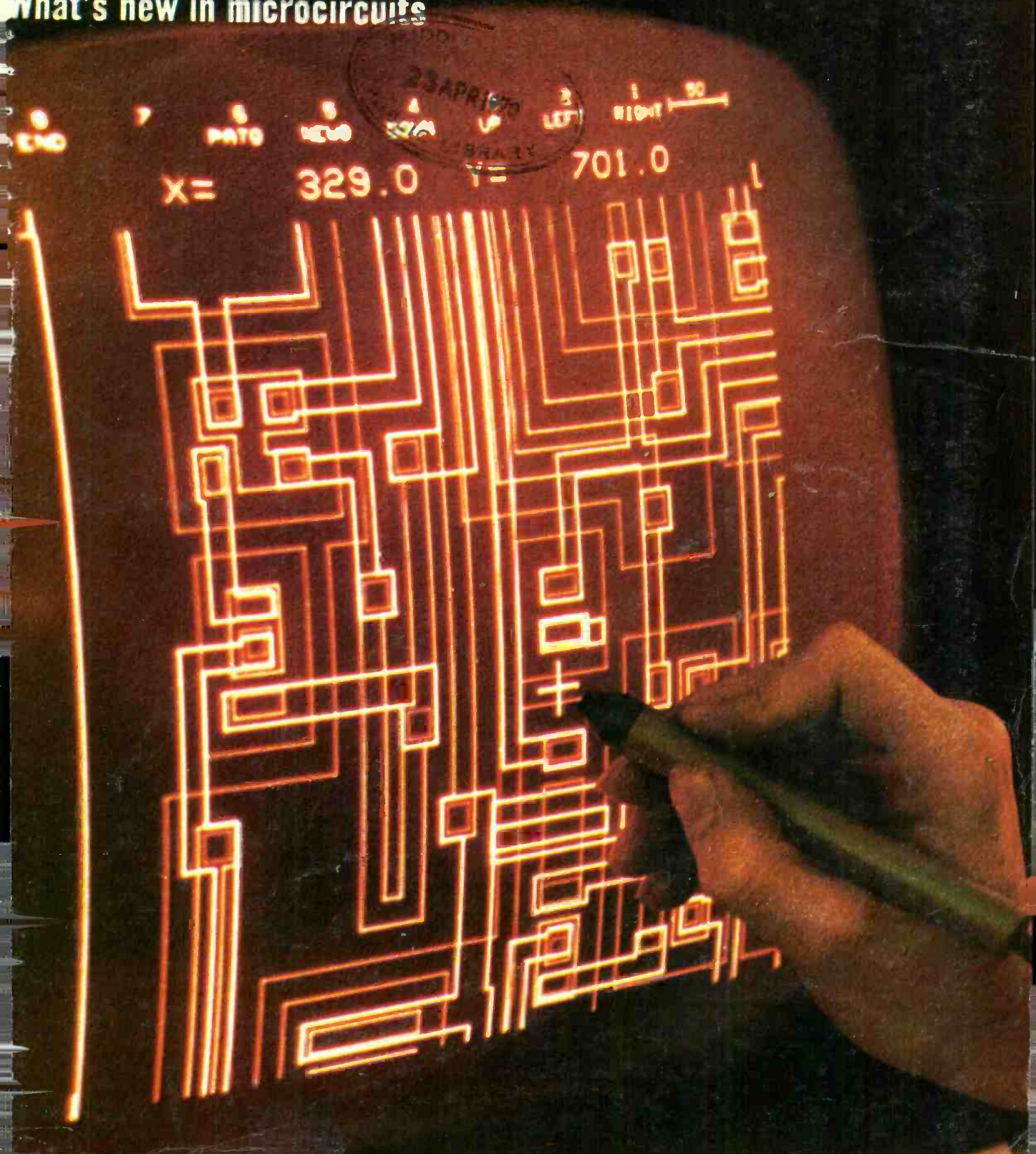
Wireless World

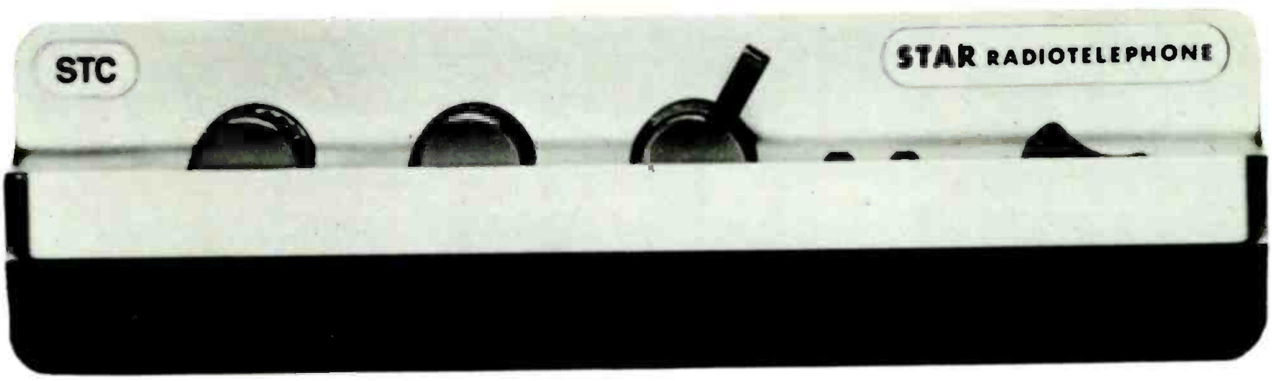
May 1970 3s 6d

Building a low-cost horn speaker

What's new in microcircuits



A new STAR is born



STC announces a new AM VHF version of the STAR Mobile Radio Telephone series.

The new Star AM7 is designed expressly for British VHF bands. It is completely solid state and meets the latest Ministry of Posts and Telecommunications 12.5 kHz specifications. It incorporates the outstanding features that are making the Star UHF range so successful, combining excellent performance with elegant appearance and outstanding speech qualities. Star mobile equipment has no relays or moving parts.

For more information about the Star AM7 or Star UHF series, post the coupon today.

STC Mobile Radio Telephones Ltd., New Southgate, London N.11. Tel : 01-368 1200. Telex : 261912.

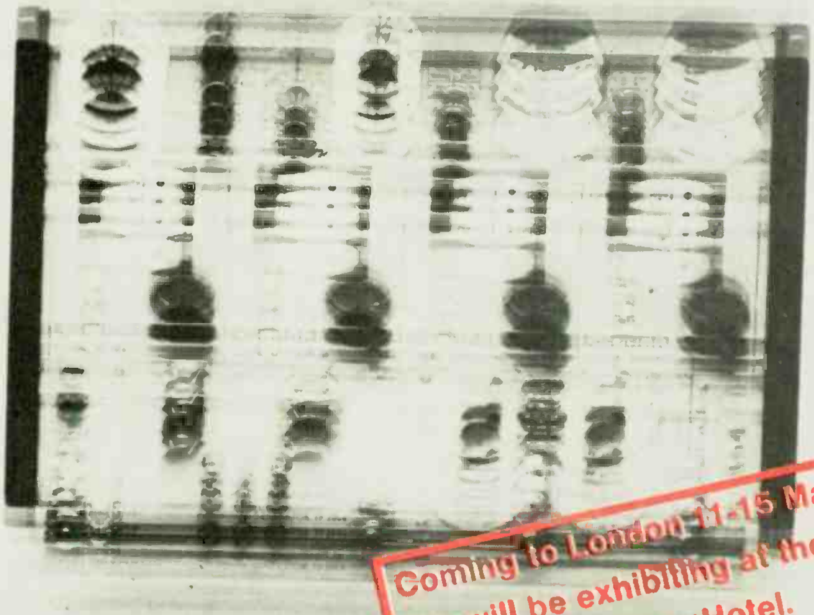
Attach your letterheading to this panel.
Please send me full details of your STAR MOBILE VHF RADIOTELEPHONE
Name...
Position.....................................
W.W.2

an associate of ITT

STC
Mobile Radiotelephones

WW—001 FOR FURTHER DETAILS

The beginning



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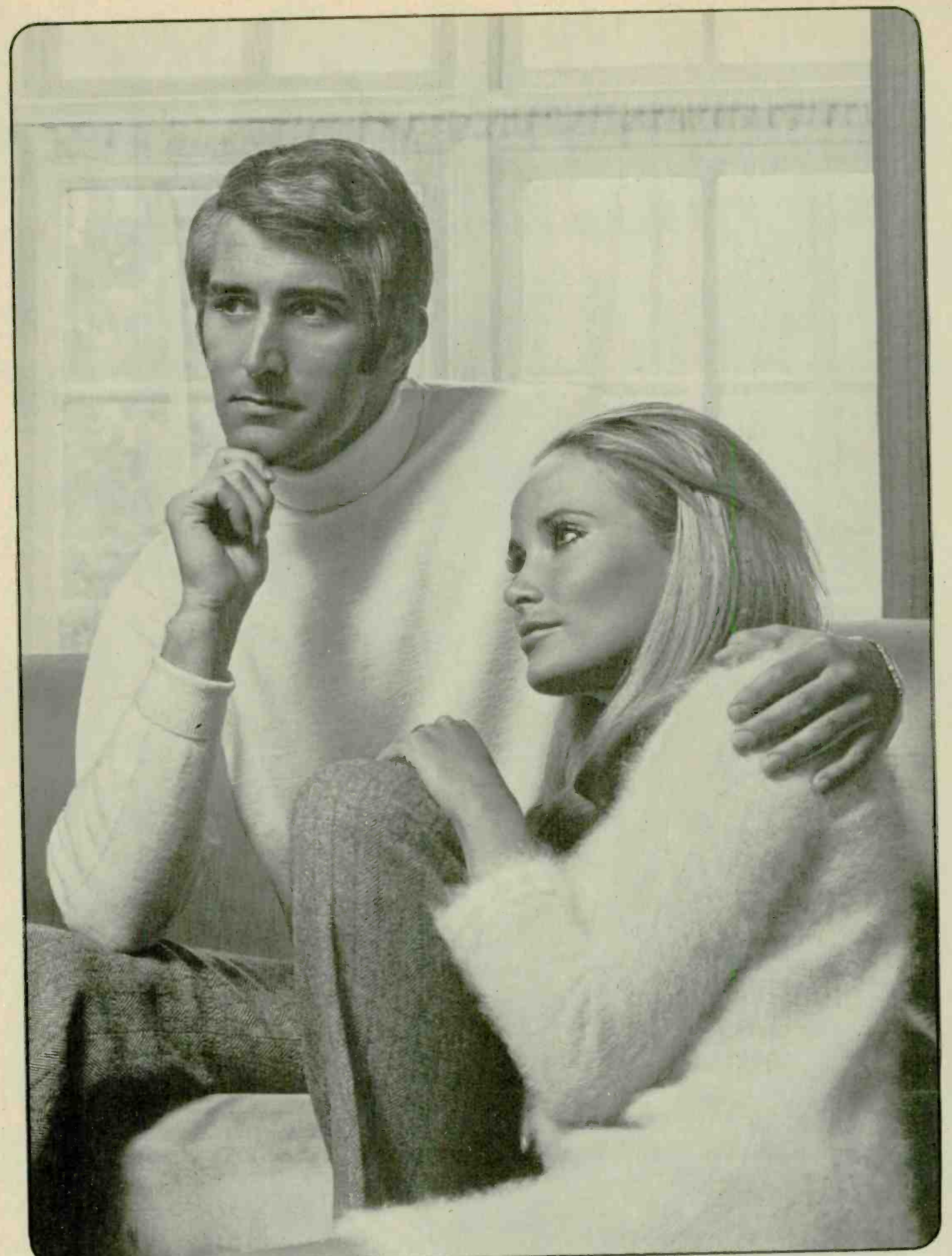
WW—006 FOR FURTHER DETAILS



From L to X-band for marine, airborne and ground radar

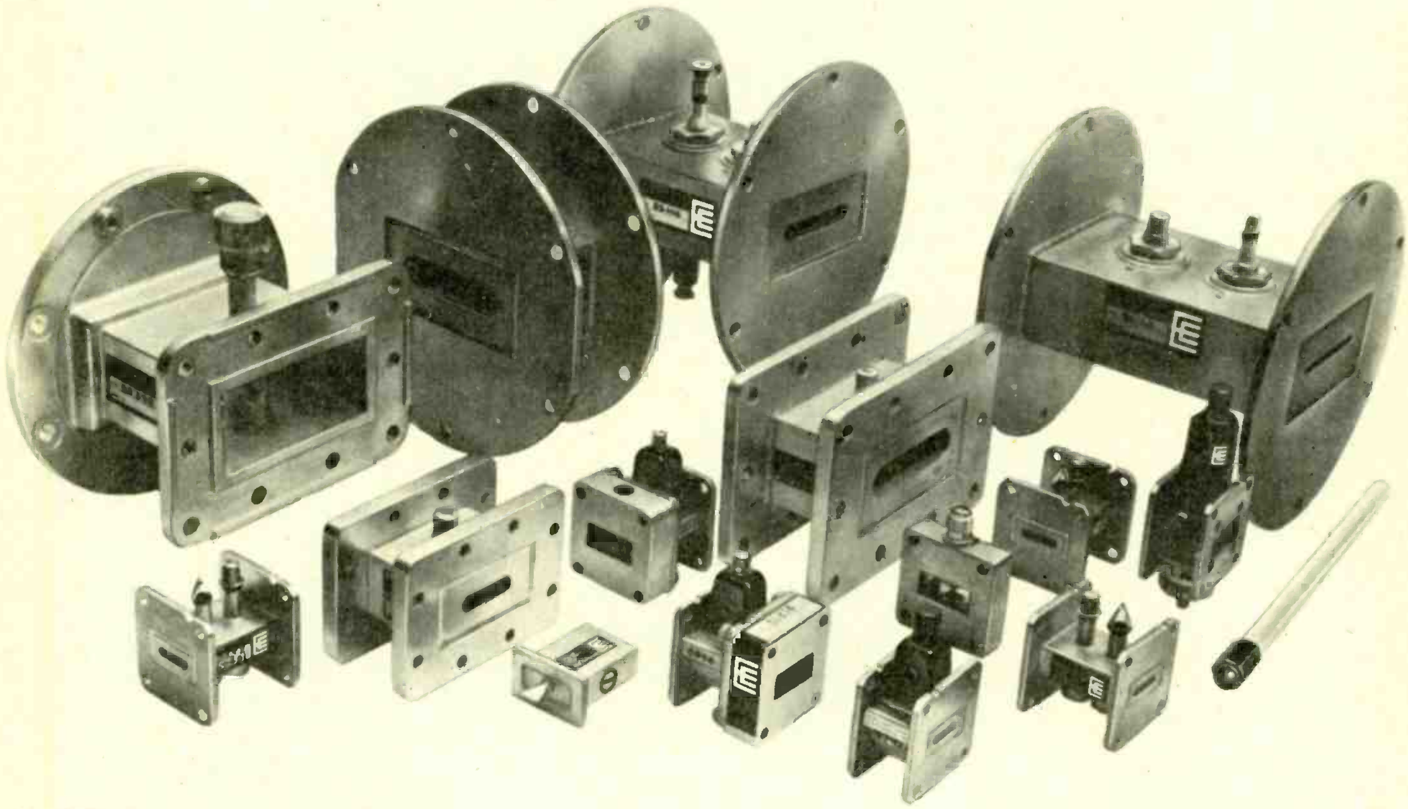
The standard range of EEV duplexer components covers applications from L to X-band marine, airborne and ground radar systems. TR cells, TB cells, pre-TR cells, solid state limiters, monitor diodes . . . whatever your requirement, in narrowband, broadband or tunable types, EEV have it. Or, if it's a 'special' you need, we can almost certainly make it.

The precision manufacture of duplexers forms only part of EEV's massive experience in the whole field of radar. And we have delivery and service to match our capability.

If you would like a copy of the EEV guide 'Duplexer Devices'–or if you are interested in a particular component–then please post the coupon.

English Electric Valve Co. Ltd. Chelmsford. Essex England. Telephone: 0245 61777. Telex: 99103 Grams: Enelectico Chelmsford

see EEV's duplexer devices.



Product	Type No.	Band	Frequency range (MHz)	Peak power (kW)
Pre TR cells	BS834	—	2000–12000	2500
	BS870	L	1240–1370	2500
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	BS824	S	2700–3100	250
	BS856	C	5300–5700	250
	BS156	X	9000–9600	200
	BS452	X	9310–9510	100
	BS810	X	9250–9550	75
TB cell	BS310	X	9375	5–200
TR Limiter cell	BS814	X	9000–9700	200
Solid state microwave switches	BS392	S	2925–3075	0.5
	BS460	X	any 100 MHz	0.5

To: English Electric Valve Co. Ltd., Chelmsford, Essex, England.
Please send a copy of 'Duplexer Devices'.
I am interested in a device with the following parameters:

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Name & Position ______

Company ______

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Tel. exchange or code ______

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ENGLISH ELECTRIC VALVE CO LTD

WW—008 FOR FURTHER DETAILS

CRC2

TRIO's New JR-310 SSB Professional Perfection for Amateur Enjoyment

JR-310

SSB COMMUNICATIONS RECEIVER

* High-stability VFO of 2 FET's and 2 transistors and easily handles QSO's for hours. * Precision double gear dial—a TRIO innovation —with linear frequency variable capacitor. Possible to get finer reading 1KHz. One dial rotation covers 25KHz, makes SSB demodulation easier. * Frequency range covers entire amateur band from 3.5MHz to 29.7MHz. One-touch selection system switches bands. WWV reception of 15MHz possible. * MHz band circuit structure patterned on Collins type double conversion system so first oscillation is by crystal control, second local oscillation by VFO.

SPECIFICATIONS OF JR-310

* FREQUENCY RANGE: 3.5-29.7MHz (7 Bands)
* SENSITIVITY: 1μV (at 10dB S/N)
* IMAGE RATIO: More than 50dB
* FREQUENCY STABILITY: ±2KHz in 1–60min. after switching on, subsequently within 100Hz per 30min.
* Dimensions: 13"(W), 7-3/32"(H), 12-3/16"(D).

Model SP-5D

COMMUNICATION SPEAKER

* Communications Speaker which has been designed for use with the 9R-59DE.
* Dimensions: 3-9/16"(W), 7-1/8"(H), 5-3/16"(D).

Model 9R-59DE

BUILT IN MECHANICAL FILTER 8 TUBES COMMUNICATION RECEIVER

* A mechanical filter enabling superb selectivity with ordinary IF transformers. * Frequency Range: 550KHz to 30MHz (4 Bands) * Sensitivity: 2μV for 10dB S/N Ratio (at 10MHz) * Selectivity: ±5KHz at −60dB (±1.3KHz at −6dB). When using the Mechanical Filter * Dimensions: Width 15", Height 7", Depth 10"

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WW—009 FOR FURTHER DETAILS

You can view X-ray pictures in daylight using only a 5 micro-Röntgen dosage

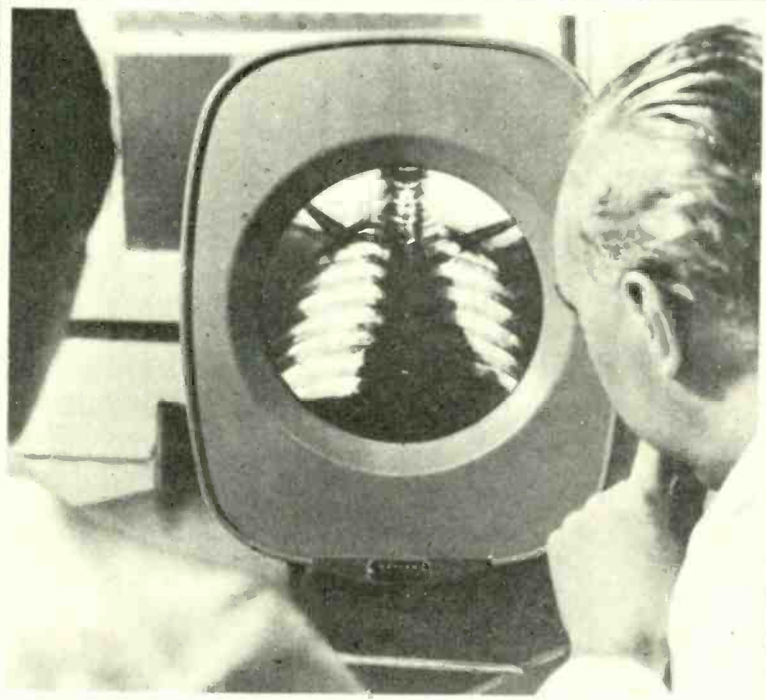
What would it mean to you? An X-ray picture that is so bright you can view it in direct daylight as it happens. EEV's Image Isocon is now being used in X-ray equipment for this very purpose – reducing X-ray dosages to as little as 5 micro-Röntgens, allowing longer exposure times for 'live' X-ray picture study, saving time by eliminating the need for operators' eyes to become 'dark-adapted'.

The Image Isocon is so sensitive that it can convert a very low dosage-level picture to a bright, clear picture on a cathode-ray tube. This in turn means simple direct-from-screen photography.

The Image Isocon is another product of EEV advanced tube technology. For complete data, please post the coupon.

English Electric Valve Co Ltd Chelmsford, Essex, England. Telephone: 0245 61777. Telex: 99103. Grams: Enelectico Chelmsford.

with the EEV Image Isocon



To: English Electric Valve Co Ltd Chelmsford, Essex, England.
Send for full details of EEV Image Isocon range.

Name & position

Company

Address

Tel. exchange or code

Number Ext.

ENGLISH ELECTRIC VALVE CO LTD

WW—010 FOR FURTHER DETAILS

Take a filter tip from us

on how to suppress interference from kHz to GHz

Effective elimination of electro-magnetic interference produced by ancillary electrical equipment is of paramount importance in present day communication and signalling systems. Erie Broadband Filters and Filtercons provide the highest attenuation, at the lowest cost, in the smallest package. In less than 1 cubic centimetre they can offer, typically, an insertion loss of 80 dB minimum in the range 1·50 kHz to over 10 GHz.

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ERIE R.F.I. FILTER DEVICES

WW—013 FOR FURTHER DETAILS

P3

Experience:

Since the beginning of industrial r.f. heating, EEV have been the pace-setters. With this experience, backed by our equal know-how in the transmitter valve field, is it any wonder that we are so well known for power triodes?

EEV make power triodes for industrial heating applications from 1kW up to 250kW. They are all conservatively rated and realistically designed to give good length of life. Whatever your application—for drying paper, baking biscuits, welding plastic, treating metal—r.f. heating the EEV way is economical and dependable.

Our sales engineers are at your service to discuss designs and to recommend the best tube or combination of tubes for your particular application.

For full details just post the coupon or telephone Mr. M. J. Pitt.

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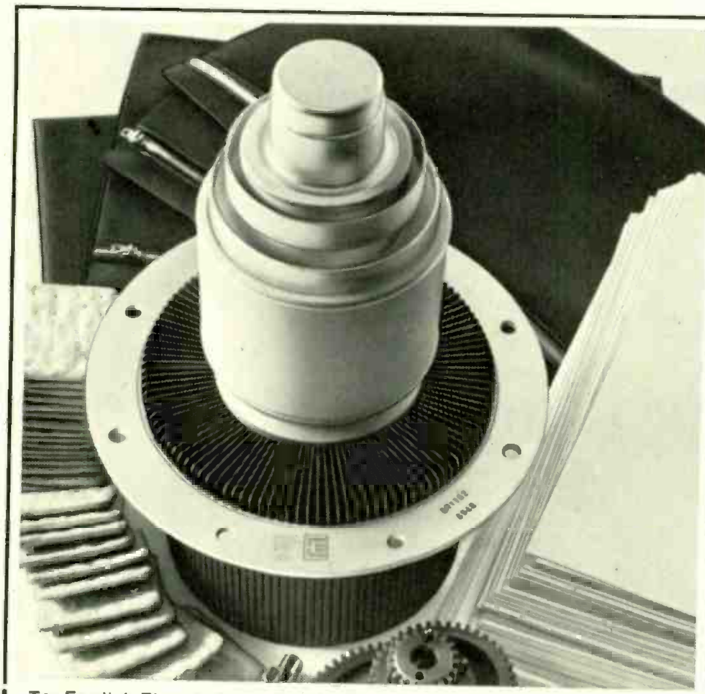
the vital factor of EEV's industrial r.f. heating power triode range



To: English Electric Valve Co Ltd, Chelmsford, Essex, England.
Please send full data on power triodes for industrial heating.
Please recommend triodes for an equipment with these ratings.
Output power (kW) ____ *Anode voltage max. (kV)* ____ *Frequency (MHz)* ____

Name & Position ____

Company ____

Address ____

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Telephone exchange or STD code ____

Number ____ Extension ____

WW—014 FOR FURTHER DETAILS

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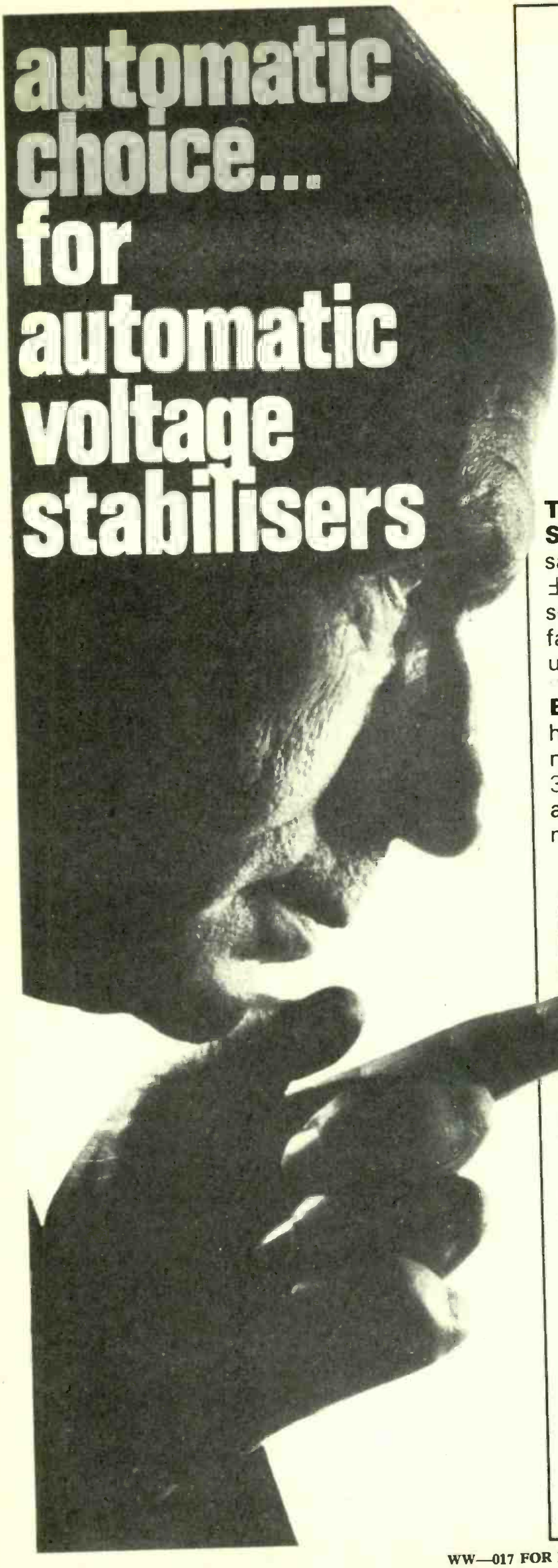

TS Distortionless Servomechanical Stabilisers provide high-speed, accurate stabilisation without distortion of waveform. Accuracy ±0·25%. Correction speed up to 60/100 volts per sec. Unaffected by load, frequency or power factor variations. 1 to 120 kVA single phase and up to 360 kVA three phase.

BTR Solid-State Electronic Stabilisers give high accuracy with extremely low distortion and no moving parts. Basic models: ±0·3% accuracy, 3% max. distortion without any filtering. Unaffected by load or frequency variations. Filtered models also available. 400 VA to 10 kVA.

Claude Lyons

CVR Constant Voltage Regulators offer considerable advantages over conventional constant voltage transformers at remarkably low cost. ±0·3% accuracy, 3·5% max. distortion without any filtering. Unaffected by load or frequency variations. 360, 600 and 1200 VA.

The range also includes VB tap-changing types and PST high-current stabilised d.c. supplies.

For full details write to Publicity Department, Hoddesdon.

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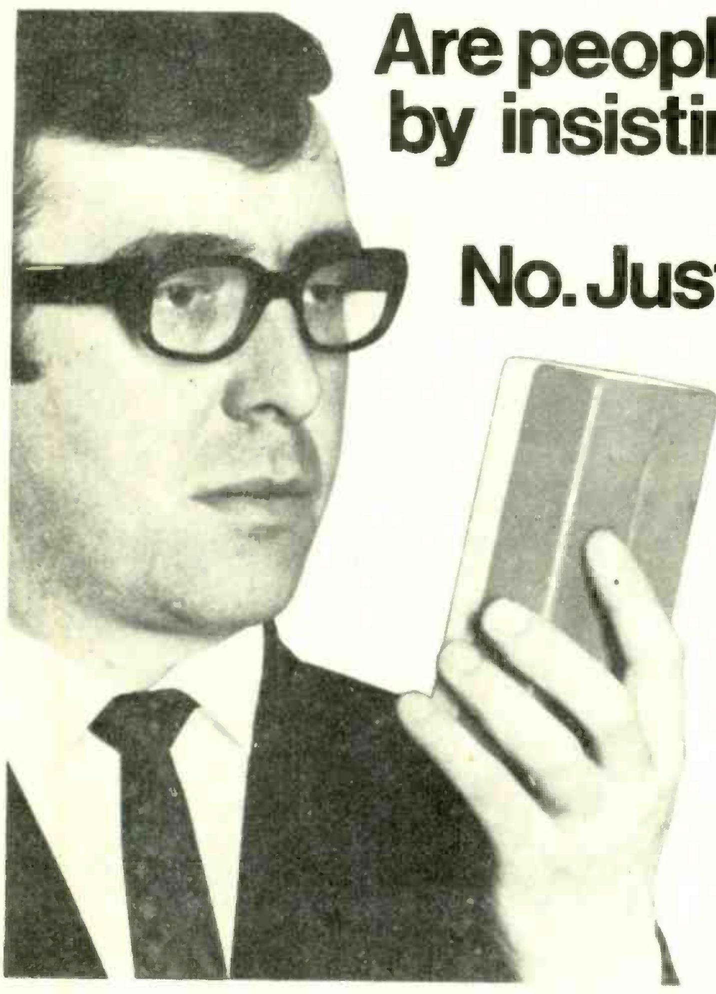

Are people being stubborn by insisting on the Minitest?

No. Just choosy!

Diminutive, sensitive, neat, tough. These are the adjectives that describe the S.E.I. Minitest. You will never be provoked into using any other for years, hence this pocket size, multi-range test set will be serving you accurately. The Minitest measures a.c. and d.c. voltages, d.c. current, and resistance over 20 ranges to a sensitivity of 20,000 and 2,000 ohms per volt d.c. and a.c. respectively. Readings are instantaneous and the minutest is clearly discernible. A steel case shields the movement from external magnetic fields and shocks. This has a robust, wipe-clean, melamine cover. All controls are handily disposed.
High voltage probes are available to extend the range of the Minitest to 25 or 30kV d.c. for testing electronic equipment with high source impedence. They can be used with any other meter of similar sensitivity. Wisdom suggests Minitest and S.E.I. probes together, right from the start. Act now: Send for the catalogue.
We manufacture a wide range of portable instruments ... write today for full information.

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G.E.C.
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They come in three basic sizes, and they're not bound by the usual limitations of metal film resistors at all. Witness temperature coefficients like 15p.p.m./°C. Selection tolerances as tight as ±0.1%.

What's more, we build the same kind of stability into special orders, too.

We don't see why non-standard customers should get sub-standard service just because their supplier doesn't like putting his production line out of gear.

In our books, made-to-measure resistors should be made to *your* measure, not ours. With the performance *you* specify.

And we don't make you pay through the nose when they arrive, either. You'll see what we mean when you ask for our price list covering the standard Filmet® range.

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First class, of course.

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Telephone: Jarrow 897771 Telex: 53353

® FILMET is a registered Trade Mark

Morgan

WW—021 FOR FURTHER DETAILS

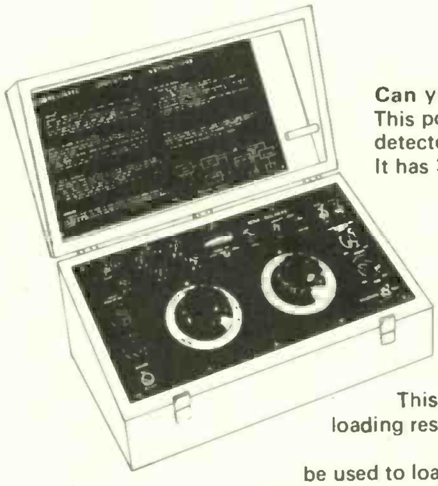
A new range from J.J.Lloyd Instruments...

From whom?

J. J. Lloyd Instruments Limited

You may already know all about us, but whether you do or not come and see our new instruments at the I.E.A.

Our product range includes L, C and R Decade Boxes, variable Mutual Inductors, Standard Resistors, Conductance Boxes, a.c. and d.c. Potentiometers, Electronic Galvanometers, power loading Resistors and Capacitors, Dynamometers and an interesting range of instruments developed specially for educational laboratories.

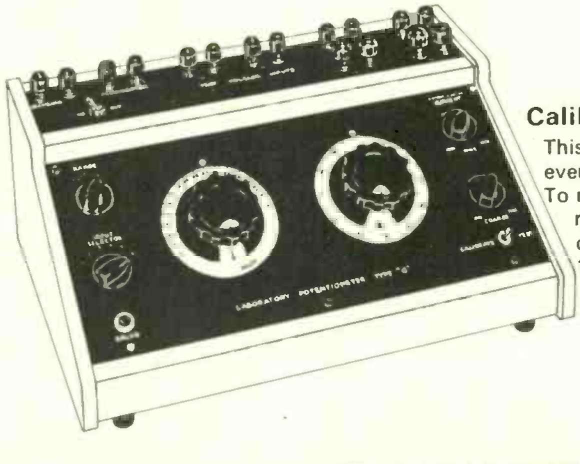


Can you measure 1°C at 1500°C? We can with the **Model 'F' Potentiometer.** This portable workshop potentiometer incorporates a sensitive electronic null detector and has the accuracy and discrimination of a laboratory instrument. It has 3 inputs, for thermo-couple use and 3 ranges.

Accuracy:—±0.03% (0.01% to special order).
Range:—0—18 mV, 0—180 mV, 0—1.8V.
Discrimination:—5μV.

Blow Power Space Saver

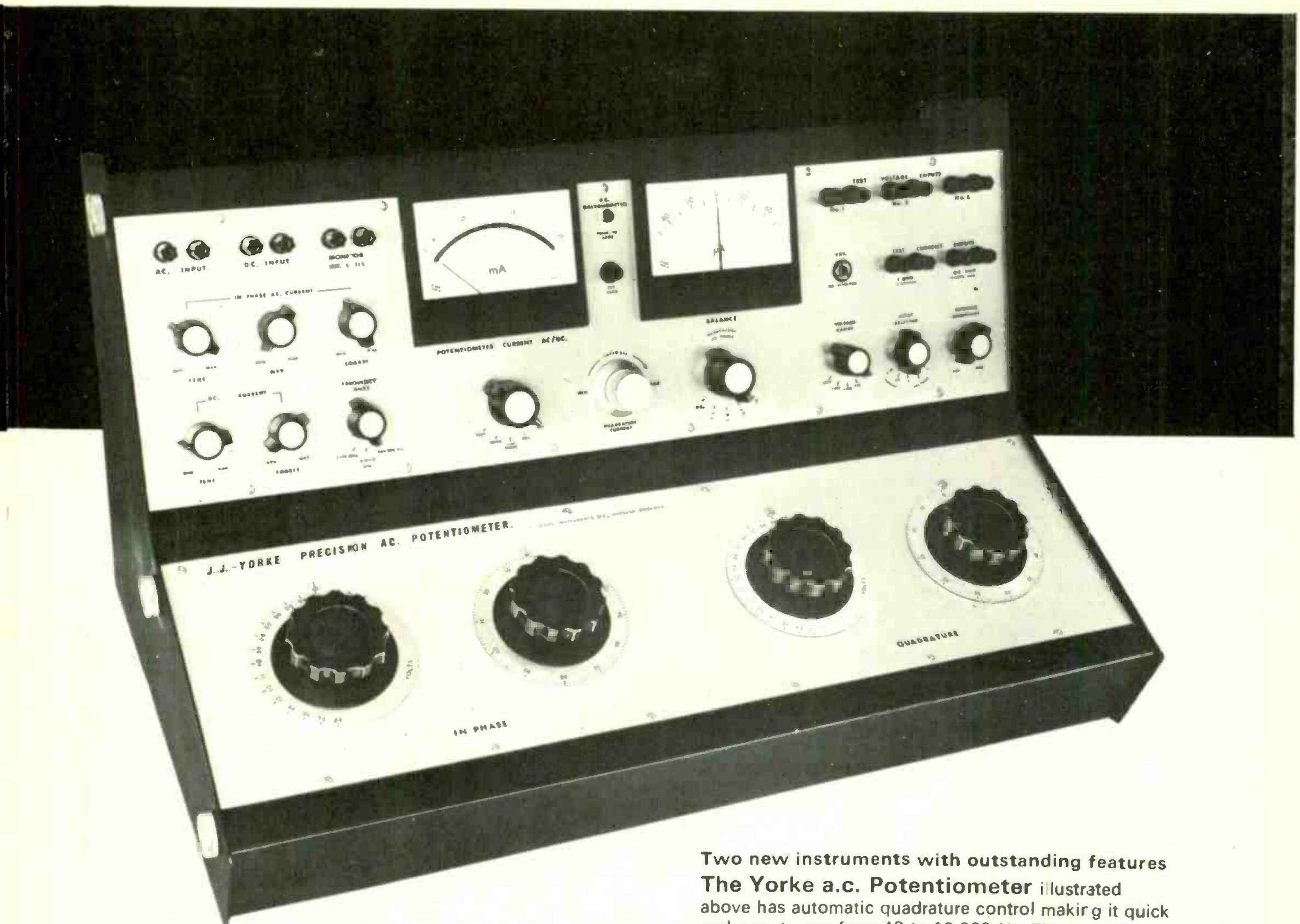
This amazingly compact, force cooled, power loading resistor, measuring under 2 cu. ft. is portable and will dissipate up to 20 Kw. It may be used to load d.c. or single and 3-phase a.c. supplies. Larger versions dissipating up to 60 Kw are also available. All units are fitted with a master contactor plus over heat and no bolt protection.



Calibration Potentiometer Type 'E'

This compact and accurate instrument measures nearly everything and is ideal for the small standards laboratory. To mention but a few of its achievements, it measures resistance from 1 μΩ to 1MΩ voltage from 10μV to 360V, current from 0.1 μA to 18 Amps, and power from 10^{-12} to 6000 watts.

WW—022 FOR FURTHER DETAILS



Two new instruments with outstanding features

The Yorke a.c. Potentiometer illustrated above has automatic quadrature control making it quick and easy to use from 40 to 10,000 Hz. The operating frequency need not be known, and all detectors, transfer instruments and mutual inductors are self-contained so there are no tricky setting up problems either.

The BR100 is a very high precision mains operated d.c. resistance Bridge with an accuracy of ±0.002%. Other refinements include a solid state null detector, giving a direct error read out in ppm. and adjustable off limit indicator lights.

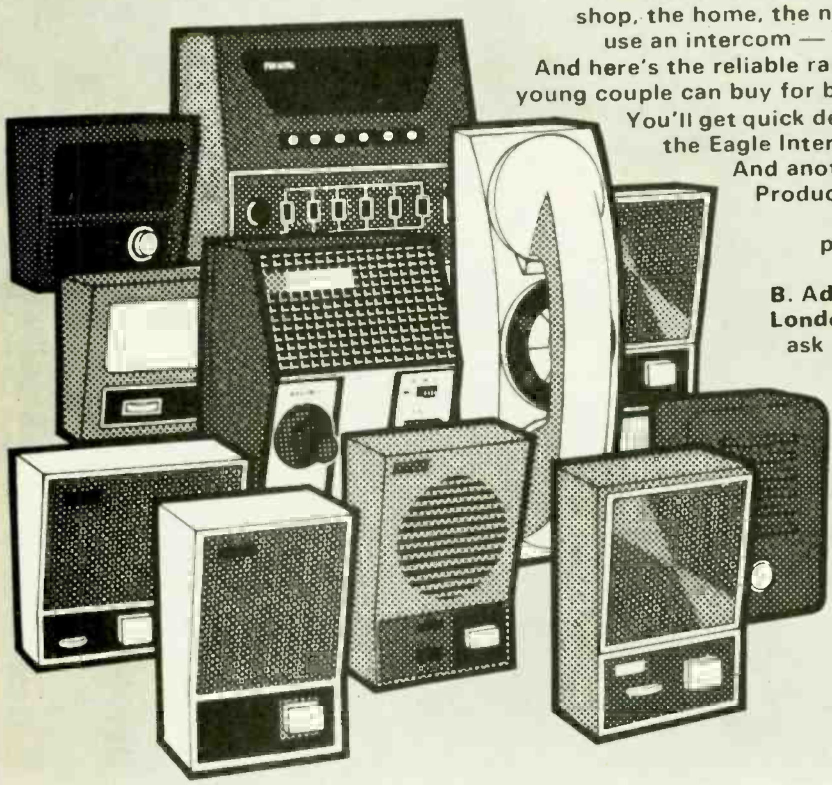
Get to know J.J. Instruments on stand E720 at the I.E.A.

JJ INSTRUMENTS

J.J. Lloyd Instruments Limited

Brook Avenue, Warsash, Southampton, SO3 6HP. Tel: Locks Heath 4221
(STD Code 048-95-4221)

EAGLE INTERCOMS



There's a vast market here — in the office, the factory, the workshop, the home, the nursery. Almost everyone in the country could use an intercom — if the trade would just push them a little bit! And here's the reliable range you can push! From an inexpensive set a young couple can buy for baby-listening to a full-scale 12-station model You'll get quick delivery, too — and you'll need it, if you display the Eagle Intercoms with their powerful colour showcards! And another attractive thing about the range of Eagle Products is the rate at which fast-selling new items are added! See our new catalogue, which proves the point! Send the coupon to the Sole Distributors of Eagle Products —
B. Adler and Sons (Radio) Limited, Coptic Street, London, W.C.1 or quicker still, dial 01-636 9606, ask for Carol Hill she'll send you one today!

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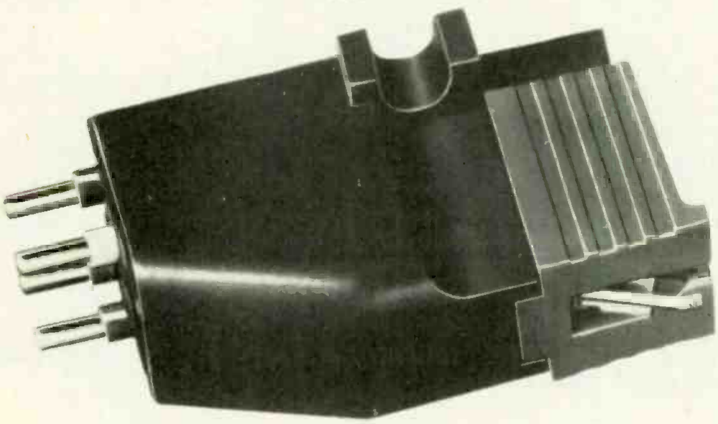
(2D)

WW—023 FOR FURTHER DETAILS

On Goldring's 850 cartridge, even the price is magnetic.



Fact: magnetic cartridges are more compatible with transistor amplifiers than crystal cartridges.

Fiction: magnetic cartridges are too expensive to warrant use with any but the more sophisticated units.

Now, there *is* a magnetic cartridge at a price within easy reach.

The 850 assures you of true tracking, superior sound quality and minimal groove destruction.

But unlike most magnetic cartridges, its British.

It's made by Goldring!

At £6/10/0, that's really magnetic.

£6/10/0

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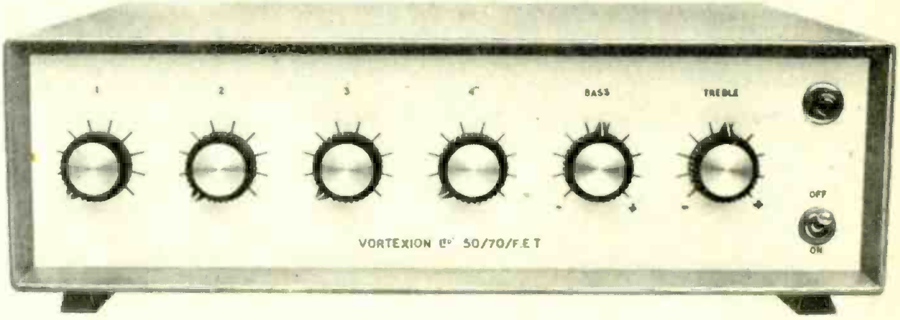
WW—024 FOR FURTHER DETAILS

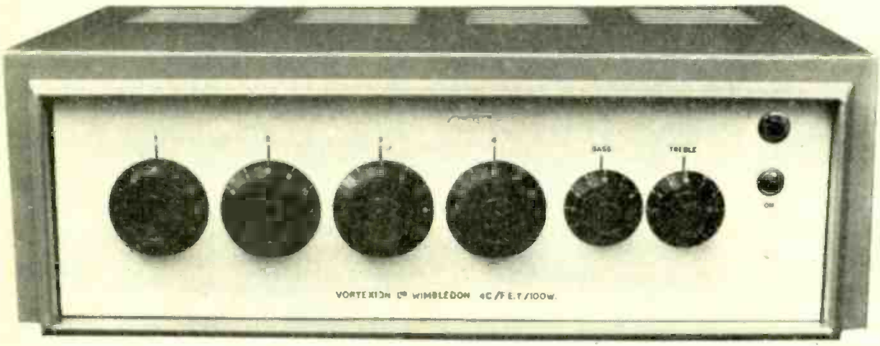
Vortexion

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) 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 3-30/60Ω balanced line microphones, and a high impedance line or gram. input followed by bass and treble controls. 100 volt balanced line output.

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



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, 3 mic. 1 gram 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.

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1 dB Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2, 3, 4 and 5 channel stereo. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5V at 20K or alternative 1mW at 600 ohms, balanced, unbalanced or floating.

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WW—025 FOR FURTHER DETAILS

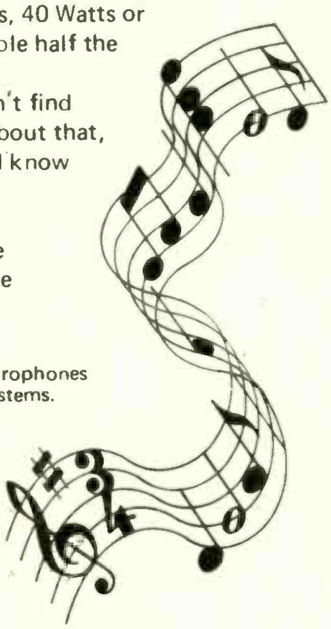
The sweet sound of saving

.... can be heard more and more if you listen in the many Schools, Hospitals, Factories and Hotels where S.N.S. Radio Rack Consoles are providing the music.

Our unique Crystal Controlled Radio Tuners, integrated with our fully transistorised amplifiers, mean that we can provide all the programmes you want, AM or FM — 12 Watts, 40 Watts or 100 Watts RMS — in a console half the height of ordinary racks.

Not only that, you won't find controls to adjust — sorry about that, knob twiddlers — and we all know that means less unnecessary service calls.

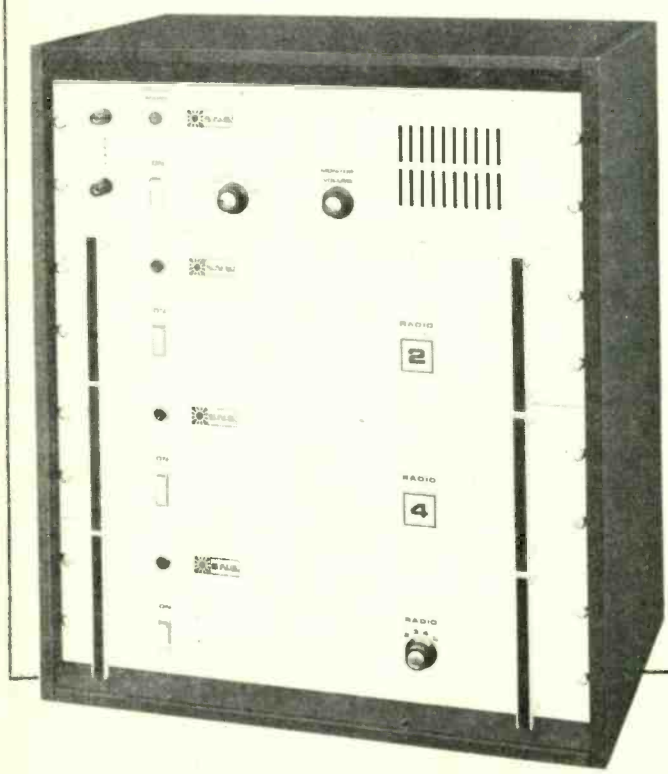
It all adds up to a triple saving to you — Size, Service Calls, and Initial Cost.



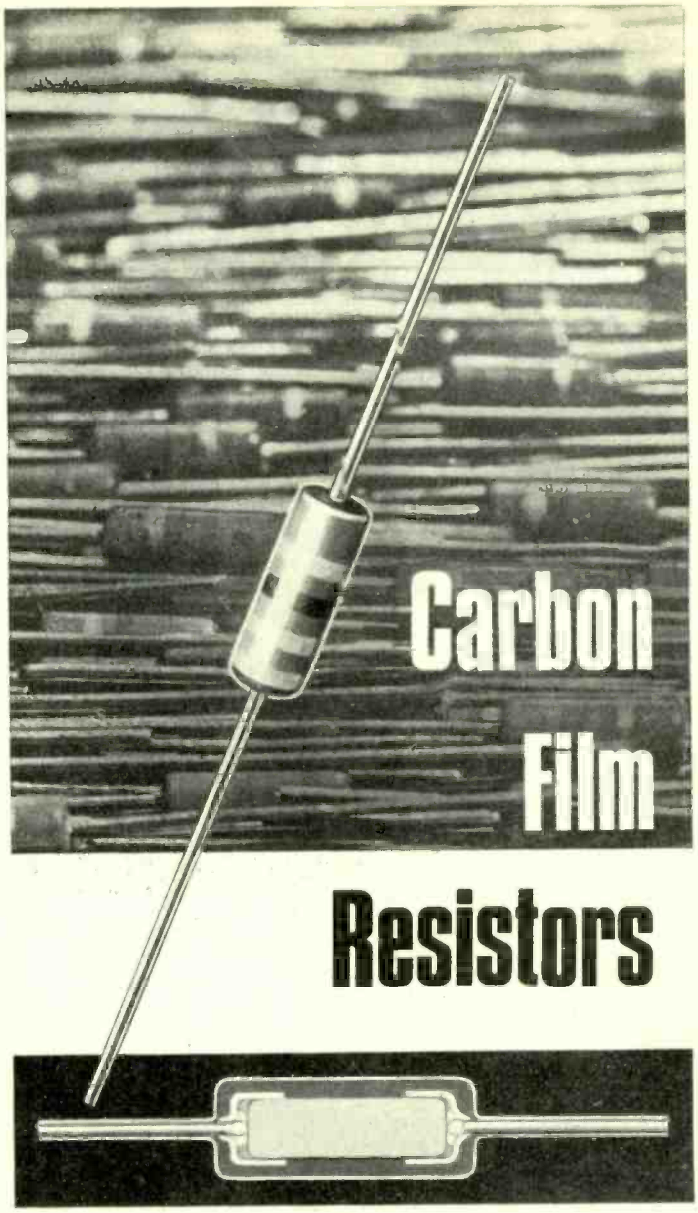
We also manufacture Radio Microphones and Loudspeaking Intercom Systems. For full details please contact

S.N.S.

S.N.S. Communications Ltd., 851 Ringwood Road, Bournemouth. Phone: Northbourne 4845



WW—027 FOR FURTHER DETAILS



- Low noise
- High reliability
- Hot moulded
- High stability
- $\frac{1}{32}$ w, $\frac{1}{8}$ w, $\frac{1}{4}$ w, $\frac{1}{2}$ w, 1 w and 2 watts
- Competitive prices
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- Tolerance ± 5%
- *Metal film precision types tolerance 0.1 to 1%*

For further information contact IMPECTRON LTD., 23-31, King Street, London, W.3. Telephone: 01-992 5388.

IMPECTRON

WW—028 FOR FURTHER DETAILS

AMPLIVOX COMMUNICATIONS LIMITED

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For noise-free communications, *without* 'carbon' crackles. Write or telephone for a *free* demonstration, at your premises, without any obligation.

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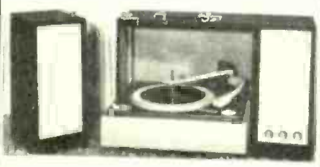
WW—036 FOR FURTHER DETAILS

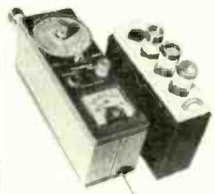
Never Built a Kit Before?

Why not prove how easy it is the HEATHKIT way. Build one of these beginner kits.

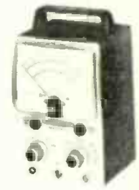


Stereo Record Player
Exciting Sound—Budget Price
Kit K/SRP-1 **£27-6** Carr. 11/-

Portable 'VVM'
For Hobbyists-Householders
Kit K/IM-17 **£14-8** Carr. 6/-

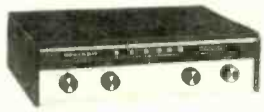


Grid Dip Meter
Covers 1-8 to 230 MHz
Kit K/GD-1U **£11-10** Carr. 5/-



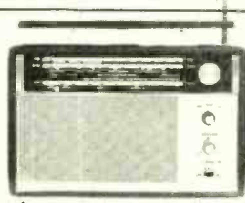
Technicians Versatile 'VVM'
7AC, 7DC. 7 ohm ranges
Kit K/IM-18U **£16-14** Carr. 5/-

Solid State Metal Locator
Find Buried Coins
Kit K/GD-48
AVAILABLE AUGUST

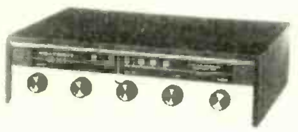


FM Mono Receiver
Modest Price—Natural Sound
Kit K/AR-27 **£22-10** Carr. 11/-
(Cab Extra)

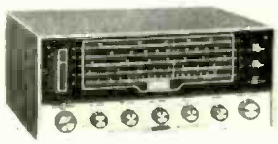
Deluxe Car Radio
Top Value—Powerful output
Kit K/CR-1 **£12-12** Carr. 5/-
(Spkr. Extra)



AM/FM Radio
Looks Good—Luxury Sound
Kit K/Severn **£18-18** Carr. 5/-

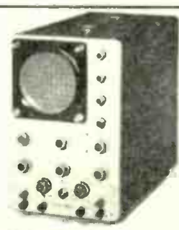


FM Stereo Tuner/Amplifier
Unbeatable Value
Kit K/AR-17 **£36-10** Carr. 11/-
(Cab Extra)



Deluxe SW Receiver
Many extras for price
Kit K/GR-54 **£48-16** Carr. 9/-

RF Signal Generator
100 KHz—200 MHz
Kit K/RF-1U **£15-18** Carr. 6/-

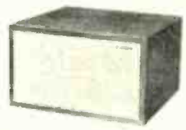


Wide-Band Oscilloscope
Excellent Service Aid
Kit K/10-18U **£38-18** Carr. 11/-

Car Tune-Up Meter
For D.I.Y. Motorists
Kit K/ID-29 **£17-8** Carr. 5/-

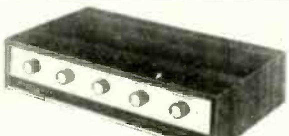
3-Speaker and Cross over System
Build into own Cabinet
Kit K/SCM-3 **£12-6** Carr. 6/-

Model Makers Tachometer
Measure RPM the easy way!
Kit K/GD-69 **£11** Carr. Pd.



Avon Mini Speaker
Luxury Sound—Small Size
Kit K/Avon **£13-8** Carr. 11/-

Berkeley Slimline Speaker
Uses 1 sq ft. Floor Space
Kit K/Berkeley **£21-4** Carr. 14/-



12w + 12w Stereo Amplifier
8 or 15 Ω outputs
Kit K/TSA-12 **£32-16** Carr. 11/-
(Cab Opt. Extra)

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QUAD 50 is a single channel 50 Watt amplifier designed for Broadcast, Recording and other applications in the Audio industry, completely proof against misuse and giving the highest quality of reproduction.

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OUTPUTS – isolated providing 50 watts into almost any impedance from 4 to 200 ohms.
DIMENSIONS – $12\frac{3}{4}'' \times 6\frac{1}{4}'' \times 4\frac{1}{2}''$

Complete the coupon and post today.

Please send me full details of the QUAD 50 Amplifier

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WW

QUAD

for the closest approach to the original sound

Two new Build·it·yourself speaker kits from Wharfedale

"Why don't you produce kits for bigger speakers?" people asked us when Unit 3 proved such a success.

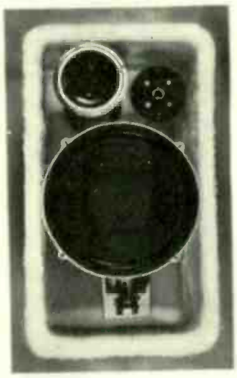
We hope you'll like our answer—Unit 4 (2-speaker floor standing system) and Unit 5 (3-speaker monitor system).

So if you're a high fidelity enthusiast who enjoys building his own equipment, send for details.

unit 4

full range floor standing system.

2 speakers (12" Bass and 3" Treble) to give full range, balanced reproduction.
Frequency response of 45-17,000 Hz. when housed in suitable cabinet.
Superior 4-element crossover unit ensures optimum performance from each speaker.
Rec. Retail Price £16-0-0.



unit 5

the monitor system you can build yourself.

3 speakers (12" Bass, 5" Mid-Range unit, and 1" Treble) give clean, smooth performance.
Frequency response of 40-20,000 Hz. when housed in suitable cabinet.
Unique mechanical/electrical 6 element crossover unit.
Rec. Retail Price £23-10-0.

All kits include speakers, crossover network, acoustic wadding, mounting bolts and connecting wire, together with full assembly instructions. No expert technical knowledge needed.

To: Rank Wharfedale Ltd., Idle, Bradford.
Please send me leaflets describing your speaker kits.
Name (Block capitals, please) ____________
Address ____________
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WW

the true sound in High Fidelity

WHARFEDALE

Rank Wharfedale Ltd.,
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**To Help the Smaller User*

VITALITY BULBS LIMITED

VITALITY are pleased to announce the appointment on 1st February 1970 of two main distributors to the electronics industry.

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Phone: 01-688-3699. Telex: 262308

Farnell Electronic Components Ltd.,
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Phone: 636311. Telex: 55147

Comprehensive stocks will be maintained and orders for up to 500 lamps will be referred.

The small quantity user will benefit by improved delivery and wholesalers also, when unable to deliver small quantities from stock, can order from these two Companies.

Vitality Bulbs Ltd.,
Beetons Way, Bury St. Edmunds, Suffolk.
Phone: 0284 2071. Telex: 81295

A Member of the General Instrument Group

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SERCEL

PROGRAMMABLE D.C. STANDARDS
Models 5500 & 5501

D.C. Voltage and current standards

	109999 read-out, 1" high digits
Two voltage ranges:	10·9999 V & 1:09999 V
Resolution:	100 µV & 10 µV
Two current ranges:	10·9999 mA & 1·09999 mA
Resolution:	100 nA & 10nA
Stability voltage:	0·005% + 30 µV
(1 year) current:	0·008% + 50 nA
Temperature:	< 4 ppm + 3 µV per °C
Co-efficient:	< 8 ppm + 3 nA per °C
Programming:	Manual or Remote (BCD)
Response Time:	within 10 milliseconds

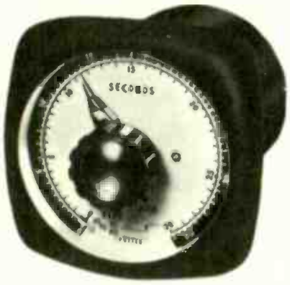
BRITEC LIMITED

17 Charing Cross Road, London, W.C.2
Tel: 01-930 3070 **Telex 915854**

Stand N525, IEA Olympia 11-16 May.

WW—046 FOR FURTHER DETAILS

OMRON PROCESS TIMERS



SYS TIMER

- ★ SYNCHRONOUS MOTOR & CLUTCH
- ★ 10 MILLION OPERATIONS
- ★ Instantaneous & Timed out 3 AMP contacts
- ★ Repeat Accuracy ± ½%
- ★ Dial ranges 0-10 secs up to 0-28 hrs. May also be used as impulse start

£11 dependent on quantity

NSY TIMER

- ★ 2 sets 5 amp changeover output contacts
- ★ 5 Million operations
- ★ Repeat accuracy ±½%
- ★ Set time can be altered whilst in operation

Dial ranges from seconds to hours

Approx. **£8.10.0** each dependent on quantity.

STP TIMER

SYNCHRONOUS MOTOR & CLUTCH
Matchbox size frontal area
Automatic re-set

- ★ PLUG-IN OCTAL BASE
- ★ INSTANTANEOUS AND TIMED OUT 2 AMP CONTACTS
- ★ RANGES: 0-10 SECS TO 0-36 MINS

£6 dependent on quantity

TDS TRANSISTORISED TIMER

- ★ On/Off Signal Lamps fitted.
- ★ Instantaneous & timed out contacts.
- ★ Plug in Octal base.
- ★ Timer Ranges up to 180 secs.

Approx. **£10** dependent on quantity

S.I.A.

S.I.A. Sub-miniature Micro-Switch. ★ 1 million ops. ★ 5 amps c/o contacts. ★ Size less than 2mm x 1mm x 0.5mm.

Approx. **3/2** dependent on quantity

IMMEDIATE DELIVERY OF LIMIT & MICRO SWITCHES
FLOATLESS LIQUID LEVEL CONTROLS, PROXIMITY SWITCHES

OMRON APPROVALS: CSA. US Mil Spec. SEV.UL

OMRON PRECISION CONTROLS

VISIT US ON STAND N545 AT OLYMPIA I.E.A. SHOW, MAY 11th-16th

VARIABLE TRANSFORMERS

★ OUTPUT 0-260V ★ INPUT 230V 50/60CPS ★ SHROUDED FOR BENCH OR PANEL MOUNTING

Inset shows latest pattern Brush gear ensuring smooth continuous adjustment.

1 amp
£5.10.0

2.5 amp	£6.15.0	8 amp	£14.10.0	12 amp	£21.0.0
5 amp	£9.15.0	10 amp	£18.10.0	20 amp	£37.0.0

50 AMP 0-24V DC L.T. SUPPLY UNIT

- ★ Continuously Rated.
- ★ Large Ammeter and Voltmeter.
- ★ Ideal for Plating Units.
- ★ Fully protected with Instantaneous cut-out & Fuse.
- ★ Infinitely variable up to 24V DC

Size and weight 16" x 12" x 27" High 70lbs. Rear wheels fitted for ease of handling.

£85 C&P (inland) £3.

20 AMP 24 & 12V DC L.T. SUPPLY UNIT £35 C & P 40/-

COMPLETE PHOTO-ELECTRIC SENSOR in one unit

- ★ REFLECTIVE TYPE WITH BUILT-IN LIGHT SOURCE
- ★ WILL ALSO OPERATE FROM REMOTE LIGHT SOURCE
- ★ MATCHBOX SIZE
- ★ SENSES ANY OBJECT—COLOURS, THICK SMOKE

Operates from 12 V.A.C. Output signal 0.2 amp. 100 V.

Approximately **£5.10.0** dependent on quantity

SOLID STATE VARIABLE VOLTAGE CONTROL

- ★ Output 25-240V
- ★ Input 240V 50 CPS
- ★ 5 amp & 10 amp models
- ★ Completely sealed

5 amp model **£8.7.6**

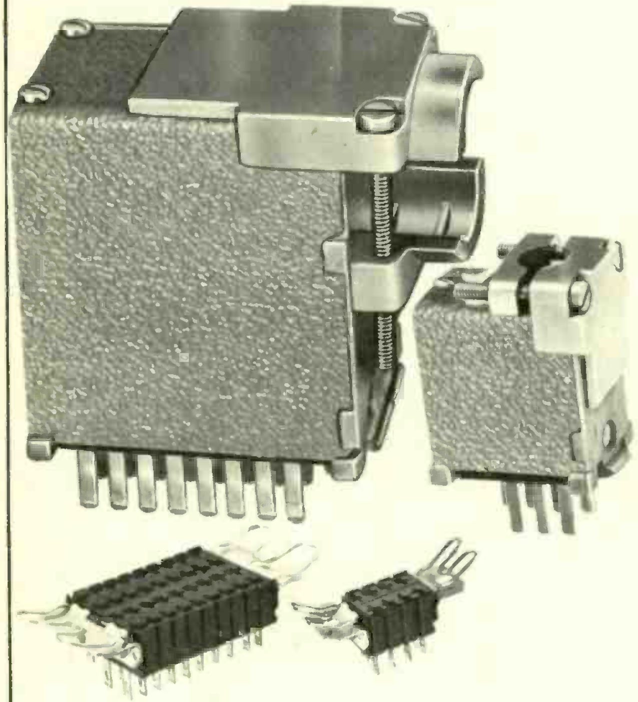
10 amp model **£13.15.0**

I.M.O. PRECISION CONTROLS

(Dept WWX) 313 EDGWARE ROAD, LONDON, W.2. TEL. 01-723 2231

New from McMurdo: 700 series plugs and sockets.

These general purpose plugs and sockets feature removable contacts with solder tails. The connectors are styled with two and four rows of contacts, giving 7—71 ways. Covers in plastic clad aluminium are available with either top or side entry.



Technical Data
(Plug & socket engaged—dry)

Plug Pins — manufactured in brass, gold plated over silver plate.

Socket Contacts — manufactured in phosphor bronze, gold plated over silver plate.

Plug and Socket Bodies. — made from general purpose Phenolic Resin.

Break down voltage —2KV DC minimum.
Current rating per contact at 30°C—5 amps DC or AC (RMS)
Current rating per contact at 65°C—3 amps DC or AC (RMS)
Maximum operating temperature —100°C.

For more details, write to:

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great facility for service

Member of the Louis Newmark Group, with access to the combined facilities of all other member companies.

McMurdo Instrument Co. Ltd., Dept. WW/5/A Rodney Road, Portsmouth, Hants. Or Telephone: Portsmouth 35361. Telex: 86112.

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WW—048 FOR FURTHER DETAILS

Fet. input Op. Amp.

rate of output .... ±10v 5mA
open loop gain 200,000
bias current .... 5pA/°C
small signal unity gain 8MHz
maximum for full output 400kHz
offset voltage vs temp ...... 20μ V/°C
c.m.r.r. .... 10^4
input impedance 100,000MΩ

Our engineers will be pleased to learn of your special requirements and applications.

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DEVONSHIRE STREET CHELTENHAM *Telephone* 53861

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STOCKISTS

MULTIMINOR MK. IV

MODEL 8 MK. III

REPAIR SERVICE 7-14 DAYS

We specialise in repair, calibration and conversion of all types of instruments, industrial and precision grade to BSS.89.

Release notes and certificates of accuracy on request.

Suppliers of Elliott, Cambridge and Pye instruments

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E.I.D. & G.P.O. APPROVED — **CONTRACTOR TO H.M. GOVT.**

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COME & MEET THE BYFLEET BABY

THE NEW SERIES 10

Stand G457

I.E.A. Exhibition

Olympia, 11-16 May.

A new size 10 power unit only $2\frac{3}{4}'' \times 3\frac{1}{4}'' \times 7\frac{5}{8}''$ is presented for the first time. From 5 models, any voltage can be preset up to 60v. D.C. with the maximum current availability. (For instance, 3A at 5V, $\frac{1}{2}$A at 60V.). Very high performance, computer grade capacitors, yet only £25 each. Delivery from stock. Other ranges in sizes 30, 40 and 60, cased models, special custom built supplies etc., are also on show—so make sure you visit our stand. Seating is provided to enable you to rest awhile and relax. Fit A.P.T. supplies in your equipment and forget them.

A.P.T. ELECTRONIC INDUSTRIES LTD
Chertsey Road, Byfleet, Surrey.
Tel: Byfleet 41131/2/3/4. Grams: Aptran, Byfleet.

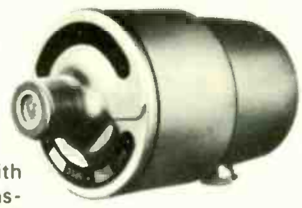
WW—051 FOR FURTHER DETAILS

Celestion PA

Loudspeakers for all Public Address Systems

Re-entrant Horns

These Horns are capable of delivering a highly concentrated beam of sound over long distances. They are recommended for recreation centres, noisy factories and workshops and all indoor and outdoor locations where a high noise level has to be overcome.



Driver Units

Pressure type units are available with or without tapped 100V line transformers. The following 'built-in' features are on all models — High Sensitivity, Weatherproof, Phase Equalising Throat and Self-centring Diaphragm Assembly.

Re-entrant Loudspeakers

Rola Celestion re-entrant loudspeakers are designed for use wherever conditions demand compactness, toughness, high efficiency and unfailing service. They are rainproof and built to withstand prolonged exposure to vibration and adverse conditions.

Loudspeaker in Glass Fibre

The Celestion Glass Fibre Loudspeaker is a compact robust and watertight unit, precision built for use on open boat decks, docks, chemical plants, plating shops, etc, where protection from the weather or corrosive atmosphere is vital.

Rola Celestion Ltd.
THAMES DITTON, SURREY
TELEPHONE 01-398 3402 TELEX 266 135

WW—057 FOR FURTHER DETAILS

Valradio

DC TO AC TRANSVERTORS

(transistorised Invertors/Convertors)

Type B12/250T
PRICE £41-18-0

The "T" range of transvertors provide an AC output from static accumulators, mobile vehicles, boats, etc. These units are very economical for obtaining a stand-by AC supply or for operating equipment where no AC power supply is available. The 400/500 Hz output versions can and are frequently used as power tone generators for audio or visual fire alarms and other signalling systems in factories, ships, stores, schools, etc.
A typical model B12/250T input 12V accumulator, output 115V and 230V 250W 50Hz. Other models for input voltages of 12 to 250V DC and outputs of square or sine wave. The standard range covers 50 or 60 Hz but frequencies of up to 10KHz are available to order.
All units are fully transistorised.
Send for full information and technical details.

VALRADIO LTD.
Dept. WC6, BROWELLS LANE, FELTHAM, MIDDLESEX, ENGLAND
Telephone: 01-890 4242 or 4837

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M. R. SUPPLIES (London) LTD.,

(Established 1935)

Universally recognised as suppliers of UP-TO-DATE MATERIAL, which does the job properly. Instant delivery. Satisfaction assured. Prices nett.

ROOM THERMOSTATS. Danfoss wall-mounted Thermostats, 40 deg. F.-80 deg. F., 380 v. A.C., 4 amps.; 240 v. A.C., 6 amps. Our nett price £1/12/6 (des. 2/-).

MINIATURE RUNNING TIME METERS (Sangamo). We have great demands for this remarkable unit and now can supply immediately from stock, 200/250 v. 50 c. synchronous. Counting up to 9,999 hours, with 1/10th indicator. Only 1½ ins. square, with cyclometer dial, depth 2 ins. Many industrial and domestic applications to indicate the running time of any electrical apparatus, easy to install, 63/- (des. 1/6).

SYNCHRONOUS TIME SWITCHES. (Another one of our popular specialities) 200/240 v. 50 c., for accurate pre-set switching operations. Sangamo S.254, providing up to 3 on-off operations per 24 hours at any chosen times, with day-omitting device (use optional). Capacity 20-amps. Compactly housed 4 in. dia., 3½ in. deep, £6/4/6 (des. 4/6).

ELECTRIC FANS (Papst), for extracting or blowing. The most exceptional offer we have yet made. 200/250 v. A.C. Induction motor—silent running. 2,800 r.p.m. duty 100 C.F.M. Only 4½in. square and 2in. deep. Ideal for domestic or industrial use. Easy mounting. £3/5/- (des. 3/6).

SMALL GEARED MOTORS. In addition to our well-known range (List GM.169), we offer small open type S.P. Units 200/250 v. A.C., 1, 6, 12, 24, 60 r.p.m., approx. 5in. long, with 1in. shaft projection each side and enclosed gearbox. Suitable for display work and many industrial uses. Only 75/- (des. 5/-).

MINIATURE COOLING FANS. 200/250 v. A.C. With open type induction motor (no interference), Overall 4in. × 3½in. × 2½in. Fitted 6-bladed metal impeller. Ideal for projection lamp cooling, light duty extractors, etc., still only 31/6 (des. 5/-).

AIR BLOWERS. Highly efficient units fitted induction totally enclosed motor 230/260 v. 50 c. 1 ph. Model SD.26, 60 CFM (free air) to 11.5 CFM at .15 WG (size approx.) 6 × 6 × 7in. Outlets 2½in. square. £8/10/- (des. 5/-). Model SD27, 120 CFM (free air) to 40 CFM at 1.2 WG, 8 × 7 × 9in. outlet 2½in. sq., £11/15/6 (des. 5/-). Model SD28, 260 CFM (free air) to 127 CFM at 1.5 WG, 11 × 8 × 9in., outlet 3in. sq., £13/17/6 (des. U.K. 7/6).

SYNCHRONOUS ELECTRIC CLOCK MOVEMENTS (as mentioned and recommended in many national journals). 200/250 v. 50 c. Self-starting. Fitted spindles for hours, minutes and central sweep second hands. Central one-hole fixing. Dia. 2½in. Depth behind dial only 1in. With back dust cover, 39/6 (des. 2/-). Set of three brass hands in good plain style. For 5/7in. dia. 2/6 For 8/10 dia. 3/6 set.

SYNCHRONOUS TIMER MOTORS (Sangamo). 200/250 v. 50 c/s. Self-starting 2in. dia. × 1¾in. deep. Choice of following speeds: 1 r.p.m., 12 r.p.h., 1 r.p.h., 1 rev. 12 hours, 1 rev. per day. Any one 42/- (des. 2/-). Also high-torque model (G.E.C.), 2½in. × 2in. × 1¾in. 6 r.p.m., 57/6 (des. 2/-).

SMITHS TIMER MOTORS. Synchronous, self-starting 200/250 volts, 1 ph., 50 c. Clockwise. 4 r.p.m. only. Only 25/- (des. 2/-).

MINIATURE D.C. MOTORS. 6/12 volts D.C. Ideal model makers. 4,000/9,000 r.p.m. no load. 1½ in. × 1¼ in. diameter. Flange fixing. Only 5/- (des. 1/6).

EXTRACTOR FANS. Ring mounted all metal construction. T/E induction motor, silent operation, 8in. blade, 10in. max. dia., 400 CFM. £6/10/0 (des. 5/-) Same model 10in. blade. 12in. max. dia., 500 CFM. £6/16/0 (des. 6/-).

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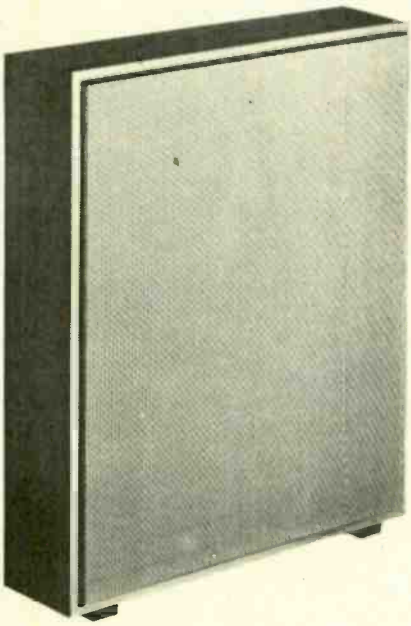

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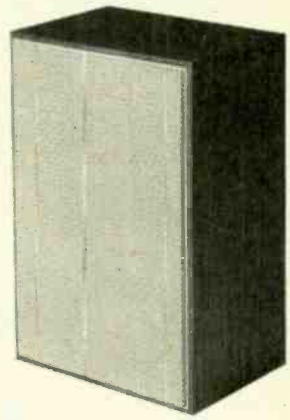

LC93

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.

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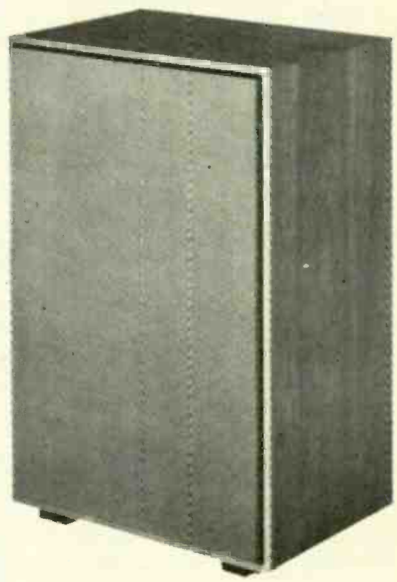

LC95

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.

