Microphone survey
Low-distortion detector
Wide-range signal generator
RELAYS

RELAYS

ex stock in 7 days
*C.S.A. APPROVED IN CANADA AND GREAT BRITAIN

*MK

* 3 pole 7.5 amp
* 5 million ops. min.
* 12/4 each per 1000
Single pole 9/7 each per 1000

*MM Contactor

* 2 pole 15 amps
* 5 million operations minimum
* 17/8 each per 1000

MHP Plug-in relay

* 4 pole, 1 amp
* 100 million operations each per 1000
SOLDER TERMS

*MKP Plug-in relay

* 2 pole 8 each per 1000

*MK103

* Single pole 3 amp
* 1 million operations minimum
* 5/11 each per 1000

MK403P NEW Plug-in relay

* 4 pole 3 amp
* 5 million operations minimum
* 29 each per 1000
SOLDER TERMS
* 21/9 each per 1000

made to measure
APPROVALS: C.E.G.B. No. 131 & 92 - B.R.
POST OFFICE KRL - U.K.A.E.A.

RELAYS

P.O. 3000 RELAY

* Manufactured to full G.P.O. specification, also to Industrial Standards
* Contacts up to 30 amp

P.O. 600 RELAY

* Compact version of BPO 3000 relay
* Contacts up to 10A
* Sensitivities down to 30mW
* Up to 18 contact springs

COMPONENT BOARD P304

* Plug-in component board unit for low cost, easy chassis fabrication
* 15 each per 500
FROM STOCK

CONTACTOR K700 RELAY

* High-current/high-voltage 3000-type relay
* Contact up to 30A240V a.c.
* Sensitivities down to 45mW
* PTFE armature bar/lifting rods

KEYSWITCH RELAYS

KEYSWITCH RELAYS LIMITED
120/132 Cricklewood Lane - London - NW2 Tel: 01-452 3344
Telex: 262754

WWW—001 FOR FURTHER DETAILS

Wireless World, April 1968
You don't have to smuggle an Avometer out of the IEA when you might win a brand-new one legally

If your entry in the big Win-An-Avometer Contest convinces the judges (not shown in the photograph above) that you've got the most unusual Avometer application in Britain. The way to convince them is (1) send them a half-plate glossy photograph clearly showing the Avometer and what it's doing and (2) complete the following assertion in 12 additional words or fewer: I like Avometers because To be eligible, the photograph must be suitable for publication in this journal, and your complete entry must be received no later than 30th April 1968; as usual, the judges' decision will be final.

Anybody who doesn't already have an Avometer may now buy one and discover its versatility for himself (or herself). There is practically nothing—amps-volts-ohmswise—that an Avometer can't do, and practically nowhere—from the equator to the poles—that an Avometer can't do it. Get yourself one, and find out. You might just get another one free!

Send your Win-An-Avometer entries (no limit on numbers) to Avo Ltd (Dept 710), Avocet House, Dover, Kent; the winner will be announced on Stand G.35 at the IEA, Olympia and will be notified by post about 15th May 1968.

AVΩ MEANS BASIC MEASUREMENTS ALL OVER THE WORLD
To your specification... with quick delivery

AND Ernest Turner RELIABILITY

Whether your need is for a single instrument or a thousand (or even more) the Ernest Turner organisation is geared to give the same renowned service. From a very wide choice of movements and case styles we can provide precisely the instrument for your application, including the manufacture of special dials and provision of built-in or external units to permit indication of any electrical quantity.

We invite your specific enquiry for any number of instruments from one upward, and we should be pleased to send you a copy of our general catalogue 86/25 on request.

ERNEST TURNER ELECTRICAL INSTRUMENTS LTD.
HIGH WYCOMBE - BUCKINGHAMSHIRE - ENGLAND.  Tel: High Wycombe 30931

Wireless World, April 1968
To catch a thief...

use EEV vidicons in CCTV

Closed circuit television is proving very sleuthful in keeping an eye on things. But when it comes to watching Rembrandts and Goyas it has to be reliable. This is where EEV high sensitivity vidicons should be used. These tubes can give up to 8000 hours viewing without dropping off in performance. They also provide unusually high resolution, high sensitivity and short lag. EEV vidicons are available with two different values of heater current, 6.3V/600mA and 6.3V/95mA, and with either separate mesh or integral mesh construction. For further information and the name and address of your nearest stockist write to:

ENGLISH ELECTRIC VALVE COMPANY LIMITED

CHELMSFORD, ESSEX. TELEPHONE: 61777
See all these models, and many more...

in the latest free HEATHKIT Catalogue

LOW-COST TRANSISTOR STEREO AMPLIFIER, TS-23

- Incorporates all the essential features - good quality sound reproduction from record, radio and other sources.
- 16 transistors, 6 diode circuit.
- Good frequency response 3 watts r.m.s. (15 ohms) each channel, 0.5% at 1000 Hz.
- Separate controls provide bass boost, treble cut, amplifier balance and volume.
- Printed circuit board construction.
- Complete kit, slimline styling. Measures 32in. high x 13in. wide x 6in. deep.
- Includes Walnut veneered cabinet (optional extra).
- Attractive Perpex front panel.

KIT £17.15.0 (less cabinet)  
KIT £18.19.0 (with cabinet)

WALNUT veneered cabinets £1.5/- extra. Ready to use price on request.

LATEST 12+12 W. TRANSISTOR STEREO AMPLIFIER, Model TSA-12

- Luxury performance at lowest cost. Full range power output, wide frequency range.  
- 7 transistor, 6 diode circuit.  
- 12W per channel at 8 ohms.  
- Output switchable for 8 or 15 ohm loudspeakers.  
- Stereo inputs for Grams., Radio and Aux.
- Modern low silhouette styling.
- Attractive aluminum, gold anodised front panel.
- Handmade assembled and finished warehouse models.
- Plaques Heathkit models TFM-1 and AFM-2 transistor tuners.

KIT £20.10.0 (less cabinet)  
Ready to use price on request.

BEVERAGE SLIM-LINE SPEAKER SYSTEM

- Specially designed to obtain optimum performance from the slim cabinet.
- Beautiful walnut veneered, fully finished cabinet.
- Wide frequency response.
- Low cost.
- Self-designed loudspeakers give adequate performance for low cost.
- Sealed on end uses only 7in. x 7in. of floor space.
- All included in kit.

KIT £19.10.0 Ready-to-use £24.00

LOW-COST SPEAKER SYSTEM SSU-1 (not illustrated)

- Build yourself in an evening.
- All wooden parts accurately pre-cut, drilled and sanded.
- Design high efficiency speakers.
- Two specially designed loudspeakers.
- Hi-Fi on a budget.
- Finished to match your own furniture.
- Easy to assemble.
- Attractive finish.

KIT £11.17.6 (less legs)  
Ready to use price on request.

TRANSISTOR AM-FM STEREO TUNER, AFM-2

- 18 transistor, 7 diode circuit.
- AML-LW/MW, FM Stereo and FM Mono tuning.
- Automatic stereo indicator light.
- Stereo phase control for maximum separation.
- Minimum distortion.
- Automatic frequency control positive feedback tuning.
- Automatic gain control for even, steady volume.
- Print-assembled and aligned circuit board.
- Handmade.
- Finished walnut veneered cabinet, available at optional extra.

KIT £18.19.0 (with cabinet)

TOTAL PRICE KIT £32.7.0 incl. P.T.

Optional extras: Walnut veneered cabinets £2.5/- extra.

TRANSISTOR FM STEREO TUNER, TFM-15

- Mono version TFMT-15 available.
- 14 transistor, 5 diode circuit for cool instant operation.
- FM Mono TFM-15 and Stereo TFM-15 models available.
- Automatic frequency control.
- Stereo phase control to maximise stereo separation.
- Minimum distortion.
- 4-stage IF section ensures high sensitivity and selectivity.
- Handmade.

TOTAL PRICE KIT (Stereo) £20.19.0 incl. P.T.
TOTAL PRICE KIT (Mono) £24.18.0 incl. P.T.

OPTIONAL EXTRAS: Walnut veneered cabinets £2.5/- extra.

Send for the Latest FREE CATALOGUE

Now with more Kits of colour. Fully describes these models along with over 50 models for Stereo Hi-Fi, test and laboratory equipment, test and laboratory equipment, radio, intercom, radio educational kits. Includes helpful information on HDI in your home and planning your Hi-Fi system. Mail coupon or write.

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Please send ( models )

Please send us FREE Heathkit catalogue.

ADDRESS

City

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WW-608 FOR FURTHER DETAILS

Wireless World, April 1968

www.americanradiohistory.com
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The construction manual provided with the kit ensures successful assembly

5 in. GENERAL-PURPOSE OSCILLOSCOPE, 10-12U

- "Y" sensitivity 10 mV r.m.s. per cm at 1 kcs.
- Bandwidth 3 c/s-1.5 Mc.
- Frequency compensated input attenuator X1, X10, X100.
- T/B; 10 c/s-500 kcs./in. 5 steps.
- Two extra switch select pre-set sweep frequencies in T/B range.
- T/B output approx. 10 x peak-to-peak,
- Built-in IF calibrator.
- Facility for Z-axis modulation.
- Electronically stabilized power supply.
- Power req. 200-250 v. A.C., 40-60 c/s, 90 watts.
- Fused. Front panel, silver and charcoal grey.
- Cabinet, charcoal grey, size 8 x 14 x 17 in. deep.
- Net weight 23 lb. 56-page construction and operation manual.

Kit £35.17.6. Ready-to-use £45.15.0

Attenuator and demodulator probes available as optional extras.

6 in. VALVE VOLTOMETER, IM-13U

- Modern styling.
- Extra features.
- The ideal VVM for the Electronic Engineer.
- 6 in. Ernest Turner 200 UA meter with multi-coloured scales.
- Unique gimbal bracket allows bench, wall or floor mounting.
- Measures A.C. (r.m.s.), D.C. volts 0-1, 5, 15, 50, 150, 500, 1,300.
- Resistance range 0-5,000 ohms.
- With inc. battery.
- Vernier action zero and ohms adjustment.
- Rollertipped printed circuit.
- High input resistance 1012 ohms.
- Comprehensive assembly and operation manual.
- Size 5 x 12 x 6 in.
- Complete with test prod and leads.

Kit £18.18.0. Ready-to-use £26.18.0


3 in. PORTABLE GENERAL-PURPOSE SERVICE OSCILLOSCOPE, OS-2

- Modern styling. Lightweight and compact size.
- Makes this ideal scope for service men, laboratory technicians, amateur radio enthusiasts or hobbyist.
- "Y" bandwidth 2 c/s-3 Mc./15 kHz.
- Sensitivity 100 mV/cm.
- Push-pull vertical and horizontal amplifiers.
- Wide range time-base generator 20 c/s-200 kcs in four ranges.
- Automatic lock-in synchronisation.
- Mu-metal c.r.t. shield.
- Printed circuit board construction.
- Power req. 200-250 v. 50-60 c/s A.C.
- 40 watts.
- Fused.
- Front panel silver and charcoal grey.
- Size 3 in. w. x 7 in. b. x 12 in. deep.
- Weight: 9 lb.

Kit £23.18.0. Ready-to-use £31.18.0

See these and other Heathkit models in the FREE catalogue

NEW! PORTABLE STEREO TAPE RECORDER, STR-1

- 1 track stereo or mono record and playback at 31/2 and 7 1/2 c/s.
- 18 transistor circuit.
- Record level indicator.
- Digital readout.
- Counter with zero reset.
- Stereo mic and aux. inputs.
- Speaker/headphone outputs.
- Built-in audio amplifier gives 4 watts rms output per channel.
- Two high efficiency 6 in. x 5 in. speakers.
- Verifiable Recording facilities.
- Spooky-to-build.
- Outstanding performance for price.

Kit £45.18.0.

NEW! PORTABLE STEREO RECORD PLAYER, SRP-1

- Compact, economical stereo and mono record playing for the whole family.
- Mains operated.
- All "solid state" circuitry.
- Modern compact styling.
- Detachable second loudspeaker gives optimum stereo effects.
- Automatic playing of 16, 33, 45, and 78 rpm records.
- Surface protractor.
- Two in. x 5 in. speakers.
- Controls: Volume, Balance and Tone.
- Dimensions: overall 20 in. wide x 14 in. high x 7 in. deep.

Kit £27.15.0.

NEW! PORTABLE STEREO RECORD PLAYER, SRP-1

- Compact, economical stereo and mono record playing for the whole family.
- Mains operated.
- All "solid state" circuitry.
- Modern compact styling.
- Detachable second loudspeaker gives optimum stereo effects.
- Automatic playing of 16, 33, 45, and 78 rpm records.
- Surface protractor.
- Two in. x 5 in. speakers.
- Controls: Volume, Balance and Tone.
- Dimensions: overall 20 in. wide x 14 in. high x 7 in. deep.

Kit £27.15.0.

THE CAR RADIO TO COMPLETE YOUR MOTORING PLEASURE CR-1

- Complete your motoring pleasure with this small, compact, high output unit.
- Superb tone and medium wave entertainment whenever you drive.
- For 12v. positive or 12v. negative car earth systems.
- 8 transistors, 2 diode circuit.
- Powerful output (4 watts) will drive two speakers.
- Stylized to harmonise with most car colour themes.
- Supplied in two units, pre-assembled and aligned RF unit kit.
- £11.36 inc. P.T. RF amplifier kit £11.36.

Total price kit (excl. LS) ... £12.17.0 inc. P.T.

L/speakers and accessories available at extra. Loudspeaker £1.45 extra.

Oxford" LUXURY TRANSISTOR PORTABLE, UXR-2

This superb transistor radio is the ideal domestic or personal portable Medium and Long Wave receiver. Solid leather case and handle, in black or brown.
- Easy-to-read tuning scale.
- Extra large loudspeaker.
- Push button L, MW and AM.
- 10 semi-conductors (7 transistors plus 3 diodes).
- Sockets for personal earphones, tape recorder, car aerial.
- Internal 3-volt battery (not supplied) lasts for months.
- Latest printed circuit techniques.
- Comprehensive, easy-to-follow, fully illustrated Instruction Manual.

Kit £14.18.0 inc. P.T.

Prices quoted are Mail Order, and include free delivery in U.K.

DAYSTROM LTD.

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MANUFACTURERS OF THE WORLD-FAMOUS EASY-TO-BUILD ELECTRONIC KITS

Wireless World, April 1968

WW-009 FOR FURTHER DETAILS
NRKV Sound Control System

a unique sound mixing system...

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KONGSBERG NORWAY

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Oslo office: Drammensveien 40, VII
Tel.: Oslo 56 67 70, telex: 1114, cable: Konsern, Oslo
Central European office: Kongsberg Væpnfabrikk, Bonn
Walter Flex Strasse 1, West Germany
Tel.: Bonn 27 422, telex: 86 65 05, cable: Korakontor, Bonn

WW—010 FOR FURTHER DETAILS

Wireless World, April 1968
# LEVELL
PORTABLE INSTRUMENTS

## R. C. OSCILLATORS

With DIGITAL or ANALOGUE

certainty calibration

<table>
<thead>
<tr>
<th>TYPE</th>
<th>TG66A</th>
<th>TG66B</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY</td>
<td>0.2 Hz to 1.22 MHz.</td>
<td></td>
</tr>
<tr>
<td>ACCURACY</td>
<td>± 0.02 Hz below 6 Hz</td>
<td>± 0.3% from 6 Hz to 100 kHz</td>
</tr>
<tr>
<td></td>
<td>± 1% from 100 kHz to 300 kHz</td>
<td>± 1% above 300 kHz</td>
</tr>
<tr>
<td>DISTORTION</td>
<td>&lt;0.11% from 15 Hz to 15 kHz</td>
<td>&lt;0.5% at 1.5 Hz and 150 kHz</td>
</tr>
<tr>
<td>SINE WAVE OUTPUT</td>
<td>Source voltage variable from 30µV to 5V. Output impedance 600Ω at all settings.</td>
<td>Source voltage variable from 250µV to 2.5V. Output impedance &lt;250Ω above 250mV, 600Ω below 250mV. Less than 1% variation of amplitude throughout frequency range.</td>
</tr>
<tr>
<td>SQUARE WAVE OUTPUT</td>
<td>None</td>
<td>Variable up to 2.5V peak. Rise time 1% of period + 0.2µs.</td>
</tr>
<tr>
<td>OUTPUT METER</td>
<td>Expanded voltage scales and —2dB to +4dB. Scale length 3.5&quot;</td>
<td>None</td>
</tr>
<tr>
<td>POWER SUPPLY</td>
<td>4 type PP9 batteries, life 400 hours. or, A.C. Mains when selected by panel control</td>
<td>2 type PP9 batteries, life 400 hours, or, A.C. Mains when batteries are replaced by Levell Power Unit.</td>
</tr>
<tr>
<td>SIZE</td>
<td>7&quot; x 10½&quot; x 7&quot; Weight 12 lb.</td>
<td>10½&quot; high x 6½&quot; wide x 4½&quot; deep. Weight 6 lb.</td>
</tr>
<tr>
<td>PRICES</td>
<td>£150</td>
<td>£120</td>
</tr>
<tr>
<td></td>
<td>+ Mains Power Unit included</td>
<td>£15</td>
</tr>
<tr>
<td></td>
<td>+ Leather Case £5</td>
<td>£5</td>
</tr>
</tbody>
</table>

LEVELL ELECTRONICS LTD., Park Road, High Barnet, Herts. Phone 01-449 5028

Wireless World, April 1968
69 F Tantalum Capacitors are now made in Britain by EMIHUS Microcomponents Limited at their Glenrothes factory.

What does this mean to you? Plenty!
You are now assured of a regular and reliable source of supply—no import problems.
Then, the EMIHUS 69 F Tantalum Capacitors are smaller and less expensive than similar capacitors obtainable in Britain. And these EMIHUS 66 F Capacitors give the lowest leakage current of all and are manufactured under the strictest quality control conditions.

Approval to DEF 5134 A-4 is pending.

For full details write or 'phone to:
EMIHUS MICROCOMPONENTS LIMITED
Sales Office:
Heathrow House, Bath Road, Cranford, Hounslow, Middx.
Tel: 01-759-9584/5 9961/2  Telex: 23613.
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Ensure that we only supply valves made by the world's foremost manufacturers.

Provide valves selected for your special needs.

Help out rapidly with that "awkward" valve that nobody else seems to have heard of.

Specialise in European or American types which are not normally easily obtainable.

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Every valve in either widespread or specialised use in the fields of Entertainment, Industry, Education and Research will be found in our catalogue, together with its main equivalents, classification, and the Pinnacle "P" number under which it may be ordered.

Pinnacle

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**SPEECH LINK**
and

**ON/OFF LINK**

are being given daily at our only address,

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LONDON, W.1.

These new devices offer features which can be exploited in an extremely wide field of applications. Their outstanding modulation and switching capabilities, coupled with completely solid state circuit design and small physical size make them ideally suited to such purposes as short distance speech and data links, remote relay controls, safety devices, burglar alarms, batch counters, level detectors, etc.

**MGA100**

Type **MGA100 General Purpose Gallium Arsenide Light Source**

A filamentless, Gallium Arsenide infra-red emitter, only 5.54 mm. dia. and 8.1 mm. long. Features a robust cylindrical package coaxial with the beam, facilitating optical alignment and heat-sinking.

