which is happening in parallel with the improvement in tapes, to narrower track widths and slower tape speeds. There have been therefore quite a large number of different approaches to the idea of dynamic range squashing. As not many of these systems are in use today, it is likely that they suffered from one or more of the general 'squasher' deficiencies, among which are poor tracking between record and replay, susceptibility to gain and law errors, poor dynamic range, poor dynamic capability, giving rise to overshoots on transients, audible 'breathing' effects and control-signal-produced distortion effects.

It was not until some considerations of the physiological properties of the mechanism of hearing were brought to bear on the problem by Dr. Ray Dolby, that a satisfactory solution was devised. As we have seen his concept does away with any processing of high-level signals, these being applied to the tape in a completely unaltered form. No noise-reduction action occurs for these signals, nor is any necessary because as far as ear is concerned the signal masks the noise. provided that the signal and the noise are fairly close to one another in frequency. This proviso gives rise to the necessity for the four-frequency band technique used in the A system and the sliding single high-frequency band (with the disadvantage that it is effective only against high-frequency noise) in the B system.

The noise-reduction action is applied only to low-level signals. A small correction signal, which we have been calling the noise-reduction signal is subtracted from the main signal on replay. On record the noise-reduction signal is added to the main signal to raise the low-level signal above the tape noise. Thus on record the wanted signal has its low-level components at a higher point than normal so that on replay these are depressed back to their normal position. The mathematics of the idea are quite simple. The record output y is related to the input x by:

$$y=(1+G_1(x))x$$

where G_1 is the record amplifier gain.
The replay output z is related to the replay input, which is equal to the record output y by:

$$z=y-G_2(z)$$

where G_2 is the replay amplifier gain.
Combining these two relations, we get:

$$z=((1+G_1(x))/(1+G_2(z)))x$$

Now if $G_1=G_2$ $z=x$
Thus if the two noise-reduction signal producing blocks are identical, and the tape record/replay system between the two processors has unity gain, the replay signal is identical with the record. How these requirements have been realized in practice has already been described.

The second of the two conditions is catered for by the record and replay calibration preset controls whose existence was mentioned without explanation. Because a piece of electronic circuitry does not know what is a high level and what is a low level signal, an operating voltage in the circuit has to be related to a specific level of flux on the tape. The circuit then regards this voltage as its zero operating level. The replay calibration control is adjusted so that when a standard level set tape is played, the correct reference voltage appears at the input to the filter circuit of the processor. Because the tape recorder system needs to have unity gain, the record calibration is then adjusted so that with a voltage at the reference level appearing at the input to the filter circuit, a flux level equal to that on the level set tape is recorded on the tape, and this criterion tested by checking that the recorded tape replays at the same level as the level set tape. This requirement is perhaps a little inconvenient since the record calibration needs to be checked and possibly changed if the type of tape used for recording is changed, due to the different sensitivities of different tapes. However, the system is not too critical of gain differences, up to 2dB being tolerable in the domestic system.

Since the wider tracks and higher speeds of $\frac{1}{4}$in tapes result in lower noise the so called 'Dolby reference level' is 180nWb/m and for cassettes 200nWb/m. To ensure compatibility it is necessary to have the highest quality test tapes, and in general tracked test tapes are undesirable unless there is some guarantee of the accuracy of vertical alignment in the head of the machine under test.

Brief mention has been made of the professional Dolby 'A' system which was the predecessor of the domestic 'B' system. Since the physiological 'raison d'etre' for the Dolby system has been explained, it will suffice to provide the reminder that noise masking by high-level signals occurs only for that section of the spectrum appearing in the proximity of the high-level signal. This suggests that to produce optimum noise reduction in high-speed recordings over the entire audio range, the processor needs to work in several discrete bands. The 'A' processor does precisely this, dividing the range into four separate bands, the amount of effect produced in each band being dependent upon the signals present within its own pass band. In practice the filters are not so sharp as to prevent some 'spill-over action' from one channel to another, which can only serve to provide a continuity over the pass-band. The frequency divisions are made as follows: 80Hz low pass; 80Hz–3kHz band pass; 3kHz–9kHz band pass; and 9kHz high pass.

The need for a division between the two systems becomes obvious when considering that at low tape speeds the most obtrusive noise is hiss — hum and low frequency noises being largely unnoticed at the listening levels employed domestically. Thus the Dolby 'B' system represents an economic solution to a vexing problem. Wherever the highest quality is required of the system and the economics are less of a governing factor, the Dolby 'A' system proves more satisfactory.

Hum and other low-frequency noise is suppressed in band 1, cross talk and print though mostly occur in band 2 where they are suppressed, bands 3 and 4 dealing with higher frequency noises. The Dolby 'A' processors are made exclusively by Dolby Laboratories.

With the increasing interest in recorded cassettes the Dolby 'B' process has come into its own. Already most of the major producers of this 'packaged music' are marketing Dolby 'B' processed tapes where the high speed duplicating copies have been prepared using the new model 320 processor designed specifically for this purpose.

On the domestic front the 'B' processor units are manufactured by licencees for inclusion either directly into recording machines or into separate 'black box' processors for use with any tape hi-fi system. Examples of the former type of unit have already appeared in such machines as the Bell & Howell Des 1700, Rank Wharfedale DC9, Harmon Kardon, Ferrograph Series 7 and Revox. Examples of the latter 'black box' units are just beginning to appear from Kellar and from Alpha (Highgate Acoustics), both manufactured in the U.K.

From the amount of interest aroused by this system, one might be forgiven for imagining that it is the only noise suppression device available. It is probably true to say that the only other domestic systems are used solely by the designer in his own machines. Sony and National Panasonic have both marketed domestic noise reduction circuits in their own machines which operate on the 'threshold switch' principle. Here, the replay signal is constantly monitored and once it falls below a pre-determined level the gain of the replay amplifiers is reduced to suppress noise. Such a system inevitably produces an effect on the signal inasmuch as a low-level signal mixed with the noise can also be suppressed. The advantages of a non-complementary system capable of dealing with conventionally recorded material is fairly obvious and is exploited in a system announced by Philips. Known as the dynamic noise limiter it is said to operate on the replayed signal to reduce high-frequency noise according to the signal level existing at the time. Insomuch as it operates in a continuous fashion there appears to be some vague resemblance to aspects of the Dolby 'B' system. However, there is no evidence that the operation and recovery times of the processor take into account the recovery time of the ear as does the 'B' system. As a result it would seem almost certain that the action of the Philips d.n.l. would be noticeable and intitial reports of demonstrations at CES in America suggest that the 'pumping' and 'breathing' typical of many early systems was noticeable on certain types of recording. What does seem a little odd is that Philips appear very reluctant to release any further information or even give a U.K. demonstration.

Future trends

Cassettes show themselves as a growth industry and it is probably time to say that domestic purchases will be almost totally in this area in the years to come. Already some clear divisions are appearing, with cartridges serving the background music and car reproducer field, cassettes eating into the disc industry and reel-to-reel machines reserved for those who make their own recordings. I feel sure that such a polarization will continue, although experiments are proceeding with even higher quality cassette machines which may well equal the performance of the best domestic reel-to-reel machines.

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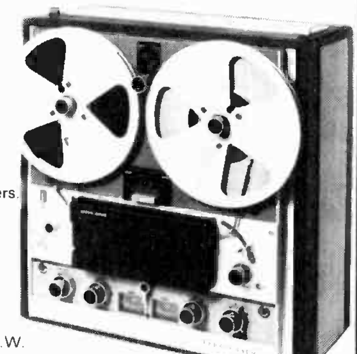

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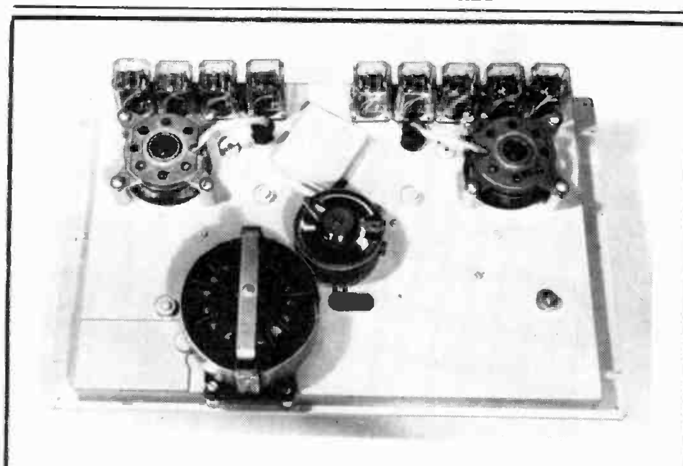

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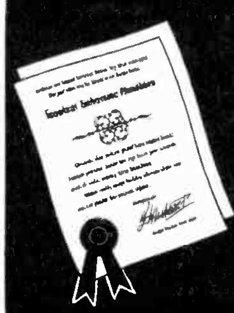

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DM7476N	(SN7476N)	Dual J-K Flip Flop with Preset and Clear Inputs	0·563	0·450	0·375
DM7486N	(SN7486N)	Quad Exclusive-OR Gate	0·575	0·488	0·425
DM74107N	(SN74107N)	Dual J-K Flip Flop with Vcc and GND on Corners	0·525	0·417	0·350

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BC 107	10p	8p	2N1132	25p	21p
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BC 113	15p	13p	2N1305	22½p	18½p
BC 114	14p	12½p	2N1613	20½p	16½p
BC 115	16½p	14½p	2N2193	27p	20p
BC 116	15p	13½p	2N2218	23p	17½p
BC 116A	19p	16½p	2N2219	23½p	17½p
BC 118	10p	8½p	2N2221	23½p	17½p
BC 125	20½p	17½p	2N2222	23½p	17½p
BC 126	20½p	18½p	2N2369	15p	12p
BC 147	10½p	9½p	2N2369A	18p	13½p
BC 148	9p	8p	2N2484	27p	20p
BC 149	13p	12p	2N2904	31p	23½p
BC 153	18½p	16½p	2N2907	30p	22½p
BC 154	20p	17½p	2N2924	13p	9p
BC 178	26½p	23p	2N2925	14½p	9½p
BC 182	10p	9p	2N2926	8p	7p
BC 183	9½p	8½p	2N3011	15½p	12p
BC 184	11p	9½p	2N3053	18p	12½p
BCY 58	25p	20p	2N3055	78p	62½p
BCY 59	27½p	22p	2N3133	22p	17p
BCY 70	17p	12½p	2N3134	23p	18½p
BCY 71	22½p	15p	2N3135	23p	16p
BCY 72	12½p	10p	2N3136	27p	22½p
BF 115	18½p	15p	2N3390	30p	25½p
BF 167	21p	17p	2N3391	20p	17½p
BF 173	24½p	20p	2N3391A	22½p	19p
BF 180	35p	28p	2N3392	13p	11p
2N697	15p	12½p	2N3393	14p	12½p
2N699	29½p	22p	2N3414	14p	12½p
2N706	11p	9p	2N3415	16p	15p
2N708	16p	14p	2N3643	27½p	22½p
2N722	79p	67½p	2N3646	26½p	21½p
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2Z930	17p	12½p			

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2N3235	·667	·467	IN5174	·300	·212
2N3441	·925	·800	IN5400	·162	·112
2N3442	£1·700	£1·375	IN5401	·183	·129
2N3715	£1·467	£1·300	IN5402	·204	·146
2N3716	£1·637	£1·375	IN5403	·221	·154
2N3771	£1·700	£1·400	IN5404	·267	·187
2N3772	£1·800	£1·500	IN1199	·392	·308
2N3773	£2·875	£2·475	IN1202	·775	·633
2N4347	£1·050	·875	IN1183	·667	·533
2N4348	£1·625	£1·375	IN1186	£1·108	·887
STS1134	£2·950	£2·525	Quantity Prices are Available on Request		
IN5170	·133	·096			

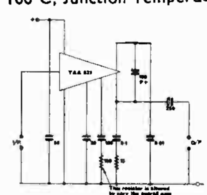
YOUR SMALL AUDIO AMPLIFIER PROBLEMS SOLVED WITH S.G.S. INTEGRATED CIRCUITS

Audio Amplifier TAA 621

Designed for use in mains operated T.V. sets and record players as an audio amplifier. The supply voltage range is from 6 to 24V and the device can deliver up to 4W output power.

Absolute Maximum Rating

Max. Supply Voltage (no signal): 27V; Power dissipation (TA=60°C) 1·06W; Input Voltage: —0·5 to 1·5Vp; Peak Output Current: 0·8A; Storage Temperature: —25 to 100°C; Junction Temperature: 125°C. 1-24 £2·025; 25-99 £1·755.



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NEW COMPLETE MODULE

3 Watts min. output power; 50Hz—25Hz bandwidth. Signal to noise ratio—86dB.
Complete with Capacitors and Resistors on 76 × 65 mm printed board: 1-24 £2·625; 24-99 £2·275.
Supplied with data sheet and application report.

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	1-19	20-99	100+
BZY95 Series 1·5 Watt ±5% 10 Volt-75 Volt	40p	32p	28p
BZX70 Series 2·5 W ±5% 7·5 Volt-75 Volt	24½p	20p	17½p

	1-24	25+
IZMT10— 3·3 Volt-8·2 Volt 1 Watt ±10%	23p	19½p
IZMT5 3·3 Volt-8·2 Volt 1 Watt ±5%	25p	21p
IZMT10 9·1 Volt-33 Volt	15p	13p
IZMT5 9·1 Volt-33 Volt	17½p	14½p

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SENSITRON AT NEW LOW PRICES

	Current Amps	P.I. Volts	1-99 £	100-999 £
SSC41B	6	200	0·865	0·693
*SSC40B	6	200	1·016	0·814
SSC41D	6	400	1·146	0·915
*SSC40D	6	400	1·302	1·050
SSC46B	10	200	1·167	0·932
*SSC45B	10	200	1·318	1·050
SSC46D	10	400	1·520	1·218
*SSC45D	10	400	1·675	1·398
SSC51B	15	200	1·201	0·966
*SSC50B	15	200	1·352	1·075
SSC51D	15	400	1·806	1·164
*SSC50D	15	400	1·953	1·562
*SSC61B	25	200	2·108	1·701
*SSC60B	25	200	2·297	1·822
*SSC61D	25	400	3·008	2·402
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All ½ in. Press Fit. * ½ in. Press Fit Stud

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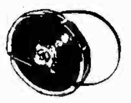
Type	P.I.V.	1-100	100+	1000+
1N4001	50	7p	6p	4p
1N4002	100	8p	7p	4½p
1N4003	200	10p	9p	5p
1N4004	400	10p	9p	5p
1N4005	600	12p	10p	7p
1N4006	800	14p	12p	9p
1N4007	1000	16p	13p	10p

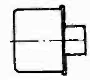


CONTINUOUS TAPES Cousino

AUTOMATIC MESSAGE REPEATING MAGNETIC TAPE MAGAZINE

Single-Reel Tape Magazine that instantly converts your tape recorder into a continuous operating message repeater. NO REWINDING Necessary. NO Attention Necessary. Repeats your message, lesson, or other recorded material regularly and continuously—hour after hour, day after day, without trouble or attention.

The Model U-1310 is the most widely used of the versatile and compact continuous loop Audio Vendor magazines. It will fit most standard tape recorders. The U-1310 Audio Vendor is 3⅜ in. in diameter. Playing time 3¾ in. per second (15 min. average) **UC-1310CC 15 Mins. £5·60.**



ULTRASONIC TRANSDUCERS DTV

These 40 Kc/s ultrasonic transducers can be used for simple remote control systems without electrical cables or electronic links, two basic units only being required. Suitable for transmitting and receiving.

APPLICATIONS:

Remote Control; Leakage Detectors; Intruder Alarms; Experimental Speech Transmission; Supplied with free Transmitter and Receiver Circuit.

Essential Component Kit for TX/RX .. £10·30

	1—9 £	10—49 £	50—249 £	250+ £
40 Kc/s Transducer	3·00	2·75	2·00	1·90

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As these are trade prices it is regretted that we have to impose a minimum order value of £2·50 U.K., £5 overseas. Orders to:

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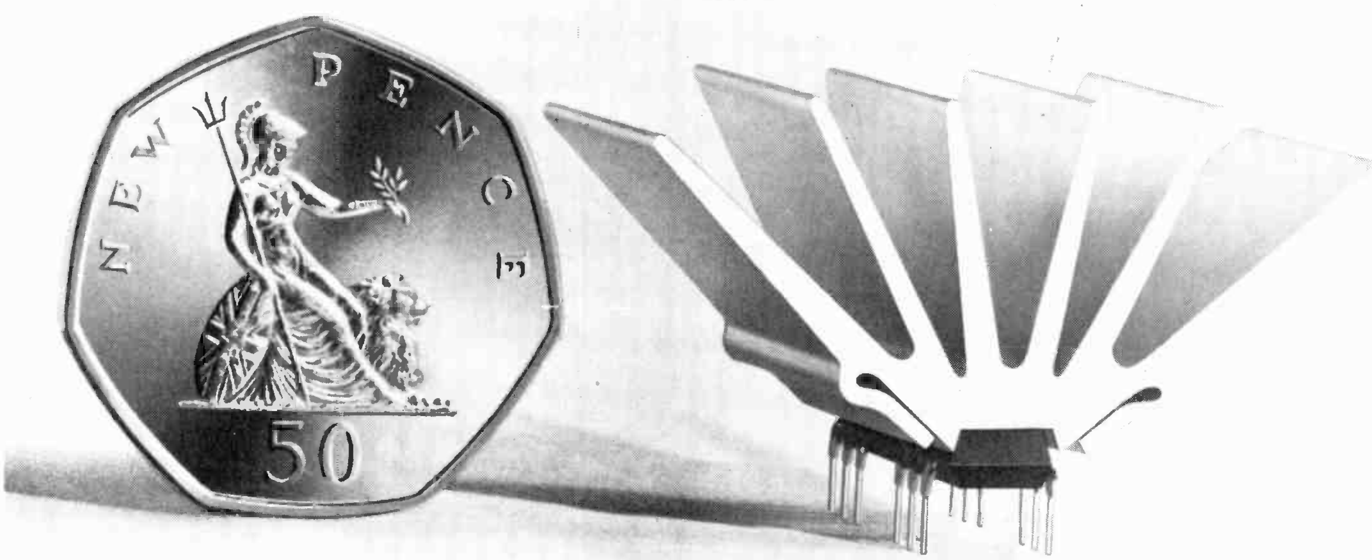
new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor, the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).

Frequency Response 5 Hz to 100KHz ± 1 dB.

Total Harmonic Distortion Less than 1%. (Typical 0.1%) at all output powers and all frequencies in the audio band.

Load Impedance 3 to 15 ohms.

Power Gain 90dB (1,000,000,000 times) after feedback.

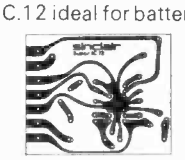
Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).

Size 22 x 45 x 28 mm including pins and heat sink.

Input Impedance 250 Kohms nominal.

Quiescent current 8mA at 28 volts.

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project-60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.



Price, inc. FREE printed circuit board for mounting.

£2.98 Post free

SINCLAIR GENERAL GUARANTEE

Should you not be completely satisfield with your purchase when you receive it from us, return the goods without delay and your money will be refunded in full, including cost of return postage, at once and without question. Full service facilities are available to all Sinclair customers.

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Huntingdonshire PE17 4HJ
Telephone St Ives (048 06) 4311

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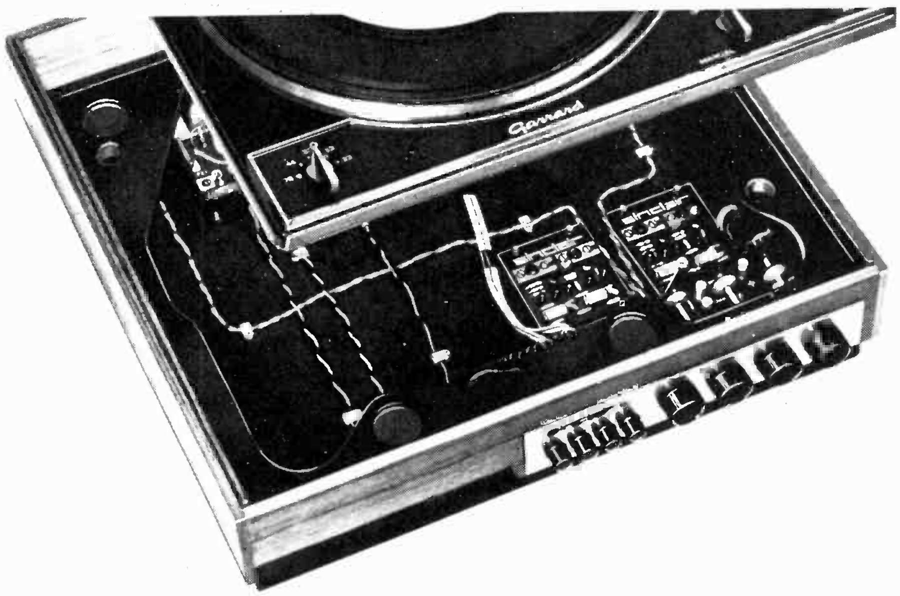
WW—101 FOR FURTHER DETAILS

Sinclair Project 60

The World's leading range of high fidelity modules



New!

Project 605

The easy way to buy and build Project 60

Project 605 is one pack containing: one PZ5, two Z30's, one Stereo 60 and one Masterlink. This new module contains all the input sockets and output components needed together with all necessary leads cut to length and fitted with neat little clips to plug straight on to the modules. Thus all soldering and hunting for the odd part is eliminated. You will be able to add further Project 60 modules as they become available adapted to the Project 605 method of connecting.

Complete Project 605 pack with comprehensive manual, post free £29.95

All you need for a superb 30 watt high fidelity stereo amplifier.

Project 60 offers more advantage to the constructor and user of high fideiity equipment than any other system in the world.

Performance characteristics are so good they hold their own with any other available system irrespective of price or size.

Project 60 modules are more versatile – using them you can have anything from a simple record player or car radio amplifier to a sophisticated and powerful stereo tuner-amplifier. Either power amplifier can be used in a wide variety of applications as well as high fidelity. The Stereo 60 pre-amplifier control unit may also be used with any other power amplifier system, as can the AFU filter unit. The stereo FM tuner operates on the unique phase lock loop principle to provide the best ever standards of sensitivity and audio quality. Project 60 modules are very easily connected together by following the 48 page manual supplied free with all Project 60 equipment. The modules are great space savers too and are sold individually boxed in distinctive white and black cartons. With all these wonderful advantages, there remains the most attractive of all – price. When you choose Project 60 you know you are going to get the best high fidelity in the world, yet thanks to Sinclair's vast manufacturing resources (the largest in Europe) prices are fantastically low and everything you buy is covered by the famous Sinclair guarantee of reliability and satisfaction.

Typical Project 60 applications

System	The Units to use	together with	Cost of Units
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control etc.	**£9.45**
20 + 20 W. stereo amplifier for most needs	**2 x Z.30s, Stereo 60, PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
20 + 20 W. stereo amplifier with high performance spkrs.	**2 x Z.30s, Stereo 60, PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
40 + 40 W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. Filter Unit **(£5.98)** may be added as required.

Sinclair Radionics Limited, London Road, St. Ives, Huntingdonshire PE17 4HJ. Tel: St. Ives (048 06) 4311

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WW—102 FOR FURTHER DETAILS

from a simple amplifier to a complete stereo tuner amplifier with Project 60 modules

Z.30 & Z.50 power amplifiers

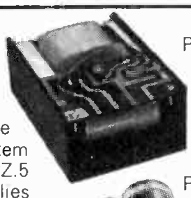
The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS ***(Z.50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M.S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms using 50 volts.
Frequency response: 30 to 300,000Hz ±1dB.
Distortion: 0.02% into 8 ohms.
Signal to noise ratio: better than 70dB unweighted.
Input sensitivity: 250mV into 100 Kohms.
For speakers from 3 to 15 ohms impedance.
Size: 14 x 80 x 57 mm.

Z.30
Built, tested and guaranteed with circuits and instructions manual. **£4.48**

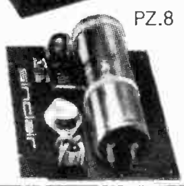
Z.50
Built, tested and guaranteed with circuits and instructions manual. **£5.48**

Power Supply Units



PZ.5

Designed special for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.