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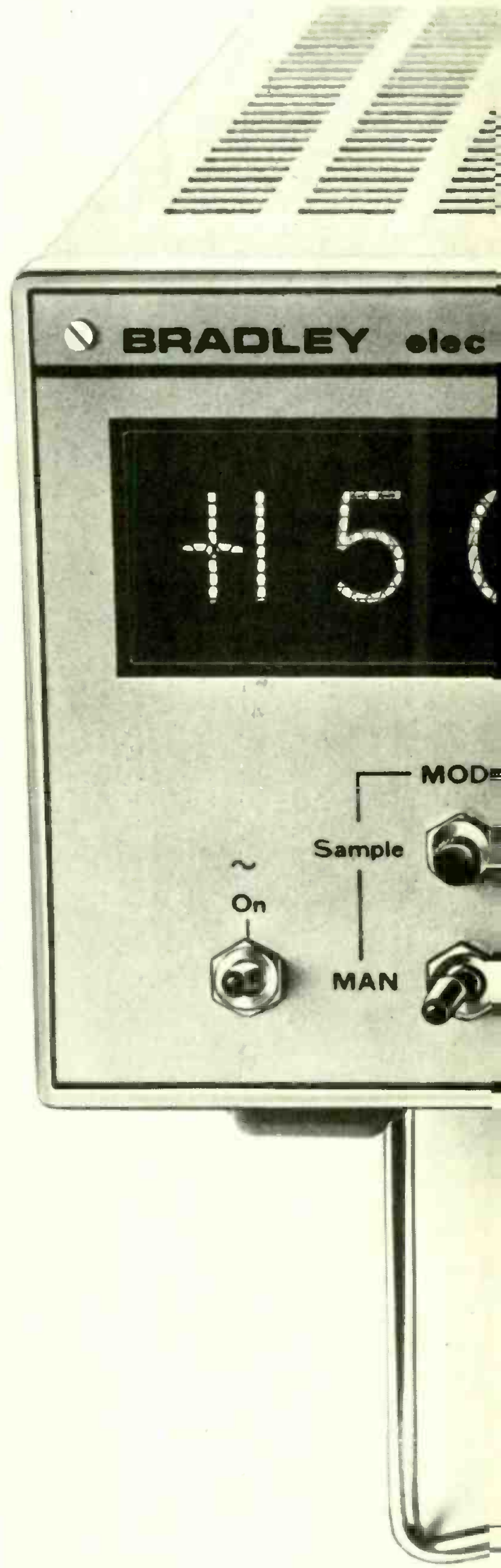

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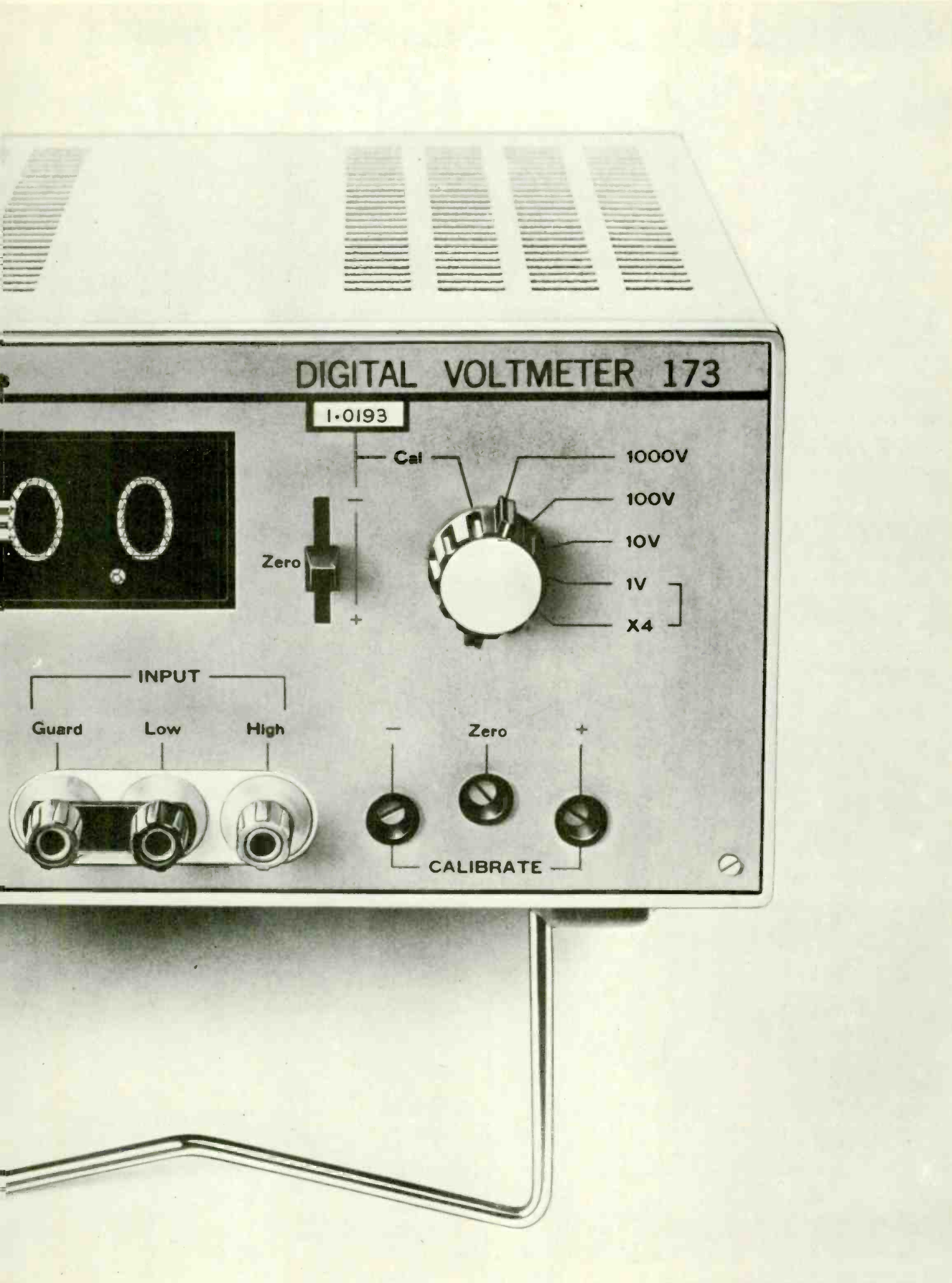
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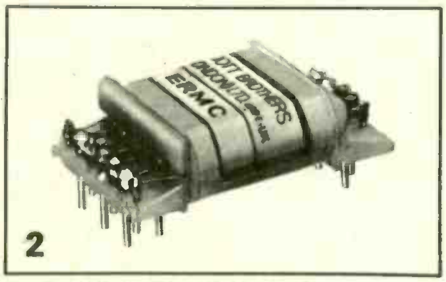

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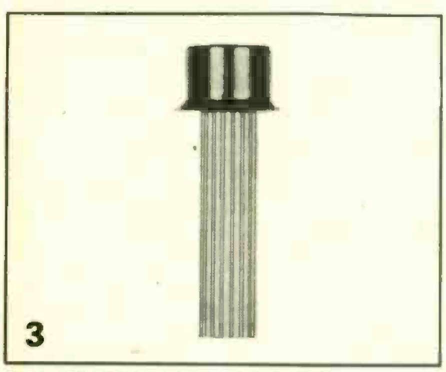

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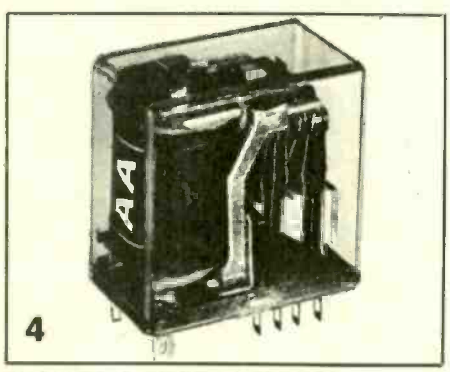

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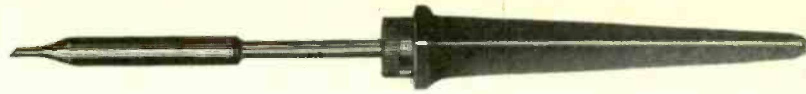

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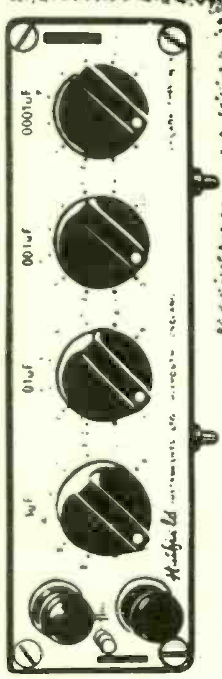

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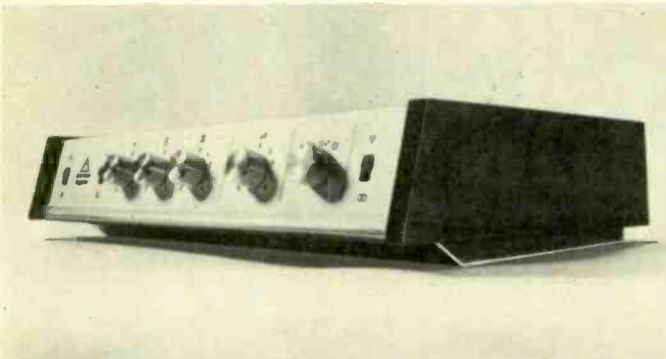

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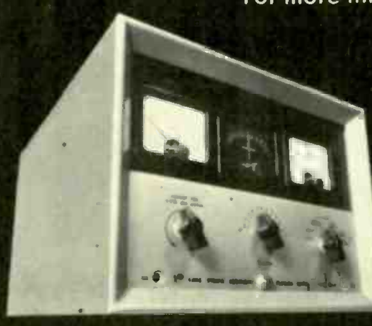

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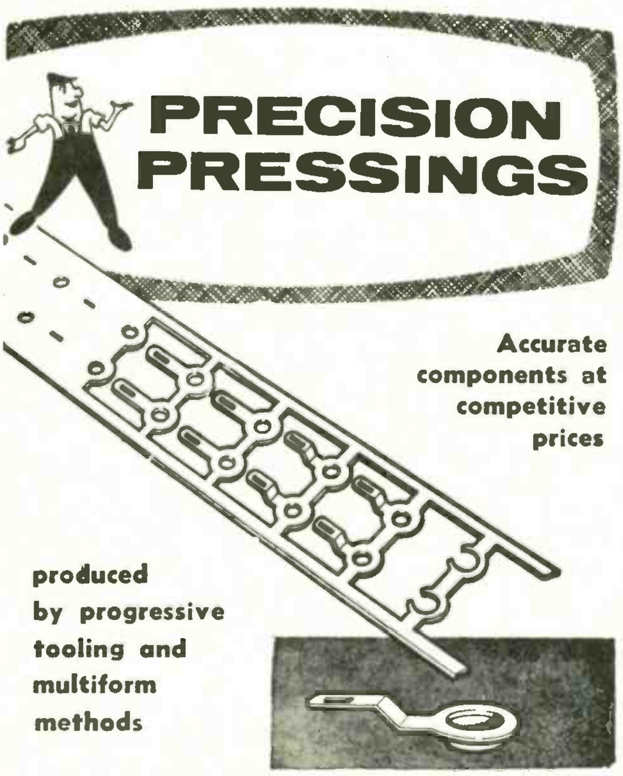

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50μA	69/6	50V. D.C.	59/6
100μA	67/6	1 amp. D.C.	59/6
500μA	62/6	5 amp. D.C.	59/6
1mA	59/6	300V. A.C.	59/6
20V. D.C.	59/6	VU Meter	75/-

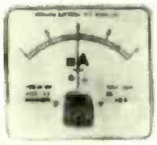
BAKELITE PANEL METERS

TYPE S-80
80 mm.
square fronts

50μA	62/6	50V. D.C.	49/6
100μA	59/6	1 amp. D.C.	49/6
500μA	52/6	5 amp. D.C.	49/6
1mA	49/6	300V. A.C.	52/6
20V. D.C.	49/6	VU Meter	67/6

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4½in. × 4¾in. fronts.



50μA	72/-	10mA	52/-
50-0-50μA	62/-	50mA	52/-
100μA	62/-	100mA	52/-
100-0-100μA	62/-	500mA	52/-
200μA	57/6	1 amp.	52/-
500μA	55/-	5 amp.	52/-
500-0-500μA	52/-	15 amp.	52/-
1mA	52/-	30 amp.	52/-
1-0-1mA	52/-	20V. D.C.	52/-
5mA	52/-	50V. D.C.	52/-
		150V. D.C.	52/-
		300V. D.C.	52/-
		15V. A.C.	52/-
		300V. A.C.	52/-
		8 Meter 1mA	57/6
		VU meter	72/-
		1 amp. A.C.*	52/-
		5 amp. A.C.*	52/-
		10 amp. A.C.*	52/-
		20 amp. A.C.*	52/-
		30 amp. A.C.*	52/-

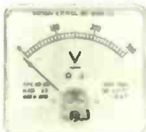
Type MR.52P. 2⅝in. square fronts.

50μA	62/-	10V. D.C.	40/-
50-0-50μA	52/-	20V. D.C.	40/-
100μA	52/-	50V. D.C.	40/-
100-0-100μA	47/6	300V. D.C.	40/-
500μA	45/-	15V. A.C.	40/-
1mA	40/-	300V. A.C.	40/-
5mA	40/-	8 Meter 1mA	42/-
10mA	40/-	VU Meter	62/-
50mA	40/-	1 amp. A.C.*	40/-
100mA	40/-	5 amp. A.C.*	40/-
500mA	40/-	10 amp. A.C.*	40/-
1 amp.	40/-	20 amp. A.C.*	40/-
5 amp.	40/-	30 amp. A.C.*	40/-

Type MR.65P. 3½in. × 3¼in. fronts.

50μA	67/6	20V. D.C.	42/-
50-0-50μA	55/-	50V. D.C.	42/-
100μA	55/-	150V. D.C.	42/-
100-0-100μA	52/-	300V. D.C.	42/-
500μA	47/6	15V. A.C.	42/-
500-0-500μA	42/-	50V. A.C.	42/-
1mA	42/-	150V. A.C.	42/-
5mA	42/-	300V. A.C.	42/-
10mA	42/-	500V. A.C.	42/-
50mA	42/-	8 meter 1mA	47/6
100mA	42/-	VU meter	67/6
500mA	42/-	50mA A.C.*	42/-
1 amp.	42/-	100mA A.C.*	42/-
5 amp.	42/-	200mA A.C.*	42/-
10 amp.	42/-	500mA A.C.*	42/-
15 amp.	42/-	1 amp. A.C.*	42/-
20 amp.	42/-	5 amp. A.C.*	42/-
30 amp.	42/-	10 amp. A.C.*	42/-
50 amp.	47/6	20 amp. A.C.*	42/-
10V. D.C.	42/-	30 amp. A.C.*	42/-

Type MR.38P. 1 21/32in. square fronts.



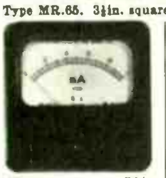
50μA	40/-	150mA	27/6
50-0-50μA	37/6	200mA	27/6
100μA	37/6	300mA	27/6
100-0-100μA	35/-	500mA	27/6
200μA	35/-	750mA	27/6
500μA	30/-	1 amp.	27/6
500-0-500μA	27/6	2 amp.	27/6
1mA	27/6	5 amp.	27/6
1-0-1mA	27/6	10 amp.	27/6
2mA	27/6	3V. D.C.	27/6
5mA	27/6	10V. D.C.	27/6
10mA	27/6	20V. D.C.	27/6
20mA	27/6	100V. D.C.	27/6
50mA	27/6	150V. D.C.	27/6
100mA	27/6	300V. D.C.	27/6
		500V. D.C.	27/6
		750V. D.C.	27/6
		15V. A.C.	27/6
		50V. A.C.	27/6
		150V. A.C.	27/6
		300V. A.C.	27/6
		500V. A.C.	27/6
		8 meter 1mA	32/-
		VU meter	42/-

Type MR.45P. 2in. square fronts.

50μA	45/-	5 amp.	30/-
50-0-50μA	42/-	10V. D.C.	30/-
100μA	42/-	20V. D.C.	30/-
100-0-100μA	37/6	50V. D.C.	30/-
200μA	37/6	300V. D.C.	30/-
500μA	32/-	15V. A.C.	30/-
500-0-500μA	30/-	300V. A.C.	30/-
1mA	30/-	8 meter 1mA	37/6
5mA	30/-	VU meter	45/-
10mA	30/-	1 amp. A.C.*	30/-
50mA	30/-	5 amp. A.C.*	30/-
100mA	30/-	10 amp. A.C.*	30/-
500mA	30/-	20 amp. A.C.*	30/-
1 amp.	30/-	30 amp. A.C.*	30/-

"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.



25μA	70/-	500mA	35/-
50μA	47/6	1 amp.	35/-
50-0-50μA	45/-	5 amp.	35/-
100μA	45/-	15 amp.	35/-
100-0-100μA	45/-	30 amp.	35/-
500μA	42/-	50 amp.	35/-
1mA	35/-	5V. D.C.	35/-
1-0-1mA	35/-	10V. D.C.	35/-
5mA	35/-	20V. D.C.	35/-
10mA	35/-	50V. D.C.	35/-
50mA	35/-	150V. D.C.	35/-
100mA	35/-	300V. D.C.	35/-
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		50V. A.C.*	35/-
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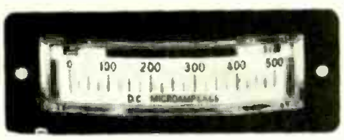

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MODEL 500 Features Mirror Scale and Buzzer Short Circuit Check. Sensitivity: 30kΩ/Volt D.C. 15kΩ/Volt A.C. D.C. Volts: .25, 1, 2.5, 10, 25, 100, 250, 500, 1,000V. A.C. Volts: 2.5, 10, 25, 100, 250, 500, 1,000V. D.C. Current: 50μA, 5, 50, 500mA, 12 amp. Resistance: 60K, 6MEG, 60MEGΩ. Decibels: —20 to +56db. Handsome Dustproof Black Plastic Case, size 3 5/16in. × 6 1/16in. × 2¾in. **£8.17.6** p/p 2/6

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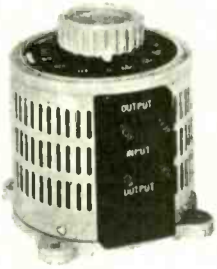

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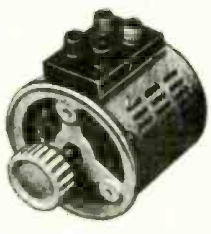

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The presentation is a low format of a depth suitable for shelf mounting. The amplifier is supplied in a metal housing suitable for fitting into a cabinet if required. The front facia is of extruded aluminium section with end pieces to form a complete frame. It is fitted with an anodised aluminium panel, screen printed.

The amplifier uses a true complementary symmetry output circuit with matched NPN and PNP transistors to obtain a virtually zero 'crossover' distortion. Improved circuitry has been developed to provide high gain in the output stages and drive circuits with wide bandwidth permitting a large amount of feedback to ensure an extremely low overall distortion. The success of the circuitry and the devices used is exhibited by the power bandwidth characteristic of 0·5 MHz at the −3 dB point.

The amplifier is unconditionally and absolutely stable with any form of output load of any impedance characteristic, from short-circuit to open-circuit. The amplifier itself is fully protected by current and voltage limiting and in addition is protected against the failure of a device in the power amplifier itself by a high speed current protection circuit in the power supply.

A new low distortion level of 0·01% has been reached for the amplifier at the −3 dB reference to the rated output, with the distortion proportionally decreasing with output power. Approximately 60 watts (continuous tone rating) is available at clipping level at 0·025% distortion both channels driven simultaneously.

Considerable attention has been given to reliability and ease of service. All components are to Mil specifications where possible. The amplifier is constructed in modules and all active circuits are on plug in type circuit boards. The contacts in the sockets and circuit boards are hard electro gold plated and the circuit boards themselves are immersion gold plated. Circuit board sockets are fitted to a printed circuit mother board thus eliminating wiring with its variations in performance and stability.

SPECIFICATION

Mains Input	110 volts. 120 V. 130 V. 220 V. 230 V. 240 V. 50-60 Hz.
Output Matching Impedance	4-16 ohms (100 V line extra).
Output Power	50 Volt-amperes nominal. (Watts into an 8 ohm resistive load).
Distortion	0·025% at clipping onset. 0·01% at −3 dB ref: clip level.
Input Facilities	High impedance 22K ohms. Low impedance, optional 200/600 ohms balanced/unbalanced.
Input Sensitivity	High impedance. 1 Volt r.m.s. Low impedance, 0·5 Volt r.m.s.
Functions	*Switched on front panel* Mains on/off. Louspeaker 1. Loudspeaker 2. Hi/Low Impedance input.

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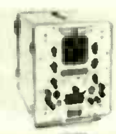


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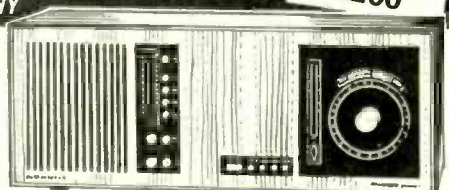

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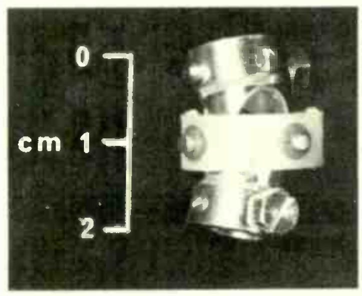

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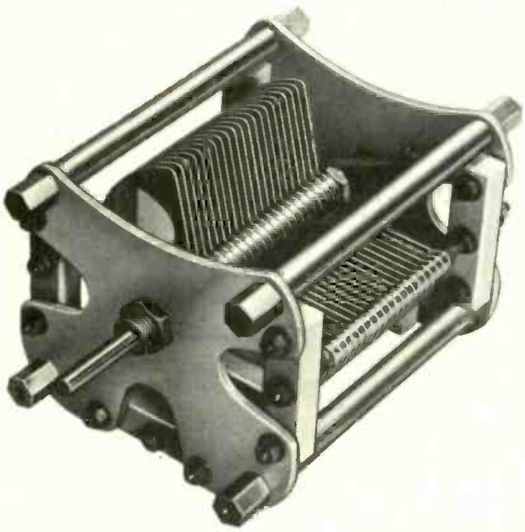

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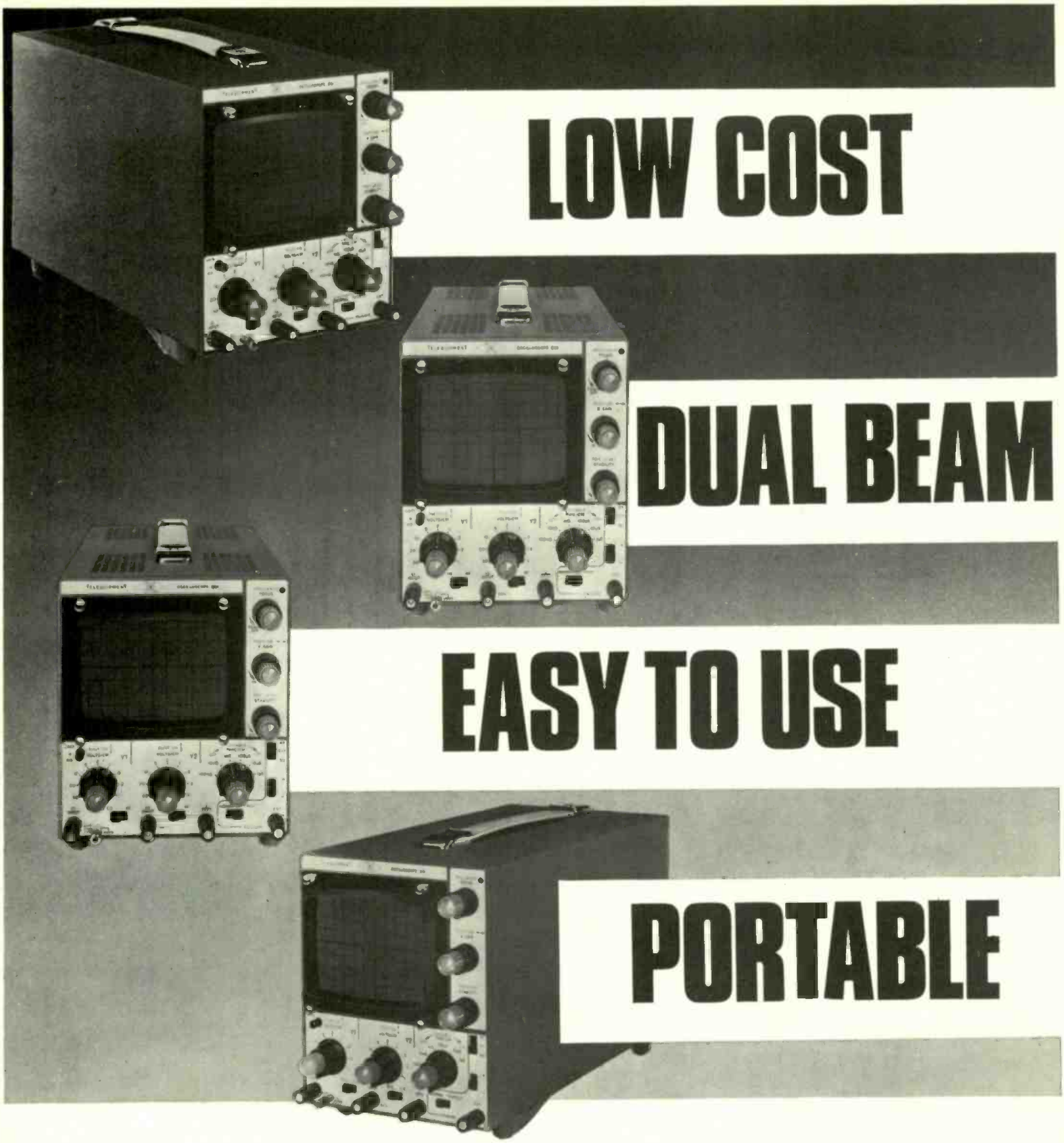

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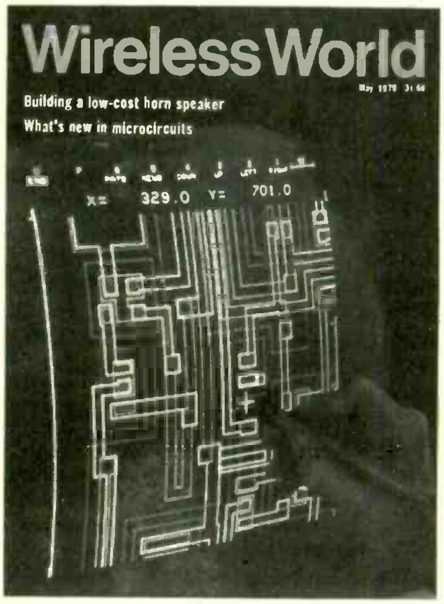

This month's cover illustrates the use of computer graphics in the design of integrated circuits at Mullard, Southampton. On p.215 we review the latest developments in microcircuits seen at the Paris components show.

IN OUR NEXT ISSUE

Simple transistor tester for diagnosing which junction has failed.

Class AB audio amplifier with performance comparable to existing class A but with reduced thermal dissipation.

Survey of communication receiver techniques with tabulated details of equipment on the U.K. market.

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Investing in the future

The prospects of the U.K. electronics industry,* which is believed to be the fourth largest in the world (the U.S.A., Japan and Germany being the first three), have been assessed by the Electronics Economic Development Committee (Little Neddy) and a lengthy report has been issued by the National Economic Development Council. This report, which is primarily concerned with the industry's prospects during the next two years, draws a number of conclusions and makes several recommendations, the most far reaching being that concerning expenditure on research and development.

The committee considers that the most important immediately practicable step which could be taken to improve the flow of resources to the industry would be the recognition on the part of the government, that the industry's research and development expenditure fulfils the same economic function as its capital expenditure, namely a provision for the future out of current resources. In this connection the E.D.C. lays stress on the industry's development effort as distinct from its research effort. This is the vital link in translating the fruits of research into marketable products, and it is here where pressure on resources is greatest. It is already national policy to encourage industry to make adequate provision for the future in terms of production hardware, but since, as regards R & D, investment grants are confined to capital expenditure incurred in producing prototypes and in providing plant or machinery for use in scientific research, the effect is to discriminate in favour of industries whose R & D effort is relatively plant-intensive at the expense of industries like electronics whose R & D effort has a high labour content. The result is to exclude from grant the bulk of the R & D expenditure of the electronics industry. The E.D.C. therefore recommends that government should find some way of extending the coverage of the investment grant system to cover the whole of the industry's R & D expenditure, including that on software, even if this means some reduction in level of hardware grants.

There may be those, possibly of other industries, who will consider that electronics will be "feather-bedded" if Little Neddy's proposal is put into effect.

What are the facts therefore, that prompted the committee to suggest this fundamental change in the attitude towards the cost of R & D in a company's accounts? The R & D effort of the electronics industry is approximately five times as important in relation to capital expenditure as the national average for the country's manufacturing industry. With the exception of the chemical and aircraft industries electronics has a higher density of qualified manpower in R & D than any other industry. In a normal year the R & D expenditure of our industry is about twice its expenditure on capital investment, as normally defined, and currently exceeds £100m. In manufacturing industry as a whole the position is reversed—capital expenditure being about two and a half times that spent on R & D. Moreover, the technological advance and innovation in electronics results in very rapid obsolescence both of the end product and, not infrequently, the means of production.

Lest it should be thought that the committee which drew up the report is heavily biased it should be stated that of the 18 representatives of management, trade unions and government (under the chairmanship of Sir Eric Mensforth) only seven represent electronics companies: Plessey, Rank Bush Murphy, Wayne Kerr, International Computers, Ferranti, Mullard and Marconi.

One question which may justifiably be asked is "what of government financed research contracts?". How will the Treasury be able to differentiate between research for which government is paying and company research which could be claimed as "capital investment"? Despite this administrative problem we wholeheartedly agree with the committee's recommendation.

*Radio, radar and electronic capital goods; computers; instruments; radio and electronic components; domestic broadcast receiving and sound reproducing equipment; and telecommunications equipment.

Low-cost Horn Loudspeaker System

Details of successful experiments

by "Toneburst"

As far as the ear can tell, consistently clean and spacious bass can be reproduced only by a driver unit coupled to a horn-type acoustic transformer. This fact has, of course, been known for years and most of the credit must go to Paul Klipsch who in 1941[1] described a split folded bass horn which outperformed theoretical expectations, and set a performance standard that cannot be excelled. If there is any quibble about the performance of such a bass horn it can only be that 'level' response below about 35Hz is difficult to achieve.

In a sense it is unfortunate that Klipsch achieved what he did. Theoretical analysis of the performance of a corner horn has not advanced significantly since. Langford-Smith[2] comments that "The only known method for handling frequencies below the flare cut-off frequency of an exponential horn, with good fidelity, is the use of an enclosed air-chamber behind the diaphragm, resonant at a frequency in the vicinity of the flare cut-off frequency, as used with the Klipsch loudspeaker". This is a very peculiar remark for it implicitly casts doubt on the exact nature and function of the horn mouth. In 1943[3] Klipsch had reported that "The improved horn has a cut-off due to flare of 50 cycles, but the impedance measurements and ear tests show that a strong fundamental is radiated down to 35 cycles. It must be concluded that the computed horn impedances are only qualitatively correct for frequencies within an octave of the low-frequency cut-off."

No experiments seem to have been done since Klipsch's design appeared, in a direct attempt to compromise horn theory without losing quality. Bearing in mind Langford-Smith's condensation of Klipsch's own experience there seems to be a good case for expecting to be able to simplify the design of a split folded corner horn whilst maintaining an acceptable low frequency performance.

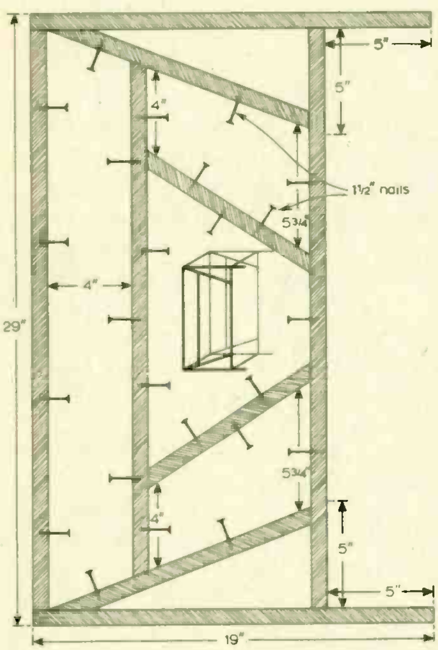

Fig. 1. One of the two side frames. Inset is a diagram of the complete frame. The nails should be knocked in before the two sides are joined together. Nails for the front panel can be added to the complete frame.

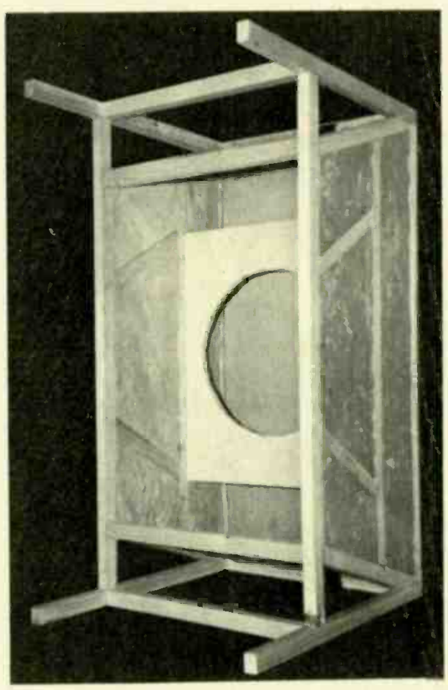

Fig. 2. Enclosure fully concreted and ready to have the bass driver mounted on its board.

Experimental work

The first necessary decisions were on size and shape. Klipsch himself gives some support in saying that "The front throat baffle may be rearranged for a simple flare rate working out of a larger cone, in which case the air chamber between the cone and throat may be eliminated."[4] A simple starting point was found in an adaptation of the Ambassador bass horn described by Briggs.[5] There is no compression chamber behind the cone in this design, but after a slightly modified version had been constructed, employing a Fane 122/12 12-in driver, good response down to about 40Hz was heard. Unfortunately there were humps and bumps from about 320Hz upwards. Further modifications, to smooth the flaring rate, removed the trouble above 320Hz but also removed the bass below 100Hz. A compression chamber to Klipsch's specification was constructed by filling up the corner space at the back of the enclosure. The result was, and is, clean bass with response down to below 30Hz.

A description of the final horn structure follows. It is recommended that all instructions are followed at least in spirit, if not to the letter, or significant resonances may be found rather late in the day.

Construction of bass horn

Raw materials required are lengths of 1 × ¾in or 1 × 1in wood, 1½in nails, sand and cement, and pieces of plywood, blockboard, or chipboard. Most of the wood items can be bought as off-cuts and the sand and cement is available in a suitable mix in convenient 7-lb bags costing 2s 6d (Rustins).

Frame. The first step is to put together a rectangular framework into the front and sides of which will be cast concrete panels. Two side frames must be constructed as in Fig. 1, and 1½in keying nails knocked in as shown. Cutting the wood should present no problems even to those with no experience. An Eclipse No.66 general purpose saw is recommended to anyone in doubt—it costs just less than £1. (After marking the wood to length remember to cut on the outside of the mark(s) and not to try to make two wood lengths out of a piece exactly the length of the two pieces finally required.)

Assembly should be on a flat surface, on a single layer of paper if need be. The recommended adhesive is Evostik Resin 'W'. The 4 fl.oz. 'oil can' dispenser is ideal for all the joining operations. This may be refilled from a ½-pt pack thus combining convenience with overall economy.

After one side frame is complete, and the resin set, four 13-in lengths are to be stood vertically at the correct positions on one of the frames and the adhesive left to dry. This is the one operation for which square-cut ends are essential.

After cutting each length of wood make sure that no saw-dust is left on the ends when the resin is applied. (A stiff wire brush is useful here.)

If 1 × ¾in wood is used the joining should allow the 1-in face to set the depth for the concrete front panel.

Concrete Panels. The front and sides must next be fitted with concrete panels to the depth of the wood limiting each area.

The side panels are the smallest and thus the best place to start the concreting. Place about ten layers of newspaper on a flat surface—table or floor—and lay the frame with one of its sides down on the paper.

The cement may be used with or without gravel. If the average particle size of any gravel used is not less than ⅜in, two or three pounds may be safely added to a 7-lb bag of sand and cement without significantly weakening the binding power. The complete contents of each bag of sand and cement should be used at once or some sandy results may be obtained due to separation of the mix during storage.

Start with 7lb of cement mix (with or without a known amount of gravel) and fill up the panels. It is then just a question of doing some arithmetic to find out how much more concrete will be required to complete the panelling for one or two horn structures.

The mix should be fluid and can be spooned into the spaces. The newspaper will quickly absorb any excess water, and it should be possible to lift the frame after about 18 hours though it is better to leave it for 24 hours. (The concrete will take up to a week to dry out completely.)

The front panel should be cast next in exactly the same manner as described, but should not be lifted from the paper for about 48 hours. Finally the other side panels may be cast.

Speaker Board. The 16½in × 13in panel carrying the bass driver should be not less than ½in thick and may be made of plywood, blockboard or chipboard. A 10-in diameter hole must be cut in the middle. It is quite easy to drill holes round the edge of a 10-in circle (as close together as possible) and then to drill round again in both directions at 45° to the surface. Finally, a sharp knock on the centre of the circle with a hammer should remove the disc and the edge of the hole can be cleaned up with a rasp or file.

The speaker board should be fitted into the concrete framework using Resin, as shown in Fig. 2. Once dry, wooden blocks should be glued as shown in Fig. 3. These blocks remove all significant resonance from the speaker mounting board.

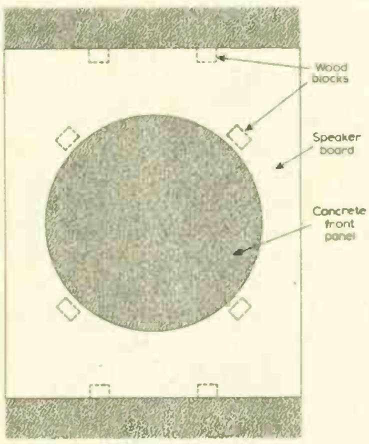

Fig. 3. Diagram of speaker mounting board within the enclosure showing position of wood blocks. These blocks were trimmed to fit—the back of the concrete panel was rather irregular.

Top and bottom concrete flare-panels. Using the same woodworking techniques as before two wooden frames should be made, using the main frame as a vice. When the joints are dry these frames should be removed and after positioning carefully on newspaper (with one wooden edge of each necessarily overhanging the table, if constructed as revealed in Fig. 4) concrete mix should be spooned in. Again, if 1 × ¾in wood is used the 1-in face should give the thickness of the panel. When dry these panels can be glued into the main frame—which should be placed on its side. Next the speaker can be screwed down, as tightly as possible, using four 1-in screws. The terminals should face the middle of one side of the enclosure.

Wooden flare-panels. Simple rectangles of ½-in plywood will do for these—it does not matter at all that the junction with the speaker board is along a 'sharp' edge—a similar edge will also be 'flush' with the rear of the enclosure so far built. To fix these panels the enclosure should be turned on its side and each panel glued along the edges that will lie along the wood strips in the sides. When the joints are dry turn the enclosure on its front and glue along the junctions between the panels and the speaker mounting board.

Back panels and duct. The details of the remaining panels (½in to ¾in thick) are deducible from Figs. 4 and 5. The angle pieces forming the 3-in high vent to the rear of the cone should be drilled so that they can be screwed down while the glue is still wet. The two panels completing the

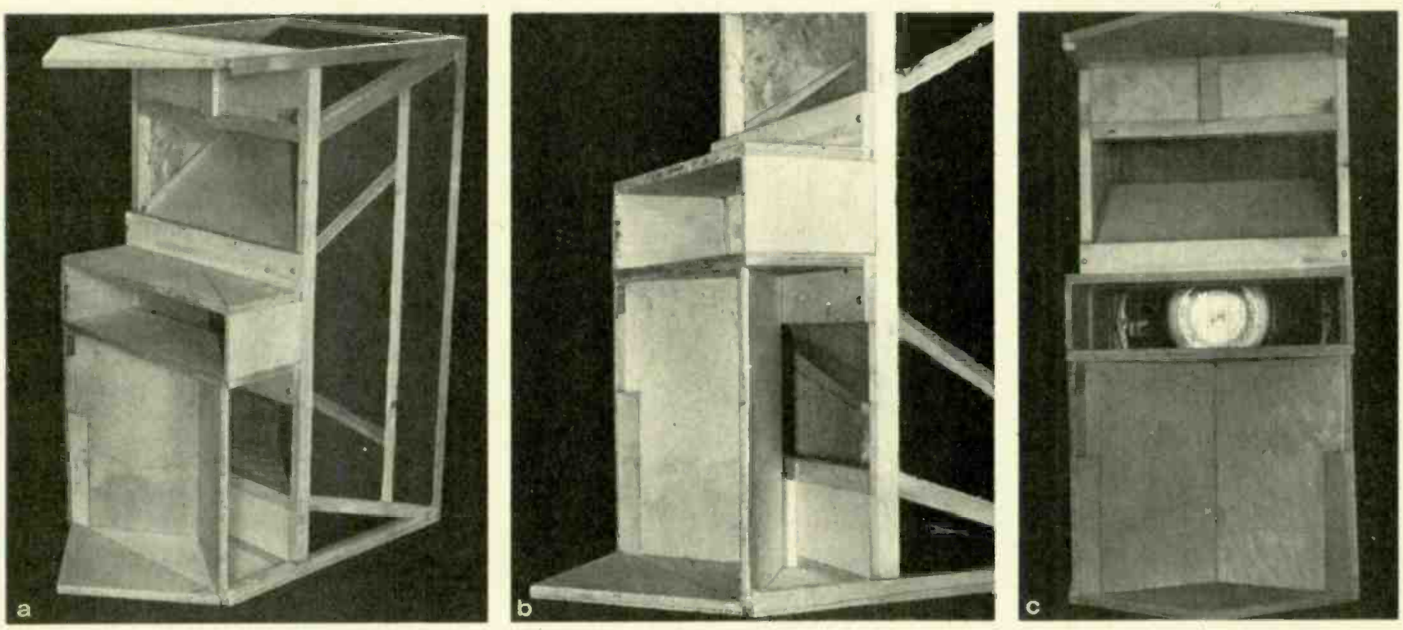

Fig. 4. Advanced stages in construction. (a) and (b) give details of the back panels and vent. The upper horn opening must be finished as the lower. (c) shows the appearance from the rear. The rectangular panels forming the exit path from the horn can be cut larger than required and trimmed with the saw when glued in place.

compression chamber should be of ¾-in ply. (The drive unit must be wired to external terminals before fitting the second panel.)

Resonances. Any concrete flanges that overlap the wood should be knocked off gently with a hammer. When satisfied that the concrete edges are clean, turn the enclosure on one side and run a stream of glue along all the wood-cement junctions. This procedure must be followed for each side, allowing each 'run' to dry while the enclosure is horizontal.

Now, standing the enclosure upright, tap the front panel with a finger. Note the dead sound—it is high-pitched, metallic and of no perceivable duration. Test each concrete panel in turn. The same should be done for the plywood panels.

If a resonance is found which suggests hollowness, then bracing must be fixed as in the case of the speaker mounting board. Such resonances, if left, will seriously colour upper bass frequencies.

Finally, the external concrete surfaces can be painted.

Fitting against skirting boards. There are four possibilities:

1. Cut out a suitable section from the back compression chamber.
2. Stand the enclosure on a triangular plinth raised above the skirting board.
3. Remove the skirting that is in the way.
4. Stand the enclosure against the skirting and fit wood strips in the gaps between the walls and horn.

The latter is the simplest way.

Treble speaker

In deciding what treble unit to use with the bass horn the main criteria for consideration are sensitivity, distortion, sound dispersion and frequency range.

Fig. 5. Two panels of ¾-in ply complete the compression chamber. The angle formed by the apex of the triangle must of course be ≥ 90° and 9-in wide panels were satisfactory. When one panel has been screwed and glued bracing blocks can be liberally fitted between the internal surfaces of the chamber. The drive unit must be wired up to external terminals. The compression chamber must be airtight.

Horn loading a treble driver raises its efficiency, linearizes its response, and allows the dispersion pattern to be controlled. Again I had recourse to the work of Klipsch. In 1963 Klipsch[6] published details of a high-frequency horn with a cut-off below 300Hz, and off-axis response correct for good stereophony. This horn was driven by a pressure unit from a throat 1in or less diameter. The area doubled approximately every 2¾in and ended in a rectangular mouth 5½in × 17in. Obviously if a suitable small cone speaker can be found the horn structure can be very simply shortened to match the cone diameter.

The Eagle FR4 driver, although sold as a full-range unit for use in a bookshelf enclosure, has excellent characteristics for use as a mid-range and treble speaker, with horn loading. The manufacturer's frequency response chart shows a ±5dB variation in the range 100Hz to 9kHz, and a steady decay out to about 17kHz. A concrete horn was therefore designed to match this drive unit.

Construction of treble horn

Cardboard mould. The horn has flat top and bottom, and curved sides. The diagrams of Fig. 6 show the exact shape and dimensions of the four cardboard pieces required. The templates may conveniently be drawn on thin card—only one of each shape being required. These can be drawn round to transfer the shape to the thick cardboard needed to make the mould. The best cardboard for the mould is the $\frac{1}{16}$-in thick "grocery box" stuff with a corrugated middle layer sandwiched between two thin flat sheets. In preparing the sides of the mould it is helpful to ensure that the corrugations assist rather than hinder the folding. The dimensions given allow for the thickness of the concrete layer and the thickness of the cardboard where the joints are made.

Once the pieces are cut glueing can begin. Evo-Stik "impact" adhesive is best for this, the sides being stuck between the top and bottom.

Although the mould can be used as it stands, it is recommended that the inside be given a layer of varnish so that the wet cement does not cause deformation.

Casting. Concreting is in four stages using a gravel-free mix. The mould should be placed on a flat surface and the bottom surfaced with a ¼-in layer of cement. It is a good idea to mark a small screwdriver ½in up the blade and use this as a probe to ensure a more or less uniform layer. The work must now be left to dry out completely. Next, one of the curved sides can be cemented, in exactly the same manner, but first a layer of Evo-Stik Resin 'W' should be applied to the side of the dried concrete to help bond the new to the old. The mould should be turned on its side while the side piece dries out. Do the other side piece and then the remaining flat piece, applying the wood resin as each new section is formed. Finally, the cardboard may be stripped off.

Throat section. Stand the horn throat down on a piece of ½-in blockboard 6in

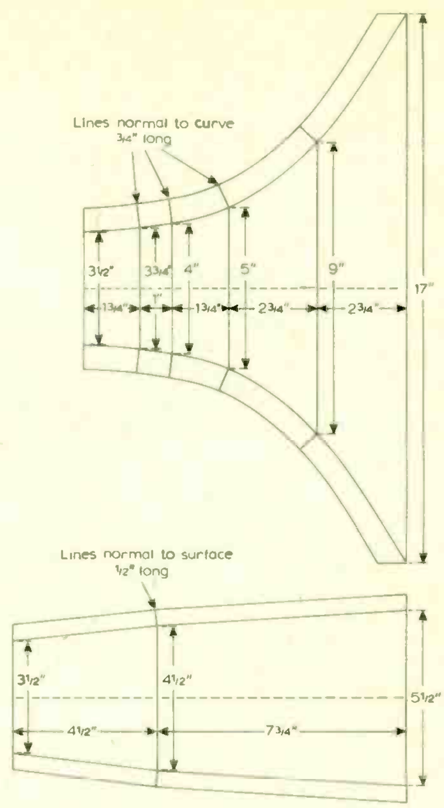

Fig. 6. Dimensions of templates for constructing treble horn cardboard mould.

square and draw round the edge. Drill out the middle section (as specified for the bass speaker board) and fit it like a collar round the throat—a hammer can help if used with due care. When the throat opening is flush with the top of the collar, wood resin should be run round the joint and left to dry. A 6-in square of ½-in plywood, with a 3½in-diameter hole in the centre (again drilled out) can be screwed or glued down over the throat opening. When dry (if glued) the inside of the throat must be concreted to give a proper exponential transition from circular to rectangular cross-section. Wet cement can be applied with an old knife, the four cement "fingers" stopping about 3½in from the now circular throat. A file can be used to remove gross roughness on the inside of the horn. One or two coats of paint can be applied to give better smoothness. The FR4 unit can now be screwed on to the horn, and the final assembly is shown in Fig. 7. Sound absorbent material must be fixed over the back of the speaker chassis to prevent unwanted wall reflections.

Crossing over between drivers

The treble horn loads its drive unit quite satisfactorily down to about 300Hz. The bass horn delivers its output with an increasing amount of distortion as the frequency rises above about 500Hz. It seems correct therefore to cross over at about 400Hz and at a rate of not less than 12dB/octave.

In constructing a crossover network of the constant resistance variety (where the impedance seen by the amplifier remains more or less constant right through the crossover point) there are four variables to

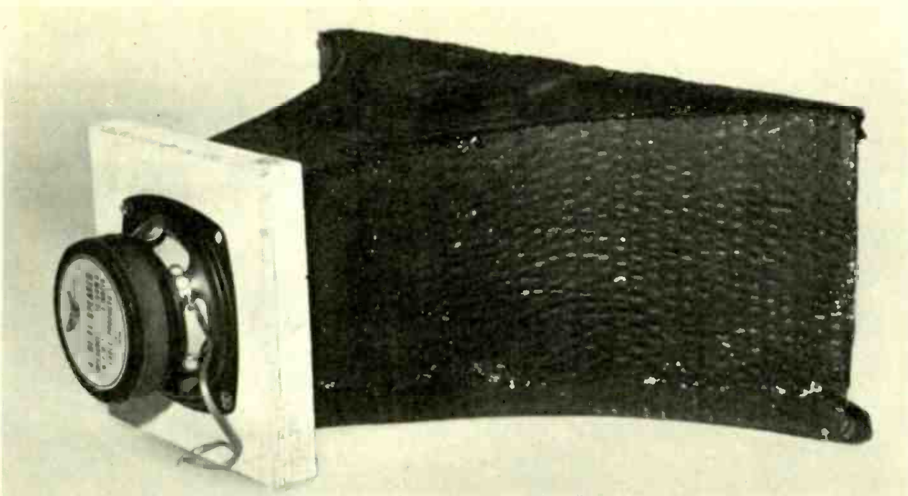

Fig. 7. Completed treble horn.

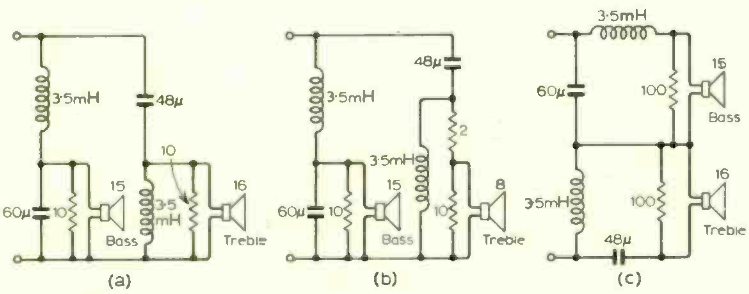

Fig. 8. Crossover circuits: (a) $\frac{1}{2}$-section parallel network arranged for 16-Ω treble driver; (b) $\frac{1}{2}$-section parallel network arranged for 8-Ω treble driver; (c) $\frac{1}{2}$-section series network that can be used with 16-Ω treble driver—this is the most efficient circuit but unfortunately the FR4 is no longer being produced in the 16-Ω version. Resistors can all be $\frac{1}{4}$W.

Fig. 9. A speaker in its corner showing hardboard guides fixed with hinges—shown from the side in Fig. 5.

consider—the crossover frequency, the load impedance, and values of L and C.

The most difficult component to obtain is a suitable capacitor. Non-polarized electrolytic types specially made for crossover networks come in a very limited range—at the large value end of the scale the choice is either 60μF or 100μF. If these capacitors are not used the alternative is a monstrous parallel-array of ex-W.D. paper types which will at the same time be quite expensive. To cut a long story short values of 60μF and about 3½mH give a network which in theory crosses over symmetrically at about 430Hz with load impedances of 12Ω or 6Ω depending on whether a series or a parallel $\frac{1}{2}$-section network is employed. The capacitor on the treble side was reduced to 48μF (3×16μF) to reduce a slight peak in the treble-horn response at the crossover point. Resistors across the driver voice coils, whilst reducing the overall impedance, also reduce the significance of changes in voice coil impedance from the point of view of the crossover network.

Three crossover circuits are shown in Fig. 8. These allow different impedance treble units to be used—I have 8Ω in one channel and 16Ω in the other. Crossover circuits (a) and (b), which I use, may be doctored further still. A small choke—say 250μH—placed in series with the 10Ω resistor across the treble unit will remove the shunting effect at high frequencies, thus extending the top. In circuit (b) the 2Ω series element can be bypassed by a 2–4μF capacitor as well.

Winding the chokes. A 2-in piece of ⅛-in diameter ferrite rod (with cardboard discs glued on at the ends) can be wound with 37ft 6in 24 s.w.g. enamelled copper wire to give an inductance of about 3½mH. The turns must be close and the layers neat. Careless winding will give a sadly low value. The treble boost choke can be wound similarly—about 10ft close wound will give 300μH.

Notes of the final assembly

Fig. 9 shows the composite horn in its corner—the total cost of materials, including that of the two driver units, amounted to about £17. The bass enclosure is properly called a driver, the bass horn being formed in conjunction with the walls and the floor.

Three points are worth making in conclusion.

1. The most striking characteristic of the treble unit is a reduction in background noise, for example when playing worn discs, compared with direct radiator treble units. Where there is a significant background noise level this seems to separate out from the music, and any odd clicks are peripheral to the sound image.

2. Provided the bass-horn driver makes fair contact with the corner walls the bass performance is not affected by the hardboard guides which theoretically define the horn mouth and the final flare rate. Considering the size of the enclosure this is an inducement to further experiment. The question remains—"What defines the actual lower limit of the bass response?"

3. If the bass enclosure is constructed to the width of the treble horn the whole system can be "cased" to give a very acceptable rectangular structure.

Crossover components

Ferrite rod of ⅛-in diameter is available from G. W. Smith (Radio) Ltd. Four-inch lengths cost 1s 3d, and six-inch lengths 1s 6d each. To break the rod, first file a shallow notch 2in from one end. Place a pin on a hard surface, such as a metal ruler, and with the notch facing upwards press the ends of the rod downwards with the pin lying exactly below the notch. This should result in a clean break.

If choke-winding is considered tiresome, 5mH chokes are available from K.E.F. Electronics Ltd, Tovil, Maidstone, Kent, for 9s 6d each. Removing 8ft of wire will reduce inductance to about 3½mH.

60μF and 16μF non-polarized 50V capacitors are also available from K.E.F. for 4s and 2s 6d each respectively.

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Circuit Ideas

Multivibrator timing control

The timing of any multivibrator can be controlled very simply, over a wide frequency range, and without risk to the transistors, by use of a diode and resistor combination as shown below. With reference to Fig. 1

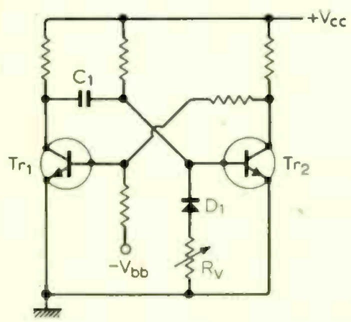


Fig. 1. Monostable circuit.

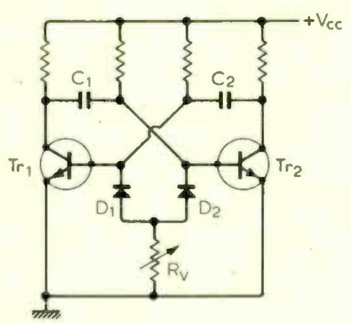


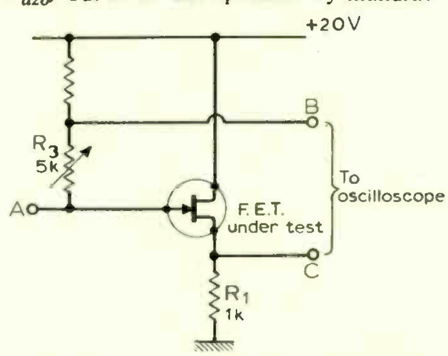
Fig. 2. Astable multivibrator.

it can be seen that in the idle condition the monostable is unaffected since the diode is reverse biased. When triggered, the base of Tr_2 approaches $-V_{CC}$ volts and diode D_1 conducts, thus providing an additional discharge path for C_1. If R_V is large, the circuit is unaffected. As R_V approaches zero, so the discharge time is shortened. Fig. 2 shows how the frequency of an astable multivibrator may be varied without altering the mark/space ratio. If R_V is large, the circuit is not affected as the diodes are back to back. As R_V is reduced capacitors C_1 and C_2 alternately discharge through R_V thereby increasing the frequency. If desired R_V may readily be replaced by a p-n-p type transistor, or other active device.

L. V. GIBBS,
Wellington,
New Zealand.

Measuring zero drain-current coefficient in f.e.ts

It is well known that f.e.ts exhibit a zero drain current coefficient at some particular quiescent drain current. This is known as I_{dzo}, but it is not specified by manufac-



Test rig for f.e.t. The unmarked resistor is 15kΩ.

turers for a particular device and the standard method of temperature cycling each device in order to find its I_{dzo} is long, expensive and laborious. The following method is a simple alternative. The f.e.t. to be tested is put in the test rig shown. A 5ms wide positive going pulse, with a baseline at −10V is applied to A. The differential inputs of an oscilloscope are connected between points B and C. The pulse on the gate of the f.e.t. turns it on, the drain current being determined by R_1 and the pulse amplitude developed across it, and it heats up. Any undershoot or overshoot on the source, compared with that on the gate is due to heating of the f.e.t. junction and corresponding changes in drain current. Therefore to find I_{dzo}, the input pulse amplitude is adjusted until a flat top waveform is obtained on the source. R_3 is adjusted to give the minimum difference between the two input settings to the oscilloscope and therefore prevent overload conditions. The drain current at which this I_{dzo} is obtained is then calculated from the peak voltage across R_1.

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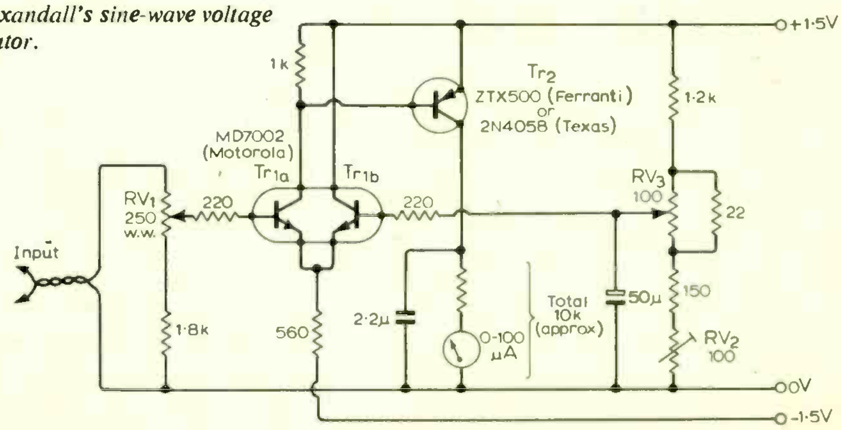
Comparator for small sine-wave voltages

This circuit, used in a production test, was designed for determining accurately the percentage difference in the output voltages (nominally 150mV r.m.s.) of two sine-wave *LC* oscillators operating at 1kHz and 100kHz respectively. In use, the input leads are first connected to the 1kHz oscillator, RV_2 and RV_3 then being adjusted for half-scale reading on the meter with RV_1 set to the "0%" mark. The leads are then transferred to the 100kHz oscillator and RV_1 moved until half-scale reading is again obtained. The percentage by which the 100kHz amplitude differs from the 1kHz amplitude is then read directly off a calibrated scale associated with RV_1. With values as shown, the model built has a frequency response level from 20Hz to 200kHz within ±0.1%, i.e. approximately ±0.01dB. It may thus also be used for making very accurate frequency-response determinations. Tr_{1a} and Tr_2 conduct current in pulses only, at the positive-going peaks of the input signal. The mean value of these pulses, which is registered by the meter, increases very rapidly with signal input voltage, once this voltage exceeds a threshold value. The circuit thus provides very good resolution of small input changes.

P. J. BAXANDALL,
Royal Radar Establishment,
Malvern, Worcs.

P. J. Baxandall's sine-wave voltage comparator.



Simple Audio Pre-amplifier

Design with high input impedance for use with radio tuner and ceramic pickup

by J. L. Linsley Hood

The circuit to be described was developed, in response to requests from friends and correspondents, in order to provide, with the minimum cost and complexity, a pre-amplifier suitable for use with a radio tuner and ceramic pickup. It was required that this unit should have low distortion and noise level, and should provide the facilities normally expected in a good quality pre-amplifier stage—bass and treble lift and cut controls, input selector switching, a switched frequency steep-cut low-pass filter, and a rumble filter giving rapid attenuation below 30Hz. Also, for convenience in use with a variety of inputs, it was required that the input impedance should be at least 2MΩ.

Ceramic pickup cartridge matching requirements

Although there can be little doubt that for the perfectionist there is no real substitute for the velocity sensitive (e.g. electromagnetic) pickup transducer, many of the better ceramic cartridges can give extremely pleasing results when suitably matched to a good amplifier and loudspeaker system, and such an arrangement fully satisfies the requirements of a large number of users.

In connection with the use of relatively low input-impedance transistor amplifiers, it has been suggested by a number of workers that a satisfactory performance can be obtained from such piezo-electric transducers if they are connected to the normal 47—100kΩ magnetic cartridge input of a pre-amplifier circuit, and then treated as if they were velocity sensitive units, with the normal recording characteristic compensation. However, while this may work with some cartridge designs, in many cases the manufacturers of the transducer have taken some care in the design to provide a proper frequency response characteristic, by electromechanical techniques,[1] on the assumption that a high impedance load (≈2MΩ) will be used, and, in these cases, a better performance is obtained if the manufacturers' intentions are realised.

Although the provision of adequately high input impedances has been difficult in the past with transistor amplifiers, the growing availability of inexpensive junction field-effect devices has removed this problem, and it is now fully practicable, even without recourse to insulated gate devices, to design systems with input impedances as high as 10^{11} Ω, and the provision of a suitable load impedance for a ceramic cartridge is now quite a straightforward design exercise.

Filter characteristics

Unfortunately, the use of piezo-electric gramophone pickup systems, though convenient in terms of the large voltage output and the avoidance, by and large, of the need for relatively complex recording characteristic equalization networks, leads to other problems in use. In particular, because they are displacement sensitive devices, such pickups are inconveniently sensitive to the almost unavoidable low-amplitude and low-velocity vertical and lateral irregularities in the motion of the turntable, and unless an effective high-pass 'rumble' filter is

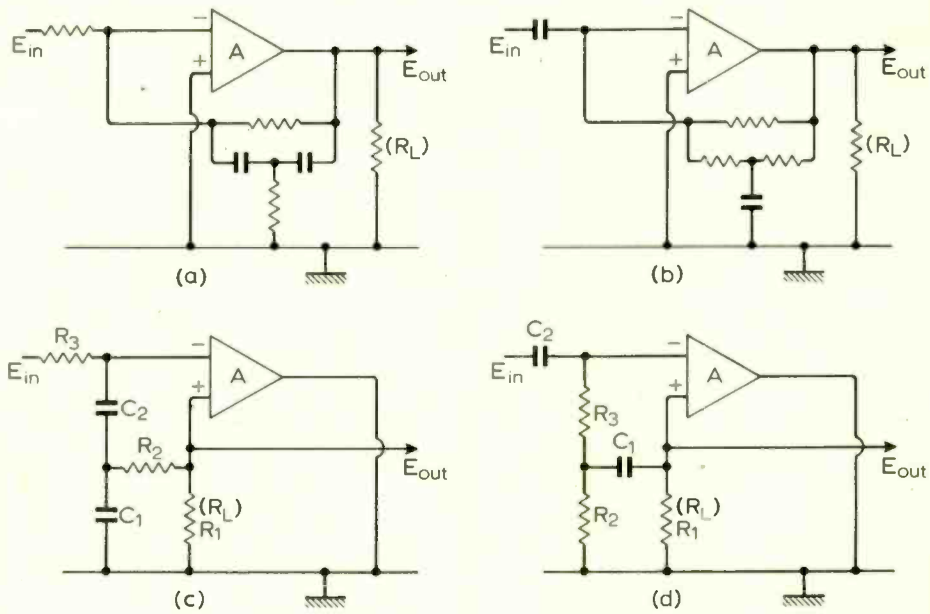


Fig. 1. Active filter circuits: (a) low-pass bridged T; (b) high-pass bridged T; (c) and (d) unity-gain arrangements of (a) and (b).

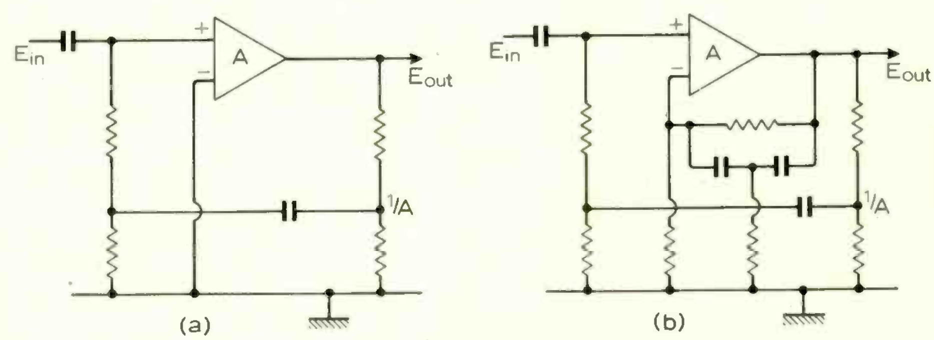


Fig. 2. Rearrangements of Fig. 1(d): (a) output to filter network taken from tap on output load resistor at point where input-output gain is unity; (b) low-pass filter incorporated in loop of Fig. 2(a).

employed, the reproduction of the recorded signal on an amplifier and speaker system with a good low frequency response is likely to be marred by the presence of a continuous low-pitched background rumble. Also, the mass of the piezo-electric ceramic elements is prone to cause mechanical resonance effects in the region 6–12kHz, which can exaggerate the record surface noise, and a steep-cut low-pass filter can then be very valuable in reducing this background. This type of filter can also be very helpful in a.m. radio reception to minimize sideband 'splash'.

Development of filter design

The use of a bridged T *RC* configuration, as shown in Fig. 1 (a), in an amplifier feedback path, to provide an active low-pass filter circuit, was described in *Wireless World* in July 1969.[2] The complement of this, shown in Fig. 1 (b), is an equivalent high-pass filter circuit. However, both of these circuits can be rearranged in unity gain form, as shown in Figs. 1 (c) and (d), and this last arrangement was used in the previous article in a rumble-filter circuit.[3] Both of these unity gain transformations have an important advantage over the circuit due to Sallen and Key[4] in that they will operate satisfactorily with a high source impedance, whereas the Sallen and Key filter requires a very low generator impedance for proper operation. It should be noted, however, in passing, that the signal should ideally be applied between the two inputs of the amplifier, whereas, in this transformation, it must be applied between one input and the common earth line. The error in function due to this cause can be ignored provided that the impedance of R_1, R_2 and C_1 is very much less than that of R_3 and C_2 (component nomenclature of Figs. 1 (c) and 1 (d)).

Although the configuration shown in Fig. 1 (d) is that for a unity gain system, such as a cathode- or emitter-follower, it can be employed with any non-inverting amplifier, provided that the output connection to the filter network is taken from a tapping point on the output load resistor at which the input-output gain is unity. This arrangement is shown in Fig. 2 (a), and has the incidental attraction that in addition to the input high-pass filter stage, an independently operating, switched frequency, low-pass filter can be incorporated within the same loop, as shown in Fig. 2 (b).

In both cases the circuit will require to be preceded or followed by a simple *RC* filter to provide the desired 18dB/octave attenuation slope. The gain/frequency characteristics of this part of the circuit arrangement are shown in Fig. 3.

Complete pre-amplifier

The circuit of a practical pre-amplifier unit, incorporating this type of input filter, and employing an inexpensive epoxy-resin encapsulated junction field effect transistor in the input stage, is shown in Fig. 4.

The preferred rail voltage for this unit is 15 V. This is not critical within a volt or two either way, except that a lower voltage will restrict somewhat the magnitude of the output signal at the quoted distortion level, and rail voltages of 20 or above would exceed the safe working ratings of the transistors in the event of a circuit fault. The few shillings cost of a zener diode to limit the maximum voltage on this line may be a wise expenditure.

Large capacitance electrolytics are employed in the source and emitter bypass networks of the first two stages to avoid unwanted phase-shift errors in the high-pass filter loop. Their presence also ensures that both the two input stages are 'bottomed' at the instant of switching on, to avoid

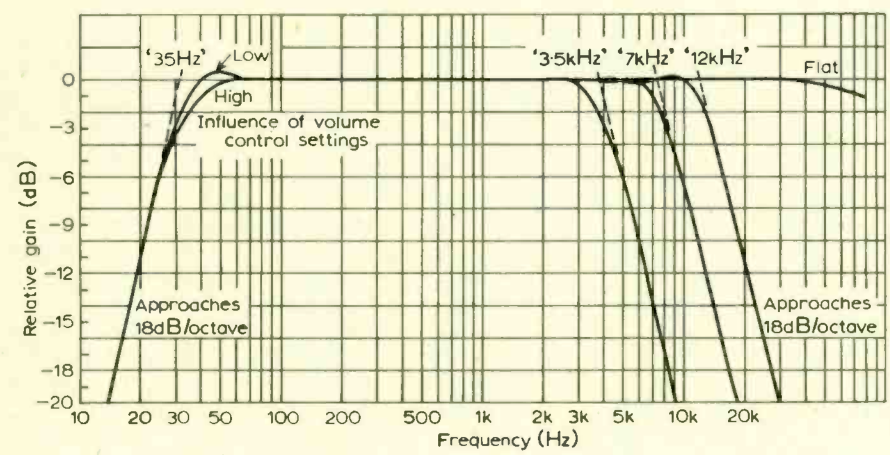


Fig. 3. Frequency response characteristics of pre-amplifier's low-pass and high-pass filters.

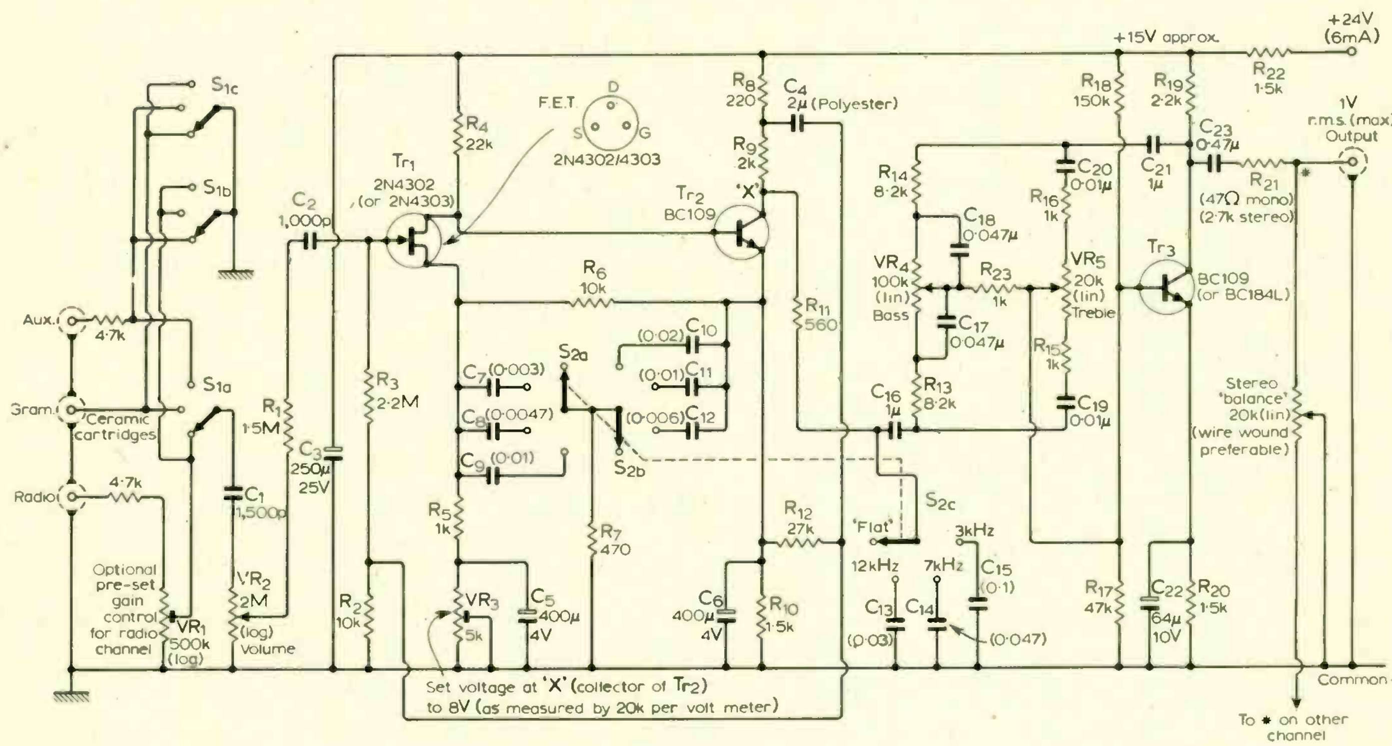


Fig. 4. Complete pre-amplifier circuit. The 4.7kΩ input resistors prevent short-circuit damage when unwanted sources are earthed.

the inadvertent application of excess voltage to the f.e.t.

Although the d.c. working point of both the input stages is stabilized by d.c. negative feedback loops; from the collector of Tr_2 to the source of Tr_1 through R_6 to R_5 and Vr_3, and from the emitter of Tr_2 to the gate of Tr_1 via R_{12} to R_2 and R_3; it is also necessary to provide some manual adjustment to the working potentials of the circuit, to allow for the unfortunately wide spread in the slope and gate cut-off point of any f.e.t. used (any n-channel f.e.t. with a negative gate cut-off voltage in the range 0.75-1.5 V can be employed provided that it has a sufficiently low noise figure). This adjustment is provided by the preset potentiometer VR_3 across C_5, and this should be used, on initial setting up, to fix the voltage on the collector of Tr_2 to 8 V. Once this voltage has been set for the particular f.e.t. in use, the constructor may replace the pre-set with a fixed resistor of approximately the same value (within 5%).

The gain of the pre-amplifier, at the flat settings of the tone control potentiometers, is entirely determined by the ratio $(R_6 + R_5)/R_5$ at frequencies within the filter pass-band. With the values chosen this gives an overall gain of 10, which is thought to be adequate for most pickup cartridges and power amplifier input sensitivities. The system can, however, be modified to give an overall gain of 20, and details of the necessary modifications are given in Appendix 1.

Adjustment to the setting of the volume control alters somewhat the input conditions to the high-pass filter and this produces a very slight change in the slope of the low-frequency roll off. This effect is also caused at maximum gain settings by the use of low impedance inputs, and the extent of this is indicated on the frequency response graph of Fig. 3. This can safely be ignored.

Tone control stage

This is largely based on the modification of the original Baxandall design due to Bailey[5], and the description of the operation of this given in *Wireless World* in December 1966 applies to the present design also, the only differences being that a higher loop feedback factor is employed, by the use of a higher gain transistor, and the utilization in the feedback path of the whole of the collector output voltage. This allows the rated distortion figure to be obtained at an output signal level of 1 V r.m.s., over the whole pass-band from 100 Hz to 10 kHz. The gain/frequency characteristics of the tone control stage are shown in Fig. 5.

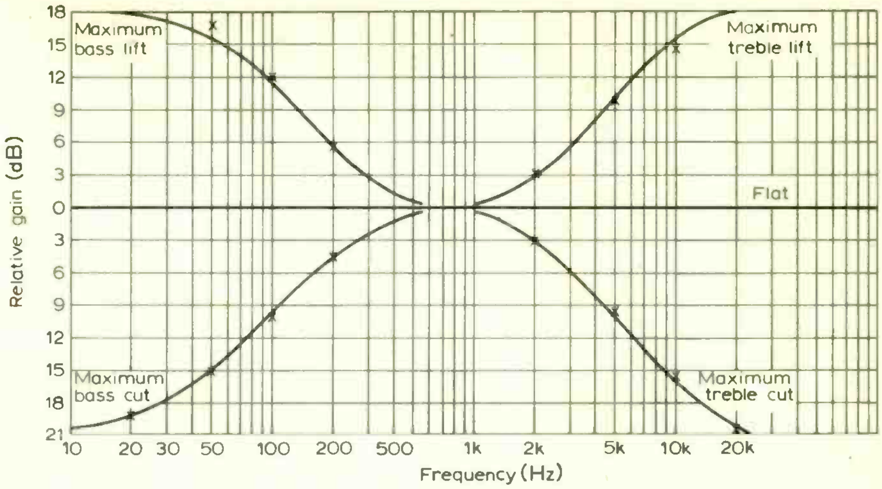


Fig. 5. Characteristics of tone-control stage

The output circuit in Fig. 4 is shown for stereo operation. For mono use, the balance control VR_4 is omitted and the value of R_{21} reduced to 47 ohms.

Hum and noise

One of the unfortunate snags in using amplifier systems with high input impedance connections is that they are extremely sensitive to hum pick-up from stray a.c. fields, and great care is necessary in screening the input leads and in earthing the associated metalwork to the correct points. The use of television-type coaxial cable, plugs and sockets helps to keep the hum pick-up to a low level, and the construction of the whole pre-amp except for its power supply, within a single die cast aluminium box (such as those marketed by Eddystone and S.T.C.) is strongly recommended.

The background noise level (noticeable as hiss) of this circuit is dependent to a large extent upon the noise figure of the f.e.t. Since these devices are, in principle, extremely low noise components, the pre-amplifier background level should be very low. Unfortunately, in the experience of the author, some of the inexpensive plastic encapsulated f.e.ts do not come up to the specifications of their manufacturers in this respect, and it cannot, therefore, be guaranteed that units of different vintages and different origins will always be as noise-free as one would wish. The f.e.t. specified, the Amelco 2N4302, has a very low noise figure, and should not give any trouble in this respect. (A 100pF capacitor can be connected across the feedback resistor R_6 to reduce the noise output from a less satisfactory component.)

Constructional notes

Several units of this design have now been built by different constructors and no problems have been encountered. However, since the amplified signal at the tone-control network is in phase with the (high impedance) input circuit with its associated switching, care should be taken to keep the stray capacitances between these two parts of the circuit as low as possible, to avoid high-frequency oscillation.

The preferred layout, in the view of the author, is in a similar form to that of the theoretical circuit, and this can be built, for a single channel, on a single "Lektrokit" 4.0in × 4.75in pin board. Two such panels, with the associated potentiometers and switches, can easily be accommodated in an 8.75in × 5.75in × 4.2in diecast box (available from G. W. Smith (Radio), Ltd.) which can then be mounted in a more elegant housing.

Pre-amplifier specification (For ceramic pickup and radio tuner inputs)

Input impedance	2 MΩ and 0.5 MΩ
Frequency response	35Hz—100kHz within ±1dB (controls flat)
Output voltage	1V r.m.s.
Distortion	Less than 0.1% 100Hz—10kHz (controls flat) (typically 0.04% at 1kHz)
Gain	×10 or ×20
Filter characteristics	−18dB/octave rumble filter, effective below 35Hz. −18dB/octave switched treble filter, turnover points dependent on choice of filter capacitors.
Bass and treble controls	Independent, continuously variable, +18 to −20dB. Mid-point 800Hz.

Appendix 1

Modification to give an overall gain of 20

The rearrangement of the circuit of Tr_1 and Tr_2 to give × 20 gain is shown in Fig. 6. This involves reducing the value of the lower feedback resistor R_5 to 470Ω, altering the values of the low-pass filter capacitors $C_{7, 8, 9}$, and the arrangement of the collector load of Tr_2. The circuit then gives an identical response to that shown in Fig. 3, but at a higher gain.

Appendix 2

Use of the pre-amp circuit with a magnetic cartridge

Although this circuit was specifically

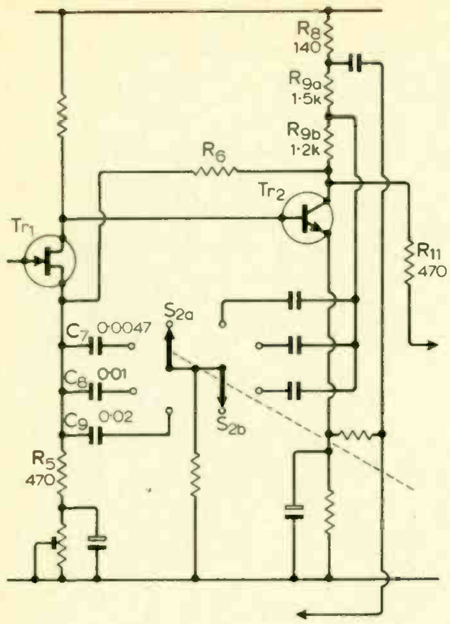


Fig. 6. Rearrangement of input circuit to give ×20 gain. Only the amended component values are given.

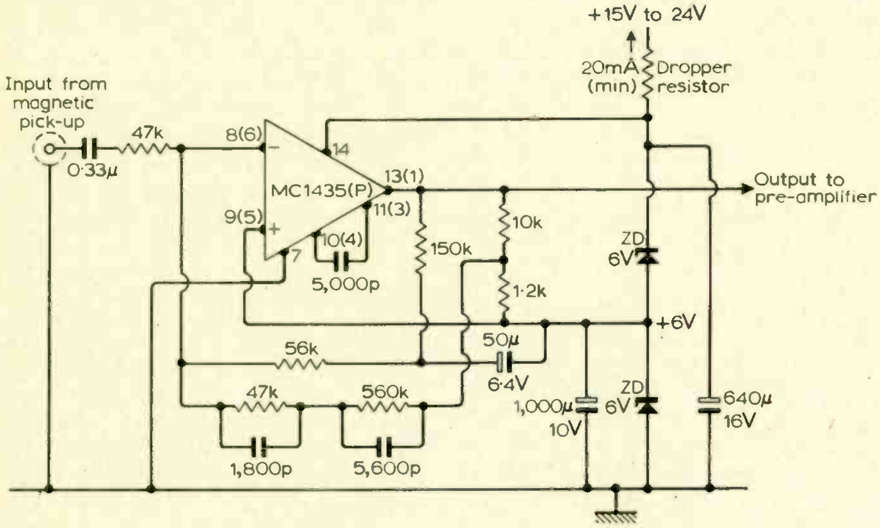


Fig. 7. Linear integrated circuit amplifier stage for magnetic pickup. Gain is 10 at 1kHz. (Numbers in brackets on MC1435P refer to pin connections for the other stereo channel. Circuit arrangement identical. Power supply to pins 14 and 7 feeds both channels.)

designed for the user of a piezo-electric ceramic pickup cartridge, it is expected that circumstances may arise in which it is desired to change over to a magnetic pickup head, and it would be convenient if this modification could be done without major alteration to the remainder of the pre-amplifier circuit.

Since additional amplification will be required, for the typical 5mV output from the magnetic head, as well as recording characteristic compensation, the most convenient way of doing this is by the use of a linear integrated circuit, with a suitable passive network. Although almost any operational amplifier type of linear i.c. can be used, with suitable phase correction, two particularly suitable types are the Motorola MC1435P and MC1303P, which are electrically almost identical and contain two, independent, amplifier units in a 0.1-in, centre dual-in-line package which can be mounted on either 0.1-in matrix pinboard or printed circuit strip-board. The MC1303P is specifically intended for use as a stereo pre-amplifier and requires a +15V and −15V supply. The +15V can be obtained from the existing supply line, but an additional −15V line will be required.

The MC1435P l.i.c. requires supply lines of only +6V and −6V, and these can be obtained from the existing rail through an appropriate resistive dropper network. A suitable circuit is shown in Fig. 7. The decoupling resistor R_{22} should, in this latter case, be adjusted in value to compensate for the additional current drain. The performance which can be obtained from a linear integrated circuit of this type in an input recording correction network is fully equal to that which can be obtained by alternative means. The resistor and capacitor values quoted give a fit to within 1dB of the required R.I.A.A. curve, with an overall gain of 10 at 1kHz.

References

1. Jones, F., *Hi-Fi News*, Vol. 14, No. 1 pp. 39-43.
2. Linsley Hood, J. L., *Wireless World*, July 1969, p. 309, Fig. 7.
3. ibid. p.308. Fig. 4.
4. Sallen, R. P. and Key, E. L., *I.R.E. Trans. Circ. Theory*, 3, 1955, pp. 74-85.
5. Bailey, A. R., *Wireless World*, Dec. 1966, p. 601.

Plotting Semiconductor Characteristics

Using an analogue computer and curve tracer to plot transistor and diode characteristics

*by W. G. Allen**

In an article by J. B. Swainston* it was shown that rectifier action can be conveniently demonstrated in slow motion by incorporating a diode into an analogue circuit. In the present article it will be shown that, not only can the characteristic of a diode be exploited in this type of analogue circuitry, but the analogue computer can actually be used to obtain diode and transistor characteristic curves. The method is not without limitations, but it is found that the characteristics can be obtained over a useful range using a modest size transistorized computer of the type widely used for educational purposes. When compared with the alternative methods of obtaining characteristics, it will be seen that the present method has the advantages of the high accuracy of point-by-point plotting, together with the speed of the commercial curve tracer.

Diode characteristics

Transistor analogue computers are usually based on a low voltage reference. In case of the machine used in the present investigation (an Electronics Associates Limited TR20) this value was 10 V. The simplest technique

*"More on Demonstrating Rectifier Action in Slow Motion", *Wireless World*, March 1969, p. 133.

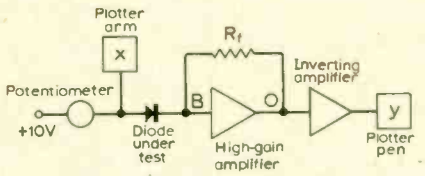


Fig. 1. Basic circuit for a diode forward characteristic.

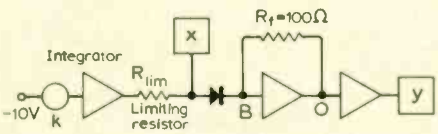


Fig. 2. Diode forward characteristic using automatic voltage sweep.

for applying a potential difference to the diode is to connect it between a computing potentiometer and the base of a high gain amplifier with a feedback resistor, R_f in circuit. This arrangement is shown in Fig. 1.

Under normal conditions as an operational amplifier, the base *B* is a virtual earth, and so the p.d. applied to the diode is directly related to the potentiometer setting. This p.d. is also connected to the arm input of an *X–Y* plotter. Since *B* is a virtual earth, the diode current *i* passes through the feedback resistor R_f and gives rise to a voltage $V_{out} = i\ R_f$ at the amplifier output *O*. In view of the inherent phase reversal occurring in this amplifier, it is convenient to add a further inverting amplifier before connecting to the plotter pen input.