**MAX RATINGS**

- Forward current 1/2 max.* D.C......... 400mA. Forward peak current 1/2 max.* (pk)........ 6A
- Power dissipation*........... 600mW. Derating factor for temp. greater than 25°C........ 7.5mW/°C.
- Reverse-voltage 7V max. ........ 1-9V.

*When mounted on an aluminum heat sink 1in.x 1in.x 1in.

Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

**31F2**

Type **31F2 Micro-miniature Infra-Red Detector**

Extremely small photo diodes of silicon NPN passivated detector, planar construction and suitable for punched card readers, counters, film sound track, etc.

Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

**MSP3**

**...and these new solid state devices...**

**RCA TRIACS Type 40432**

Intended primarily for phase control of A.C. loads in light dimming, universal and induction motor control, heater control, etc., these gate controlled full-wave A.C. silicon switches, with integral trigger, switch from a blocking state to a conducting state for either polarity of applied voltage with positive or negative gate triggering.

Supplied complete with full Data and Application Sheets.

**INTEGRATED CIRCUIT RCA—CA 3020 AF POWER AMPLIFIER & PRE-AMPLIFIER (or servo-amplifier)**

The RCA CA 3020 is an integrated-circuit, Multistage, Multi-Purpose AF Power Amplifier on a single monolithic silicon chip, providing a stabilized direct-coupled amplifier, performing pre-amp., phase inverter, driver and power output functions without transformers, and with one power supply suitable for sound, communications and control systems.

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**PROOPS BROTHERS LIMITED**

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Telephone: LANTHAM 0141 (01-580 0141)

WW-014 FOR FURTHER DETAILS

Wireless World, April 1968
HUNTS
give designers the best of both worlds...

... all the advantages of a **metallised polyethlene terephthalate film** capacitor + ... **humidity resistant housing of tough, clean epoxy resin** neatly styled to eliminate any moisture trap between terminations.

**New Hunts Type M314**
gives high standards of reliability in a new range specifically designed for printed circuitry.

---

**Hunts Type M314 Standard Capacitance Range**

<table>
<thead>
<tr>
<th>Capacitance Microfarads</th>
<th>160V. d.c. List Number</th>
<th>250V. d.c. List Number</th>
<th>400V. d.c. List Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.022</td>
<td>TMD 552</td>
<td>TMD 556</td>
<td>TMD 560</td>
</tr>
<tr>
<td>0.033</td>
<td></td>
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<tr>
<td>0.047</td>
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<tr>
<td>0.068</td>
<td>TMD 502</td>
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<td>0.1</td>
<td>TMD 506</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.15</td>
<td>TMD 452</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.22</td>
<td>TMD 456</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>TMP 540*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>TMO 541*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* These units are approved to Post Office Specification D2283

**Temperature** -55° to +100°C

**Humidity Classification**
21 days (H5 DEF 5011)

**Dimensions mm**

<table>
<thead>
<tr>
<th>L</th>
<th>W</th>
<th>T</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMD</td>
<td>18</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>TMP</td>
<td>31.75</td>
<td>22.23</td>
<td>7.94</td>
</tr>
<tr>
<td>TMO</td>
<td>31.75</td>
<td>22.23</td>
<td>10.72</td>
</tr>
</tbody>
</table>

Please use the Reader Enquiry Service to obtain full technical information or contact us direct

---

A. H. HUNT (Capacitors) Ltd
Wandsworth, London SW18, Telephone VANDYke 6454, Telex 25640
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WWW.—017 FOR FURTHER DETAILS
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AT THE AUDIO FAIR

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Just listen to Gordon J. King's summary in a February 'Hi-Fi Sound' Review: "I have no reservations whatever in thoroughly recommending this outstanding loudspeaker to all wishing to obtain large-speaker sounds from a modest 21" x 9½" x 9½" of enclosure". Suffice it to add that this is a 3 drive unit incorporating the famous ABR (Auxiliary Bass Radiator), 8" bass unit and the HF 1300 for treble notes. Full power response from 15,000 right down to 30 Hz—the threshold of audible sound.

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We will be demonstrating a remarkable new loudspeaker at the Fair. Be sure not to miss the opportunity of being amongst the first to hear this superb new addition to the Ditton range.

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WW-018 FOR FURTHER DETAILS
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- Stand for soldering iron
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Wireless World, April 1968
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This is an illustration of sixty-two different power units

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FEATURES

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Wireless World, April 1968

www.americanradiohistory.com
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Wireless World, April 1968
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Mallory made it.

What can we do for you?

Early in 1968 the British Trans-Arctic Expedition set out to accomplish the first surface crossing of the frozen Arctic. This Trans-Polar journey of 3,800 miles will take them approximately a year and half. In order to keep the four-man team supplied throughout this period, The Arctic Research Laboratory and Royal Canadian Air Force are making a number of supply drops.

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Monoblocs are to be featured in the 1968 edition of catalogue of S.T.C. Electronic Services. Monobloc and Ceramicon are registered trade marks.

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WW—042 FOR FURTHER DETAILS

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- Size: 17 x 11 x 8 in.
- Weight: 15 lb.
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A transistor operated voltmeter satisfying the requirements for audio frequency measurement.

Specification
- Sensitivity: 1 mV.-300 V. f.s.d. (12 ranges).
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- Frequency Range: ±1 dB, 10 Hz-500 kHz.
- Input Impedance: 1 MOhm. 1 mV.-300 mV. 10 MOhm. 1 V.-300 V.
- Meter Scaled: 0-3, 0-10, and dBm.
- Power Requirements: Included battery.
- Size: 11 x 6½ x 6 in.
- Weight: 7 lb.
- Price: £35.
MAGNETIC RECORDING

TYPE "A"
Standard 1/2 track, Record/Playback and Erase. Many special versions can be made to customers' requirements such as narrow track—raised track—or cut-away for cine use. Ideal head for dictating machines, etc. Size 1/8 in. dia. x 1/8 in. long. The round body makes for easy azimuth adjustment and takes up a minimum of space. Head has internal screen and fly leads for easy wiring.

TYPE "R"
Size is 1/8 in. square at the front with body 1/8 in. dia. by 1/8 in. long. Curved front 1/8 in. radius. This head is available in a wide range of Record/Playback impedances. Also available as Erase. This novel design possesses many advantages over comparable types—higher output—lower losses—extremely good H.F. response—very low noise pick up—has internal mumetal screen. Round body aids mounting arrangements—easy azimuth alignment.

TYPE "DR"
Exactly as Type R except body is 1/8 in. square along its length providing simple mounting arrangements. The Erase versions of R and DR types are double field heads. These are not just double gaps but two Erase heads in one, giving better than 60dB erasure of a saturation (±6dB on full record level), 1 kHz recording at 3/4 i.p.s.

TYPE "X"
1/1 — 1/2 — 2/2 and 2/4 Heads for 3/8 in. tape. Record/Playback and Erase Heads for high quality tape recorders. Size only 1/8 in. cube and available in a whole range of impedances. Excellent HF performance, efficient screening and very low cross-talk are features of the R/P head. Mounting brackets are available for twin or triple head assemblies.

TYPE "T"
Built into a deep drawn mumetal case ensures complete shielding. Type T is the protruding pole type with special narrow track (as narrow as .003in.) and can be made as a Record/Playback or Erase Head, or combined Record/Playback or Erase Head, or even Record/Playback and self-oscillatory Erase Head. The Erase track can be made wider than the R/P track on the Combo Head, a fully screened lead is incorporated as part of the head.

SINGLE TRACK COMBO TYPE "X"
Designed as a combined Record/Playback/Erase Head for the commercial market, such as telephone answering machines. Built into 1/8 in. cube deep drawn mumetal case it incorporates the R/P features of R-Type head. The Erase track is made wider than the R/P track to ensure complete erasure and to overcome machine to machine alignment tolerances.

TYPE "Z"
A brand new concept in combination head design incorporating all the best features of the X-Type Head combined with integral erase facilities. Accurate gap alignment between tracks makes this head eminently suitable for high quality stereo use. The one-piece deep drawn mumetal case (only 1/8 in. cube) ensures complete screening across the front as well as the sides.

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Available to special order in Two-Four-Eight or Sixteen tracks, or to specification. These tracks are located by precision machined slots and track dimensions and positions remain consistent. The track to fixing base dimensions are held to tight limits and any tolerances are non-cumulative as each track is indexed from the base. Special purpose optical equipment ensures a high order of accuracy in the alignment of the head halves. Erase heads, identically sized to the R/P head are available to special order.

TYPE "W" ERASE
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The Record/Playback Head for Cassette Recorder incorporated in a deep drawn mumetal case ensuring complete screening. As an integral part of the head the mounting plate is of tempered Beryllium copper to provide a simple azimuth adjustment. The winding is centre tapped to give the option of presenting a lower impedance to bias and signal sources during recording.

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Wireless World, April 1968

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**30 50 WATT AMPLIFIER.** With 4 mixed inputs, and bass and treble tone controls. Can deliver 50 watts of speech and music or over 30 watts on continuous sine wave. Main amplifier has a response of 30 c/s-20Kc/s ≥ 1db. 0.15% distortion. Outputs 4, 7.5, 15 Ω and 100 volt line. Models are available with two, three or four mixed inputs for low impedance balanced line microphones, pick-up or guitar.

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Wireless World, April 1968

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If you would like further details of this unique mounting assembly contact:

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Wireless World, April 1968
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GT16. Gives a general description of the Alpha series assemblies and describes their suitability for wound components where a high degree of stability is required.

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Complete coupon and post indicating publication(s) required

Lilliput Series  Alpha Series  Low Voltage Isolating, Auto Transformers

Name
Designation
Company
Address

WW—065 FOR FURTHER DETAILS
Static Characteristics:
Tracking weight: 7.5 grams.
Output: 0.9 mV/cm/sec (measured on Decca SXL2057).
Lateral static compliance: 1 gram: 30 x 10^-6 cm/dyne.
Vertical tracking stylus radii:
Inductance: 0.0003 x 0.0008" elliptical.
Mounting centres: standard 1".
Weight of cartridge: 7.5 grams.
Termination: gold plated electrodes colour coded to B.S. 1929-1965.

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WWW-067 FOR FURTHER DETAILS

WWW-068 FOR FURTHER DETAILS
New from Garrard—the AP 75 a high-fidelity single record-playing unit for less than £23*

You get all these advanced features with this elegant unit:

- Diecast aluminium pick-up arm.
- Manual or automatic playing of single records.
- Single lever selects both record size and turntable speed.
- Slide-in cartridge carrier.
- Non-magnetic turntable.
- Calibrated, fine stylus-force adjustment.
- Calibrated pick-up arm bias compensation.
- Cue and pause facility.

As well as manual control, this unit offers the additional facility of automatic play of single records. A single operation starts the turntable, lifts the pick-up arm and lowers it on to the record, and when playing is finished, returns the pick-up arm to rest and stops the turntable. A single control lever selects both record size and turntable speed for 12" records (78 rpm), 7" (45 rpm) and 12", 10" and 7" (33½ rpm). £19.3.0d. + P.T. 68/6d. Optional extras: teak-finish base WB4; rigid, clear plastic cover SPC4.

and just for the record

Garrard 401 is the ultimate in transcription turntables—magnetically shielded 4-pole induction motor; gear-cut stroboscopic markings illuminated by an integral, high-intensity neon lamp; variable speed control; heavy non-magnetic diecast turntable; anti-static mat; functional styling. £25.9.7d. + P.T. 91/2d.

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Garrard SP 25 Mk II a single-record playing unit giving exceptional performance at moderate cost. With pick-up arm bias compensator and calibrated, fine stylus-force adjustment. Cue-and-pause control allows pick-up to be raised or lowered at any point. £12.10.8d. + P.T. 44/10d. Optional extras: teak-finish base WB1; rigid, clear plastic cover SPC1.

*Recommended retail prices.

Garrard looks after your records

Ask for illustrated leaflets on the complete Garrard range.

GARRARD ENGINEERING LIMITED, NEWCASTLE STREET, SWINDON, WILTSHIRE, ENGLAND. TELEPHONE: SWINDON 5381

WWW—070 FOR FURTHER DETAILS

Wireless World, April 1968
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GOLDRING '800' FREE FIELD STEREO CARTRIDGE £12.7.6

SPECIFICATION
Type: Magnetic—(Free Field)
Frequency Response: 20 Hz—20 kHz
Sensitivity: 1 mv. per cm/sec.
Separation: 25dB at 1kHz and nowhere less than 15dB
Load: 100k—47k/ohms
Compliance: 0.0005" diamond replaceable
Stylus: 1 mg.
Effective Tip Mass: 1—3 grms.
Tracking Weight: 8 grms.
Head Weight: 15°
Vertical Tracking Angle: Mu Metal Shield for hum protection.

AUDITORY FAIR APRIL 18-21 BOOTH 93 DEMONSTRATION ROOM 402

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One three-port unit (N82) used in conjunction with two five-port units (N81) provides a very efficient unit having eight outputs and an insertion loss of only 2.5 dB over most of the band. Write for full details on the complete Hybrid range, and other new developments.

HATFIELD INSTRUMENTS LTD., Dept. WW, Burrington Way, Plymouth, Devon.
Telephone : Plymouth (0752) 72777.4. Grams : Sigilan, Plymouth

WWW—073 FOR FURTHER DETAILS

Wireless World, April 1968

www.americanradiohistory.com
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3. “Split shell” construction of cable unit housing for ease of wiring. Elimination of strain on cable joint by means of right-angle contacts.
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The Stumpi range is a new conception in design, fully sealed, meeting the requirements of DEF.5325, and is initially available in three shell sizes with nominal contact ratings of 5, 20, 40 and 60 amps.

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Wireless World, April 1968
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Serviscope D52

*Serviscope is a registered trade mark of Telequipment Ltd.
This month's cover. The tête-à-tête being overheard by a microphone, a scene from a production at the B.B.C. Television Centre, prettily introduces two features in this issue: 'Developments in Microphones' by H. D. Harwood (p. 58) and a microphone supplement. The microphone on the boom is a moving-coil type with a cardioid characteristic, a kind used extensively in television work.

April 1968

Volume 74 Number 1390

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WW—106 FOR FURTHER DETAILS

WW—1968
Audio Myths, Maths and Measurements

The other day a highly respected audio equipment manufacturer told us he was obliged to extend the frequency response of his amplifiers far beyond the normal requirements of hearing because people insisted on testing his products with square waves and wanted to see nice right-angled corners on their oscillograms. This is a case of objectivity in measurement gone crazy, to the extent of bringing in irrelevant, visual subjective criteria.

The imminence of the London Audio Fair reminds us that audio engineering, of all the branches of electronics, seems particularly prone to this irrational type of approach. The very word “audiophile” suggests that the hardware possesses some kind of human personality, best understood through psychology rather than physics. Readers of this journal are not likely to be caught in such mental traps. But it is still possible for us to fall into rather narrow—and perhaps even misleading—ways of thinking about performance testing. The trouble is that the criteria in common use tend to arise from the types of instruments that can be readily manufactured. For example, we glibly talk of “frequency response”; but, as H. D. Harwood gently reminds us in the captions to his graphs (pp. 74-78 this issue), it is really output/input amplitude ratios we are measuring, at a number of different frequencies. Frequency response curves are in fact graphical representations of transfer functions (without the phase information), in terms of $\omega$ rather than $d/dt$. And the $\omega$ comes in because we are using the rather artificial sinusoidal form of excitation. Sine-wave testing is convenient and oscillations of adequate purity are easy to generate, but sine waves as such hardly ever occur in normal sound programmes—perhaps an occasional solo note on a flute. It’s odd that we resort to them so much.

Also easy to generate are noise signals, and their use in testing audio equipment is now well established. This type of excitation, whether it be white, pink or what-have-you noise, can, of course, be considered as providing simultaneously a wide range of frequencies (as can the step functions in square-waves) and herein lies its usefulness for rapid response/frequency testing. A more realistic way of looking at noise is simply as a random function of time. As such it is much more like the transients in music or speech than are sine waves. Its statistical properties can be utilized for testing by means of correlation computing techniques. With white noise excitation, the cross-correlogram between the input and output time functions is, in fact, the impulse response (multiplied by a constant) of the device under test.

Computers are transforming not only measurement techniques but methods of system analysis. The current interest in state variables* is a case in point. Audio transducers, say, or filters, are often represented by second (or higher) order differential equations, but these can be difficult to handle by conventional methods, particularly if non-linearities are present. State variables are variables related to energy storage elements in a system (e.g. current through an inductor) and since these elements can be represented by first-order differential equations, the set of “state space” equations describing a device or system can be readily solved on analogue or digital computers. It remains to be seen how useful this approach will be in practical design work, but at least it opens another window to let us look at the old familiar scenery with a fresh eye.

* The concept of state, first used explicitly by Newton in laws of motion, was later developed into a method of analysing dynamical systems by Poincaré for his work on celestial mechanics.
How Important Is Detection?

An alternative to the common envelope detector, using integrated circuits

by R. C. V. Macario,* B.Sc., Ph.D., M.I.E.E.

A systematic study of the processes of detection in an a.m. receiver indicate that detection plays a bigger role in the final performance than one would deduce from the hardware and or cost breakdown. Previously any departure from the simplest envelope detection schemes would have been uneconomical because of the relatively small performance improvement for the added circuitry, but with the advent of integrated circuits alternative approaches may hold promise. One of these alternatives is described in this article. The operation indicates that a fresh look can be taken at the ratio of linear gains in the i.f. and a.f. sections, as well as at the selectivity performance of these two sections. A practical system designed from the result is also described. This circuit can be added to existing receivers, and comparative listening tests have indicated better reception under selective fading conditions, in particular on short-wave bands. The improvement would be greater if one were prepared to add a carrier selection filter (with no phase shift) ahead of the system. The study also suggests further ways in which reception under selective fading conditions may be realized.

It is not an undue exaggeration to represent a typical broadcast receiver by a block diagram along the lines of Fig. 1. The relative amounts of hardware are indicated for the two main sections, these being the selectivity and audio stages respectively. In terms of cost, the distribution would be even more remarkable. Considering how important a function is detection† or demodulation, it is surprising how small a part of the receiver is allocated to this undertaking.

In this article a brief review of the principles underlying the process of recovery of the transmitted signal is made. The conclusions drawn indicate that certain changes in the familiar superheterodyne structure can well take place with the advent of more easily available complex circuits as a result of integrated circuit technology. A number of these features are illustrated experimentally. In particular, a scheme is described by which additional non-linear circuitry may be added to an existing receiver to provide faithful demodulation of low level signals.

Theory

One can reasonably assume that an a.m. signal leaving a transmitter consists of a stable carrier surrounded on each side by a pair of sidebands of fixed bandwidth, with a modulation depth that never exceeds 100%. During propagation to the receiver the signal may suffer transmission impairment, which we assume is a linear function. That is, if we consider a carrier of frequency \( \omega_c \), two individual sidebands \( \omega_c - m \omega_m \) and \( \omega_c + m \omega_m \), and a modulation depth \( m \), the received signal has the form

\[
e(t) = a \cos(\omega_c t + \phi_c) + \frac{am}{2} \cos(\omega_c + \omega_m t + \phi_c) + \frac{am}{2} \cos(\omega_c - \omega_m t + \phi_c)
\]

where

- \( a \) = carrier amplitude at receiver
- \( m \) = relative u.s.b. depth of modulation
- \( m \) = relative l.s.b. depth of modulation

\( \phi_c, \phi_m, \phi_l \) are relative component phase shifts at the receiver aerial.

The general case of a broadband modulation signal is obviously more complex than that of the single tone as written here, but the latter suffices to demonstrate certain features we wish to show.