PZ.8

PZ.5 *30 volts unstabilised* **£4.98**
PZ.6 *35 volts stabilised* **£7.98**
PZ.8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ.8 *mains transformer* **£5.98**

The Sinclair Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

Project 60 Stereo F.M. Tuner

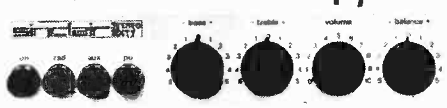
First in the world to use the phase lock loop principle

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Good reception is possible in difficult areas, and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108 MHz. **Capture ratio:** 1.5dB. **Sensitivity:** 2μV for 30dB quieting: 7μV for lock-in over full deviation. **Squelch level:** 20μV. **A.F.C. range:** ±200 KHz. **Signal to noise ratio:** > 65dB. **Audio frequency response:** 10 Hz – 15 KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2μV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. **Operating voltage:** 25-30 VDC. **Indicators:** Power on/tuning/stereo.
Size: 93 x 40 x 207 mm.

Built and tested. Post free. **£25**

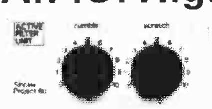
Stereo 60 Pre-amp/control unit



Designed for Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A curve ±1dB:20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE + 15 to —15dB at 10 KHz: BASS + 15 to —15dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.
Built tested and guaranteed. **£9.98**

A.F.U. High & Low Pass Filter Unit



For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two filter stages – rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28KHz to 5KHz. L.F. cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1KHz (35V. supply (0.02% at rated output. **Size:** 66 x 40 x 90 mm. *Built tested and guaranteed.* **£5.98**

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	Address
I enclose cash/cheque/money order.	

WW11 71

WW—103 FOR FURTHER DETAILS

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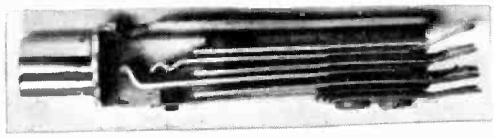
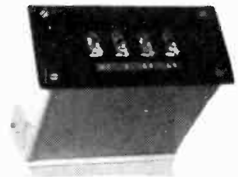

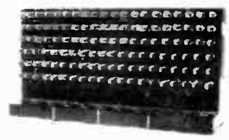

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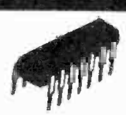

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BI-PAK Order No.	Description	Price and Qty. Prices 1-24	25-99	100 up
BP 00 = 7400	Quad. 2-input NAND Gate	15p	14p	12p
BP 01 = 7401	Quad. 2-input Pos. NAND Gate (with open collector output)	15p	14p	12p
BP 02 = 7402	Quad. 2-input Pos. NOR Gates	15p	14p	12p
BP 03 = 7403	Quad. 2-input Pos. NAND Gates (with open collector output)	15p	14p	12p
BP 04 = 7404	Hex Inverters	15p	14p	12p
BP 05 = 7405	Hex Inverter (with open-collector output)	15p	14p	12p
BP 10 = 7410	Triple 3-input Pos. NAND Gates	15p	14p	12p
BP 13 = 7413	Dual 4-input Schmitt Trigger	29p	26p	24p
BP 20 = 7420	Dual 4-input Pos. NAND Gates	15p	14p	12p
BP 30 = 7430	8-input Pos. NAND Gates	15p	14p	12p
BP 40 = 7440	Dual 4-input Pos. NAND Buffers	15p	14p	12p
BP 41 = 7441	BCD to decimal nixie driver	67p	64p	58p
BP 42 = 7442	BCD to decimal decoder (4-10 lines, 1 of 10)	67p	64p	58p
BP 46 = 7446	BCD-to-Seven-Segment Decoder Driver	£2·00	£1·75	£1·50
BP 47 = 7447	BCD-7-Seg. Decoder/Drivers (15-V outputs)	97p	94p	88p
BP 48 = 7448	BCD-to-Seven-Segment decoder Driver	97p	94p	88p
BP 50 = 7450	Expandable dual 2 Input AND-OR-INVERT	15p	14p	12p
BP 51 = 7451	Dual 2-Wide 2-Input NAND-OR-INVERT Gates	15p	14p	12p
BP 53 = 7453	Quad 2 Input Expandable NAND-OR-INVERT	15p	14p	12p
BP 54 = 7454	4-Wide 2-Input NAND-OR-INVERT Gates	15p	14p	12p
BP 60 = 7460	Dual 4-Input Expander	15p	14p	12p
BP 70 = 7470	Single-Phase J-K Flip-Flop	29p	26p	24p
BP 72 = 7472	Master-Slave J-K Flip-Flop	29p	26p	24p
BP 73 = 7473	Dual Master Slave J-K Flip-Flop	37p	35p	32p
BP 74 = 7474	Dual D Type Flip-Flop	37p	35p	32p
BP 75 = 7475	Quad Latch	47p	45p	42p
BP 76 = 7476	Dual J-K with Pre-Set & Clear	43p	40p	38p
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BP 81 = 7481	16-Bit Read-Wright Memory	97p	94p	88p
BP 82 = 7482	2-Bit Binary Full Adders	97p	94p	88p
BP 83 = 7483	Quad Full Adder	£1·10	£1·05	95p
BP 86 = 7486	Quad 2-Input Excl. Nor Gates	32p	30p	28p
BP 90 = 7490	BCD Decader Counter	67p	64p	55p
BP 91 = 7491	8-Bit Shift Registers	87p	84p	78p
BP 92 = 7492	Divide-by-Twelve Counters	67p	64p	58p
BP 93 = 7493	4-Bit Binary Counters	67p	64p	58p
BP 94 = 7494	Dual Entry 4 Bit Shift Register	77p	74p	68p
BP 95 = 7495	4 Bit Up-Down Shift Register	77p	74p	68p
BP 96 = 7496	5 Bit Parallel in Parallel out Shift-Register	77p	74p	68p
BP100 = 74100	8-Bit Bistable Latches	£1·75	£1·65	£1·55
BP104 = 74104	Single J-K Flip-Flop equiv. 9000 Series	97p	94p	88p
BP105 = 74105	Single J-K Flip-Flop equiv. 9001	97p	94p	88p
BP107 = 74107	Dual Master Slave Flip-Flops	40p	38p	36p
BP110 = 74110	Gates Master-Slave FlipFlops	55p	53p	50p
BP111 = 74111	Dual Data Lock-out Flip-Flop	£1·25	£1·15	£1·00
BP118 = 74118	Hex Set-Reset Latches	£1·00	95p	90p
BP119 = 74119	Hex Set-Reset Latches 24 pin	£1·35	£1·25	£1·10
BP121 = 74121	Monostable Multivibrators	67p	64p	58p
BP141 = 74141	BCD-to-Decimal Decoder/Driver	67p	64p	58p
BP145 = 74145	BCD-to-Decimal Decoder/Driver. O/C	£1·50	£1·40	£1·30
BP150 = 74150	16-Bit Data Selector	£1·80	£1·70	£1·60
BP151 = 74151	8-Bit Data Selectors (with strobe)	£1·00	95p	90p
BP153 = 74153	Dual 4-Line-to-1-Line Data	£1·20	£1·10	95p
BP154 = 74154	4 to 16 Line Decoder	£1·80	£1·70	£1·60
BP155 = 74155	Dual 2 to 4 Line Decoder	£1·40	£1·30	£1·20
BP156 = 74156	Dual 2 to 4 Line Decoder O/C	£1·40	£1·30	£1·20
BP160 = 74160	Sync. Decade Counter	£1·80	£1·70	£1·60
BP161 = 74161	Sync. 4-Bit Binary Counter	£1·80	£1·70	£1·60
BP190 = 74190	Sync. Up-Down BCD Counter	£3·50	£3·25	£3·00
BP191 = 74191	Sync. Binary Up-Down Counter (single clock line)	£3·50	£3·50	£3·50
BP192 = 74192	Sync. Up-Down Decade Counter	£2·10	£1·95	£1·75
BP193 = 74193	Sync. Binary Up-Down Counter (tow clock lines)	£2·10	£1·95	£1·75
BP196 = 74196	Pre-setable 50 MHZ Decade Counter	£1·80	£1·70	£1·60
BP197 = 74197	Pre-setable 50MHZ Binary Counter	£1·80	£1·70	£1·60
BP198 = 74198	8-Bit Parallel L-R Shift Register	£5·50	£5·00	£4·00
BP199 = 74199	8-Bit Parallel Access Shift Register	£5·50	£5·00	£4·00

Devices may be mixed to qualify for quantity price. Larger quantities—prices on application. (TTL 74 Series only.)

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Manufacturers' "Full outs"—out of spec. devices including functional units and part function but classed as out of spec. from the manufacturers' very rigid specifications. Ideal for learning about I.C's and experimental work.

PAK No.		PAK No.		PAK No.	
UIC00 = 12 × 7400N	50p	UIC42 = 5 × 7450N	50p	UIC80 = 5 × 7480N	50p
UIC01 = 12 × 7401N	50p	UIC50 = 12 × 7450N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
UIC41 = 5 × 7441AN	50p	UIC76 = 8 × 7476N	50p	UIC96 = 5 × 7496N	50p

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BP932	Expandable dual 4-input NAND buffer	13p	12p	11p
BP933	Dual 4-input expander	13p	12p	11p
BP935	Expandable Hex Inverter	13p	12p	11p
BP936	Hex Inverter	13p	12p	11p
BP944	Dual 4-input NAND expandable buffer without pull-up	13p	12p	11p
BP945	Master-slave JK or RS	25p	24p	22p
BP946	Quad, 2-input NAND	12p	11p	10p
BP948	Master-slave JK or RS	25p	24p	22p
BP951	Monostable	65p	60p	55p
BP962	Triple 3-input NAND	12p	11p	10p
BP9093	Dual Master-slave JK with separate clock	40p	38p	35p
BP9094	Dual Master-slave JK with separate clock	40p	38p	35p
BP9097	Dual Master-slave JK with Common Clock	40p	38p	35p
BP9099	Dual Master-slave JK Common Clock	40p	38p	35p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only.)

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Q 4	6	Matched trans. OC44/45/81/81D	50p
Q 5	4	OC 75 transistors	50p
Q 6	4	OC 72 transistors	50p
Q 7	4	AC 128 trans. P.N.P. high gain	50p
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Q12	3	AF 116 type trans.	50p
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Q14	3	OC 171 H.F. type trans.	50p
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Q16	2	GET880 low noise Germ. trans.	50p
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Q25	6	IN914 Sil. diodes 75PIV 75mA	50p
Q26	8	OA95 Germ. diodes sub-min. IN69	50p
Q27	2	10A 600PIV Sil. Rects. 1S425R	50p
Q28	2	Sil. power rects. BYZ 13	50p
Q29	4	Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	50p
Q30	7	Sil. switch trans. 2N706 NPN	50p
Q31	6	Sil. switch trans. 2N708 NPN	50p
Q32	3	PNP Sil. trans. 2 × 2N1131, 1 × 2N1132	50p
Q33	3	Sil. NPN trans. 2N1711	50p
Q34	7	Sil. NPN trans. 2N2369, 500MHZ	50p
Q35	3	Sil. NPP TO-5 2 × 2N2904 & 1 × 2N295	50p
Q36	7	2N3646 TO-18 plastic 300MHZ NPN	50p
Q37	3	2N3053 NPN Sil. trans.	50p
Q38	7	PNP trans. 4 × 2N3703, 3 × 2N3702	50p
Q39	7	NPN trans. 4 × 2N3704, 3 × 2N3705	50p
Q40	7	NPN amp. 4 × 2N3707, 3 × 2N3708	50p
Q41	3	Plastic NPN TO-18 2N3904	50p
Q42	6	NPN trans. 2N5172	50p
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U5	60	200mA Sub-min. Sil. Diodes	50p
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There are 42 Super Packs U1-U42. Please see previous advt. for ful details or send to us a s.a.e. for complete lists.
Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

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T3	8 2G3744A	OC81D
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T5	8 2G382T	OC82
T6	8 2G344A	OC44
T7	8 2G345A	OC45
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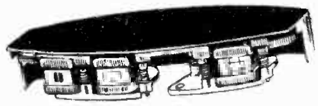

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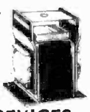
"BENSON BROS." 12v. D.C. HEAVY DUTY SOLENOID. Size: 3" overall × 1¼" × 1". Very powerful. Cont. rated. **£1·00** each. P. & P. 15p.



"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. ⅜" travel which can be increased to 1" by removing captive-end-plate. Overall size 2"×2½"×2¾" high. **£1·50.** P. & P. 25p.

MAINS SOLENOID BY MAGNETIC DEVICES LTD. A beautifully constructed solenoid at half normal price. A two-sided bracket is incorporated for vertical or horizontal mounting. Size: 2" × 1¼" × 1¼". Pull is approx. 2 lb., plunger travel 1¼". Fixing eye takes up to ¼" bolt. Plunger non-captive. New in original makers boxes. **75p** each, plus 25p P. & P. Large number available, special price for quantity.

RELAYS

Perspex enclosed, plug in, with base. Size 1½" × 1½" × ¾"
MQ 308 600Ω 24v. 4 c/o. **60p** ea., **£5·00** per doz.
MQ 508 10,000Ω 100v. 4 c/o. **50p** ea., **£4·50** per doz.

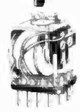
S.T.C. Midget Sealed Relay type 4109EC. 12v. 40 mA 170Ω, single H.D. make. **53p** each.

"B. & R." 3 c/o. 10 amp. contacts (silver) operates on 2 volts D.C. Draws approx. 1 amp. Size: 2" × 1½" × 1⅛". **£1·00.**

"OMRON" OCTAL BASE. A.C. mains. 2 × 5 amp. C/O contacts. Perspex enclosed. **88p.**

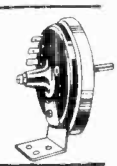
A.E. Perspex enclosed, plug in, 50Ω 6v. 2 c/o. **63p** ea. 470Ω 12v. 4 c/o. **73p** ea. 2,780Ω 48v. 4 c/o. **73p** ea. 1,260Ω 48v. 6 c/o. **83p** ea.

NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. **63p.**



NEW "ISKRA" 240v. A.C. RELAY.—3 × 6 amp Changeover contacts. **63p.**

SIEMENS HIGH SPEED RELAY, Type 89L. 1,700Ω + 1,700Ω coil. New **63p** each.



"GOYEN" PRESSURE SWITCH.—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 3/16" dia. Projection 11/16". Overall size: dia. 3¼", depth 2" plus 11/16" (air tube). **£1·25.**

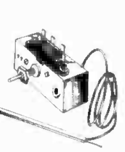
ERIE. Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV Size 1·5" dia. × 1·44" long. **50p** ea. Carriage paid.

HIGH CAPACITY ELECTROLYTICS. Cylinder-type with screw terminals on top. Average size 3" dia. × 4½" high. "Mallory" 20,000μF 30v. D.C. 45v. D.C. surge. "Mallory" 25,000μF 25v. D.C., 40v. D.C. surge. "Mallory" 35,000μF 15v. D.C., 20v. D.C. surge. "Mallory" 40,000μF 10v. D.C., 12v. D.C. surge. "Sprague" 40,000μF 10v. D.C., 12v. D.C. surge. "General Electric" 46,500μF 25v. D.C., 30v. D.C. surge. **50p** each. Minimum order **£1·00** on these items. P. & P. 10p each.

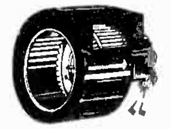
BELLING & LEE FUSEHOLDERS

TYPE L1382. Size 0. Rating 7A. Breakdown voltage (DC): > 10 kV. List price 71p. Our price **£2·00** per doz.
TYPE L1744. Size 0. Takes 1¼" × ¼" fuses. Connecting posts suitable for soldering or solderless snap-on connectors (¼" × 0·032"). Current rating 30A max. List price 30p. Our price **£1·50** per doz.

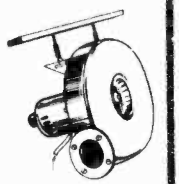
CURRENT FLOW INDICATOR. Ideal for all types of battery operated equipment (portable machines, tape recorders etc.). Four white segments appear when current flows. Coil is 600Ω 6/12v. Drawing only 8 ma on function. Neat in appearance. Size: dia. 1⅜" × 1⅜" deep. Fixing centres 1⅛". **£1·25** each. Carr. Paid.



"TEDDINGTON" CONTROLS THERMOSTAT.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. **88p.**



"PRECISION FAN CO." (Smiths Industries) DOUBLE ENTRY CENTRIFUGAL FAN/BLOWER.—This is a beautifully balanced, particularly quiet running, unit giving approx. 90 cubic ft./min. The motor is a 2 pole shaded pole 240v. Mycalex, drawing only 240ma on run. Weight 2¼ lb. Sizes: Case dia. 3·1 in., width (case only) 3·125 in., width overall (inc. motor) 5·25 in., aperture 3·125 in. by 1·85 in. Offered well below makers price at **£2·95** P. & P. 25p.



Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£12·50.** Carriage **£1·50.**

HEAVY DUTY PORTABLE BATTERIES. New ex WD. 12v. 75 AH. Built in stout metal cases with carrying handles and nifam socket outlet. Size 15½" × 7½" × 10½" high, weight 73lb. **£8·75.** Carriage £2.

ADVANCE CONSTANT VOLTAGE TRANSFORMER. Type CVS 750A. Input 190-260 v. 50 Hz. Output 240 v. r.m.s. Load 750 watts. Size: 18 3/16" × 7 3/16" × 8¾" high. Weight 68 lb. **£47·50.** Carriage £2·50 G.B. only).

"ADVANCE VOLSTAT" CONSTANT VOLTAGE TRANSFORMER. Input 190 to 260v. Output 230 R.M.S. at 10 Watts. Supplied with matching capacitor. **£2·00** plus 25p P. & P.

We will shortly be opening at

301 EDGWARE ROAD, W.2

where we look forward to welcoming all our old customers and many new ones. We promise you will find an unusual and interesting variety of electronic pot-pourri. Hope to see you soon?

L.T. TRANSFORMERS. Prim. 0-110-240v. Sec. 4·5-0-4·5v. at 1 amp. Size 1¾ × 1½ × 1 5/16". **60p.** P. & P. 15p. Prim. 220/240v. Sec. 0-5-10-15-20v. at 2 amps. **£1·25.** P. & P. 15p.

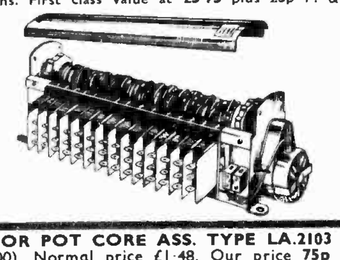
Prim. 200/240v. Sec. 0-1-56-58-60 at 3·5 amps plus 0-90 at 100 ma. Wax impregnated with screw term. blocks. Weight 10 lbs. **£3·60,** plus 40p P. & P.

"WODEN." Prim. 10-0-200-240v. Sec. two separate windings 6v. at 4 amps each. **£2·50,** plus 30p P. & P.

"WODEN." Prim. 0-110-200-220-240v. Sec. 34-36-38v. at 600va. **£7·50,** plus 50p P. & P.

PROGRAMME TIMER BY HONEYWELL

A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Designed originally for vending machines at a cost of **£15·00** plus. Many applications where continuous sequence programmes are required, such as lighting effects etc. New in original makers cartons. First class value at **£5·75** plus 25p P. & P.

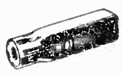


VINKOR POT CORE ASS. TYPE LA.2103 (core LA.2100). Normal price £1·48. Our price **75p** each. Special quote for quantity.

UNISELECTORS. 8 Bank 25-way 24v. Double sweep. Brand new in maker's boxes. **£5·25.** P. & P. 25p.

SYLVANIA MAGNETIC SWITCH. A magnetically activated switch operating in a vacuum. Switch speed —4ms. temperature —54 to +200°C. Silver contacts normally closed rated 3 amps at 120v. 1·5 amps at 240v. **Price 4 for £1; £2·50** per doz. P. & P. 10p. Special quotations for 100 or over.

Type A

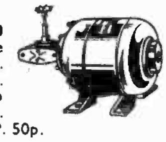


Type B

"MALLORY" LONG LIFE BATTERIES. Type A. RM12 cell 1·35v. 3,600 ma/H. CAP. 250/300 ma cont. current. Size: 2" × ⅝". 5 for **£1·00** or **£2·00** per doz. Carr. Paid. Type B. Comprises 8 × RM 625 cells. Nom. volts. 1·35 each 10·5v. Overall. 350 ma/H CAP. 20/25 ma cont. current. Size: 2 5/16" × ⅝" × ⅝". 3 for **£1·00** or **£3·00** per doz. Carr. Paid.

We welcome orders from established companies, educational depts., etc., a surcharge of 50p to cover cost of invoicing must be made on any order amounting to less than £2·50 unless remittance with order.

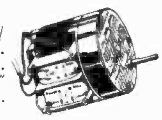
GEARED MOTORS



"Parvalux" Reversible 100 RPM Geared Motor. Type S.D.14, 230/250v. A.C. 22 lb./in. ⅜" spindle. 1st class condition. **£7·50** each. P. & P. 50p. Also limited number only as above. **Brand New. £12·50** each P. & P. 50p.

ELECTRO CONTROL (CHICAGO). Shaded pole 240v. 50 Hz. 200 rpm 10 lb./in. **£2·50.** P. & P. 25p.

MYCALEX. Open frame, shaded pole motors. 240v. 50 Hz, 7 rpm. 28 lb./in. 80 rpm. 12 lb./in. **£2·25** each. P. & P. 25p.



"CROUZET" TYPE 965. 115/240v. 50 Hz. 47/68 watts. 50 rpm. Stoutly constructed. Size: 2 11/16" dia. × 3¼" long, plus spindle 1" × ¼" dia. Anti-clock. **£2·75.** P. & P. 25p.

TYPE 955. Same as above, but 3 rpm. **£3·00.** P. & P. 25p.

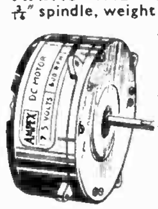
SPECIAL OFFER

BRAND NEW "GRYPHON" BROOK REVERSIBLE MOTORS. Type TE 230/250v. 50Hz. 1 Ph. ·083 h.p. 1,380 r.p.m. 0·96 amps at full load, ½" spindle. This is a superbly constructed, standard foot-mounted unit, with the extra facility of reversal by remote switching. Weight 16 lb. 10 oz. Offered in original maker's packing at approx. half price. **£7·50.** Carriage 75p.

SYNCHRONOUS MOTORS. 220/380 v. 50/60 Hz. 250-300 rpm. **75p** each.

MYCALEX MAINS. Shaded pole, 1425 rpm. 3/16" spindle. 2 for **£1·25.** Carriage Paid.

MAINS INDUCTION MOTOR. Open frame, 3/16" spindle, weight ¾ lb. Powerful. **88p** each. P. & P. 12p.

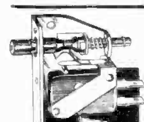


AMPEX 7.5v. D.C. MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600 rpm ± 5% speed adjustment, internal AF/RF suppression. ⅛" dia. × 1" spindle, motor 3" dia. × 1⅝". Original cost £16·50. **Our price £4·25.** P. & P. 25p. Large quantity available (special quotations). Mu-metal enclosure available **75p** each.

VACTRIC PRECISION D.C. MOTOR. Type XO7P19 10v. D.C. 0·66 amp. 8,000 r.p.m., 30 gm/cm. Size 7. Original maker's packing. Limited supply. **£3·50.** Carriage paid.

"HONEYWELL" MICROSWITCHES

Two and three bank, manual push. Ideal for vending machines, etc. Each bank comprises a change-over rated at 15 amps 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. ⅝". 2-bank **40p.** 3-bank **55p.**



"HONEYWELL" TYPE 23AC-NE.—15 amp. change-over micro switch is fitted on angled metal mount with spring-loaded plastic rod operating cam. **50p** each.

PYE MICROSWITCH. Otehall type This switch has a 1⅜" × 11/16" dia. column plus ½" plunger. Minimum travel operates switch. **25p** each. P. & P. 10p. Special discount for quantities.

HONEYWELL (USA) Sub-miniature 2 bank panel mounting micro-switch, positive toggle action giving 2 change-overs. Size: 16" × 16" × ⅜". **63p** each. Carriage paid.

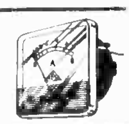
"HONEYWELL" V3 Series. Flush micro-switch 10 amp. c/o. The side panel is insulated. End plate size: 2" × 8". **£1·50** per doz. Carriage Paid.

"FIBRE GLASS" COPPER CLAD. Top grade. One size only, 7½" × 4¾" × 1/16". 3 panels **£1·00.** 12 panels **£3·50.** P. & P. 15p.

"SRBP" COPPER CLAD. Sizes: 7½" × 4 3/16" × ⅛", 16 for **£1·00.** 13 3/16" × 5¾" × ⅛", 8 for **£1·00.** 14½" × 5¼" × 1/16", 8 for **£1·00,** 19⅛" × 17⅞" × 1/16", 4 for **£1·00.**

SLIDER SWITCHES. 3 amp. type D.P.D.T. 1" × 7/16" × ⅜" deep. 1 amp type 3 P.D.T. ½" × 7/16" × 7/16" deep. **£1·25** per doz. Either type or mixed as required. Carriage Paid.