An alternative viewpoint is to regard the diode simply as a variable resistor of value $R = V/i$, where *V* refers to the p.d. across the diode. With a feedback resistor R_f, the effective voltage gain becomes $G = R_f/R$, and so the output voltage is

$$V_{out} = G\ V = (R_f/R).(i\ R) = i\ R_f,$$

as before. The choice of value for R_f is to a certain extent determined by the maximum diode current required. In order to avoid overload of the high gain amplifier, it must be ensured that $i\ R_f$ is less than 10 V for a computer with a 10 V reference. In the case of Swainston's simulation of a rectifier circuit, a value $R_f = 10\,k\Omega$ was used. This limits the maximum current to about 1 mA, which is perhaps an unrealistically low value.

It has already been stated that the high gain amplifier will overload when a certain maximum input voltage is exceeded. Another factor that can cause overload is too high a current *i*; this can cause the point *B* to no longer be a virtual earth. It is thus wise to monitor the potential at *B*, and to stop increasing the diode p.d. as soon as the potential at *B* increases from zero. Although the amplifiers are usually overload protected, the output voltage V_{out} is no longer proportional to the diode current beyond this point.

Thus, a certain amount of trial-and-error is involved with the choice of R_f, and the range of diode currents that can be accommodated by a given computer. In the present experiments performed on the TR20, it was found convenient to adopt $R_f = 100\,\Omega$ for most diode forward characteristics, so that an output voltage of 1 V represents 10 mA diode current. This would be expected to allow currents of up to 100 mA, but in practice the virtual earth condition was no longer satisfied at currents above about 60 mA. By using $R_f = 10\,\Omega$, a value of about 75 mA can be attained. It was thus considered satisfactory to run the current up to 50 mA, which is a sufficiently high value for most applications.

Automatic voltage sweep

The disadvantage of using the circuit of Fig. 1 is that it is difficult to increase the diode p.d. smoothly by the potentiometer, even though the latter is usually of the ten-turn variety. This is slightly offset by the advantage that a good degree of control is available of the p.d. applied to the diode.

A suitable circuit for automatic voltage sweep is shown in Fig. 2. With a voltage of $-10\,k$ volts (*k* being the potentiometer setting) into a unit gain on the integrator (that is, an integrator time constant of one second), a ramp of $+10\,k$ volts/sec is produced at its output. This is shared between the limiting resistor R_{lim} and the diode, since *B* is at virtual earth. In the initial section of the diode characteristic, the resistance is very high and so practically all the ramp voltage is dropped across the diode. On the other hand, when the diode starts conducting and its resistance decreases, a proportionately smaller fraction of the ramp voltage is applied. The overall effect is that the rate at which the characteristic is traced is to a certain extent self-adjusting. This refinement is particularly important in the case of zener diode characteristics.

The maximum value of R_{lim} is determined by the maximum value to which the diode current is to be taken. This is because the maximum ramp voltage is of the order of 10 V before overload occurs. On the other hand, there is little advantage to be gained by a large R_{lim} value, since the plot would then become very slow as the diode resistance decreased. This could, of course, be compensated by increasing the ramp speed, but the flat regions of the characteristic would then be traversed too quickly. For most of the characteristics plotted, the potentiometer was set at $k = 0.04$, (giving a ramp of 0·4 volt/sec), and a limiting resistor of $R_{lim} = 30\,\Omega$ was used. These values were found to be satisfactory for a wide range of diode types.

The reverse characteristic can easily be obtained by changing the polarity of the input to the integrator. At the same time it is usually necessary to increase the value of R_f so that reasonable voltages are produced by the very small reverse leakage currents commonly found. For many germanium diodes, a value $R_f = 100\,k\Omega$ is convenient.

Fig. 3 shows a reproduction of the characteristics obtained for three common diodes. Since the same scales are used for each, the reverse current of the OA202 is too small to be represented (being of the order $10^{-2}\,\mu A$).

Fig. 4. (Right) Circuit for producing common emitter output characteristics.

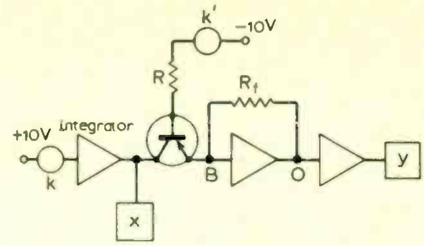
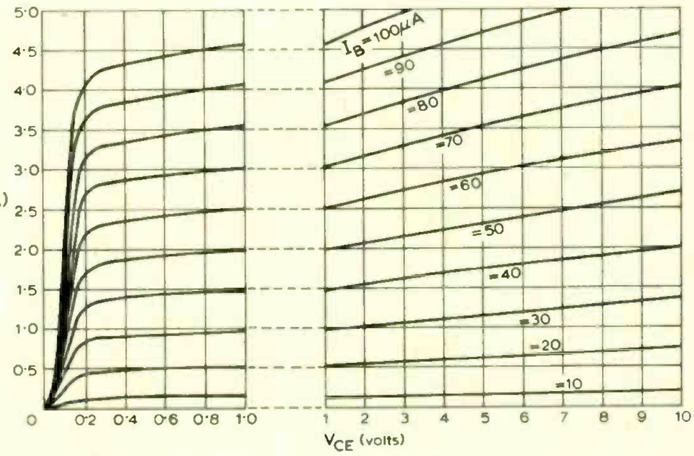


Fig. 5. (Below) Output characteristics of an OC202 transistor in common emitter mode.



Transistor characteristics

The present technique has been applied to produce the common emitter output characteristic for several types of transistor, using the circuit shown in Fig. 4.

As in the case of the diode characteristics, the voltage ramp is applied by means of an integrator. This is the voltage V_{CE}. The base bias current I_B is produced by applying a known potential difference to a large base resistor R, the p.d. being obtained from a computing potentiometer connected to the appropriate reference voltage. A convenient value of R is 100 kΩ, since this means that base currents up to 100 µA are then available. The actual resistor used was of the precision wirewound variety ($\pm 0{\cdot}1\%$). Since the potentiometer can be accurately set under load by a null method, there is no need for an ammeter to monitor the base current.

It will be noticed that the limiting resistor R_{lim} has been omitted. The reason for this is twofold. Firstly, the presence of this component can produce a zero error on the plotter arm due to the base current in the transistor.

Secondly, it will be recalled that R_{lim} was added to prevent the characteristic from being plotted too rapidly during the low resistance regions. This is not an inconvenience for most applications, as this region is at the limit of the active region and is not usually of interest to the designer of linear circuits. For switching circuits, the saturation region is of interest and this is usually plotted on an enlarged scale. When plotting this region using the circuit of Fig. 4, the ramp speed would be appreciably reduced.

Fig. 5 shows a transistor characteristic as obtained on the X–Y plotter. It was found satisfactory to use $R_f = 100\,\Omega$, together with a gain of 20 on the following inverting amplifier. When using a recorder pen scale of one volt per inch, one inch then represents a collector current of 0·5 mA.

It has been demonstrated that a small transistor analogue computer affords a convenient method of obtaining some diode and transistor characteristics. Many common types of diode have been studied with great success, but it must be pointed out that a satisfactory characteristic for a tunnel diode is very difficult to obtain in the negative resistance region, and the value of R_{lim} appears to be very critical. The common emitter output characteristic has been obtained for several transistors and the only difficulty was that, in the case of germanium transistors, adequate time must be allowed for the transistor to cool after plotting each characteristic.

This method may be of applicability to other characteristics, but it is felt that the scope of the present investigations (in which I was assisted by G. H. Olsen and E. A. Burrell) is sufficient to demonstrate the on-line possibilities of the analogue computer in this field.

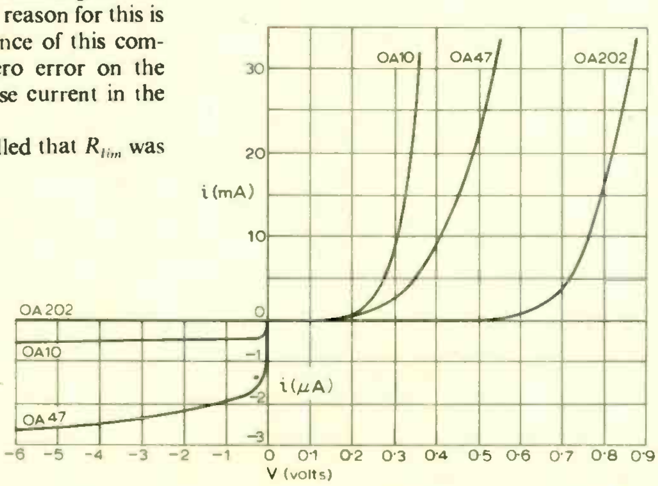


Fig. 3. The characteristics of some common diodes

Announcements

The Council of Engineering Institutions announce that the London Engineering Congress, **LECO '70**, to be held from May 4th to 7th has been cancelled.

"Principles of Colour Television" is the title of two 3-week full-time courses to be held at Leeds Polytechnic commencing May 4th and June 8th. Application forms are available from The Registrar, Faculty of Technology, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE. Fee £50.

BM Marketing International Ltd, Gaydon House, Thriplow, Royston, Herts, have been appointed sole U.K. agents for the **C.G.S. Scientific Corporation,** of America, manufacturers of a range of dynamic and fatigue materials testing equipment and vibration generating equipment.

Pye T.V.T. Ltd, has received an order from the Post Office for the supply of 12 **closed-circuit television cameras,** six monitors and control equipment to be used in Manchester's new £2M parcels sorting office.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

C-D ignition

I was delighted to read Mr. Bolton's letter in the March issue in praise of the C-D ignition circuit described by R. M. Marston in January. Like Mr. Bolton, I had a great deal of difficulty trying to construct a reliable system and I am pleased to report that Mr. Marston's really works. I too have used the Repanco TT51a transformer but wonder whether the circuit will fully realise the claims made for it—after all, at some 300 volts h.t., the charge stored in C_1 is only just over one half that at 400 volts.

The point regarding possible failure of Tr_3 is indeed a valid one—it has already happened to me! A common method of protecting a transistor against excessive reverse bias is to connect a diode between base and emitter. I am not however too sure whether this expedient can be adopted in this case.

I would be most grateful if Mr. Marston would comment on these points.

D. Burn,
Blackheath,
London S.E.3.

The author replies

I have not tried a Repanco TT51a transformer in my version of the converter circuit, and can not therefore make a positive evaluation. My general impression, however, is that it will work perfectly well on a 4-cylinder vehicle, but will give unsatisfactory operation (because of its limited power capabilities) in vehicles with six or more cylinders. The output voltage from the TT51a circuit is substantially lower than that of my original circuit, and its cold-start characteristics will not be as good as those of the original design; these characteristics should still, however, be better than those obtainable from conventional ignition systems.

As Mr. I. M. Shaw pointed out in the March issue (page 109), and as Mr. Burn now confirms, the design of the trigger circuitry is such that excessive emitter-base breakdown currents may result in the destruction of Tr_3. I believe there is also a possibility of damage due to excessive transient forward currents in this transistor. This is clearly a bad design fault on my part, and I apologise to any reader who may have suffered inconvenience as a result of it. The design fault can, however, be readily overcome by simply wiring a 180-ohm limiting resistor in series with Tr_3 base. This modification, which I first mentioned in the March issue (page 111) in replying to letters, should be regarded as a standard design change.

I have received several letters from readers complaining of misfiring with the C-D system. Unfortunately, these letters give little clue as to the actual cause of the trouble. It is probable, however, that it is caused by excessive resistance between terminal ① of the unit and the 'hot' terminal of the car battery. If this resistance exceeds half an ohm or so, it is possible for the s.c.r. to be triggered by the switching pulses of the converter circuitry, as well as from the normal C-B pulses, so that misfiring and power loss takes place in the ignition circuit. To find out if this is in fact the cause of the troubles, proceed as follows.

Disconnect from the distributor cap the e.h.t. lead (i.e., the heavy cable connecting the coil to the distributor cap) and place its free end roughly ¼in from the chassis (to form a spark gap). Turn on the ignition, and slowly turn the engine through one complete revolution by hand. If the above fault is present, heavy and continuous arcing will occur across the spark gap when the C-B is in the open position.

If the fault is present, thoroughly check the wiring between terminal ① of the unit and 'hot' terminal of the battery, looking for the cause of the high resistance. The voltage measured between these two points (with the ignition turned on) should not normally exceed a couple of hundred millivolts, and must in no circumstances be permitted to exceed 0.5 volt.

If, after the wiring has been thoroughly checked, the voltage between terminal ① and the battery can still not be reduced to negligible proportions, and the self-triggering still continues, the fault can be cured by connecting a 250mA silicon diode in series with the s.c.r. gate, to reduce the s.c.r. sensitivity. Fig. 1 shows how to connect the diode in the positive and negative earth versions of the unit.

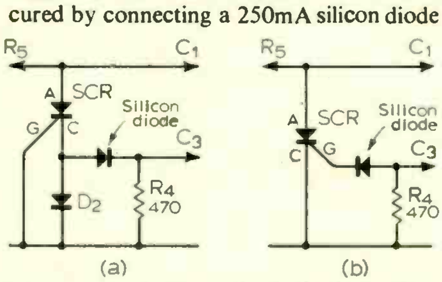


Fig. 1. Inserting a diode in the positive (a) and negative (b) versions of the C-D ignition system.

R. M. Marston

Amateurs and television interference

Reference the comments in "World of Amateur Radio" (April) about amateurs tackling their own interference problems, it might not be generally realized that the terms of the licence excludes anyone other than the licensed operator, or another licensed operator, from speaking into the microphone on an amateur station. This is a tremendous handicap when it comes to tackling one's own television interference problems.

I have so far managed to cure most of my own TV interference problems, but one has to fit filters and then ask the television receiver owner to listen or view while one puts out a test call. Often the result is very misleading and not at all like being able to check for oneself.

You will probably say "why not ask another amateur?" and this would most likely be economical because amateurs are very co-operative. However, if one had to pay for this person's time the cost would be still somewhere in the region of £2 per hour.

I would like to suggest that the time has come to end this rather peculiar rule and allow other people to speak but not to operate the station.

H. S. Wood, G8SX,
Allerton,
Bradford.

Words, pictures and customs

To quote S. W. Amos from his article on Graphical Symbols *(Wireless World* February 1970) ". . . a good diagram is worth hundreds of words. . . ."

The quotation in its original form did not qualify the type of diagram. Good or bad any diagram is worth a lot of words, as anyone who has had cause to puzzle over the maze of connections that is the average car wiring diagram will know. As bad as these are, they are never readily swapped for good prose.

Obviously a good diagram is better than a bad one, but in an industry that too often recognizes custom before truth, who will judge good from bad? The British Standards Institution? *Wireless World?*

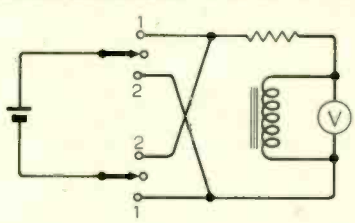


Fig. 1. Compare this with Fig. 5 on p.55 of the February issue.

Fig. 1 is a simple circuit diagram showing the function of a changeover switch. Is the non (British) standard but conventional symbol of Fig. 5, *Wireless World* Feb. 1970 p.55, preferred? In the same issue, Fig. 8

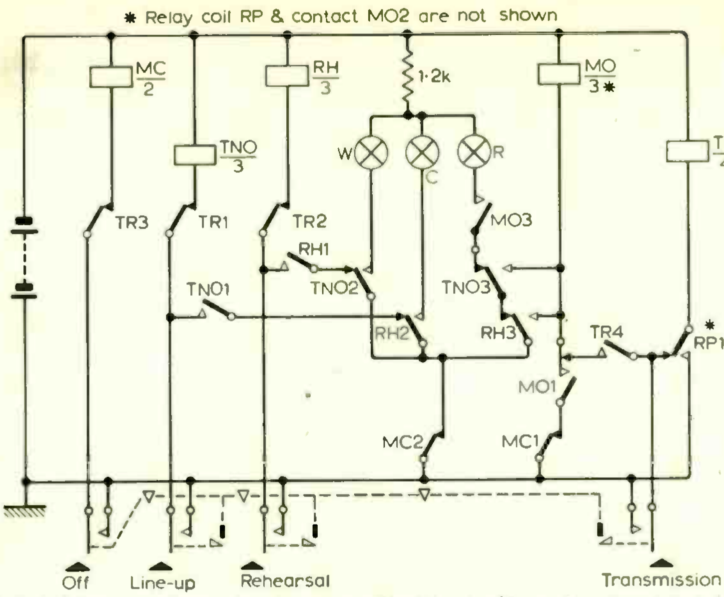


Fig. 2. Mr. Martin's suggestion for redrawing Fig. 8 of Mr. Amos' article in the February issue.

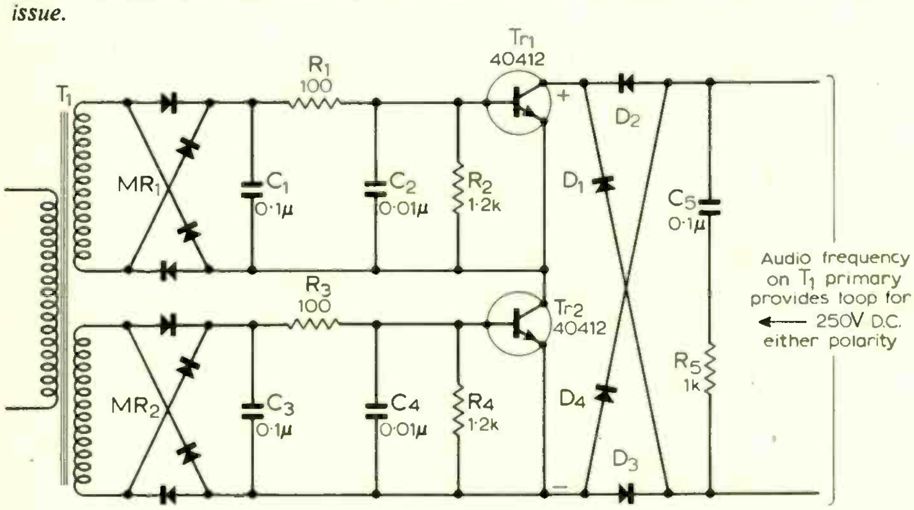


Fig. 3. A redraw of the audio switch on p.73 (Feb.) showing the "functional" full-wave rectifiers suggested by Mr. Martin.

p.65 poorly serves an article which actually proclaims the fundamental importance of careful symbol selection and correct diagrammatic form. Does the 'OFF' press button really lock ON? Rather than list faults, Fig. 2—which is thought would serve this article better than the original—is submitted for comparison.

Lastly Fig. 3 is a re-draw of the "Audio Switch" circuit diagram p.73, *Wireless World* Feb. 1970 which contained three full-wave rectifiers drawn in a manner which illustrates connection rather than function, but which are customary and standardized.

With a national standards institution that defines this particular circuit form out of existence (See B.S.204 for "Electrical Bridge" and "Bridge Rectifier" and B.S. 3939 for circuit diagram definitions), then advocates its use in the "Guiding Principles" and *justifies* this anomaly by reference to custom, it seems we have little hope of improving the low standard of circuit delineation that prevails in industry today. Unless that international institution, the *Wireless World*, periodically publishes some draughting howlers in order to encourage a competitive reaction and hence an interest in the subject among its readers. A good example to start with would be to extract the perfectly ordinary power supply components from Fig. 3 p.100 *Wireless World* Mar. 1970.

W. W. MARTIN,
London S.E.9.

The problem of dynamic range

I was interested to read Mr. O'Veering's article* in the April issue of *Wireless World* since I too have evolved a practical solution to the problem of dynamic range, but have approached the problem from a different angle.

I have developed the 'Ultimate Fidelity Listening Chair'. The basic chassis on which ten loudspeakers are mounted is conveniently provided by a heavy oak-framed wing-arm chair. Mounted on each wing are five units, two 15in bass units, two 5in mid-range units and one 2in high-flux tweeter, together capable of handling 120 watts r.m.s. per channel. A special steel framework supports the pre-stressed concrete baffles from within the heavily upholstered armchair wings, since each baffle complete with units weighs just over 1 cwt.

The amplifiers are commercially available 150-watt laboratory units fed from equally conventional sound sources.

Initial experiments showed that nylon reinforced seat belts were necessary to prevent the listener's nervous reflexes propelling him from the chair under heavy transients, and missing the most exciting musical passages.

On the advice of the local family doctor, however, I have now replaced them with an ex-R.A.F. ejector seat, triggered by electrodes placed on the listener's temples. Although the listener is restrained during normal nervous spasms, when the sound pressure approaches that considered to be detrimental to the brain, the rocket propelled ejector seat is triggered by the induced skin potentials, propelling the listener from the listening area and out of danger through a specially constructed roof trap within 10ms. This arrangement has proved most effective, in fact during the Prom season last year, and as a result of the excellent transmissions from the Albert Hall, I was ejected no less than eight times to the great amusement of my children and the annoyance of my neighbour on whose greenhouse I landed on one occasion, on re-entry.

The big drawback of this method of musical enjoyment however is that, like headphones, full benefit can be experienced by only one person at a time. It is for this reason that I am busy developing the 'Ultimate Fidelity Settee' which I hope to report on in due course.

IVOR NEDAKE
Beaconsfield,
Bucks.

*Our hard-of-hearing contributor's April article brought forth a number of suggestions similar to this one—ED.

F.E.T. modulators

I read with interest the article on f.e.t. modulators in the February 1970 issue. However, one statement made in the first paragraph bothers me. Here it says: "the relationship between r_{ds} and V_{gs} is parabolic". I agree that many things in f.e.ts relate to one another in a parabolic way but the parameters mentioned above do not.

To substantiate my objection I refer to "Field-Effect Transistors" by L. J. Sevin, page 41, eq.(2,30) and in all modesty to my own paper "The FET as a Voltage-Controlled Resistor" which appeared in the Jan. 1970 issue of ***EEE***. Eq.(2,30) in the first reference states that the channel conductance is roughly a linear function of V_{gs} and on this property I elaborated in my paper. It is obvious that converting conductance to resistance does not produce a parabolic relationship.

T. MOLLINGA,
Hengelo,
Netherlands.

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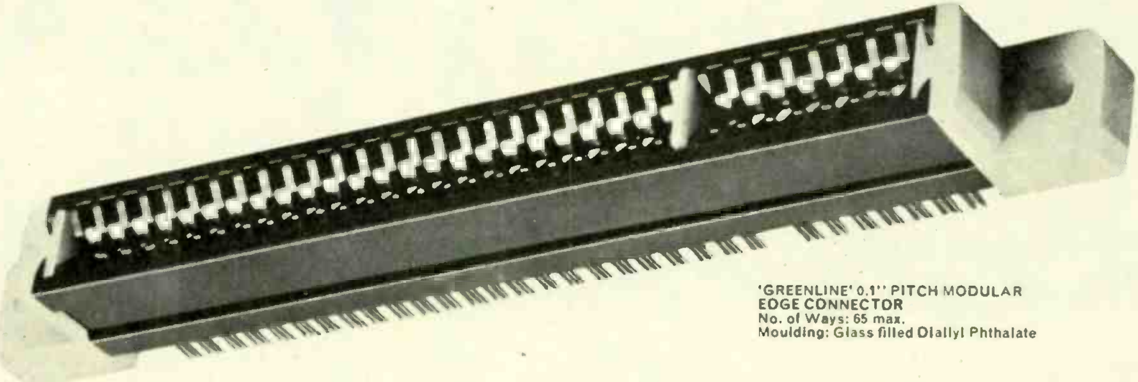

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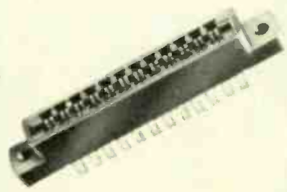

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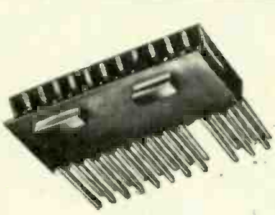

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Microelectronics at the Paris Components Show

Microcircuits seen at this year's Salon des Composants Electroniques were all the result of evolution and not revolution and there were no outstanding products employing new technologies. Most manufacturers are increasing the size of their standard ranges, particularly in the m.s.i. field, and there was evidence of the slow permeation of microelectronics into new fields. It was interesting to see that some of the major i.c. manufacturers are combining monolithic and thick and thin film practices to produce complete sub-systems and were not leaving it to firms which specialize in this process. This is only a step away from their producing complete equipments and one is bound to ask how long it will be before all that is left for the equipment manufacturer to do is to add the cabinet and knobs. Even the readout can be integrated if the display is to be in alpha-numeric form.

The Russians were exhibiting again this year and they displayed a full range of linear and digital microcircuits including m.o.s. and hybrid devices. They claim that in some other fields they are ahead of the West, particularly in capacitor manufacture and in c.r.ts for data displays. They exhibited 80mm (3.2in) diameter slices of silicon which they are using for microcircuit manufacture. Since manufacturers in the West have only fairly recently gone over to using 2-inch slices, and in some cases 3-inch slices, the Russians are advanced in this respect. Also of great interest was a multi-element 1-GHz 10W transistor they had on show. It is very probable that the devices displayed represented the Russian production achievement of a year or two ago.

Microelectrics for consumers

More firms are introducing devices for the consumer industry. For instance both Texas Instruments and Fairchild have agreements with Philips which will enable them to cash in on Philips' experience in this field.

Ferranti are now in the consumer microelectronics business although one of their latest products for this market still has strong avionic connections! A German firm commissioned Ferranti to design and produce a microcircuit for servo motor control in model aircraft. It is the type ZN430E which combines the functions of pulse width discriminator, comparator and servo amplifier. The position of the servo motor is determined by the mark-space ratio of the incoming control signal, as is standard practice now in model aircraft control. The circuit measures the mean level of the input signal and compares it with a voltage proportional to the servo motor position. This voltage is derived from a potentiometer mechanically coupled to the motor shaft. Any difference is used as an error signal which is applied to the servo amplifier, and this in turn drives the motor, via an external output stage, in such a direction as to reduce the error voltage to zero. Part of Ferranti's agreement with their German customer states that Ferranti may not sell this product to other users for model control purposes for one year.

The vital statistics of the ZN430E are: a supply voltage of plus and minus 2.5V and a maximum output current of 30mA. The "dead band" corresponds to about one degree in 100 degrees of rotation.

Last year a number of microcircuits were introduced for cars and although no new ones were seen this year Marconi-Elliott had an m.o.s. circuit designed for a toy manufacturer who produces model cars. The circuit enables the car to respond to a command produced by blowing a whistle capable of producing four tones. The tones could, of course, be generated in many other ways. One tone is used for steer left, one for steer right and one each for forward and reverse traction. The incoming signal is amplified and squared and measured using a reference oscillator and counter combination in a similar manner to the 20MHz counter/timer described on page 237 of this issue. At the end of each sampling period the contents of the counter are inspected by four gates, one for each channel. If the counter holds a number appropriate to a particular channel the correct control is actuated. The control system is activated by the output of an integrator which ensures that the input signal must be present for a predetermined time before a command is obeyed, thereby rendering the system insensitive to impulsive noises.

Other safeguards ensure that input overtones cannot overflow the counter, causing a motor to be instructed to turn in both directions at the same time. A circuit to do the same job built in d.t.l. would require about 25 packages.

A problem with the design was to keep the frequency of the reference oscillator stable as the voltage of the two 9V batteries fell. Marconi-Elliott say that it would not have been possible to do this three months earlier because the necessary computer programmes were not then available.

The computer is certainly a very important tool in microcircuit design and it is of particular value in custom designed i.cs. Our front cover this month shows a typical situation in which an engineer uses a computer and a graphic display with light pen to produce a complete microcircuit design.

Another consumer i.c. from Marconi-Elliott is intended for use in electronic organs. It provides a divide by $\sqrt[12]{2}$ function so that the twelve basic tones required in an electronic organ can be synthesized from a single oscillator instead of the twelve required before. The company were also showing how standard m.o.s. circuits could be used to make a digital clock.

Texas Instruments are working on a whole range of i.cs for the consumer industry although they were still in the design stage. Fairchild say that they will soon be announcing a high quality stereo amplifier on a single chip intended for use with a separate class A or B output stage.

Ates (Italy) were showing quite a range of microcircuits for the consumer industry. Among these was the TBA381, a 5-W r.m.s. audio amplifier intended for use with a 24-V supply and an 8-Ω loudspeaker Total harmonic distortion is 2% and voltage gain is 26dB. Another i.c. shown by this company was the TBA365 intended for a.f.c. purposes in television receivers. The chip contains an i.f. amplifier, detector, d.c. amplifier, a.g.c. amplifier and a zener voltage regulator.

For the sound section of TV receivers Ates have the TAA591, consisting of a wideband amplifier, f.m. detector and a.f. pre-amplifier and driver.

A video processing circuit, type TAA 700, was shown by Radiotechnique-Compelec (R.T.C.). This is a Philips design which, incidentally, will also be manufactured in this country by Plessey. The chip contains a video pre-amplifier, i.f./a.g.c. detector, r.f./a.g.c. amplifier, noise detector and gate, phase comparator and sync separator, using over 40 transistors—explaining why the circuit is known as the "jungle chip".

SGS showed two microcircuits for television applications; the first, the TAA261, is an audio amplifier with a 4-W output into 16Ω with total harmonic distortion of 10%. The second circuit, TBA271, is a voltage regulator for variable capacitance tuning of TV receivers. Output voltage is between 30 and 36V with a temperature coefficient of −3.3 to + 1.6mV/°C.

There were many more basically similar circuits for radio and television applications on show some being slight improvements on those mentioned last year.

Microelectronics for Industry

Motorola announced a hybrid 8,192-bit memory at the exhibition although there was not much in the way of technical information available on it. The memory consists of four substrates on which are mounted a total of 36 monolithic chips. Each substrate is identical and contains eight 256-bit read/write memory chips and an e.c.l. address decoding chip. Each of the four substrates was individually packaged and mounted one above the other. Access time is 120ns and power consumption is 6W.

Another microelectronics company about to introduce standard hybrids is Fairchild who will soon be announcing a v.h.f. frequency synthesizer contained in four packages and a 10-bit digital-to-analogue converter. This latter device employes m.s.i. bipolar chips with both thick and thin film circuitry although here again there is no technical information available as yet.

Still looking at products which are just around the corner Signetics will soon be announcing a range of monolithic active filters and Intel (U.S.A.) will also shortly announce an m.o.s. dynamic read/write memory organized as 512-words of 2-bits with a cycle time of 100ns. In this type of circuit information is stored as a charge on the gate capacitance of the m.o.s. storage elements. This information has to be periodically refreshed, not rewritten, but this is a fairly simple matter. Refresh time is 1 or 2% of the total time.

Marconi-Elliott were showing what they can do in the way of customer-designed hybrid circuits. They displayed a thick film circuit employing 26-beam-lead monolithic chips on a 3 × 1 inch substrate. A five-bit binary word at the input was converted to a two-bit octal readout and also used to select one of 32 output control lines. Lamps connected to the output lines were driven directly by the circuit.

R.T.C. showed an interesting m.o.s. dynamic shift register which could be electrically varied in length from 1 to 64 bits by means of a 6-bit control word. The register, type FDN126, requires a 2-phase clock and is compatible with d.t.l. and t.t.l. integrated circuits. Operating frequency is between 10kHz and 3MHz.

A bipolar monolithic 64-bit memory with Schottky diodes connected between the base/collector junctions of the transistors in order to reduce charge storage effect and increase speed was to be seen at the Intel display. The Schottky diode is made by depositing aluminium from the base region to the *n* region of the collector of each transistor where it forms the metal/semiconductor junction of the Schottky diode. Since the Schottky diode has a lower forward voltage compared to the collector/base junction of the transistor the diode clamps the transistor and diverts most of the excess base current, preventing the transistor from saturating. There is therefore no stored charge in the transistor or the diode, so speed is increased for a given power dissipation. The memory using this process was the type 3101 from Intel which had an access time of 60ns and a power dissipation of 6mW/bit.

The Schottky process is also used in the Texas Instruments range 54/74S which is a high-speed version of the well-known 54/74 series of t.t.l. A typical gate propagation delay of 3.5ns is quoted for the new range.

An alternative to the shift register for high-speed shifting was shown by Signetics. This is a gating system that will shift an 8-bit word in 20ns. Also shown was a decoder/driver for Nixe tubes with 180V output transistors.

Apart from the servo amplifier mentioned earlier other new devices on the Ferranti stand were t.t.l. monostables (ZN1010 E and F) which have an optional lock-out facility. This inhibits the inputs after the monostable has triggered so that the timing period cannot be affected by spurious noise pulses. A gated operational amplifier (ZN402E) with a performance a little below that of the 709 but with an extra input which results in the output being clamped to zero was also shown. Finally they exhibited a monolithic "ring-of-two" voltage reference element which could be used as a constant current source for zener diodes etc. This is type ZN401T.

Secosem (France) had on display a modified version of the 709 operational amplifier which featured built-in frequency compensation and output short-circuit protection. ITT were showing a similar circuit, the MIC741.

A voltage-to-frequency converter in hybrid form was announced by Prana (France) with a conversion ratio of 5Hz/mV. The converter has an input impedance of 100MΩ and an output of 6V from 1kΩ, the type number is CM-AD5.

On the Russian stand among the many items on display was a range of hybrid circuits employing d.t.l. monolithic chips. One type contained 13 four-input NAND gates, another an eight-bit shift register. A three-bit reversible shift register is also available. The typical gate propagation delay of these is 45ms and a noise immunity of 0.4V is specified. Also to be seen was a number of m.o.s. circuits. Among these was the K160 series consisting of gates and flip-flops with propagation delays of 0.4μs.

Monsanto were showing a monolithic seven-segment alpha-numeric display using light emitting diodes Power consumption is only 8mW (1.6V at 5mA) per segment. Each package measures about 6 × 4mm and is potted in clear epoxy resin. It is understood that the display, called MAN-3, costs about £3 per character.

Microsystems International (Canada) had on display a push-button, or touch-tone, telephone system which used a circuit designated QGL4B which combines tantalum thin film wiring, resistors and capacitors with monolithic silicon beam lead chips. In order to describe the circuit it is necessary to know something of the touch-tone telephone system. There are 16 push-buttons arranged in a four-by-four matrix and there is a separate frequency assigned to each row and each column of buttons. The row frequencies fall in a low band 697, 770, 852 and 941Hz and the column frequencies are in a higher band, 1209, 1336, 1477 and 1633Hz. Pressing any button causes the frequencies associated with that button's row and column to be transmitted.

The QGL4B has two monolithic amplifiers with twin-tee feedback networks that cause them to oscillate at the frequency determined by the value of components in the twin-tee filter. One amplifier and filter combination provides the low-band, and the other amplifier the high-band, of frequencies. The push buttons select different resistor values in the twin-tee filters to cause the necessary frequency shift. The circuit drives its output along the same two wires which are providing the power supply for the circuit and it is arranged, using a diode bridge, that it does not matter which way round the two wires are connected. Because of varying line lengths the impedance into which the amplifier has to work varies enormously, as does the power supply. In spite of these variations the output of the unit is maintained to within 0.2dB and the frequency held to much better than 5% of the desired value.

If the gain of the amplifiers in the QGL4B is lowered by altering internal resistor values the amplifiers instead of being oscillators become active filters. The circuit can then be used to demultiplex signals from touch-tone telephones.

For those interested in statistics: of the 784 companies exhibiting at the Salon (about 5% more than last year) 364 were French, 120 American, 108 German, and 64 British.

News of the Month

Displays—the answer?

Colour change displays using liquid crystal have been made in the Marconi research laboratories. (We reported work done by R.C.A. in using liquid crystal for information displays and detecting temperature changes on page 222 of the July 1968 issue.) Liquid crystal is a transparent liquid with a regular crystal-like structure in that all the molecules "point" the same way (nemantic structure). When a voltage is applied across the liquid ions move through it and disrupt the regular structure causing a colour change from transparent to white. When the voltage is removed the liquid returns to its transparent state.

Displays have been made by sandwiching a very thin layer of liquid crystal between sheets of glass. The patterns to be displayed can then be held as an invisible conductive pattern on the glass and is made visible when a voltage is applied to the pattern.

The voltage requirement of liquid crystal is low and is compatible with standard logic levels. Bright ambient lighting does not affect the clarity of the display.

The work at Marconi has resulted in a liquid crystal which changes from green to blue when a voltage is applied; no dyes are used. Marconi say that other colour displays should result from the work being carried out although more research is needed to increase the speed for some applications.

Nuclear-powered heart pacemakers

Trials of nuclear-powered heart pacemakers have now started in the U.K. and two successful animal implants have taken place. The animals concerned, both dogs, have so far responded well. These implant experiments are an essential part of an exhaustive joint technical development programme by the Department of Health & Social Security and the Atomic Energy Authority. If successful, the programme will permit patients suffering from "heart block" to be fitted with pacemakers powered by nuclear batteries having a design life exceeding ten years, in place of the short life (approximately one to two years) chemical batteries that are currently used.

Heart pacemakers have been used for over ten years to maintain the heartbeat of patients suffering from "heart-block". This disease, the failure of a bundle of nerves in the heart, can be overcome by using a pacemaker to provide the minute rhythmic electrical pulses normally transmitted through the nerve bundle.

The nuclear battery, which was developed at Harwell, utilizes the heat from the radioactive decay of a small quantity of plutonium-238 to generate power from a miniature semiconductor thermo-electric converter. The complete battery is two inches long and about half an inch across. It weighs about an ounce. There is no radiation hazard to the patient, or to anyone else, from the small quantity of plutonium used and the battery is fully encapsulated to prevent the escape of radioactive material or attack from body fluids. The pacemakers used in the trials are special units coupled to the Harwell battery through a voltage changing circuit developed at Aldermaston. The nuclear battery was developed at Harwell in close collaboration with the Institute of Cardiology and the National Heart Hospital.

GEE chain to close

The famous GEE navigation system which was developed to get bombers safely and accurately to the target and back again during World War II was taken out of service on March 26th, ending a 28-year chapter in aviation history.

The system consisted of ten transmitting stations which operated in pairs providing accurately timed radio pulses. The receiver in the aircraft measured the time of arrival of the pulses enabling the aircraft's position to be quickly determined by referring to GEE charts.

New master for B.C.S.

J. D. Platt has succeeded H. E. Barnett, who has retired from public service, as director of the British Calibration Service. Mr. Platt, who was born in 1916 at Newcastle-on-Tyne, received his early engineering training at Siemens Bros., Woolwich, and at the Woolwich Polytechnic. He has been in the Civil Service since 1939 on inspection and quality assurance of electrical and electronic equipment. Mr. Platt spent eleven years at the Harefield Laboratory of the Aeronautical Quality Assurance Directorate specializing in electrical measurements and testing. He has been with the Electrical Quality Assurance Directorate (formerly E.I.D.) since 1958. Latterly, as Head of the Components Department of E.Q.D., he has been closely associated with the B.S.I. in the implementation of the Burghard Report with responsibility for the overall inspection surveillance arrangements for BS 9000 in the electronic components industry.

To date thirty laboratories, covering measurements in many fields, have received approval. Laboratories for d.c. and l.f. measurements are: Ferranti Ltd., Wythenshawe; G.E.C. Measurements Ltd., Stafford; Marconi Instruments Ltd., St. Albans; Mann Components Ltd., Wymondham; The Solartron Electronic Group Ltd., Farnborough; Atomic Energy Research Establishment, Harwell; University of Leeds; G. & E. Bradley Ltd., London N.W.10; H. W. Sullivan Ltd., Orpington; Welwyn Electric Ltd., Bedlington.

For h.f. electrical measurements the approved laboratories are: G. & E. Bradley Ltd., London N.W.10; Aveley Electric Ltd., South Ockendon; Electrical Quality Assurance Directorate, Bromley; Marconi Instruments Ltd., St. Albans.

Other approved laboratories carry out optical, fluidic and mechanical measurements.

Thermionic products still hold sway at E.E.V.

In an age when it is generally assumed that semiconductors are rapidly taking over electronic control in industry, the English Electric Valve Company is trying to cope with increasing demands for more thermionic devices. At their Lincoln works, where 336 operatives are employed, there is scant regard for semiconductors and even their own process control equipment is based on a well tried method of mechanical sequence switching. Despite this, turnover for the

High frequency processing of a magnetron cathode at E.E.V's works.

last financial year reached an all-time record of over £1M.

Bulk of the orders comes from areas where heavy current control is required, in car factory spot welding equipment and traction motor speed control. These are mainly for the E.E.V. ignitron, a high-current rectifier with a mercury pool cathode, usually in a water-cooled envelope. E.E.V. claim to have 80% of the ignitron market in this country.

The operating gap between the low-current end of the ignitron range and the point where high-power thyristors take over is where the thyratron, a gas-filled glass rectifier, still finds a place. There has been no decline in the call for thyratrons over the past ten years, mostly as replacements in existing equipment.

E.E.V.'s Lincoln factory is also producing magnetrons up to 2MW peak for ground radar, an "S" band 2.5kW magnetron and a linear accelerator with an 8MHz tuning range. Also a 40W magnetron and duplexers for use in "X" band marine radar.

A new development by E.E.V. is a 1kW c.w. magnetron for r.f. cooking. This features a cathode with a 5-second warm-up time. Some have already been incorporated in commercial cooker designs.

Telecommunications development plan

Over £4M is the contribution being made by the National Research Development Corporation for research into a system which "will radically alter telecommunications manufacturing methods".

Total cost of the project is nearly £9M and the remaining £4M or so is being provided by the Plessey Company. Work on the system in Plessey's laboratories envisages the use of advanced stored programme control principles (SPC) in future telephone exchanges. The first full-scale model of an SPC exchange now being started at the group headquarters in Liverpool will demonstrate the interdependence of data processing technology and electronic switching.

Research studies, begun in 1964, led to a new overall approach to systems and control involving new techniques in real-time software programming, in processor design and in telecommunications switching practice. Stored programme control is the use of software and processors for the control of automatic exchanges. It is thought that SPC will be used increasingly from 1975 onwards.

A printed circuit layout aid is shown below which was developed by Alfred Clark of the Aeronautical Division of Marconi at Basildon. It enables a positional accuracy of about 0.1mm to be consistently maintained. The aid, which employs a nickel reference grid, is available from Chartpak-Rotex.

Colour TV tube patent extension refused

Mullard's level of investment in TV colour tube production stood at £10M according to J. C. Akerman, head of Consumer Electronics Division, and the break even point had not yet been reached. He was giving evidence in the High Court last month in the petition by Philips Electrical, of London, and N.V. Philips Gloeilampenfabriken, of Eindhoven, for a second extension of their patent for colour television tubes. Philips were making application for a second extension because since the first was granted in 1965 for four years, the expected number of 1.35M colour sets had not been sold and the patentees pleaded therefore that they had not received sufficient recompense. They were seeking an extension of the period by another two-and-a-half to three years. Opponents of the petition were Asahi Glass Company of Tokyo. The application was rejected by the Court but Philips intend making a fresh application on different grounds. It is understood that supporting evidence for the Asahi Glass Co. was given by the Radio & Television Retailers' Association.

Shipboard Skynet terminal

GEC-AEI (Electronics) have been awarded a contract by the Ministry of Defence, for the development of a small shipborne satellite communications terminal (SCOT) to operate in the Skynet system*, and provide secure communication links between small ocean-going warships and the U.K. The paraboloid aerials, will be only 3.5ft in diameter, and, while designed as part of the Skynet system, will be capable of operation through the American Defence Communication Satellite system should the need arise.

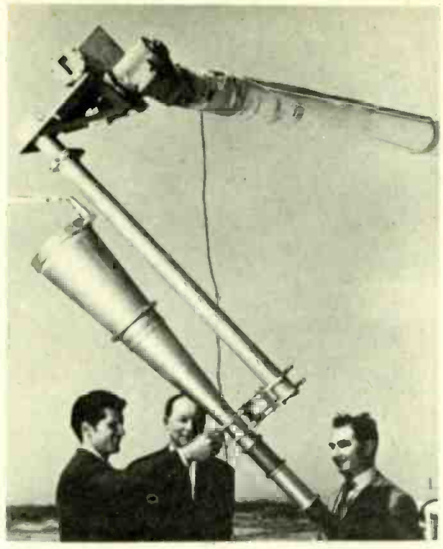
SCOT consists of two stabilized and fully-steerable dish aerials to be mounted one on each side of a ship's mast. No active communications equipment will be mounted on the aerials, but will instead be located in an unmanned engineering cabin at deck level, and connected to the dishes by a low-loss waveguide run. This arrangement should lead to high reliability and will make all elements of the system readily accessible for maintenance.

The aerials, each protected by a double skinned radome, will be stabilized against ship motion by a modified version of the inertial unit devised for the Black Arrow rocket.

All operational controls will be provided on a control console in the ship's main communications office, from which an operator will be able to acquire the satellite and select the correct receive frequency. He will also be able to switch on the transmitter and spot any faults without needing to visit the equipment cabin.

The original concept of SCOT was formulated in the Admiralty Surface Weapons Establishment, Portsdown, and an experimental model to prove the feasibility of a miniaturized terminal has been operating through geo-stationary satellites for the last twelve months. This experimental work has been so successful as to justify embarking on a programme leading into full development and production with the minimum of delay.

* See "News of the Month", *Wireless World*, p.69, April, p.263, August, p.402, November 1968 and p.210, May 1969.



Engineers from several countries have a look at the aerial system designed for the communications satellite Intelsat-4.

Domestic radio/TV show

Running concurrently with the annual conference of the Radio and Television Retailers' Association held in London last month at Grosvenor House, Park Lane, was a three-day exhibition of radio, television and electrical appliances for the domestic market. This was the first occasion for a number of years that the six major manufacturing groups, B.R.C., Decca, G.E.C., ITT/KB, Philips and Pye, representing a dozen or more brand names, had exhibited under one roof. Perhaps they had taken heart from the theme of the conference, "Unity for the 70s".

The total number of exhibitors was over forty and there was some speculation that this show could be the forerunner of an annual spring event which would replace the fragmented autumn trade show. This idea was hotly denied by the major manufacturers who have already laid plans for this year's trade shows. While most makers were unenthusiastic over the amount of business the exhibition brought them, there could have been little joy for the retailer either, since all the attractive colour sets on view are still strictly on ration.

Electron microscope views moving subjects

Recent developments at the National Physical Laboratory, Teddington, have extended the use of the scanning electron microscope, making it possible to observe dynamic phenomena at high magnification. The Laboratory can now observe continuously the changes taking place in materials subjected to stress. Carbon fibre composites are among the materials to have been observed in this way.

In the scanning electron microscope an electron beam scans the surface of the specimen in synchronism with the spot on a c.r.t. Electrons leaving the specimen are collected and the resultant current is amplified and used to control the brightness of the spot. Since the number of electrons leaving the specimen is dependent on its topography, an image of the surface is displayed on the tube. Hitherto, the electron image display has had to be built up slowly, like a radar display, on a long persistence screen. In the new N.P.L. system a high-speed scanning system is used which produces a bright, flicker-free image on a television monitor tube. The advance has been made possible by improvements in the electron detection system and in the performance of the scanning amplifiers. These improvements can be added without modification to the basic instrument which was a "stereoscan" microscope made by Cambridge Instruments.

Sound in vision

Pye T.V.T. Ltd has reached an agreement with the B.B.C. which will permit them to manufacture the p.c.m. television sound system "Sound in Vision" (See *Wireless World* January 1969, p.38 and April 1970, p.167).

Groovy senescence

"The electric guitar is one primrose path to the hearing aid." Quote from the leader article "Yet More Noise" in the April issue of *Hearing*.

BBC test tones for stereo receivers

To help with channel identification and the adjustment of cross-talk in stereo receivers, each day (except Wednesday and Saturday) the BBC transmits a 250Hz signal in the left hand channel from about four minutes after the end of Radio-3 programme until 23.55.

On Wednesday and Saturday each week, a sequence of tone transmissions during a period of approximately thirteen minutes is transmitted to allow specific checks to be made on receivers. Details of these are given below.

	time	left channel (a)	right channel (b)
1	23.42	250Hz at zero level	440Hz at zero level
2	23.44	900Hz at +7dB	900Hz at +7dB, antiphase to left channel
3	23.48	900Hz at +7dB	900Hz at +7dB, in phase with left channel
4	23.49	900Hz at +7dB	No modulation
5	23.50	No modulation	900Hz at +7dB
6	23.51.20	Tone sequence at −4dB: 60Hz, 900Hz, 5kHz, 10kHz. This sequence is repeated	No modulation
7	23.52.20	No modulation	Tone sequences as for left channel at 23.51.20
8	23.53.20	No modulation	No modulation
	23.55	Reversion to monophonic transmission	

Notes

The tests will normally start at 23.42 hours, or 2 minutes after the end of programme if this is later.

The schedule is subject to variation to accord with programme requirements and essential transmission tests.

The zero level reference corresponds to 40% of the maximum level of modulation applied to either stereophonic channel before pre-emphasis. All tests are transmitted with pre-emphasis.

Periods of tone lasting several minutes are interrupted momentarily at one-minute intervals.

The following table indicates the type of check or adjustment for which each test transmission is primarily intended.

1. Identification of left and right channels and setting of reference level.
2. Check of distortion with signal wholly in the $(A-B)$, i.e. S, channel.
3. Check of distortion with signal wholly in the $(A+B)$, i.e. M, channel.
4. Check of A to B cross-talk.
5. Check of B to A cross-talk.
6. Check of A-channel frequency response and A to B cross-talk at high and low frequencies.
7. Check of B-channel frequency response and B to A cross-talk at high and low frequencies.
8. Check of noise level in the presence of pilot tone.

Notes

With receivers having separate controls of sub-carrier phase and cross-talk, the correct order of alignment is to adjust first the sub-carrier phase to produce maximum output from either the A or the B channel and then to adjust the cross-talk (or 'separation') control on tests four and five for minimum cross-talk between channels.

With receivers in which the only control of cross-talk is by adjustment of sub-carrier phase, this adjustment should be made on tests four and five.

Adjustment of the "balance" control to produce equal loudness from the A and B loudspeakers, is best carried out when listening to the announcements during a stereophonic transmission, which are always made from a centre-stage position. If this adjustment is attempted during the tone transmissions, the results may be confused because of the occurrence of standing-wave patterns in the listening room.

Exhibitors at the I.E.A. Show

Instruments, electronics and automation exhibition at Olympia

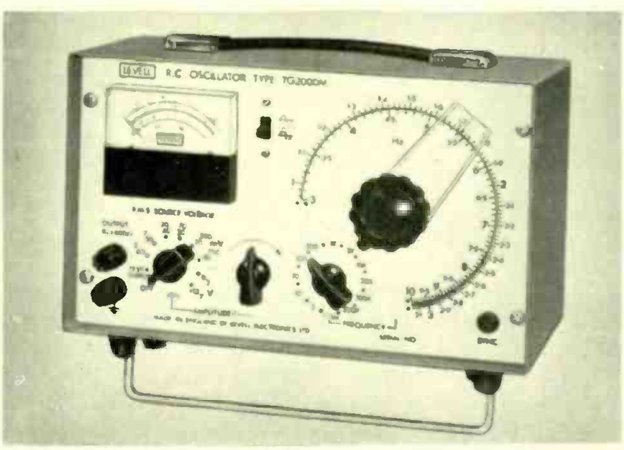
The biennial I.E.A. exhibition opens at Olympia, London, on May 11th for six days. Below are listed the 420 or more exhibitions. Many of them will be displaying equipment from companies for whom they are agents and composite exhibits are being staged by several countries so that the products of some 950 manufacturers (20% from abroad) will be on show. Organized by Industrial Exhibitions Ltd. the show is sponsored by five trade associations: Scientific Instrument Mftrs Assoc.; Radio & Electronic Component Mftrs Fed.; Electronic Engineering Assoc.; Brit. Electrical & Allied Mftrs Assoc.; and Brit. Industrial Measuring & Control Apparatus Mftg Assoc. The equipment on show will reflect the specialized interests of members of these organizations. Admission to the exhibition, which will be open from 10.00 to 18.00 daily, will cost 5s.

A.B. Electronic Components
A E Electronics
AEG (Great Britain)
A.P. Publications
A.P.T. Electronic Industries
Acbars-Meteor
Accumulatorenfabrik Sonnerschein
Addo
Aga (UK)
Air Control Installations
Airborne Instruments Laboratory
Airtech
Aladdin Components
Albert Measurements
Alden Metal Products
Allspeeds
Alma Components
Almagams Company
American Embassy
Ampex Great Britain
Amphenol
Andermann Group of Companies
Apollo Electronics
Appliance Components
Arcolectric Switches
Ariel Pressings
Aristo-Werke
Arkon Instruments
Arrow Electric Switches
Associated Automation
Astralux Dynamics
Ates Componenti Elettronici
Austen, Charles, Pumps
Automatic Control Engineering
Automation
Autonetics
Avdel
Aveley Electric
Avery, W. & T.

B & K Laboratories
B. & R. Relays
Bailey Meters & Controls
Baird & Tatlock
Bakelite Xylonite
Barden Corporation (UK)
Barr & Stroud
Batley Valve Company
Bell & Howell
Belling & Lee
Benney Electronics
Blakeborough, J., & Sons
Blundell Harling
Bonnella, D. H., & Son
Bourns (Trimpot)
Bowthorpe-Hellermann
Bribond Printed Circuits
Britec
Britimpex
British Aircraft Corp.
British Hovercraft Corp.
British Insulated Callender's Cables
British Physical Labs
British Rototherm Company
British Sonceboz Company
British Steam Specialities
Brookdeal Electronics
Brooks Instrument
Bryans
Budenberg Gauge Company
Bulgin & Company
Burgess Micro Switch Co.
Bush Beach & Segner Bayley

C.G.S. Resistance Co.
Cadmium Nickel Batteries
Cambion Electronic Products
Cambridge Consultants
Canada
Carborundum Company
Carlingswitch
Chance Pilkington Optical Works,
Channel Electric Equipment
Chart-Pak Rotex,
Ciba (A.R.L.)
Circuit Integration
Clare Electronics
Clemac
Colvern
Cole Electronics
Comark Electronics
Computer Instrumentation
Computer Memory Systems
Computer Technology
Computing Techniques
Contraves AG
Control Instruments
Controls & Automation
Cornerstone Hawthorn Baker
Cossor Electronics
Counting Instruments
Coutant Electronics
Crane
Crouzet England
Croydon Precision Inst.
D-Mac
Dana Electronics
Dansk Industri Syndikat
Data Dynamics
Davu Wire & Cables
Davy & United Instruments
Dawe Instrument
Daystrom
Deac (Great Britain)
Dek Printing Machines
Delta Controls
Deutsche Export
Diamond H Controls
Digital Equipment Company
Digital Systems
Draper, B., & Son
Dresser Manufacturing
Dubilier Condenser Co.
Dymar Electronics
Dynamco

EMI
East Grinstead Electronic Components
E.F.C.O.
Efco
Electrical & Electronics Trades Directory
Electricity Council



One of the Levell TG200 series of RC oscillators covering 1Hz to 1MHz in 12 ranges.

Six digit counter timer type TSA6636/3 from Venner covering frequencies up to 40MHz.

Solartron digital multimeter, type LM1240, which has 26 ranges.

This carrier servo generator introduced by Prosser Scientific Instruments has a frequency range of 0.0008Hz to 200kHz and provides a two phase modulated output.

Dymar modulation meter, type 785, for narrow deviation mobile v.h.f. and u.h.f. radio telephone transmissions.

A new digital frequency meter, type 801M, introduced by Racal Instruments capable of direct gating throughout the range 10Hz to 125MHz.

Electricole
Electro Mechanisms
Electrographic
Electronic Associates
Electronic Engineer
Electronic Flo-Meters
Electrosil
Electrothermal Engineering
Emerson & Cuming (UK)
Endress + Hauser (UK)
Engel & Gibbs
Engineering Enterprises
English Glass Company
English Numbering Machines
Environmental Equipments
Epsylon Industries
Erg Industrial Corp.
Erie Electronics
Ether
Eurogauge Company
Eurotherm
Ever Ready Company

FR Electronics,
Facit-Odhner Electronics
Fairchild Semiconductor
Feedback
Fenlow Electronics
Ferranti
FieldTech
Fife County Council,
Filhol, J. P.
Fischer & Porter
Fisons Scientific Apparatus
Foxall, T., & Sons
Foxboro-Yoxall
Fry's Metals

GEC-Elliott Automation
G E Electronics (London)
G.E.C. Electronic Tube Company
G.E.I.S.
General Automation
General Instrument (UK)
General Radio Co. (UK)
Gerber Scientific Instrument Co.
Gore, W. L., & Assoc. (UK)
Greenpar Engineering
Gresham Lion Group

Guest Electronics

Hallam, Sleigh & Cheston
Hartmann & Braun AG
Harwin Engineers
Hassett & Harper
Hawker Siddeley Dynamics
Hengstler, J., Company
Hewlett-Packard
Highland Electronics
Hird-Brown
Hoffmann, J. H.
Honeywell
Houchin
Huber, J. J.
Hugh Instruments
Hymatic Engineering Co.

ITT Components Group Europe
ITT Electronic Services
I.P.C. Electrical-Electronic Press
Imhof
Impectron
Imperial Smelting Corp.
Industrial Staff
Intek Charts
Interdata Inc.
Intertechnique
Irish Export Board

Jermyn Industries
Juniper Journals

K.D.G. Instruments
K & N Electronics
K.S.M. Electronics
Kalle Controls (GB)
Kemo (Consultants)
Kent, George
Kerry Ultrasonics
Kinetrol
Kistler Instruments
Klippon Electricals
Kodak
KOVO Foreign Trade Corp.
Kynmore Engineering Co.

L.T.H. Electronics
Landis & Gyr
Lan-Electronics
Leach Relais und Elektronik

Leeds & Northrup
Leesona
Leland Leroux
Lemosa
Levell Electronics
Lewis, H. K., & Company
Licon Electronics
Light Laboratories
Lindsey, C. S.
Litton Precision Products
Lloyd Instruments
Lloyds Bank
London Electrical Mfg. Co.
Lund Bros. & Company
Lucas, Joseph, Electrical
Lyons, Claude

M.B. Metals
M.C.P. Electronics
M.L. Industrial Products
McMurdo Instrument Co.
Magnetic Devices
Mallory Batteries
Mann Components
Marconi-Elliott Microelectronics
Markem (UK)
Markovits, I.
Martin-Ivo
Mayes, W. H. (Electronics)
Mercantile Leasing Co.
Meyer, Wm. A.
Micro Consultants
Microwave International
Midland Bank
Milgray International
Mills & Rockleys (Electronics)
Milton Ross Company
Mine Safety Appliances Co.
Model & Prototype Systems
Modern Precision Engineers
Modulex 3-Dimensional Planning
Mohawk Data Sciences
Montford Instruments
Moore Reed & Company
Motorola Control Systems
Motorola Semiconductors
Maldivo
Mullard
Multitone Electric Company
Mycalex Instruments

N.S.F.
National Westminster Bank

Neoflex
Newmarket Transistors
Nore Electric Company
Norgren, C. A.
Normalair-Garrett

Oliver Pell Control
Oltronix UK
O.M.R.O.N. Div. of I.M.O. Precision Controls
Optical Works
Orbit Controls
Oxley Developments Co.

P.C.D.
P.S.B. Instruments
Painton & Company
Palmer Aero Products
Pedoka
Penny & Giles
Pergamon Press
Permanoid
Philbrick/Nexus Research
Photain Controls
Pignone Sud S.p.A.
Plannair
Plasmoulds
Plessey Company
Poddy, Paul
Post Office Telecoms
Precision Instrument (UK)
Planer, G. V.
Proper Equipment
Prosser Scientific Instruments
Publisher's Association,
Pye Switches
Pyrotenax

Quickdraw Company

Racal Electronics
Radiatron
Rank Xerox
Recording Designs
Reinach Automation
Reliance Gear Company
Research Instruments
Reyrolle Parsons

Rivlin Instruments
Rosemount Engineering Co.
Ross, Courteney & Co.
Royal Worcester Industrial Ceramics

SASCO,
SGS (United Kingdom)
SIRA,
Sangamo Weston
Scientifica & Cook Electronics
Sealectro
Searle, G. O., & Company
Semiconductor Specialists Inc.
Serck Glocon
Service Electric Company
Servo Consultants
Servomex Controls
Shackman, D., & Sons
Shaw Publishing Company
Shipley Chemicals
Siemens (United Kingdom)
Sifam Electrical Instrument
Silver, Peter, & Sons
Simplifix Couplings
Sirco Controls
Sivers Lab
Skan, H. V.
Small Power Machine Co.
Smiths Industries
Solartron Electronic Group
Solidev
Souriau Lectropon
South London Electrical Equipment
Southern Instruments
Southern Watch & Clock Supplies
SOVIREL
Spear Engineering Company
Special Products Distributors
Spectronics
Spembly Technical Products
Sperry Gyroscope
Sprague Electric (UK)
Standard Telephones & Cables
Superior Electric Nederland
Surrey Steel Components
Symonds Engineering Co.
Symot

T.E.M. Sales
Tally
Taylor Instrument Companies
Techmation
Techna (Sales)
Technograph & Telegraph
Technology, Ministry of
Tectonic (Electronics)
Tektronix U.K.
Telerelay (Sales)
Texas Instruments
Thermal Syndicate
Thermo Electric Int.
Thorn Electrical Industries
Thousand & One Lamps
Tinsley, H., & Company
Topper Cases
Tranchant Electronics (UK)
Transitron Electronic
Trend Electronics
Trist, Ronald, Controls
Trumeter Company
Tufnel
Turner Electrical Instruments
20th Century Electronics

Union Carbide
Unit Data
United Trade Press

Veeco Instruments
Veeder-Root
Venner Electronics
Vero Electronics
Vision Engineering

Wadsworth, Leonard, & Co.
Wallace & Tiernan
Wandel & Goltermann (UK)
Watesta Electronics
Watkins Johnson International
Watsons Anodising
Waycom
Weller Electric
Welwyn Electric
West Instrument Div. of Gulton
Westinghouse Brake & Signal Co.
Westool
Westrex Company
Weyfringe
Whiteley Electrical
Williams, Henry
Willsher & Quick
Wire Products & Machine Design
Wireless World
Worcester Valve Company

Sound '70

A.P.A.E. Show in new surroundings

For the first time since it began 22 years ago the exhibition of equipment organized under the auspices of the Association of Public Address Engineers was held in a different, more central venue, and something should be said first about the effect of the change.

Camden Town Hall, situated in Euston Road adjacent to several main line stations, was much more accessible than was the previous location.

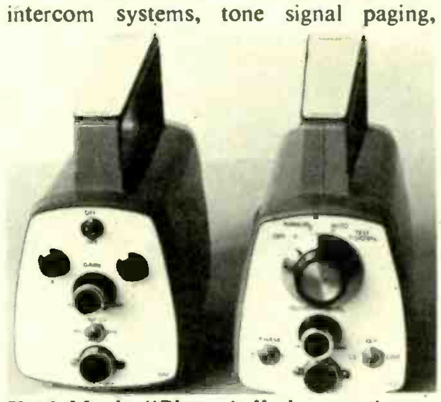
There was a serious attempt to match this exhibition, the only one of its kind in Europe, with those held by larger sections of the radio manufacturing industry. It even had an official opening by Ray Mawby, M.P., Opposition spokesman on telecommunication subjects.

Looking at the products on view confirmed the impression that public address engineering nowadays is hardly likely to be a temporarily installed "lash-up" with plenty of power output to enable the people at the back to hear.

Increasingly the p.a. engineer becomes the sound consultant and the equipment he seeks is required to be an integral part of the building construction, be it a new hotel or sports stadium. We were told that where architectural and acoustical interests conflict the architectural design need no longer be a compromise. The acoustic deficiencies can be easily and unobtrusively corrected by using the wide range of sound reinforcement equipment at the modern sound engineer's disposal.

Impact 150W slave amplifier and six-channel mixer unit

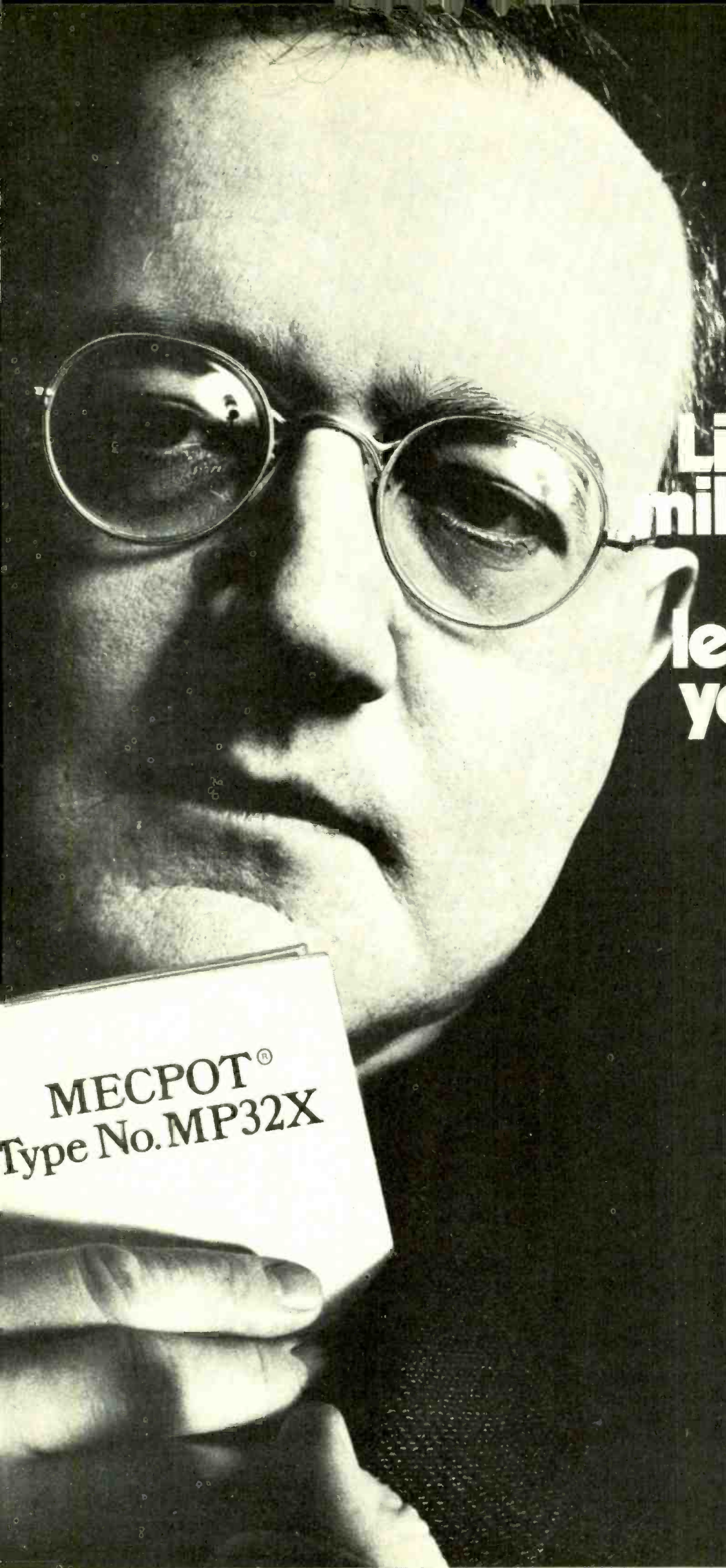
The main p.a. system is often linked with other major facilities such as private intercom systems, tone signal paging, closed-circuit TV, and even coupling to a Post Office telephone line.

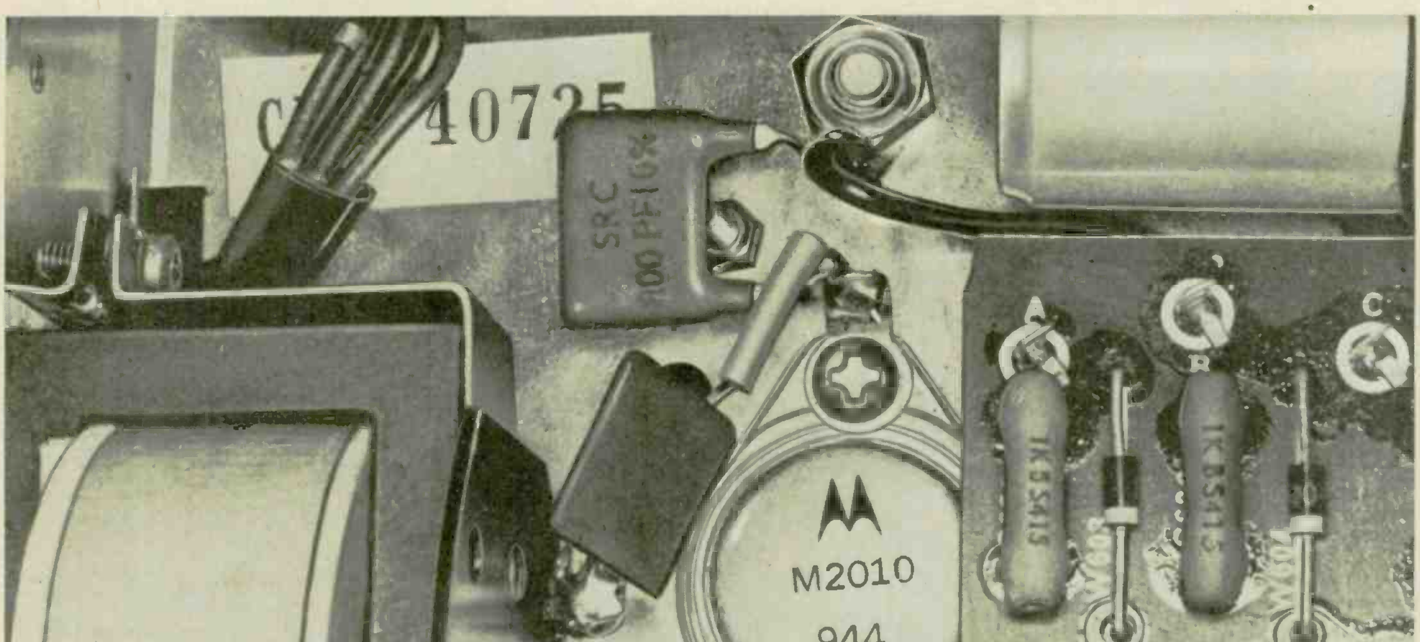

Keith Monks "Phaserite" phase testing equipment

Something like 50% of the equipment on display was there to satisfy the demands of the king of musical money spinners—Pop. Large amplifiers of 150W r.m.s. output, or more, were shown with companion mixer units sporting half-a-dozen inputs each with an array of polished metal controls, some with tell-tale legends such as "Reverb", "Tremolo" and "Echo". Matching loudspeakers had special transducers for bass and organ effects. These carried brand names like Impact and Orange, newcomers to the public address show.

One piece of useful equipment not seen before was the Phaserite phase tester shown by Keith Monks (Audio) Ltd. It was a two-unit device (transmitter and receiver) constructed in two Ever-Ready heavy duty torch cases.

The transmitter emits a train of specially shaped positive-going pulses which, when picked-up by the p.a. system microphone, can be heard in the loudspeakers. If the receiver transducer is pointed towards each loudspeaker in turn the in-phase or out-of-phase condition is indicated visually by a green or red light at the rear of the unit. Both units were battery-operated and used i.cs. In the receiver, the sense of the acoustic signal is detected by two parallel inhibit gates followed by two monostable multivibrators which operate the lamps.


MECPOT®
Type No. MP32X



M2010
944

World of Amateur Radio

Intrusion and interference

For many years amateurs have been concerned about the intrusion of broadcast and commercial services into bands allotted exclusively to amateur radio. In particular, the 7-MHz band has given rise to two main complaints. British and European amateurs have long resented unauthorized operation of broadcasting stations in the segment 7000 to 7100 kHz; while American and other Region 2 amateurs have complained about the high-power Region 1 broadcast stations in the segment 7100 to 7300 kHz beaming signals into North America.

Partly as a result of the R.S.G.B. Intruder Watch (honorary organizer C. J. Thomas, GW3PSM) a number of broadcast and point-to-point stations have been moved out from the 7000 to 7100-kHz band. The Intruder Watch passes information to Minpostel* which in turn advises the administration concerned, or, if this fails, notifies the International Frequency Registration Board of an infringement. Attempts are being made to streamline the procedure so that action can be taken more quickly.

Alleviation of interference to Region 2 operators should also result from recent pressure on broadcasters by the I.F.R.B. In a circular letter (No. 229) this body recently officially drew the attention of broadcasters to harmful interference caused to Region 2 amateur operation in the band 7100 to 7300 kHz, stressing that this contravenes Radio Regulation No. 117 (equality of rights of different services). The F.R.B. has also established a procedure which provides administrations with a basis for action in specific cases of actual harmful interference. All future broadcasting schedules for this band will include a note from the Board specifically reminding the stations of the possibility of causing harmful interference to amateurs.

Aurora and sunspots

That one amateur's meat is another's poison was seldom better illustrated than on March 8th when the B.E.R.U. h.f. contest and a 144 MHz v.h.f. contest were running simultaneously. The highly disturbed radio conditions that weekend, culminating in widespread auroral conditions on the Sunday afternoon and evening, meant tough going for the h.f. operators, and the virtual closing of the North Atlantic path into central Canada. But on 144 MHz the aurora produced an "opening" which permitted many contacts, with the characteristic buzz on all signals, over distances up to about 750 miles including contacts with Czech, Swedish and Swiss stations. During such conditions, the 144 MHz signals arrive from, and should be beamed towards, the North.

March 8th was considered one of the longest duration auroral openings recorded in recent years and the R.S.G.B. scientific studies committee is making a special study of contacts made that day (reports to G. M. C. Stone, G3FZL, 11 Liphook Crescent, London S.E.23).

Despite the poor h.f. conditions, some British Commonwealth stations in the B.E.R.U. contest were heard exchanging contact serial numbers between 300 and about 500. This represents a marked decline on the 1969 event, but this is also to be expected from the gradual decline in sunspot numbers from the peak of the present cycle in September, 1968.

Top-Band season

Those enthusiasts who, each winter, seek to overcome the formidable problems in long-distance communication on the 1.8-MHz band, appear well satisfied with the results of the 1969-70 season. According to the latest DX Bulletins issued by Stewart Perry, W1BB, many unusual countries have been heard or worked. Among those contacted by British amateurs have been 9X5SP (Rawanda), 5Z4LE/HZ (Saudi Arabia), VS9OC (Oman), and VK6NK (Western Australia). During the transatlantic tests on February 1st, ten British stations were among those who "got across". An American amateur reports "sunset" band opening conditions during the noon eclipse on March 7th.

A feature of recent operation on Top Band has been the revival of interest in Beverage receiving aerials using extremely long, but quite low, aerials pointing in the direction from which it is desired to receive stations. At the far end the aerial is usually terminated through a resistor to earth and extensive radial counterpoise wires, or efficient earths are desirable. Aerials up to 2600ft long have been used, but about 1100ft is more common. A 600 to 700ft Beverage aerial has been used effectively by (R. F. McLachlan, G3OQT, and J. P. Rogers, G3PQA.

I.E.C. station WF3IEC

During the 35th general meeting of the International Electrotechnical Commission—the oldest international standards organization in the world—in Washington D.C. from May 17th to 30th, a special amateur station, WF3IEC, will be operating from Suite 9101 in the Washington Hilton. More than 1400 delegates from 41 countries will be participating in these meetings. The amateur station will be under the supervision of Ed Redington, assisted by members of the Foundation for Amateur Radio. Operation, on a round-the-clock basis, will include s.s.b. and c.w. operation on all h.f. bands except 1.8 MHz. (QSL cards to L. M. Rundlett, W3ZA, Electronic Industries Association, 2001 Eye St., N.W., Washington, D.C.)

In Brief: Prof. Franco Fanti, I1LCF, one of Europe's keenest slow-scan TV enthusiasts, recently made contact with a New Zealand station for what is believed to be the longest-distance S.S.T.V. contact yet achieved—he has also recently exchanged pictures with two stations in Alaska. . . . The Bedford Amateur Radio Club is to operate a three-transmitter station (3.5, 7 and 144 MHz), GB3BS, at the Scout Rally Camp at Ampthill Park, Bedfordshire, on May 10th. . . . The GB3GEC 70-cm beacon station in West London now operates on 433.45 MHz. . . . Northern Amateur Radio Mobile Society is holding a mobile rally on May 17th (details D. Binns, G3MGI, 80 Gipton Wood Road, Leeds 8). . . . Thanet Radio Society has a mobile rally at the King George VI Park, Ramsgate, on May 5th. . . . Monday evenings are being established as 70 MHz "activity nights" in the Yorkshire region. . . . The annual commemoration of the 1897 Marconi-Kemp tests between Lavernock Point, Glamorgan, Flatholme Island in the Bristol Channel and Brean Down, Somerset, will take place on May 17th when the Barry College of Further Education will establish GB3FI on Flatholme and GW3VKL/P at Lavernock Point Holiday Camp operating on all bands from 1.8 to 28 MHz (s.s.b. and c.w.) and 144 MHz (a.m.). A special QSL card containing many details of the 1897 event and five historic illustrations will be sent to all stations contacted. . . . Irish VHF/UHF convention and mobile rally will be held on May 24th at the County Arms Hotel, Birr. Details from R. Williams (EI7AF/GI3UIG), 31 Main Street, Birr, Co. Offaly.

PAT HAWKER, G3VA

* Abbreviation for Ministry of Posts & Telecommunications suggested by the Minister, Mr. John Stonehouse.

Aperiodic Loop Aerial

Receiving array for h.f. communications over four octaves

by Philip G. Baker

A unique receiving aerial which provides optimum directional and performance characteristics over a frequency range of four octaves (2-32 MHz, typically) has been developed by E.M.I. Electronics Canada. It consists of eight double one-metre diameter loops spaced 13 feet apart, and each loop has a transistor amplifier fitted in the base. This particular combination results in a constant effective height over the full four-octave frequency range, that is, the pre-amplifier output voltage is constant over the complete frequency range for a fixed incident field strength. Because of the flat frequency response, the aerial has well defined phase characteristics and is particularly suited for a phased aerial system. The aperiodic configuration comprises loop/pre-amplifier elements in an "end fire" array with an inter-connecting transmission line coupling each element. Outputs at both ends enable the array to "look" both ways simultaneously, if required, or the system can be rapidly switched through 180° with a coaxial relay.

Design philosophy

At frequencies above 100MHz the problems inherent to receiving and transmitting aerial designs are generally interchangeable except that, perhaps, the radiating element operates with a voltage stress. Below 100MHz, and to a much greater extent below 30MHz, this is no longer true because of the effects of atmosphere and galactic noise sources. Although a requirement for free space coupling efficiency remains for the transmitting aerial, it does not for the receiving aerial. For example, at v.l.f. a large copper curtain is necessary for the transmitting array, but a small whip aerial having negligible free space coupling is adequate for receiving purposes.

At frequencies below 30MHz it is possible to employ a receiving aerial which is electrically small and has a poor free space coupling efficiency, without prejudicing the overall system noise factor. The aerial output noise comes primarily from atmospheric and galactic sources, hence the thermal noise introduced by the aerial radiation resistance is insignificant by comparison, provided the resistance is assumed to be at ambient temperature.

The aerial system noise factor is defined as

$$\frac{\text{incoming atmospheric s/n ratio}}{\text{aerial output s/n ratio}}$$

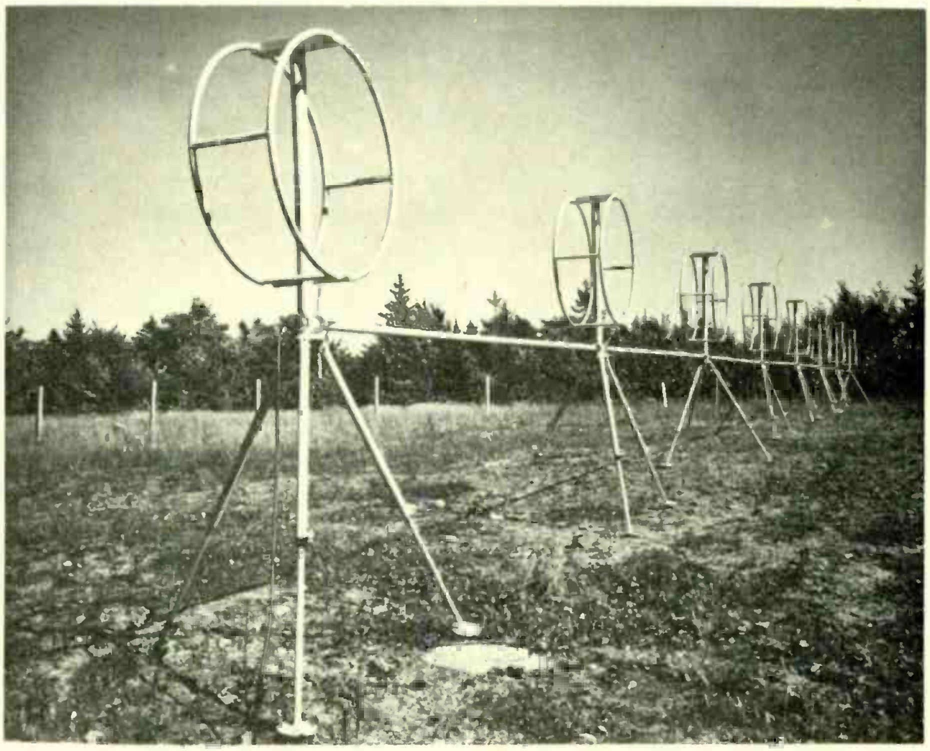
Tabulated values of the noise factor for six different geographic locations are given below for a single loop element. The atmospheric background noise values for these calculations were taken from the contours given in C.C.I.R. Report No. 65 (Atmospheric Radio Noise Data) and averaged over all four seasons. The two lower frequencies (2 and 4MHz) were calculated on the basis of night-time interference levels only, since long-haul communications using these frequencies are normally practical only at this time. For similar reasons, the two higher frequencies (16 and 32MHz) were computed for daytime only. The 8MHz frequency was taken over a full 24-hour period.

Two immediate conclusions may be drawn from these tests: that optimum directional characteristics for both long- and short-haul, point-to-point h.f. communication via the ionosphere are feasible with the E.M.I. loop system, and that the small size of the aerial does not prejudice its performance to any practical extent in most world locations.

With n loop elements arranged in an array the signal amplitude is increased n times, but the pre-amplifier noise only increases by $\sqrt{n}$, giving further impovement in the signal-to-noise ratio.