At the same time our wanted signal arrives surrounded by a very large number of similar transmissions, which are, we hope, at least separated in frequency by carrier differences of twice the minimum acceptable audio bandwidth.

Mixing

Assuming we have no cross modulation in the first stages of the receiver, a stage of mixing faces the signal. For a self-oscillating transistor mixer a type of square-law signal transfer

*Division of Electrical Engineering, University College of Swansea.

†H. S. Black has suggested the word "remodulation" for product detectors and the like, but keeps to "detector" for the simple diode circuit.

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The choice of the value of $\omega_m - \omega_c$ affects the etymology of the name given to receiver systems. This is most easily done by means of a table:

<table>
<thead>
<tr>
<th>Choice of $\omega_m - \omega_c$</th>
<th>System Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\omega_m = \omega_c$</td>
<td>heterodyne</td>
</tr>
<tr>
<td>$\omega_m - \omega_c &lt; 0$</td>
<td>superheterodyne</td>
</tr>
<tr>
<td>$\omega_m - \omega_c &gt; 0$</td>
<td>i.e. supersonic also known as singlespan</td>
</tr>
<tr>
<td>$\omega_m = \omega_c = 0$</td>
<td>synchrodyne</td>
</tr>
</tbody>
</table>

The homodyne does not have a separate oscillator and is described below. Autodyne refers to a self-oscillating mixer and so does not constitute a complete receiver system.

Returning to our main discussion and the previous equation, assuming the i.f. amplifier is tuned to $\omega_i = \omega_o - \omega_c$, the only terms which will come out of the i.f. will be the cross product terms

$$
e_i = \frac{a}{2} \cos(\omega_m - \omega_c t + \phi_m - \phi_c) + \frac{a_i}{2} \cos(\omega_m - \omega_c t + \phi_m - \phi_c) + \frac{a_i}{2} \cos(\omega_m - \omega_c t + \phi_m - \phi_c)
$$

There is thus no distortion. Departure from the square law will of course create intermodulation products, but of more concern are the other signals reaching the mixer. Each signal will undergo a similar process to the one just described and both the cross-product and square terms can give frequencies which will fall within the i.f. passband. This is the reason why in a review of broadcast receivers it was stated that adequate selectivity before the mixer stage was in fact more important than selectivity after the mixer stage.

The main reason for having a sharp sided filter in the i.f. section is to improve the adjacent channel selectivity so one wishes to receive a weak station close to a strong unwanted signal.

A way of reducing the r.f. selectivity requirement, however, is to have a linear switched modulator in which the local oscillator signal $\cos(\omega_m + \phi_c)$ effectively multiplies the incoming signals, then

$$
e = \cos(\omega_m t + \phi_m) \cdot [a \cos(\omega_c t + \phi_c) + \frac{a_i}{2} \cos(\omega_c t + \phi_c) + \ldots + \frac{a_m}{2} \cos(\omega_c t + \phi_c) + \ldots]
$$

leading to exactly the same result for the ideal square law device, but without the likelihood of interfering cross-product terms.

This, of course, advocates a separate local oscillator and a balanced on-off modulator, which could well be economic with integrated circuits and leads to better spurious signal immunity.

**Synchrodyne**

It is worth noting that in the case of the synchrodyne we make $\omega_m = \omega_c$ and $\phi_m = \phi_c$, that is, mix with an oscillation which has exactly the same phase and frequency as the received carrier. The filtered output becomes

$$
e_i = \frac{a}{2} \cos(\omega_m t + \phi_m - \phi_c)
$$

**Detection**

Let us suppose our signal arrives at the detector stage without further distortion. (This may be more difficult than one can easily suppose. For example, it is well known that in s.s.b. and i.s.b. transmissions the necessary curtailing of the low audio frequencies, and extra sharp filters, destroy speech quality.) Fig. 2 shows a basic envelope detector. The capacitance is assumed to be a short circuit to the r.f., but open circuit to the i.f. This is not practical for an i.f. of 465 kHz; there is an error of about 10$^{-6}$ which means that the full modulation index range cannot be processed in this circuit.

Of more importance, possibly, is the nature of the signal recovered when it suffers transmission impairment and has a form similar to that assigned to $e_i(t)$ above. Then it can be shown that the envelope is given by

$$
E(t) = \left[ \frac{1}{2} a + \frac{a_i}{2} \cos(\omega_m t + \phi_m - \phi_c) + \frac{a_m}{2} \cos(\omega_m t + \phi_m - \phi_c) \right]^2

+ \left[ \frac{1}{2} a \sin(\omega_m t + \phi_m - \phi_c) - \frac{a_i}{2} \sin(\omega_m t + \phi_m - \phi_c) \right]^2
$$

Apart from the fact that the envelope, which started with the form $a \cos(\omega_m t + \phi)$, certainly has changed its relative depth of modulation, harmonics of $\omega_m$ are also generated. These are more disturbing than loss of signal.

The distortion is further aggravated if the diode is not operated over its linear range. That the diode should operate in a linear mode is further required in order to gain the apparent demodulation of a weak signal by a strong one. The degree of suppression for a linear diode is

$$
\text{Wanted strong signal modulation} \quad \text{Unwanted weak signal modulation} \quad \begin{align*}
\frac{1}{\text{after}} & = 1 \left| \frac{e_{\text{strong}}}{e_{\text{weak}}} \right|^2 \\
\frac{1}{\text{before}} & = 2 \left| \frac{e_{\text{weak}}}{e_{\text{strong}}} \right|^2
\end{align*}
$$

This, as well known, explains why about an 18 dB adjacent

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channel selectivity in the i.f. of standard receivers is acceptable.

If the diode is operated at a low level on the other hand, its characteristic may no longer be linear and no apparent demodulation is obtained at all, in addition to the increased distortion just mentioned. Unfortunately, diodes with good linear characteristics usually have a forward conduction threshold. This can, however, be reduced by forward biasing. Another way is to use an amplifier/diode arrangement as shown in Fig. 310.

Fig. 4 compares the performance of these two arrangements for 1 V peak-to-peak 450 kHz carrier, modulated with a 1 kHz tone to a depth of 80%. The value of the smoothing capacitor C is chosen from the formula

$$C = \frac{1}{R_i \sqrt{\omega_c \omega_w}}$$

which gives about the optimum value.

Each illustration in Fig. 4 shows the recovered envelope superimposed on the input waveform. The diode circuit gave an 8 dB envelope amplitude loss compared with a gain of 3 dB for the amplifier/diode arrangement. The power gain difference is of course much greater due to the different source impedances. The distortion due to the unsupported diode at low carrier levels is easily seen. Both circuits distort, however, if the modulation depth is raised to 90% because of the necessary choice of the capacitor C.

Homodyne Detection

The distortion referred to earlier on the envelope of a severely impaired signal increases as the modulation depth is increased. In the homodyne system energy is put in at the same frequency (derived directly from the signal, not from a synchronized oscillator as in the synchrodyne11) an immediate result of which is to reduce the depth of modulation and hence envelope distortion. Crosby11 described a system along these lines as “exalted carrier reception,” but the difficulties of selecting out the carrier with a crystal circuit and adding it to the signal with the proper phase relationship were not to be envied.

An alternative method of obtaining knowledge of the state of the instantaneous carrier is to note whenever the incoming signal crosses zero amplitude. A zero crossing detector does just this and usually produces a square wave with a fundamental frequency equal to that of the signal oscillation within the modulated envelope $E(t)$. This signal, however, differs slightly from that of the carrier $\cos(\omega_c t + \Phi_c)$, and is given by

$$e_1 = \cos(\omega_c t + \Phi_c + \psi)$$

where

$$\psi = \tan^{-1} \left[ \frac{a m_i}{2} \sin(\omega_m t + \Phi_m - \Phi_c) - \frac{a m_o}{2} \sin(\omega_m t + \Phi_m - \Phi_c) \right]$$

and

$$\tan \psi = \frac{a m_i}{2} \cos(\omega_m t + \Phi_m + \Phi_c) + \frac{a m_o}{2} \cos(\omega_m t + \Phi_m - \Phi_c)$$

This fixed amplitude carrier can be added to the signal and used to switch the detecting diode in an on/off mode and thereby operate faithfully up to 100% modulation level. The detected components are those remaining after product mixing, namely, multiplying $e_1$ by $e_2$, then

$$E(t) = \frac{a}{2} \cos \psi + \frac{a m_i}{4} \cos(\omega_m t + \Phi_m - \Phi_c + \psi)$$

$$+ \frac{a m_o}{4} \cos(\omega_m t + \Phi_m - \Phi_c - \psi)$$

The result is similar to that obtained for ideal synchrodyne reception, except for the term $\psi(t)$. (It can be reduced to zero if the sidebands are filtered off before zero-crossing detection, i.e. synchrodyne.)

At first sight the result looks rather different from the expression for the envelope of the original signal $E(t)$, but if one studies the two results for the important selective fading condition when the phase of the carrier is rotated.
shown that E, signal available during transmission, the detected waveform shows synchrodyne gain amplifier.

For the zero crossing homodyne scheme we have:
\[ E_r = \frac{a}{2} \cos \phi + \frac{am}{2} \cos \left( \omega_m t + \phi_a + \phi_r \right) \]

which becomes
\[ a \cos \phi - \frac{am}{2} \cos \omega_m t \sin \psi \]

Clearly \( \psi \) will not have, nor can we choose, a value which will recover the modulation in all cases.

The actual value of \( \psi \) will be, for this case,
\[ \tan^1 \left( \frac{m \cos \omega_m t}{m^2} \right) = m \cos \omega_m t - \cos^2 \omega_m t + ... \]

or, for small percentage modulations,
\[ m \cos \omega_m t \]

If this value is substituted into the expression for \( E_r \), it can be shown that \( E_r \) is not dissimilar to the envelope \( E(t) \). (In the synchrodyne case the distortion is missing, but so is the modulation.)

The result is more clearly illustrated by Fig. 5. The top waveform shows the unimpaired signal, the next waveform the detected signal when the carrier phase is rotated by 90° during transmission, and the bottom waveform shows the instantaneous phase angle \( \psi \) of the zero crossing waveform. (When there is no impairment \( \psi (t) = 0 \), of course.)

The interesting feature of Fig. 5 is that though the modulation signal is missing from either detected signal, it is retained by the phase term. Clearly, if one were to use both the envelope and phase information, added in a proper manner, much of the familiar short-wave phase distortion could be reduced.

The remainder of this article is therefore devoted to a description of a circuit by which the zero-crossing waveform, and hence \( \psi (t) \), may be realized in a receiver, and of a detector utilizing this signal to achieve a very linear performance over a wide dynamic range.

**Practical System**

A practical system by which a zero-crossing detection signal can be generated falls within the sphere of digital circuit technology; as a result a large number of alternative approaches can be contemplated. The one to be described, therefore, is mainly illustrative. Its primary purpose is to demonstrate the features necessary for the system to operate satisfactorily. These features are: (1) the switching signal \( e \) must be free of amplitude modulation, and (2) should approach as nearly as possible an ideal square wave; (3) if the zero crossing signal fails during a deep fade or a 99° modulation dip, no interruption signal appears in the signal path.

A circuit system which goes some way towards meeting the requirements just set down is shown in Fig. 6. The i.f. signal available in the existing receiver is picked off by a high gain amplifier. This amplifier need not have a linear characteristic, but must limit symmetrically. The partially limited signal is then fully limited by a stage having a sharp threshold characteristic, viz., a Schmitt trigger (µA710) or a level comparator (µA714). The threshold levels of this circuit are arranged by proper d.c. levelling to correspond as closely as possible to the zero crossing level of the incoming i.f. signal—point (1). The output then consists of a sharply rising on-off waveform constituting \( e \)—point (2).

If the input i.f. signal is at too low a level, however, and so fails to exceed the threshold of the Schmitt trigger, the output \( e \) also fails. Since this interruption is effectively added to the wanted signal, when it is weakest, a balanced product detection arrangement is mandatory—point (3). A shunt modulator is shown, as this preserves knowledge of the input carrier level, i.e., d.c., which can be used for a.g.c. if a.g.c. is not derived elsewhere in the receiver. The diodes in the bridge operate as nearly ideal diodes, since they are switched by the strong derived carrier signal, \( e \), and not the signal, i.e. the homodyne mode.

Fig. 7 illustrates the waveforms associated with a system such as Fig. 6 when using a Schmitt trigger. Fig. 7 (a) shows how the Schmitt waveform is almost completely free of modulation, and how the signal envelope is accurately preserved. If, however, the modulation depth is taken to 100°, the Schmitt necessarily drops out, but, in the main, this is taken care of by the balanced drive to the diode ring.

The fact that the zero crossing detector has a threshold and that we are dealing with amplitude modulated signals whose level may well periodically pass through this threshold creates an interesting circuit problem.
For example, if we assume a usable i.f. signal is a.g.c. controlled so it only varies in carrier level by 20 dB, but on top of this we are to guarantee a 99% modulation range, this means the circuit must be able to handle at least a 66 dB dynamic range, above the threshold.

Between stations, or on a very weak station, because of the threshold the detector will be modulated at a rate equal to the number of times the incoming signals cross the threshold (a few dB wide), and if the diode bridge is not balanced for a partial switching condition (at threshold) the noise breaks through into the audio stages—emphasised by the gain in the zero crossing loop!

The practical circuit given here, therefore, in addition to meeting the requirements set forth above, has the following features: (4) symmetrical limiting, (5) high sensitivity, (6) balanced pulse drive. The circuit is shown in Fig. 8.

The first module (µL900) acts as a symmetrically limiting amplifier, and has a low output impedance to drive the comparator (µA710). The comparator provides the principal sensitivity, producing a sharply rising square wave of approximately 3.6 V amplitude. A two-winding pulse transformer on a small toroid conveniently provides the balanced drive for the diode bridge (BAX52). For a 1:1:1 winding and the drive resistances shown about 2mA is available for switching the diodes, sufficient for input signals up to 5 volts peak. The primary inductance has to be at least 100 µH.

**Performance**

A measurement of circuit performance is shown in Fig. 9. The relative audio signal (after filtering) is plotted against input signal level, for various depths of modulation. At nominal signal levels a linear relationship exists. Any departure from a linear dependence is due to variation of the zero crossing pulse width. This tends to narrow at low signals as less drive is available to the µA710, and the diodes fail to switch at the same instant as the carrier crosses zero.

At low signal levels threshold breakthrough occurs, which is a function of any unbalance in the shunt detector circuit. Below this level the detector stops altogether, and all becomes quiet. This noise plateau has the effect of raising the noise level between stations. With more gain in the control loop of Fig. 8, however, it will move to a lower level. On the other hand, the detector operates at much lower signal levels, and hence the a.g.c. control is made more accurate, so that the circuit would nearly always operate at the nominal signal level of say 100 mV (r.m.s.) or less.

**Listening Tests**

The main interest with the circuit has, of course, been comparative listening tests on a.m. stations, subject to selective fading distortion.

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**Fig. 8.** Practical circuit for detector. The core of the pulse transformer is a Ferralex type mm428 (or any other core of similar size and mu). R1 and R2 determine threshold sensitivity and maximum linear signal handling. The BAX52 is a matched quad, but some capacitance correction for minimum threshold breakthrough may be necessary.

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Fig. 9. Dynamic performance of Fig. 8 circuit (i.f. = 470kHz, a.f. = 1kHz).

Fig. 10 is included to show the difference between modulation linearity using the existing detector in a standard communications receiver (Eddystone Model 940) and the new system. Incidentally, when attempting to measure the distortion versus modulation percentage for the system on its own, the distortion was found to be below the distortion level quoted for the signal generator available.

The audio signals from Fig. 8, and from the receiver, were reproduced through the same good quality speaker system using a sharp cut-off audio filter. (This works as well as, or better than, narrowing the receiver i.f. bandwidth.) As might be expected, there is really no perceivable difference on a primary, say medium wave, broadcast, or to the operation of the receiver.

On the other hand, listening, for example, on the 15 MHz band, to speech broadcasts subject to the usual short-wave distortions, it can be stated that the detection system described adds an extra sharpness and greater degree of intelligibility to the received signal, compared with the standard receiver. This may well be due to the more faithful following of the signal during carrier fade.

Acknowledgements. The writer wishes to acknowledge the interest of Dr. K. R. Sturley during the preparation of this article, Mr. B. Santaniello for assistance with many of the practical circuits evaluated, and Mr. W. Liew for calculating the results in Fig. 5.

References

1. 'Homodyne Reception' Wireless World, Vol. 48, No. 4, April 1942, p. 87.

H. F. PREDICTIONS — APRIL

Predictions are based on an ionospheric index (IF2) of 132 and sunspot number 115. April/May is forecast as maximum of the current sunspot cycle. Seasonal changes are evident on the two northern hemisphere routes, MUF curves are lower and smoother than recent months. On the trans-equatorial routes optimum frequencies remain around 25-30 MHz throughout daylight hours.

LUF curves were drawn by Cable and Wireless Ltd. for reception in the U.K. of point-to-point telegraphy. Their proximity to the optimum traffic frequencies is a guide to weak or no-signal periods on other types of service.

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Developments in Microphones

A review of recent innovations in design

by H. D. Harwood,* B.Sc.

THERE has been a considerable amount of work on microphones during the last few years, resulting in improved frequency characteristics, better signal-to-noise ratio and smaller size. It is difficult to say at this stage whether all the variations are likely to endure or whether some will eventually predominate on the grounds of simplicity or price, but at the moment the spate of innovations shows no signs of slackening.†

Capacitor Microphones

Perhaps the class of microphone which has changed most generally over the past few years is the capacitor type. Most of these changes are associated with the design of the head amplifiers and biasing.

Circuit Design.—For many years the capsule of a capacitor microphone operated into a triode valve and special quiet valves have been designed which achieve the very high input impedance required for this purpose; however, in practice, the valves became noisy after a period of time and the reputation of capacitor microphones has suffered accordingly. When the field effect transistor, with its very high input impedance, was developed, one of the first obvious applications was to this problem, provided the necessary requirements could be met. The electrical noise from a capacitor microphone consists of three bands, at low, middle and high frequencies respectively. The low frequency portion is that generated by the resistive component of the gate input impedance. This consists of the capsule and input capacitances in shunt with the resistance of the gate input circuit and has a “red” noise spectrum falling at 6 dB per octave with respect to white noise. The middle frequency portion consists of the pink noise from the f.e.t., while the upper frequency portion consists of white noise from the f.e.t. The position is thus strictly analogous to that obtaining with a triode, and the problem is one of securing adequately low noise levels and a high degree of reliability. The red low frequency noise can be reduced to an insignificant level by increasing the input resistance of the amplifier; f.e.t.s do not present any difficulty in this respect and the other two sources of noise therefore remain the main problem. The pink and white noise levels vary considerably from type to type, and although special low-noise f.e.t.s are now made, it is usually necessary to resort to selection in order to find quiet enough specimens; this involves considerable expense.

One potential source of trouble which so far has not proved serious is dampness of the capsule, resulting in lowered resistance across the capsule terminals. In the old designs, with a valve close to the capsule, the heat was sufficient to dry the insulation but with the advent of f.e.t.s fears were expressed that dampness would prove a problem. It is to the credit of the designers that because of the use of improved insulating materials and other measures no trouble seems to have been met. One disadvantage with some types of f.e.t. however, is that the gain appears to wander over a period of time. Users requiring extreme stability of gain should therefore check this feature.