PLUNGER SWITCHES. Spring return. 3 P.D.T. 1 amp. Single action. Size: ⅝" × 7/16" plus plunger. **£1·50** per doz. Carriage Paid.



A.C./D.C. M/IRON AMMETERS. 0-5 amps or 0-8 amps (suitable battery chargers etc.). Perspex front. Size: 1⅞" × 1⅞". Any 2 for **£1·10.** Carr. Paid.

ERNEST TURNER 800μa METER. 160Ω movement, 2" case, eliptic plastic front. Green-Red-Green uncalibrated scale **£1·50** each. Carriage Paid.

ELECTRO-TECH SALES

BUSINESS HOURS: 9.30-6 (1 p.m. Sats.)

264 PENTONVILLE ROAD, LONDON, N.1
(ONE MIN. FROM KINGS X STATION) Tel. 01-837 7401/2

THE SOUND OF QUALITY

RSC HI-FI CENTRES LTD.

A COMPLETELY NEW DESIGN FURTHER IMPROVED IN APPEARANCE AND IN PERFORMANCE

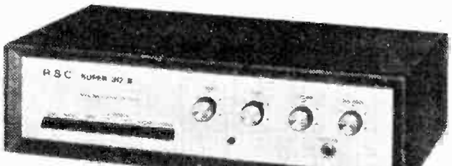
SUPER 30 Mk III

Only high grade components by leading manufacturers.

COMPLETE KIT OF PARTS Carr. 65p **£25**

Or **FACTORY BUILT** with 12 months guarantee. Dep. £5·75 and 9 mthly payments £3·50 (Total £37·25) **£33·75**

Or **FACTORY BUILT** in cabinet as illustrated. Dep. £6 and 9 monthly payments £3·86 (Total £40·74). **£36·75**



PRINTED CIRCUITRY. TWENTY SILICON TRANSISTORS. FOUR DIODES. FOUR RECTIFIERS.

TECHNICAL DETAILS (applying to each channel where appropriate).

CONTROLS: PUSH-BUTTON SELECTOR (1) Disc (2) Radio (3) Tape (4) Mono L (5) Mono R (6) SPEAKER DIS. (7) Mains on/off. Bass, Treble, and Balance Plus Ceramic Mag. P.U. Switch.

SEND FOR COLOUR BROCHURE OF MONEY SAVING FULL SYSTEM PACKAGE OFFERS

REPRESENTING VALUE FAR HIGHER THAN THE PRICES SUGGEST!

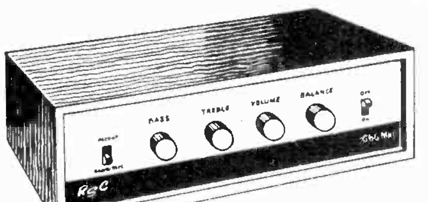
HIGH FIDELITY STEREO AMPLIFIER

- ★ **SATIN SILVER METAL FACIA** with black lettering. Black edged knobs with bright silver centres.
- ★ **PUSH-BUTTON SELECTOR SWITCHING**
- ★ **NEON INDICATOR**
- ★ **JACK SOCKET FOR HEADPHONES**
- ★ **CABINETED MODEL VENEERED IN SATIN TEAK.**

SUITABLE FOR ANY MODERN PICK-UP CARTRIDGE CERAMIC or MAGNETIC, REGARDLESS OF PRICE. WE RECOMMEND USE WITH THE REST ANCILLARY EQUIPMENT THAT CAN BE AFFORDED.

OUTPUT: 15 watts R.M.S. (Continuous) into 8 ohms.
10 watts R.M.S. (Continuous) into 15 ohms.
HUM & NOISE —75dB Min. Vol. —65dB Full Vol.
HARMONIC DISTORTION 0·1% at 1000 Hz 10 Watts
FREQUENCY RESPONSE: —3dB 7Hz to 70KHz
TREBLE CONTROL: +16dB to —12dB at 14KHz
BASS CONTROL: +17dB to —16dB at 40Hz **CROSS TALK** —58dB
SENSITIVITIES: Disc Mag. 2·5mV. Ceramic 35mV. Radio 120mV. Tape 120mV.
REAR PANEL SOCKETS ARE FOR 3 PAIRS OF INPUTS (1) P.U. (2) Radio (3) Tape Amp. Plus pair for tape recorder signal take off and 2 pairs for speaker connections.

RSC G66 Mk. II 6 + 6 Watt HIGH QUALITY STEREO AMPLIFIER

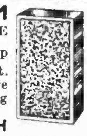


Individual Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 10 Transistors plus Diodes. Output rating I.H.F.M. Frequency range 20-20,000 c.p.s. Bass Control + − 12 d.b. Treble Control + − 13 d.b. Selector switch for P.U. or Tape/Radio. For loudspeaker output impedances of 3 to 15 ohms. For standard 200-250v. A.C. mains operation. Attractive Black and Silver finished metal facia plate & matching control knobs.

COMPLETE KIT OF PARTS INCLUDING FULLY WIRED PRINTED CIRCUIT **£10·50** Carr. 40p

and comprehensive wiring diagram and instructions. **Or FACTORY BUILT IN TEAK VENEERED CABINET** as illustrated or dep. £3.00 and 9 mthly pymnts. £1·50 (Total £16·50) **£13·99**

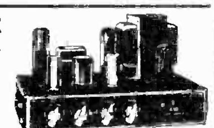
THE 'YORK' HIGH FIDELITY 3'SPEAKER SYSTEM



Performance comparable with units costing considerably more. KIT COMPLETE Moderate size (approx. 25 × 14 × 10in.). Range 30-20,000 c.p.s. Impedance 15 ohms. Consists of (1) 12in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **£22** Carr. 63p

REMARKABLE VALUE HEAR IT AT ANY BRANCH

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



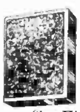
Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for **Clubs, Schools, Theatres, Dance Halls or Outdoor Functions,** etc. For use with **Electronic Organ, Guitar, String Bass,** etc. Gram, Radio or Tape. Reserve L.T. and H.T. for **Radio Tuner.** Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed.200-250 v., A.C. For 3 & 15 Ω speakers. **COMPLETE KIT PARTS, WIRING DIAGRAMS, INSTRUCTIONS.** Twin-handled perforated cover **£1·90**. Or factory built with EL34 output valves and 12 months' guarantee for **£19·75**. Tech. figs. apply to factory built units. Carr. 65p. **£15·75**

TERMS: Deposit **£4** and 9 monthly payments of **£2·10** (Total **£22·90**). Send S.A.E. for leaflet.

FANE LOUDSPEAKERS 'POP' 25/2

Dual cone 15 Ω (for uses other than Bass Guitar or Electronic Organ. Carr. free. Or dep. £1 and 9 monthly payments 75p (Total £7·75). **12in. 25watt** **£6·75**

HI-FI LOUDSPEAKER ENCLOSURES



Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr. 25p extra.

JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£5·35**

SE8 For optimum performance with any 8in. Hi-Fi 'speaker. 22 × 15 × 9in. Ported **£6·47**

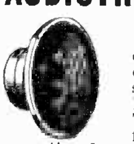
SE10 For outstanding results with Hi-Fi 10in. speaker. 24 × 15 × 10in. Ported **£6·74**

SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **£7·87**

FANE 807 HIGH FIDELITY LOUDSPEAKER

A full range 8in. 10 watt unit for excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance at 30 c.p.s. Tweeter cone is fitted to extend high note response. Frequency range 25 Hz to 15 KHz. Impedance 3 Ω or 8-15 Ω. Cast Chassis. **REMARKABLE VALUE AT ONLY £3·50**

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS



Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround, "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. exceptional performance at low cost. Impedance 3 or 8-15 ohms.

WHEN ORDERING PLEASE STATE IMPEDANCE

HF 801D	8"	8W	£2·71	HF 120D	12"	15W	£4·75
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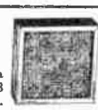

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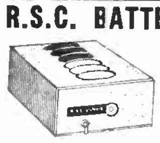

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BF178	52p	NKT271	18p	ST140	15p	2N4061	20p
BF180	37p	NKT272	17p	ST141	20p	2N4062	20p
BF181	37p	NKT274	18p	TD716	60p	2N4284	15p
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1	35	15	16
2·2	35	22	16
4·7	35	33	10
6·8	25	10	6·3
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1N4006	800	·140	·130	·110
1N4007	1000	·190	·150	·120

	p.i.v.	500 +	1000 +
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1N4002	100	·055	·045
1N4003	200	·060	·050
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Fairchild	1-11	12-24	25 +
μL900	40p	35p	32p
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Devices may be mixed to qualify for quantity price.

G.E. (U.S.A.)

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	*These types have integral triggering	
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BARGAIN TRIAC
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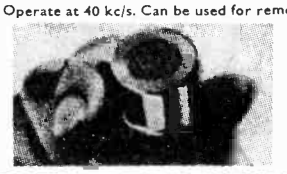
Operate at 40 kc/s. Can be used for remote control systems without cables or electronic links. Type 1404 transducers can transmit and receive.



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0·001mfd	10kV	**50p** ea.	0·05mfd	15kV	**80p** ea.
			0·01mfd	15kV	**80p** ea.
			0·0005mfd	20kV	**60p** ea.
Size 2½ × 6½ ins.			0·1mfd	7kV	**40p** ea.
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DABAR
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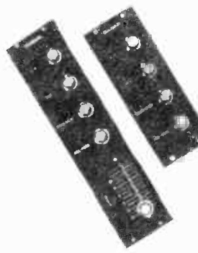

A range of audio Pre-amplifier Modules is now available enabling the construction of custom-built audio mixers for studio, P.A. and discotheque installations at reasonable cost and with many facilities usually available only on expensive systems. The Modules, constructed on glass fibre printed-circuit boards, are complete with anodised aluminium black facia plates and four control knobs identified: L.F., H.F., Echo Send and P.F.L. The modules are designed for use with external faders or volume controls and fulfil most requirements in the audio field. Up to ten input modules may be mixed into the combined Mixer/Line Amplifier Type MX/LNTA which is available on a matching facia plate with V.U. meter. The line amp will deliver +20dBM. All mixing may be effected with 10k log faders.

The modules are fixed with four screws and dimensions are 7½in x 2¾in.

Input modules available:

UM1	200-600 ohm MIC
UM2	50k ohm MIC
UM3	Mag P/U 1.5mV R.I.A.A.
UM4	Mag P/U 5mV R.I.A.A.
UM5	Crystal P/U 500mV
UM6	High Level Tape/Tuner 500mV

Mixer/Line amp MX/LNTA: 10 inputs plus expander input; 600 ohm line out with preset for V.U. adjustment.

Power Unit for above Modules: Type PU11/30, 30V, 500mA. 100W slave amplifier—100W into 4 ohm load 13¾in x 10½in x 7½in.

Prices: UM1-6, **£9** each. MX/LNTA, **£12.** PU11/30, **£8.** 100W Slave Amp **£60.**
Manual showing mixing arrangements, connection data, etc., **25p.** S.A.E. all inquiries. Trade inquiries welcome.

DABAR ELECTRONIC PRODUCTS
98a LICHFIELD STREET, WALSALL, STAFFS WS1 1UZ. WALSALL 34365

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9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET872, 3 GET872B, 1 GET875. All long leaded on panels 13" × 4". 4 for **£1.** P. & P. 25p.

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Extremely well made by FRAKO GmbH in W. Germany, with constant voltage mains transformer, tapped input from 115V to 240V. Full wave rectification and capacitor smoothing. Size 9"×6"×5", weight 11 lb. These units are brand new, unused and fully guaranteed. Maker's price believed to be around £80. Our Price **£9·50.** Carr. 50p

250 MIXED RESISTORS ¼ and ½ Watt **62p**

DIODES 1 AMP 1,000 PIV
4 for 50p P. & P. 5p
709C Operational Amplifier TO5 8 lead I.C.
1 off 50p; 50 off 35p; 100 off 20p; 250 off 15p

QUARTZ HALOGEN BULBS with long leads 12V 55W for car spotlights and projectors etc. 50p

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Single Pole Changeover Silver Contacts 2" × 6" × 7". 2.5KΩ Coil operates on 25 to 50V. 8 for **50p.** P. & P. 8p.

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We guarantee that this parcel contains at least 1,750 components. Short-leaded on panels, including a minimum of 350 transistors (mainly NPN and PNP germanium, audio and switching types—data supplied). The rest of the parcel is made up with: Resistors 5% or better (including some 1%) mainly metal oxide, carbon film, and composition types. Mainly ⅛ and ¼ watt . . . diodes, miniature silicon types OA90, OA91, OA95, IS130, etc. . . . capacitors including tantalum, electrolytics, ceramics and polyesters . . . inductors, a selection of values . . . also the odd transformer, trim-pot, etc., etc. . . . These are all miniature, up to date, professional, top quality components. Don't miss this, one of our best offers yet! Price **£3·25.** P. & P. 33p—U.K. New Zealand £1 P. & P. Limited stocks only.

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6v.	15a.	£14	30v.	7a.	£12
12v.	20a.	£16	24v.	4a.	£14

Carriage 75p per unit.

150 High Stabs ⅛, ¼ and 1 Watt, 5% and Better **62p**

LARGE CAPACITY ELECTROLYTICS
4½"×2" dia. 18,800 mfd 30V
6,500 mfd 60V
16,000 mfd 12V
40p each P. & P. 6p
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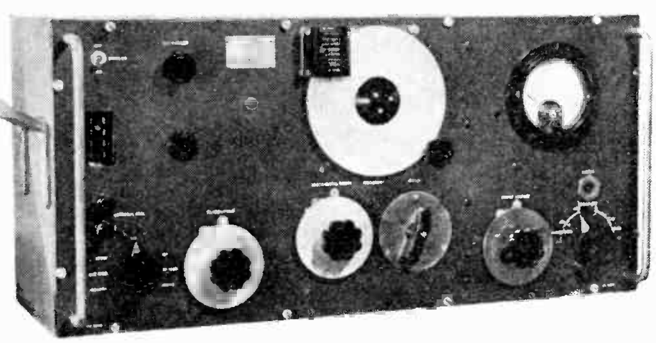

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25Mc/s in 8 ranges. Incremental: ± 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal Modulation: 400c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 10 in. Second hand condition. **£27·50** each, Carr. £1·50.

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MARCONI UNIVERSAL BRIDGE TF-866A and TF-868: £75·00 each, Carr. £2.

MARCONI DEVIATION TEST SET TF-934: 2.5-100Mc/s (can be extended up to 500Mc/s on Harmonics). Dev. Range 0-75Kc/s in modulation range 50c/s-15Kc/s. 100/250V a.c. **£45** each, £1·50 carr.

FOR EXPORT ONLY
BRITISH & AMERICAN COMMUNICATION EQUIPMENT

VRC.19X Trans-ceiver, 150-170Mc/s, 2 Channel, 20 Watts, Output 12/24V d.c. operation. General Electric Transmitter, 410-419Mc/s, thin line tropo scatter system, with antennae. W.S. Type 88, Crystal controlled, 40-48 Mc/s. W.S. Type HF-156, Mk. II, Crystal controlled, 2.5-7.5 Mc/s. W.S. Type 62, tunable, 1.5-12 Mc/s. C.44, Mk. II, Radio Telephone, Single Channel, 70-85 Mc/s. 50 watts, output, 230V. a.c. input. G.E.C. Progress Line Tx Type DO36, 144-174 Mc/s, 50 watt, narrow band width. A.C. input 115V. BC-640 Tx, 100-156 Mc/s, 50 watt output, 110V or 230V input. STC Tx/Rx Type 9X, TR1985; RT1986; TR1987 and TR1998, 100-156 Mc/s. TRC-1 Tx/Rx, Types T.14 and R.19, FM 60-90 Mc/s. With associated equipment available. Redifon GR410 Tx/Rx, SSB, 1.5-20 Mc/s. Sun-Air Tx/Rx Type T-10-R. Collins Tx/Rx/Type 18S4A. Collins Tx/Rx Type ARC-27, 200-400 Mc/s, 28V d.c. With associated equipment available. ARC-5; ARC-3; and ARC-2 Tx/Rx. BC-375; 433G; 348; 718; 458; 455 Tx/Rx. Directional Finding Equipment CRD.6 and FRD.2 complete Sets available and spares. Complete system with full set of Manuals.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order **£18·50** + £1 carr.; OR BC-221 (as received from Ministry), good condition, less charts, £8·50 + £1 Carr.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door. £8·50 each, £2 Carr.

RECEIVER TYPE R-278B (Collins' design): 225-400Mc/s; freq. controlled; 1,750 channels at 0·1Mc/s intervals; channel change time 5 secs; 115 or 230V a.c., 50-60c/s. Triple-conversion superheterodyne with automatic tuning and noise limiter; delayed and amplified automatic volume control, and carrier-operated relay circuit. Further details on request. **£150·00** each.

TELEPRINTER CREED TYPE 7B: "as new" condition, in original packing case, **£25·00** each. Second-hand condition (excellent order), no parts broken, **£15·00** each. Carriage both types £2.

If wishing to call at Stores, please telephone for appointment.

W. MILLS 3-B TRULOCK ROAD, LONDON, N17 0PG
Phone: 01-808-9213 and Wilstead 605

USM-24C OSCILLOSCOPE: 3 in. oscilloscope with 2c/s to 10Mc/s vertical response, and 8c/s to 800Kc/s horizontal response. Sensitivity 50 mv. rms/inch. Triggered sweep, built-in trigger pulses and markers. Mains input 115V, 50c/s. Complete with all leads, probes and circuit diagram. **£42·50** each, carr. £2.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to —127 db variable. O/put Impedance—50 Ω. Price: **£120** each + £2 carr.

SIGNAL GENERATOR TYPE 902: (P.R.D.). A portable, general-purpose, broadband, microwave signal generator designed for testing and maintenance of aircraft radio and radar receivers in the SHF band. The RF output level is regulated by a variable attenuator calibrated in dbm. The frequency dial is calibrated in Mc/s. Provision is made for external modulation. Power Supply—115V, ±10% A.C., 50 c/s. Freq.—3650-7300 Mc/s. Internal Transmission—CW, Pulse, FM. External Transmission—Square Wave, Pulse. Power O/put—0.2 milliwatts. O/put Attenuator: —7 to —127 dbm. Load—50 Ω. Price: **£135** each + £2 carr.

TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put —7 to —85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, + 1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. at 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: + 7 to + 30 dbm. Output — 7 to — 85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0.1-100,000 microvolts cont. variable. Impedance 50 Ω. Price: **£85** each + £1·50 carr.

FREQUENCY METER TS-74 (same TS-174): Heterodyne crystal controlled. Freq. 20-280 Mc/s. Accuracy .05%. Sensitivity 20 mV. Internal Mod. at 1000 c/s. Power Supply—batteries 6V and 135V. Complete with calibration book. (Manufactured for M.O.D. by Telemax. "As new" in cartons.) **£75** each. Fully stabilised Power Supply available at extra cost **£7·50** each. Carr £1·50.

CT.54 VALVE VOLTMETER: Portable battery operated. In strong metal case with full operating instructions. 2.4V-480V. A.C. or D.C. in 6 Ranges, 1Ω to 10MegΩ in 5 Ranges. Indicated on 4in. scale meter. Complete with probe, excellent condition. **£12·50**, carr. 75p.

CT.381 FREQUENCY SWEEP SIGNAL GENERATOR: 85Kc/s-30Mc/s and response curve indicator with 6in. CRT tube and separate power supply. Fully stabilised. Price and further details on request.

AVO WIDE RANGE SIGNAL GENERATOR: Freq. 50Kc/s-80Mc/s in 6 bands. Mains input 100-130V; 200-260V, 50-60c/s. Second-hand, excellent cond. **£14** each, or: New cond. complete with all leads and transit case **£20** each. Carriage £1.

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New Condition. **£1·75** each, post 25p.

HEADSET ASSEMBLY TYPE No. 10: Moving coil headphones and microphone. (Similar to above) new cond. **£1·75**, post 25p; or second-hand cond. **£1·25**, post 25p.

HEADSET ASSEMBLY: with lightweight boom microphone. Good second-hand condition. **£2·50**, post 75p.

DLR HEADPHONES: 2 × balanced armature earpieces. Low resistance. **£1·25** a pair, 25p post.

MOVING COIL INSERT: Ideal for small speakers or microphones. Box of 3 **£1**, post 23p.

HAND MICROPHONE: (recent design) with protective rubber mouthpiece. **£2**, post 23p.

No. 16 HAND MICROPHONE: With carbon insert, lead and plug. Price **75p** each, plus 25p post.

MICROLINE IMPEDANCE METER MODEL 201: 5300-8100Mc/s. **£75** each, £1 carr.

MICROLINE DIRECTIONAL COUPLER MODEL 209: 5260-8100Mc/s. 24DB. **£12·50** each, post 35p.

POWER UNITS AVAILABLE FOR FOLLOWING SETS: 52 set—mains input, 150V @ 60mA and 12V @ 3 amps, new cond. **£3·50.** Receiver type 88 (1475)—mains input, 250V @ 80mA and 6·3V @ 4 amps, new cond. **£3·50.** No. 19 set **£2·50.** C12 set **£4·00.** 88 set **£2·50.** Carriage all types £1 extra.

STABILISED BENCH POWER SUPPLY: fully smooth, dual output, positive or negative, 2-6V; 6-9V; 9-12V and 12-16V all at 2 amps d.c. from mains input. **£25** + £2 carr.

DIGITAL VOLTMETER & RATIOMETER Model BIE. 2116, **£65**, carr. £2.

DIGITAL VOLTMETER Model BIE. 2114, **£55**, carr. £2. (Mnftrs. Blackburn Instruments).

MARKA SWEEP GENERATOR MODEL VIDEO (Kay Electric, USA) **£65**, carr. £2.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6·50** each, post 50p. 24 v D.C. input, 175 v D.C. @ 40mA. output, **£1·25** each, post 20p.

CONDENSERS: 40 mfd, 440 v A.C. wkg. **£5** each, 50p post. 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 15 mfd 330 v a.c., wkg., 75p each, post 25p. 10 mfd 1000 v. 63p each, post 13p. 10 mfd 600 v. 43p each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p, 8 mfd. 1% 300 v. D.C. **£1·25,** post 25p, 4 mfd. 3000 v. wkg. **£3** each, post 37p. 4 mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1.** 0·25 mfd, 2Kv, **20p** each, post 10p. 0·01 mfd MICA 2·5Kv. **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price **£1·25,** post 25p.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2·50** each. post 30p.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 40 ohms at 2·6 amps. Price (either type) **£2** each, 25p post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4·50** each, carr. 75p.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts. mounted in a strong steel case 5" × 6½" × 7". Bitumen impregnated. **£6** each, Carr. 63p. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. **£3·50** each, Carr. 50p.

LT TRANSFORMER: PRI 230V. Output 3 × 6·3 at 3 amps each winding, 3½" × 4" × 5". Fully shrouded **£1·50** post 50p.

VARIABLE VOLTAGE REGULATOR TRANSFORMER: Input 230V A.C.; Output 57·5V-230V in 16 equal steps @ 21 Amps. **£22·50** each, carr. £1·50.

TRANSFORMER: 230V A.C. input. 17·75V @ 35 Amps output. **£9·50** each, carr. £1.

TRANSFORMER: 'C' Core. 230V A.C. input. 1000-0-1000V or 750-0-750V @ 250mA. **£6·50** each, carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 37p.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price **£3** each, carr. 50p.

ANTENNA WIRE: 100 ft. long. **75p** + 25p post.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. **£1·25,** post 25p.

VARIABLE POWER UNIT: Complete with Zenith variac 0-230V., 9 amps.; 2½ in. scale meter reading 0-250V. Unit is mounted in 19 in. rack. **£15** each, £1·50p carr.

AIRCRAFT SOLENOID UNIT D.P.S.T.: 24V, 200 Amps, **£2** each, 25p post.

RADAR SCANNER ASSEMBLY TYPE 122A: Complete with parabolic reflector (24 in. diameter), motors, suppressors, etc. **£35** each, £2 carr.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 25p.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3000-10,000Kc/s. Mains 230V, 50c/s. Measures crystal current under oscillatory conditions and the equivalent parallel resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£12·50** each, £1 carr.

LEDEX SWITCHING UNIT: 2 ledex switches, 6 Bank and 3 Bank respectively, 6 Pos.; 1 Manual switch, 16 Bank 2 Pos. **£4** each, 50p post.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2½Amps. **£3** each 50p post. Input 115V, output 135V at 5 Amps. **£5** each, 50p post.

GEARED MOTOR: 24c. D.C., current 150mA, output 1 rpm, **£1·50** each, 25p post. **ASSEMBLY UNIT** with Letcherbar Tuning Mechanism and potentiometer, 3 rpm, **£2** each 25p post. **SYNCHROS:** and other special purpose motors available. List 3p.