Aerial noise factor (single loop)

Location	Frequencies				
	2MHz	4MHz	8MHz	16MHz	32MHz
	(dB)	(dB)	(dB)	(dB)	(dB)
United Kingdom	2.5	< 1.0	2.3	5.5	6.9
North America	< 1.0	< 1.0	< 1.0	5.5	6.9
South America	< 1.0	< 1.0	< 1.0	4.2	6.9
Hawaii	1.5	< 1.0	2.3	5.5	6.9
South East Asia	< 1.0	< 1.0	< 1.0	4.2	6.9
Africa	< 1.0	< 1.0	< 1.0	3.4	6.9



Each loop is supported by an aluminium tube in which the pre-amplifier is housed.

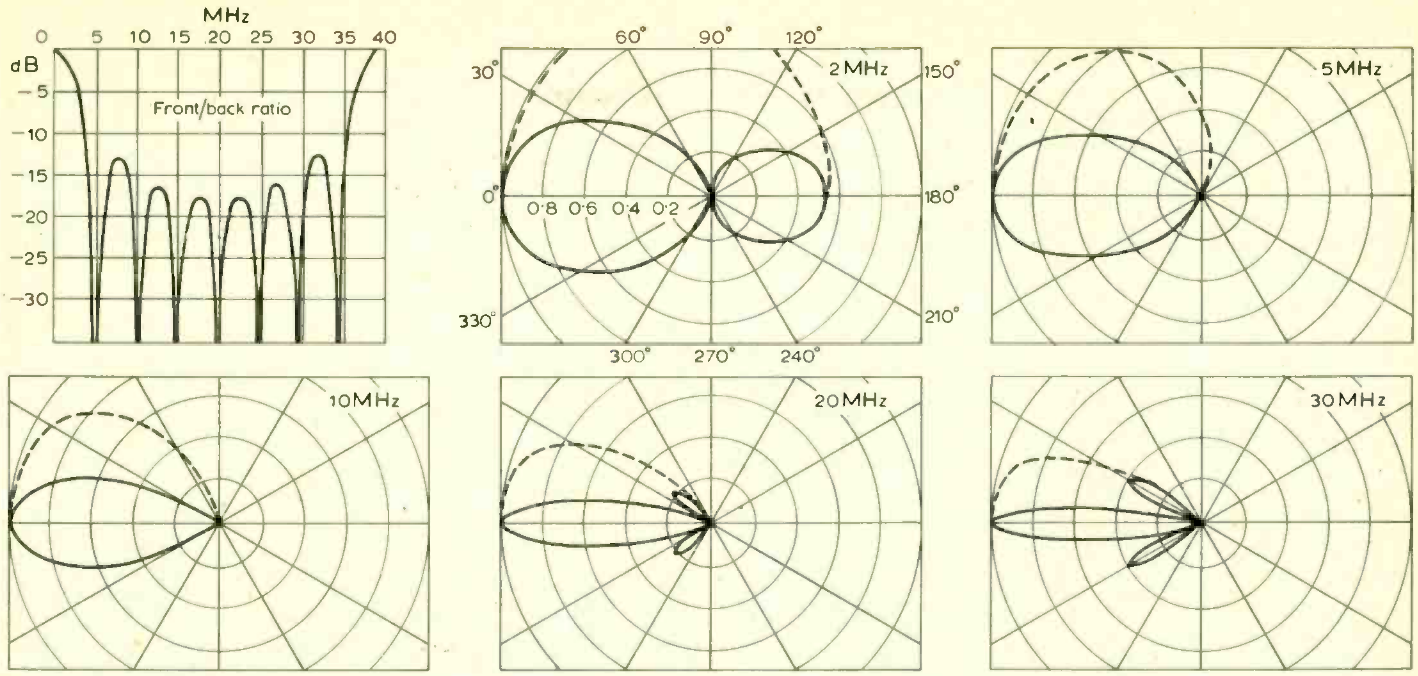


Fig. 1. Directional characteristics of the E.M.I. loop array. Broken lines show elevation patterns and solid lines the azimuth.

The polar diagrams (Fig. 1) illustrate the directional characteristics of the loop array, the elevation pattern being shown as a broken line and the azimuth as a solid line.

The polar diagrams show further that aperiodic loop arrays provide directional characteristics for both long- and short-haul communications using ionospheric reflection. Long-distance reception at higher frequencies in the 2-32MHz band benefits from the narrow beamwidth and corresponding higher aerial gain. Short-haul communications, which depend upon acute reflection angles, are generally possible only at the lower part of the frequency range because of the nature of the reflecting characteristics of the ionized layers. The wider elevation beamwidth of the aerial at these frequencies allows signals arriving at near vertical incidence to be received with substantial aerial gain.

Operation in the presence of strong unwanted signals

Each pre-amplifier is designed to handle a peak signal strength in excess of 2V/m without overloading. In the h.f. band this is greater than the signal from a 10-kW transmitter at a distance of one mile over land. Aperiodic aerial arrays yield second-order inter-modulation products down more than 70dB, and third-order down more than 100dB, below two signals of 10mV/m. This performance compares well with active multicouplers found at most receiving sites.

D.C. power is fed to the loop pre-amplifiers by the coaxial cable which connects the array to the receiver building, and no other cables are necessary. The pre-amplifiers are designed to operate over external environmental temperatures of from −40° to +70° C. They are contained in a sealed unit which plugs into the central tube of the loop from underneath, thus providing double protection from the weather.

The aperiodic loop aerial system is largely unaffected by ground conductivity and nearby objects, and, as a result, negligible site preparation is necessary. The system requires under 100 square metres of ground area and is easily erected in half an hour. The loops should be located close to the ground (in terms of wavelength) where direct and reflected signals will add in phase.

The low mutual interference between the untuned loop/pre-amplifier elements permits multiple cross array systems to be constructed. Six 8-loop arrays can be arranged radially through a common centre point in increments of 30° to provide omni-directional coverage without mutual interference. Both ends of each array can be fed to the receiving building, enabling all 12 outputs to be used simultaneously by numerous receivers. This particular configuration would require a circular site only 30 metres in diameter, and would replace an entire rhombic farm. There is virtually no restriction on the length of the aerial feeder cable, and steerable arrays are easily constructed.

Painless Electronics (we hope)

Occasionally readers say to us "I can't understand a lot of what's in *Wireless World*", perhaps adding, if they are getting on in years, ". . . any more." The fact is, if all articles had to be simplified to a standard level they would become excessively long, the technical content of each issue of the journal would be less varied and the more advanced readers would be irritated. In practice we try to steer a middle course. We do, however, recognize that we have many readers, not formally trained in electronics, who would like to be able to get a better mental grip on the technical articles published or on the technology as a whole. We have therefore asked our contributor James Franklin to write a series of short introductory articles on electronics—one page in each issue—on the principle that this could be a gradual, painless way of absorbing knowledge, in contrast to, say, a "crash" course.

This series, "Electronic Building Bricks", begins next month. It does not follow a conventional text-book approach, but emphasizes the *functions* of electronic units—as "black boxes"—rather than the circuitry and hardware from which they are constructed. Some fundamental theory comes in, but only where it is strictly necessary for this approach. Circuitry is described in a manner that should be understandable by the average electrical handyman.

But do not think *Wireless World* intends to "write down" to any of its readers. The author treats his readers as intelligent people who simply do not want to be "blinded by science".

Spring Song

Thomas Roddam discourses on circuits that are really solid

Once upon a time there was a lot of simple books on what was always a joint subject, Electricity and Magnetism. Electricity was described in many of these books in terms of water pipes and tanks. The child, an old-fashioned way of describing the sub-teenager or mini-dropout, cannot see electricity once it gets inside wires; masculine will only be things that you can touch and see: therefore if he is to understand electricity his feet must be firmly set in water. Educationalists were not so thick on the ground in those days and, just as now, some students learned something, some did not. Those were, of course, Imperial days, and, as both Joyce and Wells have pointed out, imperial powers have a cloacal obsession. The Romans built baths and the aqueducts to fill them: in every corner of the globe you can still pull a British chain—the British are a contemplative race. The Americans, always impatient, demand shower-baths wherever they go. In the gracious days, now past, every decent schoolmaster had studied Latin. The philosophy of the Latin grammar demanded water-pipes as the model, even if running water was as remote to the child as electricity.

Microwaves made easy: Le Pont du Gard. (Courtesy French Government Tourist Office.)

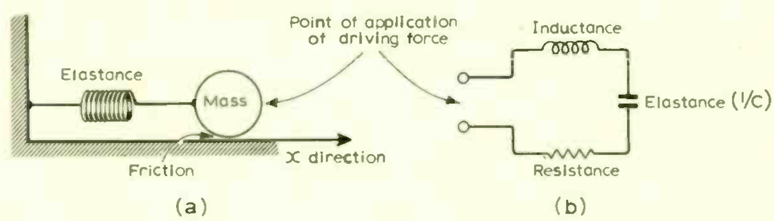


Fig. 1. Example taken from Guillemin.

Water only really works for direct current. Guillemin, in the opening chapter of *Communication Networks*, published (Vol. 1) in 1931, starts off by saying "The engineer likes to be able to visualize the mechanism of his investigations." His first figure and his first equation are for a mechanical system, not an electrical one. My own feeling, having been around with inductance and capacitance for so long, is that if there is a need for analogues it is a need to be able to draw an electrical circuit to help to understand a mechanical one. However, when I was explaining to one of the handsome and talented people whose names appear on the masthead of this journal that I thought that simple theory deserved a rest, I was assured that spring-heel Jack is a regular reader.* Some of you, apparently, would rather watch an elephant sliding down hill than connect a coil across a battery.

Analogues are models, and they can be dangerous. In any model-making operation you can hardly avoid leaving out some features of the original and adding some new characteristics. Unless you are careful to stick to the rules of the modelling process you may come to some quite erroneous conclusions. This would not surprise you. The same is true of our everyday components. A resistor is a resistor. A wire-wound resistor has some inductance, which we can measure to improve our "model", in this case the drawing we put on our circuit for calculation purposes. But the manufacturer does not usually specify the inductance and he may change his construction, giving us the same resistance with a different behaviour at high frequencies. Clever circuits, which use unspecified characteristics of practical components, live, and often die, under the shadow of this refusal to stick to the rules.

The use of analogy between electrical systems and mechanical systems is normally developed along one particular path, and is brought sharply to a full stop before the main difficulties arise. I am going to follow this path, but in such a way that the difficulties shed new light on the whole problem. At least I hope so.

The two equations we need are:

Newton's Third Law, $F = ma$,

in which F is the force, m the mass and a the acceleration; and

Hooke's Law.

Hooke's Law applies to springs, or any material which is stretched or compressed by force. For small displacements this is usually a linear elastic deformation. If it is not, Hooke's Law does not apply. The difficulty is that different sources arrange the equation of stress is proportional to

*On the other hand, Thomas Roddam may be pleased to know that the staff member concerned recently had his hot-water central heating system re-designed by a heating engineer whose regular practice is to think in electrical circuit analogues.—*Editor.*

strain in rather different ways. If we have a displacement x we can write

$F = S_m x$, in which S_m is the stiffness, or
$F = x/C_m$, in which C_m is the compliance.

S_m is the material characteristic which appears in the expression for Young's Modulus.

We need also to notice that

$$a = dv/dt = d^2x/dt^2$$

and $v = dx/dt$. Here v is the velocity. The traditional approach is to write down

$$F = ma = m\,dv/dt = m\,d^2x/dt^2.$$

Below this

$$V \qquad = L\,dI/dt = L\,d^2Q/dt^2.$$

Contemplation of these two results suggests that if we represent force by voltage, velocity by current, displacement by charge, we can represent inductance by mass.

With an ideal spring, and writing Hooke's Law as

$F = kx$ we put below it
$V = Q/C$

and this suggests that capacitance can be represented by a spring, with capacitance inversely proportional to the stiffness.

Resistance is not quite so easy as you think. At least, as I think. My first reaction is to say that it is just the ordinary friction, but the experiment we do to find the coefficient of friction gives us a force which depends only on the loading. A given pressure on a car foot brake produces roughly the same deceleration at any speed. It is viscous drag we must consider, the plunger in the bowl of treacle. Modern practice uses silicone treacle, but it must be a dash-pot, not a slide, to get the essential equation

$F = \rho v$ which we compare with
$V = RI$.

Everything in the garden is lovely: a period phrase, well suited to the stage we have reached. Let us look now at Fig. 1, which is taken direct from Guillemin and is, indeed, his Fig. 1. Notice that the mechanical force is shown as applied at a single point and that the electrical circuit has two terminals. The reader may feel that I am being a bit pernickety about this. After all, anyone can see that the other mechanical terminal is earth, the framework. If you really feel that this is a sufficient answer, write down the electrical equivalent of Fig. 2.

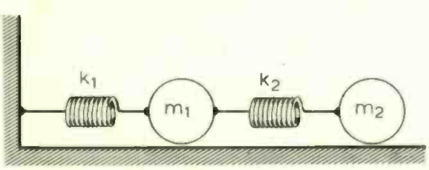


Fig. 2. If you know where earth is in Fig. 1(b), draw the electrical version of this.

If the analogue technique is any good it should be possible to write down the circuit by a simple inspection operation. This just does not work with the results we have at this stage. The elementary analogue users work on the principle that you should get away from analogues as fast as you can. Get the feel of an LCR circuit from Fig. 1 and then get stuck into the circuit theory. The only trouble is with those of us who want to make electrical models of mechanical systems so that we can connect an oscilloscope to study the behaviour, or who want to build mechanical filters. We cannot escape. Anyway, if the analogue technique is worth attempting at all, it is worth treating properly.

A sound self-consistent approach is to treat all the systems as four-terminal networks or, more strictly, two-terminal pairs. This sounds classy, but it simply means remembering that each bit has two ends and that the good earth is there below. Let us start off with the mass, drawn now as in Fig. 3. The little rods sticking out at the ends

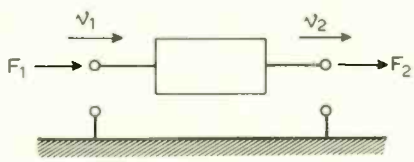


Fig. 3. Mechanical system: a mass on a friction-free support.

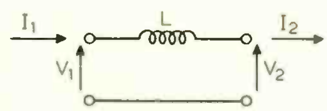


Fig. 4. An inductance in a four-terminal form.

are the two live terminals. For reasons which I do not want to explain at this point the force arrows and the velocity arrows are shown the way they are. Both must be related to the earth line which provides the other two terminals. The rod on the right may be applying a force F_2 to some other thing, and as action and reaction are equal and opposite, the load will be pushing back with an equal force. The net force on the mass is therefore $F_1 - F_2$.

The equations are now written in the following form.

$$F_1 = F_2 + m\,dv_2/dt$$
$$v_1 = \qquad v_2$$

For the circuit of Fig. 4 we have

$$V_1 = V_2 + L\,dI_2/dt$$
$$I_1 = \qquad I_2$$

The layout of these equations has been carefully contrived so that it is easy to look at the term by term relationships. A good deal of fuss about nothing, you may feel, for here are L and m sitting in corresponding spaces, just as we found before.

Now, however, let us look at the spring in Fig. 5(a). Notice that this is not the same as the spring in Fig. 5(b). The spring is assumed to have no mass. This means that the net force acting on it must be zero, because if there were a net force, zero would imply infinite acceleration and we should need to look for a new spring. The net force is simply $F_1 - F_2$, and, as we have said, this is zero. I will not write the equation down yet. The effect of applying force to the spring is to compress it, so that one end moves with

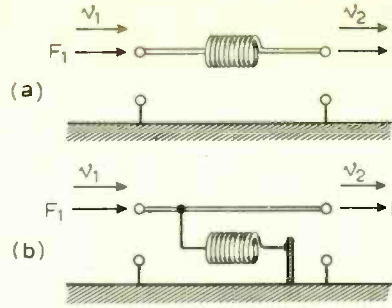


Fig. 5. Two ways of using a spring in a mechanical system.

respect to the other by an amount x. We have

$$F = kx.$$

The compression (or stretch, depending on the sense of F) is the difference in the distances travelled by the two ends:

$$x = \int v_1 dt - \int v_2 dt.$$

We then can see that $v_1 = \dfrac{dx}{dt} + v_2$.

Since $x = F/k$, $\dfrac{dx}{dt} = \dfrac{1}{k}\dfrac{dF}{dt}$.

Our final set of equations is:

$$F_1 = F_2$$
$$v_1 = \frac{1}{k}\frac{dF_2}{dt} + v_2.$$

Now let us look at the circuit of Fig. 6(a). For this circuit we obviously have $V_1 = V_2$.

We also can see that

$$I_1 = C\frac{dV_2}{dt} + I_2$$

We get the relationship that $C \rightleftarrows 1/k$.

For the restoring spring shown as Fig. 5(b) the equations are quite different. The light stiff rod is only there to separate the input and output terminals and its two ends move at the same velocity. The spring alters the force relationships, so that

$F_1 = F_2 + kx$, which gives us

$$F_1 = F_2 + k\int v_2 dt$$
$$v_1 = \qquad v_2.$$

Consider the circuit of Fig. 6(b). In this circuit the current which flows in at one terminal flows out at the other. I am not sure whether this is obvious, but if you consider a battery connected at the left-hand end you will see that the capacitor will not charge until you short-circuit the right-hand

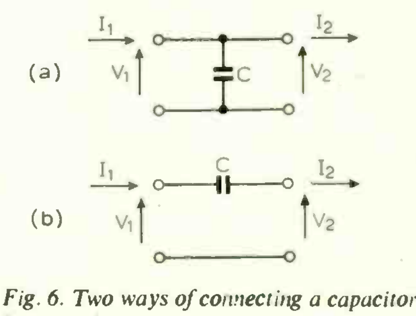


Fig. 6. Two ways of connecting a capacitor in a circuit.

terminals. There is a difference between the two voltages, which is given by

$$V_1 = V_2 + \frac{1}{C}\int I_2 dt$$
$$I_1 = I_2$$

Comparing this with the force-velocity equations we see again that

$$C \rightleftarrows 1/k$$

but we see the important difference in the method of connection. It is the first reward of our rather pedantic approach.

It is fairly easy to see that friction, the viscous friction we are concerned with, can also appear in two ways. On a level road, at constant speed, the engine of a motor car is simply providing the force needed to balance the various friction loads, drag, internal losses, the cooling fan. Bang the accelerator down on an icy road and you are aware that you rely on force transmitted through a frictional coupling. The same is true when the clutch is slipping, either of intent or age. We can draw these two forms of frictional element in the forms of Fig. 7. Fig. 7(a)

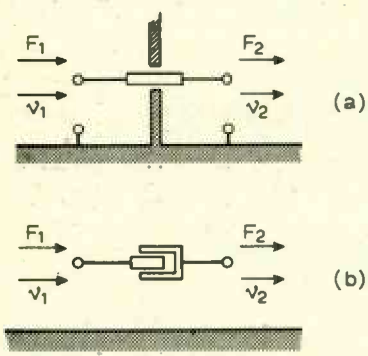


Fig. 7. Frictional mechanical elements.

shows a typical frictional loss situation, corresponding to the drag on your car, the loss at a bearing. For a unit of this kind we have the same velocity at both ends, but we must "overcome" the friction. Thus

$$F_1 = F_2 + \rho v_2$$
$$v_1 = v_2$$

The equations for this are similar in pattern to the equations we can write down for the electrical circuit of Fig. 8(a):

$$V_1 = V_2 + RI_2$$
$$I_1 = I_2$$

We see that $\rho \rightleftarrows R$.

For the circuit of Fig. 7(b) we have rather different equations. This dash-pot coupling is assumed to be without mass. Any mass which is found in a real dash-pot appears as a separate circuit element, just as the inductance, and for that matter the capacitance, of a real resistor is not included in resistance equations. No mass, no net force. We get the equations:

$$F_1 = F_2$$
$$v_1 = F_2/\rho + v_2.$$

The circuit of Fig. 8(b) gives us

$$V_1 = V_2$$
$$I_1 = V_2/R + I_2.$$

Again $R \rightleftarrows \rho$, but the method of connection is different.

Before we can apply this collection of analogues to mechanical systems of the kind shown in Fig. 1 we need to be able to convert to a two-terminal network. At the end of an analysis we finish up by either short-circuiting or open-circuiting the terminals at the extreme right-hand end. Open-circuiting a mechanical terminal means simply pretending it is not there: short-circuiting it means clamping it to earth. We can clamp the rod in Fig. 7(a) by allowing the frictional force to become very large, so that F is finite as v goes to zero. This makes R in Fig. 8(a) go off towards infinity, leaving

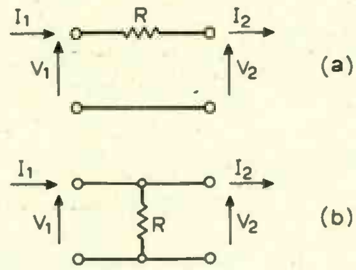


Fig. 8. Resistance in an electrical circuit.

the left-hand terminals as good as open. A clamped rod appears as an electrical open circuit, with I, v, both zero.

A free mechanical terminal is obtained if we let $\rho \rightarrow 0$ in Fig. 8(b). If the left-hand end can slide freely, it does not matter what we do about F_2 and v_2. We get the same conditions as we get if $R \rightarrow 0$ in Fig. 8(b). V and F must always be zero.

Now we can draw out Fig. 1 again. I have done this in two different ways. In Fig. 9(a) the spring is shown as a restoring spring,

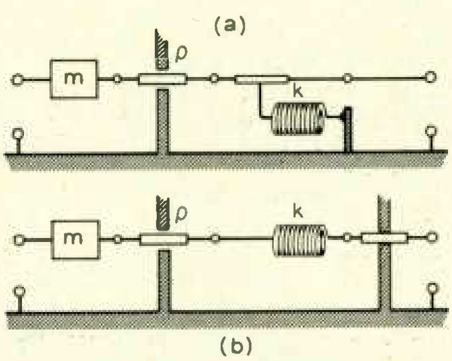


Fig. 9. The Fig. 1 mechanical circuit redrawn.

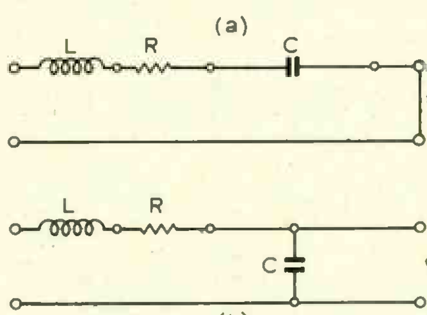


Fig. 10. The electrical forms of Fig. 9.

with the right-hand end left free. In Fig. 9(b) it is a spring coupling, connected to a clamp. Building up term by term we get the two circuits of Fig. 10. The actual end result is the same, but it is obtained in two slightly different ways.

At last, however, we can look at Fig. 2. For convenience the electrical equivalent is drawn from left to right, corresponding to reading the mechanical circuit from right to left. We get the result shown in Fig. 11.

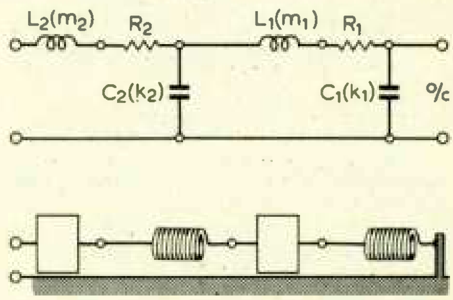


Fig. 11. Electrical equivalent of Fig. 2.

Because of this clarification between shunt and series arms the network is very easy to determine. There is, of course, the possibility of introducing a restoring spring somewhere in the middle, to provide us with a capacitance in a series arm. And this raises a rather embarrassing question. Analogues, we said at the beginning, are to give us something mechanical to look at when we cannot picture the flow of electricity in a network. What are we to do if we have a shunt inductance in the electric circuit?

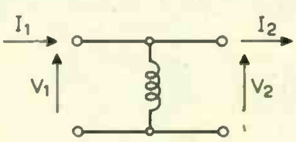


Fig. 12. Shunt inductance.

Questions like this explain why in the elementary books the use of analogues is allowed to fade away quietly. *Wireless World* authors, however, are not such mugs as to raise questions they cannot answer: at least not without laying a careful smoke-screen. We want the mechanical analogue for the circuit of Fig. 12, which satisfies the equations:

$$V_1 = V_2$$
$$I_1 = \frac{1}{L}\int V_2 dt + I_2.$$

The second equation of this pair can be differentiated, to give

$$\frac{dI_1}{dt} = \frac{V_2}{L} + \frac{dI_2}{dt}.$$

We now consider, because I know it leads to the right answer, a bar, of length $2l$, mass m, with all the mass concentrated at the centre of gravity, which is also the middle of the rod. This is shown in Fig. 13. If we waggle one end the other end will move. Rather inconveniently the two ends move in opposite directions, so I have drawn F_2 and v_2 in the common-sense way rather than the formal way. The moment of inertia about the centre of the rod is zero, and if it is not to have infinite angular acceleration

$$F_1 l - F_2 l = ml^2 d^2\theta/dt^2 = 0$$

Thus $F_1 = F_2$.

The net force acting on the rod is,

$$F_1 + F_2,$$

and this will accelerate the central mass, which is assumed to have velocity v_0, giving

$$(F_1 + F_2) = m(dv_0/dt)$$

The rod does not come apart, so that we must have

$$v_0 = (v_1 - v_2)/2$$

Hence $F_1 + F_2 = 2F_2 = \frac{1}{2}\left(m\frac{dv_1}{dt} - m\frac{dv_2}{dt}\right)$

Rearranging this:

$$\frac{dv_1}{dt} = \frac{4}{m}F_2 + \frac{dv_2}{dt}$$

Compare this with the equation

$$\frac{dI_1}{dt} = \frac{1}{L}V_2 + \frac{dI_2}{dt}$$

We see that this weighted bar gives us the right shape of equation, with L appearing as $m/4$. In order to keep things in line we

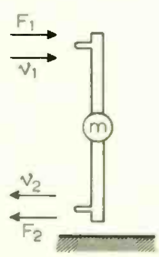


Fig. 13. A bar with its weight concentrated at the centre of gravity.

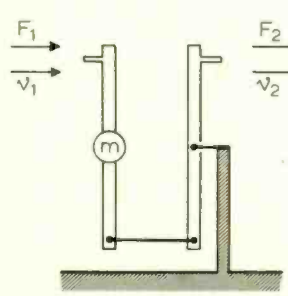
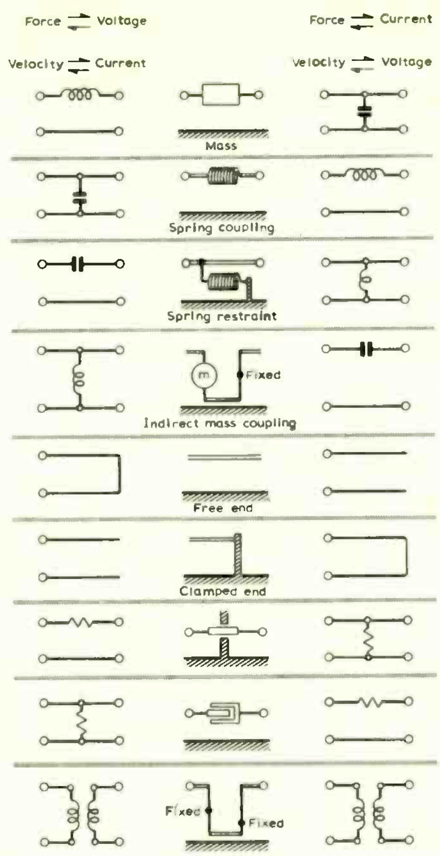


Fig. 14. To get the senses lined up we add a lever.

can add a lever, as shown in Fig. 14. This makes no difference to the analysis.

At this stage we have the complete set of elementary text-book equivalents. Sheer idleness makes me omit the proof that a pivoted lever is in fact an ideal transformer, provided that it is infinitely light. The equations are so simple that they are not worth writing down. We are all ready to take a mechanical system and draw the corresponding circuit. If the mechanical circuit is a rotary motion system we need some minor changes. We use angular velocity, not linear velocity: we use moment of inertia, not mass; torque, not force. It is much of a muchness, though. There comes, however, one difficult moment. Suppose that the mechanical circuit is not a thing by



The two sets of equivalents.

itself, but is being driven by, or is driving an electric circuit. At one end we have a transducer—it may be a loudspeaker coil—which is fed from an electrical network. Two networks in tandem will be fine, we think, until we notice that for the transducer we have the equation

$$F = \mu I$$

and working the other way round

$$V = \mu' v$$

The ideal transducer will have $VI = Fv$, so that $\mu = \mu'$ and

$$F = \mu I$$

$$v = \frac{1}{\mu}V,$$

the equations of an ideal transformer, if only we could take I as equivalent to F, and V equivalent to v. We can, and somewhere at the beginning of this article I said we had to choose in a rather arbitrary way whether to take $F \to V$ or $F \to I$. If only I had not been so stupid, and had made the other choice. Then, I hasten to explain, I would have considered at this stage the piezo-electric transducer, with $F \propto V$. More tears and gnashing of teeth.

It is clear that we need to have two sets of equivalents available if the mechanical system is to be interconnected with an electrical one. If it is not connected to an electrical circuit there is nothing to choose between the two sets, in spite of some writers who have claimed that one or the other is right. A text-book writer can find some systems which are a little easier his way, just as it is sometimes easier to work with conductance instead of resistance: he leaves out the systems which are just a little harder his way.

The other set of equivalents is derived in exactly the same way as before, except that now we compare the two sets of equations:

$$V_1 = AV_2 + BI_2$$
$$I_1 = CV_2 + DI_2$$

and

$$v_1 = \alpha v_2 + \beta F_2$$
$$F_1 = \gamma v_2 + \delta F_2$$

When we find a set in which the two patterns:

$$\begin{matrix} A & B \\ C & D \end{matrix} \quad \text{and} \quad \begin{matrix} \alpha & \beta \\ \gamma & \delta \end{matrix}$$

look alike except that one contains m or μ and the other C or L, we can trace the equivalence. We do not need any more figures: we have all the network elements we need. For Fig. 3, for example

$$v_1 = v_2$$
$$F_1 = m\,dv_2/dt + F_2$$

and for Fig. 6(a)

$$V_1 = V_2$$
$$I_1 = C\,dV/dt + I_2$$

In this set of equivalents, then, the mass is no longer the series inductance: it is a shunt capacitance.

The restoring spring of Fig. 7(b) gives us

$$v_1 = v_2$$

$$F_1 = k\int v_2 dt + F_2, \text{ or}$$

$$\frac{dF_1}{dt} = kv_2 + \frac{dF_2}{dt}.$$

This is the equation, in equivalent terms, for the shunt inductance of Fig. 12

$$V_1 = V_2$$

$$\frac{dI_1}{dt} = \frac{V}{L} + \frac{dI_2}{dt}$$

The spring has become a shunt inductance, and the relationship is that $L \propto 1/k$. For the spring of Fig. 5(a)

$$v_1 = v_2 + \frac{1}{k}\frac{dF_2}{dt}$$

$$F_1 = \qquad F_2$$

This we compare with

$$V_1 = V_2 + L\,dI_2/dt$$

$$I_1 = \qquad I_2$$

which are the equations for the series inductance in Fig. 4. Again L and $1/k$ appear as equivalents. We are left with Fig. 6(b) and Fig. 14. I propose to take it for granted that C turns into $m/4$.

Some readers may have recognized that this treatment has led us to a set of dual circuits. Duality is a topic which is always of academic importance but which has ups and downs in its value to the practical man. When the triode valve was the normal active element in circuits we did our sums with amplification factor and anode impedance. The valve became a Thevenin generator. When the pentode became the common device we threw out the anode impedance as being too high to worry about, and used mutual conductance. This brought us to Norton's dual form of Thevenin's Theorem. It was not always the right thing to do: the "starved amplifier" turned out to be working in a region where the amplification factor and the impedance mattered. Two valves with the same mutual conductance could reach that figure by two different paths, and would be quite different when used in starved circuits, even though the quoted mutual conductance characteristics were the same.

The point contact transistor brought duality in in a big way. Twenty years ago we were all hard at work converting our valve circuits into complete duals for use with transistors. The junction transistor turned up to put a stop to that, but brought us back to the high impedance current generator. Again there have been strongly partisan descriptions of one or other of the electric circuit duals, node or mesh analysis, for example, but on balance they always seem to boil down to a statement that "my system is simpler for the kind of circuit I work with". The alternative is "I'm used to doing it this way". Neither of these is a guarantee of absolute truth.

Returning to mechanical equivalents, an interesting form is the simple bar. If you hit one end of a steel bar you get a clear bell-like tone, like the voice of a Noel Coward heroine. If you consider the usual infinitesimal sections of tiny masses coupled by tiny springs you see the electrical equivalent is a transmission line, and you can find its characteristic impedance and propagation constant. There is a whole mass of material on transmission line filters which can thus be translated directly into mechanical terms. Typical structures consist of alternating sections of different characteristic impedances, which means different rod diameters. It is possible, and I am not sure of the actual application position, to make a complete multi-section i.f. filter on the lathe.

One of the most exciting developments of the mechanical analogue studies arose from the problems of the transducer and the choice of dual. A magnetic type of transducer produces a force proportional to current and in its ideal form gives us:

$$F = \mu I$$

$$v = 1/\mu\, V.$$

These equations will need to be rearranged in a moment. An electrostatic transducer, and this includes the piezoelectric devices, gives us

$$F = \mu_1 V$$

$$v = \frac{1}{\mu_1} I$$

Let us rearrange the first set of equations:

$$V_1 = \mu v_2$$

$$I_1 = 1/\mu\, F_2$$

and assume that F_2 and v_2 are applied directly to the electrostatic transducer. Then we substitute for F and v to get

$$V_1 = \frac{\mu}{\mu_1} I_2$$

$$I_1 = \frac{\mu_1}{\mu} V_2.$$

The transducers are assumed to be ideal. Real transducers have mass, and resistance, and are not infinitely stiff, so we get inductance and resistance and capacitance in the network. We are accustomed to the idea of sorting out the properties of the ideal element, however, and here is a system which, in ideal form in a black box, has electrical properties that, one might say, never were on land or sea.

On sea, especially, there was, in the long distant days when this was first noted, a mechanical system with just the equivalent properties. If a torque is applied to a gyroscope the axis moves with an angular velocity proportional to the torque. You need to support the whole thing in such a way that you can take off two shafts, but the equations are:

$$T_1 = g\,\dot{\theta}_2$$

$$\dot{\theta}_1 = \frac{1}{g} T_2$$

in which T is the torque for the two shafts and

$\dot{\theta} = d\theta/dt$, the angular velocity.

The black box with the crystal pickup driven by a moving-coil loudspeaker inside is, or would be if it were perfect, the electrical equivalent of the gyroscope in a mechanical system. This was all pulled into shape by Tellegen, who studied the implications of this system as a circuit element. He gave it a name, too, calling it a gyrator. It looks simple, but it was a tremendous step to announce that after so many years of the theory of passive networks there was an additional theoretical element. Later, either Tellegen or Avrell showed that with L, C, R, the transformer and the gyrator, the set was complete. There is not another one waiting to be found, named, studied.

One feature of the gyrator is that it throws the Reciprocity Theorem out of the window, though not out of the books. With no gyrators in a circuit you know that if a signal will go through it from left to right it will go equally well from right to left. This only applies, of course, to linear passive networks. With gyrators in the circuit this is no longer true.

An immediate result was to clean up a rather untidy situation in a theoretical area where lumped circuit theoreticians had rather come to grief. If you transmit a signal by way of the ionosphere you find that in some conditions the signal will reach a distant station, but that their signal at the same frequency will not reach you. Working away with Maxwell's equations and the equations for free electrons in a magnetic field this is perfectly resonable. To a circuit man, with two pairs of aerial terminals and some passive system in between, it seemed agin nature. The clue lies in those electrons, spinning in small circles. The gyro-coupling in the ionosphere provides the essential circuit element for making the transmission path non-reciprocal.

Here, in turn, is the key to the practical passive gyrator. We can put a lump of condensed ionosphere into a circuit. We do not, of course, bring down real ionosphere with specially built rockets. We use ferrites: the spin associated with the magnetic characteristic of a ferrite provides us with the gyro-coupling we need to produce gyrator behaviour in a waveguide at microwave frequencies.

It may appear that Roman aqueducts have nothing to do with microwave equipment but yet, as we have seen in this article, there is a continuous line of reasoning from the water flowing in pipes which we are given as an analogue of a direct-current circuit through to the gyrator used to sort out whether the signals are coming or going.

Pneumatic and hydraulic systems can equally well be treated, at a low level, in terms of electrical equivalents, and vice versa. At a low level, only, because we find that these are not really linear in normal working situations. A diode pump is not the same as a bicycle pump, because the rise in air temperature cannot be described in terms of simple circuit resistances. You can still get a good idea of what is happening, for example why you have a water hammer in your home plumbing, but it is not wise to rely too closely on the calculated results. The solution is qualitative, not quantitative. For engineers who want to understand designs in another discipline analogues are fine: a heating problem becomes just a matter of voltages (temperatures) and currents (heat) in a network of capacitances (thermal storage) and resistances (heat loss). If you do want to design a silencer for your car you may prefer to think of it as a low-pass filter—with some *m*-sections if you like—before you take up the tin-snips.

Remember, always, that though analogues are useful, they are only models, and it is quite a step from piloting your radio-controlled boat on the Round Pond to commanding the *Q.E.2*. You get worse pay in Kensington Gardens.

May Meetings

LONDON

11th. I.E.E.—"Electronic measurement in the automobile industry" by M. H. Westbrook at 17.30 at Savoy Pl., W.C.2.

12th. Soc. Relay Eng.—"Problems associated with transmission, reception and distribution at u.h.f." at 14.15 at the I.E.E., Savoy Pl., W.C.2.

13th. I.E.E.—"Colour recording media" by David F. Attenborough and J. Redmond at 17.30 at Savoy Pl., W.C.2.

13th. S.E.R.T.—"Closed circuit educational television" by E. Wykes at 19.00 at the Educational Television Centre, Tennyson St., S.W.8.

14th. I.E.R.E.—"Optimum electronic module size for a cost-effective repair policy" by T. G. Sanders and D. J. Taylor at 18.00 at 9 Bedford Sq., W.C.1.

18th. I.E.E.—"Avalanche diodes—normal and subnormal" at 11.00 at Savoy Pl., W.C.2.

27th. I.E.E./I.E.R.E.—Discussion on "Electronic circuits for medical instrumentation" at 14.00 at Savoy Pl., W.C.2.

BIRMINGHAM

13th. R.T.S.—"The introduction of colour to ITV programming" by Stuart Sansom at 19.00 at ATV Centre, Bridge St., 1.

BRIGHTON

12th. I.E.E. Grads.—"Thick film micro-electronics" by P. G. Barnwell at 18.30 at Brighton College of Technology, Moulescoomb.

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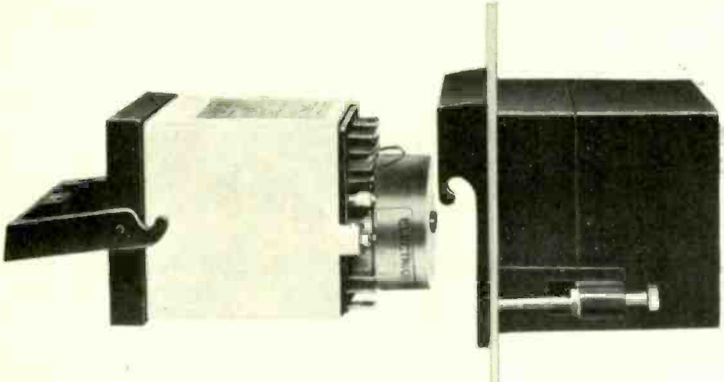

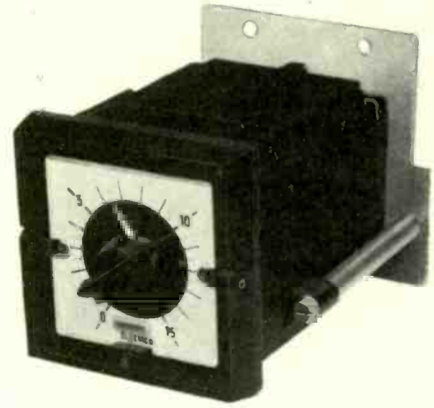

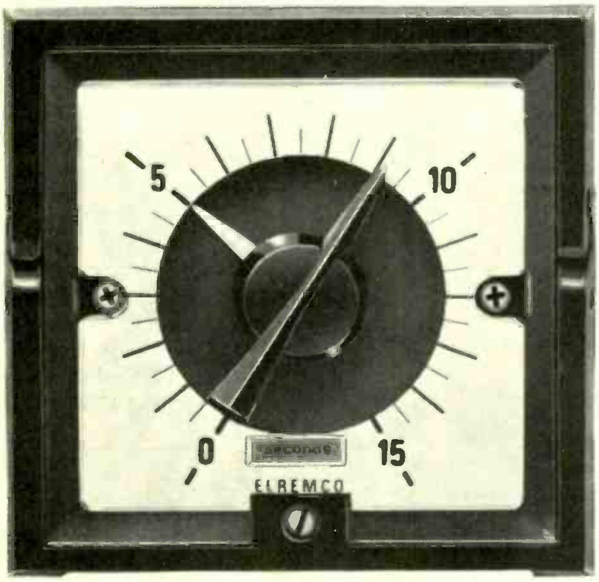

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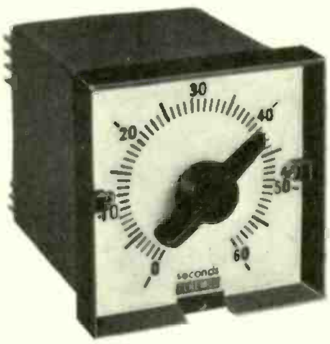

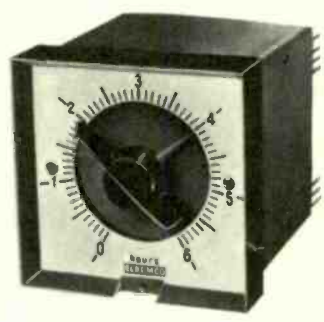

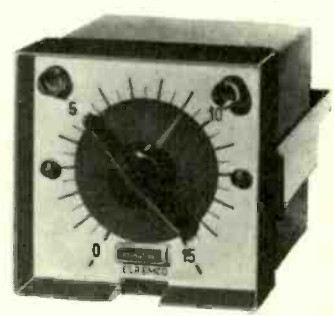

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Active Filters

10. Uses of the parallel-T network

by F. E. J. Girling and E. F. Good**

The balanced parallel-T network offers convenience and versatility, and makes less demand on amplifier gain than the two-lag loop and related circuits. It is, however, sensitive to errors that cause unbalance in the two tees, increasingly so as the Q factor is raised. It is most useful, therefore, in circuits of moderate Q in which economy in amplifier gain and in number of amplifiers is desired.

In principle the Q factor of a parallel-tee network can be increased in direct proportion to the available loop gain, Part 4, equn. (32). This is apparently a much more powerful law than the square-root relationship that applies to the two-lag loop and related circuits. The potential performance can, however, be exploited only to a degree depending on how closely equal the time constants of the two tees can be held, since the effects of any inequality increase as the required Q factor increases. Nevertheless, parallel-T circuits may be considered a practical possibility for moderate Q factors (say from 2 to 10), and may on occasion be preferred because of the economy in amplifier gain.

The particular arrangement of active parallel-T filter to which most attention is given in this article (Fig. 10(b)) is one which the present authors have found useful from time to time, and one which is easily adapted to give any 2nd-order transfer function. It can therefore be used to build higher-order filters by the method of synthesis by factors.

The parallel-T network

The basic characteristics of the balanced parallel-T network were discussed in Part 3. Its special feature is that at a certain frequency it gives zero transmission; and the necessary condition for the existence of the zero is that the short-circuited-output time constants of the two tees should be equal. Thus in Fig. 1(a) C_2 multiplied by the resistance of R' and R'' in parallel must equal R_2 multiplied by the sum of C' and C''; i.e. for a zero

$$T_2 = T_2' \qquad (1)$$

where $$T_2 = \frac{C_2 R' R''}{R'+R''} \qquad (2)$$

and $$T_2' = (C'+C'')R_2. \qquad (3)$$

(See the analysis given next month.)

*Royal Radar Establishment.

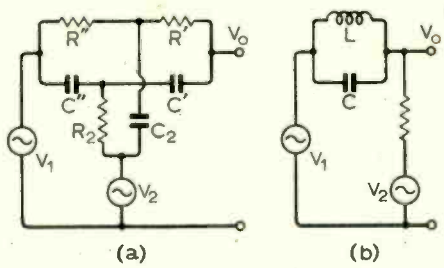


Fig. 1. (a) Parallel-T network. (b) LCR network giving symmetrical notch response.

If now T_1 is the time constant of the mesh formed by the upper four components when the lower two are removed, i.e.

$$T_1 = \frac{C'C''(R'+R'')}{C'+C''}, \qquad (4)$$

the transfer function for the input V_1 may be written

$$\frac{V_0}{V_1} = \frac{1+p^2T^2}{1+pT/q_0+p^2T^2} \qquad (5)$$

and for V_2 (see Fig. 21, Part 3)

$$\frac{V_0}{V_2} = 1-\frac{V_0}{V_1} = \frac{pT/q_0}{1+pT/q_0+p^2T^2} \qquad (6)$$

where $T^2 = T_1T_2$. These transfer functions are of the same form as those for the *LCR* network of Fig. 1(b), though, of course, for the *CR* network $q_0 \leq \frac{1}{2}$; but there the similarity between the two networks ends,

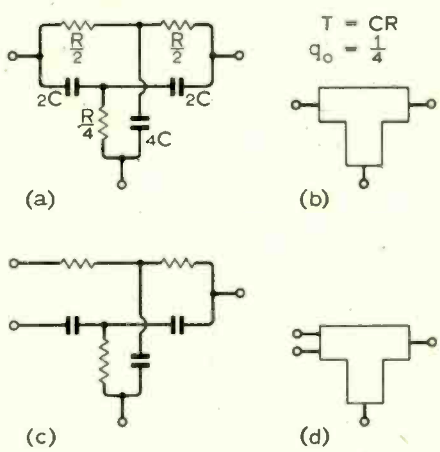


Fig. 2. (a) Balanced parallel-T network with the most commonly used set of relative values. (b) Shorthand representation of the same. (c) and (d) balanced parallel-T network with split inputs.

since there is no direct correspondence between the currents or the internal voltages.

As shown in Part 3, $q_0 \to \frac{1}{2}$ only when $T_1 = T_2$ and both R''/R' and $C'/C'' \to 0$; and it is usual to accept a lower value in exchange for the convenience of using sets of components with more equal values. Thus in most of what follows $R' = R''$ and $C' = C''$. The maximum value of q_0, obtained when $T_1 = T_2$, is then

$$q_0 = \frac{1}{4}. \qquad (7)$$

This set of relative component values is shown in Fig. 2(a) and will be represented when convenient in the shorthand form shown in Fig. 2(b).

A practical problem in using the parallel-tee network is finding from the standard ranges of values sets of components which give balance (i.e. a null) at, within allowable tolerance, the required frequency; and some suggestions made at the end of the article (next month) may be of help.

The parallel-T network with gain and feedback

As shown in Part 4 the Q factor of an (accurately balanced) parallel-tee network is magnified according to the relationship

$$q = (A+1)q_0 \simeq Aq_0 \qquad (8)$$

This result is most easily obtained by considering a system with 100% feedback, Fig. 3, in which the input voltage is applied

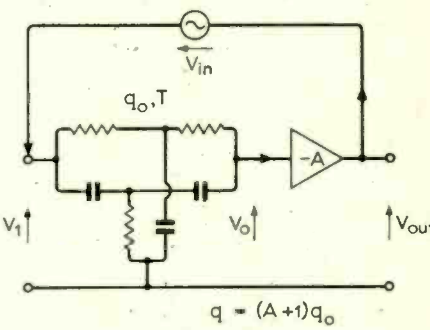


Fig. 3. Feedback loop containing parallel-T network.

in series with the output voltage. This gives

$$V_1 = V_{out} + V_{in} \qquad (9)$$

$$V_0 = -V_{out}/A, \qquad (10)$$

whence by substitution from equn. (5)

$$\frac{V_{out}}{V_{in}} = -\frac{A}{A+1}\cdot\frac{1+p^2T^2}{1+pT/q+p^2T^2} \qquad (11)$$

with q as given by equn. (8).

Theory of circuits with ideal amplifiers

Practical circuits must be arranged so that the input voltage can be applied with one side grounded, and in addition it should be possible to enter the circuit at different places so that a variety of 2nd-order responses can be obtained, l-p, b-p (tuned-circuit), etc. To obtain accurate values of Q factor (and to ensure low output impedance) the effective value of A should be stabilised by feedback; and, as usual, the easiest and most effective approach to all these problems is by considering idealised arrangements using amplifiers which are assumed to have infinite internal gain.

A convenient starting point is the circuit arrangement shown in Fig. 4(a), in which the rejection characteristic of the parallel-T

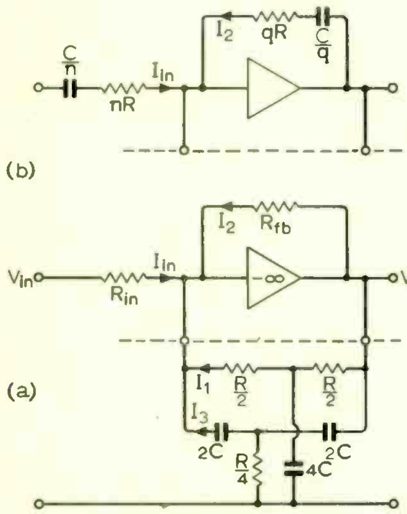


Fig. 4. (a) virtual-earth arrangement of parallel-T feedback circuit with resistance ratio arms. (b) The same with CR ratio arms with time constants matched to the tees.

network is employed in a feedback path to give the arrangement an approximate tuned-circuit response. At the rejection frequency of the network there is no feedback via this path, and (with $A = \infty$) $V_{out}/V_{in} = -R_{fb}/R_{in}$. At high frequencies the feedback network approximates to a single capacitor of value C, which in conjunction with R_{in} causes the amplitude response $|G(\omega)|$ to fall indefinitely as frequency increases. At low frequencies, however, the combined feedback network becomes equivalent to a single resistor (R in parallel with R_{fb}), and so $|G(\omega)|$ falls to a constant value. Less obviously, the maximum in the amplitude response is not at the null of the parallel-tee network (Ref. 1).

A simple modification to obtain exact tuned-circuit response was invented by S. W. Noble and F. C. Williams at the Telecommunications Research Establishment during the last war (Ref. 2). It still does not seem to be widely known. The purely resistive branches, R_{fb} and R_{in}, are replaced by CR branches with time constants equal o the time constant ($T_2 = T_2'$) of the tees, i.e. the time constant that appears in the denominators of the expressions for the short-circuit output currents, equns. (42) and (44). This is shown in Fig. 4(b). The magnitudes of the impedances of these branches can (in principle) have any values as long as the CR products equal T_2 (which $= T$ when $T_1 = T_2 = T = 1/\omega_0$, as for the circuit shown). By inspection:

$$I_1 = \frac{V_{out}}{R} \times \frac{1}{1+pT} \qquad (12)$$

$$I_2 = \frac{V_{out}}{qR} \times \frac{pT}{1+pT} \qquad (13)$$

$$I_3 = \frac{V_{out}}{R} \times \frac{p^2T^2}{1+pT} \qquad (14)$$

$$I_{in} = \frac{V_{in}}{nR} \times \frac{pT}{1+pT} \qquad (15)$$

and hence

$$V_{out}(1+pT/q+p^2T^2) = -V_{in}pT/n \quad (16)$$

i.e. $$\frac{V_{out}}{V_{in}} = -\frac{1}{n} \cdot \frac{pT}{1+pT/q+p^2T^2} \qquad (17)$$

So true tuned-circuit response is obtained with Q factor $= q$. If $n = 1$ the gain at resonance is q; if $n = q$ the whole curve is depressed so that at the peak $V_{out} = V_{in}$.

Putting $p = j\omega$ turns the numerators of the transfer functions of equns. (12) to (14) into 1, $j\omega T$, $(j\omega T)^2$. Hence, since the denominators are alike, the feedback currents, I_1, I_2, and I_3, have successive constant phase differences of 90°. At the null frequency I_1 and I_3 are equal in magnitude as well as opposite in phase. Consequently, since the sum of the currents converging on the virtual earth must be zero,† I_{in} and I_2 must also be equal and opposite. It follows therefore that at the null frequency of the parallel-tee network, which is also the peak or resonant frequency, the vectors representing the four currents form a figure with four right angles, Fig. 5, and for the relative

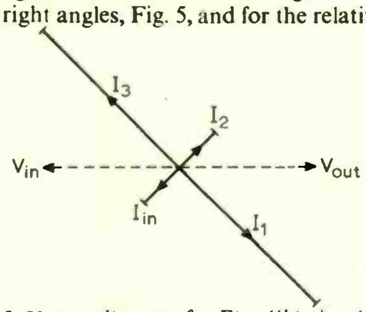


Fig. 5. Vector diagram for Fig. 4(b) showing relative phases of voltages and currents at ω_0, the null frequency of the parallel-T network.

component values of Figs. 2(a) and 4(b) the currents are at 45° and 135° to V_{in} and V_{out}.

For the arrangement without the additional Cs. Fig. 4(a), I_{in} and I_{out} are in phase with V_{in} and V_{out}, and so not in quadrature with I_1 and I_3. The independence of tuning and damping is then lost, and the behaviour of the circuit is more complex.

Any arrangement which gives the same flow of currents to the virtual earth gives the same response. Hence a considerable number of variations of the circuit are possible, and a selection are shown in Fig. 6. At (a) the number of capacitances is reduced by amalgamating those of the input and damping arms. At (b) one of the tees is made to serve also as the input arm (either or both tees may be so used); and at (c) the damping arm is eliminated by feeding to the bottom of one of the tees a fraction of V_{out}. It is necessary, of course, that in all variations the effective Ts (time constants) of the current paths are unaltered. This means, for example, since V_{in} represents an effectively zero-impedance source, that sometimes when V_{in} is introduced into a branch carrying relatively heavy current a buffer amplifier of low output impedance is needed.

Effect on Q factor of unbalance in the tees

Suppose the capacitance which ideally has

† This is true when $A \to \infty$, even when the input impendance of the amplifier is not infinite, since zero voltage drives zero current through a finite impedance.

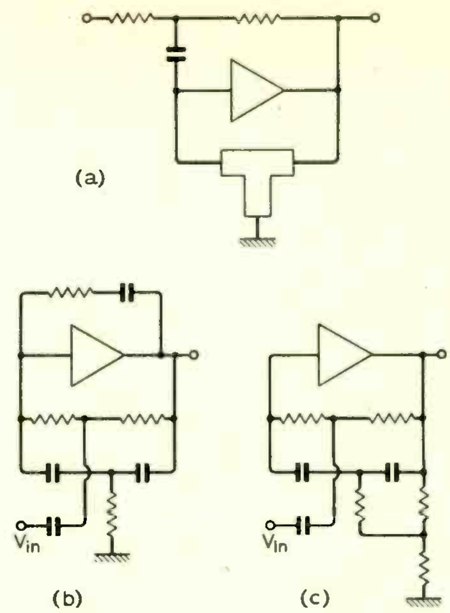


Fig. 6. Some alternative methods of applying damping.

the value $4C$ (Fig. 4) is slightly increased. Then at the frequency ω_0 which was the frequency of balance the magnitude of I_1 is slightly reduced and the phase angle it makes with V_{out} is slightly increased. At a certain slightly lower frequency the phase angle of I_1 will move back by an amount equal to about half the increase just mentioned and the phase angle of I_3 will move forward to give a figure as shown in Fig. 7. I_1 and I_3 are again equal in magnitude, and have a resultant OP which is in phase with I_{in} (Fig. 5).

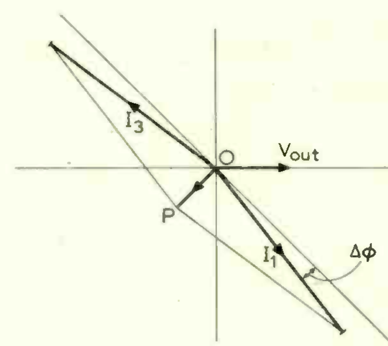


Fig. 7. Phase-angle relationships when $T_2 > T_2'$.

If at the frequency $\omega_c = 1/T$ the time constant of a simple-lag network is increased by a small fraction x, the increase in phase angle is $x/2$ radians. Hence in Fig. 7 $\Delta\phi = x/4$ radians and the length of OP (if $I_1 = I_2$ lengths $= 1$) is $x/2$.

Since OP is in phase with I_{in}, for constant I_2 (and hence for constant V_{out}) a smaller I_{in} is required. Hence at this frequency, ω_0 approx., the gain of the system is increased. At frequencies well removed from ω_0, where there was already a considerable unbalance between I_1 and I_3, the unbalance is not significantly altered. Hence it is only near the peak of the response that the gain of the system is increased, and the increase can be expressed as an increase in Q factor. Therefore, since with ideal values $|I_{in}|/|I_1| = 1/q_i$, the increase in the time constant of the low-pass tee has effectively increased the Q

factor according to the equation

$$\frac{1}{q} = \frac{1}{q_i} - \frac{x}{2} \qquad (18)$$

$$= \frac{1}{q_i}\left(1 - \frac{q_i x}{2}\right). \qquad (19)$$

This shows that when $q_i > 2$ the fractional change in Q factor is $>x$, and that if $x \to 2/q_i$, $q \to \infty$.

Similarly if the value of the resistance of the high-pass tee (nominally $R/4$) is reduced by a fraction x, the same change in q is found, though the frequency of the peak moves upwards. And in the same way the effect of changes in the horizontal elements of the tees can be estimated. In general if $T_2 > T_2'$ [see equns. (2) and (3)] q is increased: if $T_2 < T_2'$, q is reduced. The change in the frequency of the peak depends both on the change in short-circuit time constant and on whether T_1 [equn. (4)] is changed.

A fractional change in only one of the horizontal elements has only half the effect on T_2 or T_2' as the same fractional change in the vertical elements (when the two horizontal elements are approximately equal), and therefore the q sensitivity to changes in only one horizontal element is also only half as great.

Series feedback

Consider the circuit arrangement shown in Fig. 8(a). For the input V_{in}' applied between terminals 1 and 2, this is the same as that already considered except that the damping arm is missing (the amplifier is shown as a valve, as in Part 6, in order to make clear graphically the steps which follow).* Consequently if $A = \infty$ the response shows infinite q and infinite gain at the tuned frequency, i.e.

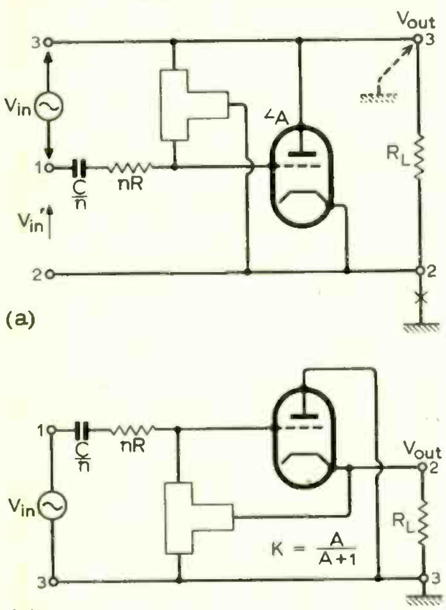


Fig. 8. (a) Series-feedback arrangement of parallel-T feedback circuit; (b) the same with changed earth point.

$$G(p) = \frac{V_{out}}{V_{in}'} = -\frac{1}{n}\cdot\frac{pT}{1+p^2T^2} \qquad (20)$$

*Also we neglect practical points such as correct biasing and the position of the h.t. battery.

To add 100% feedback we must include the whole of the output voltage in series with the input, and this is done by applying the input, V_{in}, between terminals 1 and 3. The gain found in equn. (20) is now the forward gain μ, and as $\beta = 1$, Black's formula reduces to $G = 1/(1-1/\mu)$, and the gain with the loop closed becomes

$$\frac{V_{out}}{V_{in}} = -\frac{pT}{n\left(1+\frac{1}{n}pT+p^2T^2\right)} \qquad (21)$$

Thus the series feedback connection has produced a response with $q = n$, a result which might have been expected since the input branch is now in a feedback path and takes the place of the damping branch of the previous circuit arrangement.

Now that the anode (node 3) is common to input and output it is convenient to have this point earthed (as indicated by the arrowhead), after breaking the original earth connection at ×. Fig. 8(b) is the same circuit redrawn with the earth line conventionally at the bottom, and shows that the valve is now connected as a cathode follower. It follows (or see Part 6) that an amplifier with gain $-A$ in Fig 8(a) converts to a cathode follower with gain $K = A/(A+1)$ in Fig. 8(b), and that $K \to 1$ only as $A \to \infty$. It is important to remember this when considering the effect of finite gain. Because the output terminals have been inverted, the minus sign is removed from equn. (21) for Fig. 8(b).

It does not require much practice to be able to make the step from one of these types of circuit to the other without drawing in a representative three-terminal amplifier as has been done above. For example, with the parallel-tee in the forward path, Fig. 9(a), and with $A \to \infty$,

$$\mu = -\frac{n(1+p^2T^2)}{pT} \qquad (22)$$

and hence

$$\frac{V_{out}}{V_{in}} = -\frac{1+p^2T^2}{1+\frac{1}{n}pT+p^2T^2}, \qquad (23)$$

which is symmetrical notch response with $q = n$. And the corresponding circuit, arranged in the "cathode-follower" configuration with node 3 earthed, is readily redrawn as in Fig. 9(b).

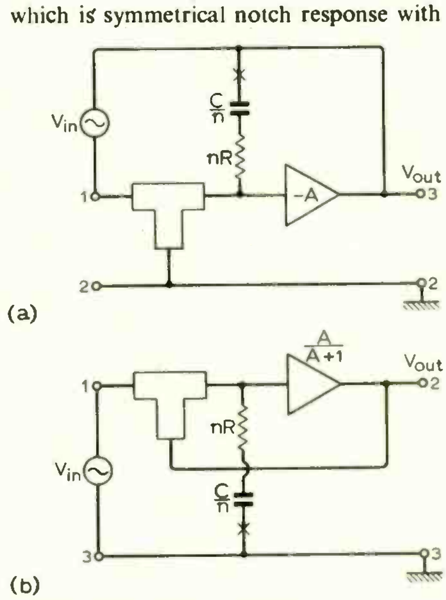


Fig. 9. Series-feedback circuits for symmetrical notch response.

The effect of finite gain

Looking again at Fig. 9(a), it is clear that removing the damping arm, by breaking the circuit at ×, will give $q = \infty$ when $A = \infty$. But now the circuit is identical to that shown in Fig. 3, so with A finite q will be as given by equn. (8). This value of q may be identified with a residual value q_r (the value obtained when all intentional damping is removed and the Q factor is limited only by the value of A). Thus we may write

$$q_r = (A+1)\,q_0 \simeq Aq_0 \qquad (24)$$

From the rule that, since losses add, qs add as their reciprocals, it follows that q with A finite will be given by

$$\frac{1}{q} = \frac{1}{n} + \frac{1}{q_r} \simeq \frac{1}{n} + \frac{1}{Aq_0}; \qquad (25)$$

that is to say: the actual loss factor is the sum of the ideal loss factor (the loss factor calculated on the assumption of infinite gain) and the residual loss factor,

$$\frac{1}{q} = \frac{1}{q_i} + \frac{1}{Aq_0}. \qquad (26)$$

When the parallel-tee network has the usual set of values (Fig. 2) $q_0 = \frac{1}{4}$ and hence

$$\frac{1}{q} = \frac{1}{q_i} + \frac{4}{A}. \qquad (27)$$

This result should be compared with the comparable result for the ordinary Sallen-and-Key circuit [Part 6, equn. (8), with $b = \frac{1}{2}$],

$$\frac{1}{q} = \frac{1}{q_i} + \frac{2q_i}{A}. \qquad (28)$$

Only when $q_i > 2$ does the parallel-tee filter show an advantage in performance, although there may be other reasons for choosing it. However, with increasing q_i the advantage grows rapidly. The residual loss factor $4/A$ in equn. (27) may, indeed, be compared with the residual loss factor $2/A$ for the two-integrator loop—but only so far as the accuracy of balance of the parallel-tee network allows.

In the virtual-earth or shunt-feedback arrangement of the circuit the presence of both input and feedback arms causes some loss of effective internal gain. This does not show in the ideal design equations as they are based on $A = \infty$. For Fig. 4(b) with the amplifier gain set at $-A$, and writing q_i instead of q,

$$\frac{V_{out}}{V_{in}} = -\frac{A}{n(A+1)} \times \frac{pT}{1+\left\{\frac{1}{A+1}\left(4+\frac{1}{n}\right)+\frac{1}{q_i}\right\}pT+p^2T^2} \qquad (29)$$

which shows that

$$\frac{1}{q} \simeq \frac{1}{q_i} + \frac{4}{A}\left(1+\frac{1}{4n}\right). \qquad (30)$$

Equn. (29) also confirms several results already derived: finite A leaves the response of the correct form; the resonant frequency is unaltered; and for $n \gg 1$, $q_{max} = A/4$ approx.

"Universal" 2nd-order filter

With the above particular examples in mind, it is not difficult to take the next step to the general situation shown in Fig. 10(a),

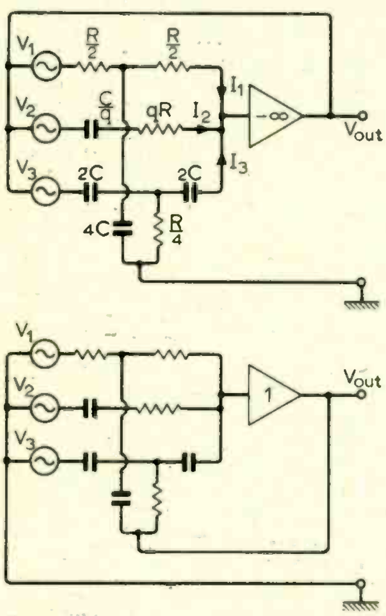


Fig. 10. Circuit of "universal" 2nd-order filter: (a) with amplifier in high-gain, sign-reversing mode; (b) with amplifier in voltage-follower mode.

in which a separate series feedback connection is made for each of the three branches. Assuming $A \to \infty$, the currents I_1, I_2 and I_3 are now given by

$$I_1 = \frac{(V_{out}+V_1)}{R} \times \frac{1}{1+pT} \qquad (31)$$

$$I_2 = \frac{(V_{out}+V_2)}{qR} \times \frac{pT}{1+pT} \qquad (32)$$

$$I_3 = \frac{(V_{out}+V_3)}{R} \times \frac{p^2T^2}{1+pT} \qquad (33)$$

and since $I_1+I_2+I_3 = 0$

$$V_{out} = -\frac{V_1 + \frac{V_2 pT}{q} + V_3 p^2 T^2}{1 + \frac{pT}{q} + p^2T^2} \qquad (34)$$

Moving the earth point in the now familiar way leads to the practical arrangement Fig. 10(b), in which each of the three generators has one side earthed (and for which, because the other output terminal is now earthed, the minus sign is removed from equn. (34)).

The two examples already considered are covered by making $V_2 = V_{in}$, $V_1 = V_3 = 0$ for tuned circuit response, and $V_1 = V_3 = V_{in}$, $V_2 = 0$ for the symmetrical notch. [Note: putting a particular generator voltage = 0 is equivalent to replacing it by a short circuit.]

Unsymmetrical notch response

$V_1 = V_{in}$, $V_2 = 0$, $V_3 = aV_{in}$ $(a<1)$, Fig. 11(a), gives the low-pass unsymmetrical notch. Making V_1 a fraction of V_{in} ($V_1 = aV_{in}$, $V_3 = V_{in}$) gives the corresponding high-pass response. In this case it is possible, as shown in Fig. 11(b), to obtain the required fraction of the input voltage by using a

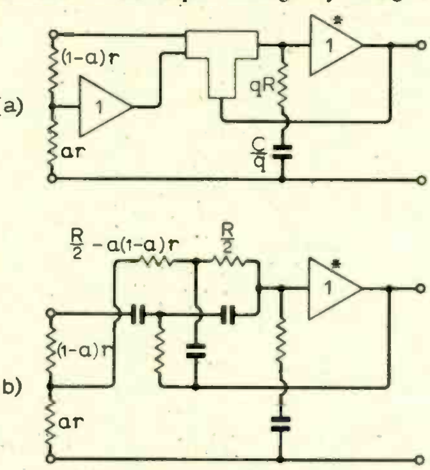


Fig. 11. Circuits for unsymmetrical notch response: (a) low-pass type; (b) high-pass type. The asterisk marks the amplifier whose high internal gain and high input impedance is important to obtaining the desired Q factor.

simple potential divider. Apart from the potentiality for higher Q factors compared with the circuits offered in Part 6, there is also the useful feature that q may be adjusted independently of T. Applications to higher-order filters are similar to those suggested in Part 9.

Simple low-pass and high-pass

$V_1 = V_{in}$, $V_2 = V_3 = 0$, Fig. 12(a) gives simple (i.e. all-pole) low-pass response, and $V_3 = V_{in}$, $V_1 = V_2 = 0$, Fig. 12(b), gives

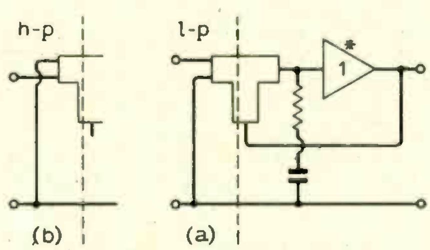


Fig. 12. Circuits for simple low-pass and high-pass response.

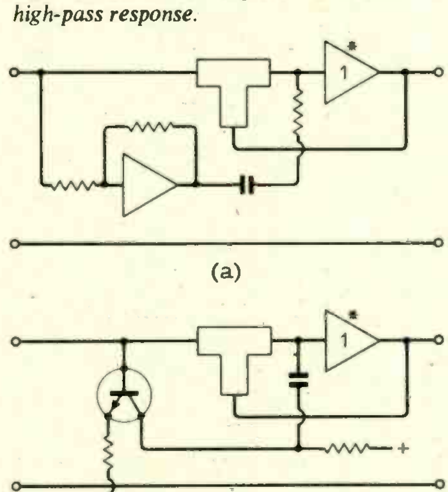


Fig. 13. Circuits for all-pass response—(b) shows possible economical alternative to (a).

high-pass. These circuits have a somewhat strange appearance in this simple role. This is because we know that two capacitances are in principle sufficient for simple 2nd-order response. It is worth remembering, however, that they retain the same potential for higher Q factor as the other circuits (for unexcited the circuit is unchanged and hence the natural motion, i.e. the decay of transients, is unaltered), and also that it is not necessary to increase the size of any C when q is increased. An obvious application is for the synthesis of the highest-q quadratic factor in a high order Butterworth series (see Part 9). There is also some attraction in a Butterworth filter composed entirely from these circuits, since the parallel-T networks are the same for every factor and only the values of the components in the damping branches differ (and even these can be alike if potential dividers are used, Fig. 14). There is no advantage in performance for the lower q factors however.

All-pass

If $-V_{in}$ is made available (by using an inverting amplifier) it is possible to set $V_1 = V_3 = V_{in}$, and $V_2 = -V_{in}$, Fig. 13. This gives the all-pass transfer ratio

$$\frac{V_{out}}{V_{in}} = \frac{1-pT/q+p^2T^2}{1+pT/q+p^2T^2},$$

which has a flat amplitude vs. frequency response with phase going from 0° to 360° as ω goes from 0 to ∞.

Variable q

If $V_2 = (1-x)\,V_{out}$, controlled by a potentiometer, Fig. 14, the q of any low-pass, high-pass or notch response can be con-

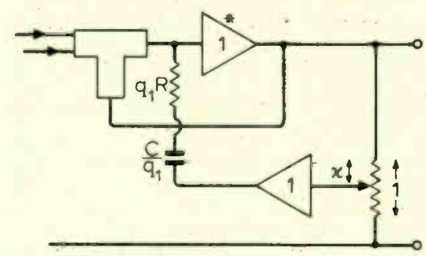


Fig. 14. Variable damping with a potentiometer.

tinuously varied. With $A = \infty$ (i.e. $K = 1$ exactly), $q = q_1/x$, where q_1 is the value of q set in with $x = 1$. With finite A, $x = 0$ gives $q \simeq q_r$.

References

1. "Network-Tuned Amplifiers with Variable Bandwidth", by R. J. Lamden. *Electronic Engineering*, Feb. 1963 (Vol. 35, pp. 109–112).
2. "Selective Amplifiers with Parallel-T Feedback", by E. F. Good. *Electronic Engineering*, May 1963 (Vol. 35, pp. 330–331, letter).

(The subject of the uses of the parallel-T network will be concluded in Part 11 next month. The article will deal with: variable tuning with constant bandwidth, third-order systems, an analysis of the parallel-T circuit, dependence of q_0 on the ratio T_1/T_2, and the eight-component parallel-T network.)

Aerospace Instrumentation

New devices for detecting and recording physical variables described at Cranfield symposium

by R. Gregory

A prominent feature of aerospace engineering for some years has been the increasing use of the digital computer. Considering, for example, that the cost of flight testing a new aircraft such as the Boeing 747 "jumbo jet" is over £8,000 per hour, it is easy to see the justification for computers—and they are in fact used not only for data processing but also to store calibrations, to present results in appropriate engineering units and even for "file keeping". Current techniques in this field were described at an international symposium on aerospace instrumentation held at the Cranfield Institute of Technology (formerly College of Aeronautics) from 23rd to 26th March. The symposium is a regular event and in the past has been jointly sponsored by Cranfield and the Instrument Society of America. On this occasion the Royal Aeronautical Society was also a sponsor.

Transducers

The use of digital information processing techniques implies the availability of data in digital form, but the transducer which will provide a pure digital output has yet to be conceived. A near approach to this has been a number of designs based upon change of resonant frequency of mechanical elements in sympathy with the measured parameter, thus giving an output in terms of frequency or period. A development of this was explained by members of the Kollsman Instrument Corporation. The company's long experience and detailed research into precision altimeters led them to the understanding that the limit of accuracy for an aneroid altimeter was within the instrumentation rather than in the aneroid capsule itself. From this they have developed an altimeter relying upon the change of mechanical resonance[1] of the capsule, Fig. 1, thus giving a change of natural frequency with pressure.

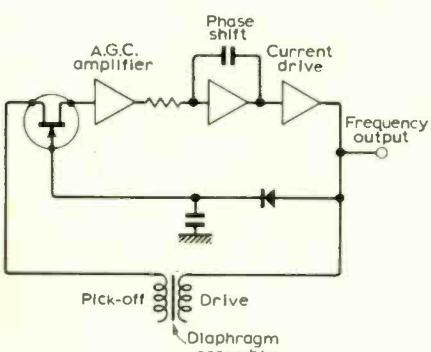


Fig.1. Basic structure of the vibrating capsule loop.

Advances in semiconductor technique have brought the semiconductor strain gauge forward to become a reliable and useful element in transducer design. There were a number of contributions on this subject and one, from the Kulite Corporation, explained how a 300 kHz response pressure transducer has been developed using silicon as the diaphragm material with the gauges diffused into this base material. Further developments of this type of transducer included putting signal conditioning circuitry into the diffusion. Ether Ltd presented a design for a low-range pressure transducer constructed in a similar manner but operating on magnoresistive principle (Ref. 1).

The force balance technique, Fig. 2, in transducers strives at reducing mechanical motion to a minimum. The input parameter is first sensed by a mechanical element, but the resulting motion of this element is resisted almost completely by an electro-mechanical forcing system. The electrical input to this system is the output of the transducer. Thus in an ideal transducer, no mechanical movement takes place. Modern designs take advantage of i.c. techniques for the necessary servo systems, and accelerometers yielding 0.1% accuracies over very wide environmental ranges are now readily available and are physically only about the size of a cigarette packet.

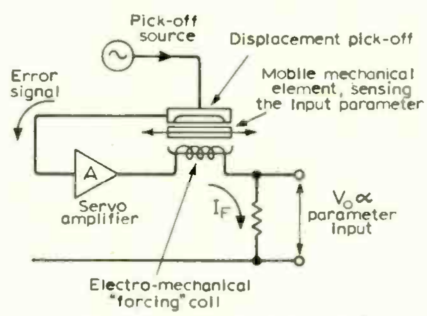


Fig.2. Sketch of a typical force-balance transducer system.

Three papers dealt specifically with force balance transducers. A N.A.S.A. paper explained a triaxial angular accelerometer involving three servo loops, Fig. 3. As with all accelerometers, the device relies upon a spring restrained mass, the mass in this case being a sphere suspended within a fluid-filled cavity. There is a servo loop to control the temperature of the fluid so that its density is always that of the sphere, another, an electrostatic forcing system, to keep the sphere centrally suspended, and the third, an electro-magnetic servo to force the sphere to zero rotational displacement during parameter inputs. A very typical side study of this transducer was the necessity to develop a special rate table for test purposes.

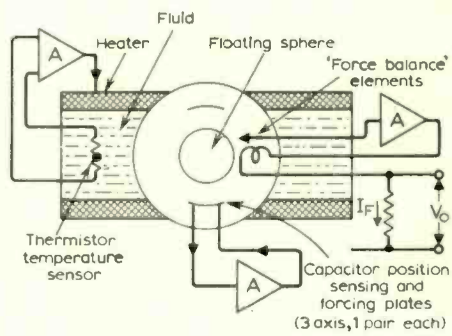


Fig.3. Triaxial accelerometer with three separate control loops.

Another paper from United Controls Corporation described a force balance multi-axis accelerometer system or "cluster" in which, by the use of cunning design, the effective centres of mass are all at a common point.

Progressing towards better reliability from the more conventional transducers, a paper from Vibrometer described how co-operation with European airlines, to develop vibration-measuring devices, resulted in a synthetic quartz accelerometer capable of operation at temperatures beyond 600°C. Endevco demonstrated their expertise in this field by exhibiting an accelerometer working

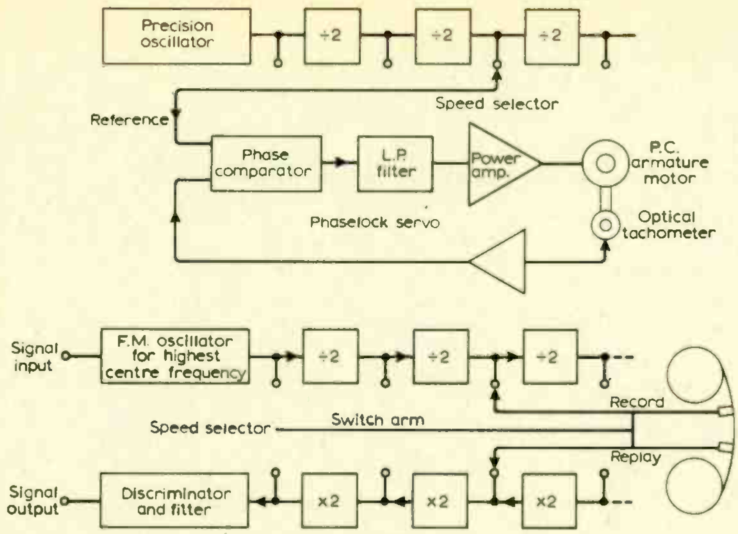


Fig.4. F.M. instrumentation recorder using "logic only" speed change.

within the flame of a blowlamp at some 630°C.

Tape recorders

Magnetic tape is likely to remain a major recording medium for many years to come. This opinion was substantiated by the nine tape recorder companies represented at the exhibition. Much of the R & D of the '50s and '60s was put to developing precise analogue recorders, but latterly greater interest has been shown in digital recording, not only for direct computer memory use, but also for recording digital data. This has changed many of the philosophies in transport design, particularly in the field of accident recorders where extremely simple transports suffice, some of them completely lacking fly wheels and belts and relying solely upon the speed control achieved from the use of an hysteresis motor.

A contribution from S.E. Laboratories gave a review of present precision instrumentation recorder design. Who would have thought a few years ago that the tape drive capstan would be mounted directly onto the motor shaft? Low inertia printed-circuit motors are being increasingly used with tight servo speed control, giving an overall response into the 200-300 Hz range; thus problems of wow and even flutter are becoming less of a design problem. Both analogue and logic i.cs are being used extensively. Tape speed change, for example, is now only a matter of electrical switching (Fig. 4)—there is no belt or pulley changing nor any filter or centre frequency changing, this all being accomplished by logic frequency division.

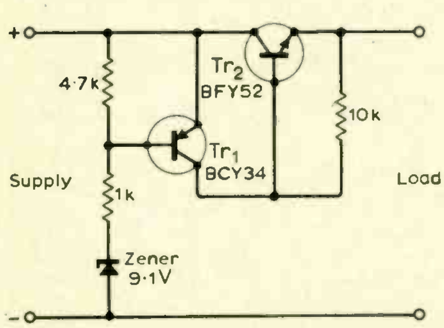
REFERENCE

"Magnetoresistance and its application", by B. E. Jones. *Wireless World*, Jan. 1970.

More Circuit Ideas *(see also page 206)*

Level-sensitive battery switch

Many present-day instruments are battery powered and not infrequently are inadvertently left switched on when not in use, resulting either in damage to the instrument through chemical leakage from Leclanche type cells or the destruction of the more expensive mercury or nickel-cadmium types. The circuit shows a method of automatically switching off when the battery voltage falls below a predetermined level. So long as the supply voltage is sufficient to cause the zener diode to conduct, transistors Tr_1 and Tr_2 are switched on and the instrument functions

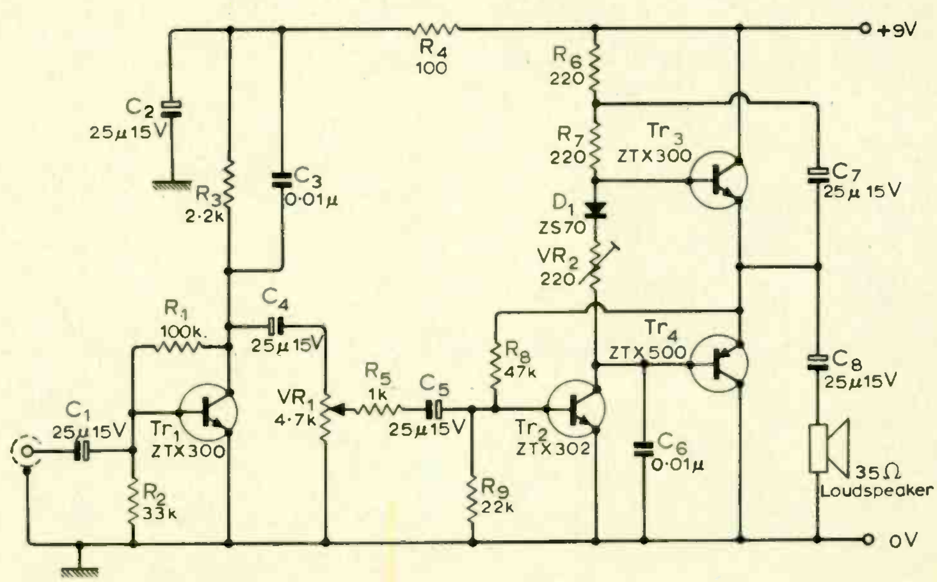


normally. Conversely, when the supply voltage drops below the diode breakdown level, Tr_1 and Tr_2 switch off. Transistor and diode leakage current still flows, but with good silicon types this will amount to only a few micro-amps which is insufficient to cause damage, except perhaps over a very prolonged period. The price paid for this protection, apart from the cost of the components, is the zener diode current and the voltage drop across Tr_2, which will be virtually constant provided it is bottomed. The circuit shown is suitable for a nominal 12V battery, and switches off when the voltage drops below 9V.