It is a pleasure to be able to record that the first microphone employing f.e.t.s was made in this country by Standard Telephones and Cables, and this microphone, the type 4126, also has the claim of being the smallest on the market. The output is comparable with that of dynamic microphones. A later version, type 4136, has a higher output and uses a cable with only two conductors instead of the multicore cable required for the earlier model. This arrangement, which is, of course, operationally more convenient and reliable, has been adopted by the Neumann company with their whole range of f.e.t. operated microphones, (an example of which, type KM76, is illustrated). In this case the power is supplied down the lead, either direct to the microphone or via a d.c. converter built into the microphone itself. In either case the power requirements are low and can be supplied by batteries, especially for the direct supply condition for which a typical life is said to be 200 hours.

A.K.G. of Vienna have also entered this field with their model C451.

The noise levels claimed for capacitor microphones with f.e.t.s are rather difficult to assess, as various weighting curves are in use in different countries (a matter which...
the I.E.C. could well look into), but at their best they appear to be slightly better than their nearest valve equivalents. With the continued development of transistors it may be expected that noise levels will decrease still further and that f.c.t.s will prove themselves to be more reliable than valves.

The second revolution which has taken place in capacitor microphones has been the reintroduction of radio-frequency biasing. It is interesting to note that in the early 1920s when it was difficult to obtain high input impedance amplifiers this form of biasing was used in various ways. Today it is usual to employ some form of bridge circuit and an r.f. of the order of 5 MHz.

In the absence of an acoustic signal the bridge should be balanced, and therefore if it is necessary to change the capsule the bridge must be rebalanced. On the other hand it is noteworthy that very low electrical noise levels are quoted by A.K.G. and Sennheiser for this form of circuit; the noise level claimed for the Sennheiser MKH104 and 105 omnidirectional microphones is so low that the air impedance is stated to affect the value obtained. Very efficient r.f. filtering is used to ensure that none of the carrier frequency is transmitted outside the microphone case. At these frequencies the impedance of the capsule is relatively low, of the order of 1kΩ, and it has been found necessary to gold-plate the capsule contacts to ensure that oxide contamination does not contribute to the noise level.

Capsules — Progress has also been made in the design of capsules to go with the improved circuits. The axial frequency range has been extended and the directional properties made more constant with frequency. For example, the Neumann KM74 cardioid type is claimed to have a directional characteristic constant with frequency out to an angle of 135° from the forward axial direction. This feature is useful not only in widening the angle within which direct pick-up can be obtained but also in ensuring that the reverberation is not coloured so as to sound different from the direct pick-up.

The front-to-back ratio of cardioid type capsules has also improved and there is not now such a tendency for this to fall off at the back as the manufacturer, S.T.C., actually claims a front-to-back ratio of 32 dB but it must require facilities of a very high order to measure this, let alone maintain it in production.

A very interesting capsule is used by Sennheiser in the type MKH110. This is of the pressure type but has been made with such a low time constant that the sensitivity is uniform down to about 0.1 Hz. As it uses the r.f. biasing system described earlier, which operates efficiently down to d.c., the full capabilities of the capsule can be exploited and it should be ideal for studying sounds such as sonic bangs which have prominent low-frequency spectral components.

Ribbon Microphones

Development work still proceeds on ribbon microphones, these having the advantage that their characteristics can be more accurately duplicated than can those of any other type of microphone. The Japanese broadcasting authority’s (NHK) research laboratories have brought out the NHK RV1-A, an instrument which is a modern version of an old R.C.A. device. It incorporates a ribbon, the rear of which is partially covered by a tube leading to an acoustic labyrinth. Omnidirectional, figure-of-eight and cardioid characteristics are available. Although much smaller than the old R.C.A. device, it is still fairly large by present-day standards, but on the other hand the performance is stated to be of very high quality.

Also worthy of note as the smallest unidirectional ribbon microphone on the market is the Beyer M160. The directional characteristic is of the hyper-cardioid type and an interesting point is that to achieve a higher sensitivity two parallel ribbons are used in the air gap; although this device has been suggested before, this is the only microphone in production in which it is used. It has significant advantages over using a ribbon of twice the thickness in that a lower resonance frequency and better control of the ribbon overtones can be obtained, but, of course, it raises a number of problems in production as the ribbons must never be allowed to touch each other.

The other ribbon microphone of interest is also from the NHK laboratories. This is the “group talk” microphone and appears to be an embodiment of patent No. 2,539,671 taken out by Olson in 1951. It consists of two figure-of-eight microphones at right angles to each other, the outputs of which are combined through a quadrature network. The polar diagram is in the form of a toroid generated by rotating a figure-of-eight about an axis at right angles to the principal axis. The object is to provide a device which is suitable for discussion groups while maintaining some directional properties in the vertical plane. However, the directivity index is of necessity low, 3 or 1.8 dB, as would be expected from a combination of two figures-of-eight, and it remains to be seen whether in practice it proves to be more useful than a cardioid with the acoustic axis vertical.

Moving Coil Microphones

The most interesting new moving coil microphone is a two-unit cardoid device, type D202, made by A.K.G. This is a development of the variable distance microphones introduced by the same firm and by Electrovoice in America. One unit is used for the low frequency end of the spectrum and another for the high frequencies. In this way it is possible to employ a much greater front-to-back path difference (about 14 cm) for the low-frequency unit than if it had to cover the whole frequency range and therefore the acoustic driving force is correspondingly greater. For this reason the susceptibility to mechanical vibration and wind noise is much less and so is the effect of close talking. The crossover frequency between the two units is at 500 Hz, and the front-to-back path for the high-frequency unit is only 1.2 cm, thus enabling a wide high-frequency range to be maintained; it is also claimed that the ±90° curves run parallel to the axial curve. The
models 200 and 224, designed for p.a. and studio use, complete the range of this type. It is interesting to note that for the first time the specification for this microphone quotes a value for the wind noise, and it is hoped that this practice will spread as soon as standards of wind speed and of weighting curves are agreed. In this connection it has been the practice for a number of years in the B.B.C. to measure wind noise at 10 m.p.h. for studio-type microphones and 40 m.p.h. for outdoor types, ASA weighting is used.

Another moving coil microphone of interest comes from the same stable, namely the type DX11. This has a cardioid characteristic but the unconventional feature about it is the inclusion of a reverberation unit of the spring type. It has been designed for dance band work and the reverberation time is controllable, with a maximum of 2.5 sec, by means of a button on the microphone handle. The associated transistors are powered by batteries located in the microphone handle.

The NHK/Sanken type ML/1 moving-coil microphone is of a different kind. This is a so-called noise cancelling type designed for use at the Olympic Games in 1964. The object was to produce a commentator's microphone which leaves the user with both hands free for writing or holding field glasses and this has been achieved by mounting the microphone on a peaked cap. Sound is picked up by two tubes, the ends of which are about 2 cm apart and placed at the side of the head at a level between the nose and mouth. The tubes are each terminated acoustically at the entrance and communicate with a moving-coil element mounted near the user's ear. The tubes are on anti-vibration mountings and a wind shield can be fitted over the openings. The whole device is very light but the necessity of wearing the cap limits the use on many occasions.

The last kind of moving-coil microphone to be considered is the Lavalier type which has now become very popular. This type was first developed in the U.S.A., where R.C.A. have carried out a considerable amount of development work in this direction, producing some very small models having an axial response designed to compensate for the lack of high frequencies at chest level. However, miniaturization can carry with it high manufacturing costs, and the latest models from this company are rather expensive. Another approach to the problem has been made by A.K.G. who have produced a model, type D109, which is nearly as small as the latest R.C.A. device. The D109 carries a sliding clip which is depressed when the instrument is held in the hand and raised when used as a Lavalier microphone. In the first instance the axial frequency response is said to be almost uniform, while raising the clip has the effect of giving an appreciable increase in response at the higher frequencies, thus compensating for the reduction of this frequency band when used in the hanging position.

**Line Microphones**

Finally, we come to the highly directional line microphone. With a simple microphone of this type the directivity varies with frequency and approximates to that of a cardioid when the wavelength of the incident sound is twice the length of the tube. Modern line microphones, therefore, have transducers with cardioid characteristics at the bass so that the directional characteristic never becomes more omnidirectional than this.

Two examples of this design are the Electrovoice types 642 and 643, with lengths of approximately 2ft and 6ft respectively. Each uses a moving coil transducer with a very large magnet and the correspondingly high signal to electrical noise ratio enables the directional properties to be fully exploited.

A third example is the Sennheiser type MKH804. This is unusual in that while the directional characteristic degenerates into a cardioid at the bass, that of the higher frequencies does not become progressively sharper with frequency but reaches a figure of about -10 dB at 90° away from the axis and maintains this over a wide frequency band. In this case the transducer is of the capacitor type and a good signal-to-electrical noise ratio is achieved by the use of the r.f. biasing circuit described earlier; this construction makes for a very light instrument.

A fourth type due to appear soon is made by A.K.G. as an attachment to the C451 f.e.t. microphone. The tube is about 2ft long and the directivity varies with frequency. A lightweight version of each type will thus be available and it will be interesting to see which proves the more popular.

A feature common to all line microphones is the fact that they have an inherently good signal-to-wind-noise ratio, as the wind-noise at each opening adds up in an r.m.s. manner whilst the signal adds up linearly. Wind shields are provided but these are unnecessary except for use in high winds.
Wide-range General Purpose Signal Generator

A transistor instrument covering 150 kHz–120 MHz in six bands


An r.f. signal generator is a most useful if not essential piece of test equipment so far as the amateur radio or electronics enthusiast is concerned. It is, however, also one of the most expensive, if an instrument of reasonable accuracy, and performance is required. The author found that the available commercial instruments fell into two main categories: Those with a means of monitoring the r.f. level and those without level monitors. In the second class there was in general an uncertainty in the generated r.f. level of at least ±6 dB. One such unmonitored instrument which the author had the misfortune to meet some years ago, changed its output by nearly 10 dB over a frequency change of 10% (41-45 MHz) on the highest frequency band.

The accuracy of the majority of monitored instruments was ±2 dB overall though a few were good to only ±3 dB. The inaccuracies were in general spread about equally between the attenuators and the level monitoring circuit. The majority of the instruments studied had a maximum output of 100 mV into either 75, or 50 Ω, and nearly all quoted a frequency setting accuracy of 1%.

From these various specifications, and the facilities available to the author, a specification was drawn up for the instrument to be described.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency setting</td>
<td>± 1%</td>
</tr>
<tr>
<td>Level monitor</td>
<td>± 1 dB</td>
</tr>
<tr>
<td>Step attenuator</td>
<td>± 0.5 dB per 20 dB step</td>
</tr>
<tr>
<td>Range of step attenuator</td>
<td>0-100 dB calibrated</td>
</tr>
<tr>
<td>Variable attenuator calibration</td>
<td>± 1 dB</td>
</tr>
<tr>
<td>Modulation level range</td>
<td>0-50%</td>
</tr>
<tr>
<td>Modulation accuracy</td>
<td>± 5% of indication from 10-50% modulation</td>
</tr>
<tr>
<td>Maximum unmodulated r.f. level</td>
<td>400 Hz ± 50 Hz</td>
</tr>
<tr>
<td>Output impedance</td>
<td>75Ω, constant</td>
</tr>
</tbody>
</table>

R.F. Oscillator

The circuit used is shown in Fig. 1 and is basically the familiar Hartley oscillator with the earth point moved to give a grounded collector configuration. The advantages found for this arrangement were that one side of the tuned circuit is grounded, greatly simplifying switching and layout; that only a single tapped winding is used on each range; and since the windings are grounded at one end it is a simple matter to arrange that unused windings are both grounded and shorted out. This prevents unused coils resonating with their stray capacitance and causing peaks or troughs in the output of the other ranges. The effect is similar to that found with the grid dip oscillator and is due to the coupling between coils resulting from their proximity to one another.

The level of oscillation is controlled by variation of the bias voltage applied to the oscillator. Further control of the level of oscillation, together with a reduction of harmonic content of the output, and some degree of equalization between ranges is provided by the degeneration produced by the unbypassed emitter resistor. Control of the oscillator by this means also saves changing the coil tapping point to find the correct degree of feedback for each range and makes it possible to use commercially available coils for the three lowest ranges. (For those with wave-winding facilities a tap at approximately 20-25% from the top of the winding is satisfactory.)

To improve the overall stability of the oscillator further and

![The author’s prototype signal generator. The front panel is overlaid with Perspex lettered on the reverse side.](image_url)

Fig. 1. The basic circuit of the r.f. oscillator employed.

*Plessey Automation Ltd.

Wireless World, April 1968
transistors, was therefore tried with considerable success. The method consists of feeding the variable attenuator, which is wired as a current-divider from a constant current generator. The result is a variable attenuator with a constant output impedance equal to the value of the potentiometer, providing that the output impedance of the constant current generator does not appreciably shunt the potentiometer.

The practical circuit used to achieve this is shown in Fig. 2. Level monitoring is achieved by the use of a diode voltmeter which measures the input to the constant generator.

The constant current generator transistor operates in class A and a bias source is used rather than a potentiometer across the supply. The bias potentiometer, if used, would have to be chosen to give sufficient collector current at minimum battery voltage and would result in a very high collector current at maximum battery voltage, with consequently reduced battery life. The current in this stage must exceed:

\[
\text{for class A operation for } 75\Omega \text{ output impedance and } 100\text{ mV r.m.s., this gives:}
\]

\[
\frac{(E_{\text{OUT}}/\sqrt{2})}{R_{\text{LOAD}}} \cdot 10^{-3} \text{ mA},
\]

\[
R_{\text{LOAD}} = 37.5 \text{ }\Omega \text{ since so far as the current generator is concerned the current divider, and load (both } 75 \text{ }\Omega \text{ are in parallel. A current of } 5 \text{ mA is, therefore, adequate. In the circuit used (Fig. 5) the bias source is three forward biased silicon diodes, which provide approximately } 2 \text{ }V \text{ is reasonably independent of supply voltage. This potential does, of course, vary with temperature, but for normal operating temperatures this is of little consequence providing that the collector current of the current generator is approximately } 150\% \text{ of the minimum as indicated above. The value of } R_s \text{ depends on the voltage available from the oscillator and on the voltage required by the diode r.f. voltmeter for a reasonable value of d.c. output current for a level indicator. A value of } 150 \text{ }\Omega \text{ was found to be a reasonable compromise, giving a d.c. current to the indicator of } 36 \mu\text{A. The meter sensitiveness should not be lowered too much however or both the r.f. oscillator and the modulation measuring transistor will be unable to provide enough drive.}
\]

The performance of the output stage is illustrated in Fig. 3 which shows the variation of actual output for a constant reading of the level indicator (that is a constant input to the current generator stage). The circuit of the voltmeter used to measure this and terminate the output of the signal generator is shown in Fig 4.

The current divider potentiometer used is a solid moulded carbon type (Plissey type E), which is stable and has a long operating life. Deposited track carbon types are not suitable because of wear problems. The lowest value available is 100 }\Omega \text{ but this can be reduced to } 75 \text{ }\Omega \text{ by connecting a } 270 \text{ }\Omega \text{ resistor across the potentiometer.}

**Attenuator**

The majority of commercial generators use a ladder attenuator having either four, or five steps of 20 dB each. Owing to the difficulty of making a suitable screened enclosure and switch for such an attenuator it was decided to make a set of five separately switched attenuators. A suitable screened enclosure can then easily be made covering the complete attenuator and the output socket (see Fig. 7). The screen has intersection screening plates, each having a small slot to allow the coupling wire to pass through. The switches themselves are standard two-pole slide switches with a change-over action. Tinmed steel sheet was used for the fabrication of the attenuator screen and all internal joints are soldered (in order to stop rusting the cut edges may be filed smooth and tinned also). The screen is made a close fit on to the aluminium front panel and secured with screws at frequent intervals.

**Output Amplifier and Attenuator**

The oscillator described above generates a good sinewave signal, but at a level and impedance unsuitable for general use. In many commercial generators a coupling winding is placed on the oscillator coil to obtain a suitable output level, this is then applied to a low inductance potentiometer followed by an attenuator pad in order to ensure a reasonably constant output impedance at the highest level settings. The use of such a coupling coil necessitates the use of another bank of contacts on the range selection switch.

It was felt that this method, though it works well enough, is a rather crude way of achieving the required end. A more fundamental method, made possible by the availability of good u.h.f.

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**Fig. 2. Oscillator output amplifier and attenuator arrangement.**

**Fig. 3. Graph showing output versus frequency for a constant setting of the r.f. level indicator.**

**Fig. 4. Circuit used to obtain the graph of Fig. 3.**
Very good screening of each section of the attenuator from the others, of the output socket from the rest of the generator; and the generator from the outside world is essential if the attenuator is to have any sort of accuracy at high degrees of attenuation, especially at the highest frequencies covered.

It was at first thought that obtaining suitable resistors for the attenuator was going to be a major stumbling block, fortunately experiments showed that the commonly available solid carbon moulded resistors were surprisingly good for this application. Such resistors are usually available only in 10% tolerance, which means buying two or three times the quantity required, and selecting resistors. This is still a cheap way of obtaining attenuator resistors. Since the resistors will be required to dissipate only a small amount of power, stability should not prove a problem, but care should be taken in soldering them into position to minimize heat transfer to the resistors. A pair of pliers gripping the lead between the resistor and the soldered joint, during soldering should suffice.

High stability cracked carbon, metal oxide, and other film resistors must not be used, since these will all have spiral tracks and will cause serious errors at the higher frequencies due to the inductive component of the resistor's impedance. Commercial attenuators do, in fact, use film resistors, but these are specially manufactured and do not have spiral tracks. Such resistors are expensive and not readily available, but if any reader is lucky enough to have such a source of non-spiral 15 and 62 Ω resistors he should certainly use them. (Calculated values 15.15 and 61.35 Ω).

A "T" configuration was chosen for the step attenuator sections since at high frequency stray capacitance is the most serious cause of attenuator error and as the value of the resistors used in the "T" are lower than in a "Π" arrangement the stray
capacitances produce less shunting action. The values for the arms are 62Ω for the series elements and 15Ω for the parallel element. 15Ω is a standard value in the 10% range and suitable resistors may therefore be selected on a bridge. For the 62Ω resistors (a standard value in 5% resistors), 68Ω resistors (unselected) were each shunted with a resistor ranging from 470 to 1,000Ω to obtain a value, as measured on a bridge, which was as close to 62Ω as possible (±1%). This method increases the shunt capacity of the series arms, but does not appear to have produced any serious error even at 100 MHz, with the "T" configuration. The resistors are soldered directly to the switches and all leads kept as short as possible. Earth tags are put under the fixing screws of each switch and the leads to them are kept as short as possible.

Modulation

The modulating voltage is applied to the base of the oscillator transistor (Fig. 1) through a high value resistor to avoid shunting the r.f. voltages, a d.c. blocking capacitor is placed in series with this resistor to avoid shunting the oscillator transistor bias circuit. The modulating voltage required to produce a given level of modulation is not constant but depends on the collector current in the oscillator transistor and this in turn depends on the operating frequency. At the higher frequencies the oscillator transistor has to pass a larger collector current because of the higher losses of the tuned circuits, the lower dynamic impedance of the high frequency tuned circuits (both factors requiring a higher loop gain to maintain oscillation) and reduction of the f with current in the oscillator transistor.