DALMOTORS: 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. **£5** each, 50p post.

GEARED MOTOR: 28V d.c. 150 rpm (suitable for opening garage doors). **£4** each, 50p post.

SMALL GEARED MOTOR: 24V d.c., output 200 rpm. Meas'm'ts 1½in. dia. × 3½in. long. **£2** each, 23p post.

FUEL INDICATOR Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price **£2** each, 25p post.

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., **£6·50** each, post 37p. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) **£6·50** each, post 25p. 1 pole, 4 throw, Type M1460-4. (New) **£6·50** each, post 25p.

PRD Electronic Inc. Equipment: FIXED ATTENUATOR; Type 130c, 2·0-10·0 KMC/SEC. (New) **£5** each, post 25p. FIXED ATTENTUATOR: Type 1157S-1 (New) **£6** each, post 25p.

CALLERS BY TELEPHONE APPOINTMENT ONLY

W. MILLS

3-B TRULOCK ROAD, LONDON, N17 OPG
Phone: 01-808 9213 and WILSTEAD 605

SEW PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES, ETC.

● LOW COST ● QUICK DELIVERY ● OVER 200 RANGES IN STOCK ● OTHER RANGES TO ORDER

NEW "SEW" DESIGNS!

CLEAR PLASTIC METERS

TYPE SW. 100
100 x 80 mm.

50µA	£3·47½	20V. D.C.	£2·97½
50-0-50µA	£3·37½	50V. D.C.	£2·97½
100µA	£3·37½	300V. D.C.	£2·97½
100-0-100µA	£3·25	1 amp. D.C.	£2·97½
500µA	£3·12½	5 amp. D.C.	£2·97½
1mA	£2·97½	300V. A.C.	£2·97½
		VU Meter	£3·75

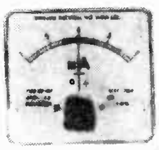
BAKELITE PANEL METERS

TYPE S-80
80 mm.
square fronts

50µA	£3·12½	50V. D.C.	£2·47½
50-0-50µA	£2·97½	300V. D.C.	£2·47½
100µA	£2·97½	1 amp. D.C.	£2·47½
100-0-100µA	£2·87½	5 amp. D.C.	£2·47½
500µA	£2·62½	300V. A.C.	£2·62½
1mA	£2·47½	VU Meter	£3·37½
20V. D.C.	£2·47½		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in. × 4¼in. fronts.



50µA	£3·60	10mA	£2·60
50-0-50µA	£3·10	50mA	£2·60
100µA	£3·10	100mA	£2·60
100-0-100µA	£3·10	500mA	£2·60
200µA	£2·87½	1 amp.	£2·60
500µA	£2·75	5 amp.	£2·60
500-0-500µA	£2·60	15 amp.	£2·60
1mA	£2·60	30 amp.	£2·60
1-0-1mA	£2·60	20V. D.C.	£2·60
5mA	£2·60	50V. D.C.	£2·60
		150V. D.C.	£2·60
		300V. D.C.	£2·60
		15V. A.C.	£2·60
		300V. A.C.	£2·60
		8 Meter 1mA	£2·87½
		VU Meter	£3·60
		1 amp. A.C.*	£2·60
		5 amp. A.C.*	£2·60
		10 amp. A.C.*	£2·60
		20 amp. A.C.*	£2·60
		30 amp. A.C.*	£2·60

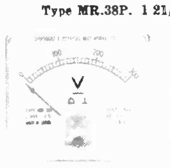
Type MR.52P. 2½in. square fronts.

50µA	£3·10	10V. D.C.	£2·00
50-0-50µA	£2·60	20V. D.C.	£2·00
100µA	£2·60	50V. D.C.	£2·00
100-0-100µA	£2·37½	300V. D.C.	£2·00
500µA	£2·25	15V. A.C.	£2·00
1mA	£2·00	300V. A.C.	£2·00
5mA	£2·00	8 Meter 1mA	£2·10
10mA	£2·00	VU Meter	£3·10
50mA	£2·00	1 amp. A.C.*	£2·00
100mA	£2·00	5 amp. A.C.*	£2·00
500mA	£2·00	10 amp. A.C.*	£2·00
1 amp.	£2·00	20 amp. A.C.*	£2·00
5 amp.	£2·00	30 amp. A.C.*	£2·00

Type MR.65P. 3½in. × 3½in. fronts

50µA	£3·37½	10V. D.C.	£2·10
50-0-50µA	£2·75	20V. D.C.	£2·10
100µA	£2·75	50V. D.C.	£2·10
100-0-100µA	£2·60	150V. D.C.	£2·10
200µA	£2·60	300V. D.C.	£2·10
500µA	£2·37½	15V. A.C.	£2·10
500-0-500µA	£2·10	50V. A.C.	£2·10
1mA	£2·10	150V. A.C.	£2·10
5mA	£2·10	300V. A.C.	£2·10
10mA	£2·10	500V. A.C.	£2·10
50mA	£2·10	8 Meter 1mA	£2·37½
100mA	£2·10	VU Meter	£3·37½
500mA	£2·10	50mA A.C.*	£2·10
1 amp.	£2·10	100mA A.C.*	£2·10
5 amp.	£2·10	200mA A.C.*	£2·10
10 amp.	£2·10	500mA A.C.*	£2·10
15 amp.	£2·10	1 amp. A.C.*	£2·10
20 amp.	£2·10	5 amp. A.C.*	£2·10
30 amp.	£2·10	10 amp. A.C.*	£2·10
50 amp.	£2·37½	20 amp. A.C.*	£2·10
5V. D.C.	£2·10	30 amp. A.C.*	£2·10

Type MR.38P. 1 21/32in. square fronts.



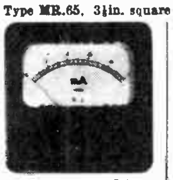
50µA	£2·00	200mA	£1·37½
50-0-50µA	£1·87½	300mA	£1·37½
100µA	£1·87½	500mA	£1·37½
100-0-100µA	£1·75	750mA	£1·37½
200µA	£1·75	1 amp.	£1·37½
500µA	£1·50	2 amp.	£1·37½
500-0-500µA	£1·37½	5 amp.	£1·37½
1mA	£1·37½	10 amp.	£1·37½
1-0-1mA	£1·37½	3V. D.C.	£1·37½
2mA	£1·37½	10V. D.C.	£1·37½
5mA	£1·37½	15V. D.C.	£1·37½
10mA	£1·37½	20V. D.C.	£1·37½
20mA	£1·37½	100V. D.C.	£1·37½
50mA	£1·37½	150V. D.C.	£1·37½
100mA	£1·37½	300V. D.C.	£1·37½
150mA	£1·37½	500V. D.C.	£1·37½
		750V. D.C.	£1·37½
		15V. A.C.	£1·37½
		50V. A.C.	£1·37½
		150V. A.C.	£1·37½
		300V. A.C.	£1·37½
		500V. A.C.	£1·37½
		8 Meter 1mA	£1·60
		VU Meter	£2·10

Type MR.45P. 2in. square fronts.

50µA	£2·25	5 amp.	£1·50
50-0-50µA	£2·10	10V. D.C.	£1·50
100µA	£2·10	20V. D.C.	£1·50
100-0-100µA	£1·87½	50V. D.C.	£1·50
200µA	£1·87½	300V. D.C.	£1·50
500µA	£1·60	15V. A.C.	£1·50
500-0-500µA	£1·50	300V. A.C.	£1·50
1mA	£1·50	8 Meter 1mA	£1·87½
5mA	£1·50	VU Meter	£2·25
10mA	£1·50	1 amp. A.C.*	£1·50
50mA	£1·50	5 amp. A.C.*	£1·50
100mA	£1·50	10 amp. A.C.*	£1·50
500mA	£1·50	20 amp. A.C.*	£1·50
1 amp.	£1·50	30 amp. A.C.*	£1·50

"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.



25µA	£3·50	500mA	£1·75
50µA	£2·37½	1 amp.	£1·75
50-0-50µA	£2·25	5 amp.	£1·75
100µA	£2·25	15 amp.	£1·75
100-0-100µA	£2·25	30 amp.	£1·75
500µA	£2·10	50 amp.	£1·75
1mA	£1·75	5V. D.C.	£1·75
1-0-1mA	£1·75	10V. D.C.	£1·75
5mA	£1·75	20V. D.C.	£1·75
10mA	£1·75	50V. D.C.	£1·75
50mA	£1·75	150V. D.C.	£1·75
100mA	£1·75	300V. D.C.	£1·75
		30V. A.C.*	£1·75
		50V. A.C.*	£1·75
		150V. A.C.*	£1·75
		300V. A.C.*	£1·75
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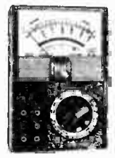

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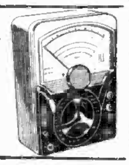

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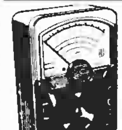

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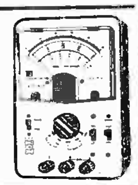

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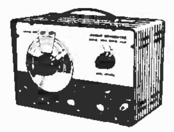
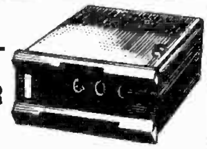


HONEYWELL DIGITAL VOLTMETER VT.100



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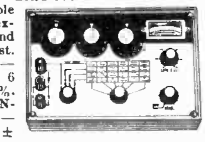

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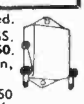

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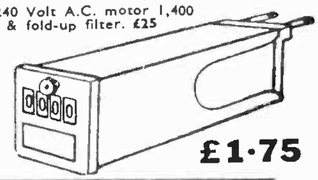

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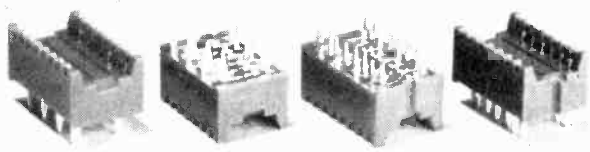

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STEPHENS

ELECTRONICS,
P.O. BOX 26,
AYLESBURY, BUCKS.

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GUARANTEE
Satisfaction or money refunded

GUARANTEED VALVES BY THE LEADING MANUFACTURERS BY RETURN SERVICE
1 YEAR'S GUARANTEE ON OWN BRAND, 3 MONTHS' ON OTHERS

AZ31	50p	E88CC	62½p	EL803	85p	PCC85	42½p	PY83	50p	UL41	57½p	6AR6	32½p	6EW6	60p	6SL7GT	32½p	12K7GT	35p	35A5	55p
AZ50	60p	ECF80/2	47½p	EL821	55p	PCC88	70p	PY88	41p	UL84	55p	6AS5	35p	6F1	70p	6SN7GT	30p	12Q7G	25p	35B5	65p
CBL1	80p	ECF86	55p	ELL80	75p	PCC89	61p	PY500	£1·00	UM80/4	45p	6AS7G	80p	6F8	40p	6SQ7	40p	12SC7	25p	35C5	35p
CBL31	85p	ECH35	67½p	EM34	80p	PCC189	61p	PZ30	80p	UY41	40p	6AT6	45p	6F6G	25p	6SR7	37½p	12SG7	35p	35D5	65p
CY31	35p	ECH42	66p	EM71	62½p	PCF80	51p	QQU02-6	£2·10	UY85	34p	6AU6	30p	6F11	32½p	6T8	32½p	12SH7	25p	35L6GT	47½p
DAF91	41p	ECH81	51p	EM80	40p	PCF82	52½p	QQUO3-10	£1·25	U301	85p	6BA6	47½p	6F12	22½p	6U4GT	62½p	12SJ7	25p	35W4	25p
DAF96	41p	ECH83	40p	EM81	42½p	PCF84	47½p	QVO3-12	65p	W729	55p	6BE6	60p	6F13	35p	6U8	35p	12SK7	40p	35Z3	55p
DF91	45p	ECH84	47½p	EM84	37½p	PCF86	61p	R19	65p	Z759	£1·22½	6BH6	42½p	6F14	60p	6V6GT	32½p	12SL7GT	40p	35Z4G	25p
DF96	45p	ECL80	40p	EM87	55p	PCF200/1	81p	R20	75p	OA2	32½p	6BJ6	42½p	6F15	55p	6X4	25p	12SN7GT	40p	35Z5GT	37½p
DK91	57½p	ECL82	49p	EN91	32½p	PCF801	61p	SU2150A	75p	OA3	45p	6BK7A	50p	6F18	40p	6X5GT	27½p	12SQ7	40p	50A5	65p
DK96	57½p	ECL83	57½p	EY51	40p	PCF802	61p	TT21	£2·40	OB2	32½p	6BL8	35p	6F22	32½p	6X8	55p	12SR7	32½p	50B5	35p
DL92	37½p	ECL86	49p	EY80	45p	PCF805	65p	TT22	£2·50	OB3	50p	6BN5	42½p	6F23	77½p	6Y6G	60p	14S7	80p	50C5	35p
DL94	37½p	ECLL800	£1·50	EY81	40p	PCF806	61p	U18/20	67½p	OC3	35p	6BN6	40p	6F24	67½p	7Y4	60p	20D1	45p	50L6GT	40p
DL96	46p	EF39	52½p	EY83	55p	PCF808	67½p	U20	67½p	OD3	32½p	6BQ5	25p	6F25	75p	9BW6	42½p	20L1	£1·00	83A1	90p
DM70	32½p	EF80	40p	EY86	40p	PCH200	70p	U25	75p	3Q4	40p	6BR7	75p	6F26	35p	10C2	50p	20P1	50p	85A2	37½p
DY86/7	40p	EF83	50p	EY87	42½p	PCL82	51p	U26	75p	3S4	35p	6BR8	95p	6F28	70p	10D1	40p	20P3	60p	90AUY	£2·40
DY802	42½p	EF85	41p	EY88	27p	PCL83	61p	U31	45p	3V4	40p	6BW6	82½p	6F29	32½p	10D2	40p	20P4	£1·00	90C1	60p
E55L	£2·75	EF86	66p	EZ35	27½p	PCL84	51p	U37	£1·50	5R4GY	55p	6BW7	69p	6F30	35p	10F1	90p	20P5	£1·00	90CU	£1·25
E88CC	40p	EF89	40p	EZ882	27½p	PCL85	52½p	U50	30p	5U4G	30p	6BX6	25p	6J4	47½p	10F9	50p	25C5	45p	807	47½p
E130L	£4·50	EF91	42½p	EZ40	45p	PCL86	51p	U52	30p	5U4GB	37½p	6BZ6	32½p	6J5GT	30p	10F18	40p	25L6GT	37½p	811A	£1·50
E180F	95p	EF92	50p	EZ41	45p	PD500	£1·52½	U76	25p	5V4G	40p	6C4	30p	6J7	42½p	10L1	40p	25Z4G	30p	812A	£3·25
EABC80	52½p	EF93	47½p	EZ80	27½p	PFL200	74p	U78	25p	5Y3GT	30p	6C5GT	35p	6K6GT	50p	10LD11	55p	25Z6GT	50p	813	£3·75
EAF42	50p	EF94	77½p	EZ81	27½p	PL36	64p	U191	75p	5Z3	45p	6CD6G	£1·40	6K7	32½p	10P13	55p	30A5	40p	866A	70p
EBC33	55p	EF95	62½p	EZ90	25p	PL38	90p	U193	41p	524GT	40p	6CA4	27½p	6K8G	30p	10P14	£1·00	30AE3	40p	5642	60p
EBC41	47½p	EF183	56p	GS10C	£5·00	PL81	51p	U201	35p	6/30L2	75p	6CA7	52½p	6K23	50p	12AB5	50p	30C15	75p	6080	£1·37½
EBC81	32½p	EF184	35p	GY501	80p	PL81A	62½p	U281	40p	6AB4	32½p	6CBC	27½p	6K25	75p	12AC6	37½p	30C17	80p	6146	£1·50
EBC90	47½p	E280F	£2·10	GZ30	37½p	PL82	36p	U282	40p	6AF4A	47½p	6CD6GA	£1·15	646GT	45p	12AD6	37½p	30C18	75p	6146B	£2·37½
EBF80	40p	EF800	£1·00	GZ21	30p	PL83	51p	U403	50p	6AG7	37½p	6CG7	45p	6L7	32½p	12A15	40p	30F5	85p	6267	32½p
EBF83	40p	EF804	£1·00	GZ32	47½p	PL84	41p	U404	37½p	6AH6	50p	6CH6	55p	6L18	30p	12AQ5	40p	30FL1	75p	6360	£1·25
EBF89	40p	EF811	75p	GZ33	37½p	PL500	82½p	U801	£1·00	6AJ8	29p	6CL6	50p	6LD20	32½p	12AT6	25p	30FL2	92½p	6939	£2·10
EB91	26p	EL34	52½p	GZ34	55p	PL504	85p	UABC80	52½p	6AK5	30p	6CW4	62½p	6N7GT	35p	12AU6	75p	30FL13	50p	7199	75p
EC53	50p	EL36	47½p	HK90	32½p	PL505	£1·45	UBF89	40p	6AK6	57½p	6CY5	40p	6P1	60p	12AV6	30p	30FL14	77½p	7360	£1·80
EC86	60p	EL41	55p	HL92	35p	PL508	£1·00	UBC41	49p	6AL3	42½p	6CY7	60p	6P25	£1·05	12AV7	45p	30L1	45p	7586	£1·25
EC88	60p	EL42	57½p	HL94	40p	PL509	£1·54	UCC85	46p	6AL5	16p	6D3	40p	6P28	61½p	12AX7	30p	30L15	85p	9002	32½p
EC90	30p	EL81	50p	KT66	£1·37½	PL802	86p	UCH42	69p	6AM5	25p	6DC6	67½p	6Q7	37½p	12AY7	67½p	30L17	85p	9003	50p
EC92	32½p	EL83	41p	KT88	£1·66	PL805	86p	UCH81	54p	6AM6	22½p	6CK6	42½p	6R7G	35p	12B4A	50p	30P12	80p		
EC93	47½p	EL85	42½p	N78	£1·05	PY33	62½p	UCL82	51p	6AQ5	32½p	6DQ6B	60p	6S2	40p	12BA6	32½p	30P18	35p		
ECC81	40p	EL86	42½p	PABC80	40p	PY80	32½p	UCL83	61p	6AQ6	50p	6DS4	75p	6S4A	55p	12BA7	32½p	30P19	75p		
ECC82/3	42½p	EL90	32½p	PC86/8	51p	PY81	41p	UF41/2	55p	6AR5	32½p	6EA8	55p	6SA7	37½p	12BE6	32½p	30PL1	77½p		
ECC82/3	42½p	EL91	25p	PC95	36p	PY800	41p	UF80/5	37½p			6EH7	32½p	6SG7	32½p	12BH7	32½p	30PL13	90p		
ECC84/5	42½p	EL95	35p	PC97	41p	PY801	41p	UF89	41p			6EJ7	35p	6SJ7	37½p	12BY7	50p	30PL14	85p		
ECC88	55p	EL360	£1·15	PCC84	46p	PY82	35p							6SK7	32½p	12K5	50p	35A3	50p		

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New and Budget tubes made by the leading manufacturers. Guaranteed for 2 years. In the event of failure under guarantee, replacement is made without the usual time wasting forms.

Type		New £	Budget £
MW36—20			£4·50
MW36—21			£4·50
MW43—69Z	CRM171		
	CRM172	£6·60	£4·62½
MW43—80Z	CRM173	£6·60	£4·62½
AW43—80Z	CME1702	£6·60	£4·62½
	CME1703	£6·60	£4·62½
	CME1706	£6·60	£4·62½
	C17AA	£6·60	£4·62½
	C17AF	£6·60	£4·62½
AW43—88	CME1705	£6·60	£4·62½
AW47—90			
AW47—91	A47 14W	£5·95	£4·87
A47 14W	CME1901	£5·95	£4·87
	CME1902	£5·95	£4·87
	CME1903	£5·95	£4·87
	C19AH	£5·95	£4·87
A47—11W	CME1905	£8·86½	£7·00
A47—13W	CME1906	£10·27½	£8·50
A47—26W	CME1905	£8·86½	£7·75
A47—26W/R	CME1913R	£9·33½	

Type		New £	Budget £
A50—120W/R	CME2013	£10·85	
AW53—80		£8·93½	£6·25
AW53—88	CME2101	£8·93½	£6·25
AW59—90			
AW59—91	CME2303	£9·58½	£7·20
A59—15W	CME2301		
	CME2303		
	CME2303	£9·58½	£7·20
A59—11W	CME2305		
A59—13W	CME2306	£13·65	£10·97½
A59—16W	CME2306	£13·65	£10·97½
A59—23W	CME2305	£12·60	£10·50
A59—23W/R		£12·60	£10·50
A61—120W/R	CME2413	£13·50	£11·50
A65—11W	CME2501	£16·50	£14·50

COLOUR TUBES

A49—191X	19 inch	£52·50
A56—120X	22 inch	£57·50
A63—11X	25 inch	£62·50

PORTABLE SET TUBES

	New £	Budget £
TSD217	£11·50	
TSD282	£11·50	
A28—14W	£9·16½	Not supplied
CME1601		£7·75
CME1602		£8·00

TRANSISTORISED UHF TUNER UNITS NEW AND GUARANTEED FOR 3 MONTHS

Complete with Aerial Socket and wires for Radio and Allied TV sets but can be used for most makes.
Continuous Tuning, £4·50; Push Button, £5·00.

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Switch Cleaner, 55p; Switch Cleaner with Lubricant, 55p; Freeza 62½p. P. & P. 7½p per item.

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Jack Plugs and Sockets		Co-Axial Plugs	
Standard Plugs	19p	Belling Lee (or similar type)	6½p
Standard Sockets	12½p	Add 2p per doz. p. & p.	

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G.E.C. BT454	£4·75	G.E.C. 2028	£4·75
G.E.C. BT456	£4·75	G.E.C. 2041	£4·75
G.E.C. 2010	£4·75	G.E.C. 2000 Series	
G.E.C. 2013	£4·75	Philips 19TG	£4·75
G.E.C. 2014	£4·75	Pye Mod. 36	£4·75
G.E.C. 2018	£4·75	Pye Mod. 40	£4·75
G.E.C. 2043	£4·75	Thorn 800—850	£4·75
G.E.C. 2048	£4·75		

STYLII—BRITISH MANUFACTURED

All types in stock.		Double Tip "S"	33p
Single Tip "S"	13p	Double Tip "D"	47p
Single Tip "D"	37p		
"S" = Sapphire		"D" = Diamond	

A discount of 10% is also given for the purchase of 3 or more tubes at any one time. All types of tubes in stock. Carriage and insurance 75p anywhere in Britain.

SEMICONDUCTORS BRAND NEW MANUFACTURERS MARKINGS NO REMARKED DEVICES

[illegible]	62½p	R.C.A.		AF106	42½p	BC142	30p	BF224	30p
[illegible]	30p	40253	P.A.	AF114	25p	BC143	P.A.	BF225	30p
2N696	20p	40398	P.A.	AF115	30p	BC147	17½p	BF257	47½p
2N698	25p	40458	P.A.	AF116	25p	BC148	15p	BFX84	30p
2N706	12½p	2N4061	22½p	AF117	25p	BC149	17½p	BFY19	33p
2N706A	12½p	2N4062	22½p	AF118	60p	BC152	17½p	BFY50	22½p
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2N1303	17½p	AC107	30p	AF125	20p	BC169B	14p	BSX21	37½p
2N1305	22½p	AC117	60p	AF126	20p	BC169C	15p	OC25	50p
2N1306	25p	AC126	20p	AF127	17½p	BC171	17½p	OC26	32½p
2N1307	25p	AC127	25p	AF139	37½p	BC175	27½p	OC28	62½p
2N1711	25p	AC128	20p	AF178	45p	BC183	22½p	OC29	75p
2N2147	72½p	AC154	22½p	AF179	45p	BC184	22½p	OC35	40p
2N2160	57½p	AC176	25p	AF180	52½p	BC187	28½p	OC36	62½p
2N2614	30p	AC187	62½p	AF181	42½p	BC213L	26½p	OC42	25p
2N2646	57½p	AC188	37½p	AF186	66½p	BCY32	37½p	OC44	20p
2N2905	40p	ACY17	27½p	AF239	42½p	BCY58	22½p	OC45	12½p
2N2926		ACY18	25p	ASY28	28p	BCY70	20p	OC46	15p
Green	14p	ACY19	25p	BC107	15p	BD115	78p	OC70	15p
Yellow	12½p	ACY20	25p	BC108	15p	BD121	65p	OC71	12½p
Orange	12½p	ACY21	25p	BC109	15p	BD123	82½p	OC72	12½p
2N3053	27½p	ACY22	20p	BC113	27½p	BD124	62½p	OC74	32½p
2N3055	75p	ACY28	20p	BC114	37½p	BD131	97½p	OC75	22½p
2N3391	20p	ACY40	20p	BC115	32½p	BD132	97½p	OC76	22½p
2N3392	20p	ACY41	25p	BC116	62½p	BF115	25p	OC77	27½p
2N3702	17½p	ACY44	40p	BC116A	37½p	BF117	47½p	OC78	25p
2N3704	22½p	AD140	40p	BC117	39p	BF160	P.A.	OC81	20p
2N3705	20p	AD142	58p	BC118	32½p	BF162	P.A.	OC81D	20p
2N3711	20p	AD149	57½p	BC134	57½p	BF163	35p	OC83	25p
2N3819	35p	AD150	62½p	BC135	P.A.	BF167	25p	OC84	25p
2N3826	30p	AD161	37½p	BC136	P.A.	BF173	32½p	OC139	32½p
2N3905	37p	AD162	37½p	BC137	P.A.	BF178	35p	OC140	32½p
2N3914	P.A.	AF102	58p	BC138	P.A.	BF179	72½p	OC170	30p
						BF180	35p	OC171	30p
						BF181	32½p	OC200	32½p
						BF184	25p	OC202	47½p
						BF194	22½p	OCP71	42½p
						BF195	27½p	P346A	25p
						BF196	42½p	TIS43	40p
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						BF198	42½p	P.A. Price on application	
						BF200	36½p		

DIODES & RECTIFIERS

1N914	7½p	BZY88		OA91	7½p
AA119	10p	(Series)	32½p	OA202	10p
BA102	22½p	OA5	12½p	BA144	12½p
BA115	7½p	OA47	7½p	BA145	20p
BA114	12½p	OA70	7½p	BA148	23p
BY100	22½p	OA79	9p	BA155	P.A.
BY126	20p	OA81	7½p	BA156	P.A.
BY127	22½p	OA90	7½p		

CARTRIDGES

		Inc. P. T. each
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GP95		£1·24
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X5H ..	S/S	£1·39
SX5M ..	S/S	£1·81
SX5H ..	S/S	£1·81
SX5M ..	D/S	£2·00
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P. & P. 7p on all orders.