N. L. BOLLAND, Farnham Common, Bucks.

150mW General Purpose Audio Amplifier

The design given here is straightforward and is suitable for intercom and many other uses. Prior to switch-on VR_2 should be set to zero and then subsequently set to give 1mA quiescent current through Tr_3 and Tr_4. The input impedance is 850Ω and 2mV input is required for full output. This circuit was extracted from the Ferranti "E-Line Transistor Applications" handbook.



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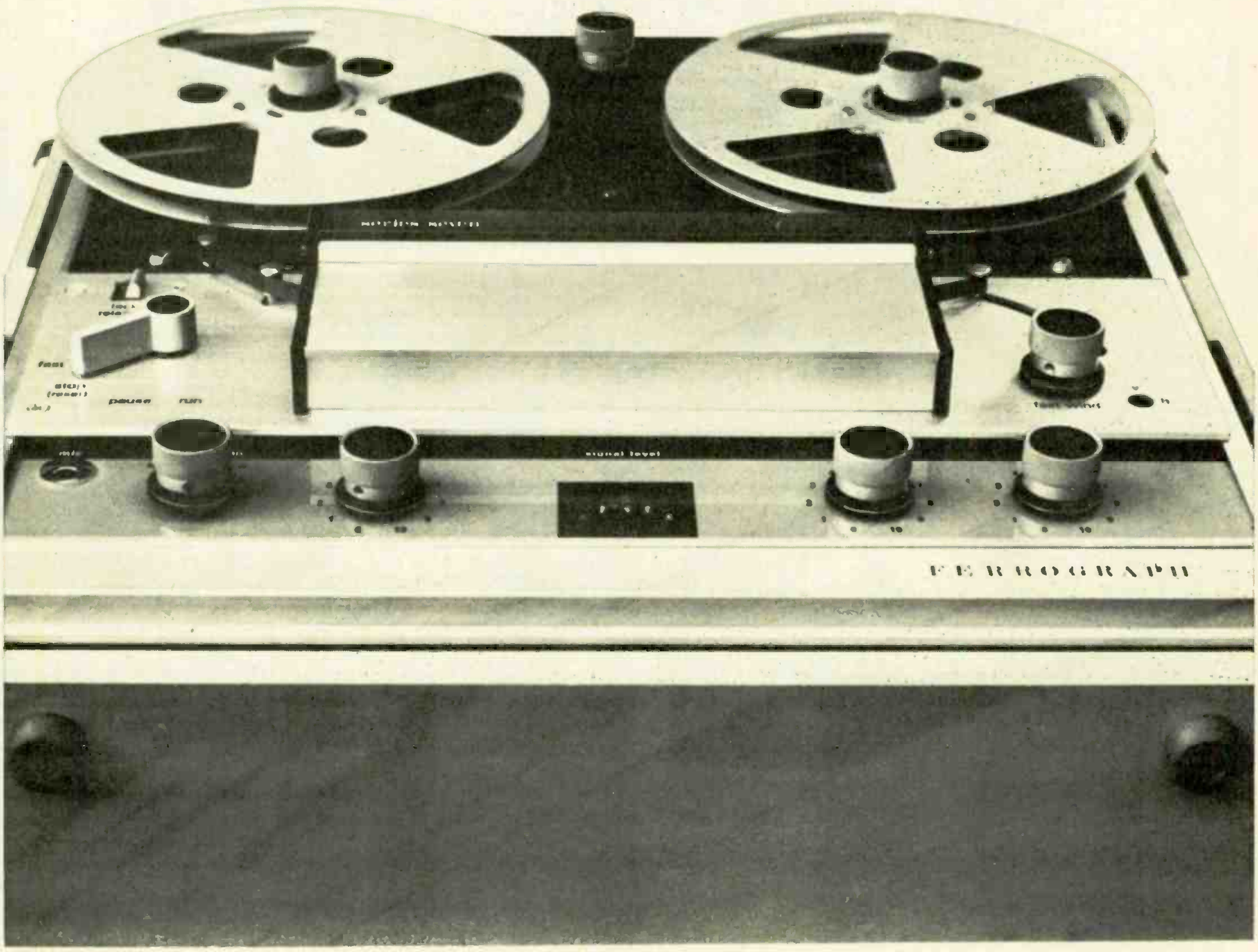


WW—102 FOR FURTHER DETAILS

20-MHz Counter Timer

The information given here was extracted from a Motorola application note

The functional blocks of the system are shown in Fig. 1. In the frequency mode of operation, the incoming signal is amplified or limited, as required. It is then conditioned by the pulse shaper in order to meet the constraints imposed by Motorola r.t.l. devices. The resulting pulse train, the frequency of which is directly dependent on the incoming frequency, is one of the inputs of the count gate.

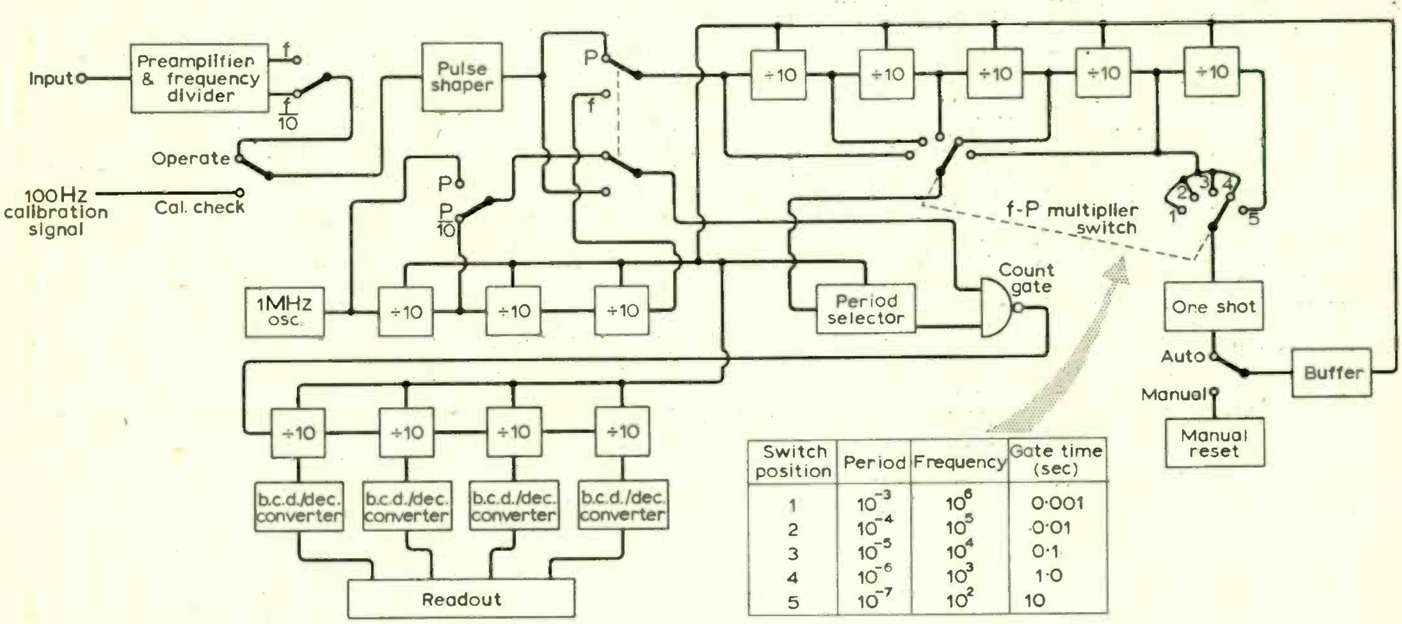
The 1-MHz oscillator signal is appropriately divided down, depending on the position of the frequency multiplier switch, and routed through the period selector to the second input of the count gate. This results in turning the count gate on for a specific "gate time". The output of the count gate is then a burst of pulses, the number of which is directly proportional to the original input frequency. These pulses are then counted by the decade counting units (d.c.us), each of which contains a b.c.d. decade counter, b.c.d.-to-decimal converter and produces one digit of the readout. The count is retained in the readout until the system is reset.

Resetting is accomplished by applying a "high", or logical one, to all direct clear (C_D) inputs of the flip-flops and decade counters. In the manual reset mode, this is done by a momentary push button switch. In the automatic reset mode, and in all but the number five multiplier switch position the output of the seventh decade divider from the oscillator is used to do the resetting. This particular output goes high during the eighth and ninth second from zero time (that time immediately following the previous reset cycle). Once this high signal is applied to the C_D inputs, the devices are reset, therefore they are effectively reset at the beginning of the eighth second. In the number five multiplier switch position, since the gate time is ten seconds, it is necessary to take the auto reset signal from the third flip-flop output of the eighth decade divider and reset occurs at the 40 second point. Since it is necessary to hold each C_D high for a minimum of 100ns to ensure resetting of all flip-flops, a one-shot multivibrator is used. The signal triggers the one shot, which holds the reset signal high for approximately 5μs. The 5μs value is strictly arbitrary; however, consideration should be given to various propagation delays due to stray line capacitances and inductances, etc., throughout the system. The output of the one-shot is buffered to provide sufficient drive for all C_D inputs.

The operation in the period mode is essentially the same with one major exception. The incoming signal is routed through

Specification

Waveforms handled:	sine; square; or negative pulses with greater than 30ns duration.
Type of measurement:	frequency; period; random pulse counting with selected gate times.
Input impedance:	10kΩ typical, 7kΩ minimum (a.c. Z_{in} on the sensitive voltage range is dependent on the forward conductance of the input protection diodes, and diminishes rapidly under over-driven conditions).
Input frequency range:	10Hz—20MHz guaranteed. 4Hz—30MHz typical.
Input period range:	50 nanoseconds to 100 milliseconds.
Gate time selection:	1 millisecond to 10 seconds in decade steps.
Input protection:	±50V d.c.; 1 volt peak in the unattenuated position; conservatively up to 200 volts peak in the attenuated position.
Input sensitivity:	50mV r.m.s. guaranteed. 25mV r.m.s. typical.
Readout:	4-digit decimal; fixed decimal point location; ranging accomplished by rotary switch.
Accuracy:	±0.05% ±1 count with self-calibration using line frequency to ±0.1%.
Resetting:	manual or automatic.



Switch position	Period	Frequency	Gate time (sec)
1	10^{-3}	10^{6}	0·001
2	10^{-4}	10^{5}	0·01
3	10^{-5}	10^{4}	0·1
4	10^{-6}	10^{3}	1·0
5	10^{-7}	10^{2}	10

Fig. 1. Block diagram of the instrument.

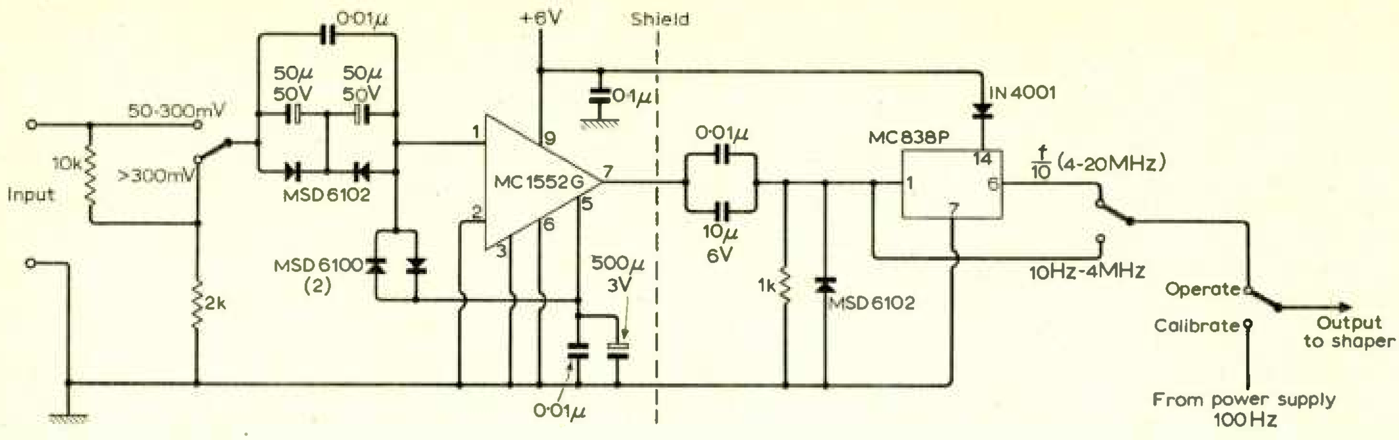


Fig. 2. Pre-amplifier and pre-scaler.

the period selector and is used as the gate time of the count gate, whereas the oscillator signal is used as the events counted.

The self-contained calibration feature is obtained by simply counting the frequency or period of the 100-Hz signal. For more accurate calibration an external signal is recommended. A calibration adjustment is provided in the oscillator section.

Pre-amplifier and pre-scaler

The pre-amplifier of Fig. 2 uses the MC1552G video amplifier. Two input amplitude ranges are provided, 50-300mV r.m.s. and > 300mV r.m.s. The 3dB down points of the pre-amp. circuit only, in the unattenuated position as shown, are 4Hz and 42MHz for small signal applications. Input impedance is typically 10kΩ.

Since Motorola r.t.l. devices are guaranteed to only 4MHz, a Motorola d.t.l. decade counter (MC838P) is utilized to extend the frequency range to 20MHz.

Note that the V_{CC} of +5V for the decade counter is derived from the +6V supply by placing a silicon diode in the line. This places V_{CC} well within the supply tolerances of the d.t.l.

In order to attain the high frequencies specified care must be taken in constructing the pre-amp. Of prime importance is the shielding between input and output circuitry and for this reason double clad printed circuit board should be used, with the input and output components located on different sides of the board. In the prototype the pre-amp. was constructed in a separate box within the chassis.

Pulse shaper

As mentioned earlier, the pulse shaper's function is to condition the incoming signal to meet the input constraints of r.t.l., J-K flip-flops. The primary requirement is for the fall time of a flip-flop's clock pulse inputs to be within the range of 10 to 100ns. (Not applicable to the MC778P). This is accomplished by using one-half of a hex-inverter, connected in a Schmitt trigger configuration as shown in Fig. 3. Under worse case conditions (15°C and 4MHz) input hysteresis is about 2V. Inputs to the pulse shaper can be periodic waves of any form or random pulses. The one constraint is a minimum input pulse duration of 30ns.

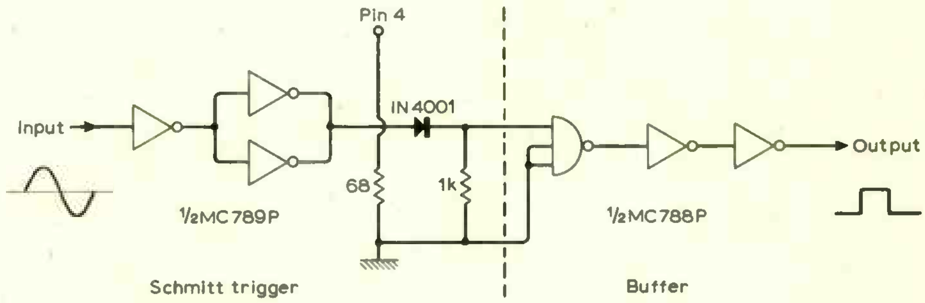


Fig. 3. Pulse shaper. Note that pin 4 is not connected directly to the earth line; the other half of the i.c. cannot be used for other purposes.

The output rise and fall times are less than 100ns for frequencies down to 10Hz.

The output of the pulse shaper is diode-coupled to a buffer which provides adequate drive.

Diode rather than capacitive coupling is used because of the large value of capacitance that would be required at the lower frequencies of the counter. A large capacitance would result in a very large time constant and require an electrolytic capacitor that would become inductive at high frequencies.

The IN4001 diode was chosen since it functions somewhat as a capacitance at the higher frequencies due to its 50pF, or so, of junction capacitance. At the lower frequencies it is more advantageous than a capacitor since it prohibits the signal input to the buffer from going below ground. The diode also drops the d.c. level by 0.7V and ensures the required V_{off} level of the r.t.l. buffer.

Crystal controlled oscillator

In the oscillator of Fig. 4 two gates are cross-coupled to form a free-running multivibrator whose square-wave output frequency is locked by the crystal. The resistors serve as biasing elements, in addition to being a part of the circuit time constants. With the crystal placed as shown, however, R_1 and C_1 determine the period. Since R_1 also establishes the bias of the gate input, and must be fixed for a given V_{CC}, C_1 and the crystal, of course, would be changed if another frequency is desired. Typical values of C_1 for other frequencies are 430pF for 500kHz and 0.001μF for 100kHz.

The trimmer capacitor permits exact adjustment of the frequency, which is stable

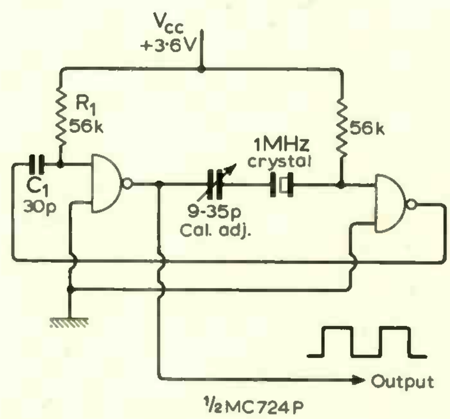


Fig. 4. 1-MHz crystal oscillator, high gain gates should be selected for this circuit.

to within ±0.01% from +15° to 55°C, without a crystal oven.

Period selector

The function of the period selector is to accurately select one, and only one, period of either the incoming signal to the counter, with the counter in the period mode, or of the oscillator, with the counter in the frequency mode. The period selected, in the form of a low or logical zero, is then used as the gate time for the NOR logic count gate. In the period mode, the count gate allows passage of the oscillator signal for one period of the incoming signal. In the frequency mode, the count gate passes the incoming signal for one period of the oscillator signal.

The period selection is accomplished by using a dual J-K flip-flop connected as shown in Fig. 5. The initial state is preset (during the reset cycle) so that the Q outputs of both devices are in the low state. The first negative transition of the incoming signal causes Q_A to go high. The second negative transition causes Q_A to go low, which in turn causes Q_B to go high. The high output of Q_B is passed by the two series connected NOR gates to the direct clear of A (C_{DA}), which inhibits any further transitions until the devices are reset. As can be observed, the high condition of the Q output of flip-flop A exists only during one complete period of the input to the period selector. This high state is inverted and becomes the gate timing signal.

During the normal operating sequence of the period selector, C_{DB} must be kept low and C_{DA} must be connected to Q_B. In order to reset the selector, both C_{DA} and C_{DB} must go high. A d.p.d.t. switch could perform this function, were it not for contact bounce. This problem is further discussed in the manual reset section. The use of the gating arrangement rather than a switch will then become clear.

Manual reset

The counter is reset by setting the Q outputs of all flip-flops to the low state. This is accomplished by making all direct clears high.

The circuit used is independent of the duration of contact bounce, and meets all constraints of the devices being used. It is, in essence, a bistable multivibrator. Fig. 6 with its accompanying table, illustrates the various high and low states of the possible switch conditions. As the table shows, once the switch arm makes contact with either the normally closed (N.C.) contact, or the normally open (N.O.) contact, no amount of bounce can change the state of the output. The only restriction for the switch arm is that it cannot rebound completely between the N.C. and N.O. contact. (Switches of this variety could be called choppers or vibrators.) As in a true switch action, this arrangement yields the complimentary output, either a momentary ON or OFF condition. In this system, unused sections of quad gates are used in the switch to perform the necessary inversion. For this purpose, gates, buffers, or inverters can be used.

One-shot multivibrator

As explained earlier the one-shot maintains the reset pulse for 5μs to insure complete reset. Fig. 7 illustrates the one shot configuration of two r.t.l. NOR gates and only one resistor and capacitor. In a quiescent condition, prior to an input pulse, a steady current flows through *R* applying a high voltage level or logical "1" to B1. This results in a logical "0" at B3 which is fed back to input A2. Since both A inputs are at a logical "0" at this time, A3 is at a logical "1" level. There is little charge stored in *C* since both plates are at about the same potential.

If a positive going pulse (logical "0" to logical "1") is now applied to input A1, A3 goes low and *C* begins to charge. The high initial charging current through *R*

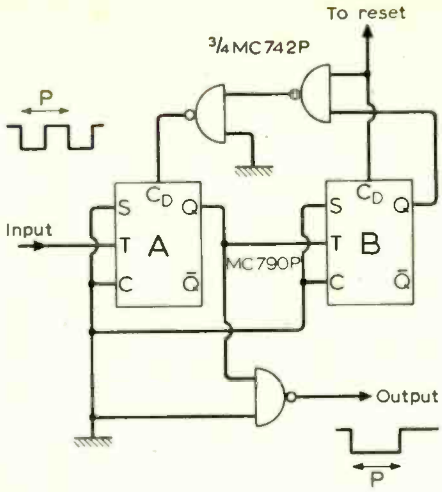


Fig. 5. Period selector.

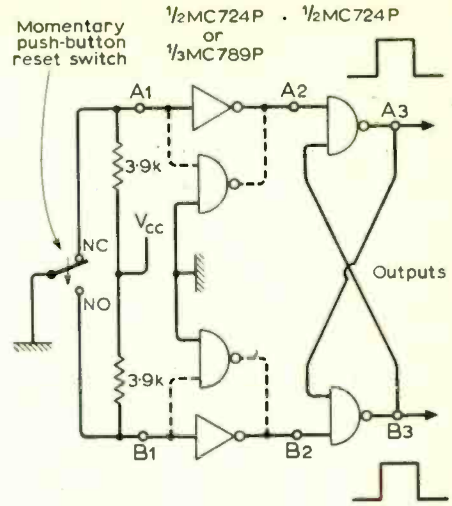
drops the voltage at B1 to a logical "0" that, together with the permanent "0" at B2, switches output B3 to a logical "1". This "1" is fed back to input A2 and maintains A3 at a low level until *C* charges to the point where B1 reaches the logical "1" threshold level. Then output B3 is switched to a "0" completing the generation of the monopulse. The "0" at B3 is fed back to A2 and the one-shot has returned to its original quiescent state.

The presence of this feedback loop makes the duration of the one-shot output relatively independent from the duration of the trigger input. It insures that the output of gate A will remain a "0" after the trigger input has reverted to a "0". Thus the duration of the "1" output from the one-shot is determined by the value of *R* and *C*, not the time duration of the trigger.

Decade counting unit

In this counter a decade counting unit is a device which contains a divide by ten counter, a b.c.d.-to-decimal decoder and a numerical readout.

As shown in Fig. 8, the divide-by-ten function is accomplished very simply by using the Motorola MC780P decade counter.



Switch status	A1	A2	A3	B1	B2	B3
NC contact	0	1	0	1	0	1
Interim bounce after NC contact	1	0	0	1	0	1
NO contact	1	0	1	0	1	0
Interim bounce after NO contact	1	0	1	1	0	0

Fig. 6. Manual reset function.

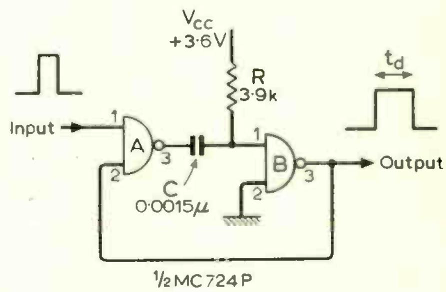


Fig. 7. One-shot multivibrator.

The most inexpensive way of performing the decoding and readout function is by using the current summing technique. Here, the outputs of the MC780P are used to control the on-off condition of four

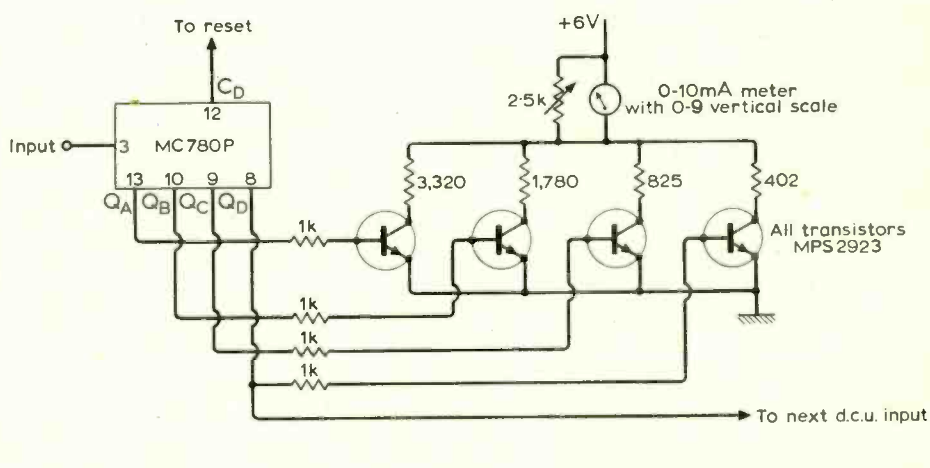


Fig. 8. Decade counter unit with meter readout.

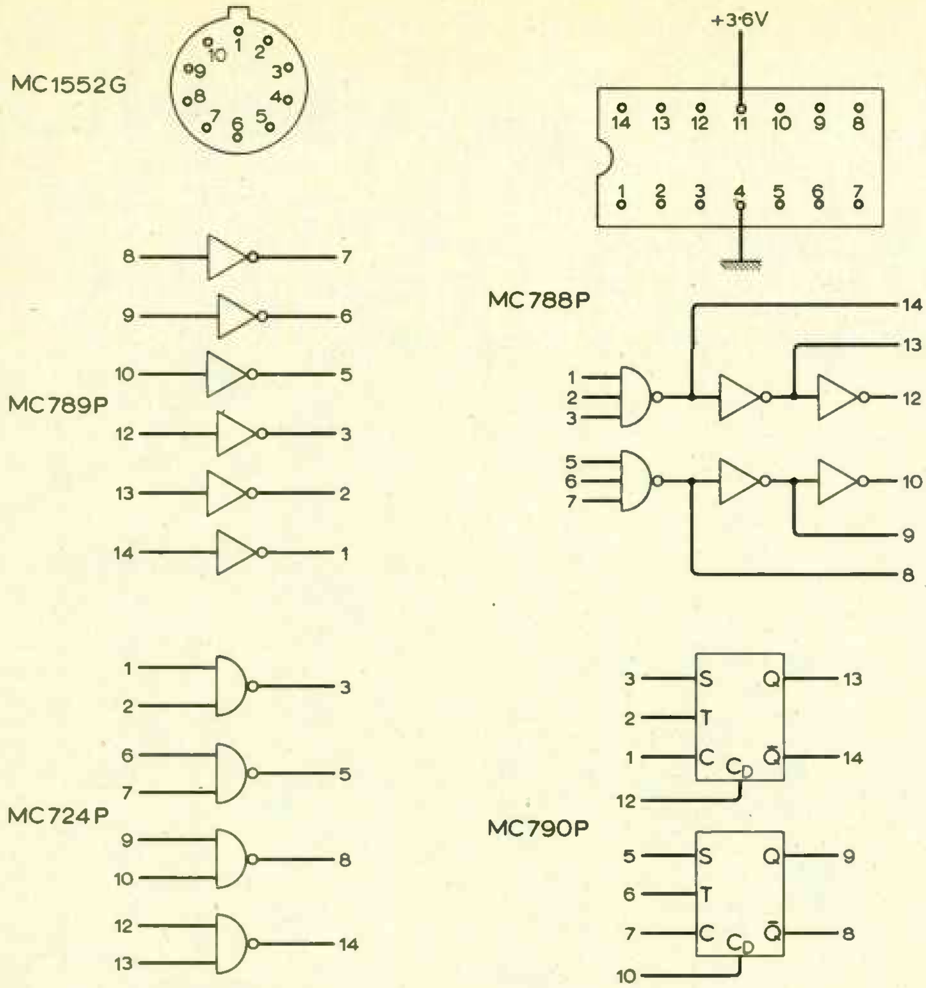


Fig. 9. Pin connections not shown on the other drawings.

transistors. The values of the collector resistors form a sequence in which each is twice the preceding, resulting in binary weighted collector currents. The currents are brought to a summing junction and since the aggregate current can be in only one of ten discrete states, it is readily displayed on a current meter with a zero to nine scale. An accumulative error of even ±0.25mA still allows plainly discernable readings. For best results, however, 1% precision resistors are recommended. The resistor values chosen provide more than 10mA to the meter. This allows shunting of the movement to compensate for meter variations.

Switch functions

The input sensitivity switch (50-300mV or > 300mV) selects the most beneficial input impedance and protection for the two positions provided.

The input frequency range switch has two ranges: the f position permits measurement over the 10Hz to 4MHz range and the f/10 position causes the input frequency to be divided by ten, extending the range by almost an order of magnitude up to 20MHz. An MC838P d.t.l. decade counter is used to divide the input frequency by ten, as shown in Fig. 11, and imposes the requirement of a 1μs input fall time for toggle operation. This constraint and input signal rise time determine the minimum operating frequency of the counter. The maximum operating frequency is also determined by the MC838P which is guaranteed only to 20MHz.

The operate/calibrate switch switches the 100Hz line frequency to the pulse shaper for a rough calibration check.

The frequency/period switch selects the mode of operation. Essentially it interchanges the input signal and the internal oscillator signal routing to the count gate inputs.

The period/period ÷10 switch provides a reduced frequency clock signal to the d.c.us to allow the longer periods to be read without over-ranging the readout.

The frequency/period multiplier and gate time switch provides decade ranging for both frequency and period measurements, selects the gate times for random pulse counting, and establishes the recycle time in the automatic reset mode.

The auto/manual switch selects the input signal sampling mode. The manual reset button is a momentary push button which resets and recycles the input signal sampling manually. The on/off switch is self-explanatory.

Power supply

A power supply circuit is not given here. Two d.c. voltages are required 6V at 100mA and 3.6V at 500mA. A low voltage 100Hz output is required from the power unit as a calibration signal.

Additions and Corrections

In the article "**Tone-balance Control**" in the March issue the following section was inadvertently omitted from p. 124, column 3. It should be inserted between "to" and "frequencies" in the 19th line from the bottom. "provide a chosen maximum bass boost of ×2.5 and the nearest standard value of 68kΩ was selected. At low frequencies $1/\omega C_1$ becomes very large and equation (2) reduces to

$$\frac{V_E}{V_A} = -\frac{R_1+R_3}{R_1+R_2}$$

The condition for maximum bass boost is $R_2 = 0$, $R_3 = 100\text{k}\Omega$.

"Next the value of $R_4 = R_4'$ was calculated to give a maximum treble boost of ×2.5. At high frequencies $1/\omega C_1$ becomes very small and equation (2) reduces to

$$\frac{V_E}{V_A} = -\frac{R_1R_2+R_1R_4+R_3R_4}{R_1R_3+R_1R_4+R_2R_4}$$

The maximum treble boost condition has $R_2 = 100\text{k}\Omega$ and $R_3 = 0$. The standard value of 22kΩ was selected.

"Finally, the value of $C_1 = C_1'$ was calculated using the second root of equation (3), which is

$$\frac{1}{\omega^2 C_1} = R_1^2\,\frac{R_2+R_3+R_4}{R_2+R_3+2R_1} - R_4^2$$

so as to give a crossover frequency of 800Hz, giving $C_1 = 4100\text{pF}$. The value actually used was 1500pF in parallel with 2200pF (both polystyrene) giving $C_1 = C_1' = 3700\text{pF}$ and a calculated crossover frequency of 880Hz.

"The selected component values were substituted back in equation (2) and the system gain was calculated for a number of"

The following corrections should be made to the article "**Stabilized Power Supply**" by A. J. Ewins which appeared last month. The collector of Tr_2 in Fig. 4 should be connected as shown in Fig. 3. In Fig. 8 there should be no connection between position 6 and the wiper of S_{2a}, and similarly in Fig. 9(a) there should be no connection between S_{2b}, position 1, and the 250Ω potentiometer. Finally amend note in Fig. 9(b) to read "+V output terminal".

Supply of low-noise f.e.ts

The Amelco low-noise field-effect transistors specified for the "80-metre S.S.B. Receiver" (March 1970) and for the "Simple Audio Pre-amplifier" in this issue, are available from Souriau Lectropon Ltd, Shirley Avenue, Vale Road, Windsor, Berks. The price is 6s 8d for the 2N4302 and 8s 3d for the 2N4303.

From the recent
London Physics Exhibition

Digital topics: Opto-electronics: Capacitor-transistor delay line

An example of what can be done with adaptive logic was demonstrated by Twickenham College of Technology. An adaptive logic gate is in fact a combination of gates which are capable of carrying out any logic function on the inputs applied to it as directed by separate control inputs. If wished, the control input to a particular gate can be derived from the output of another adaptive logic gate and in this and other ways extremely complex networks can be built up. The whole point is that a network is not necessarily purpose-built for a particular application and the network adapts itself to perform the function required of it—which may not necessarily be known in the first instance. Much work is being done in the use of adaptive logic for pattern recognition purposes.

Twickenham College of Technology showed an adaptive logic network operating in conjunction with a simulated vehicle routing system. The position of a vehicle was indicated on a c.r.t. and was determined by the contents of two bi-directional binary counters, one operating in the X and the other in the Y plane. The output of the adaptive network was used to control the direction of the two counters and the object was to establish as many routes as possible between two arbitrarily selected points within a specified number of steps.

In the system the control inputs of the adaptive gates were connected to binary counters so that every possibility was tried in turn. The adaptive gates were arbitrarily connected and the connections were altered after trials with the object of finding the most successful network.

I.C.L. were demonstrating speech recognition equipment which enabled a complex computer programme to be controlled by unskilled operators who merely had to answer Yes, No, Wrong or Stop in response to instructions and questions presented on a c.r.t. by the computer. The speech analyser used split the sound into a number of parallel paths, each path being employed to recognize the presence or absence of some particular feature.

Some of these features are indicative of the way in which speech sounds are produced. For example it is possible to distinguish between voiced and unvoiced sounds on the basis of relative energy content. A voiced sound is a vowel or vowel-like sound produced when air is forced through the vocal chords causing them to vibrate. The resulting puffs of air excite the resonances of the vocal tract. These resonances are called formants. The formant frequencies are dependent on the position of the tongue and lips as these affect the shape and volume of the resonant cavities. Information about the speech sounds is conveyed by the formants rather than by the pitch of the voice (frequency of vibration of the vocal chords). An unvoiced sound is produced when air is forced through a narrow constriction in the mouth or throat, producing a hiss-like sound. Stop sounds, e.g. "t" in eight, are characterized by a short period of silence followed by a plosive sound as the built up air pressure is released.

Other features provide information as to where in the mouth the speech sounds were produced. Thus in the speech analyser, there are circuits for measuring the frequencies of the two lowest formants. At present, the outputs of these circuits are classified into one of four frequency levels. There is also a circuit for detecting high-frequency unvoiced sounds, e.g. "s" in see.

◆ ◆ ◆ ◆ ◆

A computer for educational purposes was shown by the University of Durham in conjunction with the Darlington College of Technology which was designed and built with the aid of a grant from the National Research Development Corpn.

It does all the things one would expect an educational computer to do and has a 128-word store (a word is 12-bits long) which enables some useful computing to be done. Integrated circuits and printed circuit cards help limit the cost to something less than £2,000. Further information may be obtained from I. Sagues, Computer and Automation Group, N.R.D.C., P.O. Box 236, Kingsgate House, 66–74 Victoria St, London S.W.1.

◆ ◆ ◆ ◆ ◆

There is a growing interest in the possibility of having communications systems operating at infrared or light frequencies. The main attraction for the developers here is the enormous number of channels available and also the complete immunity from electrical interference. Military authorities have a special interest in communications at light frequencies because a further advantage is that information transmitted over an opto-electronic link can be received only at the intended reception spot and it cannot be tapped en route.

The principles of communication at light frequencies were described in the November 1968 edition of *Wireless World* pp. 393–5 where we reported on techniques for generating sub-millimetre waves, and how since the development of the laser, coherent optical transmissions have extended electromagnetic radiation into the visual spectrum of frequencies.

Two examples of infrared communication could be seen at the exhibition. The first was a simple audio rig by the North Staffordshire Polytechnic comprising a gramophone pickup at the transmitting end and an amplifier and loudspeaker at the receiving end. Signals from the pickup were amplified and used to modulate the current passing through a gallium arsenide diode. Modulated infrared radiation emitted from the electroluminescent diode was received by a silicon phototransistor some distance away and the photocurrent, after suitable amplification, was used to operate a loudspeaker. The circuits were developed from original ideas from Mullard and the second example of infrared communication to be seen was a similar set-up by Mullard themselves. This system was operated from internal 9V batteries to demonstrate its portability and since both diode and phototransistor work at wavelengths of the order of 0.9 m ordinary glass lenses were used for focusing. The prototype is claimed to work satisfactorily at a range of 600ft.

Both systems are intended for physics teachers to demonstrate the nature of infrared radiation. The techniques used have been known for a number of years. It is probable that the really advanced experiments in infrared communication are taking place behind locked doors in government research establishments and these will not see the light of day (or night) until they become redundant militarily.

A rather more ambitious system by Mullard, this time using light frequencies (0.63μm) transmitted through a 10-ft length of glass fibre bundle, demonstrated the transmission of a 4-MHz bandwidth television picture from a nearby camera tube, through the fibre-optic system, and displayed on a standard TV monitor. This had an electro-optic modulator at the transmitter and a photodiode at the receiver. Self-aligning plug-in mounts were employed thus allowing the interchange of light sources and fibres.

The light source used in the exhibit was a small tungsten bulb and a lens focusing the light through the modulator on to the end of the fibre bundle.

Interest here was mainly the design of the modulator itself. It consisted of two crystals of ammonium dihydrogen phosphate (a.d.p.) separated by a half-wave plate. The incident light beam travelled through the crystals as two rays polarized at right angles, known as ordinary and extraordinary rays. The ordinary ray travelled normally through the crystal for normal incidence whereas the extraordinary ray was refracted through a small angle. The crystals were arranged so that the two rays coincided on emergence from the modulator. The half-wave plate rotated the polarization planes of the two rays through 90° so that the ordinary ray in the first crystal became the extraordinary ray in the second and vice versa. This cancels the natural birefringence and provides temperature compensation for changes in the refractive indices.

The rays travel through the crystals with different velocities depending on the applied electric field. Incident plane polarized light emerged elliptically polarized. A polarizer set at right-angles to the incident plane selected the component of polarization induced by the modulator. The intensity is given by

$$I = I_0 \sin^2\left(\frac{\pi V}{2V_0}\right)$$

where V is the applied voltage and V_0 the half-wave voltage. The half-wave voltage at 0.63μm is 260V. Capacitance of the modulator is 46pF. A frequency range of 0-36MHz is possible, using a 100- source impedance.

Standard Telecommunication Laboratories were also showing a wideband optical communication system using an injection laser and glass fibre waveguide. The laser was pulse-code modulated by switching the pump current, allowing repetition rates up to about 1GHz. A feature of this system is that long communication links are possible using as many repeaters as necessary because p.c.m. repeaters can be cascaded indefinitely.

The exhibit simulated a 75Mbit/s signal which was fed into a pulse amplifier. This used eleven BFY90 transistors with their collectors distributed along a 1-Ω stripline feeding the GaAs laser. Current through the laser was switched between 0.1A and 1.1A and the p.c.m. optical signal thus developed was coupled to a glass fibre transmission line. This was terminated by a photodiode, the received signal being amplified and fed into a regenerator which re-timed and re-shaped the pulses.

A drawback to this system is the need to cool the laser for operation at high duty ratio, but STL say they are pursuing a lead which may make a room-temperature laser possible.

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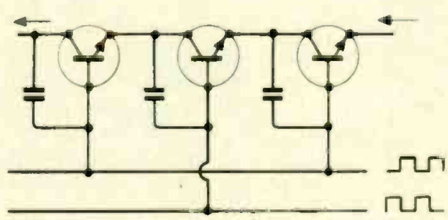
Analogies with everyday objects have found common usage in electronics language to provide simple explanations of the principle of operation of some basic circuits, although sometimes the object to which the circuit is analogous is equally vague to some. For example, what to an Englishman is a "box-car"? He is more likely to derive his explanation the other way round by observing the waveform to which it is supposed to have a likeness.

Readers may feel things have gone slightly too far when a temporary storage device for electronic signals is described as a 'bucket-brigade delay line' because its



configuration is said to resemble an old-time fire brigade passing along buckets of water. Since it was developed by Philips' Eindhoven laboratories however, it could be dismissed as being Double-Dutch!

In fact this was an interesting piece of equipment based on a chain of storage capacitors and charge transfer circuits acting as an analogue shift register with externally variable shift rate. It is suitable for delaying audio and TV signals. Outstanding among the advantages over *L/C* and glass delay line systems is the facility to vary the delay time over a wide range.

Information is transferred along an array of capacitors as a moving charge "deficit" with one transistor per capacitor. This circuit could easily be made as an i.c. Two complementary clock signals are used, with a frequency equal to the frequency with which the input signal is sampled. The device provides a delay in which bandwidth and delay are inversely related and variable within wide limits, thus: $n = 4BT$, where n = the number of 'buckets', B = bandwidth and T = time delay. Signal delay is varied electronically by varying the clock frequency which can be precisely controlled or synchronized. One application which can readily be foreseen is to compensate for undesirable echos from widely spaced loudspeakers in public address installations.

New applications for colour television continue to be found. What at first sight looked like a colour TV designer's nightmare on the stand of Delft University of Technology, Netherlands, turned out to be a demonstration of the deliberate distortion of hues for the purpose of medical diagnosis. It was done by an electronic process of expanding the colour differences of colours which lie in the yellow/red sector of the chromaticity diagram, i.e. colours which cover flesh tones, and compressing the colours which lie outside the area of interest. For purposes other than medical (e.g. colour matching), any sector of the chromaticity diagram could be selected depending on the axes chosen for the quadrature modulators.

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Because colours outside the area of interest are compressed and those inside are multiplied by a factor of 6, the colours seen on a TV monitor screen are untrue, but this is of little consequence in diagnostic work. The important point is that small changes in skin colouring, indiscernible by normal observation, become substantial changes when viewed on the screen.

It is important to retain as much of the original information as possible, particularly luminance relations, and for this reason the luminance signal Y is extracted in a matrix, leaving the two colour-difference signals for processing independently of Y. Unconvinced that we were not watching just a colour TV with a very poor grey scale, we asked the demonstrator to scan a black card covered by a white cross-hatch. It reproduced perfectly on the monitor receiver—in black and white.

◆ ◆ ◆ ◆ ◆

In developing a sonar system for charting the ocean floor out to a range of 12 nautical miles (22km) the National Institute of Oceanography has devised an efficient piezo-electric transducer operating at about 6.5kHz and capable of delivering 600 acoustic watts (duty cycle 1:6).

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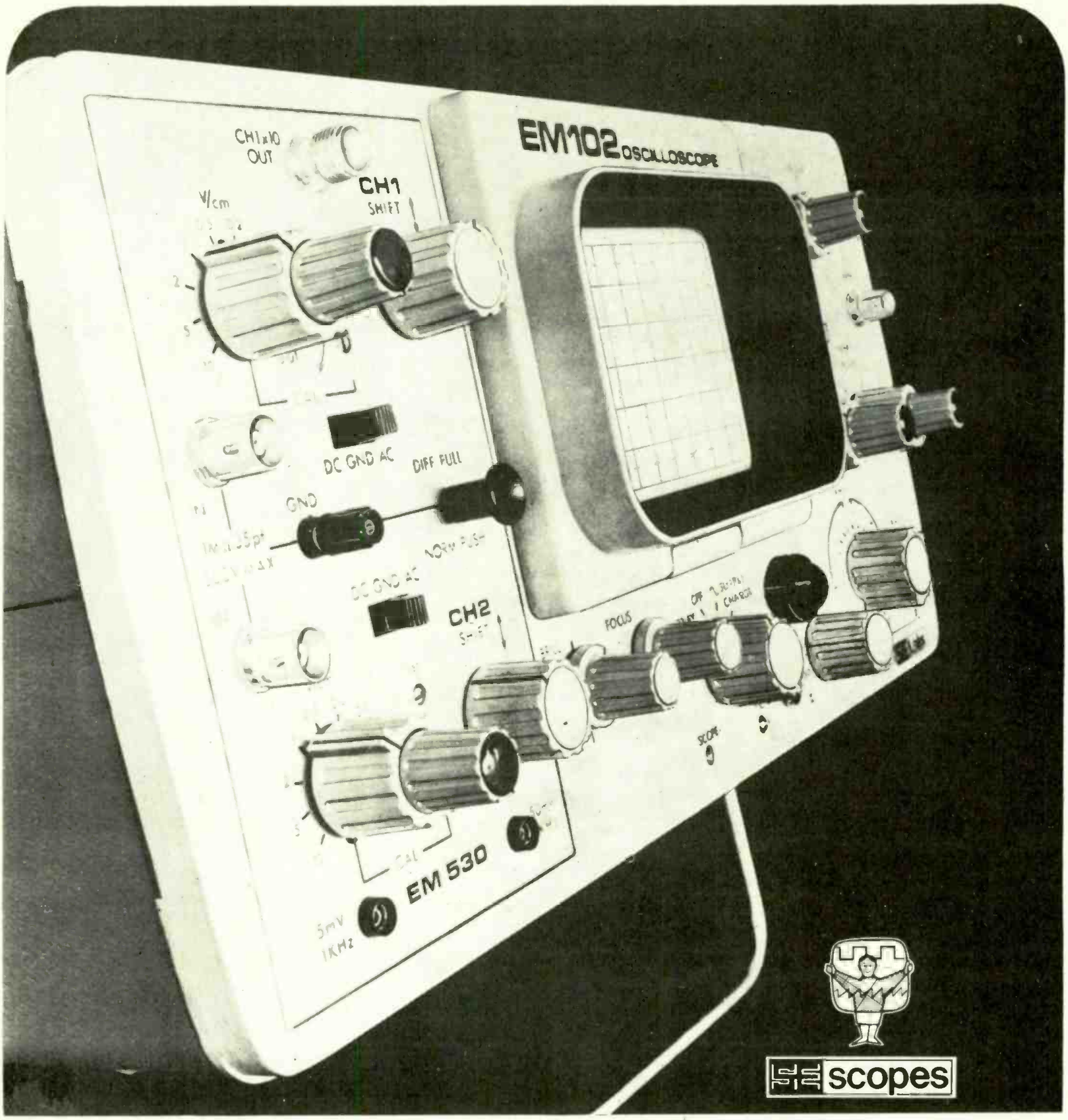

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Track-while-scan Radar System

How a radar system is used with a computer to provide automatic target tracking

*by J. L. Sendles**

Radar contacts derived from a conventional surveillance pulse radar are normally displayed on a plan position indicator (p.p.i.). The formation of tracks from the radar "paints" has hitherto been carried out by an operator by keeping a joystick controlled marker nearly coincident with successive radar paints.

This method of tracking has two main disadvantages; firstly it requires the full-time attention of a man who can track up to about eight surface, or one or two air, tracks (the actual number of targets capable of being satisfactorily tracked depends on the degree of manoeuvre of these targets), and secondly, in order to achieve reasonable tracking accuracies, expensive p.p.i. displays with minimal registration errors are necessary.

Attempts have been made in the past to produce a completely automatic contact initiation and tracking system capable of processing information from pulse surveillance radars, but due basically to the presence of excessive clutter (interference) in certain environments these systems have now been rejected in favour of the less sophisticated systems which take advantage of the human operator's considerable skill in detection and subsequent initiation of radar contacts. Once initiated, the contacts are automatically tracked by a digital data processing system which is the subject of this article.

The advantages of this automatic radar contact tracking system are, firstly, that the man is relieved of the tracking task and can therefore devote virtually his full attention to the detection of contacts and initiation of tracks and, secondly, greater tracking accuracies than those possible from a purely manual system are in general obtained.

The article describes an autotracking system which has operated with an X-Band maritime navigational radar and an S-Band surface and air surveillance radar. Both of these systems have been successfully proved at sea. Also described is an autotracking system for a (ground-based) three-dimensional C-Band air surveillance radar which has also been successfully proved.

*Elliott Bros.

System description

All autotracking systems to be described are based on similar equipment which is shown in block diagram form in Fig. 1. The display incorporated in these systems is a 16-inch horizontal p.p.i. which displays synthetic alphanumeric information supplied by the character generator, interlaced with the conventional radar range and bearing information derived from the radar's aerial bearing, video and synchronization signals. Attached to the display console is a general purpose keyboard and "rolling ball" module, the outputs of which are processed respectively by the keyboard decoding unit and the reversible counter unit, the outputs of which are fed to the 920 computer via the peripheral controller.

The "rolling ball" provides a means of manually moving a synthetic marker on the p.p.i. display which, in conjunction with the keyboard, is used to initiate or cancel tracks. The outputs from the radar to the autotrack peripheral equipment are the radar video signal, the radar synchronization pulse and the aerial's bearing which is the output of an incremental encoder together with a ship's head marker signal. In the case of the three-dimensional radar the beam's elevation is also controlled by a data processor and is fed by the computer to the radar via the peripheral controller and the autotrack peripheral equipment.

The computers incorporated in these systems are members of the Elliott 920 computer series. The associated paper tape station comprises a paper punch, reader, controller and power supplies.

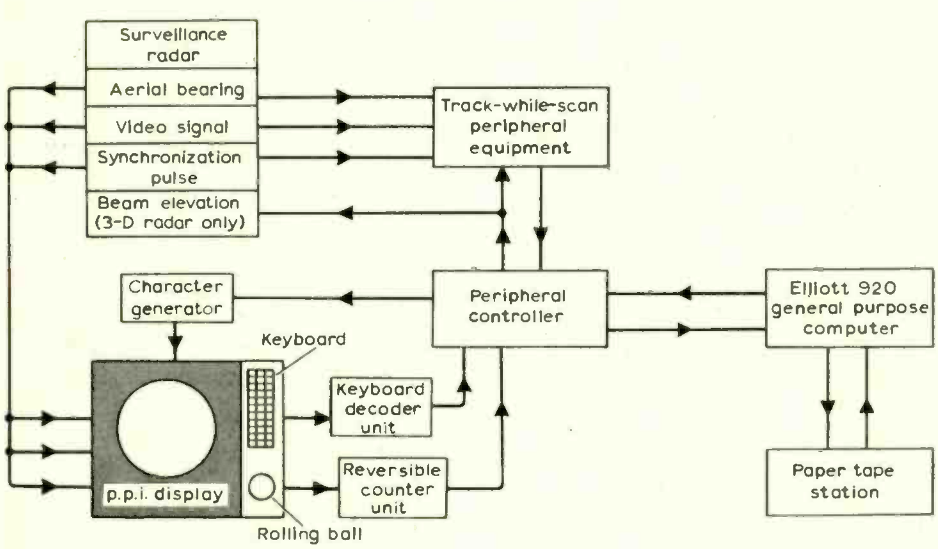


Fig. 1. Track-while-scan block diagram.

Two-dimensional surface and air surveillance

A block diagram of the track-while-scan (t.w.s.) peripheral equipment is shown in Fig. 2. The t.w.s. facility is manually initiated by an operator viewing the p.p.i. display and placing the synthetic rolling ball marker over the radar paint of the contact he wishes to track, and by feeding the appropriate instruction to the computer using the keyboard. The computer immediately stores the cartesian co-ordinates of the target and begins to track it. The computer also calculates the polar co-ordinates of the target (range and bearing R_t and B_t and derives the co-ordinates of the t.w.s. window; indicated by the shaded area of Fig. 3. This window is defined in the equipment by the opening of two gates, the range gate and the bearing gate. The bearing gate start (or open) signal is derived by comparing the output of a position digitizer attached to the radar aerial with the bearing of the leading edge of the window, already calculated by the

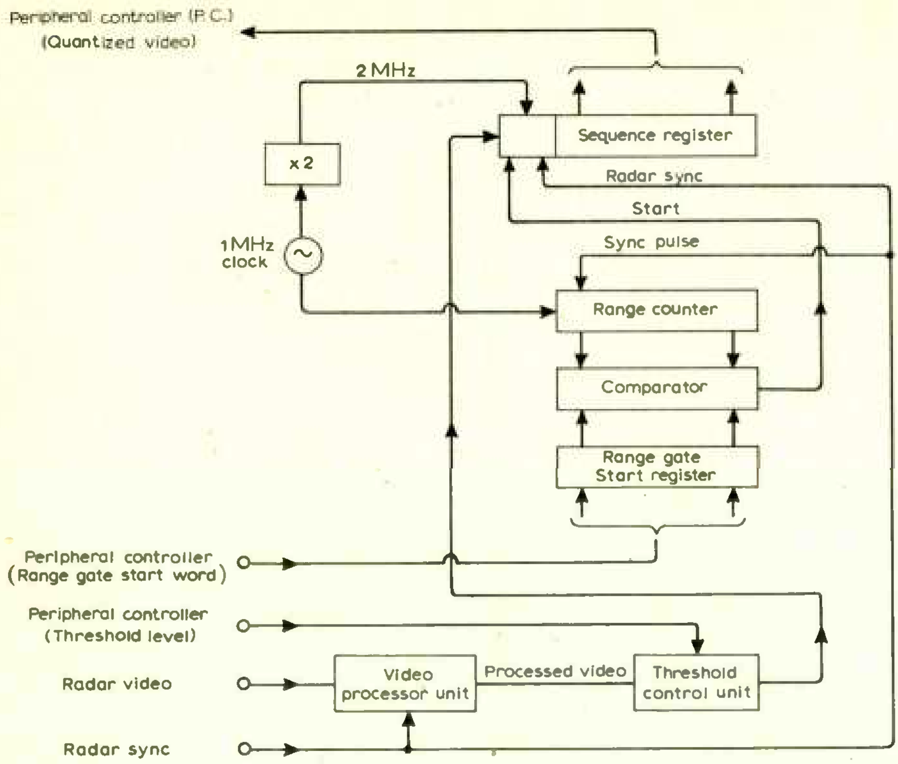


Fig. 2. Block diagram of the track-while-scan peripheral equipment.

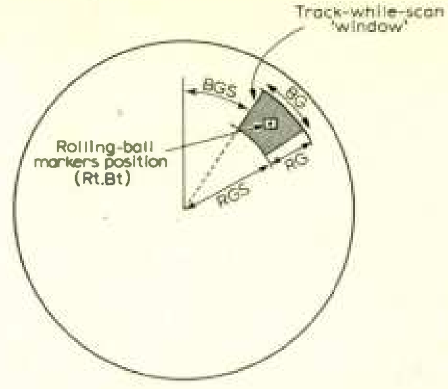


Fig. 3. Position of the t.w.s. window.

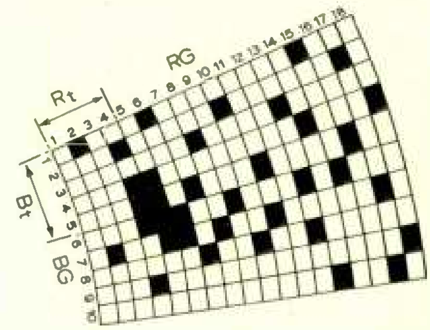


Fig. 4. Returns in the t.w.s. window.

computer, and opening the bearing gate (BGS) when coincidence occurs, i.e. when the aerial is in line with the leading edge of the t.w.s. window.

As soon as the bearing gate opens 1μsec spaced pulses are fed to the range counter of Fig. 2. The contents of this counter are compared with the contents of the range gate start register which holds the range of the t.w.s. window previously calculated by the computer. When the contents of the range counter are the same as the contents of the range gate start register shift pulses at 0.5μsec intervals are allowed to reach the sequence register. By virtue of the circuitry just described these shift pulses only reach the sequence register when the radar aerial is receiving returns from the area defined by the t.w.s. window.

Video signals, after being processed in a manner to be described later, are fed to the data input of the sequence register and can have the value of 1 or 0 depending on whether the signal is above or below a computer controlled threshold. After 18 shift pulses (9.5μsecs) the shift pulses are stopped and the contents of the sequence register are transferred to the computer.

At the start of the next radar pulse repetition interval the range counter is reset and the process is repeated.

Before arriving at the sequence register the video signal passes through the video processor unit and the threshold control unit. The purpose of the video processor is to ensure that the input to the threshold unit is virtually independent of receiver output noise variations caused by receiver gain changes—which is particularly important when autotracking targets which give a weak return signal.

The threshold control unit comprises a six-bit digital to analogue converter which is driven by the computer. The d.a.c. output is differenced with the output of the video processor unit in order that the video, after being quantized and processed, is controlled in bearing width for each target plot being extracted to approximately one beam width. The actual threshold control programme within the computer in order to achieve optimum performance depends on factors such as the type of radar and its mode of operation.

The process of video digitization over the extent of the sequence register starting when the range and bearing gate opens continues on each p.r.i. until a sufficient area around the contact's indicated position has been covered. A pictorial representation of the information which is derived and stored in the computer for further processing is shown in Fig. 4. The black areas represent points at which the processed video is above the computer controlled threshold and the remaining areas represent points at which it is below.

Controlling by the threshold control unit the threshold level above which video will enter the sequence register is a valuable facility, particularly when tracking surface contacts, for two main reasons; the first is that greater tracking accuracies can be achieved and the second that greater discrimination can be obtained in a multicontact environment.

Plot extraction

Plot extraction techniques for conventional surveillance pulse radars are well known and basically involve what is known as moving average detection criterion (m.a.d.c.).

The m.a.d.c. which is used to detect the start and end of a plot states that a target start is established if, at any particular range, three out of five (say) quanta are present, and the end of a target is detected when the average drops to two out of five or less. With this particular criterion of three out of five and referring to Fig. 4 it can be seen that target starts occur at R_4 $(B_3, B_4, B_5, B_6, B_7)$ and $R_5 (B_4, B_5, B_6, B_7)$.

Having established the extent of the target by means of the m.a.d.c. as described above the computer next derives its centre and thereby the co-ordinates (B_t, R_t) of the target with respect to the window, and thence to a suitable datum.

This plot extraction procedure, leading to the derivation of the target's co-ordinates or plot, is repeated on each aerial rotation. The position of the 'window' is fixed in the first instance as we have seen by means of a manual injection but subsequently its position is predicted as a result of a target tracking and smoothing programme.

Three-dimensional air surveillance

As can be seen from the track-while-scan system block diagram shown in Fig. 1, the only difference between two- and three-dimensional systems as far as the equipment is concerned is that in the case of the three-dimensional system the elevation of the aerial's beam, which is driven electronically, is computer controlled via the peripheral controller. The main difference between the two systems is in the computer plot extraction programme which, as its name suggests, derives the contact's position (or plot) from the quantized video input to the computer.

Having described the plot extraction process which has been adopted for the two-dimensional surveillance radar, we shall now consider the three-dimensional case. As stated previously the elevation of the aerial's beam is electronically controlled via the computer so therefore, by means of a suitable programme, it is an easy matter to execute an elevation scan as the aerial rotates at a constant speed such that the bearing separation between each vertical scan does not exceed the horizontal beam width, and also the elevation separation between each range scan does not exceed one vertical beam width, see Fig. 5. In this way the video signals returned from a volumetric element of sky are digitized in the same way as in the two-dimensional case and are stored in the computer in 'bearing blocks', for subsequent processing using the moving average detection criteria in order to derive the range, elevation, and bearing of the 'plot'.

Cases often arise, both in the surface and air environment, where two contacts, after all processing including integration by the m.a.d.c., remain within the same 'window'. Examples of this are a ship passing a buoy, two ships passing, a ship passing close to shore, a ship in a clutter environment, aircraft passing, aircraft in a clutter environment etc.

In order to minimize the requirement for manual override in such confused situations, which obviously is one method of resolving the problem, a detection shape criterion was introduced into the system. This ensures that only genuine contacts or contacts which appear to be genuine are accepted. Furthermore, it is possible by this means to detect merging tracks and thereby to predict the contact's established track until the two contacts again separate, when derived plots are once more used to update the track. Lost situations occur due to fading contacts, which can either be long term or short term. Short term fades are no problem since the loss of one plot normally has little effect upon the track formation. Long term fades in the presence of established non-manoeuvring contacts are again no problem since when the contact reappears it will be sitting at or near the centre of the 'window' which is predicted on by the tracking programme in lost situations. The circumstances which normally require manual intervention are those in which an extended contact fade is accompanied by a contact manoeuvre so that when the contact reappears it does not appear in the predicted window.

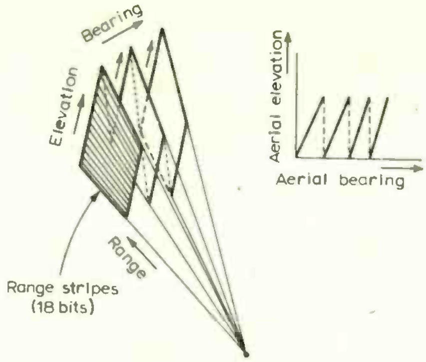


Fig. 5. (Above) Three dimensional t.w.s.

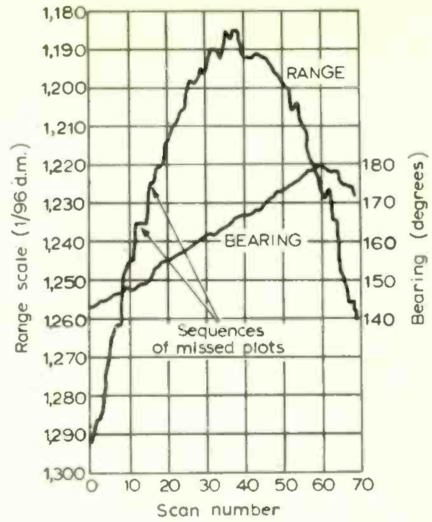


Fig. 6. (Right) Range and Bearing plots of an air contact travelling at 100 knots using the two-dimensional track-while-scan system.

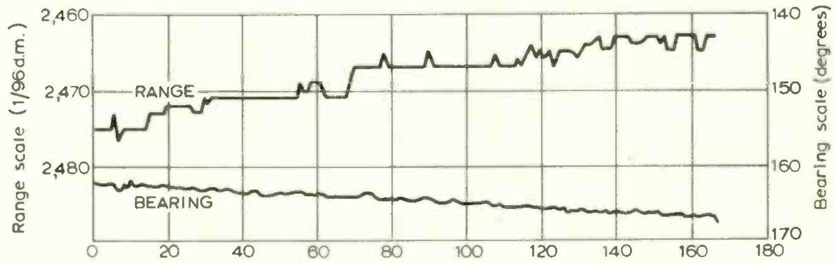


Fig. 7. Plots derived from a surface contact using the two-dimensional track-while-scan system.

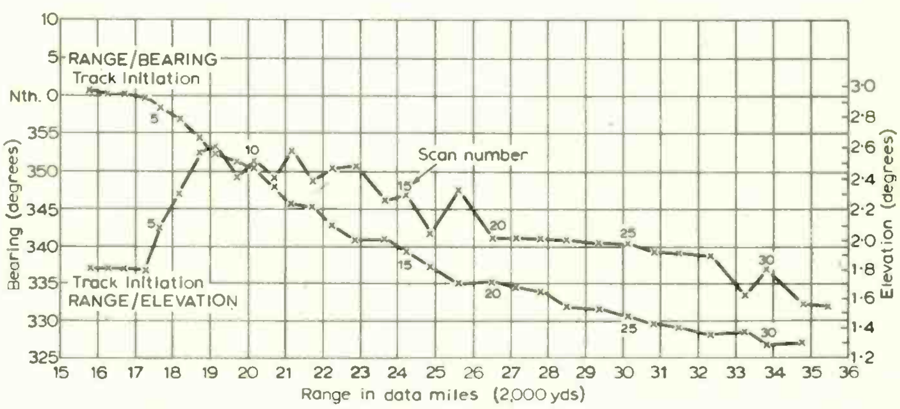


Fig. 8. Plots in bearing and elevation obtained from the three-dimensional track-while-scan system.

Results

Fig. 6 shows the range and bearing plots derived by the two-dimensional track-while-scan system from a slow air contact with a speed of 100kn, detected on a medium range air/surface surveillance radar which has a p.r.f. of 400 Hz and an aerial rotation rate of 1 rev. per 2.5 seconds. No confused plots and only isolated missed plots occurred due to contact fading.

Fig. 7 shows the range and bearing of plots derived by the two-dimensional track-while-scan system from a surface contact. Smoothing of this data is carried out by a track smoothing programme which follows the plot extraction programme. This contact was detected by a navigational radar which has a p.r.f. of 1000Hz and an aerial scan rate of 1 rev./2 secs. The contact is that of a slowly moving surface vessel at a range of 25 miles. The radar echo was rather weak and consequently short sequences of missed plots occurred which amount to 30% of all plots. Two steps of 4 × 1/96 dm (dm—data miles = 2000 yd) can be seen on the range plot, which is equivalent to one $\frac{1}{4}$ μs range increment (which is the resolution) of the sequence register. The other variation in the range plot is caused by the averaging which is being carried out within the computer.

Fig. 8 shows a graph of the plots in bearing and elevation against range obtained from the three-dimensional air

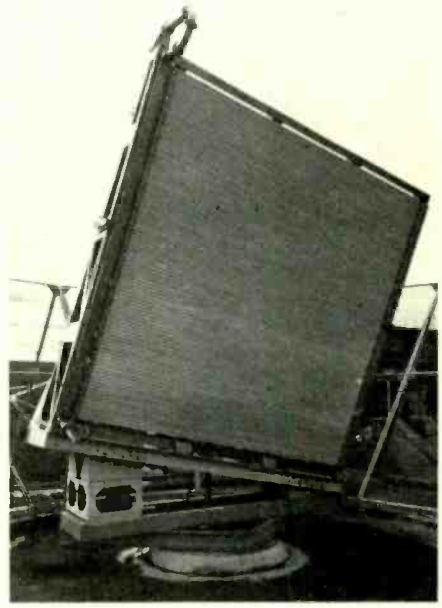


Fig. 9. Three-dimensional air surveillance radar aerial.

Fig. 10. The Elliott computer installation used in the track-while-scan system. The 920M micro-miniature computer employs a 16k word store.

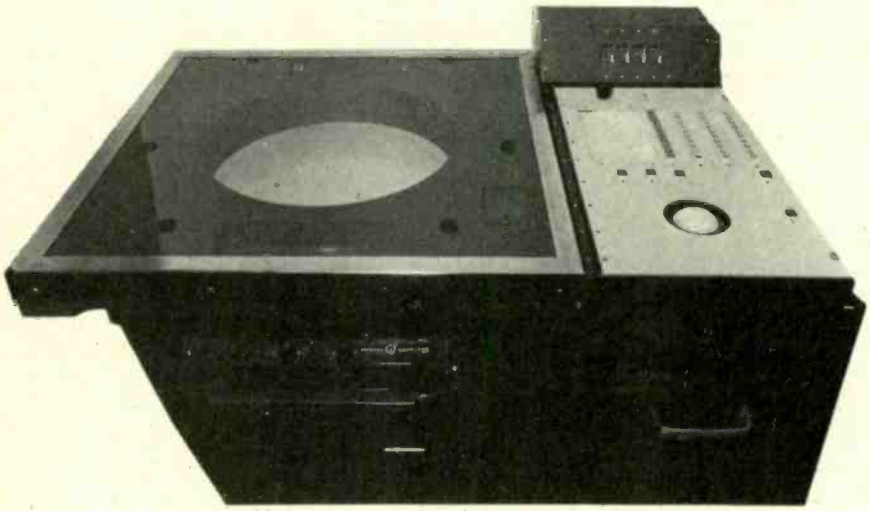


Fig. 11. Horizontal p.p.i. display.

surveillance track-while-scan system while tracking an aircraft target with a speed of about 300 miles/hour.

The aerial of the three-dimensional air surveillance radar is shown in Fig. 9. Elevation scanning is performed by electronic switching, whereas azimuth scanning is achieved by the aerial rotating about a vertical axis. Fig. 11 shows the horizontal p.p.i. display on which the range and bearing of the radar contacts are displayed together with (computer derived) alphanumeric characters. Adjacent to the display is a keyboard and rolling ball module incorporating a four-digit numerical read-out.

The computer system employed for the three-dimensional track-while-scan system is shown in Fig. 10. It incorporates an Elliott 920M microminiature computer with 16k word store, computer power supply unit, control and monitor panel, display unit and a paper tape station, comprising an on-line teleprinter, punch, reader and controller with an associated power supply unit.

Acknowledgements

I would like to thank the Admiralty Surface Weapons Establishment and G.E.C. Space and Weapons Systems Limited for the support they have given prior to and during the preparation of the article.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

May 5–15 Earls Court
Mechanical Handling Exhibition
(Iliffe Exhibitions, Dorset House, Stamford St., London S.E.1)

May 11–13 Middlesex Hosp. Med. School
Television Measuring Techniques
(I.E.R.E., 8-9 Bedford Sq., London W.C.1)

May 11–16 Olympia
Instruments, Electronics & Automation Show
(Industrial Exhibitions, 9 Argyll St., London W.1)

May 19–21 Savoy Place
Signal Processing Methods for Radio Telephony
(I.E.E., Savoy Pl., London W.C.2)

EASTBOURNE

May 5–6 Grand Hotel
Instruments in Working Environments: Design, Specification, Operation
(Mrs. S. Bryant, British Scientific Instrument Research Assoc., South Hill, Chislehurst, Kent BR7 5EH)

MANCHESTER

May 19–22 Belle Vue
ITEX 70: Industrial Training Exhibition
(John Clarke (P.R.) Ltd., St. James House, 44 Brazennose St., Manchester 2)

OVERSEAS

May 4–6 Gaithersburg
Transducer Conference
(H. P. Kalmus, Harry Diamond Labs., Dept. of Army, Washington, D.C. 20438)

May 7–8 Minneapolis
Circuit Theory
(Dept. of Conferences and Institutes, Nolte Center for Continuing Education, University of Minnesota, Minnesota, Minneapolis 55455)

May 11–14 Newport Beach
Microwave Symposium
(R. H. DuHamel, Granger Assoc., 1601 Calif. Ave., Palo Alto, Calif. 94304)

May 13–15 Washington
Electronic Components Conference
(Electronic Industries Association, 2001 Eye St., N.W. Washington, D.C. 20006)

May 18-20 Dayton, Ohio
Aerospace Electronics Conference
(I.E.E.E., 124 E. Monument Ave., Dayton, Ohio 45402)

May 25–30 Versailles
IMEKO Measurement Conference
(A.F.C.E.T., Centre Dauphine, Place de Tassigny, Paris 16e)

May 27–June 4 Paris
Mesucora
(Mesucora Secretariat, 40 rue de Colisée. 75 Paris 8e)

May 28–June 1 Basel
Didacta; European Educational Materials
(Schweizer Mustermesse, CH-4000 Basel 21)

Personalities

Among those recently elected Fellows of the Royal Society are **John F. Coales,** O.B.E., M.A.(Cantab.), F.I.E.E., F.Inst.P., professor of engineering (control) at the Engineering Department, University of Cambridge, "distinguished for his work on the development of radar, digital computers and on the theory and application of modern control systems for industrial purposes"; **Brian D. Josephson,** M.A., Ph.D., assistant director of research at the Department of Experimental Physics, Cavendish Laboratory, University of Cambridge, "distinguished for his contributions to the theory of the behaviour of junctions between superconductors, including the discovery of the Josephson effect" (readers may recall Dr. Josephson's article on superconducting devices in our October 1966 issue); and **F. Graham Smith,** M.A., Ph.D., professor of radio astronomy at the Nuffield Radio Astronomy Laboratories, Jodrell Bank, University of Manchester, "distinguished for his contributions to radio astronomy, and especially for investigations of sources and of the magnetic field of the galaxy."

Percy A. Allaway, chairman of EMI Electronics Ltd, has been elected president of the Electronic Engineering Association in succession to **Sir Ian Orr-Ewing,** Bt., O.B.E., M.A., M.I.E.E. Mr. Allaway, who is 55, joined the Gramophone Company in 1930

Percy A. Allaway

and spent the war years designing equipment for radar and other electronic devices for the Armed Forces. After the war he transferred to the domestic appliance side of EMI. He was appointed general manager of EMI Engineering Development Ltd in 1953 and works director in 1956. When EMI Electronics Ltd was formed to integrate the Group's activities in military electronics and industrial capital equipment, Mr. Allaway was appointed works director becoming managing director in 1961. He was appointed to the board of Electric & Musical Industries Ltd in 1965, and from 1st July 1969, when EMI formed its U.K. Electronics and Industrial Operations Unit by bringing together EMI Electronics with all its other electronics and industrial operations, he became chairman of EMI Electronics Ltd and deputy chairman of the U.K. Electronics and Industrial Operations.

Data Recognition Ltd, a member of the Unitech group of companies, has announced the appointment of **Roy Roper** as managing director. He was previously deputy managing director and marketing director of Racal Instruments Ltd, which he joined in 1966. Mr. Roper, who is 39, was a director of Weir Electronics (another Unitech company) before joining Racal.

A. J. Young, C.B.E., B.Sc.Eng.), M.I.E.E., chairman of GEC Electronic Tube Company and managing director of English Electric Valve Company, has in addition been appointed chairman of GEC Semiconductors Ltd which embraces AEI Semiconductors at Lincoln and Marconi-Elliott Microelectronics at Witham and Glenrothes. Mr. Young, who is 62, joined the Marconi Company in 1934 as a valve engineer. He was recently appointed chairman of the U.K. Electronic Valve and Semiconductor Manufacturers' Assoc. and chairman of the Electronic Components Board in succession to **Dr. F. E. Jones, F.R.S.**

G. H. Doust, group managing director of the Plessey Company, has been elected chairman of the U.K. Radio and Electronic Component Manufacturers' Federation, and succeeds **A. J. Young** as vice-chairman of the Electronic Components Board.

C. C. McCallum, director, Thorn Radio Valves and Tubes, is the new chairman of the British Radio Valve Manufacturers' Association.

A. J. Brunker, B.Sc.(Eng.), A.C.G.I., D.I.C., F.I.E.E., at one time chief engineer to the Ekco Group and latterly a director of a number of Ekco companies, has retired. During the war Mr. Brunker, who graduated at the City and Guilds Engineering College, was appointed deputy director of radio production in the Ministry of Aircraft Production. In 1947 he joined E. K. Cole Ltd, as general manager of the Export Department and in 1953 was also appointed director and general manager of the newly formed Ekco Electronics Ltd. He later became chief engineer to the Ekco Group and in 1966 was appointed to the board of E. K. Cole Ltd, having also become a director of a number of the Ekco group of companies. Mr. Brunker was a council member of the Electronic Engineering Association and founder chairman of its Industrial Electronics Division.

Ivan J. P. James, B.Sc., F.I.E.E. F.I.E.R.E. who has been with EMI since 1937, was recently appointed director-technical, Television Equipment Division of EMI Electronics Ltd, Hayes. Mr. James

Ivan J. P. James

has been concerned with the company's development of television equipment for the past twenty years and led the team which designed the 2001 colour television camera. For the past three years he has been general manager of television development and production.

M. W. Blades, who joined Plessey last year from AEI Semiconductors Ltd where he was manager, signal semiconductors, has been appointed general manager of the Plessey Components Group's Microelectronics Division. Mr. Blades joined Edison Swan Electric Company, Brimsdown, as a graduate apprentice in 1953, and later, when the radio and electronic components department of Edison Swan was merged with other component interests in AEI, became head of product research (semiconductors) for the AEI Valve and Semiconductor Group at Lincoln.

J. E. Morley has retired from his position as sales director of Grampian Reproducers Ltd. He joined the company in 1940 as service manager and became sales manager shortly after the war. He was appointed to the board of directors in 1966.

Bob Powell, who joined Hewlett-Packard as a sales engineer in 1965, and has successively been manager of the analytical group, North European analytical manager and marketing services

Bob Powell

manager at Slough, has been appointed to the new post of electronics sales manager at the company's south Queensferry plant, Scotland. Hewlett-Packard also announces the appointment of **Arthur Hendrie** as sales promotion manager.

A. Frank Boff, B.Sc., F.I.E.R.E. who joined Racal Instruments Ltd, as technical director five years ago has resigned "to devote himself to a wider range of interests". He will continue as a consultant to Racal Electronics Ltd. A graduate of London University Mr. Boff, who originated the Boff snap-off diode, went to America in 1950 where he joined Beckman Instruments. He then spent some time in Canada with the Marconi Company on communication system designs. Returning to the U.S.A. he became manager of research and development for the Dymec Division of Hewlett-Packard and from 1960-64 was technical manager of Hewlett-Packard in the U.K. Mr. Boff is succeeded as technical director of Racal Instruments by **Keith R. Thrower,** M.I.E.R.E. who has been with the Racal group for nine years and two years ago became a director and chief engineer of Racal Instruments Ltd. The company also announces the appointment of **J. E. Engledew** as marketing director.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

Semiconductor literature available from AEI Semiconductors Ltd, Carholme Rd, Lincoln, gives the vital statistics of microwave devices, signal diodes, reference diodes, rectifier diodes, thyristors and triacs.

AEI quick reference data WW401
Price list WW402

"Valve and Picture Tubes—Data Book, 1970" from Thorn Radio Valves and Tubes Ltd, Publicity Department, 7 Soho Square, London W1V 6DN, gives abridged data and pin connections of Mazda components. It contains an "obsolescent section" giving early warning of valves which will not be manufactured again.

Mazda 1970 data book WW403
Wall chart; colour TV tube and valve replacement WW404

A wall chart listing Motorola silicon power transistors is available from Celdis Ltd, 37-39 Loverock Rd, Reading RG3 1ED WW405

"Industrial Discrete Devices" is the title of a catalogue from SGS (U.K.) Ltd, Planar House, Walton St, Aylesbury, Bucks, giving data on a wide range of transistors WW406

Amendment No. 12 is available for the loose-leaf catalogue issued by Hivac Ltd, Stonefield Way, Ruislip, Middlesex HA4 0JT WW407

We have received more literature on the d.t.l./t.t.l. compatible m.o.s. integrated circuits produced by General Instrument Microelectronics, Stonefield Way, South Ruislip, Middlesex.

"An introduction to the Giant family" WW408
SS-6-1032: Multiple shift registers (1 package contains 2 × 1-bit, a 2-bit, a 4-bit, an 8-bit and a 16-bit shift register) WWWW409
SL-6-2050/64: dual 50/64-shift register WW410

Two water-cooled thyristors (2WD CR152'03B and 2WD CR7K'03B35), both rated at 700V, are described in leaflets from AEI Semiconductors, Carholme Rd, Lincoln. The first thyristor is rated at 700A and the second at 1,200A r.m.s. WW411

PASSIVE COMPONENTS

The "Electronic Component Catalogue—1970" from SASCO, P.O. Box 2000, Crawley, Sussex, lists capacitors, connectors, ferrite components, fuses, lamps and holders, potentiometers, semiconductors, etc ... WW425

"Gardners' new catalogue of old transformers" lists obsolescent transformers which are still available or can be manufactured to special order and is published by Gardners Transformers Ltd, Christchurch, Hampshire BH23 3PN WW426

We have received some literature concerned with ceramic filters from Brush Clevite Co., Ltd., Thornhill, Southampton, SO9 1QX. The first item listed below shows how 455kHz i.f. filters can be made using standard ceramic filters, the 6dB bandwidth and selectivity being altered by external capacitors.

Identical resonator design tables WW427
Bulletin 66006/A, miniature ladder filters WW428
Bulletin 66007, ladder filters WW429
Bulletin 66009/A, "A guide to the use of piezoelectric ceramic filter elements and ladder filters" WW430
Bulletin 66021/B, hybrid coil and ceramic resonators WW431
"High rejection filter in miniature ladder case for 12.5, 25, and 50k Hz spacing communications systems" WW432
Bulletin 66042, low-frequency ceramic filters (9-50kHZ) WW433
Bulletin 66035, miniature low-cost ceramic filters (i.f.) WW434
Price list WW435

GENERAL INFORMATION

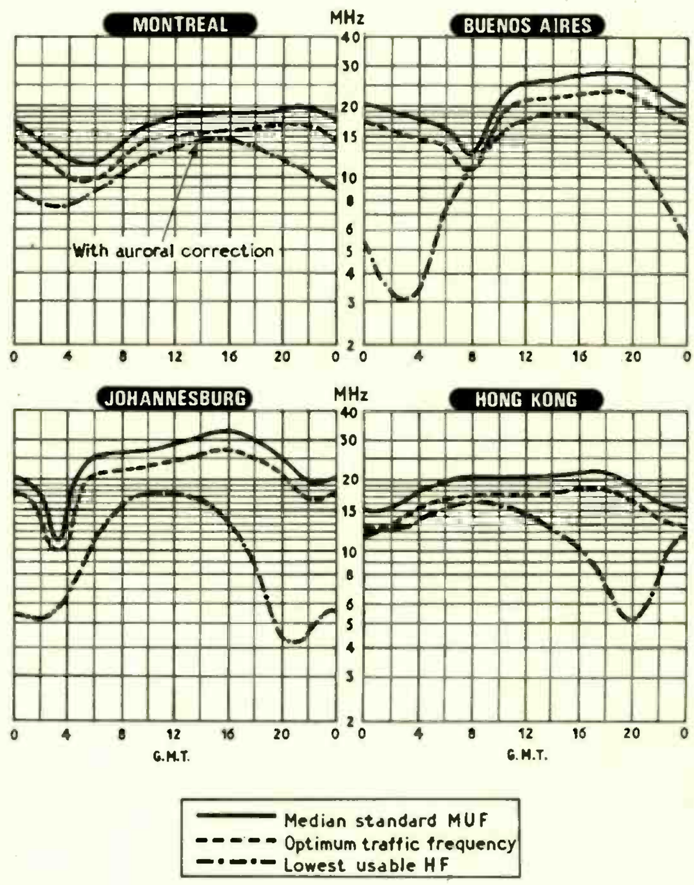
A large wall chart containing tables for converting British and U.S. units of length, area, volume, weight and liquid capacity to metric measure, and vice versa, has been produced by the Babani Finance and Trading Co, Ltd, The Grampians, Western Gate, Shepherds Bush Rd, London W.6. The chart costs 7s 11d from booksellers.