Logarithmic potentiometers are used for both the r.f. and modulation level setting controls to enable easier setting despite the wide variations in the requirements with frequency. Since the modulation depth cannot be measured by measuring the modulating voltage, it was decided to measure the audio component of the r.f. level detector output. To achieve this a resistor is substituted for the meter in the level detector and a transistor millivoltmeter measures the audio component across it with the level meter connected to the output of the audio millivoltmeter. The frequency response of the millivoltmeter is limited to a few thousand cycles so that r.f. voltages cause no errors.

In the prototype instrument the 0-50 scale of the basic 50 μA meter indicates percentage modulation, as the degree of feedback is sufficient to linearize the scale of the millivoltmeter. With the circuit shown in Fig. 5, 50% modulation corresponds to 15 mV at the input to the millivoltmeter.

The modulation depth was set (using an oscilloscope) to 33%, and the r.f. level carefully monitored (this must, as is customary, be set correctly before setting the modulation depth). The sensitivity (feedback value) of the millivoltmeter was then set to give a reading on the meter of 33 μA. 33% was chosen as being close to the commonly used figure of 30% modulation, but being easier to set up on the oscilloscope. The carrier is first set to 6 cm on the oscilloscope (peak-to-peak) and the modulation is increased until the trough of the modulation reduces the carrier to 4 cm, and the peak modulation increases the carrier to 8 cm, the modulation index is then 33%.

A simple LC oscillator was rejected for this application, although at first it might seem the most obvious choice. The main reason was the difficulty of maintaining a reasonable waveform and an adequate level of oscillation with varying battery voltage at all battery voltages. Stabilization of the supply voltage would cure this problem, of course, but this was felt to be too wasteful of battery power.

The circuit used consists of a multivibrator feeding a shaping filter which in turn drives a tuned output stage. This tuned output stage provides the necessary drive to the modulation input of the r.f. oscillator via the modulation level setting potentiometer. The main problem is to obtain an accurate inductance for the secondary of the tuned output transformer which has a value of 3 henries, in the prototype an ungapped 25 mm ferrite pot core was used. Two courses are open in order to get accurate tuning. (a) If a bridge is available, the secondary can be wound on first with excess turns, which are then removed until the correct value is obtained, and the correct number of primary turns calculated by dividing the secondary turns by 4.5; or (b) The transformer can be wound using the nominal turns given later and the tuning capacitor varied by trial. In either case the tuning is not critical as the Q is low. The effect of severe mistuning is a loss of output and increased wave-

**Fig. 6. Internal view of the r.f. oscillator enclosure.**

**Fig. 7. Rear view of the instrument. The step attenuator is behind the metal case below the r.f. oscillator enclosure.**
form distortion. The values given for the multivibrator in Fig. 5 result in a modulation frequency of a little over 400 Hz (the prototype gave 430 Hz). The base resistors of this multivibrator can, of course, also be varied to bring the multivibrator to resonance with the tuned output transformer, providing that the tuned transformer is not too far from its correct frequency.

Calibration

The dial for the r.f. section of this instrument can be calibrated in two ways:

The output of the generator can be mixed in a diode mixer with the output of another signal generator with known errors. An audio amplifier and loudspeaker are connected to the diode mixer and the dial is calibrated by beating the fundamentals together and noting the dial reading for zero beat, using the 0-100 scale printed on the Eddystone dial. The dial readings are then plotted on graph paper against the known frequency and a smooth curve drawn, from which to read off the exact readings for any desired frequency marking. This information is then transferred to the dial.

In the second method the output of the generator is fed into a receiver. The difficulty with this method is the gaps left, for instance, a receiver using a 460-470 kHz i.f. will not cover this frequency. The range above 30 MHz is also rather a problem.

In both these cases checks of the calibration of the reference standard, whether it be another signal generator, or a receiver, can be made against a crystal oscillator or other frequency standard. The author used the 1 MHz standard described in the January 1968 edition of Wireless World to check the calibration of a borrowed signal generator. The borrowed generator only covered up to 80 MHz so that harmonics were used above this, with a check using an f.m. receiver on the 88-108 MHz band. No doubt the ingenuity of readers will find other ways of achieving an accurate calibration, and the lucky few may even have access to a high-frequency digital counter for a short while.

It may be found impossible to maintain oscillation at the low frequency end of bands 5 and 6 due to the very unfavourable L.C. ratio. This is of no consequence as there is considerable overlap between these bands. The phenomena is present on at least one commercial signal generator and need cause no concern.

In the initial stages of calibration the extremes of each range are first set by means of the dust cores of the coils, and the trimmer capacitors so as to obtain a small overlap of the lowest three ranges, and with the lowest range starting at about 145 kHz. A greater overlap will be found possible on the upper ranges.

The coils specified for ranges one, two and three have their cores accessible only from outside the screened enclosure at a point lying behind the front panel, but as the normal adjuster is flexible no trouble was found in adjusting these cores. There is a space of some two inches between the panel and the oscillator enclosure to allow for the flexible coupling between the dial assembly and the tuning capacitor shaft.

Two Ever-Ready PP1 batteries or equivalent, are used in series to provide a 12-volt supply which should give 300 hours life with average use. As has been said, no stabilization of their output has been used since no advantage was found, in accuracy, or in any other way from doing so.

Constructional Details

The prototype generator is housed in a plywood case finished in polyurethane varnish. The inside of the case is lined with tinned steel, the joints being soldered. The front panel is fixed to brackets soldered to this lining and additional spring contacts provide extra connection points with the front panel so as to form a second complete screen round the oscillator which is mounted in a metal case, in order to reduce stray radiation.

The use of batteries for power is of great assistance in reducing stray radiation since there is no need for elaborate filtering of mains leads where they pass through the outer casing. In the author’s experience the mains lead of many signal generators is a major cause of such stray radiation. Another cause is the meter used for the level indicator, since this is connected to the diode r.f. voltmeter circuit. The body of the meter is in most cases of a plastic construction, and there is, as a result, a “hole” in the screen where the meter passes through the front panel. If this is found to be a source of an unacceptable level of stray radiation it will be necessary to fit a complete metal screen over the rear of the meter with feed-through capacitors for the connections. This is done in many commercial generators.

The front panel of the prototype is of P.P. Dural, but this is overlaid with a sheet Perspex panel. This overlay has all the dial markings in Indian ink (in reverse) on the rear of the panel. A lettering stencil was used to letter the panel with a stylus pen, the stencil being reversed. After lettering, the rear of the Perspex overlay was painted with two coats of white cellulose paint. The result of the use of this overlay is a front panel of neat appearance which is easily cleaned, and from which the lettering will not rub off. The overlay is held in position by the dial assembly, the meter, the output socket, and the front panel screws. A further advantage of this overlay, is that it has enabled the various other component fixing screws to be hidden, the front panel being thick enough to take countersunk screws. In marking the Perspex with Indian ink it may be found hard to get clear lines due to lack of “wetting”, but if the area to be lettered is first rubbed over well with a hard typing eraser and then cleaned well, the slight roughening will enable the lettering to adhere. The slight roughening will not show once the panel is painted white, provided it has been well cleaned after using the eraser.

The instrument described provides a standard of performance equal to many of the commercially available instruments costing many times the outlay required for its construction. It is hoped that this article will encourage others to construct their own instruments, and that it has shown the guiding principles which led to the successful conclusion of the author’s design.

Coil details

Band 1; Electroniques MZT.8.
Connections, green to chassis, yellow to R', black to S1a.
Band 2; Electroniques MZT.9.
Connections, brown to earth, yellow to $R^\prime$, black to $S_{IA}$ Link blue to green.
The coupling winding, which is not used on Bands 1 & 3, is connected in series with the main winding on Band 2 to enable coverage of the 460-470 kHz region.

Band 3; Electroniques MZT.10.
Connections as Band 1.

Band 4; 30 turns of 28 s.w.g. enamelled copper wire, tapped 6 turns from the top, close wound. Bottom of winding to earth, tap to $R^\prime$, top to $S_{IA}$.

Band 5; 8 turns of 24 s.w.g. enamelled copper wire, tapped 2 turns from the top, connections as Band 4. Close wound.

Band 6; one turn of 18 s.w.g enamelled copper wire wound with a pitch of 0.2 inches. There is no tap on this coil as the required inductance of the oscillator circuit provides a large part of the required inductance. The resistor $R^\prime$ connects direct between $S_{IA}$ and $S_{IB}$. The lead from $S_{IA}$ wiper to the tuning capacitor stator is also very much part of the tuning inductance on this range and should be as straight and short as possible. The former is cemented to the single turn coil.

Band transformers; Secondary, 667 turns, primary 149 turns, 40 s.w.g. enamelled single silk covered wire. Core, 1 pair of Mullard FX 2240 ungrounded cores. Former, Mullard DT.2179 (mounting used in prototype, terminal board DT.2227; mounting clip DT.2228).

Component comments

Band switch; $S_{IA}$ wafer TSW/2/S. $S_{IA}$ wafer TSW/6/2—Swing mechanism TSW/SH/2½. Studding 6 BA. TSW/ST/6/12 (12 inches). Spacers 0.5 inch TSW/SP/½L (4 off). Available from Electroniques.

Wafer $S_{IA}$ is assembled nearest to the front panel.

Tuning capacitor; Jackson Bros., type JB/52S0/1/365.

Trimmer capacitors; (bands 4 & 5 only) Jackson Bros., type JB/5440/8 or Mullard type E7850 or E7875. 2-8 P.F. Concentric type available from Henry's Radio who can also supply a 10 P.F. capacitor similar to the Jackson type named.

Variable attenuator; Plessey type E, 100, $\Omega$, linear. Available from Electroniques under part no. E/100/LIN.

Dial assembly and flexible coupling; Eddystone Radio type 598 with type 893 coupler or Jackson Bros., type JBF 4693.

Resistors $R^\prime$; Band 1—1k $\Omega$ Band 2—820 $\Omega$ Band 3—820 $\Omega$ Band 4—680 $\Omega$, Band 5—390 $\Omega$, Band 6—68 $\Omega$.

Attenuator resistors; Eric type 16, Morganite type S or Radiospares $\frac{1}{4}$-watt (see text).

Transistors; r.f. oscillator output stage—2N2369, 2N2369A, TIS499*, types BSX20 and BSX44 should also function satisfactorily. For the r.f. oscillator—2N2894, V405A or TIS50.

Diodes; silicon Emish HS1010 (high conductance with $V_N$ less than 1 V at $I_0=50$ mA) most high conductance silicon diodes are suitable, e., 15120*, OA200/202, CV7040. The germanium device in the level monitor circuit is Mullard GEX66 or 64. Most other germanium point contact diodes are unsuitable and give too large an error at the highest frequencies.

Semiconductors marked* are likely to be cheaper and easier to obtain than the others specified.

Feed-through capacitors; 1000 pF, Eric type 361.

Attenuator switches; (also used for ON/OFF and meter switch) Radiospares “slide switches”.

Oscillator enclosure; S.T.C. die-cast case type 46R.C500-064.A00 available as type 46R.064.A from many suppliers.

P.C.M. Copes with Everything

The recent introduction of 24-channel pulse code modulation systems using 1.536 Mbit/s, carried by conventional telephone cables repeated at 2000 yd intervals, is only the first step in an integrated system covering the whole country. This emerged from a colloquium at the I.E.E. at which the present state of p.c.m. was discussed by representatives of the Post Office and the communications industry. At present the larger capacity systems are only at the laboratory stage and some are little more than gleams in the eyes of the designers. The next step (according to A. C. Frost and K. W. Cattermole) will probably be 96-channel systems using 6-8 Mbits. These will make the viewphone a practical proposition, probably causing an increased demand for communication links. It is visualized also that bit rates will be increased to between 100 and 1000 Mbits to accommodate future needs including television links. Signals with these high bit rates will probably be transmitted by microwave links either in waveguides or flyspace, intercontinental links using satellite relay stations.

The subject of distortion was discussed at some length, and a recording of music, presented by D. E. L. Shorter of the B.B.C., very effectively demonstrated the increase in background noise when the number of quantizing steps is reduced. The quantizing noise gets less “white” and an audible interference pattern is produced. While 2-levels are quite adequate for telephonic speech, 2 or 2 levels need to be used for high quality music. It is possible to accommodate 4 music channels in a 1.336 Mbit system normally used for carrying 24 speech channels. Television is more tolerant of quantization distortion than music and 2 or 2 levels provide a good quality picture. However, this results in a bit rate in excess of 100 Mbits.

The closing talk was given by A. H. Reeves, the inventor of p.c.m. Letting his imagination take over, he spoke of a world in the not too distant future where communication links will permit people to carry out many jobs from the comfort of their homes, conferences using closed-circuit television etc. For this, he said, reliable links capable of bit rates of the order of 10 or 100 bits will be required. Light is the most probable answer. At present the loss in glass-fibre guides is about 200 dB/km. The theoretical loss is of the order of 6 dB/km so that fibres with losses of only 30 to 40 dB/km should be practical in the near future. With these, repeated cables using 30 or more fibres are possible for both land and transoceanic links. The repeaters will probably use gallium arsenide i.e. lasers.

He went on to predict that an electro-optical revolution is in the offing and that the sooner this was recognized and a start made the better, as it would be cheaper in the long run. His closing words were “I'm prepared to take a large bet that I'm right!”
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Wireless World, April 1968
Low Distortion Class B Output

New approach to the problem of cross-over distortion in transistor audio power amplifiers

For some time designers of transistor high-fidelity amplifiers have been restricted to a choice between three types of class B output circuit: (1) a pair of matched complementary transistors; (2) a pair of identical transistors in series cascade with a twin-secondary driver transformer; and (3) a quasi-complementary circuit using identical output transistors in series cascade but with complementary driver transistors. All three raise problems in design and manufacture, the best known ones being lack of circuit symmetry, difficulty of proper control of transistor quiescent currents and problems of the l.f. rolloff. Now a new type of output circuit has appeared which, the designers say, overcomes these problems and makes possible a transistor or power amplifier of exceptionally high performance. The circuit, shown in Fig. 1 in slightly modified form, has been developed by The Acoustical Manufacturing Company for a new power amplifier.

As will be seen from Fig. 1 the circuit is really a development of the quasi-complementary arrangement, but each half of the class B system contains three directly coupled transistors instead of just the usual driver and output. The first two, Tr, and Tr, are low power complementary types, the second two, Tr and Tr medium power complementary types and the final two high power identical devices.

One reason for this arrangement is to avoid the distortion which normally occurs in the quasi-complementary circuit as a result of the asymmetry of the upper and lower halves of the output stage. In the Fig. 1 arrangement each of the transistor “triples” can be considered as an “emitter follower”, as brought out in the much simplified form of Fig. 2. And each of these “emitter followers” has the usual characteristics of this device: high input impedance, low output impedance, and the voltage across the emitter resistor (and hence the current through it) following the base voltage independently of the characteristics of the active device. For these conditions to hold, of course, the loop gain of the “emitter follower” must be very high, and this is assured by the use of the three transistors—the overall current gain approaching the product of the three individual / values. The two units shown shaded in Fig. 2 can be considered as two “black boxes” exactly equivalent to a complementary pair of output transistors of very high current gain. The arrangement has, however, a very important advantage over a complementary pair when we come to consider quiescent current and temperature effects.

Ideally in a class B amplifier the two transistors should be biased so that one is completely cut off while the other is conducting. In practice this cannot be done because it results in cross-over distortion. It is necessary in fact to apply a small forward bias to the transistors to obtain a suitable value of quiescent current that will reduce this distortion to a minimum. The required quiescent current should be kept constant, but in many power amplifier circuits this is difficult to achieve because the quiescent current depends on the temperature of the base-emitter junction of the power transistors and this in turn varies from moment to moment due to variations of audio power and thermal storage time constants.

In the Quad circuit the voltage developed across the 0.3Ω resistors by the quiescent current is compared with a fixed reference voltage at the Tr and Tr base-emitter junctions. Since these are operating at very low power there is negligible change due to temperature resulting from varying audio power. Ambient temperature changes are exactly compensated by the same temperature changes in the diodes D and D providing the reference voltage. Thus the two “black boxes” can be seen to be the equivalent of a complementary pair with thermally isolated base emitter junctions.

The other two diodes, D and D, are limiting devices which prevent the output transistors from exceeding their current ratings. If, in either half of the class B circuit, the current through the 0.3Ω resistor attempts to exceed a given safe upper limit (approx. 3A), the increased voltage across the resistor will cause the corresponding diode to conduct and thus prevent the corresponding transistor (Tr or Tr) from being turned on further by the incoming signal. As can be seen, the arrangement is symmetrical, providing limiting for both directions of output current swing.

![Fig. 1. (Above) The output section of the Quad 303 power amplifier (slightly simplified) showing the two transistor triples.](image)

![Fig. 2. (Right) Simplified representation of the Fig. 1 circuit as two “emitter followers”.](image)
News of the Month

Numerical Control Advisory Service

"The use of numerically controlled machines in this country is growing but not nearly fast enough. This is partly due to the genuine difficulty of many firms in assessing the technical and economic value of numerical control for their machining requirements in comparison with conventional methods, and making the necessary investment appraisal. To assist industry in this I am establishing a Numerical Control Advisory Service," said the Minister of Technology, Mr. Anthony Wedgwood Benn, in reply to a written Parliamentary question. He went on to give brief details of the service. "The service will be provided by the Production Engineering Research Association under contract to my department and by the Royal Aircraft Establishment, Farnborough. P.E.R.A. will concentrate on the economic, investment and production planning aspects of the adoption of numerical control, and will provide courses for senior management. It will also have the important task of providing a consultancy service for firms by carrying out appraisals of the suitability of numerical control in their works."

"The Royal Aircraft Establishment will provide courses with a technical bias for designers and production and planning engineers. It will also provide facilities and technical support for individual firms in the programming, machining and inspection of components."

It has been estimated that the cost of this service to the Government over the next three years will be £685,000. This includes £350,000 for the provision of numerically controlled machine tools and associated equipment at R.A.E. and P.E.R.A., the remaining sum being used to offset the major part of the cost of the courses at P.E.R.A. and for meeting 50% to 90% of the cost of appraisals.

The Ministry is also supporting a complementary establishment at High Wycombe set up by Airmec—A.E.I. Ltd. This centre is equipped with machine tools fitted with Airmec-AEI control systems that will be used for educational purposes and for subcontract work on a commercial basis.

Ministry Contracts aid Microelectronic Research

The Ministry of Technology has placed contracts with Elliott-Automation Microelectronics Ltd and Ferranti Ltd under the Government's policy of support for the U.K. microelectronics industry. The Ministry will contribute half of the £82,700 which Elliotts are spending on their development programme and half of the £175,000 being devoted to development at Ferranti's Gem Mill plant near Oldham. The Elliott contract is for developing a new method of making connections to m.o.s.t. microcircuit arrays. The method, known as the beam lead technique, has already been used by Elliotts for normal bi-polar microcircuits. It is a very much more reliable method of making external connections to microcircuit contact pads than the conventional fine wire methods currently employed. The first part of the contract covers a feasibility study of the technique as applied to a range of circuits associated with computer applications. The second part includes the subsequent development of suitable production equipment, the production of trial quantities of circuits and field testing in a computer environment. Work on this new technique is to start immediately at the company's Glenrothes research establishment and the company hope to be producing beam lead, single chip, large m.o.s.t. arrays by 1969. The standard method of linking circuit connection pads with output wires is to use fine wires bonded to the appropriate interconnection points. The new process forms part of the manufacture of the circuit itself and is a mass-production operation. A strip of gold is deposited on top of a layer of dielectric material covering the microcircuit; breaks in the dielectric layer being used to allow the gold strip to make contact with the correct circuit connection point. The dielectric layer can now be etched away from underneath the gold strip to provide a free connecting lead that can be bonded to the output terminal in the final microcircuit package. Each beam lead is formed in a fixed position and it is hoped to develop production equipment which will bond all such leads on a chip to appropriate terminals in a single automatic process.