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TERMS, CASH WITH ORDER ONLY. POST AND PACKING PAYABLE ON ORDERS UP TO £6, AFTER THAT, FREE EXCEPT C.R.T.'s.

SERVICE TRADING CO

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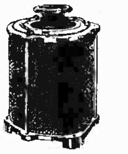
VARIABLE VOLTAGE TRANSFORMERS



50 AMP

1 AMP

INPUT 230 v. A.C. 50/60
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BRAND NEW. Keenest prices in the country. All types (and spares) from ½ to 50 amp. available from stock.

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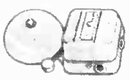
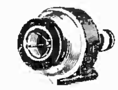


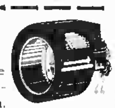
Manufactured by GENTS. 6 inch bell, 3/6 volt D.C. operation. As NEW. Only **£1·50** plus 45p P. & P.

12-28 VOLT D.C. BLOWER UNIT



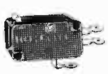
Powerful, smooth running, precision made Blower Unit. 5,000 RPM, ·54 amps. Size 3" diameter × 3¾" long over all. Price **£2·00** post paid.

220/240 VOLT A.C. CENTRIFUGAL FAN/BLOWER



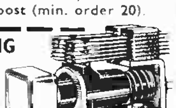
Smooth, balanced running unit. Two pole shaded pole Mycalex motor gives approximately 90 cubic ft./min. but draws only 240 ma. on run. Weight 2½ lb. Case dia. 3.1", width (case only) 3·125", width overall (inc. motor) 5·25", aperture 3·125" × 1·85". Price only **£2·95**. P. & P. 25p.

MICRO SWITCH



5 amp. c/o contacts. Fitted with removable push button assembly. Ex. P.O. 20 for **£1·00** inc. post (min. order 20).

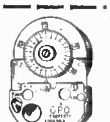
T.M.C. ILLUMINATED LOCKING PUSH BUTTON KEY SWITCH



NO 5528857 6 c/o

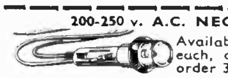
Complete with mounting bracket, Push Knob and Lenses (GREEN, AMBER, RED or CLEAR state colour preference). Price **88p** each excluding bulb, Post Paid.

VENNER ELECTRIC TIME SWITCH



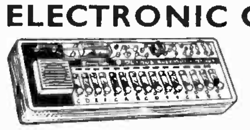
200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 10amp. **£2·75**. 15amp. **£3·25**. 20amp. **£3·75**. P. & P. 20p. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

200-250 v. A.C. NEON INDICATOR



Available in RED or AMBER at **20p** each, or in GREEN at **32p**. Min. order 3 units. P. & P. 5p.

ELECTRONIC ORGAN KIT



Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, powered by two pen-lite 1½v. batteries.

Complete set of parts including speaker, etc., together with full instructions and 10 tunes. **£3·00**. P. & P. 25p.

50 in 1 ELECTRONIC PROJECT KIT

50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc., etc. Price **£7·75**. P. & P. 30p.

CRYSTAL RADIO KIT

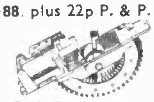
Complete set of parts including: crystal diode, ferrite aerial, drilled chassis and personal ear-piece. No soldering, easy to build, full step-by-step instructions. **£1·75** inc. post.

POWER RHEOSTATS

(NEW) Ceramic construction winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES: 100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA.,** Diameter 3¼in. Shaft length ¾in. dia. $\frac{15}{64}$ in., **£1·50**. P. & P. 15p.
50 WATT 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at **£1·12**. P. & P. 11p.
25 WATT 10/25/50/100/250/500/1K/1·5K/2·5K/3·5K ohm. All at **78p**, P. & P. 5p.

Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats, **18p** ea.

UNISELECTOR SWITCHES—NEW



4 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation **£5·88**. plus 22p P. & P.

6 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. **£6·50**, plus 22p P. & P.

8 BANK 25 WAY FULL WIPER
24 v. D.C. operation. **£7·63**, plus 22p P. & P.

VERY SPECIAL OFFER

500 v, 50 MEG "RECORD" INSULATION TESTERS. Excellent condition, fully tested. Complete with leather carrying case. **£12**. P. & P. 50p.

STROBE! STROBE! STROBE!

THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION. The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + instructions **£6·30** plus 25p P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor Adjustable 1-80 f.p.s. Price **£10·50**. 50p P. & P.

HY-LYGHT STROBE
This strobe has been designed for use in large rooms, halls and the photographic field, and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 1-30 f.p.s. Light output approx. 4 ioules. Price **£12·00**. P. & P. 50p.

SPECIALLY DESIGNED FULLY VENTILATED METAL CASE. £4·00. P. & P. 45p. Post paid with kit.

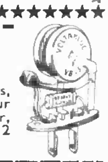
AND NOW!

THE '*SUPER*' HY-LYGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Incorporating, Heavy duty power supply.
Variable speed from 1-23 flash per sec.
Fantastic Octal based tube with massive electrodes.
Reactor control circuit producing an intense white light.
The brilliant light output of the 'SUPER' HY-LYGHT gives fabulous effects with colour filters.
Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £20·00 plus 75p P. & P.

ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE specially designed for the Super Hy-Lyght Kit including reflector, **£7·00**. P. & P. 45p.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **53p** and 13p P. & P. or post paid with kits.

RECHARGEABLE NICKEL CAD. BUTTON CELLS.



2 × 1.2 v. 250 MA/HR Nickel Cad. Cells, connected to give 2.4 v., at 25 milliamp/10 hour rate, complete with 200/250 v. A.C. charger, unused. Price **48p** each plus 8p p. & p. or 2 units for **£1·00** post paid.

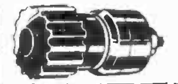
NICKEL CADMIUM BATTERY

Sintered Cadmium Type **1.2 v. 7AH.** Size: height 3½ in., width 2⅛in. × 1$\frac{3}{16}$in. Weight: approx. 13 ozs. Ex-R.A.F. Tested **63p**. P. & P. 15p.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price **£1·05** plus 7p P. & P. Suitable Diac 30p (RCA40583).

INSULATED TERMINALS

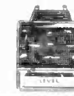


Available in black, red, white, yellow, blue and green. New **10p** each. Post paid.

HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. **£2·25** plus 18p p. & p.

MINIATURE LEVEL METER



Approximately 300 micro amp basic, as fitted to Tape Recorders, etc. Strip type dual coloured dial. **50p** + 8p P. & P.

RELAYS *NEW* SIEMENS PLESSEY, etc.

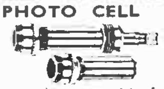
MINIATURE RELAYS AT COMPETITIVE PRICES.

1	2	3	4	1	2	3	4
45	6-9	2 HD M	**50p**	700	15-35	2 c/o HD	**73p***
185	12-18	4 c/o	**73p***	700	16-24	6 M	**63p***
230	9-12	4 c/o	**78p***	1250	24-36	4 c/o	**63p***
280	9-12	2 c/o	**73p***	2500	36-45	6 M	**63p***
600	18-32	4 c/o	**78p***	2400	30-49	4 c/o	**50p**
700	16-24	4 M 2 B	**63p***	5800	40-70	4 c/o	**63p***
700	16-24	4 c/o	**78p***	9000	40-70	2 c/o	**50p***
700	12-24	2 c/o	**63p***	15k	85-110	6 M	**50p***

(1) Coil ohms: (2) Working d.c. volts: (3) Contacts: (4) Price HD = Heavy Duty. All Post Paid. *including Base.

MAINS RELAY
230 v. A.C. coil 3 c/o, 10 amp. A.C. contacts. **50p** + 8p p. & p.

LIGHT SOURCE AND PHOTO CELL MOUNTING



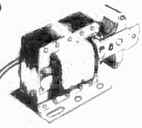
Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair **£2·75** p & p 18p.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price £1·25**, plus 12p P. & P. **ORP. 12 and Circuit 63p post paid.**

220/240 A.C. MAINS MODEL
incorporates mains transformer rectifier and special relay with 1 make, 1 break. H.D. contacts. Price inc. circuit **£2·38**, plus 20p P. & P.

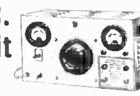
230 VOLT AC SOLENOID



EXTREMELY POWERFUL SOLENOID with approximately 14lb. pull, 1inch travel. Fitted with mounting feet. Size 4 inches long, 2⅜ inches wide and 3 inches high. Price **£2·00** including post & pkg.

230-250 VOLT A.C. SOLENOID
(Similar in appearance to above illustration.) Approx. 1½ lb. pull. Size of feet 1¾ × 1$\frac{3}{16}$. Price **85p** incl. post. Manufactured by Westool Ltd.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit



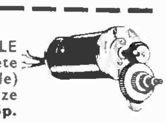
Input 220/240 v. A.C. Output Continuously variable 0-36 v. A.C./D.C. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. **£58** plus £2 p. & c.

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
1 rev. per hour. Clockwise rotation.
1 rev. per hour. Anti-clockwise rotation.
2 revs. per hour. Clockwise rotation.
3 revs. per hour. Anti-clockwise rotation.
15 revs. per hour. Anti-clockwise rotation.
60 revs. per hour. 1 rev per minute clockwise

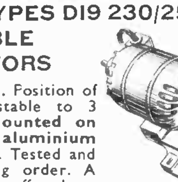
Fraction of makers' price. All at **75p** incl. P. & P.

12 VOLT DC MOTOR



Powerful 12 volt 1 amp REVERSIBLE motor. Speed 3,750 rpm. Complete with external gear train (removable) giving final speed of 125 RPM. Size 4½in. × 2¼in. dia. Price inc. post **95p**.

PARVALUX TYPES D19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. **Mounted on substantial cast aluminium base.** Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **£6·30**. P. & P. 50p.

ALL MAIL ORDERS, ALSO CALLERS AT:
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Tel.: 01-437 0576

28watts, r.m.s. 40Hz to 40kHz ±3dB

PRICES SYSTEM 1

Viscount III R101 amplifier	£22.00 + 90p p&p
2 x Duo Type II speakers	£14.00 + £2 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23.00 + £1.50 p&p
Total	£59.00

Available complete for only £52.00 + **£3.50 p&p**

SYSTEM 2

Viscount R101 amplifier	£22.00 + 90p p&p
2 x Duo Type III speakers	£32.00 + £3 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23.00 + £1.50 p&p
Total	£77.00

Available complete for £69 + **£4 p&p**

SYSTEM 3

Viscount III amplifier R100	£17.00 + 90p p&p
2 x Duo Type II speakers, pair	£14.00 + £2 p&p
Garrard SP25 Mk. III with CER. diamond cartridge, plinth and cover	£21.00 + £1.50 p&p
Total	£52.00

Available complete for only £49.00 + **£3.50 p&p**

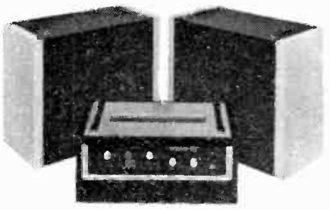
SPEAKERS Duo Type II
Size Approx 17″ x $10\frac{3}{4}$″ x $6\frac{3}{4}$″. Drive unit 13″ x 8″ with parasitic tweeter. Max. power 10 watts. 3 ohms. Simulated Teak cabinet. **£14 pair** + £2 p&p. Duo Type II Size Approx $23\frac{1}{2}$″ x $11\frac{1}{2}$″ x $9\frac{1}{2}$″. Drive unit $13\frac{1}{2}$″ x $8\frac{1}{4}$″ with H.F. speaker. Max. power 20 watts at 3 ohms. Freq. range 20Hz to 20kHz. Teak veneer cabinet. **£32 pair** + £3 p&p

SPECIFICATION R101
14 watts per channel into 3 to 4 ohms. Total distortion @ 10W @ 1kHz 0.1%. P.U.1 (for ceramic cartridges) 150mV into 3 Meg. P.U.2 (for magnetic cartridges) 4mV @ 1kHz into 47K. equalised within ±1dB R.I.A.A. Radio 150mV into 220K. (Sensitivities given at full power). Tape out facilities; headphone socket, power out 250mW per channel. Tone controls and filter characteristics. Bass: +12dB to −17dB @ 60HZ. Bass filter: 6dB per octave cut. Treble control: treble +12dB to −12dB @ 15kHz. Treble filter: 12dB per octave. Signal to noise ratio: (all controls at max) RT101 − P.U.1. & radio − 65dB. P.U.2 − 58dB. **R100** same as RT101 but P.U.2. (for crystal cartridge) 450mV into 3 Meg. Cross talk better than −35dB on all inputs. Overload characteristics 26dB on all inputs. Size $1\frac{3}{4}$″ x 9″ x $3\frac{3}{4}$″.

Viscount III Audio Suite complete

£49

SOUND 50 — 50 WATT AMPLIFIER & SPEAKER SYSTEM



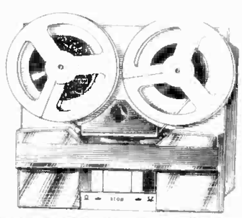
Output Power. 45 watts R.M.S. (Sine wave drive). *Frequency response:* −3 db points 30 Hz at 18 KHz. *Total distortion.* less than 2% at rated output. *Signal to noise ratio:* better than 60 db. *Speaker Impedance.* 3, 8 or 15 ohms. *Bass Control Range:* ±13 db at 60 Hz. *Treble Control Range:* ±12 db at 10 KHz. *Inputs:* 4 inputs at 5 mV into 470 K. Each pair of inputs controlled by separate volume control. 2 inputs at 200 mV into 470K. To protect the output valves, the incorporated fail safe circuit will enable the amplifier to be used at half power. *SPEAKERS:* Size 20″ x 20″ x 10″ incorporating 12″ heavy duty 25 watt high flux, quality loudspeaker with cast frame. Cabinets attractively finished in two tone colour scheme—Black and grey.

COMPLETE SYSTEM £50 Plus £6 P. & P.
Sound 50 amp and 2 speakers

or available separately
Amplifier: £28.50 plus £1.50 P. & P.
Speaker: £12.50 each plus £2.25 P. & P.

CONTINENTAL 4-TRACK, 3-SPEED TAPE DECK

with high impedance heads



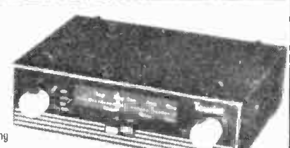
R.C.74 tape deck. Three speeds—$7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ ips. 4-track record/playback head. Plus 4-track erase head. Positive pressure pad system. Takes any tape spool up to and including 7″. The R.C.74 is driven by a powerful 200/250V 50-cycle A.C. motor. A heavy, accurately balanced, flywheel brings wow and flutter levels down to approx. 0.3% total at $3\frac{3}{4}$ and $7\frac{1}{2}$ ips. Fast rewind in both directions.

Controls couldn't be simpler! Just five push buttons that interlock to cut out accidental tape damage. Efficient servo-action type braking. Easy drop-in tape loading.

The R.C.74 comes with an attractive moulded deck cover, which has positions for tone and volume controls. The unit is built into a rigid die-cast frame, and overall size of the whole unit is $12\frac{7}{8}$ x $11\frac{3}{8}$ x 6 inches. Every single deck fully tested before dispatch. Spools not supplied.

Price complete **£15.00.** Plus 75p p. & p.

TOURIST MARK 3 ALL TRANSISTOR CAR RADIO



Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensures excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1 MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3 watts. Pre-aligned I.F. module and tuner together with comprehensive instructions guarantees success first time. 12 volts negative or positive earth. Size 7″ x 2″ x $4\frac{1}{2}$″ deep.

Circuit diagram 13p Free with parts. Speaker, baffle and fixing kit £1.25 extra plus 20p P. & P. Speaker postage free when ordered with parts.

SET OF PARTS
£6.30
Plus 50p P. & P.

R+TV

RADIO & TV COMPONENTS (Acton) LTD
21a High Street, Acton, London, W3 6NG.
323 Edgware Road, London, W.2.
All orders by post to Acton. Goods not dispatched outside U.K. Terms C.W.O. All enquiries S.A.E.

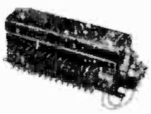
0–8 Ammeter. 2 in. square full vision face for flush mounting. Moving iron instrument. Ideal for charger. Price **43p** each. 10 for **£3·90**.
8 Vol Gramophone Unit. Collaro battery operated with pick up on unit plate. 4 speed auto-stop turnover cartridge. Price **£2·50** plus 40p post and insurance.
Buy Time Slot Meter. Made by Sangamo Weston. 3 types—one for each coin, 2½p, 5p or 10p. Price **£1·75p** each plus 25p post and insurance.
Photo Electric Kit. Contains photo cell, relay, transistor and all parts to make light operated switch. Originally £2. Limited quantity to clear. **£1·25p** plus 20p post and ins.
Desk Hand Mike. Made by Acos. Crystal insert in neat plastic case which opens at right angles for desk or opens completely for hand holding. Good general purpose mike. Price **85p** each.
Printed Circuit Kits. Hagato Pk. 3 facilities in kit form include printing, etching, resist removal, polishing and complete manufacture of printed sets to own specifications. Price **£1·25**+20p.
4 Station Transistorised Interon. Solid state three transistor printed cct. master and 3 sub station push button/press talk system. 200mW output complete with installation accessories and 9v. Everready power pack approx. dimensions. Master 4½×1 1/3×3¼ in. Sub station 3×1½×4 in. Price **£8·50**+20p.
Laboratory Instruments. For horizontal use in strong black reinforced bakelite cases with screw down terminals especially suitable for experiments and demonstrations. All have precision meters (manufacturers quoted accuracy of better than 1·5%). Following available:
D.C. Voltmeter 0–300v. f.s.d. moving coil mirror scale meter size approx. 5×4½×1½ in. Price **£1·75**.
D.C. Voltmeter, 0–30v. f.s.d. moving coil mirror scale meter. Size approx. 5×4½×1½ in. Price **£1·75**.
AC/DC Milliameters 3 range, moving iron mirror scale meter. Range selection 25, 50 and 100mA by selection switch mirror scale (coil resistance marked) size. 7½×5×3½ in. type 359/9/1. Price **£9·75**.
Microammeter 100 Micro Amps f.s.d., moving coil mirror scale precision meter (coil resistance marked) size, 5×4½×2½ in. type M/109/1 Price **£3**.
Galvometer 20–0–20 f.s.d. moving coil precision laboratory instrument of extremely high sensitivity (3×10-7 A per division). Size approx. 6½×3½×2 in. Price **£5**.
Acos. 'G' Meters. For use with Acos transducers and accelerometers or others of any make provided they have a sensitivity of not less than 17·5mv. per g.8 and a linear output over the frequency range under investigation.
This is a precision instrument. It measures 'g' in three steps, 0-10, 0-100 and 0-1000 directly on a large clear meter scale 0-1-. We have two models. Standard Model (ID00I). Price **£12** and:
Auto cutout model (ID00I) which has an inbuilt circuit with relay to trip the external circuit (trip level is adjustable by a control which is virtually linear with the meter scale). The trip load may be up to 2a. Once the circuit has been tripped it can be restored by a reset button. Price of this model is **£18**. Please note also we have Acos Transducers ref. no. ID100I in stock. Price **£4** each.
Parmeko Neptune Series C. Core Transformers. These transformers are beautifully made, steel encased, stove enamelled black, upright mounting. All have normal 50cps. primary 230/240v. with primary screen and are new and unused. Small quantities only of each type available as follows:
Model 6000/79. 275-0-275v. at 330mA. and 6·3v. at 4·6a. Price **£4·50**+50p post.
Model 6000/71.290–215–0–215–290 at 125mA. and 2 at 6·3v. 6a. Price **£4·50**+40p post.
Model 49. 250v. at 10mA. 6·3v. at 3a., 5v. at 0·75a. Price **£2** 30p. post.
Model 47. 620-0-620 at 9mA. 4v. at IA. Price **£4·50** + 40p post.
Parmeko Neptune C. Core Chokes. These are encased and match the transformers above.
Model 6000/73 4H at 560mA. **£2·50** + 40p post.
Model 55. IOH at 1mA. **£2·50** + 40p post.
Model 49. IOH at 70mA. **£1·50** + 30p post.
Model 69. IOH at 110 mA. Price **£2** + 40p post.
Fuse Holders. Heavy duty type B.S.S. 88 440. Reyrolle power fuse holders. English Electric type S.100.1, ex. equipment. Price **50p**.
Fuses. H.R.C. 100A 160A. type EA......Eng. Electric 100A. 160A. type 84TF........Kantark **60** A.. new all at **25p** each.
Electronic Car Ignition. In addition to the kits for 12v. cars we can also supply systems for 6v. cars. These are not kits but made up and ready to work. Price **£5·50** + 30p post
Carbon Resistors. We are now stocking these in a big way and will be pleased to quote special prices to quantity buyers. Made by Erie, Morganite or Dubiliar.

	Price per each			
	1-9	10-99	100-999	1,000 up
¼ Watt	1p	8p	6p	5p
½ Watt	2p	18p	15p	125p
2 Watt	4p	32p	30p	275p

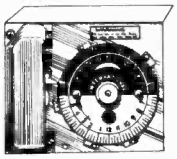
Special Resistor Assortment Offer (1). 100 × ¼ watt resistors made up of 2 each of 50 different values fairly evenly spaced between 1 ohms and 10 megs. Price **50p**.
Special Resistor Assortment Offer (2). 1,000 × ½ watt resistors made up of 20 each of 50 different values fairly evenly spaced between 1 ohms and 20 megs. Price **£4**.
Special Resistor Assortment Offer (3). As offer 1 but 1 watt. Price **£1**.
Special Resistor Assortment Offer (4). As offer 2 but 1 watt. Price **£8**.
12 Way Sub-Miniature Multi-core Cable 7·0076 copper cores each core P.V.C. insulated and of different colour. P.V.C. covered overall and approx. 3/16in. thick. Price **20p** per yard.
Snap Action Slide Switch. Rated 5a. 240v. Made by Arrow. Type fitted in the handles of electric drills, vacuums, etc. **5p** each, 10 for **45p**.
P.E. Gemini Amplifier. This amplifier is a 30 + 30 watt stereo amplifier and pre-amplifier of exceptionally high performance. The performance is certainly equal to anything one can buy no matter what the cost. The P.E. Gemini has been designed for both hi fi applications and for use with discothequs and for this reason, has a microphone input that can be mixed with any other input. The amplifier is designed to be capable of driving two Quad electrostatic speakers and is thus capable of driving any other speakers, provided they are of the correct impedance. We offer the complete kit cabinets at **£45**. Price list including reprint of data. **55p** post paid.
Neon Indicator Lamps. With amber lens, standard type with built in resistor for mains. **10p** each. 10 for **90p**.
Condensers. Another addition to our range. 500uF at 50v. **15p** each. 10 for **£1·25**.
Thermistor Bead Type. For instruments, medical applications, etc. ITT No GL23. **75p** each. 10 for **£6·75**.
3 Core Mains Leads. Special offer this month is a 6ft. lead with 23/36 cores and coloured according to the new code i.e. Brown—live; Yellow/Green—earth; Blue—neutral. Price **8p** each or 10 for **50p**.
Integrated Circuit Mountings. Enables I.C's to be plugged in and out for quick substitution and to prevent damage to soldering. 14 pin type **14p** each or 10 for **£1·26**. 16 pin type **16p** each or 10 for **£1·44**. Note these are suitable for use with printed circuit or vero boards.
Plain Paxolin Panels. Medium thickness. Ideal for fronts and for transistor projects generally.