List No. 171 "UKAEA list of publications available to the public" may be obtained from Atomic Energy Research Establishment, Harwell, Didcot, Berks WW458

The Computer Services Bureaux Association (COSBA), Berkeley Square House, Berkeley Square, London W1X 6JU, has available a directory of its members and the services offered by them WW459

Lloyd's Register of Shipping, Garrett House, Manor Royal, Crawley, Sussex, have published a booklet "List of type-approved instruments and control equipment" for the shipping industry price £1 including postage.

H. F. Predictions—May



Since February solar activity has been somewhat higher than predicted by smoothed sunspot numbers so conditions for May are expected to be the same as for 1968 and 1969. Seasonal changes are most striking on routes within the northern hemisphere, the peaks of recent months are depressed giving optimum traffic frequencies (FOTs) below 20MHz which vary only very little for most of the 24 hours. Daylight FOTs on the trans-equatorial paths continue above 20MHz and amateur 10-metre band openings should be possible.

LUF curves are for reception in the UK of point-to-point telegraph services using several kilowatts of power and high-gain aerials. For other services they will be displaced vertically but generally the proximity of FOT and LUF is a measure of difficulty of communication.

New Products

Filters for Marine Communications

Anticipating that all new ships will have to comply with the new G.P.O. and European Post and Telegraph Marine Communications Specification from 1972, Cathodeon Crystals have introduced crystals and *L/C* filters which meet this specification. Double, upper and lower sideband crystal filters are available at a reference frequency of 1.4MHz. An *L/C* filter, type BP4805, provides the r.f. selectivity in the 1.6 to 3.8MHz band. A single sideband filter for A3A and A3J transmission meets the specifications for both transmitter and receiver. All filters have the same physical dimensions, 76 x 27 x 30.5mm. The operating temperature range is wider than the specified −10 to +40°C. Brief specifications: type BP4704 (A3 and A3H), 6dB bandwidth −3.5 to +1kHz, insertion loss < 6dB, terminating impedance 1kΩ/15pF; type BP4705 (A3A and A3J), 6dB bandwidth +350Hz to −2.7Hz, insertion loss < 6dB, terminating impedance 1kΩ/15pF or 5 Ω; type BP4805, 2dB bandwidth 1.605 to 3.8MHz, insertion loss < 3dB, rejection at 1.4MHz > 70dB, terminating impedance 200Ω or 50Ω. Cathodeon Crystals Ltd, Linton, Cambridge.

WW 315 for further details

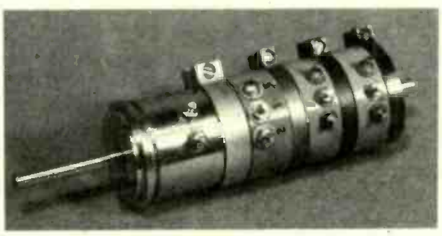
F.M. Signal Generator

An f.m. signal generator, model 188, manufactured by Measurements, of New Jersey, U.S.A., is available in the U.K. from Wessex Electronics. Two-speed tuning is featured and modulation can be internal or external. This can be measured in three ranges without the need for an external voltmeter. Frequency range is 86-108MHz with ±0.5% accuracy. Output is 0.1-100,000μV and modulation 400, 1,000 and 10,000Hz (internal). Deviation is in three metered ranges of 0-30kHz, 0-100kHz and 0-300kHz, and deviation response is within 1dB from d.c. to 75kHz. Wessex Electronics Ltd, Royal London Buildings, Baldwin Street, Bristol 1.

WW 316 for further details

Clutch/Brake Precision Potentiometer

Fairchild Controls have introduced a precision potentiometer incorporating a clutch/brake unit in one complete package. When the potentiometer is de-energized, the rotor-wiper is braked to prevent rotation imparted by shock, acceleration and vibration. At the same time, the input shaft is free to rotate. With the clutch/brake energized with 24-32V d.c., the input shaft is coupled to the rotor-wiper to permit adjustment of the potentiometer. The clutch/brake module is easily adaptable to all Fairchild Controls precision potentiometers ranging in size from $\frac{7}{8}$ to 3 in. Fairchild Controls, Seestrasse 233, 8700 Kusnacht, Zurich, Switzerland.



WW320 for further details

TO-3 Packaged Power Amplifiers

A family of hybrid i.c. class-D power amplifiers introduced by TRW Semiconductors Inc. is being marketed by MCP Electronics. The first four type specifications released are designated MCA1001/2 and MCB1001/2. They handle currents up to 10A from voltage lines up to 40V. With appropriate external connections a linear, efficient power control function is obtained. A complementary planar output stage is employed, and the circuits operate from a dual unregulated power supply. Typical electrical characteristics are: input hysteresis 200mV; input offset voltage 100mV; thermal resistance 2°C/W; switching time MCA series 1.0μs, MCB series 0.5μs. Absolute maximum ratings for the MCB1002 include: power stage supply voltage 40V; continuous d.c. output current 5A; peak output current (25% duty cycle), 10A; and switching frequency 40kHz. MCP Electronics Ltd, Station Wharf Works, Alperton, Wembley, Middx. HAO 4PE.

WW321 for further details

Current Monitor

A precision current monitor designed to replace the ammeter in the control of mechanical, electronic, heating and security systems is announced by G & M Electronics. When the input current exceeds or falls below the required setting, the monitor provides a signal. It is adjustable and can detect currents of the order of 1-10mA. Higher currents can be monitored by shunting the input with a precision resistor. For transient input currents, an optional lock-up feature is available, which retains the signal until reset. G & M Electronics Ltd, 46 Castle Road, Bedford.

WW304 for further details

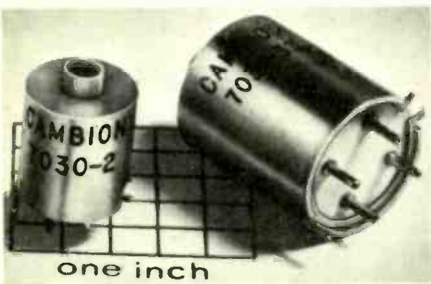
Wide-range Autobridge

Autobalance universal bridge, type B642, from Wayne Kerr measures an extended range of *R*, *L*, *C* and *G* values with an accuracy of 0.1%. Two meters respond immediately to changes in the resistive or reactive term of any impedance (including negative resistance) with decade controls available for backing-off to increase the discrimination up to 4 or 5 figures on all ranges. Normal frequency of operation is 10,000 radians/sec (1592Hz) but the bridge can be balanced manually at any frequency from 200Hz to 20kHz using an external source and detector. Analogue outputs are available from both meter circuits. Connectors are also provided for external standards. Sensitivity increases automatically as digits are backed-off; for special

applications, however, operators can select the sensitivity. This allows sudden changes to be accommodated without re-setting the back-off controls. The electronic nulling process is fully operative at all sensitivity levels. Overall measurement ranges are 1 femtofarad (0.001pF) to 10 farads, 10 picomhos to 100 kilomhos, 1 nanohenry to 10 megahenrys and 10 micro-ohms to 100gigohms. Two-terminal and three-terminal connections are available on most ranges, with a four-terminal arrangement to overcome lead losses for low impedance measurements. The bridge measures 482 × 311 × 152mm (19 × 12¼ × 6in) and weighs 11kg (24½lb). Wayne Kerr Co. Ltd., New Malden, Surrey.
WW309 for further details

Coils for P.C. Boards

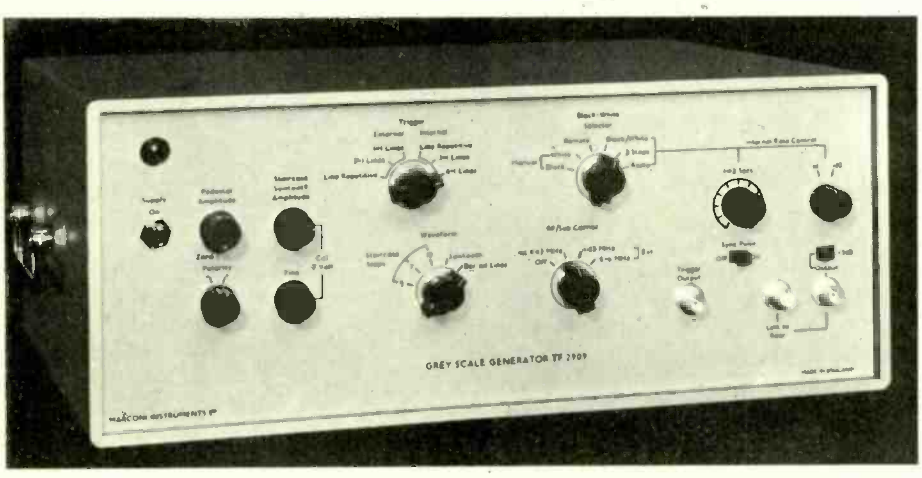
Cambion are now offering a range of shielded variable coils with pins that can be directly soldered to p.c. boards. Six coils in the series P/N558-7031, cover an induc-



tance range of 12-120mH. Individually the mean inductance values are 15, 22, 33, 47, 68 and 100mH with a variable range of ±20% from the mean. The coils are vertically tuned and have an operating temperature range of −55 to +125°C. Protection from both electrostatic and electromagnetic interference is claimed. Cambion Electronic Products Ltd, Cambion Works, Castleton, near Sheffield.
WW 318 for further details

Colour TV Grey-scale Generator

Designed for checking non-linear distortion on colour and monochrome 625-line television transmission systems a new grey-scale generator, type TF2909, is announced by Marconi Instruments. It offers a differential gain accuracy of 0.1%, a differential phase accuracy of 0.1° and a wide range of test facilities. When used together with the sine-squared pulse and bar generator TF2905/8 a versatile combination is formed which will perform a major number of tests required on TV transmission systems. For 525-line systems, version TF2909/1 and TF2905/9 are available. Output waveforms provided are: sawtooth, 5, 7 or 10 riser staircase on every line or on every 4th or 5th line, or full line bar on every line. An internal (crystal controlled) or external sub-carrier can be superimposed on the sawtooth or staircase with a colour burst on every line. Provision is made for an r.f. input of 0.5 – 6MHz and the generator can be locked to external pulses to produce a composite video waveform. Marconi Instruments Ltd, Longacres, St. Albans, Herts.
WW 314 for further details



Video Output Transistor

General Electric's (U.S.A.) 300V video output transistor type D40N is now available from Jermyn Industries. This transistor has a continuous rating of 300V, 6W, 100mA and the flat pins can be formed to TO5 or TO66 configurations. It is a silicon n-p-n power type suitable for video and audio output stages and for horizontal sweep drive. Price 15s each for 100 upwards. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW 315 for further details

Marine V.H.F. Radio-telephone

Cossor Electronics have announced a new solid-state 28-channel v.h.f. radio-telephone designed to meet international maritime specifications for ship-to-ship and ship-to-shore communications. It is designated type CC.414.ME28. Simplex and duplex operation is provided on the 50kHz channels 1 to 28 (maritime band) and the set can be easily modified to meet future 25kHz channel separation requirements. A dual watch facility is incorporated as standard and local control can be provided as an optional extra. Operation is stable over a wide range of battery voltages and protec-

tion is given against reverse polarity. The transmitter output is 20W and the receiver audio output 3W to a built-in loudspeaker. Power supply is a nominal 24V d.c. and a range of converters is available for operation from any a.c. or d.c. ships' mains. Transceiver and extended control unit can be bulkhead mounted. Cossor Electronics Ltd, The Pinnacles, Elizabeth Way, Harlow, Essex.
WW312 for further details

I.C. Mounting Cards

Dualine i.c.-cards available from Shirehall Electronics, are intended for mounting and interconnecting dual-in-line packages (up to 16-way), for development or test application. Two card sizes are available: DL 109 (95mm × 94mm), which will accept 9 i.cs and DL 110 (95mm × 152mm), for 15 i.cs—each with 22 gold-plated edge contacts. Each size is also available with double-sided contacts (44-way), designated DL 109/44 and DL 110/44. The board is s.r.b.p. with roller-tinned copper conductors, and supplied drilled ready to accept d.i.ps or i.c.-sockets. Supply lines are adjacent to all i.c. locations, which have 3-hole pads for ease of connection. Also provided are plain holes for terminal-pin into connection of circuit networks. These cards are part of the Dualine "100" series and fit any of the standard range of housings—pack, box, rack or case. The price range is 14s to 21s. Shirehall Electronics Ltd, Borough Green, Sevenoaks, Kent.
WW328 for further details

High-frequency Video Amps

Voltage gain of 20dB at 100MHz, five nanoseconds rise and fall times, and fixed or variable gain are features of a new group of monolithic video amplifiers being

→

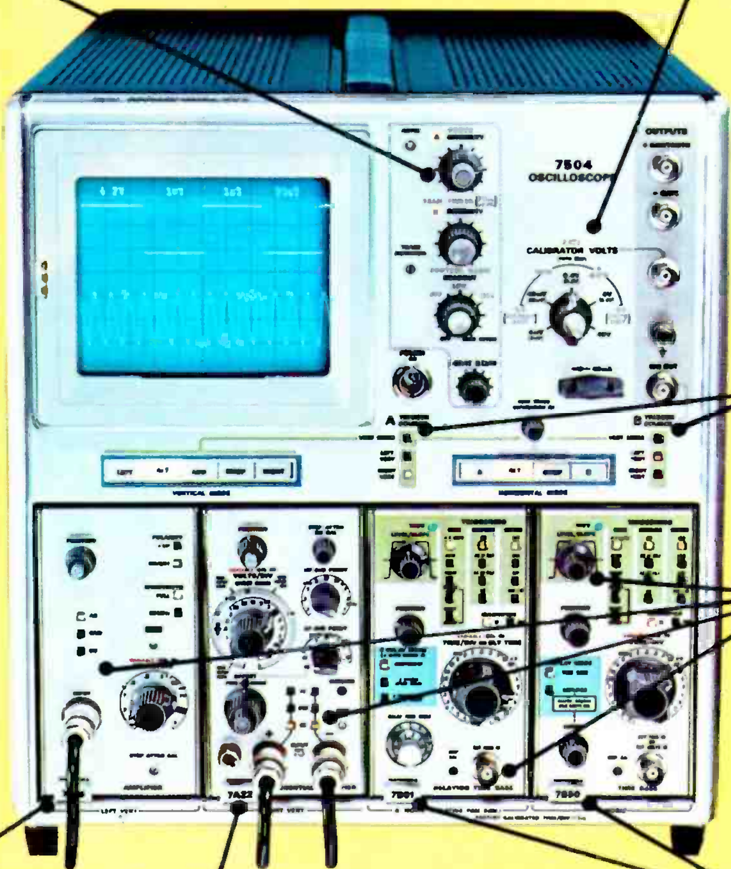
WW250 for further details

7504

OLS
" sweep, "B" sweep,
endently. A single-
gmatism adjustment,
complete the control

CALIBRATOR

A multi-function generator usable as a "standard" for calibration of voltage and current GAIN, time/div, and probe compensation. The output is DC or AC (1 kHz or variable) voltage or current (fixed at 40 mA). The amplitude accuracy is within 1% and the time accuracy is within 0.5% at 1 kHz.



TRIGGERING

The signals from both vertical plug-ins are coupled through a mainframe logic circuit and made available to each horizontal plug-in, selectable from LEFT channel, RIGHT channel, or slaved to VERTICAL MODE. The latter frees the operator from manual source changes during single-trace operation and, in conjunction with the P-P AUTO TRIGGER MODE in the time-base units, provides true hands-off triggering during routine measurements.

FOUR PLUG-IN CHANNELS

The modular approach is the answer to instrument flexibility. With dual-trace switching in the mainframe amplifiers, each plug-in can be "specialized" in function and operate in combination with other units. Thirteen plug-ins are currently available for the 7000-Series. Together, they represent the widest range of performance options for multi-trace, differential and sampling applications available today.

mplifier
2.4 ns tr) in the
) in the 7504.
liv at full band-

7A22 High-Gain Differential Amplifier

Bandwidth—DC to 1 MHz with selectable upper and lower —3 dB points.

Min deflection factor—10 μV/div at full bandwidth.

7B51/7B50 Time-Base Units for the 7504

5 ns/div maximum sweep speed. Operable singly or in combination for delaying sweep capability.

7M11 Delay Line Unit

Two 75 ns, 50-Ω delay lines. Trigger selection from either line.

7S11 Sampling Amplifier

Accepts the plug-in sampling heads for bandwidths to 14 GHz (25 ps tr).

7T11 Random Sampling Time Base

10 ps/div to 5 ms/div sweep range, accomplished with equivalent-time and real-time techniques.

Triggering to 12 GHz.

TEKTRONIX

NEW 7000 SERIES Plug-In Oscilloscopes

150 MHz Bandwidth . . .

USABLE performance to 150 MHz or 90 MHz. Combined mainframe and plug-in bandwidths are specified at minimum deflection factors with or without probes. With . . .

MORE Sensitivity . . .

Higher sensitivities are achieved at greater bandwidths than ever before. 5 mV/div at 150 MHz, 1 mV/div at 100 MHz and 10 μV/div at 1 MHz. With . . .

MORE Flexibility . . .

Each mainframe accepts up to four plug-in units. Thirteen plug-ins are currently available to cover virtually all multi-trace, differential, sampling, and X-Y applications. Plus . . .

NEW Convenience . . .

Greater convenience in all areas of instrument operation. Features such as Auto Scale Factor Readout, lighted push-button switching, and true automatic triggering assure faster, more accurate, less complicated measurements.

Please turn for additional information.

7704

AUTO SCALE FACTOR READOUT

A character generator senses the position of volts/div, amps/div, time/div, polarity, and uncalibrated variable controls, then accounts for probe attenuation and displays the correct scale factors for all channels directly on the CRT.

DISPLAY CONTR

Three intensity controls adjust "A
and READOUT brightness indep
focus control, a screwdriver ast
and a two-position beam finder
group.

BRIGHT TRACE

The acceleration potentials are 24 kV for the 7704 and 18 kV for the 7504 for improved trace visibility. Single-shot photographic writing speed is 3300 cm/μs (7704) measured with the standard P31 phosphor, the new C-51 camera and 10,000 ASA film. The display area is 8 cm x 10 cm with a parallax-free illuminated graticule.

DUAL-TRACE SWITCHING

Both the vertical and horizontal *mainframe* amplifiers are "dual trace" providing a unique level of flexibility with plug-in combinations. A relatively small number of plug-ins can then meet a wide range of application requirements. The CHOP and ALT modes permit simultaneous displays of delaying and delayed sweep, and, through switching logic, may be "slaved" to provide a functional dual-beam type of display.

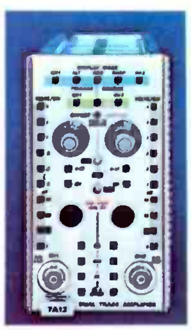
7A13 Differential Comparator Amplifier
Bandwidth—DC to 100 MHz (3.5 ns tr) in the 7704; DC to 75 MHz (4.7 ns tr) in the 7504. Min deflection factor—1 mV/div at full bandwidth.

7B71/7B70 Time-Base Units for the 7704
2 ns/div maximum sweep speed. Operable singly or in combination for delaying-sweep capability.

7A16 Wide-Band A
Bandwidth—DC to 150 MHz (
7704; DC to 90 MHz (3.9 ns tr
Min deflection factor—5 mV/d
width.

7A11 Captive FET Probe Amplifier
Bandwidth—DC to 150 MHz (2.4 ns tr) in the 7704; DC to 90 MHz (3.9 ns tr) in the 7504. Min deflection factor—5 mV/div at full bandwidth.

7A12 Dual-Channel Amplifier
Bandwidth—DC to 105 MHz (3.4 ns tr) in the 7704; DC to 75 MHz (4.7 ns tr) in the 7504. Min deflection factor—5 mV/div at full bandwidth.

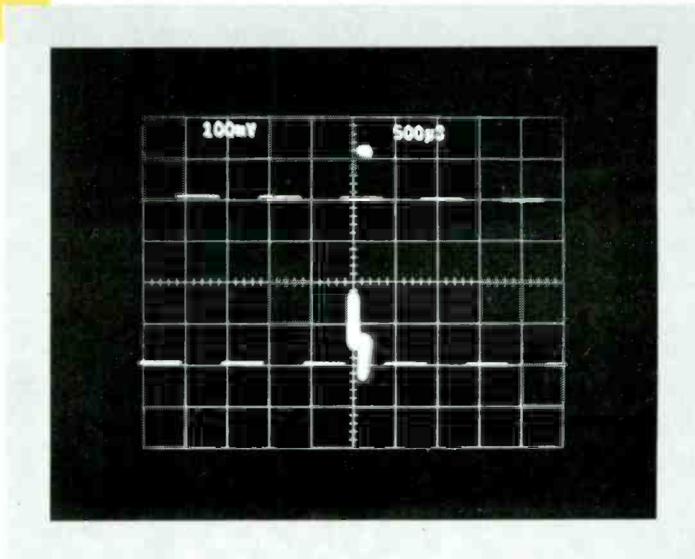


7A14 AC Current Probe Amplifier
Bandwidth—25 Hz to 105 MHz depending on mainframe and current probe; two probes available. Min deflection factor—1 mA/div at full bandwidth.

C-51/C-50 Trace-Recording Cameras

Two new compact trace-recording cameras have been designed for direct compatibility with the 7000-Series Oscilloscopes. The C-51 and C-50 cameras are basically identical units, differing only in the lens system. The C-51 has an f/1.2, 1:0.5 lens; the C-50 uses an f/1.9, 1:0.7 lens. The C-51 is recommended for single-shot photography at the fastest sweep rates, the C-50 for more general purpose applications. Photographic writing speed of the two 7000-Series mainframes with the C-51 and 10,000 ASA film (without prefogging) is 3300 cm/μs (7704) and 2500 cm/μs (7504).

The cameras offer a new level of operational convenience for mistake-proof trace photography. The guess work normally associated with selection of f stop and shutter speed to match the ASA index and trace brightness is eliminated. After setting the ASA index, the built-in photometer allows a *visual* correlation of trace intensity to the correct f stop setting and shutter speed. After initial adjustment, a change of f stop or shutter speed will still maintain the same exposure. Focusing is accomplished by two beams of light projected on the CRT which, when superimposed, indicates optimum focus. The insert shows the photometer spot and the rangefinder focusing images.



SCOPE-MOBILE® CARTS

The 204-2 Scope-Mobile® Cart is specifically designed for the 7000-Series instruments. It provides a securing mechanism for the oscilloscope, nine positions of selectable tray tilt, a large storage drawer, storage for five 7000-Series plug-ins, and large locking-type wheels.

PROBES

The P6053 is a miniature fast-rise 10X probe designed for full compatibility with the 7000-Series instruments. Input R and C is 10 MΩ, 10.3 pF. Probe risetime is 1.2 ns or less.

The P6052 is a passive dual-attenuation probe designed for measurements below 30 MHz. A sliding collar selects 1X or 10X attenuation. Input R and C is 1 MΩ or 10 MΩ, 100 pF or 13 pF. Risetimes are 60 ns (1X) and 7 ns (10X).

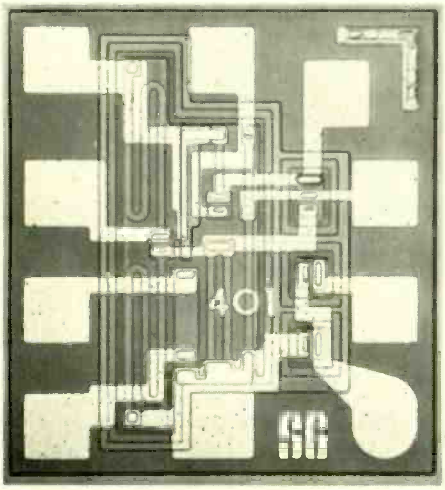
7704 Oscilloscope	£1,167
7504 Oscilloscope	£933
7A11 Amplifier Plug-in	£397
7A12 Amplifier Plug-in	£327
7A13 Amplifier Plug-in	£513
7A14 Amplifier Plug-in	£268
7A16 Amplifier Plug-in	£280
7A22 Amplifier Plug-in	£233
7B71 Time-Base Plug-in	£320
7B70 Time-Base Plug-in	£280
7B51 Time-Base Plug-in	£238
7B50 Time-Base Plug-in	£210
7S11 Sampling Plug-in	£210
7T11 Sampling Time-Base Plug-in	£513
7M11 Dual Delay Line Unit	£117
204-2 Scope-Mobile ® Cart	£85+£11.6.0 duty
C-51 Trace-Recording Camera	£427+£97.4.0 duty
C-50 Trace-Recording Camera	£333+£75.16.0 duty
P6052 or P6053 Probes	£24+£3.8.0 duty

Delivered U.K.

Tektronix U.K. Ltd. *Beaverton House, P.O. Box 69, Harpenden, Herts.*
Telephone Harpenden 61251. Telex: 25559

For overseas enquiries: **Australia**: Tektronix Australia Pty. Ltd., 4-14, Foster Street, Sydney, N.S.W. **Canada**: Tektronix Canada Ltd., Montreal, Toronto & Vancouver. **France**: Relations Techniques Intercontinentales, S.A., 91, Orsay, Z.I. Courtaboeuf, Route de Villejust (Boite Postale 13). **Switzerland**: Tektronix International A.G., P.O. Box 57, Zug, Switzerland. **Rest of Europe and the Middle East**: Tektronix Ltd., P.O. Box 36, St. Peter Port, Guernsey, C.I. *All other territories: Tektronix Inc., P.O. Box 500, Beaverton, Oregon, U.S.A.*

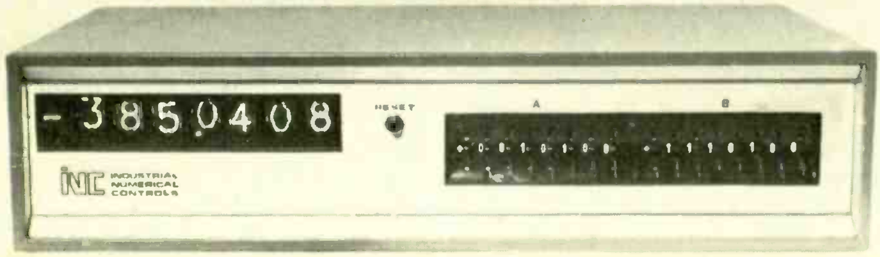
introduced by Silicon General (U.S.A.). Requiring only 100mW of power at 12V the series 401 high-frequency video amplifiers also offers single-supply operation and symmetrical limiting. Internal emitter followers are used to achieve high input and low output impedances, allowing simple capacitor coupling. Biasing and gain-setting resistors are internally diffused, eliminating external resistor networks. The gain may be



externally varied through the use of a.g.c. diodes which are included in the circuit. These devices are designed to provide maximum versatility as general purpose, single-ended amplifiers. Typical applications include use as i.f. and r.f. amplifiers, symmetrical non-saturating limiters, oscillators, low-level audio stages and for automatic gain control and pulse amplification. The SG1401 operates over the temperature range −55° to +125°C while the SG2401 and SG3401 are designed for 0° to +70°C. Various packages are available. Price: (1000 pieces) $1.10 to $2.25 depending on temperature range. Silicon General, Inc., 7382 Bolsa Avenue, Westminster, California 92683, U.S.A.
WW301 for further details

Presettable Counters

Built-in facilities for programme presetting are a feature of a range of bi-directional or reversible counters. Series III, introduced by Industrial Numerical Controls. This enables an external function to be operated at a preset count by means of an internal relay rated at 250 a.c., 7.5A. the basic counter has an input sensitivity from 100mV pk-pk to 250V r.m.s., a frequency range of d.c. to 50kHz, and a 15.5mm numerical tube display with plus, minus and decimal point indication. Each counter incorporates two input sockets A and B. Three standard inputs are available: (1) input to A adds, input to B subtracts, (2) input A counts, input to B determines whether count is add or subtract, (3) inputs A and B are two sine- or square-wave signals 90° out of phase. Voltage supplies are provided for energizing external transducers. Temperature range of the Series III is 0-60°C and the case size is 450 × 240 × 110mm. Operation can be from 110 or 240V 50-60Hz supplies. Industrial Numerical Controls Ltd, P.O. box 8, Portland Street, Accrington, Lancs.
WW306 for further details

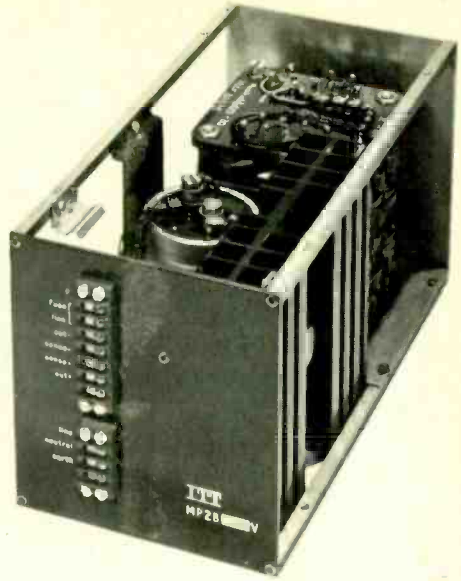


Contactless Signal Couplers

The first in a range of contactless signal couplers based on gallium arsenide emitters and light-to-current convertors contained in a single device, is announced by MCP Electronics. Type ISC52 is a high-sensitivity, medium-speed, low-voltage device primarily intended for d.c. insulated connections in telephone terminals and computer peripherals. Input and output are insulated from each other, electrically, therefore no loading effects are felt at the input when circuit conditions change at the output. Bandwidth covers many more octaves than transformers, starting at genuine d.c. Thus in digital applications no d.c. restoration is necessary. With the ISC52 a typical input necessary to produce a "useful" output is 7.5mA. Recommended supply voltage is 3V and typical rise time 10μ sec (4μ sec in a special version). Fan out is 3. In digital applications, four modes of operation are possible: voltage in/voltage out, voltage in/current out, current in/voltage out, and current in/current out. Input/output insulation will withstand several hundred volts. The pin pattern is spaced at 2.54mm pitch. MCP Electronics Ltd, Alperton, Wembley HAO 4PE.
WW 313 for further details

Stabilized Power Supplies

ITT Components Group have introduced an extension to their existing range of stabilized power supplies. The new MP range is designed to provide high quality sub-units at low cost for incorporation



into customers' own equipment. It is available in output d.c. current ratings of 0.5, 1, 2, 3, 5 and 10A and each current rating may be specified in stabilized output voltage ranges of 0-16, 30 and 50V. Two versions of each unit are offered: industrial, to meet most normal industrial requirements, and professional where severe performance parameters are demanded. Basic power supply is identical in both versions but voltage stability in the professional model is achieved with a monolithic i.c. Stability ratio of the industrial version is 1000:1 above 6V output and 250:1 below, compared with 10.000:1 at all levels for the professional version. Ripple is 500μ V and 200μ V respectively. Output current is automatically reduced when a fault occurs, and it returns to normal when the fault is rectified. ITT Components Group Europe, Rectifier Product Division, Edinburgh Way, Harlow, Essex.
WW302 for further details

N-Channel GaAs Transistor

An n-channel gallium arsenide field effect transistor, type GAT1, particularly suitable for u.h.f. low-noise amplifier applications, is being produced by Plessey. It has high transconductance—typically 6mmhos at 900MHz, and low input and feedback capacitances (around 1pF and 0.15pF respectively). Housed in a four-lead TO-18 package, the device operates up to 1.5GHz, and offers low noise characteristics, typically 3.5dB at this frequency. Common source power gain is a minimum of 10dB at 1GHz. Power supply requirements are 5V for the source-drain, and up to 12V for the gate. Plessey Components Group, Microelectronics Division, Optoelectronic and Microwave Unit, Wood Burcote Way, Towcester, Northants NN 12 7JN.
WW326 for further details

Video Delay Lines

Matthey Printed Products announce a new range of Silver Star video delay lines for 625-, 525- or 405-line colour television

transmission, designed jointly with the B.B.C. Three small fixed modules replace bulky delay cable and equalizer circuits and provide 75-μ delays of 200 and 500ns and 1μ s. Built in equalizers give insertion loss/frequency response of 0.7dB, 1.5dB and 2.6dB $\pm$ 0.1dB respectively up to 5.5MHz. The modules simply plug in and no adjustment is necessary. Data sheets are available on request. Matthey Printed Products Ltd, William Clowes Street, Burslem, Stoke-on-Trent.
WW305 for further details

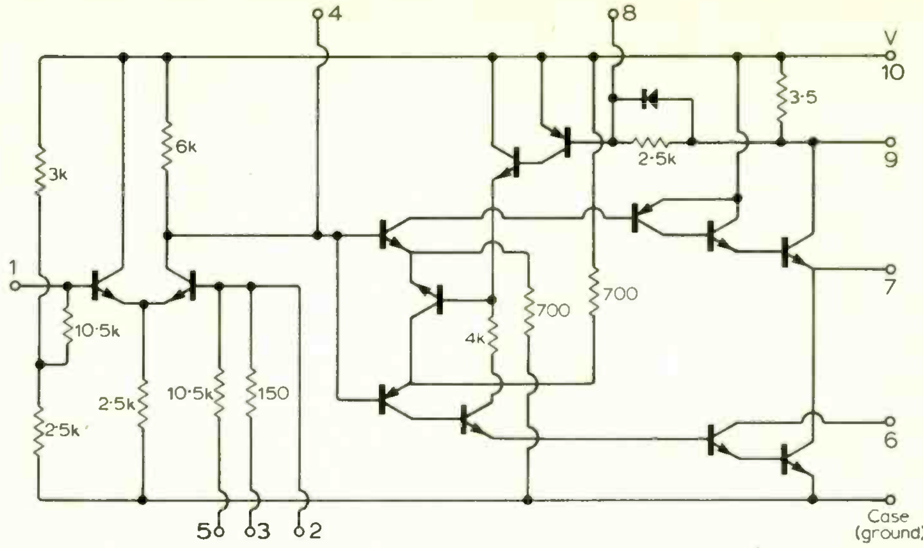
Field Strength Meter

G.P.O. Radio Receiver type 35A, available from Microwave International, is a portable transistorized field-strength meter used for the measurement of radiated field strength and conducted voltages in the v.h.f. frequency range 34-225MHz. The receiver is powered by three 8.4V dry batteries. A dipole aerial with adjustable telescopic elements is used for the measurement of field strengths. The output meter is scaled to read microvolts or dB relative to 1μV. The dynamic range of the meter is

from 10-100μV and 0-40dB relative to 1μV. Two 20dB attenuators and one at 10dB are provided. These may be switched into the i.f. amplifier permitting voltages up to 90dB above 1μV to be measured. A standard jack socket is provided on the front of the receiver enabling an operator to listen to the transmitted signal via an audio amplifier. The case is fitted with shoulder straps and carrying handle. Microwave International (U.K.) Ltd, 33-37 Cowleaze Road, Kingston-upon-Thames, Surrey.
WW327 for further details

I.C. Audio Amplifier

Designed for use in consumer products such as radio and TV receivers and for industrial applications such as servo amplifiers, the 3-W audio amplifier, type M5102Y, from U.E.C.L. is available in a 10-lead TO3 type package. The function of the device is that of a driver and power



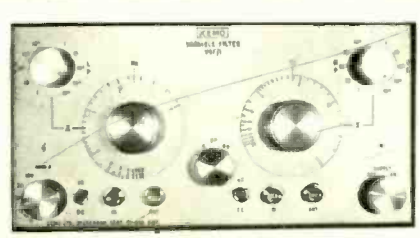
amplifier. Sensitivity is 50mW for 3W output and voltage gain 37dB. Other characteristics are: input resistance 7kΩ, output resistance 0.2Ω, bandwidth 50Hz to 70kHz and distortion $<$0.2%. With a supply voltage of 13.2V (nominal 12V car supply), it is capable of delivering up to 2W output power without a fin or 3W with the incorporation of a fin. This device can be obtained on a cash-with-order basis at £2 2s (including post). Ultra Electronics (Components) Ltd, Microelectronics Division, 35-37 Park Royal Road, London N.W.10.
WW329 for further details

High-power Op. Amp.

Originally designed for work with the Australian Electricity Board, the Ancom 15A-1b high-power op. amp. is now available as a standard production item. It has an output of $\pm$ 10V at $\pm$ 10mA and a typical open loop gain of 36,000. Frequency response is 2MHz at small signal unity gain, and offset voltage and current are 5μV/°C and 6nA (differential input). The module, which occupies only 12.3cm^3, is fully protected against overload. Ancom Ltd, Devonshire Street, Cheltenham, GL50 3LT.
WW320 for further details

Tunable Filter

A twin-channel tunable filter, type VBF/1 comprising two fourth-order Butterworth filters which can be each used in the high-pass or low-pass configuration, has been announced by KEMO. Each section has a cut-off rate of 24dB/octave. The channels can be used in series or parallel to produce a bandpass or band reject response. Alternatively with both units



switched to high- or low-pass function a cut-off of 48dB/octave can be achieved. The voltage gain is unity while channel 1 has additional amplification of $\times$3, $\times$10, $\times$30 and $\times$100. Input impedance is 100kΩ and output impedance 50Ω. The instrument is continuously variable from 1Hz to 100kHz using five switched-in decade ranges. The noise level referred to input is 5μV. Price of the VBF/1 is £250; dimensions 254 $\times$ 140 $\times$ 190mm. KEMO (Consultants) Ltd, 42 Chancery Lane, Beckenham, Kent.
WW303 for further details

10-turn Potentiometers

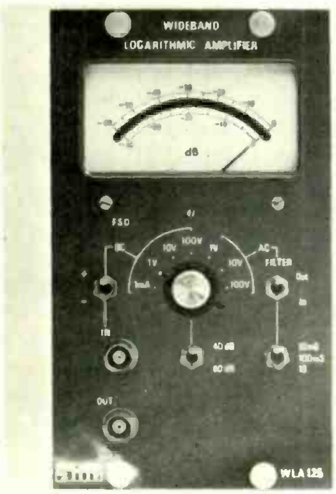
Precision 10-turn potentiometers with 0.2% linearity in less than 1 cubic inch have been introduced in the U.K. by GDS (Sales). These potentiometers, the Fairchild MF-78 series, are available in nine standard resistance values from 500Ω to 125kΩ with 3% tolerance. Rating is 2W at 40°C and resolution is

from 0.007% (125kΩ) to 0.033% (500Ω). It is claimed that the wiper carriage and drive will withstand severe shock and vibration without deterioration in performance. Cost of the MF-78

potentiometers is 98s 6d (quantity 1-9). GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
WW308 for further details

Logarithmic Amplifier

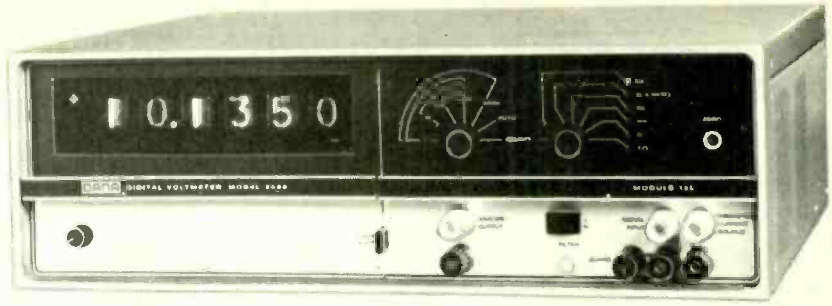
A wideband logarithmic amplifier, type WLA125, has been announced by AIM. It is a 100mm module designed for fields where exponential functions occur or where dynamic range may be unknown. The amplifier has a range of 60dB for a.c. and d.c. signals in a voltage mode, and 40dB for d.c. signals in a current mode. Three input



a.c. and d.c. voltage ranges are provided, giving coverage from 1mV to 100V, and a current range from 10μA to 1mA. Output is a proportional d.c. voltage of 50mV/dB via a front panel socket. There is also a built-in meter with an accuracy of 0.3dB at f.s.d. Frequency range is from 5Hz to 3kHz on the 1V range or 5Hz to 300kHz on the 100V range. The unit is driven by AIM PSU101 power supply module. The addition of a frequency-to-voltage convertor, FVC 250A, makes the logarithmic amplifier suitable for the measurement of frequency-dependent variables. Price £220. AIM Marketing Division, The River Mill, St. Ives, Huntingdon.
WW 317 for further details

Digital Multimeter

Dana Electronics have introduced a digital multimeter, type 5500, which will provide 1μV d.c. resolution and additionally can give a.c. voltage, ohms and ratio readings. All readings are remotely programmable. Three models are available: the 5500/112, a d.c.-only unit, the 5500/130 and 5500/135, basically d.c. units which can be modified by plug-in cards to add either a mean-sensing a.c. convertor or a computing r.m.s. a.c. convertor. An ohms convertor can be added to the computing convertor. The 5500 is a five-digit instrument, with six-digit over-range giving a d.c. accuracy



of ±0.005% plus one digit. Input resistance is 10,000MΩ. The computing r.m.s. convertor provides true r.m.s. readings up to 3:1 crest factor and the resistance measurement option for model 135 gives f.s.d.s of 10, 100, 1,000Ω and 10, 100, 1,000 and 10,000 kΩ with a resolution of 100μΩ. Model 135 is fitted with an analogue output facility permitting direct driving of external devices. Outer case measurements are 430mm wide (482mm for rack mounting) by 95mm high and 445mm deep. Prices around £1,350. Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Beds.
WW 311 for further details

Portable Sound System

A p.a. system and radio microphone receiver combined with a loudspeaker in one transportable unit is being offered by Reslosound. An amplifier with an output of 10W and a frequency response of 50Hz to 10kHz ±3dB is used, and there are three low-

impedance microphone inputs. Controls include separate bass and treble cut and boost. The radio microphone receiver incorporated is a standard unit working at 174.8MHz. It is complete with a 430mm telescopic aerial and a coaxial aerial socket. The loudspeaker enclosure contains three 200mm cone units. Additional loudspeaker systems can be connected where required and alternative signal sources can be fed into the amplifier. This unit, designated ISR/10, can be used in conjunction with any Reslo Audac transmitter. It measures 855×305×230mm and weighs 13.5kg. Reslosound Ltd, Romford, Essex.
WW 319 for further details

Switching m.o.s.f.e.ts with low On-Resistance

Two p-channel m.o.s.f.e.ts, 3N167 and 3N168, from Siliconix have built-in zener diodes between gate and body to eliminate static-charge accumulation on the gate (a potential source of oxide breakdown). Drain/source, gate/source and gate/drain breakdown voltages are 30V (3N167) and 25V (3N168); threshold voltage is 6V maximum. On resistances $r_{ds(on)}$ are 20 and 40Ω maximum respectively for the 3N167 and 3N168; drain or source cut-off current I_{dss} is less than 0.5nA and 1nA respectively. The encapsulation is TO-72. Siliconix Limited, Saunders Way, Sketty, Swansea.
WW324 for further details

Fast Thyristor Family

A new family of fast-switching thyristors announced by Mullard is intended for pulse modulation in radar equipment. The thyristors, which comprise the BTX95 series and have SO-35A encapsulation, can switch peak powers of up to 150kW at 5kHz. Voltage ratings are from 500 to 800V. They have a low forward voltage drop during conduction and a dI/dt rating of 1000A/μs. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW322 for further details

Correction

In last month's issue, p.196, the new audio transformers by Gardners have a 2,000V capability, not 20,000V as stated. They come in three basic sizes, not two.

Real and Imaginary

by "Vector" (with apologies to Longfellow)

Electronic totem

Where the turgid Thames drifts slowly
Slowly, slowly ever seaward
To the oil-slicked North Sea water
Past the Big Smoke tranquil rising
From the lodges of the Koknees
In the land of Owsyerfarver,
Dwell the tribesmen of West-minster
Loafing in their hot-air wigwams
—House of Lords and House of Commons—
Making laws for all the nation
(Except when on the beach at Capri)
Driving all the common people
Up the creek without a paddle.

There the bigger smoke drifts heavenward
From the pipe of Aroldwilson
Aroldwilson, chief of chieftains
Overlord of all trade unions
Father of the Labour party
Patron saint of all the Scillies,
Wily, crafty Aroldwilson
Smokes the calumet, the peace-pipe
Planning strategy and tactics
For the General Election.
See the puffs of smoke arising
In a simple on-and-off code
Summoning the beavers to him
—All those not-so-eager beavers
Chiefs of all the Civil Service—
From their lodges hard by Whitehall.
See Ahmeek the King of Beavers
(Wedgewood Benn in paleface language)
Wedgewood Benn the King of MinTech
Sitting in his lodge in Whitehall
Amid the clatter of the tea-cups
Awaiting word from Aroldwilson.

See the blue-grey smoke arising
From the tenth tepee at Downing
"Come at once, O King of Beavers
Remove the Pb! do not dally
Or my tomahawk may chop thee"
—Thus the message in the smoke-rings
From the pipe of Aroldwilson
From the chief of all the chieftains.

In the tenth tepee at Downing
In the lodge of Aroldwilson
Sits Eye-Bee-Em the great computer
—Eye-Bee-Em the magic maker
From the land across the water
Bought with many bales of wampum

To foretell for Aroldwilson
All the fortunes of his party
In the General Election
In the choosing by the people
Of their true accepted leader.
Will they root for Aroldwilson?
Or for Edward the Digressor?
(Full of blandishments and pleadings
For a chance to prove his mettle.)
"Welcome in, O faithful Wedgewood
Welcome in, my dear old china!"
Thus the voice of Aroldwilson
As he stands beside the lodge-pole
Of the tenth tepee at Downing
While Eye-Bee-Em the great computer
Crouches monstrous in the background
Winking evil eyes of neon
Muttering incantations darkly.
"Bend thy head O Chief of MinTech"
(Thus Aroldwilson, *sotto voce*)
"Let me whisper in thy ear-hole
Lest Eye-Bee-Em should overhear me
For I fear this Yankee monster
Which thou didst connive to get me
On the never-never system.
List, O Wedgewood and I'll tell thee
Reasons for my dark forebodings
About this diabolical computer
And, when I have done the telling,
Thou must be the judge of whether
I am round the twist of reason."

Thus the voice of Aroldwilson
In the ear of trusty Wedgewood
"Know you, O my Chief of MinTech
That I, when more than apprehensive
Of our fate in the Election
Have, at divers times and often
Turned to Eye-Bee-Em for solace
Feeding him with signs and portents
Trends and tendencies together!
All the data I have gathered
Into appetising programs
That Eye-Bee-Em may work his wonders
And tell us plainly of the future
Who will win the next election.
But alas! I fear that gremlins
Are having fun with his internals
With L.S.D. his memory filling
Giving him hallucinations
For, no matter how he's programmed
His print-out message never varies
—Always 'The Star-Spangled Banner'
Every verse and every chorus—
While upon his cathode-ray tube
Appears the picture of a wasteland
Charred and blackened tree-stumps lying
Upon a plain of ling and heather.
—Tell me, Wedgewood, tell me truly
Are we harbouring a nut-case
Within the walls of this computer?"

At these words the face of Wedgewood
—Wedgewood Benn the Chief of MinTech—
Turns as pale as any spectre's
" 'Tis a curse!" he mutters weakly
"'Tis the curse of Little Neddy!
They have wished this ill upon us
Because we bought a Yank computer
They have tampered with its innards
Rigged the print-out to remind us
Of its foreign antecedents
Every time we seek to use it."
"—But the picture?" Aroldwilson
Quavers as his peace-pipe
Shatters in a hundred fragments
On the wigwam's floor before them.
"Why the wasteland, bleak and sombre
Why the desolated landscape?"
Wedgewood's face is grim and tortured
As he answers Aroldwilson
" 'Tis an omen! 'tis a symbol!
'Tis a dreadful allegory
Of the General Election.
'The blasted Heath' is plain its message
Written in the beam's electrons
Of the cathode-ray display tube!"

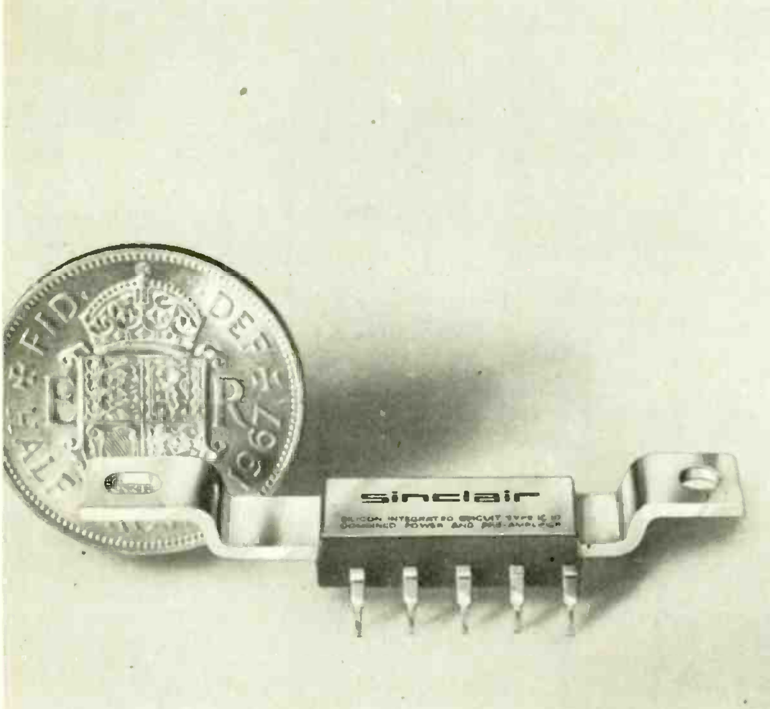
Still the bigger smoke drifts heavenward
From the pipe of Aroldwilson
(Stand-in for the fractured favourite)
Aroldwilson, chief of chieftains
Planning strategy and tactics
How to win the wayward voters
Of electronics engineering
How to placate Little Neddy
(Free research for every member?
Green stamps with every MinTech contract?
Banish every Yank competitor?)
Aroldwilson, chief of chieftains
Feeding all the trends and portents
To a *British-made* computer
Obtaining now much cheerier answers
(At least he does when it is working).

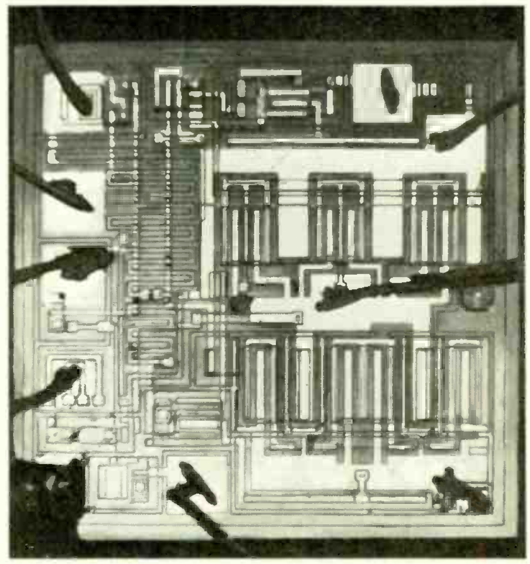
So at last we leave our hero
Overlord of all trade unions
Father of the Labour party
Dispensing cheer to all his cohorts
Via a British-made computer
(And, of course, those daily columns
Disclosing what the stars foretell us)

"Vector" has pointed out that a printer's gremlin sabotaged a sentence in his March contribution. The sentence in question, in the middle column, should have read "John's definition of high-quality reproduction was a big bad *woof* in the bass register . . ." not "big bad wolf"!

SINCLAIR IC-10

MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP





A 13 transistor circuit measuring only one twentieth of an inch square by one hundredth of an inch thick!

the world's most advanced high fidelity amplifier

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a full guarantee on every IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

■ SPECIFICATIONS

Output:	10 Watts peak. 5 Watts R.M.S. continuous
Frequency response:	5 Hz to 100 KHz ± 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100.000.000.000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

■ APPLICATIONS

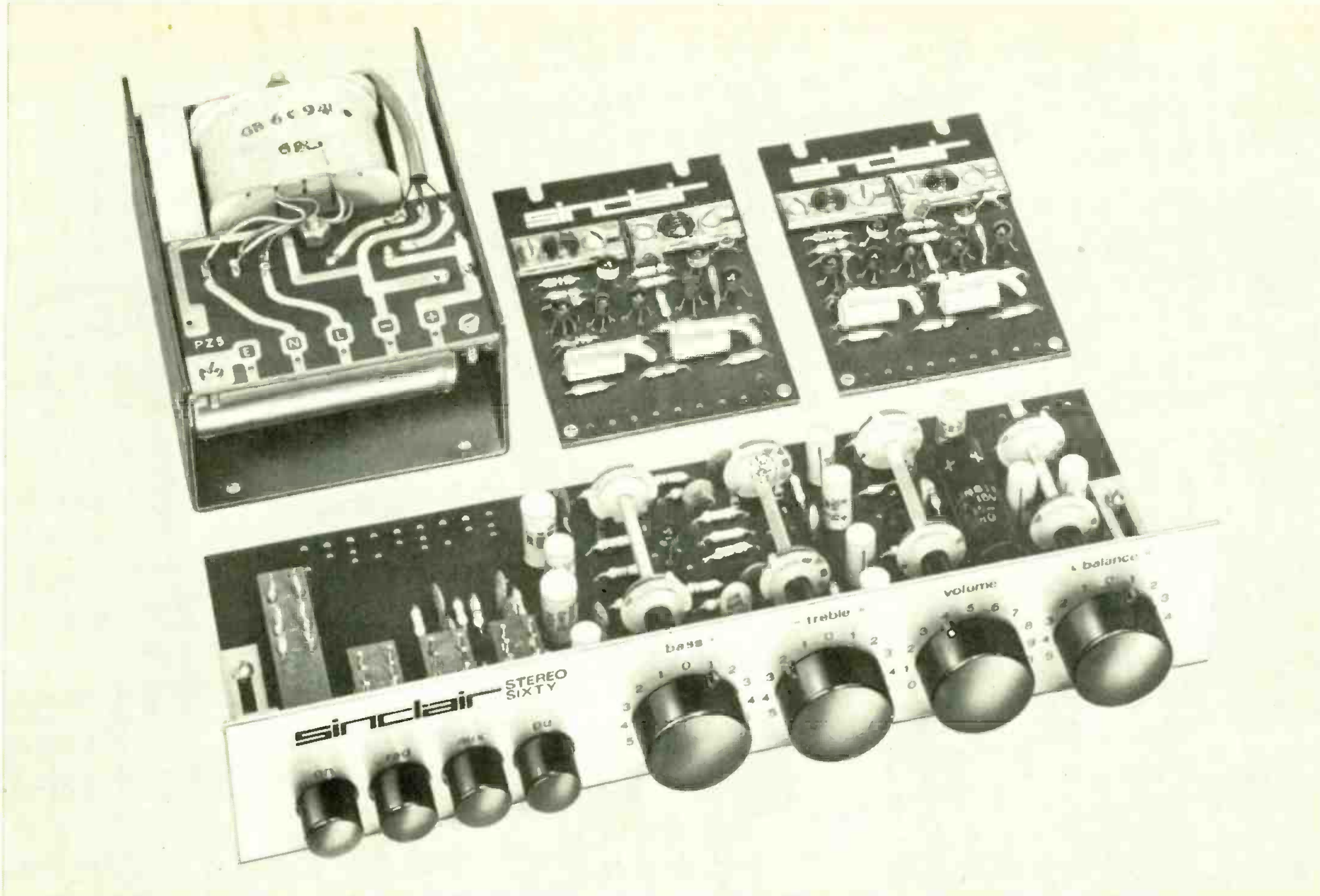
Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

SINCLAIR
IC-10 *with IC-10 manual Post free.* **59/6**

sinclair

SINCLAIR RADIONICS LTD. 22 NEWMARKET ROAD, CAMBRIDGE
Telephone: 0223 52731

WW—108 FOR FURTHER DETAILS



Project 60 an exciting alternative

It is not likely that anyone purchasing an amplifier today would have difficulty in finding one that met all his requirements, although the price might not be as low as could be wished. But one's needs can change, also the technically correct amplifier may be physically inconvenient. If there is an amplifier available, of the right size and price, to meet all your needs for the foreseeable future, then that is your best buy. If not, we offer a possibility which we believe to be an exciting alternative approach. That alternative is **Project 60.**

Project 60 now comprises a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance. Now with the addition of three new modules to the range, the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules now are: **1.** The Z.30 and Z.50 high gain power amplifiers, each of which is an immensely flexible unit in its own right. **2.** The Stereo 60 preamplifier and control unit. **3.** The Active Filter unit with both high and low audio frequency cut – offs. 4. The PZ.5 and PZ.6 power supplies. A complete system could comprise, for example, two Z.30's one Stereo-60, and a PZ.5. The PZ.6 is stabilised and should be used where the highest possible continuous sine wave rating is required. An A.F.U. may be added later. In a normal domestic application, there will be no significant difference between using PZ.5 or PZ.6 unless loudspeakers of very low efficiency are being used, in which case the PZ.6 will be required. For assemblies using two Z.50's there is the new PZ.8 supply unit to ensure maximum performance from these amplifiers.

All you need to assemble your Project 60 system is a screwdriver and soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly. Project 60 modules have been carefully designed to fit into virtually all modern plinth or cabinets and only holes need be drilled into the wood of the plinth to mount the control unit. Any slight slip here will be covered by the aluminium front panel of the Stereo 60. The Project 60 manual gives all the buildings and operating instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as the latest additions to the range show. A stereo F.M. tuner is next to come. These and all other modules we introduce will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

sinclair

SINCLAIR RADIONICS LTD · 22 NEWMARKET ROAD · CAMBRIDGE
Telephone: 0223 52731

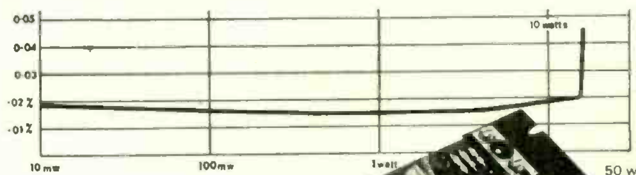
WW—109 FOR FURTHER DETAILS

Z-30 TWENTY WATT R.M.S. (40 WATT PEAK) POWER AMPLIFIER

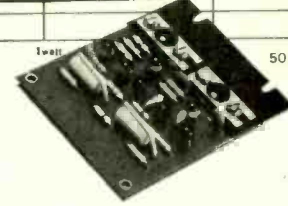
The Z-30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z-30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z-30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z-30, are covered in the Project 60 manual.

APPLICATIONS

High fidelity amplifier; car radio amplifier; record player fed direct from pick-up; intercom; electronic music and instruments; P.A., laboratory work, etc. Full details of these and many other applications are given in the manual supplied with your Z.30.



Power versus distortion curve of Sinclair Z.30.



Z.30
Ready built, tested and guaranteed, with Z.30 manual.
89/6

SPECIFICATIONS

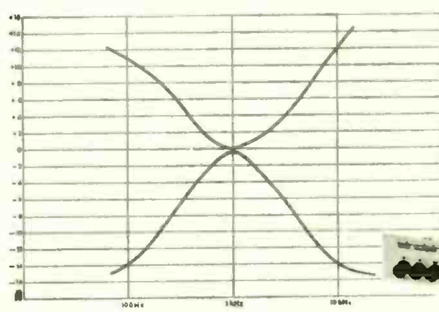
Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply; 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

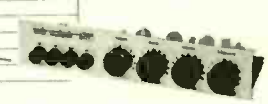
Frequency response:	30 to 300,000 Hz ± 1dB.
Signal to noise ratio:	better than 70dB unweighted.
Distortion:	0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.
Size:	3½ x 2¼ x ½ inches.
Input sensitivity:	250mV into 100 Kohms.
Damping Factor:	>500.
Loudspeaker impedances	3 to 15 ohms.
Power requirements:	8 to 35 V.d.c.

STEREO 60 PREAMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.



Treble and bass control curves

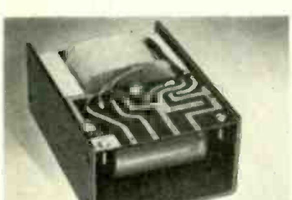


STEREO 60
Ready built, tested and guaranteed
£9 19s.6d.

SPECIFICATIONS

- Input sensitivities—Radio—up to 3mV: Magnetic Pickup—3mV Correct within ± 1dB on R.I.A.A. curve. Ceramic Pickup—up to 3mV: Auxiliary—up to 3mV.
- Output—250 mV.
- 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 100 Hz.
- Power consumption 5mA.
- Power requirement—PZ.5 or PZ.6.
- Finish—brushed aluminium front panel with black knobs.
- Mounting—on cabinet front by spindle bushes and adjustable brackets.

SINCLAIR POWER SUPPLY UNITS



PZ-5 30 volts unstabilised—sufficient to drive two Z-30's and a Stereo 60 for the majority of domestic applications.
£4 19s. 6d.

PZ-6 35 volts stabilised—ideal for driving two Z-30's and a Stereo 60 when very low efficiency speakers are employed.
£7 19s. 6d.

PZ-8 45 volts unit for use with two Z-50's and Stereo 60 (less mains transformer).
£5 19s. 6d.

BUILDING A PROJECT 60 ASSEMBLY

The illustration here shows quite clearly how easily Project 60 can be contained in one of today's slim, modern plinths. Very little space is required to house these Sinclair units, and within the space of the motor plinth, you can install a stereo amplifier of the very highest quality. If, for example, you have already put together an assembly as illustrated here, adding the Active Filter Unit would be very easy.

GUARANTEE

If at any time within 3 months of purchasing Project 60 modules 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.

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for which I enclose cash/cheque money order

NAME.................................
ADDRESS.................................

WW470

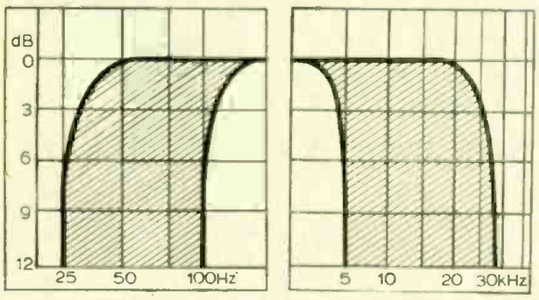
New for Project 60

Active Filter Unit

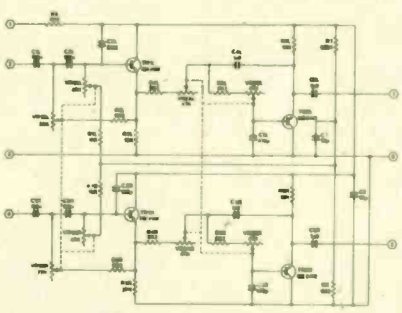
The Sinclair Active Filter Unit is a new addition to our Project 60 range of high fidelity modules and is designed to complement the other modules in the range. Its performance is such, however, that users of other amplifier systems might well consider adding it to their assemblies.

The purpose of a filter unit is to reject frequencies above (scratch) or below (rumble) a specific cut off frequency when these frequencies contain unwanted interference. The Sinclair A.F.U. is unique in that the cut off frequency is continuously variable for both the scratch and rumble units and, as the attenuation in the rejection band is rapid (12dB per octave), the removal of interference can be achieved with less loss of the wanted signal than has previously been possible.

Each channel of the A.F.U. has an overall gain of unity and, as the imput impedance is high and the output impedance is low, it may be connected between the pre-amplifier and power amplifier sections of any amplifier. Both amplitude and phase distortion have been made quite negligible by the careful design and the large amount of negative feedback employed.



HIGH PASS LOW PASS


Circuit Diagram of Sinclair Active Filter Unit

Specifications

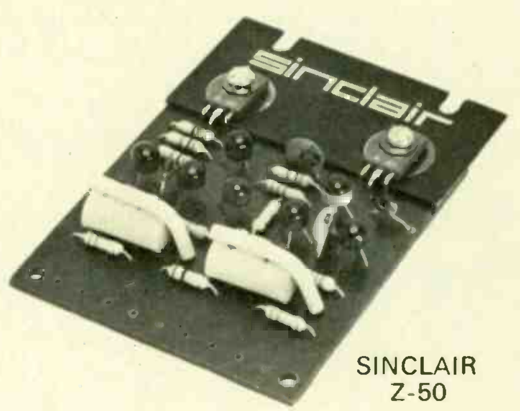
Designed for connection between the Stereo 60 pre-amplifier and two Z-30 or Z-50 power amplifiers.
Employs two Sallen & Key type active filter stages, the first being a rumble (high pass) filter and the second a scratch (low pass) filter. The two stages use complementary transistors to minimise distortion.
Supply voltage 15 to 35V Current 3mA max.
Gain at 1KHz, filters flat 0.98 (—0.2dB)
H.F. cut off (—3dB) variable from 28kHz to 5kHz
H.F. filter slope 12dB/octave
L.F. cut off (—3dB) variable from 25Hz to 100Hz
L.F. filter slope 12dB/octave
Distortion at 1kHz (35v supply) 0.02% at rated output (250mV R.M.S.)
Frequency response, flat position, 35Hz to 20kHz—1dB
25Hz to 28kHz—3dB

Built, tested and guaranteed £5.19.6

Z-50 FORTY WATT R.M.S. (80 WATT PEAK) HIGH FIDELITY POWER AMPLIFIER

The Z-50 has been designed for applications requiring higher output power than the Z-30. The maximum supply voltage is raised to 50 Volts and the output power is **40 watts continuous R.M.S. into 3 or 4 ohms and 30 watts continuous into 8 ohms.** The Z-50 is otherwise identical to the Z-30 in design and specification, the increased power being obtained by using much higher current power transistors used well within their rated limits.
The Z-50 is, of course, compatible with the other Project 60 modules, such as the Stereo 60, and since the price is only 20/- higher than that of the Z-30, customers may like to consider the advantages of buying two Z-50's for their systems now in case higher power is required later.
Where the full output power is not required the Z-50 may be used with the PZ-5 or PZ-6 but for the full output power the PZ-8 should be used. This unit is a stabilised power supply providing 45 volts at up to 3 amps. It is supplied without mains transformer as it is designed for use with a readily available "Radiospares" unit.

Z-50 Power Amplifier built, tested and guaranteed £5.9.6 *PZ-8 Power Supply Unit* £5.19.6



SINCLAIR Z-50

USE THIS COUPON TO ORDER A.F. UNIT AND Z-50's

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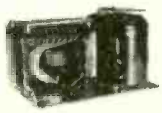
WW—111 FOR FURTHER DETAILS

ISOLATING/STEP DOWN TRANSFORMER
Primary 0, 240v., Sec. 0, 115, 240v. 10a. Ideal for workshop supply, only 6in. × 7in. × 7in. **£8**, carr. 20/-.

STEP DOWN TRANSFORMER
Primary 0, 240v., Secondary 0, 115v. 300 watts (conservatively rated). 4½in. × 4in. × 4in. **45/-**, p. & p. 8/-.

12v. 4a. POWER SUPPLY



Brand new, weighs 11 lb. Constant voltage transformer, Input 0 – 112.5 – 123.5 – 195 – 220 – 235v., produces 12v. 4a. capacitor smoothed output. **£9.10.0** plus 10/– carr.

EX-COMPUTER POWER SUPPLIES
Reconditioned, fully tested and guaranteed. These very compact units are fully smoothed with a ripple better than 10mv. and regulation better than 1%. Over voltage protection on all except 24v. units. 120v. – 130v. a.c. 50c/s input. Mains transformer to suit **£3** extra if required.

We offer the following types:

6v. 8a. **£10**	20v. 15a. **£15**
6v. 15a. **£14**	30v. 7a. **£12**
12v. 20a. **£16**	24v. 4a. **£14**

Carriage 15/– per unit

DIODES EX EQUIP, SILICON

150 PIV 10 amp.	4 for **10/–**
150 PIV 20 amp.	4 for **20/–**
400 PIV 35 amp.	4 for **45/–**

p. & p. 1/–

LARGE CAPACITY ELECTROLYTICS
4½in., 2in. diam. Screw terminals. Top quality German manufacture. Will withstand short circuit discharge.
4,000µF 72v. d.c. wkg.
16,000µF 12v. d.c. wkg.
7/6 each, p. & p. 1/–
£3.10.0 doz., p. & p. 10/–.

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Push Button Tuning Heart

This PRESTOLOCK 5 station Push-Button Tuner Heart with Manual Over-ride is an ideal basis for a quality AM car radio. Size 6¾in. × 4in. × 2in. **25/–**plus 3/– p. & p.

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These are extension phones and do not have bells.

1,750 COMPONENTS FOR 65/– ? ?
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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 valves . . . also the odd transformer, trimpot, etc., etc. . . . These are all miniature, up to date, professional, top quality components. Don't miss this, one of our best offers yet!! Price **65/–**, post and packing 6/6 U.K., New Zealand 20/–. Limited stocks only.

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200 capacitors, electrolytics, paper, silver mica, etc. **10/–**. Postage on this pak 2/6.
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100 c.f.m. 4½ × 4½ × 2in. 2,800 r.p.m., 240v. A.C. Precision made in West Germany by Papst. These Fans are the best available. Genuine bargain at **50/-** each. P. & P. 5/-.

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EZ80 4/6; EZ81 4/9; EZ90 4/3; FW4/500 6/6; GZ30 7/-; GZ32 9/-; GZ33 12/6; GZ34 10/-; GZ37 14/6; HABC80 8/6; HL13C 4/-; HL23DD 5/-; HL41DD 19/6; HL42DD 9/-; HN309 27/4; HVR2 10/6; HVR2A 10/6; IW3 5/6; IW4/350 5/6; IW4/500 6/-; KT2 5/-; KT8 34/6; KT41 19/6; KT44 20/-; KT61 12/-; KT63 5/-; KT66 17/3; KT74 12/6; KT76 12/6; KT88 29/-; KTW61 12/6; KTW62 12/6; KTW63 6/-; L63 3/9; LN152 7/-; LN309 10/-; LN319 13/9; LN339 13/9; M8162 12/6; ME1400 14/9; MHL4 12/6; MHLD6 12/6; MU12/14 4/-; MX40 12/6; N78 40/3; N108 27/10; N119 6/6; N152 9/6; N154 6/6; N308 17/6; N329 6/6; N339 25/-; N359 7/3; N379 6/6; N709 4/9; P61 10/6; PABC80 7/3; PC86 10/3; PC88 10/3; PC95 8/3; PC97 8/6; PC900 7/6; PCC84 6/3; PCC85 6/6; PCC88 9/9; PCC89 9/6; PCC189 10/6; PCC805 13/9; PCC806 15/6; PCE800 15/-; PCF80 6/6

PCF82 6/3; PCF84 8/-; PCF86 12/9; PCF87 16/-; PCF200 13/3; PCF800 13/-; PCF801 7/-; PCF802 9/-; PCF805 14/-; PCF806 11/6; PCF808 14/6; PCH200 12/3; PCL82 7/3; PCL83 10/-; PCL84 7/6; PCL85 9/-; PCL86 8/6; PCL88 15/-; PCL805 9/-; PEN45 7/-; PEN45DD 15/-; PEN46 4/-; PEN453DD 19/6; PENA4 19/6; PEN/DD 4020 17/6; PFL200 11/9; PL33 19/6; PL36 9/6; PL81 9/6; PL81A 10/6; PL82 6/6; PL83 6/6; PL84 6/6; PL302 12/-; PL500 13/-; PL504 13/6; PL505 28/9; PL508 27/10; PL509 28/9; PL802 15/-; PM84 7/9; PY32 10/-; PY33 10/-; PY80 6/-; PY81 5/3; PY82 5/3; PY83 5/9; PY88 6/9; PY301 12/6; PY800 7/6; PY801 6/9; PZ30 9/6; QQV03/10 24/-; Q875/20 12/6; Q8150/15 12/6; QVO4/7 12/6; R10 15/-; R11 19/6; R16 34/11

R17 17/6; R18 10/-; R19 6/6; R20 11/9; R52 7/6; RG1/240A 39/6; RK34 7/6; SP13C 12/6; SP42 12/6; SP61 3/3; TH4B 10/-; TH233 7/-; TP2620 8/9; UABC80 6/6; UAF42 10/3; UB41 6/6; UBC41 9/-; UBC81 7/-; UBF80 5/9; UBF89 6/9; UBL21 9/-; UC92 5/6; UCC84 8/-; UCC85 7/3; UCF80 8/3; UCH21 9/-; UCH42 12/-; UCH81 6/6; UCL82 7/-; UCL83 10/-; UF41 10/-; UF42 9/-; UF80 6/9; UF85 6/9; UF86 9/-; UF89 6/9; UL41 10/6; UL46 12/6; UL84 6/6; UM80 6/6; UR1C 10/6; UU5 7/-; UU8 14/-; UU9 7/3; UU12 4/9; UY1N 9/-; UY21 9/6; UY41 7/6; UY85 5/9; U10 9/-; U12/14 7/6; U16 15/-; U17 5/-; U19 34/6; U22 7/9; U25 13/-; U26 11/9; U31 6/-; U33 29/6; U35 16/6; U37 34/11; U45 15/6; U47 13/-

U49 11/9; U50 5/6; U76 4/9; U78 4/3; U107 18/3; U191 12/6; U193 6/9; U251 14/6; U281 8/-; U282 8/-; U301 11/-; U329 14/6; U403 6/6; U404 7/6; U801 19/6; U4020 7/6; VP2 3/6; VP2B 9/6; VP13C 7/-; VP23 2/6; VP41 7/6; VR75 24/-; VR105 6/-; VR150 6/-; VT61A 7/-; VT501 3/-; VU111 7/3; VU120 12/-; VU120A 12/-; VU133 7/-; W76 6/9; W81M 13/6; W107 8/-; W729 12/-; XE3 £5; XFY12 9/6; XH1.5 9/6; X41 10/-; X61 5/9; X65 10/-; X66 10/-; X101 30/6; X109 26/-; Z329 16/-; Z749 14/3; Z759 45/-

Transistors and diodes

1N1124 10/6; 2N404 6/-; 2N966 10/6; 2N1756 10/-; 2N2147 17/-; 2N2297 4/6; 2N2369A 4/3; 2N2613 7/9; 2N3053 6/6; 2N3121 50/-; 2N3703 3/9; 2N3709 4/-; 2N3866 20/-; 2N3988 10/-; 2S323 10/-; AA119 3/-

AA120 3/-; AA129 3/-; AAZ13 3/6; AC107 3/-; AC113 5/-; AC114 8/-; AC127 2/6; AC154 5/-; AC156 4/-; AC157 5/-; AC165 5/-; AC166 5/-; AC167 12/-; AC168 7/6; AC169 6/6; AC176 11/-; AC177 5/6; ACY17 3/-; ACY18 3/8; ACY19 3/9; ACY20 3/6; ACY21 3/9; ACY22 3/6; ACY28 4/-; AD140 7/6; AD149 8/-; AD161 9/-; AD162 9/-; ADT140 12/6; AF102 18/-; AF106 10/-; AF114 4/-; AF115 4/3; AF117 4/6; AF119 3/-; AF121 6/-; AF124 7/6; AF126 5/-; AF139 13/-; AF178 13/6; AF179 13/6; AF180 9/6; AF181 14/-; AF186 11/-; AF239 7/6; ASY27 8/6; ASY28 6/6; ASY29 10/-; AY100 26/-; B1181 10/-; BA102 9/-; BA115 2/8; BA116 5/-; BA129 2/6; BA130 2/-; BCY10 5/-

BCY12 5/-; BCY33 5/-; BCY34 4/6; BCY38 5/-; BCY39 4/6; BC107 4/-; BC108 3/6; BC113 5/-; BC115 3/-; BC116 5/-; BC118 4/6; BCZ11 3/6; BD119 9/-; BF154 5/-; BF159 5/-; BF163 4/-; BF173 7/6; BF180 6/-; BF181 8/-; BF185 8/-; BFY50 4/-; BFY51 4/-; BFY52 4/6; BTX34/400 40/-; BY100 3/6; BY101 3/-; BY105 3/6; BY114 3/6; BY126 3/-; BY127 3/6; BYY23 20/-; BYZ10 5/-; BYZ11 5/-; BYZ12 5/-; BYZ13 5/-; BYZ15 35/-; CG12E 4/-; CG64H 4/-; FSY11A 4/6; FSY28A 4/6; GD4 6/6; GD5 5/6; GD6 5/6; GD8 4/-; GD9 4/-; GD10 4/-; GD11 4/-; GD12 4/-; GD14 10/-; GD15 8/-; GD16 4/-; GET111 15/6; GET113 4/-; GET115 17/-

GET116 6/6; GET118 4/-; GET119 4/-; GET573 7/6; GET587 8/6; GET872 19/-; GET873 3/-; GET874 23/6; GET882 10/-; GET887 4/6; GET889 4/6; GET890 4/6; GET896 4/6; GET897 4/6; GEX13 3/6; GEX35 4/6; GEX36 10/-; GEX45 6/6; GEX55 15/-; GT3 5/-; M1 2/10; M3 2/10; MAT100 7/9; MAT101 8/6; MAT120 7/9; MAT121 8/6; OA5 5/6; OA9 2/6; OA10 8/6; OA47 2/-; OA70 3/-; OA73 3/-; OA79 1/9; OA81 1/9; OA85 1/6; OA86 4/-; OA90 2/6; OA91 1/9; OA95 1/9; OA200 1/-; OA202 2/-; OA210 9/6; OA211 13/6; OAZ200 12/-; OAZ201 10/6; OAZ202 9/-; OAZ203 9/6; OAZ204 9/-; OAZ205 9/-; OAZ206 9/-; OAZ207 10/6; OAZ210 7/-; OAZ213 7/-; OAZ224 16/6; OC19 25/-

OC22 5/-; OC23 5/-; OC24 5/-; OC25 5/-; OC26 5/-; OC28 5/-; OC29 23/6; OC35 5/-; OC36 7/6; OC38 9/6; OC41 10/-; OC42 12/6; OC43 23/6; OC44 2/-; OC44PM 8/3; OC45 1/9; OC46 3/-; OC65 22/6; OC70 2/3; OC71 2/-; OC72 2/-; OC73 16/-; OC74 2/6; OC75 2/-; OC76 2/6; OC78 3/-; OC78D 3/-; OC79 8/-; OC81D 2/-; OC81M 5/-; OC82 2/3; OC82D 2/3; OC83 2/-; OC84 3/-; OC123 4/6; OC139 12/-; OC140 19/-; OC169 3/6; OC172 4/-; OC200 4/4; OC201 5/6; OC202 4/6; OC203 4/6; OC204 5/6; OC205 7/6; OC206 10/-; OC812 8/-; S6M1 5/-; SX1/6 3/6; SM1036 10/-; ST1276 10/-; UI4706 5/-; XZ30 5/-; Y543 3/6; Y728 3/6; ZE12V7 1/9

MATCHED TRANSISTOR SETS:—
LP15 (AC113, AC154, AC157, AA120). 10/6.
1—OC44 and 2—OC45. 8/6.
1—OC82D and 2—OC82, 8/6.
1—OC83D and 2—OC83. 8/6.
S.T.C. 1 watt Zener Diodes. 2.4v., 2.7v., 3.0v., 3.6v., 4.3v., 13v., 15v., 16v., 18v., 3/6 each.

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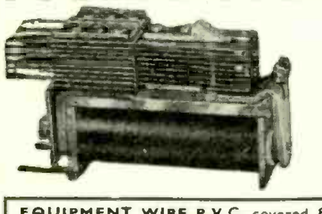
Wilkinsons FOR RELAYS



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HEAVY DUTY ROTARY SWITCHES Blue Line by Kraus & Naimer Type C25 AAL 213, 32 amp 600 v 3 ph, also Type C16 600 v. No. 8AA036, complete with handles.

SUB-MINIATURE LAMPS. Flying leads 0.75 v., 50/- 100.

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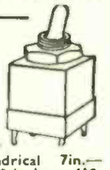
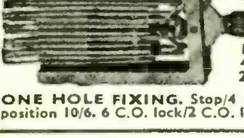
ONE HOLE FIXING SWITCHES DOUBLE POLE ON/OFF



3 amp 250 volt A.C. 1⅛in. × ⅝in. × ⅝in. 30/- per dozen, 200/- per 100. Post 3/- per dozen, 6/- per 100.

AIR BLOWERS. 200/250v. A.C. cylindrical 7in.—7in. suitable for intake or extraction. 1/50th h.p. £10. 1/15th h.p. £11. 1/10th h.p. £14. Stockists of **Stuart Turner** Centrifugal Pumps. Nos. 9, 10 and 12, Details available.

GEARED MOTORS. 1 r.p.m. or 3 r.p.m. 4 watts very powerful, reversible 24v. A.C. 35/-, post 2/6, can be operated from 230v. with our 20/- Transformer. Post 5/-.



STANDARD LEVER KEYS, 3 POSITION 4C lock/4C lock 17/6 each. Stop/6C 15/6 each. 2C 2M non-lock/2C 2M non-lock 14/6 each. 4C non-lock/6C lock 20/- each.

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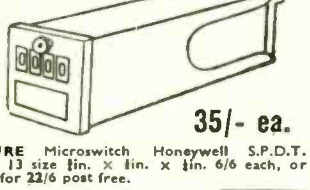
AMAZING VALUE. 1/6th hp G.E.C. Fractional hp **MOTOR** 230/250v A.C., fitted with thermal protector with push button reset, ensures complete protection against overheating or burn-out, 1440 r.p.m. ½in. shaft 1½ins. long. Fully guaranteed 97/6, carriage 15/-.

DIGITAL INDICATOR made by well-known manufacturer displaying 0 through 9, weight only 3¼ oz., size 1in. wide, 3 5/16 in. deep, 1 1/16 in. high, available with 28 volt single contact midget flanged lamps, quick disconnect at rear for lamp replacement, 65/- each, post 4/6. Also supplied as above with letters, and in banks of five ready for fitting into equipment.

HIGH SPEED COUNTERS

3¼ × 1in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6v., 12v., 24v., 50v. or 100v.



35/- ea.

SUB-MINIATURE Microswitch Honeywell S.P.D.T. type 11 SM1 TN 13 size ⅜in. × ⅜in. × ⅛in. 6/6 each, or mounted in fives for 22/6 post free.

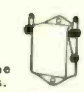
JACK PLUGS. 2 Point with screw-on cover, 2/6, post 9d. PO 201 on headphone cord 3/-, post 1/6.

PLUG-IN RELAYS. Londex 4 change-over HD contacts 28v. D.C. with base and cover, 35/- each.

UNISELECTORS. New 8 bank, 25 way, non-bridging full wipers, £7.10 each.

VARLEY Miniature Relays. 700 ohms 4 CO, 15/6 ea.

MINIATURE BUZZERS. 12 volts with tone adjuster, 7/6 each as illustrated. Quantity Rates.