The Ferranti contract will enable the company to improve yields and to further develop automatic production processes. The work that will be carried out includes the automation of slice handling in the photoetch and diffusion processes for slices up to three inches in diameter. This will involve the development of new metallization techniques and the automation of assembly and interconnection methods.

The successful completion of this work will make equipment available so that the present range of integrated circuits can be manufactured at higher yield rates and lower prices also it will lead to more complex circuits becoming available.

Research Scheme

To encourage collaboration between universities and industry a proportion of the Science Research Council's awards for research studentships in pure research during 1968-9 will again be reserved for specific co-operative projects. The awards—in biology, chemistry, mathematics and physics—are intended to provide an opportunity for graduates to undertake research of direct interest to industry and to become acquainted with industrial problems and people. In all, 130 awards will be made to university departments. To secure an award a member of the university staff is required to submit proposals for a joint project to the Science Research Council, State House, High Hol-
born, London W.C.1, by April 1st. The project should be suitable for a graduate studying for a Ph.D. and the proposal should give details of the degree of industrial collaboration; which is hoped will be substantial and could take many forms. For instance, the student could spend a proportion of his time with industry or a straight cash payment or equipment could be provided, facilities not normally available to a university could be made available by industry or industrial staff could take part in, or supervise, the project. Any firm interested in participating in the scheme should get in touch with those members of university departments most likely to be working in the field. Further information may be obtained from the Science Research Council.

**SkyNet Station**

A fixed satellite communications terminal is to be installed in Southern England to operate in the British military SkyNet satellite network. In addition, as part of the same programme, two existing stations in the Middle and Far East are to be modified. The two stations were part of a three-terminal network supplied by Marconi to a Ministry of Technology order for operation in the Anglo-American Initial Defence Communications Satellite Programme (I.D.C.S.P.). They were partly experimental and represented the first U.K. practical examination of satellite communications for military purposes. The third terminal station of this I.D.C.S.P. network is in Christchurch, Hants, but this will not be used in the present skyNet set-up although it will still be used for satellite work. A feature of the overseas stations is the ease with which they can be moved, each is capable of being rapidly dismantled, transported by aircraft, reassembled and operational again within 24 hours.

The construction of the new U.K. terminal and the modification of the existing stations will be carried out by the Marconi Company who, following the collapse of World Satellite Terminals* seem to have completely cornered the U.K.-placed contracts of this type. The large amount of work, being capable of being dismantled quickly, will consist of a 42-ft diameter dish employing the now usual aluminium honeycomb and sheet method of construction. The aerial will have 90° freedom in elevation and 270° in azimuth, signals will be conveyed from the aerial to ground equipment at I.F.


**Post Office Domestic Relay System**

A new village, Barston, to be built as part of Washington New Town, Durham, is the site of the Post Office's first entry into the domestic radio relay business. Twin cables will be laid for this pilot scheme to each of the houses; in the construction, the new cable will be for normal telephone services and the other will carry radio and television signals from aerials mounted on a new telephone exchange. With an eye to possible future developments widespread cables have been used throughout the extensible system.

Perhaps these cables will eventually provide the long foreseen domestic, educational and closed circuit television systems, video-phone services, remote reading of gas and electricity meters, facsimile apparatus and computer access facilities.

**Export Design Exhibition**

Some details of the Design for Export project jointly organized by the British National Export Council and the Council of Industrial Design have been announced. It is to include an exhibition occupying the whole of the Design Centre and a series of seminars. The exhibition will be held between June 10th and July 13th and will include more than a thousand items. A special exhibition on a separate floor will trace the correlation between good design and successful export performance. Of the nineteen items selected for these case studies the electronics industry will supply five as follows: D-Mac Ltd—emulator; Elliott Flight Automation—Concorde autopilot control panel; (see Wireless World March 1968, page 11); Pye TVT Ltd—television equipment; Wayne Kerr Co. Ltd—B331 autobalance precision bridge; (as part of a range); BSR Ltd—UA70 automatic/manual turntable unit and UA30 minichanger.

**Programmed Instruction**

Four schools belonging to the school district of Philadelphia in America have installed a computer network that provides a source of programmed instruction enabling tutorial staff to concentrate on backward students. The network has been installed by the Philco-Ford Corporation under a contract worth $1.3m. Teachers co-operated with computer programmers to write the programmes for the installation and, to assist in this, a language known as INFORM was produced. Using this language teachers can write programmes without having to study computer programming.

Each student has an electric typewriter and a television-type monitor, designated a SAVI, for Student's Audio Visual Interface, equipped with a light pen. At the start of the day's work the type in an identification number that has been assigned to him and the computer starts presenting him with the information in the curriculum from the point at which he finished the day before. This information can take the form of straight textual matter, diagrams, animated cartoons, or television pictures and is liberally punctuated with questions. The student may indicate his answer on the screen with the light pen or by using the typewriter. If the student is particularly fast and accurate he will be taken into the subject in greater depth than one who is just managing to cope. In the event of a wrong answer being given the computer will branch into a sub-routine and present the information in a different way until the student has understood the point. If this stage is not reached then the assistance of a human instructor is requested. At the end of a lesson a typewriter accessible to the teacher prints out a detailed record of the student's progress.

Each school has a "computer cluster" consisting of a central processor, data storage and student terminals. These "clusters" communicate directly with a remotely situated computer which contains all the lesson programmes, school curricula and school and students records. The detailed records of individual class and student progress are transmitted to the computer at convenient times and are used to update student and school files. At the start of each day each school "cluster" receives details of the day's work from the central computer and records them on a large disc memory with a 1 M bit capacity, this can be expanded to 16 M bits if required. The central computer is similar to several large scale machines developed and manufactured by the Communications and Electronics Division of Philco-Ford to form the basic processing power from the U.S. North American Air Defence Command (NORAD). It has a core memory of 32k, words of 48 bits each and employs sixteen magnetic tape stores. The use of this large machine frees the smaller "clusters" from a large amount of control and storage work so they can concentrate purely on tutorial matters.

The system as a whole has the advantage over a "fixed wire" system of being completely flexible—for instance, instruction may be carried out on practically any subject in any language with appropriate programming.

**Domestic Receiver Sales Up**

Figures prepared by the British Radio Equipment Manufacturers' Association show that although the total radio and television receiver disposals to the trade was higher in 1967 than in 1966, it was well below that achieved in 1965. The Government's partial relaxation of rental and hire purchase terms during August coupled with the introduction of colour television are factors that combined to increase the 1967 figure. Rounded off totals show that of the 1.348 M television receivers delivered to the trade 30,000 of them were colour sets. TV sets showed an increase of 56,000 over 1966, but a reduction of 339,000 when compared to 1965. The combined figures for radio receivers and radiograms tell a similar story, the total delivered during 1967 was

*Image of the page is not provided.*

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*www.americanradiohistory.com*
British Company Receives American Award

The sales director of Decca Radar Ltd. accepted two awards on behalf of his company from the Information on the Naval Marine Electronics Association. The first award, which Decca have won for three consecutive years, was for the best single product or model of equipment at the New York Boat Show based on performance and reliability. In 1966 and 1967 this award was received by the company for its D202 marine radar equipment. This year the award was made for the type 101 small boat radar. The second award, for continued excellence of design, performance and reliability for the main product line, was made for the Decca Transar series of marine radars. It is believed that this is the first time that both awards have been made to one company in a single year.

Applications are invited from students for a scholarship in the Department of Electronics at Southampton University by Advance Electronics Ltd., Poebuck Road, Harlault, Ilford, Essex. The successful applicant will receive a grant of £1,000 per annum for two years (not subject to any post-graduate conditions) to carry out research into a branch of electronics associated with instrumentation or control. Students who wish to apply should graduate this year and should expect to obtain at least a second class honours degree. This is the second scholarship to be granted by Advance Electronics. The first was awarded to a student who is engaged in evolving a new form of algebra for solving problems in digital circuits.

A flight Information Display (FIND) system is to be installed at London's Heathrow airport by R.C.A. Great Britain Ltd., which has been developed by the company in collaboration with British European Airways. The system displays flight arrival and departure information for a total of over 200 television monitors located at strategic points in B.E.A's offices. The input of a complete day's schedules is fed into the FIND store using punched tape that has been prepared on B.E.A's main computer complex. The information is read out of the store to an R.C.A. Divison display system where it is converted into standard video format and modulated with an h.f. carrier prior to being distributed to the various television monitors. The main store can hold 1,000 lines of 56 characters and spaces of which 20 lines can be displayed at one time. Five keyboard inputs are provided for updating the stores and displays, and provision is made for new or altered information to flash on the screens for a period of time.

Further to our report last month on the preparations made to utilize the Intelsat network we understand that another station is to be built in Germany by Siemens. The existing earth station, also built by Siemens, at Raisting will also be expanded to enable it to handle Intelsat communications.

The European Space Research Organization has ordered from Elliott Automation two mobile check-out stations to test the control and experimental payloads of satellites. Elliotts will be responsible for the assembly of the various parts of the check-out systems, for the manufacture of the necessary interface equipment and for providing the complete system. SONECTRO of France are co-operating with Elliotts in the integration of the system. The trailers, housing the equipment, will accompany the satellites from the factory to the test establishments in Europe and finally to the launching site where they will continue measurement and analysis throughout the test period. The first trailer will be delivered to the European Space Technology Centre at Noordwijk in the Netherlands in time for the testing of the TD satellites in the spring (see Wireless World, February 1968, page 682).

Apprentice Awards Each member company of the Telecommunication Engineering & Manufacturing Association may enter one candidate in each of the three classes—graduate-in-training, student apprentice, and technician apprentice—for the Association's annual competition. Each entrant has to write a technical essay. Each forms personal aspect of his training or work relating directly or indirectly to the T.E.M.A. side of his company's activities. This year's winners, who were presented with cheques and certificates at the annual dinner on February 6th, were: A. J. W. Jackson, B.A., Marconi graduate-in-training; M. R. Colley, S.T.C. student apprentice; and P. G. O'Donovan, technician apprentice with Automatic Telephone & Electric Co.

ANNOUNCEMENTS

A residential vacation school on "Electrical measurement practice" will be held from 15th to 26th July at the University of Manchester Institute of Science and Technology. The school has been arranged by the I.E.E. joint professional group on measurements in collaboration with the British Calibration Service and the I.E.E. Inquiries should be sent to the Secretary, I.E.E., Savoy Place, London, W.C.2.

A three-day conference entitled "Modern aspects of research and development" will be held at Southall College of Technology commencing 8th April. Registration forms are available from The Department of Electrical Engineering, Southall College of Technology, Beaconsfield Road, Southall, Middx. (Fee £7 gn).

"WIRELESS WORLD" INDEX

The Index to Volume 73 (Jan. 1967-Feb 1968) is now available price 1s. (postage 2d.). Cloth binding cases with index cost 9s. 6d., including postage and packing. Our publishers will undertake the binding of readers' issues, the cost being 35p. per volume including binding case, index and return postage. Copies should be sent to Associated Hulfe Press Ltd., Binding Department, c/o 4 Hulfe Yard, London, S.E.17, with a note of the sender's name and address. A separate note confirming despatch, and enclosing the remittance, should be sent to the Publishing Department, Dorset House, Stamford Street, London, S.E.1.

"An introduction to some aspects of digital computer design" is the title of a specialist short course of lectures to be held at Norwood Technical College. The six weekly lectures commence on 23rd April. Enrolment forms can be obtained from the Secretary, Norwood Technical College, Knight's Hill, London, S.E.27. (Fee 15s.)

A series of short lecture courses in selected mathematical topics are to be held at Twickenham College of Technology. These will take place on Mondays, Wednesdays and Fridays from 13th May to 28th June. Enrolment forms may be obtained from the Principal, Twickenham College of Technology, Egerton Road, Twickenham, Middlesex.

A colour television receiver has been installed in the Science Museum's Radio Demonstration Room. It forms part of a continuous demonstration of radio communications equipment.

Hand-soldered Joints in Electronics is the title of an eight-minute Mullard training film, in colour, now available for hire from the C.O.I., Central Film Library, Bromyard Avenue, London, W.3.

Seven films produced by Educational Services Inc., U.S.A., as part of their advanced college physics film programme, are now available for hire through the Central Office of Information, Bromyard Avenue, London, W.3. The titles include (1) "Photo-emission of electrons", (2) "Electromagnetic induction of electrons" and (3) "Positron-electron annihilation".

A short-wave communication system is to be built by Marconi to be used in controlling the new oil pipe-line between Dar-es-Salaam in Tanzania and Ndola in Zambia. Effective communications by day and night are required, to achieve this by wireless means it will be used at each end of the 1,000-mile line in conjunction with intermediary broadband dips.

Two unmanned radar stations, part of the NADGE (Nato Air Defence Ground Environment) radar chain, are to be equipped with transmitters from the Marconi S600 series. The contract is worth £350,000.

The Ministry of Technology has granted test house facilities approval to Transitron Electronic Ltd., Gardner Road, Maidenhead, Berks. This approval refers to the test and inspection of semiconductor devices to CV specifications.

Six companies active in the research, development and production of military infra-red equipment and components have formed the British Infra-Red Manufacturers Organization (B.I.R.M.O.). The companies are: Barr & Stroud Ltd., EMI Electronics Ltd., Hawker Siddeley Dynamics Ltd., Hymatic Engineering Co. Ltd., Mullard Ltd. and Standard Telephones & Cables Ltd.

The British National Export Council have decided to co-operate with Kompass Register, an INI company, in publishing an export marketing guide entitled "British Exports '69". Designed for use by overseas buyers, the first edition is scheduled for publication in the Autumn.

Crompton Parkinson Ltd., a Hawker Siddeley company, have agreed to acquire the plant, equipment and stocks of Vidor Ltd. and Burndedt Ltd., part of the Royston Industries Group.

The Wired TV product group of Thorn EMI have moved its sales offices and laboratories to the Internal Electronics division at High Street, New Basford, Nottingham. Thorn EMI manufacture transistor wired television distribution systems.

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Personalities

R. D. A. Maurice, Dr. Ing., F.I.E.E., assistant head of the B.B.C. Research Department since 1961, has become head of the Designs Department in succession to S. N. Watson, F.I.E.E. who as recently announced, has been appointed chief engineer, television. Dr. Maurice joined the B.B.C. Research Department in 1939 and after some years in the receiver and measurements section transferred to the television group, of which he became head in 1958. Dr. Maurice has served for many years on the television study group of the C.C.I.R. and was chairman of the general characteristics sub-group of the European Broadcasting Union's ad-hoc group on colour television.

W. P. Williams, Ph.D., B.Sc. (Eng.), who joined the Marconi International Marine Company in 1964 as leader of a group working on echo-sounding and ultrasonic techniques and just over a year ago became assistant technical manager responsible for new product engineering, has been appointed deputy technical manager. A graduate of Nottingham University, Dr. Williams was awarded a research scholarship while studying for his doctorate. In 1963 he received the first Baird travelling scholarship from the Royal Television Society under which he toured Europe studying the Eurovision television network. He is 29.

T. H. Bridgewater, O.B.E., F.I.E.E., who retires this month from the B.B.C. joined the Corporation in 1932 before which he worked for four years with John Logie Baird. When the B.B.C. television service started in 1936 Mr. Bridgewater was appointed senior maintenance engineer at the Alexandra Palace station. After war service in the R.A.F. he returned to the B.B.C. in 1946 and was at one time superintendent engineer O.Bs. He has been chief engineer (television) since 1962.

F.C. Loveless, A.Inst.P., has been appointed to the Board of 20th Century Electronics Ltd., but will continue as head of technical services having responsibility for all sales activities. Mr. Loveless, who is 38, joined the Company in 1952 as a junior physicist to work on radiation detectors. After completing two years as assistant to the general manager he took over responsibility for the Company's technical sales in 1961.

Grants for the design, construction and maintenance of radio, unusual or much-improved types of physical instruments and apparatus for investigations in pure or applied physical science are made from time to time by the Paul Instrument Fund Committee which is composed of representatives of the Royal Society, the Institute of Physics & Physical Society and the I.E.E. Among the recent recipients are Dr. A. P. Anderson, lecturer in the department of electronic and electrical engineering in the University of Sheffield, who receives £2,000 for the construction of an instrument for the measurement of energy in laser beams; Dr. W. J. Jones, demonstrator in the department of physical chemistry, University of Cambridge, £1,500 for the construction of a spectrometer employing frequency selective intensity modulation; Professor J. D. McGee, O.B.E., F.R.S., professor of applied physics at the Imperial College of Science and Technology, London, £6,250 for continuation of his work on the development of a photo-electronic image device for time images for which in 1964 he received a grant of £8,100 over three years; and Dr. K. L. Mayne, senior lecturer in the department of natural philosophy in the University of Edinburgh, £4,000 for the construction of a polarized electron source.

A. G. J. Holt, Ph.D., M.I.E.E., reader in electrical engineering in the Department of Electrical Engineer, of the University of Newcastle-upon-Tyne, has received grants totalling £9,779 from the Ministry of Technology in aid of research work on computer methods in active network design and on thin-film RC communications networks. Dr. Holt has also received a contract worth £2,100 from the G.P.O. for work on the design of RC-active electrical filter networks.

The appointment of two associate directors is announced by Gardner's Transformers. They are R. P. Henegan, A.Soc.I.E.R.E., who joined the company in 1964 becomes director and general manager and J. W. McPherson, B.Sc.(Eng.), M.I.E.E., who joined as technical manager in 1964 is now technical director.

Stanley Baker, B.Eng., A.M.I.E.E., has joined the magnetic recording head division of the Gresham Lion Group as a senior development engineer. A graduate of the University of New South Wales, Mr. Baker has submitted a thesis on "an investigation of crosstalk in multitrack recording heads" as part of his studies for a doctorate of philosophy. His University professor was Dr. C. B. Speedy who was technical director of Gresham before joining the staff of the University.

H. Stern, B.Sc., who contributed an article on digital voltmeter techniques to our November 1967 issue, has joined Fluke International Corp., as U.K. sales manager. A graduate of Queen Mary College, London University, he was at one time sales manager of Cawkell Research and Electronics and was latterly product manager for test instruments with Honeywell.

J. M. Tompsett, B.Sc., M.I.E.E., who has been with the English Electric Valve Company since 1952, has been appointed quality assurance manager. A graduate of Bristol University he began his career with the Admiralty Signals Establishment, Haslemere, in 1944. From 1948 until joining E.E.V. he was with Standard Telephones & Cables. Mr. Tompsett was initially in the gas tube department of E.E.V. but later transferred to the travelling wave tube department of which he has been head since 1962.

Group Captain T. C. Imrie, M.I.E.R.E., who is to become air officer in charge of engineering, R.A.F. Coastal Command (with the acting rank of Air Commodore), at one time commanded No. 30 Maintenance Unit at Sealand, Cheshire, and later the Radio Engineering Unit at Henlow, Beds.