Size	1	10	Size	1	10
6 × 2	6p	54p	6 × 6....	18p	£1·62
12 × 2	12p	£1·08	12 × 6....	30p	£2·70
6 × 2½....	7p	63p	6 × 8....	21p	£1·89
12 × 2½....	14p	£1·26	12 × 8....	40p	£3·60
6 × 4½....	12p	£1·08	12 × 12....	60p	£5·40
12 × 4½....	24p	£2·16	24 × 12....	£1·00	£9·00

HONEYWELL PROGRAMMER



This is a drum type timing device, the drum being calibrated in equal divisions for switch purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs. per min. Some of the many uses of his timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated signs, Signalling etc. Price from Makers probably over £10 each. Special snip price **£5·75** plus 25p post and ins. Don't miss this terrific bargain.

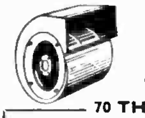


ELECTRIC TIME SWITCH

Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods **£2·50**, post and ins. 23p. Additional time contacts. **50p** pair.

BATTERY CONDITION TESTER

Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese nicad—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace" "weak" or "good." The tester is complete in its case, size 3¾" × 6¼" × 2" with leads and prods. Price **£1·75** plus 20p postage.

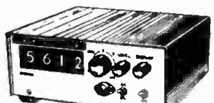


CENTRIFUGAL FAN

Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1/10th h.p. giving considerable air flow but virtually no noise. Approx. dimensions 10¼ in. wide × 12 in. dia. outlet into trunking 10¼ × 4¼ in. **£4·95** plus £1 post and insurance.

70 THINGS YOU CAN MAKE

Send S.A.E. today for list of 70 constructor projects—instruments—alarms—counters—locks—rados, etc., etc.

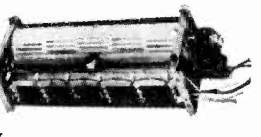


DIGITAL COUNTER TIMER

Very stable and reliable crystal controlled circuit. Capable of work in excess of 15 MHz. Construction simplified by use of 15 integrated circuits. Complete kit of parts **£39·50** or construction data and price list **30p**.

THIS MONTH'S SNIP
IMMERSION HEATERS

Made by G.E.C. 2,750 watts, 200/240v. Complete with fixing ring and two rubber washers. These are beautifully made, copper clad and plated elements which could be used to heat any non-corrosive liquid. Provision is made for a rod type thermostat but this would have to be an unusual type so it might be cheaper to use our contact thermostat at **50p**. Special snip price for element is **40p** each 20p post and insurance. 10 or more post free.



TANGENTIAL HEATER UNIT

This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. **£3·50**. 2kW. Model as above except 2 kW. **£2·50** Don't miss this. Control Switch **35p**. P. & P. 40p.

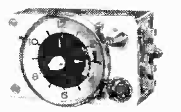
CAPACITOR DISCHARGE CAR IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago. We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price **£4·95** plus 30p post. When ordering please state whether for positive or negative systems. Also available, ready made ignition systems for 6V. vehicles. **£5·25** plus 20p.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, **£2·25** less plug; **£2·50** with fitted 13 amp plug; **£2·65** with fitted 15 amp plug, plus 23p P. & P.

20 AMP ELECTRICAL PROGRAMMER



Learn in your sleep! Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5¾ × 3¾ × 2¼ in. deep. Metal encased, glass fronted with chrome surround. Offered at **£2·40** plus 23p postage and insurance.

INTEGRATED CIRCUITS

A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £ each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices **25p** upwards with circuits and technical data of each. Complete parcel only **£1** post paid or List and all technical data.

BARGAIN OF THE YEAR
MICROSONIC RADIOS

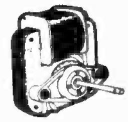
7 transistor Key chain Radio in very pretty case, size 2¾ × 2¼ × 1¼ in.—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superhetrodyne Frequency range: 530 to 1600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency: 465 Kc/s, or 455 Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. **£1·25** plus 13p post and rechargeable batteries 43p per pair. Charger **40p**.

Numicator Tubes. For digital instruments, counters, timers, clocks, etc. Hi-vac XN. 3. Price **£1·45** each. 10 for **£13**.
Pressure Switch. Containing a 15 amp. change over switch operated by a diaphram which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10 in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machines to turn off water when tub has reached correct level but no doubt has many other applications. **50p** each. 10 for **£4·50**.
Papst Miniature Extractor Fans. Beautifully made as are all papst motors. Intended for cooling computers but suitable for any equipment. Size 4⅛in. square and 1⅛in. thick. Price **£2** each. Post and insurance 20p.
Commutator Motor. Small. Size approx. 3 in plus 1 in. of shaft, 3 in. high × 1¾ in. wide, but high speed and very powerful. These motors operate from the mains. Are particularly useful as they can be speed controlled by our thyristor kit or by variable resistor. **£1** each.
Auto Light Kit. The circuit for this appeared in *Practical Wireless*, October issue. It is a simple circuit but has many uses: Parking light, porch light etc. Uses light cell and two transistors. Complete kit, no case **95p**. Suitable case **20p**.
Charger Kit. Comprises of 3 amp. transformer, 5 amp. rectifier and a pair of hefty crocodile clips. With wiring diagram. **£1·40** plus 20p post and insurance.
24 hr. Clock Switch. In metal case with 13 amp. socket Smiths movement, 2 ons and 2 offs per 24 hours. Very neatly made and finished. Original retail price **£7** each. Few only, new and perfect. **£4·00** each.

DRILL CONTROLLER

New 1kW model.

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **£1·50**, plus 13p post and insurance. Made up model also available **£2·25** plus 13p p. & p.



MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at **50p**. Postage 20p for first one then 5p for each one ordered.

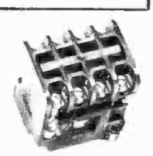
MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **83p**, plus 18p postage.

TREASURE TRACER

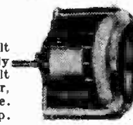
Complete Kit (except wooden battens) to make the metal detector as described editorially in Practical Wireless, August issue. **£2·95** plus 20p post and insurance.

MAINS OPERATED CONTACTOR

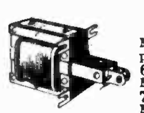


220/240v. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2¼ × 2 × 2 in. **£1** each.

PAPST MOTORS



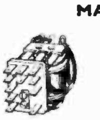
Est. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·50** each. Postage one 23p, two 33p.



MAINS OPERATED SOLENOIDS

Model 772—small but powerful 1" pull—approx. size 1¼ × 1¼ × 1½" **60p**.
Model 400/1 ¾" pull. Size 2¾ × 2 × 1¾" **75p**.
Model TT10 1¼" pull. Size 3. × 2¼ × 2¼" **£1·80** plus 20p post and ins.

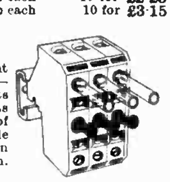
MAINS RELAY BARGAIN



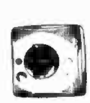
Special this month are some single, double and treble pole changeover relays. Contacts rated at 15 amps. Operating coil wound for 240V. A.C. Good British Make.
Size approx. 1¼×1 ins. Open construction.

Single pole	25p each	10 for £2·25
Treble pole	35p each	10 for £3·15

MAINS CONNECTOR



A quick way to connect equipment to the mains safely and firmly—disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7,029 cables. **85p** each.



LIGHT DIMMER

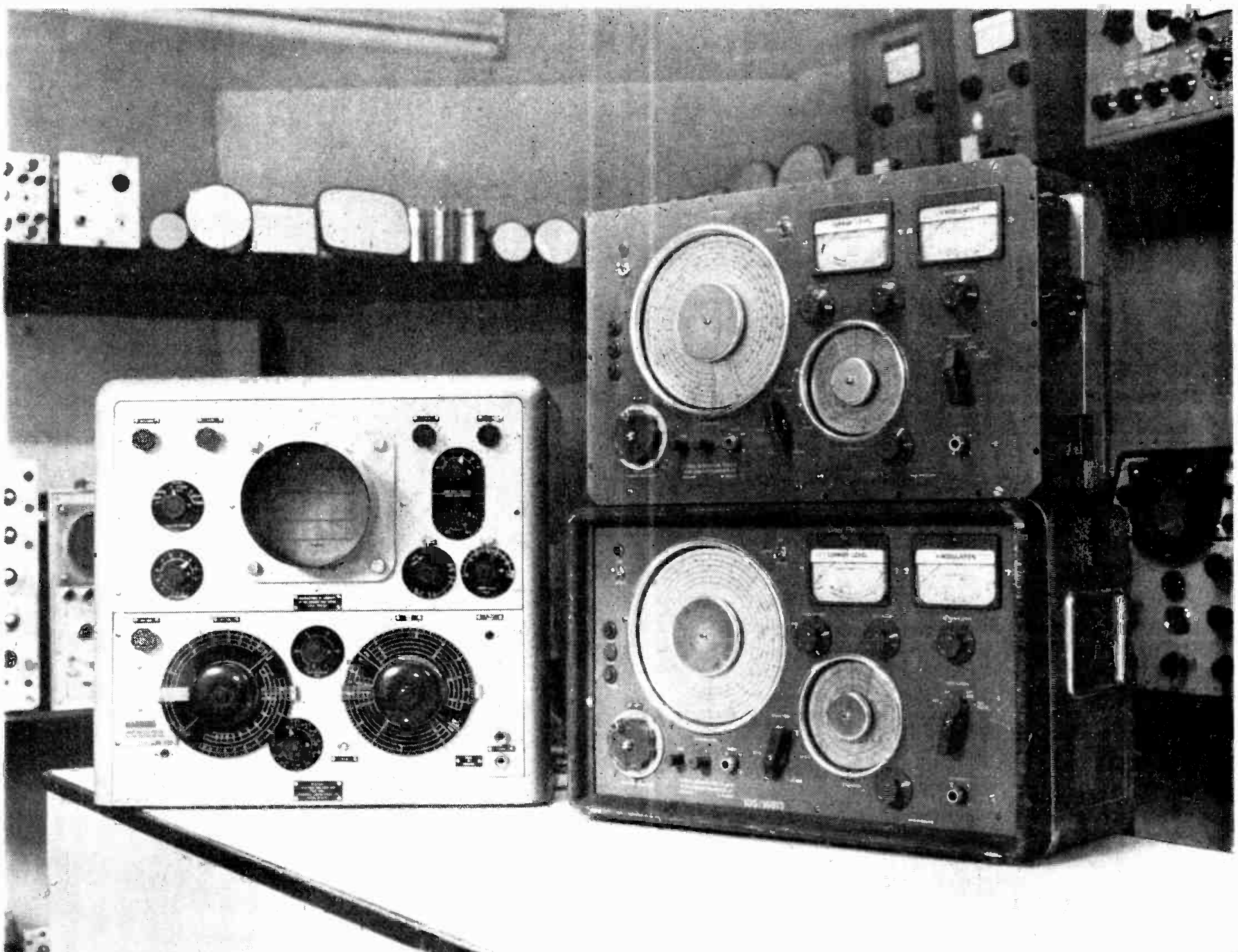
For any lamp up to 200 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price **£1·99** plus 20p post and ins.

A New Service to Readers. A bulletin bringing news of new lines, special snips and "too few to advertise" lines will be posted to subscribers during first week of each month. The bulletin will be called "Advance Advert News" and the Subscription is **60p** per year. Subscribers will also receive our completed 1971 catalogue when this is published.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

J. BULL (ELECTRICAL) LTD.

Dept. W.W.7, Park Street, Croydon, CRO 1YD



MARCONI
Spectrum Analyser
OA 1094
3TTO 30 MHZ
P.O.R.

MARCONI 801B
A.M. Signal Generator
10-500 MHZ Output
0·1μV to 1V.
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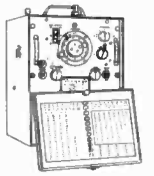
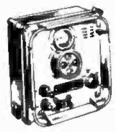
BETTER GET 'SET'



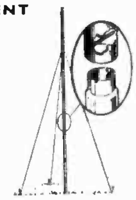
Famous BC.221 Frequency Meter 125 KHZ-20 MHz. Complete with valves, crystal and charts. **Only £13·50.** Carr. £1·50. Less Charts **£6.** Carr. £1·50. Less Charts and Xtal **£5.** Carr. £1·50.

Marconi 801A Signal Generator. 10-310 MHz. In original transit case. **£45.** Carr. £2·50.



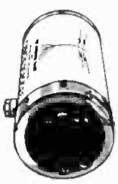
Crystal Calibrator No. 10. Crystal controlled heterodyne wavemeter covering 500 KHz-10 MHz (Harmonics up to 30 MHz). Power required 300V. D.C. 15mA. 12V. 0·3A D.C. Test equipment for 62TM/RC.
Only £4·25. P. & P. 50p.
Few only—No. 62 TM/RC 1·5-10 MHz. **£17·50.** Carr. £2.

AERIAL MAST EQUIPMENT

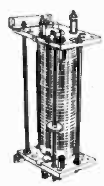


20' Telescopic Masts. £3·75. Carr. £1.
5' 2" extension sections to fit bottom of above mast to increase height. **£1·25** each (any number supplied)
35' Mast. (7—5'2" interlocking sections) with base plate and 12 nylon guys with semi-auto tensioner. **£22·50.** Carr. £2·50.
70' Mast. Ditto. 16 guys, block and tackle. **£45.** Carr. £2·75.

AERIAL RODS. 3 ft. screw-in 1" dia. sections. Brand new, green finish. Suitable for many other uses. **10 for £2.** Carr. 50p. **25 for £5.** Carr. Paid.



R.F. ANTENNA TUNER (A.T.U.) Cylinder design 10" x 4½". Precision calibrated scale. Suitable for tuning most aerials for increased signal strength. A must for serious operators for RC or TM. Full instructions.
Only £1·75. P. & P. 25p.

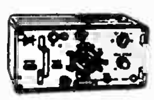


R.F. ANTENNA TUNER (A.T.U.) OPEN TYPE

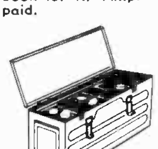
Mounted on ceramic former and feet. "Roller Coaster" design 16G silver or silver plated wheel traversing on wire on ceramic former. Will handle considerable R.F.
In original packing. As used with No. 53 Transmitter. **Only £2·50.** P. & P. 50p.

No. 19 SET TRANSMITTER RECEIVER

No. 19 TM/RC Rebuilt. Complete station with PSU, Cables, Mic., Aerial etc. **£22·50.** Carr. £3.

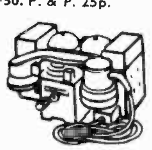


No. 19 SET 500uA Meters. Scaled 0-600 and 0-15v. Brand New, Boxed. **£1·25.** Post paid. (Quantity prices on request.)
R.F. Amplifier. To increase output of No. 19 set. **Only £3·75.** Carr. £1·25. Instruction book for RF Amp. **37½p.** Post paid.



All No. 19 spares in stock. Complete instruction book with circuits for No. 19 equipment. **37½p.** Post paid.
Heavy Duty Batteries. New in metal cases with carrying handles.
6v. 85AH. 13" x 9½" x 7" **£3·25.** Carr. £1·25.

Liquid Prismatic Compasses, 2" dia. **£7·50.** P. & P. 25p.



Famous Tele 'F' Field Telephones. Suitable for Farms, Building Sites, etc. Communication up to 5 miles or more. Rugged construction, will last a lifetime. **Only £5·75 pair.** Carr. £1. (Twin telephone wire for above available—ask for price.)

Ex RAF Periscopes. Made by Kelvin Hughes containing a precision made optics system providing crystal clear wide range vision (2 prisms and 8 lenses). Built in 24v heating circuit to prevent misting and freezing. Approx. 24" long with folding handles and rubber eyepiece. Weight 4lbs. Complete, as new, in instrument case. **Only £5.** Carr. 75p. (Less case—store soiled **£3·75.** Carr. 75p.)

Many other Ex-Govt. Surplus Equipment items in stock. Receivers etc. in small quantities too numerous to mention. Enquiries invited. **List 25p.** Post paid. (Refundable against purchases over £3.)

C.W.O. Carriage charges apply to Mainland only.
Minimum Export Order £50.

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We are a Polish company exporting high stability electronic components which have good mechanical characteristics and long life expectancy.

Valves **Electron Guns**

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Tape Recorder Heads

We can offer production capacity and the ability to produce tape recorder heads to meet our customers' own specifications.

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P.O. Box: 638

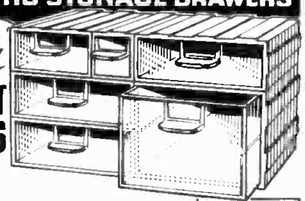
If you are interested, please send for catalogues and quotations.

WW—114 FOR FURTHER DETAILS

I-N-T-E-R-L-O-C-K-I-N-G PLASTIC STORAGE DRAWERS

NEAT! HANDY! TIDY!

DISCOUNT PRICES



5 SIZES ALL INTERLOCK

Newest, neatest system ever devised for storing small parts and components: resistors, capacitors, diodes, transistors, etc. Rigid plastic units, interlock together in vertical and horizontal combinations. Transparent plastic drawers have label slots/handles on front. Build up any size cabinet for wall, bench or table top.

BUY AT TRADE PRICES!

Single units **(1D) £1.35** per dozen size approx (2¼" high 2¼" wide 5" deep) **2D £2.25** per dozen. **3D £2.35** for 8 units. **6D2 £3.65** for 8 units (2 3D's in 1 outer) **6D1 £3.30** for 8 units. Postage/Carriage 35p for orders under £5. Carriage paid for orders over £5.

PLUS QUANTITY DISCOUNTS!

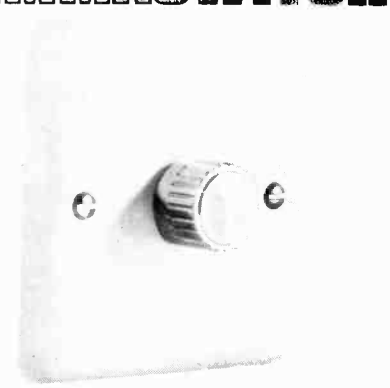
Orders £5 and over DEDUCT 5% in the £
Orders £10 and over DEDUCT 7½% in the £
Orders £20 and over DEDUCT 10% in the £

QUOTATIONS FOR LARGER QUANTITIES

IVORYET LIMITED (Dept.WW 11) 124 CRICKLEWOOD BROADWAY LONDON, N.W.2 TEL. 01-450 4844

Vary the strength of your lighting with a

DIMMASWITCH



The DIMMASWITCH is an attractive and efficient dimmer unit which fits in place of the normal light switch and is connected up in exactly the same way. The ivory mounting plate of the DIMMASWITCH matches modern electric fittings. Two models are available, with the bright chrome knob controlling up to 300w or 600w of all lights except fluorescents at mains voltages from 200-250V, 50Hz. The DIMMASWITCH has built-in radio interference suppression.

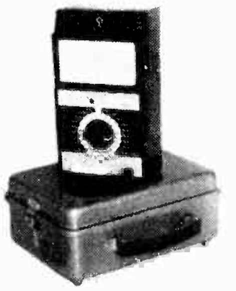
Price: 600w—**£3.20.** Kit form—**£2.70.**
300w—**£2.70.** Kit form—**£2.20.**

All plus 10p post and packing.
Please send C.W.O. to:—

DEXTER AND COMPANY
(4), ULVER HOUSE, 19 KING STREET, CHESTER CH1 2AH TEL: 0244-25883
As supplied to H.M. Government Departments, Hospitals, Local Authorities, etc.

Z AND I AERO SERVICES LTD

ZAERIX BRAND



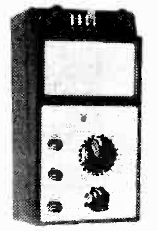
TWO NEW A.C./D.C. MULTIMETERS FROM RUSSIA

TYPE 4312—low sensitivity (667 o.p.v.) extremely sturdy instrument for general electrical use.
D.C. ranges: 0.3-1.5-7.5-30-60-150-300-600-900V and 75mV; 300µa-1.5-6-15-60-150-600mA 1.5-6A.
A.C. ranges: 0.3-1.5-7.5-30-60-150-300-600-900V. 1.5-6-15-60-150-600mA. 1.5-6A.
Resistance: 0.2-3-30kΩ.
Accuracy: D.C. 1%; A.C. 1.5%.
PRICE, with carrying case and leads **£9·75**

TYPE 4313—high sensitivity for general electronic and TV-radio repair applications.
Sensitivity: 20,000 o.p.v. DC and 2,000 o.p.v. AC.
D.C. ranges: 75mV-1.5-3-7.5-15-30-60-150-300-600V. 60-120-600µA-3-15-60-300mA-1.5Amp.
A.C. ranges: 1.5-3-7.5-15-30-60-150-300-600V. 600µA-3-15-60-300mA-1.5A.
Resistance: 0.5-5-50-500kΩ.
Capacity and Transmission level scales.
Accuracy: 1.5% D.C.; 2% A.C.
PRICE, with carrying case and leads **£10·50**.
Both instruments have knife edge pointers and mirror scales.

SOLID STATE LIGHT EMITTING DIODES MV10B

T018 outline. Brightness 500 FT-L at 50mA. Forward voltage 1·65 to 2V. Diode gives bright red pinpoint of light when supplied from a 2V source. Lens diameter 0·170 in. PRICE **£1·05**



AC/DC MULTIMETER AND TRANSISTOR TESTER TYPE U4341

27 AC/DC ranges 0·3-900v DC, 1.5-750v AC; 0·06-600mA DC, 0·3-300mA AC; Resistance 0·5-500k ohms. Transistor collector cut-off current 60 microamps. DC current gain 10-350.

Sensitivity 16700 o.p.v. DC and 3300 o.p.v. AC.