RECTIFIER UNITS/BATTERY CHARGERS—WESTALITE TYPE BC 3-3/15. Input 200/250 volts A.C., output up to 6 volts 15 amps D.C. Heavily damped 0/20 ammeter moving coil 2½in. reads true charging current, which is regulated by a four position rotary switch and sliding resistance. A ballast is fitted to smooth out mains variations. A.C. and D.C. fuses fitted. Size 17½ × 13½ × 12in., designed to stand on bench or fit to a wall. £8.10.0. Carriage 15/-.

MAGNETIC COUNTERS. Veeder Root with zero reset. 800 counts per minute, counting to 999,999. 110 volts A.C. or 110 volts D.C. 65/- each, post 3/-.

PRECISION GERMAN MADE MAGNETIC COUNTERS. 2¼in. × 1½in. × 1in. with push button zero reset. 3 digits, 12 volts D.C., 25 imp/sec., 50/- ea.

METERS GUARANTEED. Complete list available.

Microamps 0/500 2in. MC....25/-
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Milliamps 0/50 2½in. MC......35/-
Milliamps 0/500 3½in. MC....54/-
Amps 50-0-50 2in. MC........17/6
Amps 0/5 2in. MC..............42/6
Volts 5/0/5 2½in. MC..........25/-
Volts 0/20 2in. MC..............42/6
Volts 0-40 2in. MC..............42/6
Volts 0/10 A.C. 3½in. MCR....70/-

"VISCONOL-CATHODRAY" CONDENSERS. .002 mfd. 15 kV, 9/-; .02 mfd. 10 kV, 10/-; .025 mfd. 2.5 kV, 5/-; .05 mfd. 5 kV, 9/-; 0.1 mfd 4 kV, 9/-; 6 kV, 17/6; 0.5 mfd. 2.5 kV, 17/6; 1 mfd. 2kV. 17/6.

PORTABLE VOLTMETERS 30v moving coil DC precision sub standard grade 5in. mirror scale, in polished wood case £8.17.6, post 8/6.; 160v moving iron AC/DC 8in. mirror scale in p. wood case £4.19.6, post 7/6; 250v moving iron AC/DC 6in. scale in p. wood case £8.10.0, post 7/6.

CELL TESTING VOLTMETERS 3-0-3 v moving coil DC with leads and prods. in leather case 3in. scale 35/- ea., post 4/6

CAMBRIDGE PORTABLE MILLIAMMETER precision grade AC moving iron 7in. scale ranges—50, 100, 200, 500 and 1,000 mA. enclosed case £25, post 10/6.

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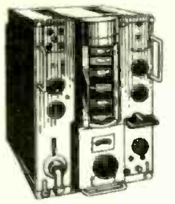
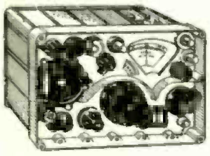
ADMIRALTY B.40 RECEIVERS



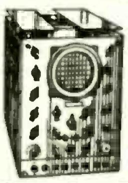
High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. **£22/10/0**, carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. **£17/10/-**. Carr. 30/-.

R209 Mk. II COMMUNICATION RECEIVER

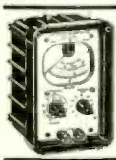


11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked. **£15.0.0** Carr. 20/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN



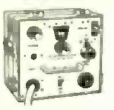
An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition, **£22/10/-**. Or complete with all accessories, probe, leads, lid, etc. **£25**. Carriage 30/-.



MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts. **£20**. Carr. 20/-.

CLASS D. WAVEMETERS



A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition **£5.19.6** Carr. 7/6. Or brand new with accessories **£7.19.6** Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition **£12/10/0**. Carr. 30/-.

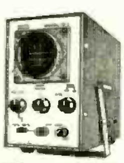
LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition. **£12/10/-**. Carriage 10/-.

VOLTAGE STABILISER TRANSFORMERS.

180-260v. input. Output 230v. Available 150w or 225w. **£12.10.0**. Carr. 5/-.

TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22/10/-**. Carr. 10/-.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook. **£37-10.0** Carr. 10/-.

CRYSTAL CALIBRATORS NO. 10

Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. **89/6** Carr. 7/6.

MARCONI TF885 VIDEO OSCILLATORS

0-5 mc/s Sine Square Wave **£45**. Carr. 20/-.

MARCONI TF195M BEAT FREQUENCY OSCILLATORS

0-40 kc/s. **£20**. Carr. 30/-.

WS62 TRANCEIVERS

Large quantity available for EXPORT! Excellent condition. Enquiries invited.

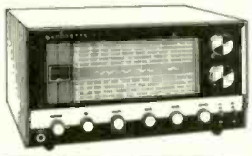
UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. **13gns**. Carr. 7/6.

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. **£150**.
Both types in excellent condition.

LAFAYETTE SOLID STATE HA600 RECEIVER

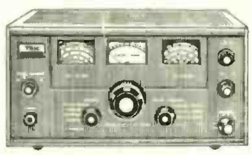


5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noiselimiter ● S Meter ● 24½in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. × 9½in. × 8½in. Wt. 18 lbs. EXCEPTIONAL VALUE **£45**. CARR. 10/-. S.A.E. FOR FULL DETAILS.

UR-1A SOLID STATE COMMUNICATION RECEIVER

4 bands covering 550 Kc/s-30 mc/s continuous. Special features are use of FET transistors, S meter, built-in speaker and telescopic aerial, variable BFO for SSB reception, noise limiter, bandspread control, sensitivity control. Output for low impedance headphones. Operation 220/240 volt A.C. or 12 volt D.C. Size 12¾" × 4½" × 7". Excellent value. Only **£24**. carr. 7/6.

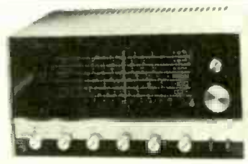
TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 × 15 × 10in. With instruction manual and service data. **£42**. Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price **£3.15.0** if purchased with above receiver.

TRIO TS 510 Amateur Transceiver with speaker and mains P.S.U.	£180
TRIO JR 500SE 10-80 Metre Amateur Receiver	£65

LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.



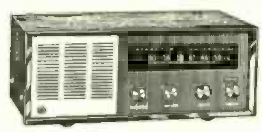
Dual conversion on all bands. 2 × 455 Kc/s mechanical filters. Product detector. Variable B.F.O 100 Kc/s crystal calibrator. 'S' meter. Huge slide rule dial. Operation 230v AC or 12v DC. Size 15" × 9¼" × 8¼". Complete with instruction manual. **£57-10-0**. Carr. Paid. (100 Kc/s Crystal **39/6** extra.)

TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0

RCA COMMUNICATIONS RECEIVERS AR88D

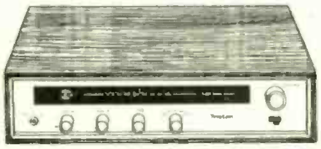
Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s—32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price **£87-10-0**. Carr. £2.

LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER



A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. **£37/10/-**. Carr. 10/-.

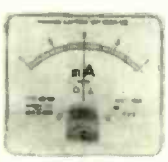
TELETON MODEL CR-10T AM/FM STEREO TUNER AMPLIFIER



A new model from Teleton. 31 solid state devices. 4+4 watt output. Inputs for ceramic/crystal cartridge. Frequency range AM 540-1600 KHz, FM 88-108 MHz. Automatic FM Stereo reception. Stereo Indicator. Controls: Tuning, function selector, Tone and R & L volume controls. AFC switch. Stereo headphone socket. Size 13½in. × 3½in. × 9½in. approx. Price **£34/0/0**. Carr. 7/6.

SEW PANEL METERS

Type MR.38P. 1 21/32in. square fronts.



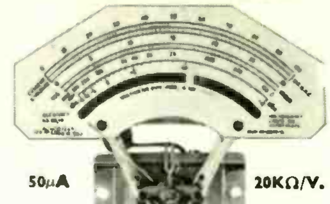
50μA	40/-	50mA	27/6	100V. D.C.	27/6
50-0-50μA	37/6	100mA	27/6	150V. D.C.	27/6
100μA	37/6	150mA	27/6	300V. D.C.	27/6
100-0-100μA	35/-	200mA	27/6	500V. D.C.	27/6
200μA	35/-	300mA	27/6	750V. D.C.	27/6
500μA	30/-	500mA	27/6	15V. A.C.	27/6
500-0-500μA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	150V. A.C.	27/6
1-0-1mA	27/6	2 amp	27/6	300V. A.C.	27/6
2mA	27/6	5 amp	27/6	500V. A.C.	27/6
5mA	27/6	3V. D.C.	27/6	S meter 1mA	32/-
10mA	27/6	10V. D.C.	27/6	VU meter	42/-
20mA	27/6	20V. D.C.	27/6		

FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 14/6. P. & P. 1/6.
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms, 21/-. P. & P. 1/6.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms, 27/6. P. & P. 1/6.

AVOMETER MOVEMENTS



50μA 20KΩ/V.

Spare movements for Model 8 or 9. (Fitted with Model 9 scale) or basis for any multimeter. Brand New and Boxed **69/6** P. & P. 3/6

MARCONI TF.142E DISTORTION FACTOR METERS

Excellent condition. Fully tested **£20**. Carr. 15/-.

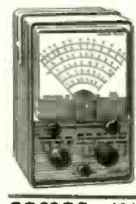
T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17/10/-**. Carr. 5/-.

PLESSEY SL 403A

3-watt. integrated amplifier circuit. **49/6** post paid.

TE-65 VALVE VOLTMETER

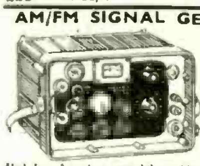


High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions **£17/10/0**. P. & P. 6/-. Additional Probes available; R.F. **35/-** H.V. **42/6**.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

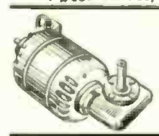
D.C. coupled. Band width 1 Kc/s. Perfect order. **£25**. Carr. 30/-.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 × 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested, **£45**. Carr. 20/-.

GEARED MAINS MOTOR



Paralux type SD19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. **99/6**. Carr. 10/-.

TE-16A TRANSISTORISED SIGNAL GENERATOR

5 Ranges 400 KHZ-30 MHZ. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5¼" × 5¼" × 3½". Complete with instructions and leads. **£7/19/6**. P/P 4/-.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.

A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¾" × 5" × 2". **£20**. P. & P. 5/-.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded
150 W. **42/6**. P. & P. 3/6
300 W. **59/6**. P. & P. 4/6
500 W. **£4/10/0**. P. & P. 6/6
1,000 W. **£6/10/0**. P. & P. 7/6
1,500 W. **£7/19/6**. P. & P. 8/6
7,500 W. **£15/10/0**. P. & P. 20/-.

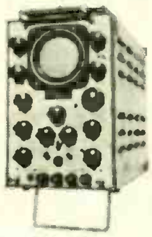
G. W. SMITH & Co. (Radio) Ltd.

ALSO SEE OPPOSITE PAGE

BROKERS

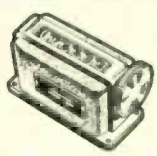
OSCILLOSCOPES

Solartron CD513	£49.10
Solartron CD 513/2	£49.10
Solartron AD 557	£55. 0
Solartron CD 711	£65. 0
Solartron CD 7118-2	£80. 0
Solartron QD 910	£275. 0
Solartron 5238-2	£52.10
Furzehill 0.100	£25. 0
Airmec 249	£25. 0
Airmec 723	£19.10
Philips PM 3230	£85. 0
Mullard L101 Double Beam	£96.10
Cossor 1035	£25. 0
Cossor 1049 MkIII	£40. 0
Cossor 1049	£35. 0



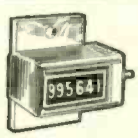

COUNTERS

VEEDER ROOT 6 DIGIT COUNTER



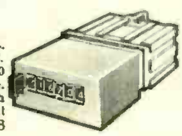
Suitable for counting all kinds of production runs, business machine operation. Mechanically driven Type KA1337. Reset manual knob. Ex-equipment but new condition. Special price 25/- plus 5/- P. & P.

MINIATURE SQUARE COUNTER 6 DIGIT



By Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft. 9/6 plus 2/6 P. & P.

6 DIGIT ELECTRICAL IMPULSE COUNTER



With electrical and mechanical reset. Counter driven by a 110 v. D.C. 4,400 ohms coil. Reset 110 v. D.C. 800 ohm coil. Housed in plastic-alloy case. The units can be interlocked with each other to give vertical or horizontal displays. Ex. equipment. Price 59/6 plus 5/- P. & P.

EAC DIGIVISOR Mk. II DIGITAL READ-OUT DISPLAY

Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to charge the digits. The DIGIVISOR incorporates a moving coil movement which moves a translucent scale through an optical system and the resultant single plane image is projected on a screen. The translucent scale is made to represent digits 0-9. Specification: 6.3 volt, 250 microamp. Image height ⅝ in. Size 4 9/16 × 2 39/64 × 1⅞ in. Our price £3/13/6. List price 8½ gns.

BERKELEY DECIMAL COUNTING UNIT 0-9

4 valves double triode type 5965 special quality Unit plugs into standard octal base, Modular construction with 10 miniature neon lamps on display panel. Power supplies 6.3v. A.C. 150v D.C. Cut-on or Cut-off—15v. Size 5½ × 5⅜ in. × ⅞ in. Price 65/- p. & p. 5/-.

MINIATURE DIGITAL DISPLAY

Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width, 3 $\frac{1}{16}$ in. deep, 1 $\frac{1}{16}$ in. high. Weight 3½ oz. Character size ⅝ in. high, 0.9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. Our price 49/6. Giant digital display 4". Price £8.8.0. P. & P. 10/-.

5 DIGIT COUNTER

A very sturdy counter. Coil resistance 100 ohms. Minimum operational voltage 5v. Counting speed 13 counts per sec. Suitable for continuous counting with sine wave drive. Coincidence, recording and frequency meter 35/- p. & p. 5/-.

MOTORS

HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz. ¼ r.p.m., ½ r.p.m., 1/6 r.p.m., 120V 60 Hz, 1/10 r.p.m., 30/- each. P. & P. 3/-.

HIGH TORQUE INDUCTION MOTOR

3-30 oz/inch. Available in the following speeds only 240V 50 Hz ½ r.p.m., 1 r.p.m., 2 r.p.m. 120 V 50 Hz. 20 r.p.m 30/- each. P. & P. 3/-.

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranges: 240V 50 Hz 4 r.p.m., 2 r.p.m., 1½ r.p.m., 1 r.p.m., ½ r.p.m., 1/3 r.p.m., 1/5 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/360 r.p.m., 1/720 r.p.m., ½, 1/20, 1/45 r.p.m.; 120V 50 Hz 1/6 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/20 r.p.m., 1/24 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1/440 r.p.m. 25/- each. P. & P. 3/-.

HYSTERESIS CLUTCH MOTOR

With integral clutch allowing the motor to drop out of engagement with the gear train, thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v., 50 c/s. L = left, R = right. 15 r.p.m. L. 4 r.p.m., ½, ¼ r.p.m. L, 1/5 r.p.m.. 1/6 r.p.m.. R & L, 1/10 r.p.m., 1/12, 1/15 r.p.m. L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/-. P. & P. 3/-.

HIGH PRECISION MAINS MOTOR

230V 50 Hz 1/8 h.p. continuously rated. 3000 r.p.m. Made by Croydon Engineering Model KA 60 JFB. Suitable for capstan motor. Size. 8 in. long, 4½ in. diameter with 6 in. diameter flange and 4 fixing holes. £4.10.0 each. £1.5.0 postage and packing.

SYNCHRONOUS MOTORS

Model S 71 r.p.h. and 1/60 r.p.h. Self starting complete with gearing shaft ⅛ in. dia. ¼ in. long, 200/250V 50 Hz. New condition Ex. Equipment. 40/-. P. & P. 3/-.

METERS

DIGITAL VOLTMETERS

DM2022 digital voltmeter and ratiometer, accurate to 0.0025% offering exceptional linearity.
Reading rate of 50 per second. Outputs: Parallel B.C.D. Scale 39999. Inputs: 25000MΩ CMR 160dB on d.c. Range 10μV to 1KV. This is a rare opportunity to obtain such an instrument at such a low price of £350. Carriage free.
DM2006. An all solid state D.V.M. having a wide application. Scale 9999. D.C. accuracy 0.017f.s.d. with a D.C. range of 10μV to 1KV. Input impedance 10000MΩ. C.M.R. 154dB. Outputs parallel B.C.D. £245. Carriage free.
DM2023. This D.V.M. is suitable for data-logging due to the high C.M.R. 175dB. It has six operating modes. Accurate to 0.001% and complete with plug in units to give either manual or automatic ranging from 10μV to 1KV with a 10MΩ input impedance. £460. Carriage free.
Type LM902-2. 4 digit £75. LM902-2R. 4 digit £75. LM1010. 4 digit £75. All the above units have been calibrated.
Digital Voltmeters 2003 A.C./D.C. D.C. range 1mV.-1KV. 4 digits. £135.
2 in. dia. mounting A.C. voltmeter 0-300 V. A.C. £1/15/0. Carriage 6/-.
Precision A.C. & D.C. Wattmeter. Model S.67 certificated. Accuracy to ½% up to 133 c/s. Range 250/450 V. and 0.5 to 1 A. £29/10/0. Carriage 30/-.

MULTI-RANGE TRANSISTORISED VOLTMETER 1063

Employing silicon planar F.E.T., this instrument gives long-term stability and negligible drift over a wide temperature range. Wide frequency band 0-300 MHz. using HPV 1063. Voltage range 0-30KV. Centre zero on DC ranges for differential circuit application. Input resistance 1 M.ohm/Volt on all DC ranges. Accuracy ± 3% F.S.D. Meter scale 5in. with 1M different colour for different scales. Special price £42/10/0 each. Carriage £1/10/0.

MARCONI VALVE VOLTMETER TF 428B/1

Frequency response on probe 10Kc/s/3-100Mc/s. Five separate Voltage Ranges. Overload Protection 100-250 A.C.I.P. Input 1MΩ Acc. ±2% or 00.2V. Size: 10 × 16½ × 9in.—15lb. £5/19/6.

LOW OHM SAFETY METER

12 milli-amps 5 ohms suitable for testing circuits where current must be limited. £12/10/-. P. & P. 17/6.

GENERATORS

SIGNAL GENERATOR

T.F. 801A Sine Wave, Square Wave Generator. Frequency Range: 10-310 Mc/s. Output Voltage (maximum) 200 milli-volts ± 2db. Output impedance 75 ohms.
Mark/Space Ratio 50/50 on square wave. Price £79/10/0. Packing and carriage £2.
T.F. 517F/1 Sine Wave, Square Wave Generator. Frequency Range: 120-300 M. C/s Auxiliary 18-58 Meg. c/s. Output Voltage 0.2 Volts. Output impedance 75 ohms. £85.

MARCONI T.F.144G

Frequency Range 85kc/s 25Mc/s. Output voltage 1 micro-volt to 1 volt. Output impedance 1 micro-volt, 100 milli-volt, 10 ohms. 100 milli-volts to 1 volt, 52.5 ohms. £59/10/0 + £2 carriage.

PULSE GENERATORS

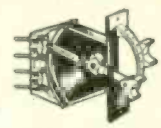
Model 101 Repetition rate 10 Hz-10MHz. Delay 30 n-10 m. secs. Output 10V into 50 ohms. £95.

SQUARE WAVE GENERATOR

Frequencies: 1M 100kc/s 10kc/s 50c/s. Load impedance 75 ohms. Output Voltage 10V 75 ohms. 0-18 volts into 2000 ohms. Rise time from 30-50 Milli micro seconds at 1 meg. Cycle. £59/10/0.

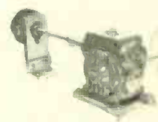
HIGH GRADE COMPONENTS

DOUBLE AUDIO FADERS 1W



100 plus 1000 ohms. Each resistive dimmer is adjustable and independent of each other. Ex-equipment but in an almost new condition. Price £3/19/6. P. & P. 7/6.

RIGHT ANGLED GEAR BOXES



Gear boxes give a drive ratio of 2.5 : 1 at right angles to the input. Driveable through the i/p shaft only. Dimensions 4 in. wide × 3½ in. deep × 4½ in. high. Robust construction in cast iron. Price 74/-.
With pulley and ball race shaft mountings. Price 99/6. Carriage 15/-.

DIMMERS

SCR Type. 600W. F.W. Bridge circuit suitable speed control A.C./D.C. commutator motors, lights, etc. Fits standard 2 inch conduit box. 59/6. P. & P. 5/-.

VOLSTATS

VOLSTATS and constant voltage transformers. Large range in stock Prices from £8/10/0.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100/100		Beckman	A	160/-
100	0.5	Beckman	A.8.	60/-
200	0.5	Beckman	A	60/-
500	0.1	Beckman	8.	70/
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EBC90	9/6
EBF80	8/–
EBF83	8/–
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EB91	5/3
ECC81	8/–
ECC82/3	8/6
ECC84/5	8/6
ECC88	11/–
E88CC	12/6
ECF80/2	9/6
ECF86	11/–
ECH35	13/6
ECH42	13/3
ECH81	10/3
ECH83	8/–
ECH84	9/6
ECLL800	20/–
ECL80	8/–
ECL82	9/9
ECL83	11/6
ECL86	9/9
EF39	10/6
EF80	8/–
EF83	10/–
EF85	8/3
EF86	13/3
EF89	8/–
EF91	8/6
EF92	10/–
EF93	9/6
EF94	15/6
EF95	12/6
EF183	11/3
EF184	11/3
EH90	10/3
EL34	9/9
EL41	10/–
EL81	9/6
EL84	7/9
EL95	9/–
EM81	11/6
EM84/7	12/9
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EY86/7	7/9
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PL81	10/3
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PL83	10/3
PL84	8/3
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PL504	17/–
PL505	29/–
PL508	20/–
PL509	30/9
PL802	17/3
PL805	17/3
PY32	10/–
PY33	10/9
PY81	8/3
PY800	8/3
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PY82	7/–
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PZ30	16/–
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R20	15/–
UABC80	10/6
UBF89	8/–
UBC41	9/9
UCC85	9/3
UCH42	13/9
UCH81	10/9
UCL82	10/3

UCL83	12/3
UF41/2	11/–
UF80/5	7/6
UF89	8/3
UL41	11/6
UL84	11/–
UM80/4	9/–
UY41	8/–
UY85	6/9
U25	15/–
U26	15/–
U191	14/6
U193	8/3
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30C17	15/9
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30PL14	18/6
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90% B.V.A. BOXED (NORMAL GUARANTEE) OR OWN VALVES SUPPLIED, 1 YEAR'S GUARANTEE. ADD 6d. PER VALVE ON ORDERS UNDER 6, OTHERWISE FREE POST & PACKING.

CATHODE RAY TUBES

TWO YEARS GUARANTEE ON CATHODE RAY TUBES

Rebuilt

17in.	19in.	21in.	23in.	Twin Panel 19in.	Twin Panel 23in.
£4	£4.10	£5.10	£6	£7.15	£10.19.6

New

17in.	19in.	21in.	23in.	Twin Panel 19in.	Twin Panel 23in.
£5.19.6	£6.19.6	£7.19.6	£9.10	£9.10	£12.10

Panorama

19in.	23in.
£8.10	£11.10

All types of tubes in stock. Carriage and insurance 15/-

SEMICONDUCTORS

BY127	2/6	AC107	3/–	AD149	7/6
AC127	2/6	AC128	2/6	OC4/5	2/6
AF117	3/–	BC107	5/6	OC71	2/6
AF181	5/6	BC108	5/6	OC81	2/6
BF181	5/6	BC109	5/6	OC81D	2/6
BF200	5/6	AC126	3/–		

OA79. OA81. OA91. OA95. OA200. OA202. **1/6**

Add 5d. per item for Post and Packing for orders under 24 pieces.

STYLII

TC8. GC2. GP59. GC8. DC284. Stereo 105. 106. 208. **2/–** each (individually boxed).

ST3/5. ST8/9. 9TA. 9TA/HC. GP91. **8/–** Diamond

Post and packing 5d. per item for orders under 24

TAPES (Polyester PVC)

4in. L.P. **8/6** 3in. L.P. **5/6**

Standard Play
600ft. 5in. **8/6** 900ft. 5¾in. **10/6** 1200ft. 7in. **12/6**

Long Play
900ft. 5in. **11/–** 1200ft. 5¾in. **13/–** 1800ft. 7in. **18/–**

Double Play
1200ft. 5in. **16/–** 1800ft. 5¾in. **19/–** 2400ft. 7in. **28/–**

Philips type Cassettes. (In plastic library pack)
C60 **10/6** C90 **12/6** C120 **19/6**

Post and packing 1/6d. on all orders.

ACOS CARTRIDGES

GP91–1	Medium output Mono Crystal	21/–	inc. P. Tax
GP91–3sc.	High output Mono Crystal (TC8H TC8M BSR X3H X3M)	21/-	,,
GP93–1	Stereophonic Crystal	24/9	,,
GP94–1	Stereophonic Ceramic	31/-	,,
GP95–1	Stereophonic Crystal	24/9	,,
GP96/1	Stereophonic Ceramic	31/6	,,

TERMS, CASH WITH ORDER ONLY. POST & PACKING PAYABLE ON ORDERS UP TO £3, AFTER THAT, FREE EXCEPT C.R.T.'s.

ELECTROVALUE

EVERYTHING BRAND NEW AND TO SPECIFICATION • LARGE STOCKS

BARGAINS IN NEW TRANSISTORS

ALL POWER TYPES SUPPLIED WITH FREE INSULATING SETS

2N696	5/6	2N3707	4/–	AF127	7/–
2N697	5/6	2N3708	3/–	BA102	9/–
2N706	2/9	2N3709	3/–	BC107	2/9
2N1132	9/9	2N3710	3/6	BC108	2/6
2N1302	4/–	2N3711	3/11	BC109	2/9
2N1303	4/–	2N3904	7/6	BC147	3/6
2N1304	4/6	2N3906	7/6	BC148	3/3
2N1305	4/6	2N3731	24/–	BC149	3/6
2N1306	6/9	2N4058	5/3	BC153	10/–
2N1307	6/9	2N3325	10/9	BC154	11/–
2N1308	8/9	2N3794	3/3	BC157	3/9
2N1309	8/9	2N4284	3/3	BC158	3/6
2N1613	6/–	2N4286	3/3	BC159	3/9
2N1711	7/–	2N4289	3/3	BC167	2/6
2N2218	9/3	2N4291	3/3	BC168	2/3
2N2147	18/9	2N4292	3/3	BC169	2/6
2N2369A	5/3	2N4410	4/9	BC177	6/3
2N2646	10/9	2N5192	25/–	BC178	5/8
2N2924	4/–	2N5195	28/3	BC179	6/–
2N2925	4/6	40361	12/6	BD121	18/–
2N2926R	2/3	40362	16/–	BD123	24/3
2N2926O	2/3	AC126	6/6	BF178	10/6
2N2926Y	2/3	AC127	6/–	BFX29	10/9
2N2926G	2/3	AC128	6/–	BFX85	8/3
2N3053	5/6	AC176	11/–	BFX88	6/9
2N3054	14/3	ACY22	3/9	BFY50	4/6
2N3055	16/–	ACY40	4/–	BFY51	4/3
2N3391A	6/3	AD140	19/–	BSX20	3/9
2N3702	3/6	AD149	17/6	MJ480	21/–
2N3703	3/3	AD161 } AD162 }	16/- comp. pr.	MJ481	27/–
2N3704	3/9			MJ491	30/–
2N3705	3/5	AF118	16/6	NKT403	15/6
2N3706	3/3	AF124	7/6	NKT405	15/–

RESISTORS

Code	*Power*	*Tolerance*	*Range*	*Values available*	*1 to 9*	*10 to 99* (see note below).	*100 up*
C	1/20W	5%	82Ω–220K Ω	E12	18	16	15
C	1/8W	5%	4·7Ω–330K	E24	2·5	2	1·75
C	1/4W	10%	4·7Ω–10M Ω	E12	2·5	2	1·75
C	1/2W	5%	4·7Ω–10M Ω	E24	3	2·5	2·25
MO	1/2W	2%	10Ω–1M Ω	E24	9	8	7
C	1W	10%	4·7Ω–10M Ω	E12	6	5	4·5
WW	1W	10% ± 1/20 Ω	0·22Ω–3·3Ω	E12		15d. all quantities	
WW	3W	5%	12Ω–10K Ω	E12		15d. all quantities	
WW	7W	5%	12Ω–10K Ω	E12		18d. all quantities	

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Prices are in pence each for same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total resistor order.)

Values:
E12 denotes series: 1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, 8·2 and their decades.
E24 denotes series: as E12 plus 1·1, 1·3, 1·6, 2, 2·4, 3, 3·6, 4·3, 5·1, 6·2, 7·5, 9·1 and their decades.

NEW PLESSEY INTEGRATED CIRCUIT POWER AMPLIFIER TYPE SL403A. Only **48/6 nett.** Operates with 18V power supply. Sensitivity 20mV into 20M Ω, 3 watts into 7·5 Ω.
Supplied complete with application Data on orders for 2 or more.

PE NOV. 69 STEREO AMPLIFIER KIT
less metalwork .. **£11/18/– NET complete**

CARBON SKELETON PRE-SETS
Small high quality, type PR: Linear only: 100 Ω, 220 Ω, 470 Ω, 1K Ω, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M Ω, 2M2, 5M, 10M Ω vertical or horizontal mounting .. **1/– each**

S-DeCs PUT AN END TO "BIRDS-NESTING". Components just plug in.
Saves valuable time. Use components again and again.
S-DeC .. .. .. Only **30/6** post free

Compact T-DeC, increased capacity, may be temperature-cycled.
T-DeC .. .. .. only **50/–** post free

WAVECHANGE SWITCHES
1P 12W; 2P 6W; 3P 4W; 4P 3W—long spindles .. .. **4/9 each**

SLIDER SWITCHES
Double pole, double throw .. .. **3/– each**

MULLARD SUB-MIN ELECTROLYTICS C426 RANGE .. .. .. **Price 1/3 each**
Axial leads. Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS. ALL NEW STOCK
High ripple current types: 2000μF 25V 7/4; 2000μF 50V 11/4; 5000μF 25V 12/6; 5000μF 50V 21/11; 1000μF 100V 16/3; 2000μF 100V 28/9; 5000μF 70V 36/–; 5000μF 100V 58/3; 1000μF 50V 8/2; 2500μF 64V 15/5; 2500μF 70V 19/6.

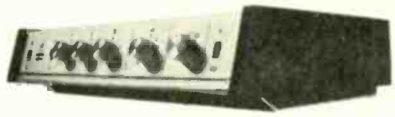
MEDIUM RANGE ELECTROLYTICS
Axial leads. Values (μF/V): 50/50 **2/–**; 100/25 **2/–**; 100/50 **2/6**; 250/25 **2/6**; 250/50 **3/9**; 500/25 **3/9**; 1000/10 **3/3**; 500/50 **4/6**; 1000/25 **4/–**; 1000/50 **6/–**; 2000/25 **6/–**; 330/25 **2/6**.

SMALL ELECTROLYTICS
Axial leads: 5/10, 10/10, 25/10, 50/10 **1/– each**
25/25, 47/25, 100/10, 220/10 .. .. **1/3 each**

COMPONENT DISCOUNTS
10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
(No discount on nett items)

POSTAGE AND PACKING
Free on orders over £2.
Please add 1/6 if order is under £2.
Overseas orders welcome: carriage charged at cost.

PEAK SOUND ENGLEFIELD KITS



Build it 12 + 12 or 25 + 25

Brilliant new styling and available in two forms:

STEREO 15 WATTS PER CHANNEL
Supplied in kit form with complete amplifier and pre-amplifier modules and power supply components. Output per channel into 15Ω —13 watts R.M.S. **Price £38.9.0 Nett**

STEREO 25 WATTS PER CHANNEL
Supplied in kit form with complete amplifier, pre-amplifier and regulated power supply modules. Output per channel into 15Ω —28 watts R.M.S. **Price £58.15.0 Nett**

Specifications on these amplifiers in accordance with the Specifications in Guarantee published in Peak Sound advertisements.

Inputs:

Magnetic, RIAA	3·5mV	Tape	100mV
Ceramic	35mV	Radio	100mV

Signal to noise ratios: Better than 60dB all inputs.

ENGLEFIELD CABINET to house either above assemblies (as illustrated) **£6.0.0. Nett**
Other Peak Sound Products as advertised.

ZENER DIODES: Full range of 5% 400 mV available in E24 series, 2.7 V to 30 V .. .. **4/6 each**

COLVERN 3 WATT WIRE-WOUND POTENTIOMETERS: 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 150Ω, 250Ω, 500Ω, 1KΩ, 1·5KΩ, 2·5KΩ, 5KΩ, 10KΩ, 15KΩ, 25KΩ, 50KΩ.
Price .. .. **only 5/6 each**

CARBON TRACK POTENTIOMETERS
Double wiper ensures minimum noise level. Long plastic spindles.

Single gang linear ..	220 Ω, 470 Ω, 1K, etc. to 2M2 Ω	2/6
Single gang log. ..	4K7, 10K, 22K, etc. to 2M2 Ω ..	2/6
Dual gang linear ..	4K7, 10K, 22K, etc. to 2M2 Ω ..	8/6
Dual gang log. ..	4K7, 10K, 22K, etc. to 2M2 Ω ..	8/6
Log/Anti-log. ..	10K, 47K, 1M Ω only	8/6
Dual anti-log ..	10K only	8/6

Any type with ½ amp double pole mains switch .. extra 2/3
Please Note—only decades of 10, 22 and 47 are available with range quoted.

FETS n-channel
Low cost general purpose 2N5163, 25 volt .. only **5/– each**
Audio/r.f. Texas 2N3819 .. .. **8/6 each**
Motorola 2N5457 (MPF103) .. .. **9/9 each**
Motorola 2N5459 (MPF105) .. .. **9/9 each**

30 WATT BAILEY AMPLIFIER COMPONENTS:
Transistors for one channel £7/5/6 list, with 10% discount .. .. only **£6/11/–**
Transistors for two channels £14/11/– list, with 15% discount .. .. only **£12/7/5**
Capacitors and resistors for one channel, Nov. '68 circuit list £2.
Printed circuit board free with each transistor set.
Complete unregulated power supply kit £4/17/6 mono or stereo, subject to discount.
Complete regulated power supply kit Nov. '68 circuit £9/5/– subject to discount.
Further details on application.

MAIN LINE AMPLIFIER KITS AS ADVERTISED. PRICES NET AUTHORISED DEALER

SINCLAIR IC.10 INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMPLIFIER
This remarkable monolithic integrated circuit amplifier and pre-amplifier is now available for despatch from stock. It is the equivalent of 13 transistor/18 resistor circuit plus 3 diodes and the first of its kind ever. It is d.c coupled and applicable to an unusually wide range of uses all of which are detailed in the manual provided with it.
59/6 NETT post free
Sinclair products as advertised

ELECTROVALUE

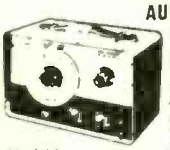
DEPT. WW.704, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY,
Hours: 9-5.30 daily; 1.0 p.m. Saturdays. ***Telephone: Egham 5533 (STD 0784-3)***

SCOOP—PA SYSTEM

Complete system comprising Control Unit, 4 Tannoy loud hailers, microphone and headphones, etc., 12V D.C. operation. Low battery drain. 8 watts power output. The ideal system for mobile use, outdoor meetings, sports days, factories, garden fetes, etc. Speakers can be spaced effectively over hundreds of yards. Also has talk back facility. Guaranteed Brand New in sealed cartons. Original cost over £60.

QUANTITIES AVAILABLE FOR EXPORT

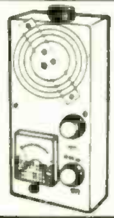
✻ SINE/SQUARE WAVE AUDIO GENERATOR



Provides audio output on 4 bands, Sine wave 20c/s to 200 kc/s, output up to 7V; square wave 60c/s to 30kc/s, 7V p-p. Distortion under 2%. Output impedance 1kΩ. Variable output amplitude control. Supplied with leads and instructions. A.C. mains operated.

TE22 Price £16.10.0
Also TE22D (Size as TE20D) £16. 0.0

✻ GRID DIP METER

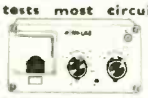


All transistor grid dip meter, absorption wavemeter and bsc. detector. Frequency range 440kc/s to 280Mc/s in 6 coils. Uses 3 transistors plus diode with 500µA meter. Internal battery.

TE15 £11.10.0 p.p. 3/6

✻ 10 in 1 TEST UNIT

A new design tests most circuits. Model SE400 Price £9.10.0.



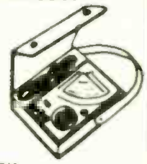
- ★ A.c./d.c. Volts (4K/Volt) 0/15/50/150/500.
- ★ Resistance 0/10K/100k/1 Meg.
- ★ Five values resistance and capacitance substitution.
- ★ RF F/S Meter 1 to 140Mc/s.
- ★ 455/700kc/s RF Generator Size 7¼in. x 3⅜in. x 1 7/16in.
- ★ D.c. Ammeter 0/500mA.
- ★ 400c/s Audio Generator.

✻ VACUUM TUBE VOLTMETER

Features low price for such an instrument. Large 6in. full view scaled meter. 28 ranges. **D.C. volts:** 0/1½/5/15/50/150/500/1500. **A.C. volts:** 0/1½/5/15/50/150/500/1500 r.m.s.: 0/1.4/4/14/40/140/400/1400/4000 p-p. **Resistance:** R x 10-100-1k-10k-100k-1m-10m. Range 0.2 ohm to 1000MΩ. dB scales: —10 to +65dB. Complete with instructions and leads.

TE65 £17.10.0 p.p. 7/6

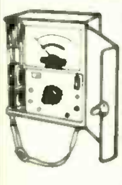
✻ 20,000 OHMS PER VOLT MULTIMETER



Popular model but with extra scale range. 20,000 ohms per volt. 0/5/25/50/250/500/2500 V d.c., 0/10/50/100/500/1000V a.c., 0/50µA, 0/2½/250mA. Resistance 0-6kΩ and 6MΩ. Also dB scales or capacitance.

Model 200H Price 77/6
(Leather case, Price 15/- p.p. 2/-)

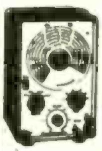
✻ 50,000 OHMS PER VOLT MULTIMETER



Recommended quality instrument with mirror scale and overload protection. 0/0.3/3/12/60/120/300/600/1200V d.c. (50KΩ/V); 0/6/30/120/300/600/1200V a.c. (10KΩ/V); 0/30µA/6/60/300mA, 0/12A; resistance 0/10kΩ/1/10/100MΩ. Meter movement 20µA. Polarity reversing switch. Complete with batteries, leads and instructions.

AF105 £8.10.0 p.p. 2/6
Leather case 28/6

✻ RF SIGNAL GENERATOR



Accurate wide range signal generator covering 120Kc/s-500Mc/s on 6 bands. Directly calibrated. Variable RF. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. Size 140 x 215 x 170mm.

TE20D Price £15 p.p. 7/6

✻ TRANSISTORISED RF MILLIVOLTMETER

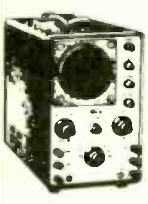
Mains or battery operated. 0/3mV up to 300V AC. Input 1Meg. Response ±0.2dB 20c/s to 1Mc/s and ±1dB at higher and lower frequencies. Fully stabilised. Size: 150 x 240 x 114mm. Complete with handbook. 11 scales 0.003 FSD to 300V FSD. Also dBM and dBV scales.

VM51 Price £32 p.p. 8/6

NOMBREX TRANSISTORISED Test Equipment

MODEL		PRICE £ s. d.
29s RF.Generator	Spin wheel	21 0 0
29x Xtal RF Gen.	Spin wheel	29 10 0
30 Audio Generator	..	19 10 0
31 R.F. Generator	..	12 10 0
32 C.R. Bridge	..	10 10 0
33 Inductance Bridge	..	20 0 0

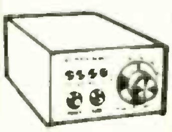
✻ PORTABLE OSCILLOSCOPE



Features 3in. clear view tube, easy to use controls and good stability. Y amp. Sensitivity. 1V p-p/CM. Bandwidth 1.5cps-1.5 MHz. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. 9V p-p/CM. Bandwidth 1.5 cps-800 KHz. Input imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps-300 KHz. Synchronization. Internal/external. Illuminated scale.

TO3 Price £37.10.0 p.p. 10/-

✻ DC STABILISED POWER SUPPLY

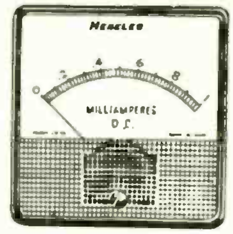


Switched DC Stabilised Outputs UP TO 1 AMP. 3-6-9 & 12 VOLTS. Indicator lamp for each voltage. Fully fused. Mains operated. Negligible ripple. Regulation 1%.

SE101A £8.15.0

FREE 18 PAGE TEST EQUIPMENT CATALOGUE (Ref. No. 33)

QUALITY PANEL METERS



38 SERIES
Face Size 42 x 42mm. DC types.

50	µA	37/6
100	,,	35/–
200	,,	32/6
500	,,	27/6
50-0- 50	,,	35/–
100-0-100	,,	32/6
500-0-500	,,	25/–
1	mA	25/–
5	,,	25/–
10	,,	25/–
50	,,	25/–
100	,,	25/–
500	,,	25/–
1	Amp	25/–
5	,,	25/–
10	Volts	25/–
20	,,	25/–
50	,,	25/–
300	,,	25/–
500	,,	25/–
'S' Meter	1mA	29/6
VU Meter		37/6

65 SERIES
Face Size 86 x 78mm. DC types.

50	µA	62/6
100	,,	52/6
200	,,	47/6
500	,,	45/–
50-0- 50	,,	52/6
100-0-100	,,	49/6
500-0-500	,,	37/6
1	mA	37/6
5	,,	37/6
10	,,	37/6
100	,,	37/6
500	,,	37/6
10	Volts	37/6
20	,,	37/6
50	,,	37/6
100	,,	37/6
300	,,	37/6
500	,,	37/6
'S' Meter	1mA	42/6

85 SERIES
Face Size 120 x 110mm. DC types.

50	µA	69/6
100	,,	59/6
500	,,	52/6
100-0-100	,,	59/6
1	mA	49/6
100	,,	49/6

ELECTRONIC COMPONENTS

- Vast range of transistors, diodes, valves, tubes, IC's in stock. Free list No. 36, or see Catalogue A.
- Complete range of components in stock, including special and hard to get components.

If you are at all interested in Electronics then you are missing out without a copy of 'Henry's' 350-page Catalogue 'A.' Price 7/6 p.p. 2/- with 10/- value discount vouchers.

FREE
To all schools, colleges etc. and all companies interested.

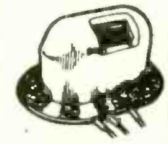
UK's largest stockists of Electronics for every use. Over 6500 lines in stock.

✻ DE-LUXE SINE-SQUARE WAVE RC AUDIO GENERATOR

ORC 27A Price £30 p.p. 10/-.

Weinbridge RC Audio oscillator featuring four overlapping scales covering 18c/s to 200 Kc/s. Output waveforms are sine, square and complex. Mirrored scale with smooth geared tuning control. Output 5 volts RMS or 10 volts P-P. Sinewave response ± ½dB. Distortion under 1% at 1Kc/s. Stability ± 1%. Accuracy ± 2%. O/P impedance under 3K ohms. Variable attenuator. Mains operated. With handbook.

GRAVINER FIRE DETECTOR UNIT



Fire Detector Unit containing G31A photo multiplier and cold cathode tube. Shock and fire proof. Originally made for £74. Price complete with data sheet £6 Brand new.

STC CRYSTAL FILTER ±7.5 K/cs BAND WIDTH

25Kc/s Spacing. New purchase, brand new type 445 LQU 923E. 10.7 Mc/s. 6dB ± 7½Kc/s. Insertion Loss 3.5dB. Terminations 820 Ohms. Usually £12. Price £6 with Data Sheet.

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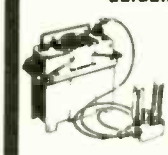

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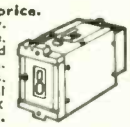

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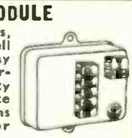

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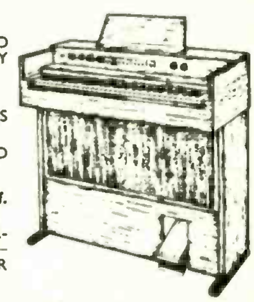

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1B	25–33–40–50	10	£7 12 6	9/6
1C	25–33–40–50	6	£6 15 0	9/6
1D	25–33–40–50	3	£4 0 0	7/6
2A	4–16–24–32	12	£7 2 6	8/6
2B	4–16–24–32	8	£5 7 6	8/6
2C	4–16–24–32	4	£3 12 6	7/6
2D	4–16–24–32	2	£2 7 6	5/–
3A*	25–30–35	40	£16. 10 0	12/6
3B*	25–30–35	20	£10 5 0	10/6
3C	25–30–35	10	£7 5 0	8/6
3D	25–30–35	5	£4 2 6	7/6
3E	25–30–35	2	£3 2 6	7/6
4A*	12–20–24	30	£13 0 0	12/6
4B	12–20–24	20	£8 5 0	9/6
4C	12–20–24	10	£4 5 0	8/6
4D	12–20–24	5	£3 12 6	7/6
5A	3–12–18	30	£9 12 6	9/6
5B	3–12–18	20	£7 2 6	8/6
5C	3–12–18	10	£4 5 0	7/6
5D	3–12–18	5	£2 17 6	7/6
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6B	48–56–60	1	£2 12 6	6/6
7A*	6–12	50	£10 7 6	10/6
7B	6–12	20	£6 2 6	8/6
7C	6–12	10	£3 17 6	7/6
7D	6–12	5	£2 15 0	6/6
8A	12–24	1	£1 12 6	6/6
9A	17–32	8	£6 5 0	8/6
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5	1000	15 lb	£7 2 6	9/6
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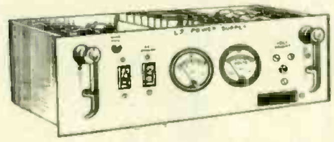

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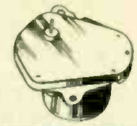

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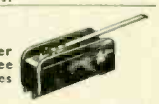

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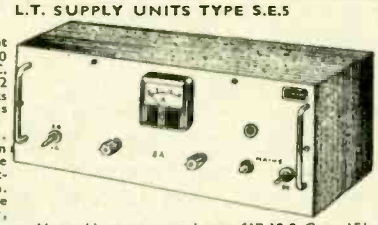

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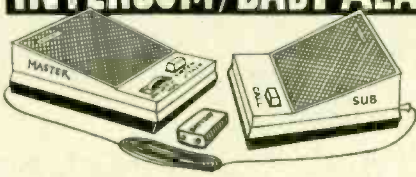

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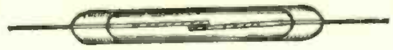

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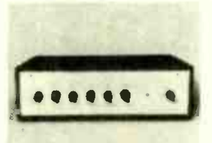

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Frequency Response: ± 1db 40 Hz to 15 KHz.
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Sensitivity: Input 1a 15mV Z=50K ohms flat.
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Input 2a 4.5mV Z=50K ohms RIAA compensated.
2b 200mV Z=100K ohm. flat.
Input 3 200mV Z=100K ohm. flat.
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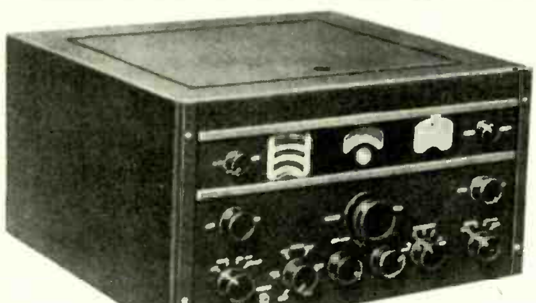


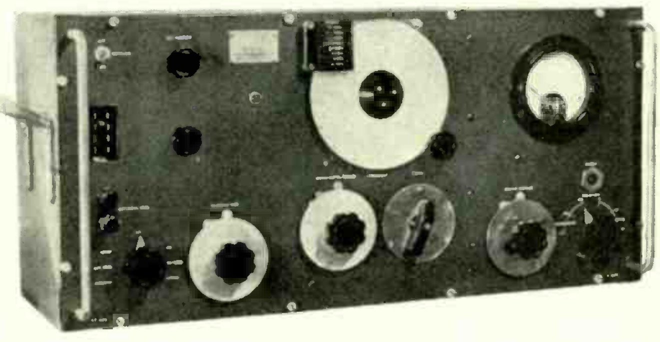
BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price £87/10/- each, carr. £2.

Same model as above in secondhand cond. (guaranteed working order), from £45 to £60, carr. £2.

***SET OF VALVES:** new, £3/10/- a set, post 7/6; **SPEAKERS:** new, £3 each, post 10/-. ***HEADPHONES:** new, £1/5/- a pair, 600 ohms impedance. Post 5/-.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price 10/- each, post 2/6. RF Coils 13 & 14; 17 & 18; 23 & 24; and 27 and 28. Price 12/6 each. 2/6 post. By-pass Capacitor K.98034-1, 3×0.05 mfd. and M.980344, 3×0.01 mfd., 3 for 10/-, post 2/6. Trimmers 95534-502, 2-20 p.f. Box of 3, 10/-, post 2/6. Block Condenser, 3×4 mfd., 600 v., £2 each, 4/- post. Output transformers 901666-501 27/6 each, 4/- post.

** Available with Receiver only.*



MARCONI SIGNAL GENERATORS

TYPE TF-144G

Freq. 85Kc/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: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¼ × 12¼ × 10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

S.A.E. for all enquiries. If wishing to call at Stores, please telephone for appointment.

W. MILLS

3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: 01-808-9213

HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Complete HRO 5T SET (Receiver, Set of 5 Coils & Power Unit) for £27/10/-, carr. 30/-.

COMMAND RECEIVERS; Model 6-9 Mc/s., as new, price £5/10/- each, post 5/-.

COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

AIRCRAFT RECEIVER ARR. 2: Valve line-up 7 × 9001; 3 × 6AK5; and 1 × 12A6. Switch tuned 234-258 Mc/s. Rec. only £3 each, 7/6 post; or Rec. with 24 v. power unit and mounting tray £3/10/- each, 10/- post.

RECEIVERS: Type BC-348, operates from 24 v D.C., freq. range 200-500 Kc/s, 1.5-18 Mc/s. (New) **£35.0.0** each; (second hand) **£20.0.0** each, good condition, carr. 15/- both types.

MARCONI RECEIVER 1475 type 88: 1.5-20 Mc/s, second-hand condition **£10.0.0** each. New condition £25.0.0 each, carr. 15/-.

RACAL EQUIPMENT: Frequency Meter type SA20: **£35** each, carr. £1. Frequency Counter type SA21: **£65** each, carr. 30/-. Converter Frequency Electronic VHF Type S.A.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, **£40** each, carr. £1.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6/10/-** each, 8/- post. 24 v D.C. input, 175 v D.C. @ 40mA output, 25/- each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., **£7/10/-** each, carr. 15/-. 40 mfd, 440 v A.C. wkg., **£5** each, 10/- post. 30 mfd, 600 v wkg. D.C., **£3/10/-** each, post 10/-. 15 mfd, 330 v A.C. wkg., 15/- each, post 5/-. 10 mfd, 1000 v, **12/6** each, post 2/6. 10 mfd, 600 v, **8/6** each, post 5/-. 8 mfd, 1200 v, **12/6** each, post 3/-. 8 mfd, 600 v, **8/6** each, post 2/6. 4 mfd, 3000 v wkg., **£3** each, post 7/6. 2 mfd, 3000 v wkg., **£2** each, post 7/6. 0.25 mfd, 2Kv, 4/- each, 1/6 post. 0.01 mfd. MICA 2.5 Kv. Price **£1** for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. **£3.15.0** each, 10/- post.

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.
COSSOR 1035 OSCILLOSCOPE, £30 each, 30/- carr.
COSSOR 1049 Mk. 111, £45 each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., **£2** each, 6/- post.
12 Small American Relays, mixed types £2, post 4/-.

Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request 6d.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available **6d.**

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2/10/-** each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 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, £4/10/- each, 15/- carr.

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"W×11"H×14"D. (All connections at the rear). Excellent condition **£6.10.0.** each, Carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5" × 6½" × 7". Bitumin impregnated. £5 each, Carr. 12/6. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. £3 each, Carr. 10/-.

POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., **£17/10/-** each, 30/- carr. SMOOTHING UNITS suitable for above £7/10/- each, 15/- carr.

DE-ICER CONTROLLER MK. III: Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20-30 v., 12 r.p.m.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay etc., sealed in steel case (4 × 5 × 7 ins.) **£3** each, post 7/6.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7/10/-** each, 15/- carr.

NIFE BATTERIES: 4 v, 160 amps, new, in cases, **£20** each, £1 10/- carr.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

FREQUENCY METERS: BC-221, meter only **£30** each, BC-221 complete with stabilised power supply **£35** each, carr. 15/-. LM13, 125-20,000 Kc/s., **£25** each, carr. 15/-. TS.175/U, **£75** each, carr. £1.

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω, with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New condition. Price **35/-** each, post 5/-.

AUDIO OSCILLATOR 382/F: Input 115 v. A.C., 50 c/s, 20-200,000 c/s per sec. in 4 ranges. Cont. wave. Output 0-10 v. in 7 ranges. Power output 100 mW. Output impedance 1,000Ω. **£27/10/-** each, £1 carr.

RACK CABINETS (totally enclosed) for std. 19in. panels. Size: 6ft. high × 21in. wide × 16in. deep. With rear door. **£12** each, £2/10/- carr. OR 4ft. high × 23in. wide × 19in. deep. With rear door. **£8/10/-** each, £2 carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3/10/-** each, post 7/6.

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. 10/-.

TEST EQUIPMENT

MARCONI	TF-1274	VHF Bridge Oscillator	£75 each
	TF-1275	VHF Bridge Detector	£75 each
	TF-1067/1	Heterodyne Frequency Meter	£85 each
	TF-899	Valve Millivoltmeter	£35 each
	TF-978	VHF Admittance Bridge	£85 each
	TF-894A	Audio Tester	£55 each
	TF-329G	Circuit Magnification Meter	£45 each
	TF-428/2	Valve Voltmeter	£12/10/- each
	TF-428/1	Valve Voltmeter	£8/10/- each
	TF-726C	UHF Signal Generator	£65 each
	TF-934	Deviation Test Meter	£35 each
	6075A	Deviation Test Meter	£65 each
	TF-987/1	Noise Generator	£20 each
	TF-956	(CT.44) A.F. Absorption Wattmeter	£20 each
FIRZ HILL	V.200	Sensitive Valve Voltmeter	£35 each
	B.810	Incremental Inductance Bridge	£75 each
SOLATRON	CD-513	Oscilloscope	£45 each
	CD-513-2	Oscilloscope	£47/10/- each
	AW-553	Power Amplifier	£30 each
AIRMEC	Type 701	Signal Generator	£50 each
PHILLIPS	Type GM-6008	Valve Voltmeter	£35 each
DAWE	Type 402C	Megohm Meter	£12 each

CANADIAN C52 TRANS/REC.: Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set **£50.** Carr. £2/10/-. Power Unit for Rec., new **£3/5/-.** Carr. 10/-.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0.9 ohms. Tolerance ±1% **£3** each, 5/- post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ±1% **£3/10/-** each, 5/- post.

TELESCOPIC ANTENNA: In 4 sections, adjustable to any height up to 20 ft. Closed measures 6 ft. Diameter 2 in. tapering to 1 in. **£5** each + 10/- carr. Or **£9** for two + £1 carr. (brand new condition).

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., **£6/10/-** each, post 7/6. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) **£6/10/-** each, 4/6 post. 1 pole, 4 throw, Type M1460-4. (New) **£6/10/-** each, 4/6 post.

PRD Electronic Inc. Equipment: FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) **£75** each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) **£5** each, post 4/-. FIXED ATTENUATOR: Type 1157S-1, (new) **£6** each, post 5/-.

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BRITISH & AMERICAN COMMUNICATION EQUIPMENT

Type B.44 Tx/Rx, Crystal controlled, 60-95 Mc/s, 12V. d.c. operation. 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. Telephone Installation type XY, (U.S.A.), 600 Line Automatic Telephone Exchange. Complete system with full set of Manuals. Mobile Communications Installation mounted in a trailer with 4 × pneumatic tyres. Consisting of 3xARC-27 Tx/Rx with all associated equipment (as new).

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AC127	3/6	OC200	3/6
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AC176	5/-	2G301	2/6
ACY17	3/-	2G303	2/6
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AF115	3/6	2N1302-3	4/-
AF116	3/6	2N1304-5	5/-
AF117	3/6	2N1306-7	6/-
AF239	12/6	2N1308-9	8/-
AF186	10/-	2N3819 F.E.T.	9/-
AF139	10/-	Power Transistors	
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BSY25	7/6	OC20	10/-
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BSY29	3/-	OC28	7/6
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OC41	2/6	OC36	7/6
OC44	2/6	AD149	10/-
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OC71	2/6	2N2287	20/-
OC72	2/6	2N3055	15/-
OC73	3/6	Diodes	
OC81	2/6	AAY42	2/-
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OC83	4/-	OA79	1/9
OC139	2/6	OA81	1/9
OC140	3/6	[illegible]	1/6

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NE840A	Dual 4 I/P Exclusive OR Gate TTL	7/-
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SP825A	D.C. Clocked J-K Flip-Flop TTL	17/6
SP840A	Dual 4 I/P Exclusive OR Gate TTL	7/-
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NE500K	Video Amplifier	40/-
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NE808J	Single 8 I/P Nand Gate TTL	7/-
NE816J	Dual I/P Nand Gate TTL	7/-
NE825J	D.C. Clocked J-K Flip-Flop TTL	17/6
NE840J	Dual 4 I/P Exclusive OR Gate TTL	7/-
NE855J	Dual 4 Power Driver TTL	7/-
NE870J	Triple 3 I/P Nand TTL	7/-
NE880J	Quad 2 I/P Nand TTL	7/-
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B91	8	NKT163/164 PNP GERM. TO—5 EQUIVALENT TO OC44, OC45	10/-
B92	4	NPN SIL. TRANS. AO6 = BSX20, 2N2369, 500MHz, 360mW	10/-
B93	5	GET113 TRANS. EQUIV. TO ACY17-21 PNP GERM.	10/-
B96	5	2N3136 PNP SIL. TRANS. TO—18 HPE100-300 IC. 600mA. 200MHz	10/-
B98	10	XB112 & XB102 EQUIV. TO AC126 AC156, OC81/2, OC71/2, NKT271, ETC.	10/-
B99	200	CAPACITORS, ELECTROLYTICS, PAPER, SILVER MICA, ETC. POSTAGE ON THIS PAK 2/6.	10/-
H4	250	MIXED RESISTORS POST & PACKING 2/-	10/-
H7	40	WIREWOUND RESISTORS MIXED TYPES & VALUES. POSTAGE 1/6	10/-

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TYPE A
PNP SILICON ALLOY
TO-5 CAN
Spec:—
ICER AT VCE = 20v
1mA MAX.
HFE. 15-100
These are of the 2S300 type which is a direct equivalent to the OC200/205 range.

TYPE B
PNP SILICON
PLASTIC ENCAPSULATION
Spec:—
ICER AT VCE = 10v
1mA MAX.
HFE. 10-200
These are of the 2N3702/3 and 2N4059/62 range.

TYPE E
PNP GERMANIUM
FULLY MARKED AND TESTED.
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Make a Rev. Counter for your Car. The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a perfectly linear and accurate rev. counter for any car. **20/- each**

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B83	200	200 TRANSISTORS. MAKERS REJECTS. NPN-PNP. SIL. & GERM.	10/-
B84	100	SILICON DIODES DO—7 GLASS EQUIV. TO OA200, OA202	10/-
B66	150	HIGH QUALITY GERM. DIODES MIN. GLASS TYPE	10/-
B86	50	SIL. DIODES SUB. MIN. IN914 & IN916 TYPES	10/-
B87	100	GERM. PNP TRANS. EQUIV. TO OC44, OC45, OC81, ETC.	10/-
B88	50	SIL TRANS, NPN, PNP, EQUIV. TO OC200/1, 2N706A, BSY95A, ETC.	10/-
B60	10	7 WATT ZENER DIODES, MIXED VOLTAGES	10/-
H5	16	1 AMP. PLASTIC DIODES 50–1000 VOLTS	10/-
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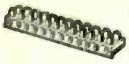
TOGGLE SWITCH

3 amp 250v. with fixing ring. 1/6 each 15/- doz.

MINIATURE EAR PIECE

As used with imported pocket radios. 1/6 each 15/- doz.

15/20 AMP CONNECTORS



Polythene insulated 12-way strip. 2/6 each 24/- doz.

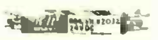
13 AMP FUSED SWITCH

Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type 3/6 each 30/- doz. Metal boxes for surface mounting 1/6 each 15/- doz.

SUPPRESSOR CONDENSER TCC

.1 mfd. 250v. A.C. working metal cased with fixing lug. 1/9 each 18/- doz.

REED RELAY

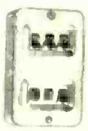


Glass encapsulated reed switch in 24-volt solenoid, neatly enclosed in neat metal case, size 2½in. × ½in. × ½in. 3/6 each. Operates from 24 volts D.C or from A.C. mains using rectifier, resistor and condenser (3/6 extra).

SHEET PAXOLIN

Ideal for transistor projects, panels 12in. × 6in., 1/9 each 15/- per dozen.

G.E.C. MULTIPLE SWITCHES

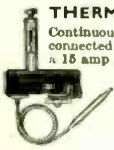


Metal boxes (with cable knockouts) sprayed silver with cover and switch mounting grid. For 12 switches 6/-, 6 switches 5/-, 4 switches 4/-, 2 switches 3/6.

G.E.C. Clipper Switches

For the above boxes, 5 amp A.C. rating, one-way 1/6. 2-way 2/-, bell push 2/-, intermediate 2/6, secret 2/6. 15 amp one-way 2/6.

THERMOSTAT



Continuously variable 30°-90°C. Has sensor bulb connected by 33in. of flexible tubing. On operation a 15 amp 250 volt switch is opened and in addition a plunger moves through approx. ⅛in. This could be used to open valve on ventilator etc. 29/6 plus 4/6 p. & ins.

HI FI BARGAIN

FULL FI 12-INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address.

Flux Density 11,000 gauss—Total Flux 44,000 Maxwells—Power Handling 15 watts R.M.S.—Cone moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12⅜ over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—¼in. diam. on pitch circle. 11⅝in. diam.—Overall height 5½in. A £6 speaker offered for only £3.19.6 plus 7/6 p. & p. Don't miss this offer. 15in. 25 watt £7.19.6. 18in. 100 watt £19.10.0.

REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:

Miniature. 1in. long × approximately ⅛in. diameter. Will make and break up to ½A up to 300 volts. Price 2/6 each. 24/- dozen.

Standard. 2in. long × 3/16in. diameter. This will break currents of up to 1A, voltages up to 250 volts. Price 2/- each. 18/- per dozen.

Flat. Flat type, 2in. long, just over 1/16in. thick, approximately ⅛in. wide. The Standard Type flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price 6/- each. £3 per dozen.

Small ceramic magnets to operate these reed switches 1/9 each. 18/- dozen.

NEED A SPECIAL SWITCH?

Double Leaf Contact. Very slight pressure closes both contacts, 1/3 each, 12/- doz. Plastic push-rod suitable for operating, 1/- each, 9/- doz.

50-Way Connector Block. Heavy duty block, size 24in. × 2½in. × 1¾in. approximately. Each of the 50 ways has a multi cable inlet and outlet designed for easy connection. Also, each way has 2 test sockets and a disconnecting plug. Ideal for inserting ammeter or other device without breaking circuit, offered at 69/6 each, which is only a fraction of the regular price, postage and insurance 5/6.

Under-floor Heating Cable. 200ft. lengths, suitable for dissipating 1,000 watts at 80 volts. Join three in series to make a 240 volt mains operated element of 3kW. Price 20/- per length, 4/6 post on any quantity.

3-Core Leads. Heavy duty 23/36, average length 5ft. 10/- per dozen lengths, plus 4/6 P. & I.

Papst Motors. Est. 1/40th 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. 30/- each.

Instrument Knobs. ⅝in. dia. head with ⅜in. shank for flatted ¼in. spindle, 9d. each, 8/- dozen. Ditto but with metal disc, 1/- each, 11/- dozen.

Midget Output Transformer. Ratio 140 : 1. Size approx. 1in. × ⅝in. × ⅝in., primary impedance 450 Ω. Connection by flying leads. 4/6 each, 48/- doz.

Midget Output Transformer. Ratio 80 : 1. Size approx. 1¼in. × 1in. × ⅞in. Primary impedance 132 Ω. Printed circuit board connection. 5/6 each. £3 doz.

4-Gang Air Spaced Tuning Condenser for AM/FM circuits. AM rf section 200 pf osc section 80 pf both with trimmers.—FM rf section 9.5 pf osc section 11.2 pf—integral slow-motion drive. 9/6 each.

Mains Connector. A quick way to connect equipment to the mains safely and firmly—L., N. and E. coded to new colour scheme; 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. 12/6 each.

ERGOTROL UNITS

These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.

Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.

The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thyristor firing control.

4 models are available—all are brand new in makers cases:

Model 2410 for up to 5 amps £17.10.0
Model 2411 for up to 10 amps £27.10.0
Model 2413 for up to 45 amps £47.10.0
Model 2415 for up to 80 amps £95. 0.0
Note: 2415 is a floor mounting unit.

DISTRIBUTION PANELS

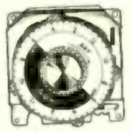
Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, 39/6 less plug; 45/- with fitted 13 amp plug; 47/6 with fitted 15 amp plug, plus 4/6 P. & I.

STANDARD WAFER SWITCHES

Standard size 1½ wafer—silver-plated 5-amp contact, standard ¼" spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	10 way	12 way
1 pole	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6
2 poles	6/6	6/6	6/6	6/6	6/6	6/6	10/6	10/6
3 poles	6/6	6/6	6/6	6/6	10/6	10/6	14/6	14/6
4 poles	6/6	6/6	6/6	10/6	10/6	10/6	18/6	18/6
5 poles	6/6	6/6	10/6	10/6	14/6	14/6	22/6	22/6
6 poles	6/6	10/6	10/6	10/6	14/6	14/6	26/6	26/6
7 poles	10/6	10/6	10/6	14/6	18/6	18/6	30/6	30/6
8 poles	10/6	10/6	10/6	14/6	18/6	18/6	34/6	34/6
9 poles	10/6	10/6	14/6	14/6	22/6	22/6	38/6	38/6
10 poles	10/6	10/6	14/6	18/6	22/6	22/6	42/6	42/6
11 poles	10/6	14/6	14/6	18/6	26/6	26/6	46/6	46/6
12 poles	10/6	14/6	14/6	18/6	26/6	26/6	50/6	50/6

24 HOUR TIME SWITCH

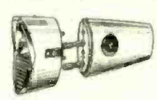


Mains operated. Adjustable Contacts give on/off per 24 hours. Contacts rated 15 amps, repeating mechanism so ideal for shop window control, or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only 39/6 complete with perspex cover, new and unused, plus 3/6 postage and insurance, a real snip which should not be missed.

THIS MONTH'S SNIP

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 £1 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 5/- upwards with circuits and technical data of each. Complete parcel only £1 post paid; or List and all data 10/- post free. Credited when you order I.C.s value £1 and upwards.

RE-CHARGEABLE TORCH



Neat flat torch, fits unobtrusively in your pocket, contains 2 Nicad cells and built-in charger. Plugs into shaver adaptor and charges from our standard 200/240 volt mains. American made, sold originally at over 4 dollars. Our price only 19/6 each.

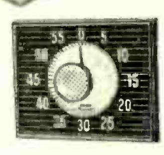
VARYLITE

Will dim incandescent lighting up to 600 watt from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob £3.19.6.

PROTECT VALUABLE DEVICES

FROM THERMAL RUNAWAY OR OVERHEATING: Thyristors, rectifiers, transistors, etc., which use heat-sinks can easily be protected. Simply make the contact thermostat part of the heat-sink. Motors and equipment generally, can also be adequately protected by having thermostats in strategic spots on the casing. Our contact thermostat has a calibrated dial for setting between 90 deg. to 190 deg. F. or with the dial removed range setting is between 80 to 800 deg. F. Price 10/-.

1 HOUR MINUTE TIMER



Made by famous Smiths company, these have a large clear dial, size 4⅛in. × 3⅛in., which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. 22/6.

VARIAC CONTROLLERS

With these you can vary the voltage applied to your circuit from zero to full mains without generating undue heat. One obvious application therefore is to dim lighting. We offer a range of these, ex-equipment but little used and in every way as good as new. Any not so, will be exchanged or cash refunded. 2 amp £4.19.6. 6 amp £8.19.6. 8 amp £12.19.6. 10 amp £15.19.6.

HOUR COUNTERS

If you wish to know how long your equipment has been switched on then this is what you need. Counts running time up to 999 hours. 50 c/s mains operation. 49/6 plus 3/6 post and insurance. Resettable type 69/6 plus 3/6 post and insurance.

THE PECTRON HEATING/VENTILATING CONTROL

This neat unit contains all the controls needed for a gas-fired central heating system as follows:—

(a) A clock switch giving 2 on/off periods per 24 hours.
(b) A thermal delay switch to prevent cold air being blown while fire warms up.
(c) Auto transformer to vary voltage and thus control fan speed.
(d) A 24-volt transformer to provide the low voltage necessary to operate solenoid of gas valve.
(e) A changeover switch to bypass the clock.
(f) Changeover switch to cut off heat so allowing cold air to be blown for Summer ventilation.
(g) Neon indicator and fuses.

The unit has a circuit diagram and five leads labelled "Mains," "Fan," "Thermostat 1," "Thermostat 2," "Gas valve." £5.19.6 plus 4/6 postage and insurance.

MICRO SWITCH

5 amp. changeover contacts. 1/9 each 18/- doz. 15 amp model 2/- ea. or 21/- doz.

MINIATURE WAFER SWITCHES

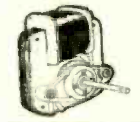
2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each. 36/- dozen, your assortment.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. 10/- post free.

DRILL CONTROLLER

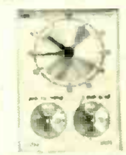
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions 19/6, plus 2/6 post and insurance. Made up model also available 37/6 plus 2/6 p. & p.

MAINS MOTOR



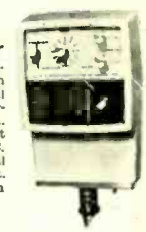
Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 9/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

ELECTRIC CLOCK WITH 25 AMP SWITCH



Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only 39/6, less than the value of the clock alone—post and insurance 2/9.

COOKER CLOCK with temperature contoller



Cooker clock with temperature controller. This is as the clockswitch described above but with additional panel which incorporates oven thermometer and thermostatic switch. The thermostat switch may be set anywhere between 50°C. and 90°C. Made for high-class continental cooker, this is a very fine instrument. £4.19.6. plus £1.10.0 for oven sensor unit.

THERMAL CUTOUT

A miniature device ⅝in. dia. on one screw fixing mount—can be used for motor overload protection—fire alarm—soldering iron switch off, etc., etc.—15 amp contacts open with flame radiant or conducted heat. 1/6 each, 15/- doz. £5 100.

0·0005mFd TUNING CONDENSER

Proved design, ideal for straight or reflex circuits 2/6 each. 24/- doz.

SUB-MINIATURE MOVING COIL MICROPHONE

as used in behind the ear deaf aids

Acts also as earphone size only ⅛in. × ⅜in. × ⅛in. Regular price probably £3 or more. Our price 19/6. Note these are ex-equipment but if not in perfect working order they will be exchanged.

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 16/6, plus 3/6 postage.

PP3 BATTERY ELIMINATOR

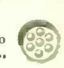
Run your small transistor radio from the mains—full wave circuit. Made up ready to wire into your set and adjustable high or low current. 8/6 each.

85 Watt Tubular Element. Very well made unit. The element is wound on a porcelain former then encased in a brass tube terminated with beaded leads 12in. long. Normal mains voltage. Price 5/- each or 54/- per doz.

250V AC working condensers for power factor correction, motor starting etc. 3.5 mfd. 6/6 ea., 6.5 mfd. 8/6 ea., 8 mfd. 9/6 ea.

3 amp battery charger kit comprises copper backed circuit board, 3 amp mains transformer, regulator resistors and smoothing condenser 29/6 inc. wiring diagram, post & ins, 4/6.

BALANCED ARMATURE UNIT



500 ohm, operates speaker or microphone, so useful in intercom or similar circuits. 4/6 ea., £2.10.0 doz.

Acos crystal microphone. Adjustable stand converts this from hand mic. to desk mic. 19/6 ea.

RADIO STETHOSCOPE

Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece 29/6—twin stetoset instead of earpiece 7/6 extra—post and insurance 2/9.

Where postage is not stated then orders over £3 are post free. Below £3 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

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PLEASE NOTE Unless offered as "as seen" ALL EQUIPMENT ordered from us is completely overhauled mechanically and electrically.

MARCONI TEST EQUIPMENT

SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** DITTO but **801/A/1** with additional high level output. **£89.** Both P. & P. 20/-, including necessary connectors, plugs, and instruction manual.

TF 899 VALVE VOLTMETER, 10mV to 2V, **£17.10.0.** Carriage 30/-.

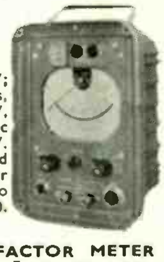
VIDEO OSCILLATOR TF 885A & 885A/1, £55 and £85 resp. Carr. 30/-.

FM DEVIATION METER TYPE TF 791B. Frequency range: 4-250MHz, deviation 1-75kHz. **£62.10.0**

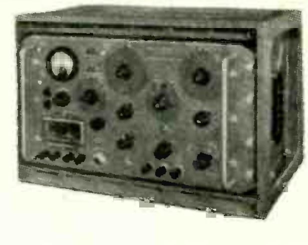
TF 144 SIGNAL GENERATOR. To clear. In very good "as seen" condition. Complete with mains and battery cables, etc. **£15.**

IGNITION TESTER TYPE TF 1348 For all vehicle electrical fault-finding and tuning £60.

VALVE VOLTMETER TYPE TF 958. Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1·5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32.10.0.**



DISTORTION FACTOR METER TYPE TF 142E. Frequency range: 100-8,000Hz in four ranges. Distortion range: 0.05 to 50%. Input impedance 600Ω, attenuation 0-60db continuously variable. Sensitivity 1mW. **£42.10.0.** Carriage 20/-.



IMPEDANCE BRIDGE TYPE TF 369 (No. 5). Measures L & C at 80Hz, 1kHz, 10kHz. Ranges:—L: 1µH-100H. C: 1mF-100µF. R: 0.1ohms-100mohms. AC Bridge volts monitored and variable. Automatic detector sensitivity control. **£105.** Carriage 30/-.

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AVO SIGNAL GENERATOR CT 378, 2-225MHz. **£38.10.0.** Carriage 18/-.

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Model 7X with leads **£15.10.0.**
Model 7 with leads, **£14.10.0.**
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Carriage for each of above 7/6.

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PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy of ± 1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition. **£75.** Carriage 30/-.

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BC134	5/-
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NKT162	6/-
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NKT164	5/6
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NKT212	6/-
NKT213	4/-
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NKT215	4/-
NKT216	10/-
NKT217	13/-
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NKT219	6/-
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NKT223	3/6
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OC22	8/-
OC23	8/-
OC24	8/-
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OC29	15/-
OC35	9/-
OC36	12/6
OC41	4/6
OC42	4/6
OC43	4/6
OC44	3/-
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OC70	2/6
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2N698	6/-
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2N716	7/6
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2N3606	5/6
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2N3702	3/3
2N3703	3/-
2N3704	3/3
2N3705	3/-
2N3706	2/9
2N3707	3/-
2N3708	2/-
2N3709	3/-
2N3710	3/-
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2N3819	8/-
2N3820	18/9
2N3826	6/-
2N3854	5/6
2N3854A	5/6
2N3855	5/6
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2N3906	7/6
2N4037	15/-
2N4058	4/6
2N4059	5/-
2N4060	5/-
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2N4062	4/6
2N4284	3/-
2N4285	3/-
2N4286	3/-
2N4287	3/-
2N4288	3/-
2N4289	3/-
2N4290	3/-
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2N5175	10/6
2N5176	9/-
2N5232	5/6
2N5249	13/6
2N5249A	13/6
2N5305	7/6
2N5306	8/-
2N5309	12/6
2N5354	5/6
2N5355	5/6
2N5356	10/6
3N128	18/6
3N140	19/6
3N141	21/6
3N142	16/6
3N143	19/6
3N152	24/-
2S001	10/-
2S002	12/6

2S003	12/6
2S004	15/-
2S005	15/-
2S006	15/-
2S012	25/-
2S012A	22/6
2S017	15/-
2S018	17/6
2S019	19/6
2S104	12/6
2S301	8/6
2S302	7/6
2S303	10/-
2S304	12/6
2S306	15/-
2S320	9/-
2S321	6/-
2S323	10/-
2S701	8/6
2S703	12/6
2S720	25/-
2S732	8/6
2S1002	10/-

DIODES AND RECTIFIERS

AA119	2/-
AAY11	2/-
AAZ12	6/-
AAZ13	2/6
BA110	6/-
BA111	6/-
BA112	18/-
BA115	1/6
BA130	3/-
BAY31	2/6
BAY38	3/-
BY100	5/-
BY125	3/6
BY127	4/-
BY234	2/3
BYX10	3/-
BYX36 150	2/6
BYX36 300	2/10
BYX36 600	3/9
BYY21	25/-
BYY23	26/3
BYY25	31/9
BYY142	3/9
BYZ10	9/-
BYZ12	6/-
BYZ13	5/-
CG6E	4/-
CG63	2/-
EA403	3/6
EC401	5/-
EC402	4/8
EB383	3/6
GEX45/1	4/-
GJ3M	4/-
OA5	3/8
OA10	6/-
OA47	1/6
OA70	1/6
OA73	1/6
OA79	1/6
OA81	1/6
OA85	1/6
OA90	1/6
OA91	1/6
OA95	1/6
OA200	2/-
OA202	2/-
SD19	-/7
TD716	12/-
IN34A	4/-
IN60	4/-
IN64	4/-
IN82A	9/6
IN87A	4/6
IN191	5/-
IN914	1/9
IN4001	2/-
IN4005	4/-
IN4007	5/-
IN4148	1/9
IS44	1/9
IS130	2/-
IS131	2/6
IS132	3/-
IS113	4/6

LOWEST I.C. PRICES YET!

IC10	59/6	Sinclair IC amp.
PA230	20/-	IC Preamplifier
PA234	20/-	1 watt audio amp.
PA237	32/6	2 watt audio amp.
PA246	52/6	5 watt audio amp.
PA424	43/-	Zero voltage switch
SL403A	49/6	3 watt Plessey amp.
TAA263	15/-	Mullard linear amp.
TAD100	45/-	IC receiver
TAA293	20/-	Mullard gen. purp. amp.
TAA310	30/-	Record/Playback preamp.
TAA320	13/-	MOS LF amplifier
UL702C	29/6	Plessey linear amplifier
3N84	26/-	Silicon controlled switch

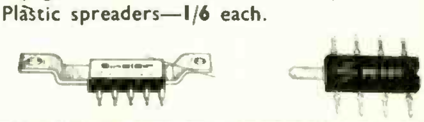
Data sheets available on request 1/- per copy.

PLEASE NOTE: Only new—full specification integrated circuits, no below-specification types.

FAIRCHILD MICRO-LOGIC

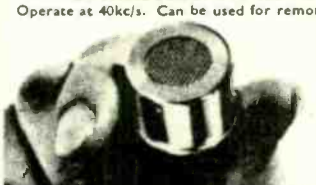
	1–6	7–11	12+
ul 900	9/9	9/-	8/-
ul 914	9/9	9/-	8/-
ul 923	12/6	11/9	11/-

Prices for 100+ and 1,000+ on application.
5 page data and circuits article—2/6.
Plastic spreaders—1/6 each.



ULTRASONIC TRANSDUCERS

Operate at 40kc/s. Can be used for remote control systems without cables or electronic links. Type 1404 trans-ducers can transmit and receive.



FREE: With each pair our complete transmitter and receiver circuit.
PRICE
£5.18.0 Pair
(Sold only in pairs

ZENER DIODES

400mW 10% GLASS CASE
TEXAS Mfr.

1S2036	3·6 volt
1S2039	3·9 volt
1S2043	4·3 volt
1S2047	4·7 volt
1S2056	5·6 volt
1S2062	6·2 volt
1S2068	6·8 volt
1S2075	7·5 volt
1S2082	8·2 volt
1S2100	10 volt
1S2110	11 volt
1S2120	12 volt
1S2160	16 volt
1S2180	18 volt
1S2270	27 volt
1S2300	30 volt

1-24 3/6d. 25-99 2/9d.
100+ 2/3d.

2N3819 8/-
Texas FET
25 + 6/9 100 + 5/9

2N4871 6/9
Motorola unijunction
25 + 5/9 100 + 4/9

2N3055 15/-
115 watt silicon power transistor
25 + 13/- 100 + 11/-

IRC 20 8/6
Plastic SCR Thyristor, 200 piv 1·2amp (similar C106B1)
25 + 7/9 100 + 7/-

BC107/8/9 2/9
NPN Planar transistors
BC107 & 9 25+2/5 100+2/2
BC108 25+2/3 100+2/-

BY 127 4/-
Mullard Plastic HV rectifier 800 piv 1 amp (similar BY100 etc.)
25 + 3/3 100 + 3/-

2N2926 2/-
NPN Planar transistors
25 + 1/8 100 + 1/6

INFRA-RED DEVICES

56 CAY 29/6
Gallium arsenide emitter

MGA 100 35/-
Gallium arsenide emitter

31F2 28/6
Infra-red detector diode

AD161/2 10/-
Siemens/Telefunken NPN/PNP output pair
25 + 9/- 100 + 8/-

OCP 71 19/6
Mullard Phototransistor
25 + 17/3 100 + 14/9

Prices quoted are current at time of going to press and may be subject to variation without notice.
Semiconductors offered in this advertisement bear the relevant Manufacturers' original markings and are subject to our full replacement guarantee if not to published specifications.
WE DO NOT offer "Re-marked" makers' rejects or similar out of specification devices.
Please enclose a stamped self-addressed envelope with any query.
Quantity prices on application: many more types in stock and expected daily. If you buy in bulk we can save you money!
Export enquiries particularly welcome. Cable Address: Lestroco Brentwood.
TERMS OF BUSINESS: Retail orders; cash with order please.
TRADE: Please furnish references if credit account required.
POSTAGE: 1/- per order inland; 4/- Europe; 12/- Commonwealth.