W. A. Jackson, B.B.C., engineer-in-charge, operations, Scotland, is to be head of engineering, Scotland, in succession to J. A. G. Mitchell who is retiring on 31st May, after more than 40 years of service. Mr. Jackson joined the B.B.C. in 1937 as a junior maintenance engineer at the Alexandra Palace television station. From 1941 he was engineer-in-charge of the Whitewash transmitting station and in 1944 he joined the B.B.C. War Reporting Unit as engineer-in-charge of a mobile transmitter which served in France and Germany. After the war he rejoined the B.B.C. television service in London. For six months during 1967 Mr. Jackson was seconded to the Government of Iran in an advisory capacity to assist in the setting-up of a national television service. Mr. Mitchell joined the B.B.C. in 1927. He was appointed assistant engineer-in-charge of the B.B.C.'s war-time centre at Wood Norton, near Evesham, Worcestershire, in 1941, and later held a similar post in Birmingham. From 1950 he was regional engineer, Northern Ireland, and has been head of engineering, Scotland, since September 1961.
Simple F.E.T. Pre-amplifier

Equalizing circuit for microgroove recordings

by D. B. G. James* B.Sc.

The higher input impedance and lower noise figure of the field effect transistor compared with the normal bi-polar transistor suggests that one of its applications could be in the input stage of an audio pre-amplifier circuit for the reproduction of disc records.

An equalization circuit has to boost the bass frequencies and attenuate the high frequencies to produce a frequency characteristic which is the inverse of the recording characteristic. The recording characteristic which has been used by most of the recording companies since 1954 is the R.I.A.A. characteristic. This assumes that the output frequency characteristic of the pickup used is identical with that of the recording characteristic, this is the case for most of the high-quality magnetic pickups now available. It is for this form of output voltage-frequency characteristic that the F.E.T. equalization circuit which follows has been produced.

The gain of the basic F.E.T. amplifier of Fig. 1 is approximately ten, so it should just be possible to obtain the required bass boost using a feedback network over one stage, if the gain at 1 kHz is arranged to be approximately unity. Above 1 kHz the attenuation should increase until at 15 kHz it is approximately -17 dB. The values for the equalizing components to give the necessary equalization were found experimentally, and are shown in Fig. 2. The circuit gave a response which was within ±1 db of the ideal replay characteristic over the frequency range 50 Hz to 15 kHz. The first stage gain is approximately unity at 1 kHz and in order to increase the output voltage to a suitable value for input to a power amplifier, an additional F.E.T. stage is used. This second stage is similar to the basic amplifier stage of Fig. 1, but the gate resistor has been increased from 1 MΩ to 4.7 MΩ. With an input of 15 mV the output of the second stage at 1 kHz was 195 mV, i.e., a gain of about 13 times.

*University College, Swansea.

**Fig. 1.** The basic F.E.T. amplifier. All resistors of 10% tolerance.

**Fig. 2.** Two-stage amplifier with equalization. All resistors are of 10% tolerance.

Fig. 3. Frequency response of Fig. 2.

Fig. 4. Alternative equalization circuit using 100 kΩ gate resistor. All resistors are of 10% tolerance.

The results obtained with this circuit are shown in Fig. 3. It was found that varying the 15.6 MΩ within its ±10% tolerance resulted in a change of only 0.2 dB and varying the 100 kΩ within the same limits caused an 0.6 dB change.

An alternative circuit is shown in Fig. 4 using a gate resistor of 100 kΩ instead of 1 MΩ. This circuit should be suitable for pickups having an impedance of the order of 100 kΩ and again has a frequency response within 1 dB of the required equalization characteristic for micro-groove recordings.

**References**

2. BS 1928.
Microphone Supplement

The following tables are intended to help the prospective buyer in making comparisons between microphones available in the U.K. To allow quick and easy comparison it has been necessary to restrict the information given on each type to the most important characteristics, such as physical structure, transducer type, directional properties and price.

The tables have been compiled with the co-operation of those suppliers who have responded to a questionnaire sent out by *Wireless World*.

One point about the "sensitivity" column in the tables: A common method of specifying sensitivity is in decibels relative to a sensitivity reference value, and a reference frequently used by manufacturers is 1V/dyne/cm² (or, with an equivalent unit of pressure, 1V/µb). Since *Wireless World* has now adopted SI units, the pressure part of the reference is shown in the tables in newtons per square metre, and 1V dyne cm² = 10V N/m². Some microphone suppliers prefer to use other methods of specifying sensitivity, and these will be noticed in the tables. Where several sensitivity values are listed for a microphone it will be seen that these correspond with the alternative impedances available.

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Type</th>
<th>Transducer</th>
<th>Impedance Values (ohms)</th>
<th>Directional Characteristics</th>
<th>Front-to-Back ratio (dB)</th>
<th>Sensitivity (dB) at 1 kHz (ref. 0.5V/N/m²)</th>
<th>Pin Connections</th>
<th>Output Connector</th>
<th>Application</th>
<th>Price</th>
<th>Accessories not included in price</th>
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</table>

Wireless World, April 1968
Microphone Supplement
NOW MADE BY RESLO SOUND

Chapman Transistorised Stereo Tuners

3 outstanding microphones from the RESLO range
For the Hi-Fi enthusiast

NOW MADE BY
RESLO SOUND

Chapman Transistorised Stereo Tuners

VHF/FM Tuner type: FM 1000A/B — Fully Transistorised
FM 88-108 Mc/s only.
£28 + P.T. £5.12.7

AM/FM Tuner type
FM 1005A/B — Fully Transistorised
Long, Medium and two Short wavebands
FM 88-108 Mc/s.
£48 + P.T. £9.13.0

The High Fidelity Tuner units in the Chapman range are optionally fitted with multiplex decoders for stereo broadcast reception. Models FM 1000A/B and FM 1005A/B illustrated are also available in chassis form for fitting in owners' cabinets.

Wireless World, April 1968

For Sales and Service write or 'phone

RESLO SOUND LTD
Reslo Works, Spring Gardens, London Road,
Romford, Essex: Romford 61926 (3 lines)
<table>
<thead>
<tr>
<th>Type No.</th>
<th>Type</th>
<th>Transducer</th>
<th>Impedance Values (ohms)</th>
<th>Directional Characteristics</th>
<th>Front-to-back ratio (dB) at 1 k是一件 (ref.) 10V/N/m²</th>
<th>Sensitivity (dB)</th>
<th>Pin Connections</th>
<th>Output Connector</th>
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Ampex (Gr. Britain) Ltd, 72 Berkeley Avenue, Reading, Berks.

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<th>Type</th>
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Audax Marketing Co., Ltd., Forest Works, Carey Road, Warsham, Dorset

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Audix B.B. Ltd, Stansted, Essex

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B. & K. Laboratories Ltd, Cross Lane, Maudow, Middx.

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A. P. Besson & Partner Ltd, St. Joseph's Close, Move, Sussex

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Beyer (Fic-Cord International, Charriwood Road, East Grinstead, Sussex)

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neumann transistor condenser microphones

EMT, STUDER & NEUMANN
THE BEST IN PROFESSIONAL SOUND RECORDING EQUIPMENT
Sole U.K. Agents: F.W.O.BAUCH LIMITED
Holbrook House, Cockfosters Herts.
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WWW—202 FOR FURTHER DETAILS
Our "Series Four" microphones will catch anything without damage or distortion. No need to use transformers, each microphone is multi-impedance and will work into 25 Ohms, 200 Ohms, 600 Ohms and 50K Ohms. Imagine how useful that is when you change recorders. These four microphones have been produced to extract the last drop of performance from your recorder or P.A. System. Combining Lustraphone dependability with superb performance and exciting styling. These instruments will give you pride of ownership for years to come.

4.20 Dynamic Omnidirectional 4.30 Dynamic Cardioid 4.40 Studio Ribbon 4.50 Professional Miniature Ribbon See the "Series Four" Microphones at leading Hi-Fi dealers – or write direct to LUSTRAPHONE LTD for free illustrated literature giving full description and specification. A comprehensive "Selection and Instruction" pamphlet is also available free on request.

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4.20 Dynamic Omnidirectional 4.30 Dynamic Cardioid 4.40 Studio Ribbon 4.50 Professional Miniature Ribbon

See the "Series Four" Microphones at leading Hi-Fi dealers – or write direct to LUSTRAPHONE LTD for free illustrated literature giving full description and specification. A comprehensive "Selection and Instruction" pamphlet is also available free on request.
The Philips P33 is a superb, professional microphone at a medium price, which provides cardioid or omni-directional characteristics — at the click of a switch.

The frequency response is 80 Hz to 15 Kc/s ±3db. It is flat over a wide range and remains flat in the low frequency range when used close up. In the cardioid mode sensitivity at the rear is 17db less than at the front. Impedance is 500 ohms.

The P33 is mounted in a quick-release holder and can instantly be used as a hand-held microphone complete with a detachable, twin screened cable 16 feet in length. In addition an anti-vibration mounting is available, preventing transmission of rumble from the stand.

In Room 355 at the Audio Fair, visitors will hear original stereo recordings. These stereo recordings were made under domestic conditions using various pairs of Sennheiser microphones with a B and O tape recorder. By changing the microphones at regular intervals during the recordings sensible comparisons can be made regarding the quality and characteristics of these microphones. Microphones such as the MD 421 studio cardioid microphone, the MD 211 studio omni microphone (probably the finest moving coil omni-directional microphone in the world), the MKH 405 RF condenser microphone and the MD 411 triple impedance dynamic microphone were used to make comparisons in these stereo recordings. All questions regarding microphone technique, acoustics and sound recording in general, relating to these recordings will be answered in the above room by our sound engineers.
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<th>Output Connector</th>
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</tr>
<tr>
<td>GC1/M</td>
<td>Hand</td>
<td>M.C.</td>
<td>600</td>
<td>Cardioid</td>
<td>15</td>
<td>72</td>
<td>1 &amp; 2 signal</td>
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<tr>
<td>GC1/H</td>
<td>Hand</td>
<td>M.C.</td>
<td>50k</td>
<td>Cardioid</td>
<td>15</td>
<td>53</td>
<td>1 &amp; 2 signal</td>
<td>Matched pairs for stereo</td>
<td>£15 5s</td>
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### Grundig (Gt. Britain) Ltd., Newlands Park, London, S.E.36

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<td>700</td>
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<td>GD5MH20</td>
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### Harriety Electromotives Ltd., Monkmoor, Shrewsbury, Salop.

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### Knowles Electronics, Ltd., Victoria Road, Burgess Hill, Sussex

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<td>Miniature</td>
<td>Magnetic equipment mounting</td>
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<td>Magnetic equipment mounting</td>
<td>5k</td>
<td>Various</td>
<td>75 to 85</td>
<td>Solder tags</td>
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<td>Various</td>
<td>75 to 85</td>
<td>Solder tags</td>
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### LEM (Douglas A. Lyons & Associates Ltd., 32 Grenville Court, London, S.E.19)

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### Lennard Developments Ltd., 7 Stades Hill, Enfield, Middx.

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<td>LD2</td>
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### London Microphone Co., Ltd., 183/4 Campden Hill Road, London, W.8

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<td>50</td>
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<td>200/50k</td>
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<td>50</td>
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<td>Omni</td>
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<td>Omni</td>
<td>66</td>
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<td>200/50k</td>
<td>Omni</td>
<td>50</td>
<td>£3 10s</td>
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</table>

Wireless World, April 1968

Microphone Supplement vii
SHURE Microphone Supplement

Public Address

Model 533SF This small rugged omnidirectional dynamic microphone features flat response for faithful reproduction of voice and music. Ideal for close-to-mouth operation, protects against ‘pop’ and can be used on stand or in the hand. On-off switch can be locked in ‘on’ position. Low impedance.

Model 419B Ranger II. A small-size noise-cancelling controlled-magnetic microphone specially designed to give superior speech intelligibility and rejection of unwanted noise. Ideal for outdoor and indoor public address and call systems in noisy areas. Low impedance.

Model 581SF Unidyne With this undirectional dynamic microphone, feedback problems can be solved even in low-budget public address systems. Gives quality reproduction at low cost. For hand or stand use, indoors or out. 25 ohm impedance, built-in on-off switch, detachable cable.

Communications

Model 450 Controlled magnetic ‘Dispatcher’. New modern design fits every decor for paging use. Telescoping height adjustment for maximum convenience. Switchable to low impedance or high, push-to-talk switch bar.

Model 414A Ranger II. A hand microphone about half the size or weight of a conventional microphone, yet giving even better performance for miniaturized or portable outdoor-indoor communications. High impedance. Recommended load 100,000 ohms or more.

Model TH100 A controlled magnetic mobile telephone handset which allows the operator to expand or upgrade his equipment and to obtain a degree of privacy in radio communications and two-way conversations. Transmitter is high impedance, receiver low.

Model 401A Controlled magnetic palm microphone for fixed station or mobile uses. Shaped voice response assures maximum intelligibility. Long-life slide switch. Professional design and construction.

Model M62 Audio Level Controller. A transistorized variable gain amplifier designed to keep electrical output constant even though the input signal from the microphone varies considerably. Permits greater freedom of distance when using a microphone, eliminates blasting and fadeouts, upgrades recording systems, reduces loud vibration noises.

FOR FURTHER DETAILS

Wireless World, April 1968
Model SM60 A slim, neck omni-directional dynamic microphone suitable for stage, studio, or field use, in hand or on stand. Built-in wind and pop filter minimizes breath and wind noise. A rugged and versatile performer. Proper match with any low impedance input.

Model SM51 A small lightweight dynamic lavalier microphone for use in TV, films, radio and similar applications where a small, wearable microphone of professional quality is required. Matches any low impedance input.

SETTING THE WORLD'S STANDARD IN SOUND

Shure Electronics Limited · 84 Blackfriars Road · London, S.E.1. Tel: 01-928 6361

Wireless World, April 1968
Faithful Reproduction

with the Grampian TC12 loudspeaker

The Grampian TC12 loudspeaker is a high quality twin cone unit at a reasonable price. The loudspeaker is built of high quality materials to a rigid specification and is eminently suitable for good quality sound reproduction. Let us send you full details or better still go and hear one at your local dealers now.

Design for suitable cabinet available.

Grampian manufacture high grade microphones, parabolic reflectors, windshields and accessories, also mixers and amplifiers.

Grampian SOUND EQUIPMENT

Send for leaflet giving full details

GRAMPIAN REPRODUCERS LTD
Hanworth Trading Estate, Feltham, Middlesex
Tel: 01-894 9141/3 Cables REAMP, FELTHAM

---

FILM INDUSTRIES RIBBON MICROPHONES

Reprinted from a technical review of the Model M8A.
"... this microphone shows evidence of careful design, and the workmanship, technical performance, and styling are excellent. It can be thoroughly recommended for studio or semi-professional use, or for home use where the associated equipment can do justice to its very wide range of response."

From a review of the Model M8A.
"... The Film Industries M8A ribbon microphone has a most attractive appearance coupled with a performance which, in many respects, can stand comparison with the best designs at three or four times its price.

Write for full details

FILM INDUSTRIES LTD.
STATION AVENUE,
KEW GARDENS, SURREY.
Telephone: RICHMOND 8078

Lightweight Headset

New from Spembly—the HS.4 lightweight headset with bone transducer microphone and miniature loud speaker unit. Excellent reproduction—for airborne or ground use. Can be worn under most types of protective helmets. Send for leaflet to:
Sales Department,

SPEMBLY ELECTRONICS
Enham Arch, Newbury Road, Andover, Hampshire.
Telephone: Andover 5741/2/3 Telex: 47272

Wireless World, April 1968
### Mikrofonbau (Denham & Morley Ltd., 173/5 Cleveland Street, London, W.1.)

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Type Transducer</th>
<th>Impedance Values</th>
<th>Directional Characteristics</th>
<th>Front-to-Back ratio (dB)</th>
<th>Sensitivity (dB) at 1 kHz (volts/m²)</th>
<th>Pin Connections</th>
<th>Output Connector</th>
<th>Application</th>
<th>Price</th>
<th>Accessories not included in price</th>
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<td>M8160T</td>
<td>Stick, Std. M.C.</td>
<td>200/50k</td>
<td>Omni</td>
<td>1.2mV/N/m² at 200 Ohms</td>
<td>2 &amp; 3 3002</td>
<td>DIN</td>
<td>Amateur recording</td>
<td>£3 3s</td>
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<td>M8160T</td>
<td>Stick, Std. M.C.</td>
<td>200/50k</td>
<td>Cardioid</td>
<td>2 &amp; 3 1,500</td>
<td>DIN</td>
<td>Amateur recording</td>
<td>£4 14s 6d</td>
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<td>Stick, Std. M.C.</td>
<td>200/50k</td>
<td>Omni</td>
<td>1.5mV/N/m² at 1,000</td>
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<td>DIN</td>
<td>Amateur recording</td>
<td>£4 4s (includes switch)</td>
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<td>Stick, Std. M.C.</td>
<td>200/50k</td>
<td>Cardioid</td>
<td>1.5mV/N/m² at 1,000</td>
<td>2 &amp; 3, 3002</td>
<td>DIN</td>
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<td>£8 15s 6d</td>
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### Neumann (F.W.O. Bauch Ltd., Holbrook House, Cockfosters, Barnet, Herts.)

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<th>Front-to-Back ratio (dB)</th>
<th>Sensitivity (dB) at 1 kHz (volts/m²)</th>
<th>Pin Connections</th>
<th>Output Connector</th>
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<th>Accessories not included in price</th>
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<td>K673</td>
<td>Studio Capsulator</td>
<td>50 or 200</td>
<td>Omni</td>
<td>30mV/N/m²</td>
<td>1 &amp; 2 signal, 3 screen</td>
<td>Tuchel</td>
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<td>£87 6s</td>
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<td>1 &amp; 2 signal, 3 screen</td>
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<td>5mV/N/m²</td>
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<td>Tuchel</td>
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<td>£87 6s</td>
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<td>Tuchel</td>
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<td>£87 6s</td>
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The Technician Engineering Scene

What are the prospects for ‘non-chartered’ engineers?

A strong spotlight is being thrown just now upon technician engineering manpower; recruitment, education, training, qualifications and status. Government departments, educational authorities and establishments, and industry in general, are devoting much time to these matters. Why should this be so? For many years industry has been perplexed over the “technician problem”, so why only recently has it emerged as a frontline consideration?

In the electrical and electronics engineering industries there appear to be four main reasons for this:

1. The growing concern expressed over the present shortage of technician engineering personnel, and the seemingly discouraging future recruitment prospects.
2. The poor “image” of engineering as a career seen by school-leavers and parents.
3. The part-time study route to corporate membership of institutions for chartered engineers having gradually been closing, soon to be blocked altogether (the I.E.E. and I.E.R.E. now setting their corporate membership standards at degree level will mean the end of H.N.C.-chartered engineers).
4. The emergence of the concept of technician engineers and technicians as being people pursuing distinct careers of their own; with their own qualifications and status; their own qualifying bodies and learned societies.

The setting up of the Council of Engineering Institutions by 14 organizations for “professional” engineers, whose 150,000 members may now use the designation “C.Eng.” denoting a chartered engineer, has helped to bring things to a head. In our Editorial of last June, “Engineers—Professional and Technician”, we drew attention to the need for recognition to be given to the status, work and qualifications of technician engineering personnel and letters subsequently received showed how much our view was shared by industry.

Until three years ago the future for non-chartered engineers, and technicians, appeared unenviable, to say the least. For many the path to chartered status was impracticable; yet often being well qualified to H.N.C. level, and having good practical experience, they were the Cinderellas of the electrical, electronics and radio industries.

Questions concerning their status, qualifications and career expectations were dealt with piecemeal: they had nowhere to go; nobody seemed to care. At the beginning of 1965, however, two new organizations for technician engineers and technicians were set up; the Society of Electronic and Radio Technicians and the Institution of Electrical and Electronics Technician Engineers each acting as a qualifying body.