Price complete with probes, leads and steel carrying case, **£10·50.**

INTEGRATED CIRCUITS

TAA263 Direct coupled 3-stage amplifier, up to 600 kc/s. Supply voltage 6-8V. Output 10mW. To72 outline .... .. **£0·75**

TAA293 Medium frequency amplifier up to 600 kc/s. Supply voltage 6V. Output 10mW. To74 outline .. .. **£0·95**

TAA320 MOST stage followed by a bi-polar transistor. Gate-to-source voltage 9-14V. Power dissipation 200mW. .. **£0·65**

TAA570 Four-stage Limiter-amplifier with F.M. quadrature detector and remote D.C. volume control facility. Nominal supply voltage 12V .. .. **£0·95**

WHEN ORDERING BY POST PLEASE ADD £0·12½ (2/6) IN £ FOR HANDLING AND POSTAGE.
NO C.O.D. ORDERS ACCEPTED

TRANSISTORS

Type	£	Type	£	Type	£	Type	£	Type	£
2N404	0.17	2N3054	0.55	AC188	0.30	ASZ18	0.75	BF181	0.25
2N444A	0.25	2N3055	0.75	ACY17	0.275	ASZ20	0.25	BF184	0.25
2N696	0.17	2N3133	0.30	ACY18	0.20	ASZ21	0.40	BF185	0.20
2N697	0.17	2N3134	0.30	ACY19	0.25	BC107	0.125	BF194	0.15
2N698	0.30	2N3391	0.20	ACY20	0.20	BC108	0.125	BF195	0.15
2N705	0.70	2N3391	0.15	ACY21	0.20	BC109	0.125	BF196	0.20
2N706	0.10	2N3393	0.15	ACY22	0.15	BC113	0.25	BF187	0.20
2N708	0.15	2N3394	0.15	AD140	0.50	BC118	0.30	BF200	0.35
2N916	0.40	2N3395	0.20	AD149	0.50	BC134	0.30	BFW87	0.20
2N929	0.22	2N3402	0.15	AD161	0.35	BC147	0.175	BFW88	0.23
2N930	0.25	2N3403	0.15	AD162	0.35	BC148	0.15	BFW89	0.20
2N987	0.30	2N3404	0.15	ADZ11	1.25	BC149	0.15	BFW91	0.20
2N1131	0.25	2N3414	0.20	ADZ12	1.25	BC151	0.15	BFX88	0.25
2N1132	0.25	2N3415	0.15	AF114	0.20	BC152	0.15	BFY10	0.50
2N1184	1.25	2N3416	0.25	AF115	0.20	BC158	0.15	BFY11	0.50
2N1301	0.40	2N3417	0.25	AF116	0.20	BC171	0.20	BFY17	0.40
2N1302	0.175	2N3646	0.40	AF117	0.20	BC175	0.20	BFY18	0.55
2N1303	0.25	2N3702	0.12	AF118	0.45	BC182K	0.20	BFY19	0.60
2N1304	0.25	2N3703	0.12	AF124	0.30	BC186	0.25	BFY50	0.25
2N1305	0.25	2N3704	0.17	AF125	0.25	BC187	0.30	BFY51	0.20
2N1306	0.25	2N3707	0.15	AF126	0.20	BCY30	0.25	BFY52	0.25
2N1307	0.30	2N3709	0.12	AF127	0.20	BCY31	0.40	BSX19	0.175
2N1308	0.25	2N3710	0.12	AF139	0.30	BCY33	0.25	BSY26	0.20
2N1309	0.30	2N3711	0.15	AF178	0.30	BCY34	0.30	BSY27	0.20
2N1613	0.22	2N3819	0.35	AF180	0.35	BCY39	1.25	BSY28	0.20
2N1711	0.25	2N3904	0.35	AF181	0.35	BCY70	0.20	BSY65	0.20
2N1756	0.75	2N3905	0.20	AF186	0.40	BCY72	0.20	BSY95A	0.15
2N1905	2.10	2N3906	0.30	AF239	0.40	BCZ10	0.30	OC16	0.50
2N2147	0.75	AC107	0.50	AFY19	1.00	BCZ11	0.40	OC24	0.60
2N2160	0.65	AC113	0.15	AFZ11	0.45	BD115	0.80	OC25	0.35
2N2217	0.30	AC125	0.30	ASY26	0.25	BD121	0.45	OC26	0.25
2N2218	0.30	AC126	0.20	ASY27	0.30	BD123	0.80	OC28	0.40
2N2219	0.35	AC127	0.20	ASY28	0.25	BD131	0.75	OC29	0.40
2N2369A	0.20	AC128	0.15	ASY29	0.30	BD132	0.85	OC35	0.50
2N2646	0.60	AC132	0.35	ASY54	0.25	BD133	0.80	OC36	0.20
2N2905	0.35	AC151	0.25	ASY74	0.50	BD135	0.80	OC44	0.20
2N2923	0.15	AC153	0.20	ASY77	0.35	BF115	0.20	OC45	0.15
2N2924	0.15	AC154	0.15	ASY82	0.20	BF157	0.80	OC70	0.10
2N2926	0.12	AC157	0.20	ASY86	0.20	BF173	0.20	OC71	0.12
2N3053	0.25	AC169	0.10	ASZ15	0.70	BF178	0.25	OC72	0.25
		AC173	0.25	ASZ16	0.70	BF179	0.30	OC75	0.20
		AC187	0.30	ASZ17	0.75	BF180	0.35	OC76	0.20

FULLY GUARANTEED ZAERIX BRAND FIRST QUALITY VALVES

Type	£
OA2	0.38
OA3	0.45
OA4G	1.00
OB2	0.35
OB3	0.70
OC2	1.00
OC3	0.38
OD3	0.35
1A3	0.35
1A5GT	0.35
1AB5	0.40
1B3GT	0.40
1B24	5.00
1C5GT	0.40
1G4GT	0.50
1G6GT	0.50
1H5GT	0.50
1L4	0.20
1N5GT	0.55
1Q5GT	0.60
1R4	0.45
1R5	0.40
1S4	0.30
1S5	0.30
1T4	0.30
1T5GT	0.50
1U4	0.30
1U5	0.60
1V2	0.50
1X2B	0.50
2A3	0.50
2AP1	2.75
2C26A	0.60
2C40	4.00
2C51	0.45
2CW4	0.70
2D21	0.38
2E24	3.20
2K25	8.00
2X2	0.40
3A4	0.40
3BP1	3.00
3D6	0.25
3D21A	3.00
3Q4	0.50
3Q5GT	0.50
3S4	0.35
3V4	0.48
4-250A	13.50
4-400A	16.00
4B32	4.50
4HA5	0.48
4THA	0.50
5AR4	0.60
5B/254M	2.50
5CP1	5.00
5D21	6.00
5R4GY	0.75
5U4G	0.35

Type	£
5V4G	0.45
5W4GT	0.50
5X8	0.60
5Y3GT	0.40
5Z3	0.60
5Z4G	0.40
6/30L2	0.80
6A8G	0.40
6AB4	0.35
6AC7	0.40
6AF4A	0.55
6AG5	0.22
6AG7	0.40
6AG6	0.50
6AJ8	0.30
6AK5	0.35
6AK5W	0.45
6AK6	0.60
6AL3	0.43
6AL5	0.20
6AM5	0.35
6AM6	0.33
6AN8	0.55
6AQ5	0.38
6AQ6	0.65
6AR5	0.45
6AR6	0.55
6AR11	1.25
6AS5	0.45
6AS6	0.40
6AS7G	0.85
6AT6	0.35
6AU5GTA	1.25
6AU6	0.25
6AV5GTA	0.80
6AV6	0.30
6AW8A	0.60
6AX4GTB	0.60
6AX5GT	0.70
6B4G	1.00
6B7	0.40
6B8G	0.25
6BA6	0.25
6BA6	0.25
6BE6	0.30
6BF5	1.00
6BF6	0.55
6BH6	0.75
6BJ6	0.50
6BK4B	1.25
6BK7A	0.60
6BL7GTA	0.80
6BN6	0.45
6BQ5	0.25
6BQ6GTB	0.75

Type	£
6BQ7A	0.45
6BR7	0.90
6BR8	0.70
6BS7	1.30
6BW6	0.85
6BW7	0.80
6BX6	0.25
6BX7GT	0.85
6BZ6	0.40
6C4	0.33
6CB5A	1.50
6CB6	0.35
6CD6GA	1.25
6CG7	0.55
6CH6	0.60
6CL6	0.55
6CU6	0.75
6CW4	0.65
6CY5	0.45
6CY7	0.70
6D3	0.50
6DC6	0.80
6DK6	0.50
6DQ6B	0.70
6DS4	0.75
6E5	0.60
6EA8	0.60
6EH7	0.30
6EJ7	0.35
6F5	0.75
6F6G	0.35
6F11	0.40
6F13	0.45
6F14	0.70
6F15	0.65
6F17	0.60
6F18	0.50
6F22	0.30
6F23	0.85
6F24	0.75
6F25	1.00
6F28	0.65
6GK6	0.60
6J4	0.50
6J5GT	0.30
6J6	0.20
6J7	0.45
6K6GT	0.60
6K7	0.35
6K8G	0.40
6K8GT	0.50
6K23	0.60
6K25	0.75
6L6GT	0.45
6L7	0.40
6L18	0.45
6LD20	0.50
6N7GT	0.45
6P1	0.60
6P28	0.65
6Q7	0.40

Type	£
6R7G	0.45
6S2	0.40
6S4A	0.65
6SA7	0.40
6SC7	0.75
6SG7	0.40
6SH7	0.40
6SJ7	0.40
6SK7	0.40
6SL7GT	0.35
6SN7GT	0.35
6SQ7	0.40
6SR7	0.40
6SS7	0.30
6T8	0.35
6U4GT	0.65
6U5	0.60
6U8A	0.40
6V6GT	0.40
6X4	0.35
6X5GT	0.40
6X8	0.60
6Y6G	0.70
6Z4	0.40
7B5	0.75
7B6	0.70
7B7	0.50
7F8W	0.90
7S7	1.35
7Y4	0.65
7Z4	0.60
8BW6	0.60
10C2	0.50
10D1	0.55
10D2	0.50
10F1	0.75
10F9	0.60
10F18	0.50
10L1	0.50
10LD11	0.65
10P13	0.60
10P14	1.10
11D3	0.50
11D5	0.50
11E2	3.00
11E3	4.00
12AB5	0.70
12AC6	0.50
12AD6	0.55
12AH7GT	0.35

Type	£
12AL5	0.50
12QA5	0.50
12AT6	0.30
12AT7	0.33
12AU6	0.35
12AU7	0.30
12AV6	0.40
12AV7	0.65
12AX4GTB	0.60
12AX7	0.30
12AY7	0.75
12B4A	0.60
12BA6	0.40
12BA7	0.40
12BE6	0.40
12BH7	0.45
12BY7	0.60
12C8	0.35
12E1	1.80
12E14	4.00
12H6	0.35
12J5GT	0.30
12J7GT	0.50
12K5	0.70
12K7GT	0.40
12K8	0.50
12Q7GT	0.40
12SC7	0.45
12SG7	0.35
12SH7	0.35
12SJ7	0.40
12SK7	0.50
12SN7GT	0.50
12SQ7	0.50
12SR7	0.40
12X4	0.45
20CV	3.15
20D1	0.50
20F2	0.65
20L1	1.10
20P1	0.50
20P3	0.60
20P4	1.10
20P5	1.20
25L6GT	0.50
25Z4G	0.30
25Z6GT	0.85
30A5	0.50

Type	£
30AE3	0.40
30C1	0.30
30C15	0.80
30C17	0.90
30C18	0.80
30F5	0.85
30FL1	0.75
30FL12	1.20
30FL14	0.85
30L1	0.40
30L15	0.85
30L17	0.80
30P12	0.80
30P19	0.85
30PL1	0.75
30PL13	0.93
30PL14	0.90
35B5	0.65
35C5	0.50
35D5	0.75
35L6GT	0.50
35W4	0.35
35Z3	0.70
35Z4G	0.35
35Z5GT	0.50
42	0.50
50A5	0.75
50B5	0.50
50C5	0.50
50CD6G	1.20
50EH5	0.60
50L6GT	0.55
52KU	0.40
53KU	0.70
75B1	0.50
75C1	0.45
80	0.55
83	1.25
85A2	0.50
85A3	0.50
90AG	2.40
90AV	2.50
90C1	0.65
90CG	2.40
90CV	2.40
108C1	0.35
150B2	0.60
150B3	1.50
150C4	0.60
305	0.70

Type	£
310A	1.50
311A	2.00
328A	2.00
329A	1.90
715A	2.50
715C	6.00
723A/B	7.00
725A	16.00
807	0.50
811A	1.60
813	3.75
829B	3.50
833A	17.00
837	1.00
865A	0.75
872A	3.50
884	0.75
927	3.50
931A	4.00
955	0.30
4378	2.00
4687	2.90
5544	8.00
5551A	16.00
5654	0.45
5670	0.50
5751	0.60
5763	0.70
5796	12.00
5814A	0.60
5894	5.50
6072	0.85
6080	1.60
6146	1.60
6146A	2.00
6146B	2.50
6293	3.25
6360	1.25
6883	2.70
6939	2.25
7199	0.80
7586	1.25
7591A	1.00
7895	1.25
9002	0.40
9003	0.50
A1834	0.85
A2293	1.40
AC/HL/DD	0.60
AC/TH1	0.50
AX50	2.25

Type	£
AZ31	0.55
BT5	7.00
C1166	26.00
C1K	5.00
CBL1	0.90
CBL31	1.00
CL4	0.75
CL33	1.30
CY31	0.35
DAF41	0.50
DAF91	0.30
DAF92	0.60
DAF96	0.45
DC90	0.50
DF91	0.30
DF92	0.20
DF96	0.45
DH76	0.45
DH81	0.65
DH101	0.60
DK40	0.60
DK91	0.40
DK92	0.55
DK96	0.50
DL66	1.25
DL68	0.65
DL91	0.30
DL92	0.35
DL93	0.40
DL94	0.48
DL95	0.50
DL96	0.45
DM70	0.45
DY86	0.32
DY87	0.33
DY802	0.35
E55L	2.75
E80CC	1.10
E80CF	1.50
E80L	0.95
E81L	1.15
E83F	1.10
E84L	0.50
E86C	1.00
E88C	1.00
E88CC	0.65
E88CC/01	1.10
E90CC	0.45
E91H	0.70
E180F	1.00
E182CC	1.20

Type	£
E186F	1.25
E188CC	1.00
E280F	2.10
E810F	2.90
EA50	0.20
EA52	4.50
EABC80	0.35
EAF42	0.55
EAF801	0.50
EB34	0.20
EB91	0.20
EBC33	0.50
EBC41	0.55
EBC81	0.30
EBC90	0.35
EBC91	0.30
EBF80	0.40
EBF83	0.40
EBF89	0.30
EBL21	0.60
EBL31	1.50
EC53	0.50
EC86	0.60
EC88	0.60
EC90	0.33
EC92	0.35
EC93	0.25
EC8010	2.25
ECC34	0.40
ECC40	0.65
ECC70	1.00
ECC81	0.33
ECC82	0.30
ECC83	0.30
ECC84	0.30
ECC85	0.40
ECC86	0.75
ECC88	0.40
ECC89	0.50
ECC91	0.20
ECC189	0.65
ECF80	0.35
ECF82	0.35
ECF86	0.65
ECF804	1.65
ECH35	1.00
ECH42	0.75
ECH81	0.30
ECH83	0.45
ECH84	0.45

Type	£
ECL80	0.45
ECL81	0.50
ECL82	0.35
ECL83	0.70
ECL84	0.55
ECL85	0.55
ECL86	0.40
ECLL800	1.65
EF9	0.75
EF37A	1.20
EF39	0.50
EF40	0.50
EF41	0.65
EF42	0.70
EF80	0.25
EF83	0.55
EF85	0.35
EF86	0.30
EF89	0.28
EF91	0.33
EF92	0.25
EF93	0.25
EF94	0.25
EF95	0.35
EF96	0.22
EF97	0.65
EF98	0.65
EF183	0.30
EF184	0.35
EF800	1.00
EF811	1.00
EF812	0.85
EF814	0.75
EH90	0.40
EK32	0.50
EK90	0.30
EL5	0.55
EL33	1.25
EL34	0.45
EL35	0.50
EL36	0.50
EL37	1.60
EL41	0.60
EL42	0.65
EL81	0.55
EL83	0.42
EL84	0.25
EL85	0.43
EL86	0.40
EL90	0.38
EL91	0.35

Type	£
EL95	0.35
EL360	1.15
EL803	1.00
EL821	0.60
EL822	1.30
ELL80	0.75
EM71	0.80
EM80	0.45
EM81	0.60
EM84	0.35
EM85	1.00
EM87	0.70
EN10	4.80
EN11	4.30
EN32	1.50
EN91	0.38
EY51	0.40
EY80	0.55
EY81	0.40
EY83	0.55
EY84	0.60
EY86	0.40
EY87	0.43
EY88	0.43
EZ35	0.40
EZ40	0.50
EZ41	0.50
EZ80	0.27
EZ81	0.29
EZ90	0.35
FG17	5.00
FW4/500	0.75
FW4/800	0.75
GC10B	4.00
GR10M	1.50
GS10C	5.25
GS10D	6.00
GS10H	4.50
GS12D	7.50
GS47X	3.50
GU50	2.60
GY501	0.80
GZ30	0.40
GZ31	0.35
GZ32	0.48
GZ33	0.70
GZ34	0.60
HABC80	0.45
HBC90	0.30

Type	£
HBC91	0.40
HF93	0.40
HF94	0.35
HK90	0.40
HL23	0.50
HL23DD	0.50
HL42DD	0.60
HL92	0.50
HL94	0.50
KT8	2.50
KT36	1.00
KT44	0.60
KT45	2.00
KT66	2.05
KT71	0.55
KT76'	0.50
KT88	2.00
KTW61	1.00
ME91	0.55
MH4	0.50
ML4	0.55
ML6	0.40
MSPEN/7	0.50
MT17	5.00
MU12/14	0.75
N78	1.50
NGT5	9.00
NSP1	4.30
NSP2	4.80
PABC80	0.40
PC86	0.60
PC88	0.60
PC900	0.48
PCC84	0.40
PCC85	0.45
PCC88	0.55
PCC89	0.50
PCC189	0.55
PCC805	0.85
PCC806	0.80
PCE800	0.75
PCF80	0.30
PCF82	0.35
PCF84	0.60
PCF86	0.60
PCF87	0.90
PCF200	0.75

Type	£
PCF201	0.75
PCF800	0.80
PCF801	0.50
PCF802	0.50
PCF805	0.80
PCF806	0.70
PCF808	0.85
PCH200	
PCL81	0.50
PCL82	0.35
PCL83	0.65
PCL84	0.45
PCL85	0.40
PCL86	0.45
PCL88	0.90
PCL200	0.75
PCL800	0.93
PCL801	0.75
PCL805	0.50
PD500	1.30
PEN4DD	0.50
PEN36C	0.75
PEN45	0.75
PEN45DD	0.75
PEN46	0.40
PEN383	0.75
PEN384	0.75
PEN453DD	0.75
PF86	0.65
PF818	0.85
PFL200	0.65
PL33	0.35
PL36	0.55
PL81	0.50
PL82	0.45
PL83	0.45
PL84	0.40
PL302	0.85
PL504	0.80
PL508	0.90
PL509	1.10
PL801	0.80
PL802	0.95
PLL80	0.65
PM84	0.60
PX25	2.50
PY31	0.30
PY33	0.63
PY80	0.40
PY81	0.30
PY82	0.35
PY83	0.38
PY88	0.40
PY500	1.00
PY800	0.40
PY801	0.50

Type	£
PZ30	0.35
QQV02-6	2.25
QQV03-10	1.25
QQV03-20A	5.25
QQV06-40A	5.50
QS83/3	0.50
QU37	2.10
QV03-12	0.70
QY4-250A	13.50
QY4-400A	16.00
R18	0.60
RG3-250A	0.75
RL18	0.50
S130	1.75
S130P	1.75
SP2	0.75
SP4	0.50
SP41	0.60
SP61	0.75
TP22	0.75
TP25	0.50
TT21	3.00
TT22	3.20
U18/20	0.75
U19	3.60
U20	0.75
U25	0.80
U26	0.80
U31	0.60
U37	2.10
U50	0.40
U52	0.35
U76	0.35
U78	0.35
U191	0.75
U201	0.35
U281	0.40
U282	0.40
U301	0.40
U403	0.60
U404	0.60
U801	0.80
UABC80	0.40
UAF41	0.50
UAF42	0.55
UB41	0.60
UBC41	0.50
UBC81	0.40
UBF80	0.40
UBF89	0.35
UBL1	0.60
UBL21	0.65
UC92	0.40
UCC85	0.40

Type	£
UCF80	055
UCH21	0.60
UCH42	0.70
UCH81	0.40
UCL81	0.60
UCL82	0.35
UCL83	0.60
UF9	0.40
UF11	0.50
UF41	0.60
UF42	0.60
UF43	0.60
UF80	0.35
UF85	0.40
UF89	0.40
UL41	0.65
UL84	0.40
UM4	0.50
UM84	0.25
UU5	0.75
UY1N	0.50
UY11	1.00
UY41	0.48
UY82	0.50
UY85	0.40
VLS631	2.00
VP41	0.75
VP133	1.00
VR75/30	0.45
VR105/30	0.38
VR150/30	0.35
VU33	0.75
VU39A	0.75
VU111	0.75
VU120	1.00
VU133	0.75
W729	0.75
X65	0.55
X66	0.55
X76M	0.50
XC11	1.00
XC15	0.25
XC15T	0.40
XC23	0.90
XC25	0.35
XR1-1600	12.00
XR1-3200	8.00
Z329	0.85
Z700U	0.80
Z700W	0.80
Z719	0.25
Z729	0.30
Z749	0.85
Z759	2.00
Z800U	2.00
Z801U	2.00
Z900T	1.00

OUR NEW 1971/1972 CATALOGUE IS NOW READY. PLEASE SEND STAMPED AND ADDRESSED QUARTO ENVELOPE FOR YOUR FREE COPY

PLEASE NOTE THAT VALVES LISTED ABOVE ARE NOT NECESSARILY OF U.K. ORIGIN

Head Office:
44a WESTBOURNE GROVE, LONDON, W.2
Tel.: 727 5641/2/3
Cables: **ZAERO LONDON**
Retail branch (personal callers only)
85 TOTTENHAM COURT RD., LONDON W.2. Tel: 580 8403

A.R.B. Approved for inspection and release of electronic valves, tubes, klystrons, etc.

EXPORT PRICE LIST AVAILABLE FOR LARGE SCALE FOREIGN BUYERS

WE WANT TO BUY:
SPECIAL PURPOSE VALVES. PLEASE OFFER US YOUR SURPLUS STOCK. MUST BE UNUSED.

TELEX 261306

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £8 per single col. inch.
LINE advertisements (run-on): 45p per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 25p.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to THURSDAY, 12 p.m., 4th NOV., for the DECEMBER issue, subject to space being available.

Telecommunications Engineers KENYA

- ★ Salary up to £2,718
- ★ Low Taxation
- ★ Contract 24 months
- ★ Gratuity 25% (45% if leave foregone)
- ★ Education allowances
- ★ Subsidised accommodation
- ★ Appointment Grant £100 or £200 payable in certain circumstances

Required by the Police Department Signals Branch.

The officer will normally be based at the Provincial Headquarters Workshop although he may be required to undertake extensive safari throughout Kenya.

Candidates, 25-58, must have served an approved apprenticeship followed by at least five years' experience in telecommunications engineering. They must hold City and Guilds Certificates or an equivalent qualification and have had experience in two or more of the following: (i) HF transceivers with emphasis on SSB and ISB in fixed mobile and portable roles; (ii) VHF transceivers (AM and FM) used in fixed, mobile and portable roles; (iii) Multiplex equipment in VHF and HF bands together with a knowledge of teleprinters; (iv) Fixed, mobile and portable equipment in the UHF band; (v) Aerial arrays in the HF, VHF and UHF bands.

The ability to train local engineers in practical work would be an advantage.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference number M2k/710927/WF.

Electronic Test Engineers

Pye Telecommunications of Cambridge has immediate vacancies for Production Test Engineers.

The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable.

Pye Telecommications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are therefore excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs. A. E. Darkin,
Pye Telecommunications Limited,
Cambridge Works, Haig Road, Cambridge.
Telephone: Cambridge 51351 Ext. 355

Pye Telecommunications Ltd

BUSINESS OPPORTUNITY

Earn a substantial extra income through a fascinating part-time business of your own that you could share with your wife and operate from your own home. This is an outstanding business opportunity with rewards exceeding £5000 per annum at the higher levels. We are looking for organisational and managerial ability.

Telephone for an appointment

VISTA MARKETING **MAIDENHEAD 28754**

1447

WALSALL & STAFFORDSHIRE TECHNICAL COLLEGE

Applications are invited for the following post, duties to commence as soon as possible:

LECTURER GRADE I in TELECOMMUNICATIONS

Applicants should be prepared to teach Telecommunication Principles and Telephony to the Final Year of the City and Guilds Course in Telecommunication Course C.G.L.I. No. 49, and to assist in the organisation of the Telephony Laboratory.

Qualifications should include the Final Certificate of the C. & G. Course in Telecommunications Technicians and Post Office experience is essential.

SALARY for the above post will be in accordance with the Burnham Further Education Scale, viz. Lecturer Grade I £1,110 to £1,955 per annum with appropriate additions for education and training.

APPLICATION FORM and further particulars may be obtained by applying to the Principal, Walsall and Staffordshire Technical College, St. Paul's Street, Walsall, Staffs. WS1 1XN. Applications should be returned by Monday, 25th October, 1971.

Assistance with cost of removal will be granted in approved cases.

R. D. NIXON,
Secretary to the Joint Education Committee.

1463

PAPUA NEW GUINEA

Vacancies in Telecommunications

The Department of Posts and Telegraphs in Papua New Guinea is currently looking for skilled Telecommunications Engineers and Technicians to help get its $A14 million development programme under way.

This programme provides for an S.T.D. system throughout the entire communications network, and for automatic functioning of the telegraph and telex services, all using the latest equipment available.

Duties

Engineers: Class 3 – Exchange Planning or Telegraph and data equipment maintenance.

Class 2 – Installation of radio external plant, exchange and telephone equipment design, workshop construction.

Senior Telecommunications Technical Officers and Telecommunications Technical Officers Grade 2: A number of positions at both levels of responsibility in the fields of radio station installation and inspection, broadcast and mechanical equipment design and installation, and similar functions in respect of telephone subscriber and exchange equipment. There are also positions involved in management of teleprinter workshop maintenance.

Senior Technical Officer (Mechanics) – responsible for provision of auto-plant, mechanical aids and power plant services.

Telecommunications Technical Officer Grade 1: A number of positions covering maintenance of VHF, HF and Microwave systems, installation of telephone exchange equipment and power plant, manufacture of special telephone equipment, installation and maintenance of telegraph and telex services.

Technicians: Installation and maintenance of radio, or telephone or telegraph equipment.