ADDRESS YOUR ORDERS TO:

L.S.T. LTD. 7 COPTFOLD ROAD, BRENTWOOD, ESSEX

DIRECT LINES TO SALES DEPT: BRENTWOOD (ESSEX) 226470/1

SUPER-BARGAIN STOCKTAKING SALE!!

Use form below for your order. CONDENSERS MUST BE ORDERED BY STOCK NUMBER ONLY.
If any sale item is 'sold-out' when order received we shall substitute items of equal value.

ELECTROLYTIC CAPACITORS

Capacity	Voltage	No. required	Stock No.	Price s. d.	£ s. d.
1 uf	6		1	4	
20 uf	6		7	4	
8 uf	6		11	4	
32 uf	150		9	9	
100/200/200/50	275		18	7 6	
50/80	300		19	3 0	
24	275		21	1 0	
16/32	350		25	2 6	
32	275		26	1 6	
3,000	35		32	7 6	
3,000	15		33	3 0	
2,500	9		36	2 0	
750	12		38	1 9	
100	275		39	2 6	
30	10		40	3	
16	50 REV		42	2 0	
16/16	275		43	2 0	
16	275		44	1 0	
350	12		45	9	
20/4	275		46	1 0	
64	275		51	1 9	
32/32	350		52	2 6	
8/8/8	275		53	1 9	
500	6		54	6	
500	4		60	3	
64/32/8	275		62	2 6	
30	6		67	3	
50/50/50	350		69	4 0	
40/40/20	275		70	2 0	
400	6.4		71	3	
320	10		72	3	
32/32	275				
+25	25		73	2 6	
250	150		G4/3	2 6	
50/50	200		G4/4	2 6	
16	300		G4/5	1 6	
60	350		G4/5A	2 6	
60/200	275		G4/6	5 6	

Capacity	Voltage	No. required	Stock No.	Price s. d.	£ s. d.
32/300/70	275		G4/6A	6 6	
40/40	275		G4/7	3 0	
40/40	300		G4/8	3 0	
8/8	350		G4/9	3 0	
350	25		G4/10	2 6	
60/100	350		G5/4	5 0	
400	275		G5/5	3 6	
60/100	275		G5/6	4 6	
100/400/32	275		G5/6A	7 6	
100/400	275		G5/7	7 6	
100/64	500		G5/7A	7 6	
4/4	250		G5/8	1 6	
100/65	250		G5/8A	4 0	
8/8	450		G5/9	4 0	
100/100/50	350		G5/10	7 6	
100/380/16	275		G5/10A	7 6	
100/100	25		G5/11	2 6	
100/20/10 }	350				
20 }	50		G5/12	5 6	
1,000/1,500	25		G5/12A	6 0	
40/100	350		G5/13	3 6	
40/40/40	350		G5/13A	3 6	
8/8/8	275		G5/14	2 6	
12,500	15		G6/1	15 0	
800	6		G6/2	1 6	
1,600	80		G5/5	7 6	
1,000	60		G5/6	7 6	
100	275		G5/7	2 6	
200	250		G5/8	3 0	
200	150		G5/9	2 6	
8	200		G5/10	1 6	
200	25		G5/10A	2 0	
40	350		G5/11	2 6	
400	300		G5/11A	3 6	
250	25		G5/12	2 6	
1,000	12		G5/12A	2 0	
40	450		G5/13	4 0	

Total:

RESISTORS. Mainly 5 per cent. **7/6** per 100 of any one value. **2/-** per dozen of any one value.
Smaller quantities **3d.** each. Most values in stock.
Mixed bags (our selection) **6/6** per 100.
Mixed bags (our selection) ½ to 3 watt 7/6 per 100.
MAINS DROPPER TYPE. Hundreds of values from .7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted". **10/-** per dozen.

SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS
10/- per 100 of any one value. **3/-** per dozen of any one value. Smaller quantities **6d.** each. As available.

COMPARE THESE PRICES!!

MULLARD POLYESTER CONDENSERS

			No.	Price
1,000 pf	3d. each	400V		
1,500 pf	3d. each			
1,800 pf	3d. each			
2,200 pf	3d. each			
.15 uf	6d. each	160V		
.22 uf	6d. each	160V		
.27 uf	6d. each	160V		
1 uf	1/- each	125V		

Total:

25% discount lots of 100 per type.

TRANSISTOR BARGAIN! THEY CAN'T GET ANY CHEAPER!!!
OC 44. First-grade Mullard. **4/-** each.
OC 45. Mullard. Boxed. **4/-** each.
P.N.P. Audio. Untested, unmarked. MAINLY O.K. **10/-** per 100.
N.P.N. Silicon. R.F. types, unmarked. ALL USUABLE. **10/-** per 50.
Power Output (Similar OC 35). ALL TESTED. **4/-** each; £2 doz.
ZTX 300. Transistors similar to, tested in P.E. organ circuit and approved for use in same by designer. **1/-** each.
OCP 71 (similar to). Light-sensitive. **2/-** each.
Light-sensitive Diodes. Can be used to control any transistorised device. **1/-** each. **75/-** per 100. **£25** per **1,000.**

RECTIFIERS. Latest type. All marked. 800 volt peak, 1 amp mean current type 1N4006. 2/6 each, **24/-** dozen, **£7/10/-** 100. S.T.C. 3/4 (400 volt) **2/6** each, **24/-** dozen, **£7/10/-** 100. BYZ 13 or 19 (6 amp) **2/6** each, **24/-** dozen, **£7/10/-** 100.
BY 127 2/6d. each. **24/-** dozen. **£7/10/-** per 100. **£50** per 1,000.

RECORDING TAPE GIVE-AWAY! ALL BRITISH MADE, BEST QUALITY!

5" Standard	**7/6d.**		
5¾" Standard	**9/-**	5¾" Long-play	**12/-**
7" Standard	**12/-**	7" Long-play	**16/3**
3" "Oddends" Minimum 150	**2/3d.**		

GIANT SELENIUM SOLAR CELLS. Last few to clear at half price! Circular, 67 mm. diameter **5/-** each. 50 mm. × 37 mm. 3 for **10/-**.

RECORD PLAYER AMPLIFIERS. All transistor. Complete with screened input lead, volume control and speaker leads. This excellent unit also has built-in rectifier and smoothing components enabling same to be used direct on 6 to 9 volt A.C. supply. Small number only! Cannot be repeated at this price! **30/-** ea.

TRANSISTOR RADIOS. Fantastic bargain! Tremendous value! Superb quality sound from large speaker! Excellent sensitivity! Complete with earpiece, battery and plastic carrying case, all packed in a colourful presentation box. You would expect to pay £5—but our price due to huge purchase is only **37/6d.!**

CO-AXIAL CABLE. Semi-air spaced. 8d. yard. 60 yd. rolls **30/-** Postage **4/6d.**

CRYSTAL TAPE-RECORDER MIKES, 12/- each. **CRYSTAL EAR-PIECES WITH PLUG, 5/-** each. Magnetic earpieces. No plug. **1/6d.** each.

THIN CONNECTING WIRE. 10 yds **1/-**, 100 yds **7/6d.**, 1,000 yds. **50/-**.

RECORD PLAYER CARTRIDGES

ACOS GP67/2 **15/-** (Mono)	GP94/1 **30/-** (Stereo, ceramic)
ACOS GP91/3 **20/-** (Compatible)	ACOS GP93/1 with diamond needle **32/6d.**
ACOS GP93/1 **25/-** (Stereo)	ACOS GP94/1 with diamond needle **37/6d.**

TRANSISTORISED FLUORESCENT LIGHTS. 12 VOLT
8 watt 12" tube, Reflector type **59/6** 15 watt 18" tube, Batten type **79/6**
Complete with tube. Postage 3/-

TRANSISTORISED SIGNAL INJECTOR KIT	**10/-**
TRANSISTORISED SIGNAL TRACER KIT	**10/-**
TRANSISTORISED REV. COUNTER KIT (CAR)	**10/-**

VERO-BOARD

2½" × 1" × .15	**1/3**	17" × 3¾" × .15	**14/8**
3¾" × 2½" × .15	**3/3**	3¾" × 2½" × .1	**4/2**
3¾" × 3¾" × .15	**3/11**	3¾" × 3¾" × .1	**4/9**
5" × 2½" × .15	**3/11**	5" × 2½" × .1	**4/7**
5" × 3¾" × .15	**5/6**	5" × 3¾" × .1	**5/6**
17" × 2½" × .15	**11/-**		

Spot Face Cutter **7/6d.** Pin Insert Tool **9/6d.** Terminal Pins **3/6d.** for 36. Spot Face Cutter and 5 2½" × 1" boards **9/9d.**

VOLUME CONTROLS. ½M ohm, 1M ohm with D.P. switch. 5k (no switch) all **2/-** each.
Double pots (most with concentric spindles).

500k log + 50k lin + switch	**3/-**	10k log + 10k log + switch	**4/6**
50k S/log + 1M log + switch	**3/-**	1M lin + 1M lin no switch	**2/6**
100k lin + 100k log + switch	**3/-**	500k lin + 1M lin no switch	**2/6**
100k log + 100k log + switch	**3/-**	1M lin + 2.5M lin no switch	**2/6**
250k log + 100k lin + switch	**3/-**	500k lin + 500k log no switch	**2/6**
250k log + 500k log + switch	**3/-**	100k log + 100k log no switch	**2/6**
1M log + 1500 ohm lin + switch	**3/-**	2M log + 2M log no switch	**3/6**
1M log + 100k lin + switch	**3/-**		

Skeleton presets/Wire wound presets. Mixed. Very good value. **7/6** per dozen.

SCREENED LEADS. Specially designed to fill the demand for the most popular types—all leads consist of 9 ft. screened lead—except SL 11 which has 10 ft. co-axial cable.

SL 1	Phono Plug to Phono Plug	**5/3**
SL 2	Standard Jack Plug to Standard Jack Plug	**12/-**
SL 3	Standard Jack Plug to Phono Plug	**9/-**
SL 4	3 pin Din Plug to Phono Plug	**7/6**
SL 5	Phono Plug to Wander Plugs	**9/-**
SL 6	Standard Jack Plug to Wander Plugs	**9/-**
SL 7	3 pin Din Plug to Wander Plugs	**6/9**
SL 8	Phono Plug to Phono Coupler	**9/-**
SL 9	3.5 mm. Jack Plug to Phono Plug	**7/6**
SL 10	Co-ax Plug to Co-ax Plug	**6/9**
SL 11	Car Aerial Plug to Car Aerial Socket	**7/6**
SL 12	3 pin Din Plug to 3 pin Din Plug	**9/-**
SL 13	Co-ax Plug to 3.5 mm. Jack Plug	**7/6**
SL 14	3 pin Din Plug to 3.5 mm. Jack Plug	**8/3**
SL 15	Standard Jack Plug to 3 pin Din Plug	**10/6**
SL 16	3.5 mm. Jack Plug to Wander Plugs	**6/9**
SL 17	3.5mm. Jack Plug to Standard Jack Plug	**10/6**
SL 18	3.5 mm. Jack Plug to 3.5 mm. Jack Plug	**8/3**
SL 19	3 pin Din Plug to 5 pin "A" Din Plug 180°	**9/-**
SL 20	3 pin Din Plug to Soldered Ends	**6/-**
SL 21	5 pin Din "B" Plug 360° to 2 Phono Plugs	**9/-**

PLUGS AND SOCKETS

Standard Jack Plug	**3/6**	Standard Chassis Mounting Socket	**2/7**
3.5 mm. Jack Plug	**2/-**	3.5 mm. In-Line Socket	**2/-**
3.5 mm. Screened do.	**2/3**	3.5 mm. In-Line Screened Socket	**2/4**
3 pin Din Plug	**2/6**	3 pin Chassis Mounting Socket	**1/9**
5 pin Din Plug	**3/3**	5 pin Chassis Mounting Socket	**2/-**
Phono Plug	**1/-**	Adaptor, 3.5 mm. Plug/Standard Jack Socket	**6/-**

These prices cannot be repeated. Order now. Don't forget to add your name and address!
Please include suitable amount to cover post and packing. Minimum 2/-.

G. F. MILWARD, DRAYTON BASSETT, near TAMWORTH, STAFFS. Phone: TAMWORTH 2321

BRAND NEW SEMICONDUCTORS & COMPONENTS GUARANTEED

TRANSISTORS Brand new and fully guaranteed. **PLEASE NOTE:—A large number of our transistors have now been reduced in price. Many more semi-conductors in stock. Please enquire for types not listed.**

2G301	4/-	2N3402	5/6	3N143	19/6	BC168C	3/9	BFW58	5/6	NKT272	4/-
2G302	4/-	2N3403	5/6	3N152	24/-	BC169B	3/6	BFW59	5/-	NKT274	4/-
2G303	4/-	2N3404	7/6	R.C.A.:		BC169C	3/9	BFW60	5/-	NKT275	4/-
2G306	8/6	2N3405	9/-	40050	18/6	BC170	3/6	BSX19	3/6	NKT281	5/6
2G308	6/-	2N3414	5/6	40250	12/6	BC171	3/6	BSX20	3/6	NKT401	17/6
2G309	6/-	2N3415	6/6	40309	9/6	BC172	3/6	BSX21	7/6	NKT402	18/-
2G371	3/-	2N3416	7/6	40310	13/-	BC175	6/-	BSX26	10/6	NKT403	15/-
2G374	4/-	2N3417	9/6	40311	10/6	BC182	4/6	BSX27	10/6	NKT404	12/6
2G381	4/6	2N3439	39/6	40312	13/6	BC183	4/6	BSX28	6/-	NKT405	15/-
2N388A	10/6	2N3440	25/-	40314	10/6	BC184	4/6	BSX60	19/6	NKT406	12/6
2N404	4/6	2N3570	17/6	40315	10/6	BC182L	4/6	BSX61	12/6	NKT451	12/6
2N696	4/-	2N3572	17/6	40316	13/-	BC183L	4/6	BSX76	4/6	NKT452	12/6
2N697	5/-	2N3605	5/6	40317	11/-	BC184L	4/6	BSX77	6/6	NKT453	9/6
2N698	5/-	2N3606	5/6	40319	15/-	BC212L	5/-	BSX78	6/6	NKT603F	6/6
2N699	7/6	2N3607	4/6	40320	10/6	BCY10	5/6	BSY10	5/6	NKT613F	6/6
2N706	2/6	2N3662	7/6	40323	10/6	BCY12	5/6	BSY11	5/6	NKT674F	5/-
2N706A	2/6	2N3663	8/-	40324	12/6	BCY30	5/6	BSY24	4/-	NKT677F	5/-
2N708	3/-	2N3702	3/6	40326	10/6	BCY31	5/6	BSY25	4/-	NKT713	5/-
2N709	12/6	2N3703	4/6	40329	7/6	BCY32	7/6	BSY26	4/-	NKT717	8/6
2N718	6/-	2N3704	4/6	40344	8/-	BCY33	4/-	BSY27	4/-	NKT734	5/6
2N718A	6/-	2N3705	4/-	40347	9/6	BCY34	4/6	BSY28	4/-	NKT736	7/-
2N726	5/-	2N3706	4/6	40348	14/6	BCY38	4/6	BSY29	4/-	NKT773	5/-
2N727	5/-	2N3707	4/-	40360	11/6	BCY39	7/6	BSY32	5/-	NKT781	6/-
2N914	3/6	2N3708	3/6	40361	12/6	BCY40	6/6	BSY36	5/-	NKT10339	6/6
2N916	3/6	2N3709	3/6	40362	14/6	BCY42	3/-	BSY37	5/-	NKT10419	6/-
2N918	6/-	2N3710	4/-	40370	8/6	BCY43	3/-	BSY38	4/6	NKT10439	7/6
2N929	4/6	2N3711	4/-	40406	16/-	BCY54	7/6	BSY39	4/6	NKT10519	6/6
2N930	7/-	2N3713	27/6	40408	16/-	BCY58	4/6	BSY40	6/6	NKT20329	9/6
2N987	10/6	2N3714	27/6	40467	16/6	BCY59	4/6	BSY51	8/6	NKT20339	7/6
2N1131	5/6	2N3819	9/-	40468A	16/6	BCY60	19/6	BSY52	9/-	NKT80111	15/6
2N1132	6/6	2N3823	27/6	AC107	6/-	BCY70	4/6	BSY53	8/6	NKT80112	19/6
2N1302	3/6	2N3854	5/6	AC126	4/-	BCY71	8/6	BSY54	10/6	NKT80113	22/6
2N1303	3/6	2N3854A	5/6	AC127	5/-	BCY72	4/-	BSY56	18/-	NKT80211	18/6
2N1304	4/6	2N3855	5/6	AC128	4/-	BCZ10	5/6	BSY78	9/6	NKT80212	18/6
2N1305	4/6	2N3855A	6/-	AC154	4/6	BCZ11	5/6	BSY79	9/6	NKT80213	18/6
2N1306	5/-	2N3856	6/-	AC176	5/-	BD116	35/-	BSY82	10/6	NKT80214	18/6
2N1307	5/-	2N3856A	6/-	AC187	12/-	BD118	22/6	BSY90	11/6	NKT80215	18/6
2N1308	6/-	2N3858	5/-	AC188	12/-	BD121	17/6	BSY95A	2/6	NKT80216	18/6
2N1309	6/-	2N3858A	6/-	ACY17	5/-	BD123	21/6	BSW41	8/6	OC20	15/-
2N1507	5/6	2N3859	5/6	ACY18	5/-	BD124	12/-	BSW70	5/6	OC22	8/-
2N1613	5/-	2N3859A	6/6	ACY19	5/-	BD131	24/-	D16P1	7/6	OC23	8/-
2N1631	8/6	2N3860	6/-	ACY20	5/-	BD132	24/-	D16P2	8/-	OC24	8/-
2N1632	8/6	2N3866	30/-	ACY21	5/-	BDY10	27/6	D16P3	7/6	OC25	8/-
2N1637	8/6	2N3877	9/-	ACY22	4/-	BDY11	37/6	D16P4	8/-	OC26	6/6
2N1638	7/6	2N3877A	9/6	ACY28	4/-	BDY17	37/6	GET102	6/-	OC28	10/6
2N1639	7/6	2N3900	10/6	ACY40	4/-	BDY18	49/6	GET113	4/-	OC29	15/-
2N1701	32/6	2N3900A	11/6	ACY41	5/-	BDY19	62/6	GET114	4/-	OC35	6/6
2N1711	6/6	2N3901	19/6	ACY44	8/-	BDY20	22/6	GET118	4/-	OC36	6/6
2N1889	6/6	2N3903	7/-	AD140	8/-	BDY38	19/6	GET119	4/-	OC38	10/6
2N1893	8/6	2N3094	7/-	AD149	11/6	BDY60	36/-	GET120	6/6	OC41	4/6
2N2147	14/6	2N3905	7/6	AD150	15/-	BDY61	36/-	GET873	3/-	OC42	5/-
2N2148	12/6	2N3906	7/6	AD161	7/6	BDY62	27/6	GET880	6/-	OC44	4/-
2N2160	11/6	2N4058	5/6	AD162	7/6	BF115	5/-	GET887	4/-	OC45	2/6
2N2193	5/6	2N4059	5/-	AF106	9/-	BF117	9/6	GET889	4/6	OC46	3/-
2N2193A	10/-	2N4060	5/-	AF114	5/-	BF163	7/6	GET890	4/6	OC70	3/-
2N2194A	4/6	2N4061	4/6	AF115	6/-	BF167	5/6	GET896	4/6	OC71	2/6
2N2217	5/6	2N4062	4/6	AF116	5/-	BF173	7/6	GET897	4/6	OC72	2/6
2N2218	6/6	2N4244	9/6	AF117	5/-	BF177	11/6	GET898	4/6	OC74	4/6
2N2219	6/6	2N4245	8/6	AF118	12/6	BF178	10/6	MAT100	6/-	OC75	4/6
2N2220	5/-	2N4254	8/6	AF119	4/-	BF179	14/6	MAT101	6/-	OC76	3/-
2N2221	5/-	2N4255	7/6	AF124	4/6	BF180	7/-	MAT120	6/-	OC77	5/6
2N2222	6/6	2N4284	3/6	AF125	4/6	BF181	6/6	MAT121	6/-	OC81	4/-
2N2287	21/6	2N4285	3/6	AF126	4/-	BF184	7/6	MJ400	21/6	OC81D	4/6
2N2297	6/-	2N4286	3/6	AF127	3/6	BF185	5/6	MJ420	22/6	OC83	4/6
2N2368	5/-	2N4287	3/6	AF139	7/6	BF194	5/-	MJ421	22/6	OC84	5/-
2N2369	3/-	2N4288	3/6	AF178	12/6	BF195	5/6	MJ430	20/6	OC139	6/6
2N2369A	5/6	2N4289	3/6	AF179	14/6	BF196	5/6	MJ440	19/6	OC140	6/6
2N2410	8/6	2N4290	3/6	AF180	16/-	BF197	5/6	MJ480	20/6	OC170	6/-
2N2483	5/6	2N4291	3/6	AF181	8/6	BF198	5/6	MJ481	27/6	OC171	6/-
2N2484	6/6	2N4292	3/6	AF239	7/6	BF200	10/6	MJ490	22/6	OC200	6/6
2N2539	4/6	2N5027	10/6	AF279	16/6	BF224	6/-	MJ491	29/6	OC201	7/6
2N2540	4/6	2N5028	11/6	AF280	16/6	BF225	6/-	MJ1800	43/6	OC202	10/6
2N2613	7/-	2N5029	9/6	AFZ11	5/6	BF237	6/6	MJE340	15/-	OC203	6/6
2N2614	6/-	2N5030	8/6	ASY26	5/6	BF238	6/6	MJE520	19/6	OC204	6/6
2N2646	11/6	2N5172	3/-	ASY27	8/6	BFX12	4/6	MJE521	19/6	OC205	8/6
2N2696	6/6	2N5174	10/6	ASY28	5/6	BFX13	4/6	MPF102	8/6	OC207	7/6
2N2711	6/-	2N5175	10/6	ASY29	5/6	BFX29	8/-	MPF103	7/6	OCP71	10/6
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2N3011	12/6	2N5365	9/6	BC116	12/6	BFY21	8/6	NKT219	6/-	TIP29A	17/6
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38 Series—FACE SIZE 42 × 42 mm. All prices for 1-9 pieces.

50	Microamp	37/6	5	Milliamp	25/-
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500	"	27/6	100	"	25/-
50-0-50	"	35/-	500	"	25/-
100-0-100	"	32/6	1	Amp	25/-
500-0-500	"	25/-	5	"	25/-
1	Milliamp	25/-	10	Volts	25/-
			20	"	25/-
			50	"	25/-
			300	"	25/-
			500	"	25/-

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10" × 6"	37/6	3"	9/6
9" × 4"	23/6	5"	14/6
8" × 5"	19/6	8"	27/6
7" × 4"	15/6	12"	39/6
5" × 3"	12/6		

Post and packing 2/9.

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Twin Ganged Stereo Pots. Log. and Lin. Less Switch 7/6

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1 Watt (from 2.4 to 200v) 7/6
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3A	3/-	—	—	4/6	—	6/-	—	—
6A	—	—	5/-	6/-	6/6	7/-	10/-*	—
10A	8/-	12/6	13/6	16/6	16/6	19/6	23/-	30/-
17A	—	15/6	16/9	21/-	21/-	26/-	32/6	43/6

*5 AMP only. 1 AMP Types are plastic.

DIODES & RECTIFIERS

1N461	1/6	AA119	2/-	BAY38	2/6	OA5	2/6
1N914	1/6	AA129	2/-	BY100	4/6	OA10	2/6
1N916	1/6	AAZ13	2/-	BY103	4/6	OA9	2/-
1N4007	4/6	AAZ15	2/6	BY122	7/6	OA47	1/6
1S010	3/-	AAZ17	2/6	BY124	3/-	OA70	1/6
1S021	4/-	BA100	6/6	BY126	4/-	OA73	2/-
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1S113	3/-	BA115	1/6	BYX10	9/-	OA85	1/6
1S120	2/6	BA144	5/6	BYZ11	7/6	OA90	1/6
1S121	2/6	BAX13	2/6	BYZ12	6/6	OA91	1/6
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2 amp. Sec. tappings from 6 to 50v 45/6
1 amp. Sec. tappings 0-3.5-9-17v 19/6
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SL402A 42/6
SL403A 49/6
Data & Application Sheet 2/-

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L914 Dual Gate	11/-	9/6	8/4
L702C	40/-		
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MC792P 20/-
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Quantity Prices on Application.

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FCH 221	Triple 3 Input DTL Line	28/6
FCJ 101	3 Input JK Flip Flop	35/-
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TAA 243	Operational Amplifier	45/-
TAA 263	Linear A.F. Amplifier	15/6
TAA300	Liner A.F. Amplifier	47/6
TAA 320	Most L.F. Pre Amplifier	15/6
TAA350	Wideband Lim. Dif. Amplifier	45/-

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PA237 2 Watt Audio Amplifier 45/-
PA246 5 Watt Audio Amplifier 57/6
Data sheets 1/- except PA246 2/-.

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1A	5/-	5/6	7/6	8/-	9/6
3A	6/-	7/6	8/-	9/-	10/6
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7A	—	11/-	13/-	14/-	19/6
25A	27/6	30/-	33/-	—	37/6

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5 watt 5% (Up to 8.2k ohms only) 2/-
10 watt 5% (Up to 25k ohms only) 2/9

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2.5	16	1/6	40	6.4	1/6	500	25	3/9
4	10	1/6	40	16	1/6	500	50	4/9
4	40	1/6	50	12	1/6	640	16	3/6
4	350	2/3	50	25	1/6	640	25	5/-
5	18	1/6	50	50	2/-	1000	16	5/-
5	50	1/6	64	25	1/6	1000	25	5/-
6.4	6.4	1/6	80	16	1/6	1000	50	7/6
8	40	1/6	80	25	1/6	2000	25	8/6
8	450	3/-	100	6.4	1/6	2000	50	12/6
10	12	1/6	100	12	1/6	2500	25	9/6
10	25	1/6	100	25	2/-	2500	50	13/6
12.5	25	1/6	100	50	2/6	2500	64	15/6
16	10	1/6	125	10	1/6	3000	25	10/6
16	15	1/6	200	10	1/6	5000	25	12/6
16	450	3/3	250	25	2/9	5000	50	19/6
25	6.4	1/6	250	50	3/9	16 + 16	450	7/6
25	10	1/6				32 + 32	450	7/6
25	25	1/6						

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This amplifier unit is a printed circuit module incorporating the popular and well tried PA234 i.c. amplifier. The unit is a complete AUDIO AMPLIFIER and requires no external components, you simply connect an 18 volt power supply and a 15 or 16 ohm speaker or head phone, even the supply smoothing capacitor and the output capacitor are included! The overall dimensions, including capacitors, are 2½" x 3" x ⅞". The input for 1 watt output at 1 kHz is typically 300mV into 100 kohms.
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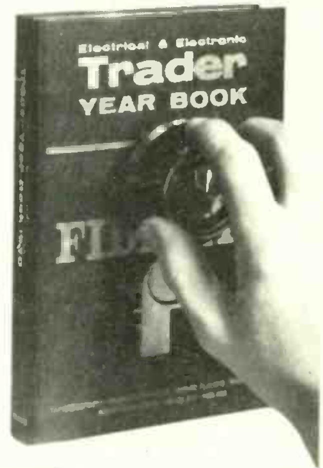

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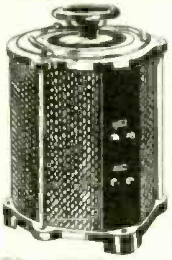
VARIABLE VOLTAGE TRANSFORMERS



50 AMPS

1 AMP

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

BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.

0–260 v. at 1 amp.	£5 10 0
0–260 v. at 2·5 amps. ..	£6 15 0
0–260 v. at 5 amps.	£9 15 0
0–260 v. at 8 amps.	£14 10 0
0–260 v. at 10 amps. ...	£18 10 0
0–260 v. at 12 amps. ...	£21 0 0
0–260 v. at 15 amps. ...	£25 0 0
0–260 v. at 20 amps. ...	£37 0 0
0–260 v. at 37·5 amps. .	£72 0 0
0–260 v. at 50 amps. ...	£92 0 0

20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.

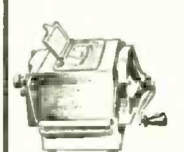
Double Wound Variable Transformers

Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £9.12.6—p. & p. 8/6
0-36 v. at 20 amp. £21.0.0—15/- p. & c.

These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

INSULATION TESTERS (*NEW*)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb.

500 VOLTS, 500 megohms. Price **£28** carriage paid.

1,000 VOLTS, 1,000 megohms, **£34** carriage paid.

5Amp. AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. X 8¾in. X 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. **Price £38 plus 30/- p. & c.** Similar in appearance to illustration below.

OPEN TYPES

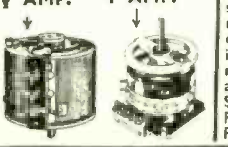
Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable.

0-260 v.

½ amp	£3 18 6
1 amp.	£5 10 0
2½ amp.	£6 12 6

P. & P. 7/6

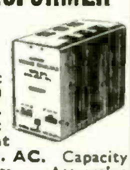
½ AMP. 1 AMP.



VAN DE GRAAF ELECTROSTATIC GENERATOR

fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price **£7/7/-**, plus 4/- P. & P. L't. on req.

CONSTANT VOLTAGE TRANSFORMER



Input 185-250 v. A.C. Output constant at 230 v. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-**, P. & P. 10/-.

LATEST TYPE SOLID STATE VARIABLE CONTROLLER

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

SPEEDIVAC HIGH VOLTAGE HIGH FREQUENCY GENERATOR

Input 100/110 volts or 200/250 volts AC/DC Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case. Offered at fraction of maker's price. £10.0.0 plus 7/6 p. & p.

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.

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 40/- p. & c.

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Dunkelbräu, weisswurst, all-night carousing . . . Oktoberfest comes only two weeks a year, but business in Bavaria slows down to a walk. Import agents everywhere do take time out to observe local holidays and customs. And they do have other clients to accommodate as well as you. Face it : nobody can promote your sales more cheaply, consistently and convincingly than you yourself. And nobody can help you reach your world markets better than I.B.P.A.

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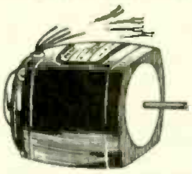
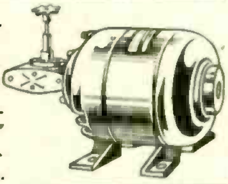
Electro-Tech Sales

NEW HYSTERESIS MOTORS BY WALTER JONES. Type 14050/12, 240v. 50 c/s 1500 RPM cont. rating, output 2.0 oz./in. Size: Length (less spindle) 3½". Width 2½"×2½". Spindle 1"×3/16". Weight 3 lb. Maker's price in region of £22.10.0. Our price **£6.10.0.** each.



K.L.G. Sealed Terminals. Type TLS1 AA, overall length 11/16", box of 100, **25s.** Type TLS1 BB, overall length 1", box of 100, **35s.**

"Parvalux" Reversible 100 RPM Geared Motor Type S.D.14, 230/250v. A.C. 22 lb./in. Standard foot mounted, variable angle final drive. Removable 9-tooth chain spiggot on 3/16" spindle. 1st class condition. **£7.10.0 each.** P. & P. 10/-.



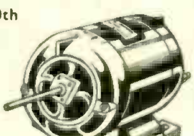
PARVALUX TYPE S/D23 GEARED MOTORS. 240v. A.C. 1 RPM. 14 lbs./in. Also 240v. A.C. 2 RPM. 11 lbs./in. Continuous rating. Standard foot mounting. **£4.15.0** each. P. & P. 10/-.

NEW "CARTER ELECTRIC" 12 r.p.m. MOTOR.—Non-reversible, ¼" spindle. 240v. A.C. Open frame with cast aluminium cased gearbox. Stoutly constructed. Approx. 25 lbs./in. Overall size (approx.) 3"×3"×4" plus spindle. **45/-.** P. & P. 5/-.

NEW "MYCALEX" 240v. A.C. 115 r.p.m. MOTOR.—Similar to above (12 r.p.m.) but flat rectangular gearbox. Overall size (approx.) 3"×3"×4" plus spindle. Few only. **45/-.** P. & P. 5/-.

"BONNELLA" 15 AMP. 240v. TOGGLE SWITCHES.—Single pole change-over, ¾" Long Dolly. Standard single hole mounting. **30/-** per doz. (minimum ½ doz.).

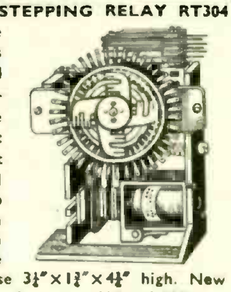
NEW "CROYDON" 240v. A.C. reversible motors. Choice of 1/50th HP, 1,500 RPM, or 1/100th HP, 750 RPM (identical in appearance). Size 3⅜" high × 5" long plus spindle 1⅛"×¼" dia. A beautiful motor at less than half maker's original price. **£6.10.0 each.**



English Electric ¼ h.p. Motors. 240v. single-phase, standard foot mounted, 1,425 r.p.m., continuous rating. **£4.15.0.** Carriage 20/-.

Isolation Transformers. 1 to 1 ratio. 240v. input, 240v. centre tapped out, at 2 K.V.A., mounted in metal case measuring 8½"×8½"×11" high. Weight 65lb. **£16.10.0.** Plus £1 carriage.

SCHRACK ROTARY STEPPING RELAY RT304 48v. coil (28 ohm). The relay has 48 basic segments shorted in step by the 4 sweep contacts to 4 pole-plates (banks of 12). There are 2 secondary switches: (1) one c/o H/Duty contact set which changes over and back with each step; (2) two H/Duty changeovers which change over on each 12th step and return on the following pulse. Size: Base 3½"×1¾"×4½" high. New in maker's packing, also, as above, but 110v. (1,290 ohm coil), **£4.15.0 each.**

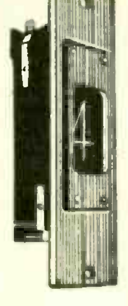


Welwyn high value Resistors Type GA 36501. Values between 9.4 and 10.9 kilo-meg ± 1%, glass encapsulated **15/-.**

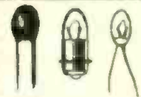
"WELWYN" RESISTORS.—Type H12. One value only. 1 kilo-meg ±20%. **5/-** each. (Minimum order 2.)

THORN ILLUMINATED PRESS SWITCH for 250v. operation. M.E.S. Pressure on cap completes a second circuit. Very robust. Length 44.5 mm. dia. 30.5 mm. in amber, green or red. **10/6 each.**

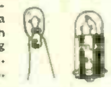
THORN DIGITAL INDICATOR designed as a modular unit for easy mounting where 1st class numerical readout is required. Easily read through a wide angle of view and under bright ambient lighting. 12 characters, 0 to 9, decimal point and minus sign. Characters 13/16" high engraved on acrylic slides and individually edge-lit by 1 watt midget-panel lamps. Overall size of front panel 4⅞" high × 1⅝" overall depth 1" finished in matt black supplied with 12 lamps, choice of following ratings—6v. .1A. or 12-14 v. .08A. **£4.0.0** each, spare lamps **24/-** per dozen.



ATLAS SUB-MINIATURE LAMPS type L1122 and L1123—a high efficient light-source with excellent light-output and low power demand. Ratings 5v. 60 ma. .35± 25% lumens. Life expectancy 60,000 hours or at 6 v. 70 ma. .75± 25% lumens 5,000 hours. Dimensions: Uncapped 6.3 × 3.1 mm. leads 12.7 mm. capped 9.1 × 3.1 mm. Ideal for instrument lighting normally sold in excess of 12/- each, our price 30/- per dozen or boxes of 50 at £5 per box.

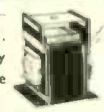


ATLAS MIDGET PANEL LAMPS unrivalled for indication purposes requiring a brilliant but tiny light source. Available with flange cap or wire ended in the following ratings: Capped: 6v. .1A and 12-14v. .08A. Uncapped: 4v. .25A., 6v. .1A., 6v. .2A. **24/-** per dozen or boxes of 50 at £4 per box.



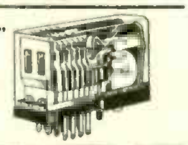
INDICATOR LAMP HOLDERS AND CAPS for **MIDGET PANEL LAMPS** (as above) available red, green, blue, 2/6 each (complete) minimum order 4 units.

"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"×2¼"×2⅜" high. **35/-.** P. & P. 5/-.



New "Magnetic Devices" solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size 1½"×1¼"×1". **20/-** each.

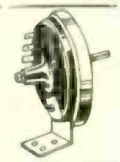
"AUTOMATIC ELECTRIC" ENCLOSED RELAYS
6v. 50Ω 2 c/o, 12/6
24v. 470Ω 4 c/o, 13/6
48v. 2,780Ω 4 c/o, 13/6
48v. 1,260Ω 6 c/o, 15/-



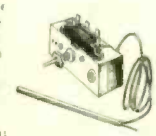
NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. **17/6.**

NEW DIAMOND "H" 240v. A.C. RELAY.—3 heavy duty silver change-over contacts. **17/6.**

"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 1¼". Overall size: dia. 3½", depth 2" plus 1¼" (air tube). **25/-.**



"TEDDINGTON" CONTROLS THERMOSTAT.—Adjustabl between 75° and 100°C. A furthe internal adjuster takes the maximu up to 120°C. Circuit cuts in again a 3° below cut-out setting. 42" capillar and sensor probe. The thermost actuates a 15 amp. 250v. c/o switc A second single pole on/off switch incorporated in the adjustmen mechanism. **17/6.**



American "Powerstat" Variable Voltage Transformer by Superior Electric Co. Input 120v. 50/60 c.p.s. Output 0-120v. at 2·25 amps. ¼" spindle with alternative pre-set locking device. Size (approx.) 3" dia. × 2" long. First class condition. **£2.15.0.** P. & P. 5/-.

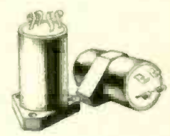
Berco Rotary "Regavolt," variable voltage transformers input 240v. 50/60 cps., output 0-240v. at 6 amps. Not new, but in 1st class condition. Few only, **£8.10.0.** P. & C. 10/-.

WE WELCOME OFFICIAL ORDERS FROM ESTABLISHED COMPANIES, EDUCATIONAL DEPTS., ETC.

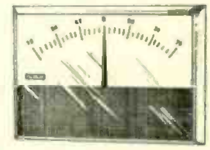
SYLVANIA MAGNETIC SWITCH—a magnetically activated switch operating in a vacuum. Switch speed—4ms. temperature −54 to + 200° C. Silver contacts normally closed rated 3 amps. at 120v. 1.5 amps. at 240v. **10/-** each. **£4.10.0** per dozen. Special quotations for 100 or over. Reference Magnets available **1/6** each.

SYLVANIA CIRCUIT BREAKERS gas filled providing a fast thermal response between 80° and 180°C. Will withstand pressures up to 2,000 lb. sq./in. rated 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures (degs. cent.) 80, 85, 95, 100, 105, 110, 120, 125, 130, 135, 140, 145, 150, 155, 160, 170, 175, 180. **10/-** each or **£4.10.0** per dozen.

MINIATURE "LATCH-MASTER" RELAY 6, 12, or 24v. D.C. operation. One make one break, contacts rated 5 amps. at 30v. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length ⅞", dia. 9/16" (including mount). Please state vertical or horizontal mount and voltage. **£2.5.0 each.**



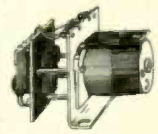
New 75-0-75 Micro-ammeter by Sifam. 750 ohm movement, clear reading, 5μa divisions × ⅛"; plastic front, projection ½" (tapering forward). Size: 4¾"×3¾", **57/6** each.



Ernest Turner 5"×4" 0-1 Ma. meter calibrated 0-10 in 50 divisions mirrored scale, handsome chrome escutcheon for flush mounting. A quality instrument. **£6.10.0.**

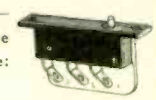
MINIATURE B.P.L. 500-0-500 Micro-Ammeter. 13/16" Diam. scale. Through-Panel mounting, **45/-.**

Motor Driven Variable Voltage Transformers by Ohmite (U.S.A.). Input 120/240v., 50/60. c.p.s. Output 0-240v. at 480 v.a A reversible 115v. a.c. geared motor drives the contact sweep arm in the direction required. There is a micro switch mounted at each end of the track which is cam-operated and intended to be connected as a safety-stop. First class condition. **£8.15.0.** P. & P. 10/-.

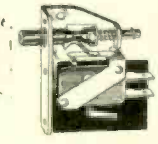


"HONEYWELL" MICRO-SWITCH.—Single and double bank, manual-push. Ideal for vending machines, etc. Each bank comprises a change-over rated 15 amps. 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. ⅜". Single **10/-** each. Double **15/-** each. Also few only 3 bank. **20/-** each.

"HONEYWELL" V3 SERIES.—Flush micro-switch 10 amp. c/o. The side panel is insulated. End-plate size: 2"×⅞". **36/-** per doz.



"HONEYWELL" TYPE 23AC-N—15 amp. change-over switch is fitte on angled metal mount with spri loaded plastic rod operating car **10/-** each.



"Tansitor" (U.S.A.) Tantalum, Wet Sintered Anode Polarised Capacitors. 1200 UF. 6v. D.C. size: 1½" long × ⅝" dia. 200 UF. 25v. D.C. size: ⅞" long × ⅜" dia. 180 UF. 25v. D.C. size: ⅞" long × ⅜" dia. 150 UF. 30v. D.C. ⅞" long × ⅜" dia. 33UF. .75v. D.C. size: 1" long × 9/32" dia. One wire each end. All types 5/- each. Also few only, Tansistor "MICRO-MODULE" capacitors 0.2 Mfd. 15v. wire-ended, size: 3/32" dia. (disc) 5/- each.

WHERE NO CARRIAGE CHARGE IS INDICATED PRICE IS INCLUSIVE. PERSONAL CALLERS WELCOME.

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**

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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.
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Advertisements accepted up to THURS., 12 p.m., 7th MAY for the JUNE issue, subject to space being available.

SENIOR TELEVISION TECHNICIAN

is required to be responsible for facilities in a small wired TV Systems Laboratory. He should be conversant with Colour Television Receivers and will be responsible for the maintenance of specialised test equipment. Other duties will include maintenance of records and equipment movement control.

Qualifications in R.T.E.B. and Colour Endorsement or H.N.C. desirable.

Good prospects of promotion for a keen young man with initiative. Salary negotiable up to £1,500 p.a. depending on qualifications. Training can be given. Subsidised canteen.

Write, giving details of past experience to:

Head of Operational Services Dept.
Rediffusion Engineering Ltd.
187 Coombe Lane West
Kingston-upon-Thames, Surrey
Tel: 01-942 6641

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TEST ENGINEERS

EKCO AVIONICS (A Division of Pye Telecommunications Ltd.) urgently require a number of tester Engineers for their expanding production lines.

They will be employed on the test and diagnosis of VHF equipment and a City and Guilds Radio and TV Servicing or Intermediate Telecommunications Certificate qualification would be preferred.

Salary commensurate with experience and qualifications. Excellent working conditions, good fringe benefits and opportunities for promotion.

Apply to: The Personnel Manager

EKCO AVIONICS

Priory Crescent, Southend-on-Sea. Tel: Southend-on-Sea 49491

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technical instructor

(radio/radar)

We have a vacancy in our Engineering Training Branch for a man with a combination of technical expertise and teaching ability. If you have . . .

- ★ An Aeronautical/Engineering apprenticeship or equivalent standard of training.
- ★ At least 5 years practical experience in the maintenance of Aircraft Radio and Radar installations.
- ★ A marked ability to express yourself both verbally and in writing.
- ★ A keen interest in training and training technology

then you could be our man. If you also have an Aircraft Radio Maintenance Engineers licence or a teaching qualification you are even more likely to be our man.

The vacancy is at our superbly equipped training centre at Heston.

The salary starts in the range £1,750—£2,000 and the successful applicant could expect to progress fairly rapidly to as high as £2,900.

BEA

Write now to:
Personnel Officer Engineering (General) (W.W.)
BEA Engineering Division, Engineering Base, Heathrow Airport—London, Hounslow, Middx.

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Test Engineers

Looking Ahead?

At Solartron we place great emphasis on the importance of career planning and development and we are concerned that people who consider joining us should be aware of the opportunities available to them.

Not only can we offer enormous scope for Test Engineers over a wide range of product lines but we also believe that they will be looking for moves into other areas of the company's activities in order to achieve greater flexibility and promotion.

Vacancies currently exist in the following areas:

- Dynamic Analysis
- Digital Voltmeters
- Oscilloscopes

Promotional moves can be made at a later date into:

- Test Gear Development
- Quality Engineering
- Technical Sales
- Technical Writing
- Contract Engineering
- R. and D.

Our present vacancies would suit young men, preferably with experience of modern digital and/or analogue techniques, who have a technical background equivalent to that of Inter. C. and G. (Telecomms.) or Radio and Television Servicing.

Experience of test work or of television servicing would be very advantageous.

We can offer rates of pay up to £1,200 per annum exclusive of overtime.

If you are looking for a successful career in electronics we would be pleased to talk to you. Please write or telephone for an application form to:

R. D. Scambler,
Senior Personnel Officer,
The Solartron Electronic Group Ltd., Farnborough, Hants. Tel: 44433

SOLARTRON
Schlumberger

419

Rank Pullin Controls is a precision mechanical and electronic manufacturing company within the Industrial Division of Rank Precision Industries Limited. The R & D Department's current programme includes advanced sonar, metal and foreign body detection work, also research equipment developed for oceanography. The Company's plans require the R & D Department to expand substantially in the next two years in both M.O.D. work and commercial products.

Vacancies exist for:—

Senior Electronic Development Engineers

These vacancies will interest young engineers who are ready to take responsibility (including financial aspects for parts of projects) and who will advance to Principal Engineers. Applicants should be aged 23+, have a degree, H.N.D. or H.N.C., and at least two years' relevant experience. Salary up to £2,250 according to age and experience.

Electronic Servicing and Test Engineer

To start a team for commissioning, servicing and maintaining in the U.K., experimental electronic equipment built in the Department. Applicants should be aged 23+, with H.N.C. or equivalent, and some years experience with solid state electronic equipment. Salary up to £2,250 according to age and experience.

Draughtsmen

(electro-mechanical and Printed Circuit)

To work in close co-operation with senior engineers on the design of sophisticated electronic equipment employing the latest techniques of electronic packaging. Applicants should be aged 26-40 years, with O.N.C. Electrical or Mechanical (C & G would be considered) and electronic or electro-mechanical experience.

Salary £1,400-£2,000 according to age and experience.

Technical Assistants

To build and test breadboards and prototype electronic equipment. Applicants should be over 21 years with O.N.C., and experience with wiring and testing electronic circuits. Salary up to £1,400 according to experience.

The Company offers favourable career prospects within the Organisation. There is a contributory Pension Scheme and free Life Assurance. There are many other staff fringe benefits including first class catering on site. Relocation assistance will be considered.

Write or telephone during office hours:
The Personnel Manager,
Rank Pullin Controls, Phoenix Works,
Great West Road, Brentford, Middx.
01-560 1212
Evenings: Mr. I. W. D. Cox
Gerrards Cross 83227.

RANK PRECISION INDUSTRIES

The Rank Organisation

The man with the gong — a man of many skills

429

THE STOCK EXCHANGE, LONDON

require an additional

Television Service Engineer

to maintain a closed circuit television system recently commissioned for the display of market prices.

Applicants must possess appropriate television and radio servicing certificates and must be able to prove their ability as competent Service Engineers by a suitable trade test.

An attractive salary is offered in the region of £1,500-£1,600 per annum. In addition, there is a non-contributory pension scheme, 3 weeks holiday in a full year and 3s. luncheon vouchers.

Applications giving brief details of qualifications and experience should be sent to:

Personnel Officer,
Council of the Stock Exchange,
The Stock Exchange Building,
London EC2.

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Computicket

wants

MAINTENANCE TECHNICIANS

Computicket is now implementing its entertainment seat-booking system. This service, which operates in real-time, will ultimately involve hundreds of on-line CRT Terminals, sited in a wide variety of public places.

Computicket is now recruiting Maintenance Technicians based in the London Area to perform a vital role in this exciting new service.

Applicants should have had experience in the maintenance of Electro-mechanical and Electronic equipment situated in the field and should be happy to find themselves part of a technically advancing but nevertheless consumer orientated team.

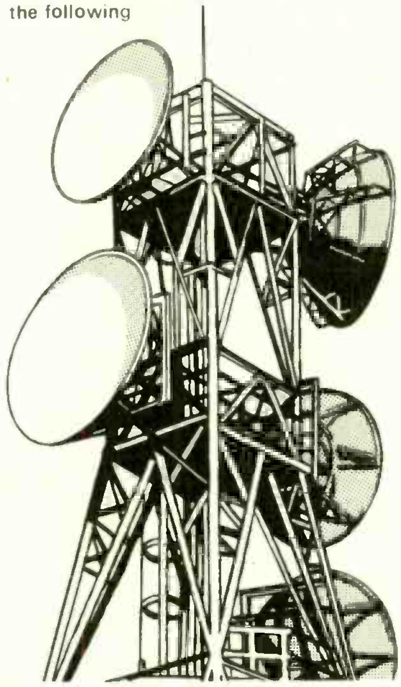
Salaries up to £1,700 are being paid. There are also posts vacant at senior level for Electro-Engineers with a broad design experience and leadership potential.

Write for an application form to:–

Colin Roberts, Chief Engineer,
Computicket Limited
247 Tottenham Court Road,
London W.C.1.

CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following



Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.

STC

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AIR FORCE DEPARTMENT

RADIO TECHNICIANS

Starting pay according to age, up to £1,295 p.a. (at age 25) rising to £1,500 p.a. with prospects of promotion.

Vacancies at RAF Sealand, Near Chester and RAF Henlow, Bedfordshire

Interesting and vital work on RAF radar and radio equipment.

Minimum qualification, 3 years' training and practical experience in electronics.

5-day week—good holidays—help with further studies—opportunities for pensionable employment.

Write for further details to:
Ministry of Defence, CE3h (Air),
Sentinel House,
Southampton Row,
London, W.C.1.

Applicants must be UK residents 423

ENGINEERING OFFICER (MAINTENANCE)

Required by the GOVERNMENT OF MALAWI

POSTS AND TELECOMMUNICATIONS

Department, to serve on contract for one tour of 24-36 months in the first instance. Salary, according to experience, in scale rising to £M.1,223 a year plus Overseas Addition rising to £Stg.682 a year. A Supplement of up to £Stg.244 a year is also payable by the British Govt. direct to the officer's bank in the U.K. Gratuity 25 per cent total emoluments (excluding Supplement) on completion of 30 months' tour. Liberal paid leave. Furnished accommodation. Free passages. Education and outfit allowances. Contributory pension scheme available in certain circumstances.

Candidates, 25-45, must possess appropriate City and Guilds Certificates and have had a minimum of two years' approved training, with not less than five years' subsequent experience, on the maintenance of carrier systems, H.F., V.H.F. or U.H.F. radio. Experience in the maintenance of X-ray equipment would be an advantage.

The officer will be required to undertake the maintenance of multiplex carrier, telephone and telegraph equipment, H.F., V.H.F., and microwave radio, electro-medical equipment, and to give assistance and guidance to local staff under training.

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/680847/WF.

445

VISUAL SYSTEMS ENGINEERS

THE JOBS

Project & Systems Engineering on Advanced Training Aids for Aircraft.

THE MEN

Electronic Engineers preferably H.N.C. or B.Sc. having had practical experience in one or more of the following fields. Flight test, Auto Pilot, Weapons Control, General Process Control, Instrumentation, Systems Design, Colour Video, Systems Maintenance and Design, with a keen desire to learn new techniques and applications.

THE REWARDS

A salary up to £2,000 per annum. High job interest. Opportunity to work on complex systems incorporating digital and analogue computers, associated peripherals, colour television systems and servo systems as a member of a team. Opportunity to fly and operate simulated aircraft and other equipments. High quality training will be given.

OTHER BENEFITS

Our terms and conditions of employment are good and include contributory pension scheme, free life assurance, etc. We are not merely offering posts which will afford candidates opportunities of attaining a good job. Selected candidates will be offered long-term careers. Opportunities for occasional overseas travel, etc.

Apply, quoting reference WW/170 to:
H. C. Hall, Personnel Manager,
REDIFON LIMITED
Flight Simulator Division
Gatwick Road, Crawley, Sussex
Tel: Crawley 28811

REDIFON
A Member Company of the Rediffusion Organisation

495

BBC tv

HOLIDAY RELIEF

ASSISTANT FILM RECORDISTS

BBC Film Operations require Assistant Film Recordists on limited contracts for Holiday Relief duties during the summer months. Initial Contract will be for two months but may be extended as circumstances demand on a month by month basis.

Duties involve the operation of sound transfer equipment, also working in the recording rooms of dubbing theatres. Candidates must have some professional experience in film sound transfer and recording work, a good technical knowledge of sound recording practice and an understanding of the principles of cinematography. Work will be on a day or shift basis (not night shifts). Salary will be in the range of £1,260 to £1,404 per annum depending upon qualifications and experience. Based Ealing or Shepherds Bush.

Write for application form (enclosing addressed foolscap envelope and quoting reference 70.G.615) to Appointments Department, BBC, London W1A 1AA by April 28th.

RADIO TECHNICAL OFFICERS

Earnings up to £2,000 p.a.

The P.L.A. operate a wide telecommunications network from Tower Pier to the outer Thames Estuary, and vacancies exist at Gravesend and King George V Dock for Radio Technical Officers to maintain the equipment at maximum efficiency.

To ensure adequate coverage, a shift system is operated.

Salary scale:—£1,280 to £1,520 p.a.—plus an allowance for week-end and public holiday working, where applicable. Payment at enhanced rates is made for overtime working when required.

Earnings of up to £2,000 p.a. are possible.

Minimum qualifications:—

O.N.C. Electrical Engineering
or City & Guilds Intermediate Certificate in Telecommunications Engineering plus Radio II
or equivalent Service qualifications.

Applicants should have at least 5 years' experience in two of the following fields:—

- V.H.F. and U.H.F. Radio
- Radar and Microwave Links
- Telemetry and Digital
- Telephone exchange equipment
- and land lines.

Application forms may be obtained from:—

The Chief Engineer (Personnel)
Port of London Authority,
P.O. Box 242,
Trinity Square,
London, E.C.3.

PLA PORT OF LONDON AUTHORITY

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Electronics Maintenance Engineers

There are excellent opportunities in the Installation and Maintenance Division of U.K. Electronics and Industrial Operations of E.M.I. Ltd., at Hayes, Middlesex, for engineers to carry out maintenance work on a wide variety of electronic equipments including laboratory test gear and trans-ceivers.

Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

Commencing salaries of up to £1,500 per annum will be paid and staff conditions include contributory pension scheme and free life assurance.

Please apply in writing giving brief personal and career details to:

G. W. Fox, Personnel Department,
U.K. Electronics & Industrial Operations,
E.M.I. Ltd., Blyth Road,
Hayes, Middlesex.
Tel: 01-573 3888, Ext. 411.

EMI 1968

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Applicants are invited for the post of

JUNIOR TECHNICAL OFFICER

with the MEDICAL RESEARCH COUNCIL. Duties will include the construction, maintenance and development of electronic equipment and assistance in observations on normal subjects and patients occasionally during neurosurgical operations. Training in metal workshop practice would be an advantage. Male candidate aged 21-26 with O.N.C., H.N.C. or equivalent will be considered.
Salary in range plus £90 London Weighting.
Applicants should give details of age, qualifications and experience to: Dr. J. A. V. Bates, National Hospital for Nervous Diseases, Queen Square, London, W.C.1.

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THE UNIVERSITY OF LEEDS

Applications are invited for a post in the following Department:

PHYSICS

EXPERIMENTAL OFFICER/
SENIOR EXPERIMENTAL OFFICER

The successful applicant will be responsible for the design of a wide range of electronic apparatus covering DC and pulse amplifiers and digital recording systems. Minimum qualifications: Degree in Physics or Electrical Engineering together with appropriate experience.
Closing date 30th April 1970.

SALARY SCALE:
Experimental Officer £995–£2,235.

Applications giving age, qualifications and experience, together with the names of two referees should be sent to the Administrative Assistant, Physics Department, The University, Leeds LS2 9JT.
Please quote reference number 491.

Senior Systems Engineers

With continued expansion the Digital Systems Department has vacancies for Senior Systems Engineers.

The Man. Applicants should preferably be graduates with engineering or science degrees or equivalent qualifications. Experience in one or more of the following fields is desirable:– ☐ Digital computers and their application to real time digital computer systems. ☐ Digital computer peripherals. ☐ Military defence systems, including fire control systems. ☐ Radar and synthetic display systems. ☐ Surveillance and tracker radar systems. ☐ S.S.R. systems. ☐ Servo systems.

The Job. The work involves conducting technical negotiations with potential customers, carrying our System Design Studies and preparing technical proposals. The successful applicants will be based at Bracknell and travel in the U.K. and abroad will be necessary.

This appointment carries a high degree of personal responsibility and requires the ability to hold discussions with military and civil personnel at a very senior level. The Digital Systems Department is situated in pleasant countryside surroundings. Working conditions and holiday arrangements are excellent. The Company operates a contributory Pension and Dependants Assurance Scheme. Promotional prospects are excellent.

Write giving brief details and quoting reference D/109/w.w to:–
Mr. D. J. O'Connor, Personnel Officer, Ferranti Limited, Western Road, Bracknell, Berks. or telephone Bracknell 3232.

FERRANTI

451

technicians

– join a success story

Everybody appreciates success. Three years ago when our development labs started work on a completely new range of Mobile Radio equipment we were on to a winner. Launched last year, we now have the most advanced compact and competitive equipment on the market. Our problem now is to ensure that the quality of our products and our maintenance and service is as good as our design. We need Testers and Service Engineers to help.

test:

Based at a temporary site near Watford. Testers will transfer to our new factory between Radlett and St. Albans when it opens towards the end of this year.

Duties include testing, fault finding and alignment on UHF pocket phones and base stations. Senior testers will also take on systems test and trouble shooting work.

service:

Based at New Southgate—one vacancy at Croydon—service engineers are responsible for the repair and maintenance of our complete range of UHF and VHF equipment. A clear driving licence is essential as some local travel is involved.

If you have experience of test or servicing radio equipment this is your chance to link your success story with ours.

Write or phone:
T. G. Anderson, Asst. Personnel Manager,
Standard Telephones and Cables Limited,
Oakleigh Road, New Southgate, N.11.
01-368 1234, ext. 2578.

STC

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DYMAR

Very IMPORTANT to YOU –
Very IMPORTANT to DYMAR
TEST ENGINEERS with a FUTURE

DYMAR is an *independent* rapidly expanding Company with long term plans and a very impressive order book for VHF communications equipment, including an immediate major export success of over $250,000 to the U.S.A., providing secure and interesting work, with high value and responsibility placed on the individual.

- **Salaries negotiable to earn real money for real experience.**
- **Continuous expansion, new additional premises, creating immediate and future supervisory positions.**
- **Company assistance for continuation of technical education.**
- **Three weeks annual holiday rising to four with service.**
- **Ample opportunity for overtime.**
- **Free pension scheme with free life assurance.**
- **Subsidised canteen facilities – modern working conditions.**

Contact John Cybulla by letter or telephone – reverse charges:- **Watford 21297**

Dymar Electronics Limited,
Colonial Way,
Radlett Road,
Watford,
Herts.

COMMUNICATIONS

459

ANTARCTIC EXPEDITION

require

Wireless Operator/Mechanics

With current morse speed of 20 w.p.m. PMG Certificate, teleprinter experience essential. Salary from £1,003 according to qualifications and experience with all living and messing free.

For further details apply to:

BRITISH ANTARCTIC SURVEY
30 Gillingham Street, London, S.W.1

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PHONODISC LIMITED
Record Works, Walthamstow Avenue, E.4
require a

SERVICE ENGINEER

Experienced in one or more of the following fields:

Modern Professional Tape Recording Equipment;
Automatic Control Systems using Logic Circuits;
Disc Cutting Equipment;
State-of-the-Art A.F. Amplifiers using the latest Solid State Techniques.

Weekly staff appointment, 37-hour week. Good starting salary supported by generous holiday and sick pay schemes, and contributory pension fund.

Please apply in writing to the Personnel Manager at the above address.

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RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1970 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in September, 1970.

During training a salary will be paid on the following scale:

Age 21	£800 per annum
„ 22	£855 „
„ 23	£890 „
„ 24	£925 „
„ 25 and over	£965 „

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

Age 21	£965 per annum
„ 22	£1025 „
„ 23	£1085 „
„ 24	£1145 „
„ 25 (highest age point)	£1215 „

then by six annual increases to a maximum of £1650 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 35 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from:

Recruitment Officer, (R.O.3) Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ

Telephone No. Cheltenham 21491, Ext. 2270

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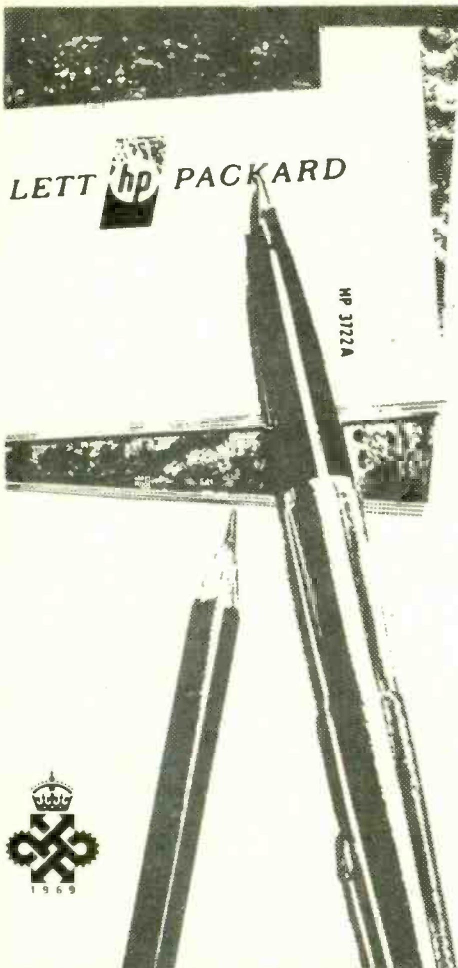

ENGINEERS
TECHNICAL AUTHORS

Are you in the limelight?

Hewlett-Packard will put you there

To maintain our acknowledged position as one of the world's largest manufacturers of precision electronic equipment we require more Technical Authors, who will become active members of the R. & D./Marketing team.

Our Authors are encouraged to expand and widen their experience and to use their various talents in communicating ideas, influencing product design preparing operating and service manuals.

We offer career growth in a rapidly expanding organisation.

Applicants with experience of writing, design, test or service engineering, preferably in test equipment or the communication industry should post the coupon to: quoting reference M. 12/1

John Young,
Personnel Department,
Hewlett-Packard Limited,
South Queensferry,
West Lothian.

Name ....

Address ....

Qualifications ....

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TECHNICIAN or SENIOR TECHNICIAN REQUIRED

For work in the development of automated teaching equipment. Experience in electronics and/or television essential. Knowledge of optics, photography, cinematography desirable.
Salary scales (under review) £898—£1,252 p.a. or £1,181—£1,486 p.a. according to experience and qualifications.
Further information and application forms from the Laboratory Superintendent (T.EA1), Departments of Physics and Electronics, Chelsea College, Manresa Road, London, S.W.3
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CONSULTANCY REQUIRED

Messrs. Toshniwal Bros. Private Ltd. of Bombay, wish to contact persons in England to provide consultancy services on their know-how with a view to manufacturing the following items in India:

Dry Mini Cells, Transducers for medical and other applications, A.C.-D.C. Servo Motors, Low Loss Ceramic Materials for use in high frequency switches, Delay Line for use in oscilloscopes, Low Frequency High Gain D.C. Amplifier, Choppers for use in D.C. amplifiers, Deflection Coil and Transformers for television.

Please write to SHRI B. D. Toshniwal, 198 Jamshedji Tata Road, Bombay 1, who will be able to meet the persons concerned in England during June this year.
465

GEC-Marconi Electronics

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON

QUALIFIED OR NOT!

VACANCIES exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits.

RE-LOCATION EXPENSES available in many instances.

CONDITIONS excellent; free life assurance, pension schemes, canteen, social club.
37½-hour, 5-day, office-hours week.

WRITE or phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required, quoting WW3.

mi

MARCONI INSTRUMENTS LIMITED,
Longacres, St. Albans, Herts.
Tel: St. Albans 59292
Luton Airport, Luton, Beds.
Tel: Luton 31441.
A GEC-Marconi Electronics Company

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CAREERS in SCIENCE and ENGINEERING

Exciting and rewarding opportunities in these fields are almost unlimited

Write now for details of the following courses offered by:—

BOURNEMOUTH COLLEGE OF TECHNOLOGY

UNIVERSITY OF LONDON EXTERNAL DEGREES

B.Sc. General (Hons.)—
Mathematics, Physics, Chemistry, Botany, Zoology, Statistics.

B.Sc. (Eng.) (Hons.)—Electrical (including Electronics).

These courses are suitable for both men and women.

Study by the Sea in Britain's foremost international and cultural resort.

For prospectus apply to:
The Principal, Room 67,
College of Technology, Lansdowne,
Bournemouth, BR1 3JJ. Tel. B.20844.

475

Radio Operators

Your chance of a shore job with good pay from the start!

If you hold a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Minister of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic, the Post Office can offer you employment at a United Kingdom Coast Station, with a starting salary of £965—£1,215 (depending on age). Annual rises will take you to £1,650 and there are good prospects of promotion to more responsible and better paid posts.

If you are 21 or over, please write for more details to:

**The Inspector of Wireless Telegraphy,
External Telecommunications Services,
Wireless Telegraph Section (WW),
Union House, St. Martins-le-Grand,
LONDON E.C.1.**

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A WAY OUT from TV SERVICING

We believe an Ex T.V. Engineer may be just the type who would fit into one of our Electro-Mechanical Development teams.

We do prototype work in connection with an extremely wide range of Industrial and Laboratory processes. An experienced technician with at least an O.N.C. or R.T.E.B. Certificate is required to assist with construction and testing.

This staff appointment offers excellent prospects with a progressive Company. There are the usual benefits, a contributory pension fund, free lunches, etc.

Applications should be made in writing to the Assistant Staff Manager, Johnson, Matthey & Co. Limited, 78 Hatton Garden, London, E.C.1, quoting reference S.77.

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PROJECT ENGINEER

SOUND DIFFUSION, a rapidly expanding organisation, would like a word in your ear: about a job working on Hotel and Industrial paging, signalling and sound distribution systems. We envisage that the successful applicant will preferably have had between 3 and 5 years experience of working with

Fire Detection systems

Design and development of Audio and Public Address systems

involving low level signalling and solid state techniques.

If this is your field and you're between 25 and 35, with minimum C and G, but preferably of HNC standard, and looking for a job with security and good promotion prospects, you may be the man we are looking for.

The rewards are excellent—a good salary, pension and sickness schemes, subsidised canteen, sports and social facilities, and to go with these, assistance will be given towards removal expenses to the attractive South Coast.

Sound Diffusion is expanding fast—we need YOU to expand with us—

The Sound Diffusion Group

Personnel Manager
Datum Works
80/86 Davigdor Road
Hove BN3 1RZ Sussex
Tel: Brighton 775499

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TECHNICAL INSTRUCTORS

Urgently required for instructing our customers' maintenance personnel in the operation and maintenance of FLIGHT SIMULATORS. We have openings in both digital and colour closed circuit projected television fields. Must be able to work to a pre-prepared syllabus and able to prepare notes on courses.

Applications to:

Personnel Manager,
REDIFON AIR TRAINERS LIMITED,
Bicester Road, Aylesbury, Bucks.

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HERTFORDSHIRE COUNTY COUNCIL

EDUCATIONAL TELEVISION UNIT

Applications are invited for the following vacancies with the County Television Unit based at Goldings, Hertford:

1. **A TECHNICIAN**, to maintain language laboratories and some other audio equipment in the County. A suitable technical qualification (e.g. H.N.C.) is required, and practical experience of audio equipment. Ability to drive essential. Salary: £1,130—£1,345.
2. **A TECHNICAL ASSISTANT.** A person with practical experience with audio visual equipment who could be trained as a camera operator and do preventative maintenance on video and audio equipment. Ability to drive essential. Salary: £835—£1,130.

For further details and application forms for these posts please write, within 7 days of date of publication, to: **The Director, County Television Unit, Wall Hall College, Aldenham, Watford, WD2 8AT,** stating which post is to be considered.

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NEWCASTLE UPON TYNE POLYTECHNIC
Department of Physics and Physical Electronics

The following courses will be offered during the session 1970-71

B.Sc. (Honours and Ordinary) in Physical Electronics

A four year 'thick sandwich' course (i.e. three years full-time in College and one year in Industry) leading to the above qualification is open to both college-based and industry-based students. Industrial sponsorship may be obtained for suitably qualified students. Entry qualifications include two appropriate 'A' levels, or an appropriate O.N.C. or O.N.D.

M.Sc. in Advanced Experimental Physics (Full-time or Part-time)

A twelve month full-time or three year part-time course commencing in October, 1970. Optional subjects of study include Semi-conductor Device Physics and Electrical Properties of Thin Films.

Further information may be obtained from the Head of Department of Physics and Physical Electronics, Newcastle upon Tyne Polytechnic, Ellison Building, Ellison Place, Newcastle upon Tyne, NE1 8ST. (Ref Al70)

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LEC

RADIO & TELEVISION SERVICING
RADAR THEORY & MAINTENANCE

This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721.

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COMPUTING DEVICES CO. LTD.
require
ELECTRONIC TECHNICIANS

to assist with construction and evaluation of prototype AVIONIC equipment at their LONDON HEADQUARTERS.

Experience in solid state electronics and ability to make accurate measurements is essential. Candidates should possess O.N.C. or equivalent. Day release for further study will be considered. Salary according to experience and qualifications.

Applications to The Personnel Manager, Computing Devices Company Limited, 5/25 Scrutton Street, London, E.C.2.

487

ELECTRONICS TECHNICIAN

to assist with the electronics for automating biochemical analysis with an on-line computer and to help with the assessment of new equipment for biochemical screening and other interesting work. Salary in range £1,265—£1,635 per annum.

Applications to the Secretary
ROYAL POSTGRADUATE MEDICAL SCHOOL
Hammersmith Hospital, London, W.12,
quoting ref: 4/260.

498

DELANE LEA MUSIC LTD

have a vacancy for an Engineer in their servicing department to take part in the construction and installation of new recording studios. The successful applicant should have experience of professional audio equipment—circuit wiring and some mechanical ability would be an advantage.

Telephone 01-242 2743 or 01-437 4252

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HERTFORDSHIRE COUNTY COUNCIL
Consortium of Colleges of Education

Applications are invited for the post of

CCTV ENGINEER

for Mobile Unit based at Wall Hall College near Watford. Qualifications: A suitable degree in Electronic Engineering and knowledge of video and audio systems. Ability to drive and experience with ETV an advantage. Salary: £1,570-£2,205 plus London weighting. 457

ENGINEERS

Have you considered a career in Technical Authorship? If you have sound experience in electronics and ability to write clear concise English we can offer positions as Technical Authors. The salary range is £1500-£2000 plus with excellent prospects and rewards. Box No. W.W.364, Wireless World.

University of Exeter

INSTITUTE OF EDUCATION AND CALOUSTE GULBENKIAN FOUNDATION

Regional Resources Centre Research Project

SENIOR TECHNICIAN

Required to operate, maintain and devise audio-visual equipment and teaching aids within the above project, which will commence in September 1970. Applicants should have suitable qualifications and/or experience in one or more of the following fields: experimental technical work, electrical work, graphics, photography. Current driving licence necessary. Appointment to commence July 1st, 1970.

Salary £1,018 to £1,080.

Further details from Mr. J. Walton, Institute of Education, Gandy Street, Exeter, EX4 3QL, to whom completed applications should be sent by Thursday, April 30th.

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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

AIRCRAFT RADIO/RADAR MAINTENANCE ENGINEERS and MECHANICS with workshop experience in Civil and Military Airborne Communications and Radar equipment. 3 weeks' holiday per year, pension scheme. Apply: The General Manager, Air Transport (Charter) (C.I.) Ltd., Willow Road, Colnbrook, Bucks. Tel. Colnbrook 2654. [472

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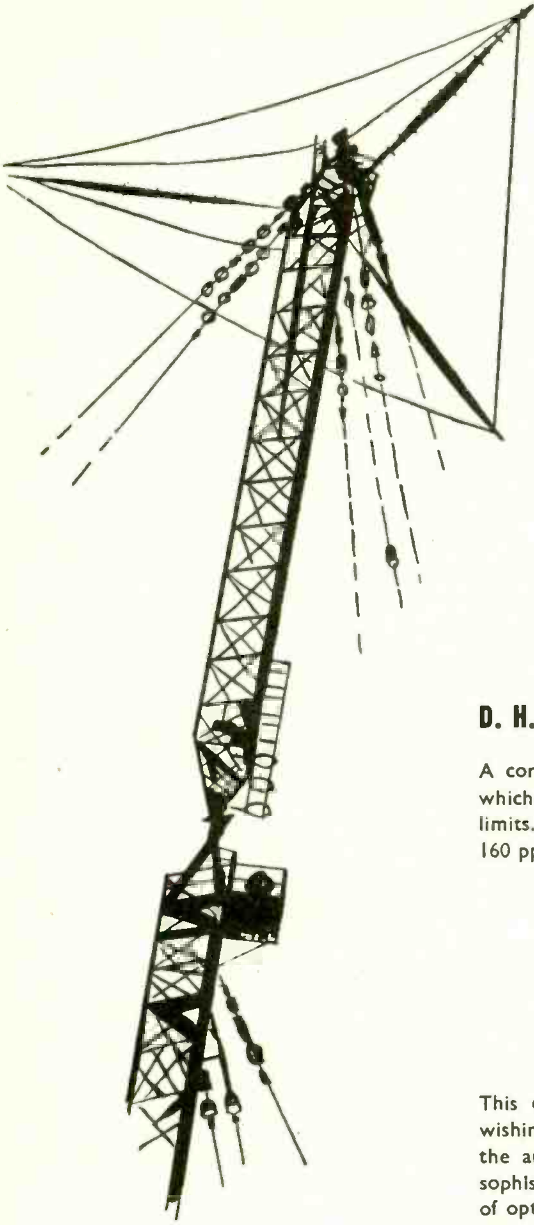

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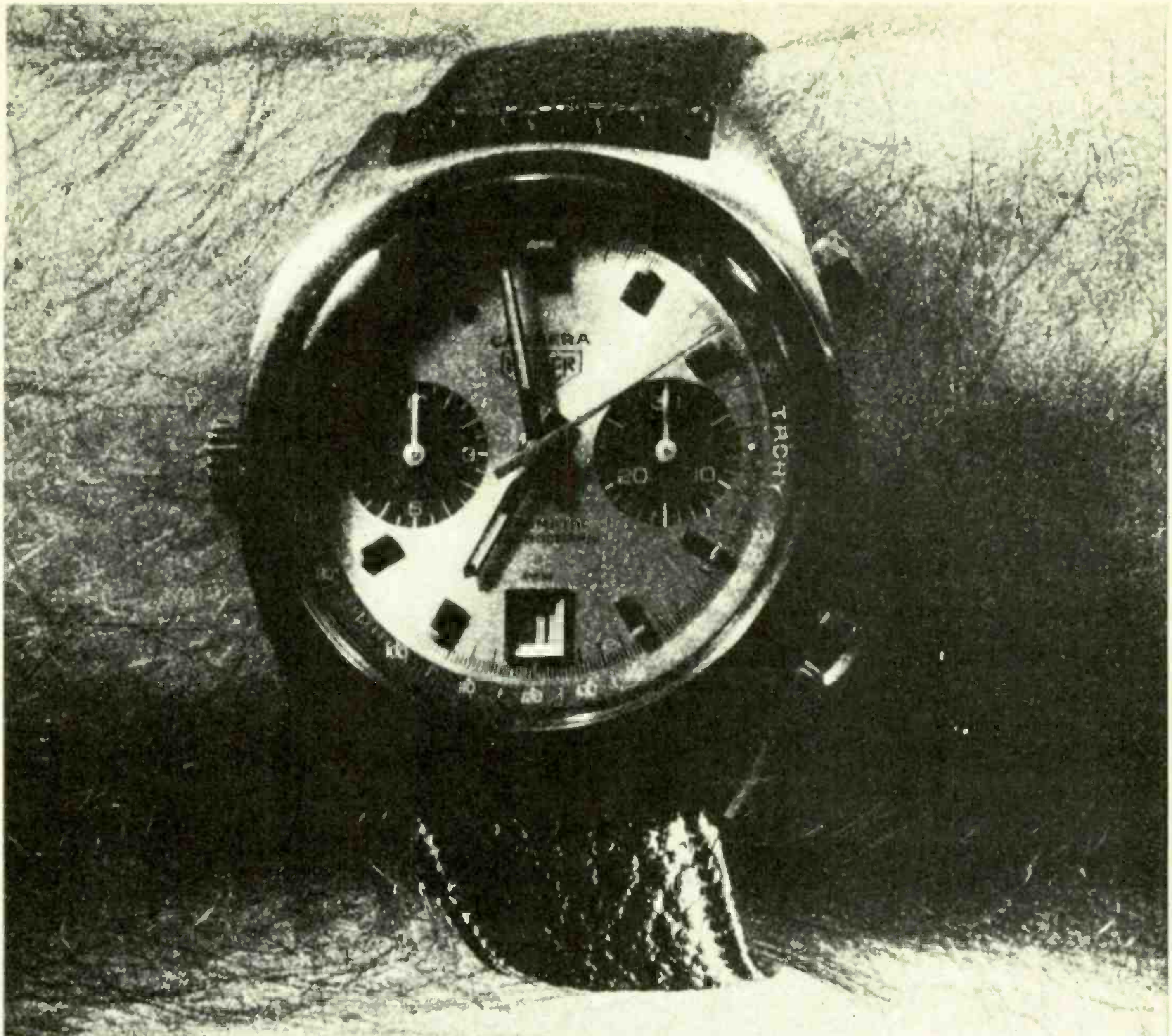

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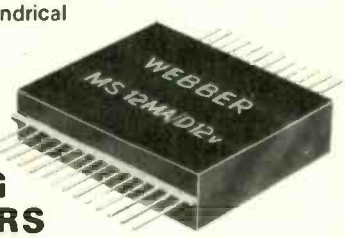

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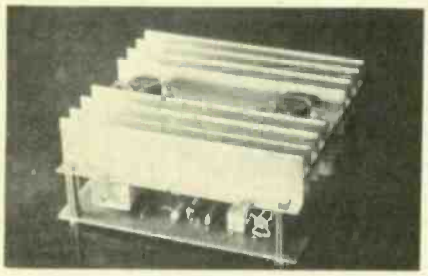

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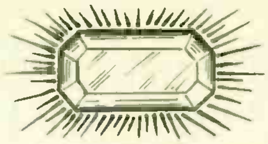

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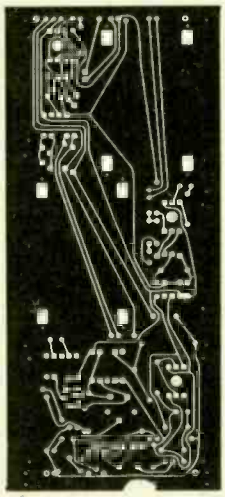

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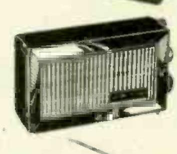

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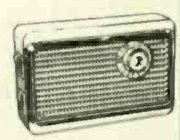

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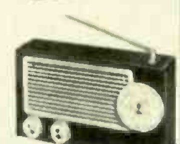

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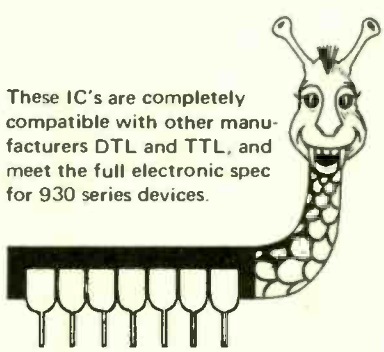

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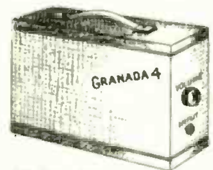

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WW—131 FOR FURTHER DETAILS

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- **Rate: 8/- PER LINE. Average seven words per line.**
- **Name and address to be included in charge if used in advertisement.**
- **Box No. Allow two words plus 1/-.**
- **Charges etc., payable to "Wireless World" and crossed "& Co."**
- **Press Day 7th May for June 1970 issue.**

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Please write in block letters with ball pen or pencil.

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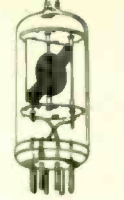

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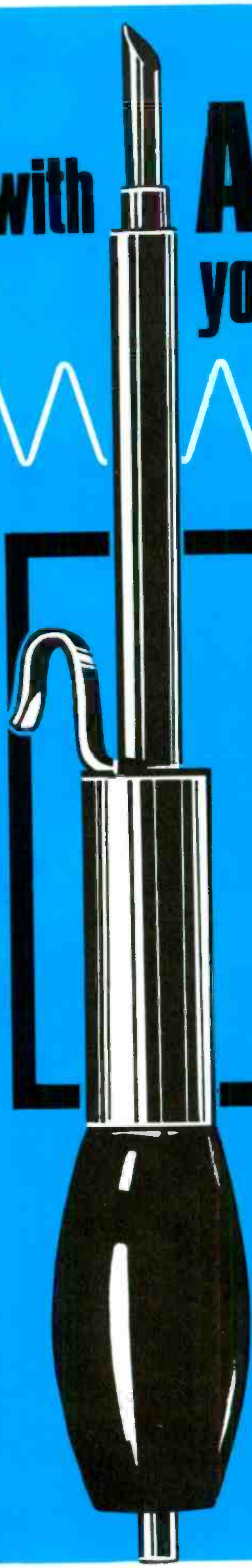

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