Qualifications

Engineer: Applicants must be eligible for membership of the Institution of Engineers, Australia (eligibility for membership of Institution of Electrical Engineers, U.K., generally determines this) and have at least 2 years' relevant experience since qualifying.

Senior Telecommunications Technical Officers and Telecommunications Technical Officers: City and Guilds Telecommunications Technician Certificate in Radio, Telephone or Telegraphs, preferably with at least two supplementary certificates and extensive relevant experience.

Senior Technical Officer Grade 1 (Mechanical) – an appropriate technical certificate or diploma is essential, plus extensive mechanical, electrical or automotive experience.

Technicians: City and Guilds Telecommunications Technician Certificate in Radio, Telephone or Telegraphs.

Salaries

Engineers Class 3 (Telecommunications)
$A9601 – $A10,682
Engineers Class 2 (Telecommunications)
$A8150 – $A9070
Senior Telecommunications Technical Officers Grade 1 $A6632 – $A7012
Senior Technical Officers Grade 1 (Mechanics)
$A6632 – $A7012
Telecommunications Technical Officers Grade 2 (Radio – Telephones – Telegraphs) $A6060 – $A6441
Telecommunications Technical Officers Grade 1 (Radio – Telephones – Telegraphs)
$A5175 – $A5919
Technicians (Radio – Telephones – Telegraphs)
$A3952 – $A5175
($A1 = 46½p. stg.)

* An additional $A360 p.a. is payable to married men.

Income tax in Papua New Guinea is currently about half that in the United Kingdom.

Conditions

* 4 year contract engagement
* Fares paid to Papua New Guinea, and to the U.K. on completion of contract
* 3 months' leave after each 21 months' service
* Generous allowances for leave fares to Sydney, accommodation, children and their secondary education.

Apply – with **full** details of qualifications and experience indicating the position in which you are interested, to –

Recruitment Officer,
Public Service Board,
Canberra House,
Maltravers Street,
London WC 2R 3EH
***Telephone:* 01-836 2435.**
Applications close October 29th.

Opportunities with Redifon in Radio Communications

Experienced Test Engineers are invited to write to Redifon with regard to vacancies in our Test Department at Wandsworth.

The salary range for these positions is £1,248–£1,749 plus. The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment from military pack-set to broadcast transmitter, including communications receivers, M.F. beacons, teleprinter terminals, complete radio office installations for the Merchant Marine and mobile H.F. S.S.B. stations. Our Test Engineers have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment.

The work is varied and interesting and offers excellent opportunity to broaden experience in semiconductors S.S.B. and Frequency Synthesis.

Please write in the first instance to
Norman Manion,
The Recruitment Officer, Redifon Limited
Broomhill Road, Wandsworth, S.W.18

REDIFON
A Member Company of the Rediffusion Organisation 1970

1437

BALLS PARK COLLEGE OF EDUCATION HERTFORD

Educational Television Unit

TELEVISION ENGINEER

required for 1st January, 1972, to assist Director of unit and be responsible for operation and maintenance of studio and mobile equipment.

Experience with ½" and 1" V.T.R. equipment essential, together with detailed knowledge vidicon cameras and associated audio and vision mixer facilities.

The person appointed will be expected to organise most of his work without direct supervision, and to consult with staff at the college and at local schools regarding the arrangements for recording and replay of video tapes.

Salary will be on N.J.C. Scale T3/4 with additional allowances for recognised qualifications.

Further particulars and application form from the Principal at the College.

1430

St. George's Hospital, S.W.1 and S.W.17

A SENIOR ELECTRONICS TECHNICIAN or TECHNICIAN

is required for the Department of Medical Physics at the above Hospital. The work is varied and includes design and development of interesting projects in connection with all departments of the Hospital.

Applicants should have, preferably, for the senior position an H.N.C., but other qualifications will be considered. Salary scales, which are at present under review, within the range:

Grade V—£1,035 - £1,335
Grade III—£1,356 - £1,764

Please apply to Mr. G. Davies, St. George's Hospital, Hyde Park Corner, London, S.W.1 or telephone him on 01 235 4343, Ext. 335, for further details.

1426

ASSISTANT TECHNICIAN

for servicing radio sets, tape recorders, cine and still projectors, in educational establishments throughout Berkshire. Vehicle provided for travelling. Salary scale: £1,194 to £1,395 per annum, starting salary depending on experience and qualifications. For further particulars and application form write to: The Director of Education, County Education Office, Shire Hall, Reading RG1 3EZ.

1466

VOCATIONAL TRAINING
CIVILIAN INSTRUCTIONAL OFFICERS, GRADE III
RADIO AND TELEVISION SERVICING

required at

HM BORSTAL, PORTLAND, Dorset.
HM PRISON, THE VERNE, Portland, Dorset.

SALARY: The commencing salary is £1,549 (at age 26); £1,779 (at age 30 or over) rising to £1,960. An additional allowance of £92 a year is also paid. The posts carry the prospect of pensionable employment.

HOURS: A 40 hour, 5 day week is worked with 18 working days annual leave in addition to the usual 9 public and privilege holidays.

QUALIFICATIONS: Full apprenticeship plus at least five years practical experience in the Radio and Television and/or Electronics servicing industry. City and Guilds Certificate (or equivalent) is desirable. Teaching, instructing or colour TV experience are added advantages.

DUTIES: The successful candidates will train inmates in Radio and Television servicing and prepare them for City and Guilds examinations.

One of the candidates selected for the posts at THE VERNE will be required to perform some relief duties at other Prison and Borstal Service establishments.

PLEASE WRITE FOR APPLICATION FORM TO: The Establishment Officer, Home Office, Portland House, 10/10, 33T, Stag Place, London, SW1, stating for which post you apply.

Closing date for the receipt of completed application forms: November 2, 1971.

1457

COLOUR TELEVISION TEST ENGINEER

Rediffusion have a limited number of vacancies for test engineers capable of fault tracing on colour television receivers.

Applicants must have a sound knowledge of transistor and colour receiver circuitry and holders of the R.T.E.B. final certificate will be preferred.

Salary scale according to experience and qualifications.

Applications to: A. E. Cox, Rediffusion Vision Service Ltd., Fullers Way South, Chessington, Surrey.
Tel. 01-397-5411

1488

up to £1741 p.a.
and all the variety you want
as a Radio Technician

Variety is the keyword. As a Radio Technician with the National Air Traffic Services, you would be installing and maintaining a wide range of sophisticated electronic systems and highly specialised equipment. You would be involved with RT, radar, data transmission links, navigation aids, landing systems, closed circuit T.V. and computer installations. All custom-built to meet the stringent operational requirements of air traffic control throughout the U.K.

If you're aged 19 or over and have at least two year's electronics experience, preferably with O.N.C. or C. & G. (Telecoms.), you could qualify for entry to our training course. Your starting salary would be £1,143 (at 19) to £1,503 (at 25 and over), scale max. £1,741 – shift duty allowances. Good career prospects.

Write NOW for full details to:
A. J. Edwards, C.Eng., MIEE,
Room 705, The Adelphi, John Adam Street, London WC2N 6BQ,
marking your envelope
'Recruitment — B/WW/30'.

Not applicable to residents outside the United Kingdom.

NATS
National Air Traffic Services

1274

Careers in EMI
Electronics Service Engineer for work on numerical machine tool equipment

EMI ELECTRONICS LTD., has a vacancy in the Installation and Maintenance Division, for an Engineer to be responsible for the installation, commissioning and maintenance of numerical control equipment for machine tools. He will be based at Hayes, Middlesex, but the position will involve work in the field in the U.K. as well as occasional overseas visits.

Applicants, aged 25-45, should have reached H.N.C. Electronics standard, and should have experience in fault finding on solid state equipment. A knowledge of pneumatics and machine tools would also be an advantage.

Starting salary would be up to £2,000.00 per annum, assistance will be given with removal expenses. Company benefits include free Life Assurance and a contributory Pension Scheme. Please apply in writing, stating brief career details, or ring:—

R. C. Dwyer, Personnel Department
EMI Limited, Hayes, Middlesex.
Tel. No. 01-573 3888 Ext. 632.

International leaders in Electronics, Records and Entertainment

REDIFFUSION
REDIFFUSION VISION SERVICE LTD
ST. HELENS AUCKLAND, BISHOP AUCKLAND Co. DURHAM.

TELEVISION EQUIPMENT ENGINEER

Our rapid expansion of manufacturing facilities at Bishop Auckland has created an opportunity for an Engineer who understands television especially in respect of Test Equipment.

H.N.C. or equivalent preferred but lack of formal qualification will not debar a suitable applicant if he has practical knowledge and experience of Production Methods.

Salary will be by negotiation and assistance will be given towards relocation expenses. Applications which will be treated in confidence should be marked Confidential and addressed to:

Mr. J. Davison, Engineering Manager
at the above address.

'A member Company of the Rediffusion Organisation

New posts available at SOUTHERNGAS H.Q. Southampton

Radio Technician
£1,707-£2,013 p.a.

Will assist with installation and surveying of new radio and trunk network schemes.

Should have H.N.C. Telecommunications or City and Guilds Certificate plus formal training with telecommunications manufacturer or major user plus several years experience; also knowledge of V.H.F., U.H.F., Microwave and Radio Multiplex techniques essential. Ref. P.621/D.

Radio Technician
(Conversion)

£1,596-£1,884 p.a.

Will survey and plan V.H.F. and U.H.F. systems ahead of the Conversion activity.

Applicants should have City and Guilds Final Certificate and have had formal training with a manufacturer or major user and subsequent operational planning experience totalling at least five years. Ref. P.622/D.

SOUTHERNGAS

Salaries within ranges shown according to qualifications, experience and ability. Assistance with cost of moving will be given.

Application forms may be obtained from the Senior Personnel Officer, The Southern Gas Board, 164 Above Bar, Southampton, SO1 ODU, to whom they should be returned by 1st November, 1971. quoting the appropriate reference number.

RADIO OPERATORS

DO YOU HOLD

PMG II OR PMG I OR NEW GENERAL CERTIFICATE

OR

HAD TWO YEARS' RADIO OPERATING EXPERIENCE?

Looking for a secure job with good pay and conditions?

Then apply for a post with the Composite Signals Organization. These are Civil Service posts, with opportunities for service abroad, and of becoming established, i.e., non-contributory pension scheme.

Specialist Training Course (free accommodation) starting April and September 1972 and January 1973.

If you are British born and resident in the United Kingdom, under 35 years of age (40 for exceptionally well qualified candidates), write NOW for full details and an application form from:—

Government Communications Headquarters,
Recruitment Officer,
Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ.
(Telephone: Cheltenham 21491, Ext. 2270).

OXFORD REGIONAL HOSPITAL BOARD

ELECTRONICS TECHNICIANS

required for the areas of Oxford, Aylesbury and Reading.

Salary scales in the ranges:
Senior Technicians: £1797—£2568 pa
Technicians: £1104—£1764 pa
according to qualifications and experience.

Qualifications:
Senior Technicians: HNC (Electronics) or equivalent.
Technicians: ONC or equivalent, HNC (Electronics) advantageous.

Successful candidates will form small teams engaged by Hospital Management Committees for maintenance, repair and modification of a wide range of medical electronics and allied equipment used in hospitals. The posts offer challenging and rewarding work in a new and expanding field. Opportunities available for further study.

Write for further information and application forms to the Secretary, Oxford Regional Hospital Board, Old Road, Headington, Oxford OX3 7LF. Completed applications required by 8th November quoting ref V73/71/G.

1465

JAPANESE RADIOS

Distributors of quality Japanese Radios, Tape Recorders, etc., require experienced repairers.

Tel: 628 6157

1473

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

A. V. AIDS TECHNICIAN required for Language Laboratory. Technician needed to maintain College's modern language laboratory and associated tape recording and duplicating equipment. Experience of relay and transistor circuits and O.N.C. or City and Guilds qualification in electrical engineering or electronics preferred. Duties will involve some operation and maintenance of other recording and projection equipment and a small amount of clerical work involved in keeping maintenance records and advising users of the laboratory. Salary on scale £1,041-£1,410 plus £175 a year London Allowance according to qualifications and experience.—Applications to the Personnel Officer, London School of Economics and Political Science (WW/N1486), Houghton Street, London, W.C.2. to be received not later than 29th October, 1971. [1486

DRAUGHTSMEN. Mechanical and Electrical required by expanding electronics company specialising in lighting control and audio visual products. This position is salaried and gives ample opportunity for advancement. Please apply Electrosonics Ltd., 47 Old Woolwich Road, Greenwich. London, S.E.10. Tel. 858 4784. [22

EXPERIENCED Tape Recorder Engineer—familiar with Revox, Akai, Ferrograph, etc. Good wages and bonus. Telesonic Ltd., 92 Tottenham Court Road, W.1. 01-636 8177. [1425

GRAMPIAN have a further vacancy for a Senior Development Engineer. He must have a proven record of experience and responsibility in audio electronic equipment design and preferably with some knowledge also of transducer design. Qualifications H.N.C., H.N.D. in electronic subjects.—Write in first instance to Grampian Reproduces Ltd., Ref. H.G./1, Hanworth Trading Estate, Feltham. Middlesex. [1454

IF you have had at least 5 years continuous technical experience with an audio equipment manufacturer then GRAMPIAN may be able to offer you a situation of interest appropriate to your ability. We are only interested in people who are truly conscientious and dedicated to this section of industry.—Apply to Grampian Reproduces Ltd., Ref. S.M./1, Hanworth Trading Estate, Feltham, Middx. [1455

JAPANESE Radio importers require experienced engineer for servicing radios and allied goods. Tel. 628 6157. [1432

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T.V. Service Engineer, preferably with some colour experience. A permanent post. Salary according to ability. Hydes of Chertsey Ltd., 56/60 Guildford Street, Chertsey, Surrey. Phone Chertsey 63243. [1367

UNIVERSITY COLLEGE requires ELECTRONICS TECHNICIAN for the construction and maintenance of research equipment involving digital control, computer interfacing, CCTV, and audio techniques. Some metalworking experience an advantage. C. & G. Telecommunications certificate or O.N.C. desirable. Salary £1,041-£1,410 plus £170 London Weighting.—Application form from Personnel Officer (Technical Staff CK2), University College London (WW/N), Gower Street, London WCIE 6BT. [1446

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Find out more by writing to: The Inspector of Wireless Telegraphy, IMTR, Wireless Telegraph Section (WW), Union House, St. Martins-le-Grand, London, EC1A 1AR.

Post Office Telecommunications

RESIDENT COMPUTER ENGINEER

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1467

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City Engineer and Surveyor's Department

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Senior Engineer

(system equipment and data transmission)

£2766—£3180 or £3390

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(c) control displays
(d) equipment and transmission procedures and monitoring.

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Application forms from City Engineer and Surveyor, Broadgate House, Coventry CV1 1NH, returnable by 1st November, 1971.

coventry

1481

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WANTED, surplus transistors, semiconductors, resistors, and radio and TV parts. Please state price.—Velco Electronics, Bridge Street, Ramsbottom. Bury, Lancs. Tel. 070-682 3036. [1456

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0·0047	30V	2p
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0·022	30V	2p
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·0022 MFD	400V	3p
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1 MFD	40V	4p
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33PF	5%	350V	10p
47PF	5%	350V	10p
75PF	5%	350V	10p
82PF	1%	500V	5p
270PF	5%	350V	10p
320PF	5%	350V	8p
390PF	1%	500V	5p
500PF	5%	200V	18p
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33 MFD	10V	10p
33 MFD	35V	35p
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BCY 30	20p
BCY 70	10p
BFY 51	10p
BFX 87	20p
BSX 21	12p
BSX 60	50p
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C 407	25p
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Value µF		Description	Cost each
0·001	30V.	10% Suflex H5	
0·005	250V.	Paper Hunts W95-BD14 or 310 SLM 51	
0·01	250V.	Paper ,,	
0·1	160V.	10% Polyester Film	
0·1	250V.	10% Polyester Film	2p
0·022	250V.	Paper Hunts W95-BD14 or 310 SLM 51	
0·047	20/25V.	Ceramic	
2·5	16V.	Electrolytic	
25	25V.	Electrolytic Hunts AW1515 A00 or MEW 29T	
100	15V.	Electrolytic	
0·47	160V.	Foil Waycom Tropyfol M	4p
2	35V.	Electrolytic Waycom Printilyt I	
5	25V.	Electrolytic Waycom Printilyt I	
10	25V.	Electrolytic Waycom Printilyt I	
250	25V.	Electrolytic Hunts MEF 35BT	
1	160V.	Foil Waycom Tropyfol M	
1	250V.	Polyester	
1·5	20V.	Tantalum	8p
12·5	25V.	Electrolytic	
1·5	35V.	Tantalum	
2·2	35V.	Tantalum	
2·7	35V.	Tantalum	
3·3	100V.	Polycarbonate S.T.C. PMA 3·3K 100	
3·3	35V.	Tantalum	15p
3·9	35V.	Tantalum	
4·7	35V.	Tantalum	
4·7	63V.	Polycarbonate Waycom MK5	
5·6	35V.	Tantalum	
8·2	20V.	Tantalum	

Price each in quantities 1-100

SEMI-CONDUCTORS

		Description		Cost each
Diode	15921	Texas		2·5p
Zener Diode	C7V5	Mullard BZY88		
Zener Diode	C6V2	Mullard BZY88		
Zener Diode	C9V1	Mullard BZY88		
Zener Diodes	C4V7	Mullard BZY88		
Zener Diode	C8V2	Mullard BZY88		
Transistor	2N3704	Texas Silec		7·5p
Transistor	2N4062	Texas Silec		
Transistor	2N3711	Texas Silec		
Transistor	2N3708	Texas Silec		
Transistor	2N3702	Texas Silec		
Transistor	2S 302			20p
Transistor	OC 28	Mullard		40p

Price each in quantities 1-100

POTENTIOMETERS

Value	Description	Cost each
1K	Pre-set ISKRA PN11B	
2K	Pre-set ISKRA PN11B	
2K5	Pre-set ISKRA PN11B	2·5p
50K	Pre-set ISKRA PN11B	
100K	Pre-set ISKRA PN11B	
1K	Welwyn Pre-set P345	
10K	Welwyn Pre-set P345	3·5p
50K	Welwyn Pre-set P345	

Prices each in quantities 1-100

THERMISTORS

Description	Cost each
VA 10665 Mullard	5p
Ziemens Halske K273 1·2KΩ at 60°C, 2·8 KΩ at 20°C (Nom.)	20p

Prices each in quantities 1-100

½ WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
22	5	ISKRA UPM	
56	5	ISKRA UPM	
100	5	ISKRA UPM	
150	5	ISKRA UPM	
180	5	ISKRA UPM	
220	5	ISKRA UPM	
270	5	ISKRA UPM	
560	5	ISKRA UPM	
820	5	ISKRA UPM	
6K8	5	ISKRA UPM	35p
8K2	5	ISKRA UPM	
33K	5	ISKRA UPM	
1M2	5	ISKRA UPM	
1M5	5	ISKRA UPM	
2M7	5	ISKRA UPM	
3M3	5	ISKRA UPM	
3M9	5	ISKRA UPM	
4M7	5	ISKRA UPM	
82	2	ELECTROSIL TR5	
91	2	ELECTROSIL TR5	
150	2	ELECTROSIL TR5	
270	2	ELECTROSIL TR5	
390	2	ELECTROSIL TR5	
910	2	ELECTROSIL TR5	
1K2	2	ELECTROSIL TR5	
1K5	2	ELECTROSIL TR5	
1K8	2	ELECTROSIL TR5	
2K4	2	ELECTROSIL TR5	100p
2K7	2	ELECTROSIL TR5	
3K3	2	ELECTROSIL TR5	
3K9	2	ELECTROSIL TR5	
4K5	2	ELECTROSIL TR5	
5K1	2	ELECTROSIL TR5	
6K2	2	ELECTROSIL TR5	
8K2	2	ELECTROSIL TR5	
9K1	2	ELECTROSIL TR5	
13K	2	ELECTROSIL TR5	
15K	2	ELECTROSIL TR5	

Prices per 100 in quantities 100-10,000

¼ WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
33	5	MULLARD B803104 NB	
47	5	ISKRA UPM	
68	5	ISKRA UPM	
150	5	ISKRA UPM	
220	5	ISKRA UPM	
270	5	ISKRA UPM	
330	5	ISKRA UPM	
390	5	ISKRA UPM	
470	5	ISKRA UPM	
680	5	ISKRA UPM	
820	5	ISKRA UPM	
1K	5	ISKRA UPM	
1K2	5	ISKRA UPM	35p
8K2	5	ISKRA UPM	
10K	5	ISKRA UPM	
220K	5	ISKRA UPM	
820K	5	ISKRA UPM	
1M2	5	ISKRA UPM	
2M7	5	ISKRA UPM	
4M7	5	ISKRA UPM	
5M6	5	ISKRA UPM	
3K9	10	MORGANITE	
1M8	10	ISKRA UPM	
2M2	10	ISKRA UPM	
6M8	10	ISKRA UPM	
1K	2	ELECTROSIL TR4	
1K2	2	ELECTROSIL TR4	
2K2	2	ELECTROSIL TR4	100p
2K7	2	ELECTROSIL TR4	
12K	2	ELECTROSIL TR4	
18K	2	ELECTROSIL TR4	

Prices per 100 in quantities 100-10,000

¼ WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
150	5	MULLARD B803104NB	
220	5	MULLARD B803104NB	
330	5	MULLARD B803104NB	
820	5	MULLARD B803104NB	
1K2	5	MULLARD B803104NB	
1K5	5	MULLARD B803104NB	
1K8	5	MULLARD B803104NB	
2K2	5	MULLARD B803104NB	
3K3	5	MULLARD B803104NB	
5K6	5	MULLARD B803104NB	
6K2	5	MULLARD B803104NB	
6K8	5	MULLARD B803104NB	
8K2	5	MULLARD B803104NB	
10K	5	MULLARD B803104NB	
11K	5	MULLARD B803104NB	
12K	5	MULLARD B803104NB	
15K	5	MULLARD B803104NB	
18K	5	MULLARD B803104NB	
22K	5	MULLARD B803104NB	
27K	5	MULLARD B803104NB	35p
33K	5	MULLARD B803104NB	
39K	5	MULLARD B803104NB	
47K	5	MULLARD B803104NB	
56K	5	MULLARD B803104NB	
82K	5	MULLARD B803104NB	
100K	5	MULLARD B803104NB	
120K	5	MULLARD B803104NB	
150K	5	MULLARD B803104NB	
180K	5	MULLARD B803104NB	
220K	5	MULLARD B803104NB	
270K	5	MULLARD B803104NB	
390K	5	MULLARD B803104NB	
470K	5	MULLARD B803104NB	
820K	5	MULLARD B803104NB	
1M	10	MULLARD B803104NB	
1M2	10	MULLARD B803104NB	
1M5	10	MULLARD B803104NB	
3M3	10	MULLARD B803104NB	
1K2	2	ELECTROSIL TR5	

Prices per 100 in quantities 100-10,000

6 WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
22	10	WELWYN W22	750p

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Any parcel of components will be made up to suit customer's requirements. Termsare cash with order. P. & P. 10p on orders less than £5·00. Quantity discount 5% on orders over £25·00, 10% on orders over £50·00, 12½% on orders over £100·00, negotiable on orders over £250·00.

We also offer for sale the following equipment, much of it less than 2 years old and all in good 'as used' condition.

	Quantity	Price each
Oscilloscopes and accessories		
Telequipment type D43R	2 off	£85
Tektronic plug in unit Type H	1 off	£45
Power supplies		
Electronic Industries Ltd. (APT) type TSU 512 pre-set 12V. DC 5 amp	3 off	£40
Electronic Industries Ltd. (APT) type TSU 1012 pre-set 12V. 10 amp	5 off	£30
Advance Static Investor type IVS 5A. Input 24/28V. DC output 220/240V. AC. 500W	1 off	£75
Brico P.S.U. 440V. 3ph 11 and 16V. DC 20 amp	1 off	£30
Coutant A.S.B. 2000. 6-30V. DC 20 amp	2 off	£95
Coutant A.S.B. 1000. 6-15V. DC 10 amp	2 off	£50
Coutant A.S.B. 500. 9-16V. DC 5 amp	1 off	£35
Francis 440V. AC 3ph. 12V. DC 50 amps (brand new)	2 off	£50
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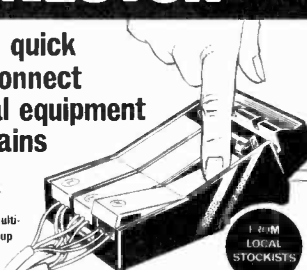

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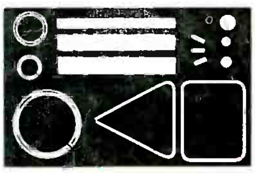

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