These organizations hold differing views on the identification of technician engineering personnel. The I.E.E.T.E., contending that the H.N.C.-man is as much entitled to the description “engineer” as is the chartered engineer, recognizes two grades, the technician engineer and technician, but admits to membership only the first of these. The S.E.R.T. says that two classes are not required; only the technician being identifiable within the whole span of manpower between the chartered engineer and the craftsman.

Both bodies have made good progress, and the qualifications derived from membership are becoming well recognized. Last December the C.E.I., on the basis of non-commitment, called together 31 organizations wholly or partly having technician engineering grades of membership, to explore the possibility of establishing for them a common national qualification and title. On first consideration it appeared to be a hopelessly complicated business: 31 separate bodies covering a wide field of engineering interests (from agriculture to quarrying, building to lighting, automobiles to welding) and all manner of qualification standards for entry and grading of their members who total some 75,000. However, the organizations split up into three groups thought to have like interests; each being asked to meet informally, and to offer conclusions to another C.E.I.-convened general meeting held on 23rd February. As a result of this meeting it was unanimously resolved that: “A Qualification Committee be formed to establish the qualifications of non-chartered engineers (a name to be determined) and that this Committee be formed of representatives of the bodies taking part in the discussions, together with representatives of the C.E.I., and such other members and observers as the Committee may co-opt”. This resolution has now been referred back for consideration and ratification by the councils of the participating bodies.

One of the questions under discussion has been a technician counterpart to the C.E.I. Reaction apparent so far indicates that opinion is divided on whether or not such a new body is required, though many recognize a need for unification; but some concede that if a national qualification for technician engineering people emerges from the present tangled skein of opinions and theories, then there must be an independent authority to maintain the general standards.

Against the background of all this, there have been two announcements of considerable significance: first the intention of the Engineering Industry Training Board to publish a report next Autumn on technician engineering training, and secondly the setting up by the National Advisory Council on Education for Industry and Commerce on Technicians Courses and Examinations of a committee, under the chairmanship of Dr. H. E. Haslager, to examine the whole question of courses and examinations for technicians.

A closely related question, which undoubtedly will be examined by these bodies, is that of definitions (what is a Technician Engineer, or a Technician?): a number of attempts have been made, dating from the one produced by the Conference on Engineering Societies of Western Europe and the United States (E.U.S.E.C.) in 1954 but, so far, none has been found fully acceptable.

The importance to industry of an adequate force of technician engineering personnel is now being “brought home” on all sides. Employers are becoming most concerned over where the trained and experienced manpower is coming from, both now and in the future. As more and more electronic and instrumentation techniques are introduced so, employers rightly say, more and more young people should be encouraged to enter technician engineering; but they realize that the sophisticated school-leavers of today will not do so unless they, their parents, and their advisors see good career prospects and status before them.

An engineering technician is one who can apply in a responsible manner proven techniques which are commonly understood by those who are expert in a branch of engineering, or those techniques specially prescribed by professional engineers. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of the task in the light of well-established practice. An engineering technician requires an education and training sufficient to enable him to understand the reasons for and purposes of the operation for which he is responsible.

Wireless World, April 1968

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New B.B.C. Monitoring Loudspeaker

2. Bass equalization: The cabinet: Frequency response characteristics of the units

by H. D. Harwood,* B.Sc.

In a modern monitoring loudspeaker the choice lies in practice between two- and three-unit designs. In a two-unit loudspeaker one of the difficulties is that the high-frequency units available at present cannot be operated below approximately 1.5 kHz, so that the low-frequency unit must operate in a predictable manner up to about 2 kHz. In the past, reproducible operation of a low-frequency unit above about 500 Hz was not possible but the situation has been changed by the advent of the 305 mm plastic cone described in the March issue.

It is still difficult, however, to maintain the required frequency characteristics away from the axis of a two-unit design. At 1.5 kHz the wavelength of sound is about 220 mm and thus a 305 mm cone has a diameter considerably larger than a wavelength. It follows that the radiation will be directional at such frequencies and that even when the axial frequency characteristic is made uniform the off-axis curves will depart from this condition. On the other hand the high-frequency units used in B.B.C. monitoring loudspeakers, 58 mm in diameter, are small compared with a wavelength, and therefore nearly omnidirectional, up to about 6 kHz. The resulting axial and off-axis characteristics are typified by the curves in Fig. 10. To some extent the difference between the curves can be reduced by fitting a slot in front of the low-frequency unit, but, as will be shown later, this device is by no means wholly successful in overcoming the trouble.

The use of a three-unit system with crossover frequencies in the region of 500 Hz and 3 kHz allows these difficulties to be largely overcome, provided a suitable type of middle-frequency unit can be found. There is the extra advantage that, with a frequency range restricted to the band from 3 kHz upwards, the high-frequency unit will be able to handle a larger programme level than if it had to operate at 1.5 kHz. On the other hand an additional unit and a more expensive and elaborate crossover network are required.

Bass Equalization

In practice the axial frequency characteristics of low-frequency loudspeaker units are not uniform. The reasons for this are that in the middle-frequency range the unit becomes directional, concentrating the sound energy increasingly in the axial direction, while at low frequencies over-damping of the bass resonances takes place, thus producing a bass cut; the resulting rise in axial response above the resonance frequency usually amounts to between 6 and 10 dB. This rise must be equalized electrically and in past B.B.C. designs, e.g. the type I.S3 1A loudspeaker, it has been carried out in the crossover network, thus enabling a standard amplifier with a

* B.B.C. Research Department.

Fig. 10. Typical frequency characteristics of a two-unit loudspeaker on axis and at 60° from axis.

Fig. 11. Peak levels in octave analysis of programmes. Item (a) Kramer with Dakotas, (b) Mars 1, (c) Organ Prelude in G.

Fig. 12. Peak octave analysis of programmes, all tints.

Fig. 13. Response/frequency characteristics of bass-lift circuits.

Fig. 14. Circuit used for determination of acceptable distortion with bass-lift circuits.

Wireless World, April 1968
uniform response frequency characteristic to be used. This method involves a considerable loss of power in the mid-band region: for example, if a 20 watt amplifier is employed and 10 dB of bass equalization is required, only 2 watts are available to drive the loudspeaker in the mid-band region.

An alternative method is to use equalization ahead of the power amplifier, but if an excessive degree of equalization is applied, over-loading of the amplifier will occur first in the bass and once again the usable mid-band power will be reduced. The question therefore arises as to whether the programme spectrum is such that it is possible to apply equalization before the amplifier without causing overloading in the bass. Experiments were accordingly designed to explore this possibility and to determine the optimum shape for the pre-emphasis curve. It will be seen that, in effect, the object of the experiment was to obtain the low-frequency equivalent of the high-frequency pre-emphasis employed in f.m. broadcasting.

Experimental details.—Various types of programme were examined to find those which had the highest power levels in the bass. Eleven recorded items were finally chosen, two of which were organ solos, three were light (pop) music and the remainder orchestral music, the total playing time amounting to about 13 minutes; details of the items are given in the appendix. In all cases the recording was arranged to peak to 6 on a peak programme meter, the peak occurring usually, although not necessarily, during the excerpt chosen.

The spectrum was examined by means of octave filters centred on frequencies ranging from 1 kHz down to about 50 Hz, the peaks in each band of frequencies being recorded by a peak counter reading in steps of 2 dB, due allowance being made for the insertion loss of the filters. Typical analyses are given in Fig. 11 and the overall peak levels for the whole range of items is plotted in Fig. 12; a smoothed curve of the peak spectrum is also shown in this figure. It will be noted that the smoothed curve passes below the point plotted for 68 Hz. This point represents a single note from a bass guitar which stood out considerably above the rest and was therefore ignored in drawing the smoothed curve as it was felt not to be representative.

Equalization was designed for the smoothed curve and for two similar but progressively more extreme conditions as shown in Fig. 13. The recordings were then replayed through the different circuits to see by how much the equalization increased the peak level of the complete programme as read on a peak programme meter; the results are given in Table 1.

![Figure 15](image_url)

**Fig. 15.** (a) Response/frequency characteristic of unequalized low-frequency unit without slit at 0° and 60° to the axis. (b) Response/frequency characteristic of unequalized low-frequency unit with 100 mm slit at 0° and 60° to the axis.

It will be seen that the level of item (c) is increased by 1 dB even by circuit (i) and it was decided to determine whether this degree of overload at low frequencies would be audible with a typical amplifier using a considerable degree of negative feedback.

A circuit was set up as shown in Fig. 14, in which the peak clipping is arranged to occur in a separate amplifier followed by an attenuator which feeds a loudspeaker amplifier. The gain of the peak clipping amplifier was adjusted so that a 1 kHz signal of +8 dBm from the source was just clipped at the peaks. The bass-lift circuits were inserted in turn ahead of the amplifier and the programme items played through the system, allowance being made for the insertion loss of the circuits. It was found that when using circuit (iii) of Fig. 13 distortion was clearly audible on items (c) and (d), i.e. the organ passages, none being noticed on the remainder; when circuit (ii) of Fig. 13 was inserted, distortion was only just detectable on item (c) and it was therefore concluded that this degree of bass pre-emphasis is permissible. Any equalization required in excess of this must therefore be applied after the power amplifier.

**Table 1**

<table>
<thead>
<tr>
<th>Effect of Bass Equalization on Peak Level of Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>programme item</td>
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<tr>
<td>(see appendix)</td>
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<td>a</td>
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<td>j</td>
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<tr>
<td>k</td>
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</tbody>
</table>

**The Cabinet**

Experience with the earlier B.B.C. monitoring loudspeaker type LS5/1A had shown that it had an adequate bass range. Calculations indicated that a similar range would be obtained with the new 305mm plastic cone unit by employing a cabinet of only 0.085 m³ internal capacity, that is 60° of the volume used for the LS5/1A.

Measurements were then made with an experimental cabinet to determine the vent resonance frequency giving the best combination of power handling capacity and frequency characteristic; this frequency was found to be 38 Hz, close to that employed for the type LS5/1A. Two types of cabinet were made, one floor-standing and the other for hanging from the ceiling, corresponding to the LS5/1A and the LS5/2A respectively. The volume and front dimensions of each model were the same.

†Version designed to hang above picture monitors in television control rooms.

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www.americanradiohistory.com
Use of Slit.—The next factor to be dealt with was the directivity of the units. Fig. 15 (a) shows the response on the axis and at 60° from it for the unequalized bass unit in the cabinet. It will be noted that there is an appreciable difference between the two at the higher frequencies. This difference can be reduced by placing a slit in front of the unit; the diffraction from the edges of the slit will make the radiation more nearly omnidirectional in the horizontal plane. There is, however, a limitation to this device: the Helmholtz resonator formed by the mass reactance of the slit and the compliance of the air enclosed between the slit and the cone increases the output to an undesirable extent in the region of the resonance frequency, but acts as a low-pass filter above the resonance, severely reducing the output at high frequencies. The minimum slit width which could be employed without either of these two effects becoming excessive was found to be 100 mm and it would appear at first sight that this width, which amounts to only a third of a wavelength at 1 kHz, should be quite small enough for this purpose.

In the first instance the slit may be regarded as a source having uniform sound pressure all over its area, but with conditions of radiation intermediate between those for free space and those for an infinite baffle and there are three possible configurations which may be regarded as approximations to these conditions. Of these, a line source and a circular piston in a baffle may be shown¹ to have directional patterns given respectively by

\[ R_\text{a} = \frac{\sin \left( \frac{\pi l}{\lambda} \sin a \right)}{\frac{\pi}{\lambda} \sin a} \]

where \( R_\text{a} \) is the sound pressure radiated at an angle \( a \) between the direction of radiation and the axis, \( l \) is the length of the source and \( \lambda \) is the wavelength and

\[ R_\text{c} = \frac{2J_1 \left( \frac{2\pi r}{\lambda} \sin a \right)}{2\pi r \sin a} \]

where \( r \) is the radius of the piston and \( J_1 \) is a Bessel function of the first order and first kind. The directional pattern for a piston in the end of a semi-infinite pipe is more complicated² viz:

\[ R_\text{p} = \frac{4}{\pi \sin^2 \alpha} \cdot \left( \frac{J_1(kr \sin a)}{[J_1((kr \sin a))^2 + (Y_1((kr \sin a))^2)]^{1/2}} \right) \times \left( 1 - \left| R \right|^2 \right) \exp \left\{ \frac{2kr \cos \alpha}{\pi} \int_{\pi/2}^{b} \left[ x \tan^{-1} \left( \frac{J_1(x)Y_1(x)}{x^2 - (kr \sin a)^2} \right) \right]^{1/2} dx \right\} \]

where \( R \) is the phase shift for a slit of finite width.

The calculated response at 60° with respect to that on the axis is shown in Fig. 16 for these cases. As expected it will be noted that for slit widths up to 0.6\( \lambda \) there is not much difference between them (curves (a), (b) and (c)), and for the proposed slit width of \( \lambda/3 \) considered at 1 kHz, the mean difference between the axial and 60° responses is not more than about 1 ½ dB.

In contrast to this the actual frequency characteristics obtained with a 100 mm slit are shown in Fig. 15 (b). It may be observed by comparison with Fig. 15 (a) that, with the slit, the deviation from the axial response is almost unaltered up to about 700 Hz, although beyond this frequency there is an appreciable change; furthermore at 1 kHz the deviation with the slit is not 1 ½ dB as calculated but nearly 6 dB. The measured deviation is replotted as curve (d) in Fig. 16 and it will be seen that it does not correspond to any of the three calculated cases.

This lack of improvement in directivity with the use of a slit was first noticed during the design of the LS5 1A, when it was found that, reducing below 180 mm, the width of the slit in front of the 380 mm cone did not bring about a corresponding improvement in the off-axis curves.

One possible explanation which has been examined is that the distribution of energy across the slit is not uniform and the extreme case when all the energy has been concentrated at the two edges has been calculated and is shown in Fig. 16 as curve (e). Even under these conditions the directivity is not nearly as great as that experienced in practice with the low-frequency unit for small values of \( d/\lambda \), where \( d \) is the width of the slit; furthermore, measurements show that although the pressure across the slit is not quite uniform it is actually higher in the centre by about 2 dB; in addition the phase change across the slit is also small.

The further possibility arises that re-radiation from the edges of the cabinet might be responsible for the directivity. Taking the width of the front baffle as 350 mm, the actual values obtained for the deviation of the 60° curve from the axial for the new values of \( d/\lambda \) are plotted as crosses in Fig. 16. It will be seen that in fact the agreement with the theoretical curves is quite good up to a value of \( d/\lambda \) of 0.75 after

††In Reference 2 \( Y_1(a) \) is denoted by \( N_1(a) \) throughout.

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Fig. 16 Deviation of 60° characteristic from axial characteristics for differing types of source: (a) line source (calculated); (b) piston source in infinite plane (calculated); (c) piston source at end of pipe (calculated); (d) measured values obtained with slit on low-frequency unit; (e) sound pressure concentrated at edges of slit (calculated); (f) measured values taking \( d/\lambda \) as front of cabinet.

Fig. 17 Response/frequency characteristics of 110 mm diameter middle frequency unit at 1° and 60° to the axis.
which the loudspeaker is less directional. This value of \( d', \lambda \) corresponds to a frequency of about 700 Hz, the frequency above which it was observed that the slit has an appreciable effect.

It appears therefore that up to 700 Hz** the directivity is largely determined by the width of the cabinet but that above this frequency the width of the slit plays a large part. That it does not fully determine the directivity even then is shown by the fact that the upper part of curve (d) of Fig. 16 does not lie in the region of the calculated curves. This discrepancy is further emphasized by the fact that in the final design the smaller middle-frequency unit employs the same width of slit, 100mm, in the same baffle, yet the deviation of the 60° curve from the axial curve at 1 kHz is different from that of the low-frequency unit, the value being 3 dB closer to the theoretical figure. Unexpectedly it appears therefore as though the size of the unit still affects the directional properties in spite of the slit and the exact mechanism accounting for the directivity for the values of \( d' \), greater than 0.75 is obscure.

**Details of units**

As already mentioned, the bass unit employed is the 305mm plastic cone unit described last month. A chassis with a more powerful magnet is now available and an increase in sensitivity of about 2 dB is thus possible. Further experience with the unit revealed a slight colouration in the 1.5 kHz region, and this is accentuated with a later material manufactured as a replacement for the type of Bextrene formerly used. It is however completely removed by painting the cone with a layer of polyvinyl acetate damping compound known as Plastiflex type 1200 P, even though this treatment does not cause any appreciable change in the frequency response. (The effect on colouration can easily be demonstrated by applying pink noise (i.e. random noise with equal power per octave) to the unit in a free-field room and making a tape recording of the output before and after painting the cone. The two conditions can then be compared sequentially and the improvement obtained by the treatment is evident.)

In spite of the use of the vent mentioned earlier some electrical low-frequency equalization is also necessary. As explained previously, it is best to apply this equalization mainly as pre-emphasis ahead of the power amplifier and to introduce the remainder in the crossover network. It is expected that, as with the LS5/2A loudspeaker, a further bass lift, amounting to about 3 dB at 40 Hz over that required for the floor-standing model, will be required for the hanging model, and this lift also is conveniently applied ahead of the amplifier. It will be seen from curve (ii) of Fig. 13 that this leaves about 4 dB available for the floor-standing model: before the permissible amount of pre-emphasis is exceeded.

The frequency characteristics of the bass unit on the axis and at 60° from it are those already shown in Fig. 15 (b).

**Middle-Frequency Units.**—No satisfactory commercially-produced middle-frequency unit is available, but at the time when the new loudspeakers were commissioned experiments on a 110mm diameter unit were already proceeding in the B.B.C. Research Department. This unit used a 25.4mm voice coil and a flared cone of Bextrene type 237, 0.4mm thick, together with a surround made of p.v.c. 0.5mm thick. The bass resonance, at about 400 Hz, was well damped, the intention being to employ this unit over the frequency range 450 Hz to 3.5 kHz. The frequency characteristics on the axis and at 60° from it are shown in Fig. 17, and it will be seen that over the required frequency range the two are smooth and nearly parallel. Listening tests, however, showed a noticeable colouration in the 1.5 kHz region and chopped-tone tests were therefore applied. In the region 1.2 kHz to 1.7 kHz these tests revealed three resonances with Q-factors of the order of 500, some 40 dB below the steady-state condition. If in phase with the steady-state condition, these resonances represent irregularities of no more than 0.1 dB on the axial curve and can only therefore be measured by chopped-tone techniques. It was however shown that the application of a layer of Plastiflex type 1200 P damping compound to both sides of the cone reduced the resonances to a marked extent; furthermore, the use of pink noise and the recording technique mentioned for the bass unit demonstrated a great improvement in the reproduction and the colouration was reduced to a very low level.

The sensitivity of the 110mm unit is comparable with that of the bass unit described last month, but there is a growing demand for even greater sound levels from monitoring loudspeakers; whereas the sensitivity of the low-frequency unit could be increased, that of this middle-frequency unit could not, and it was therefore decided to make a 200mm diameter unit of increased sensitivity as an alternative design.

The cone of the 200mm unit is made from 0.4mm thick Bextrene type 730 and, as with the 110mm diameter unit, employs a surround of 0.5mm thick p.v.c. The experience obtained in the design of the surround of the 305mm unit was applied to this unit and in addition a heavily flared cone was used. The bass resonance frequency in free air is about 50 Hz, but to avoid reaction with the cabinet vent resonance the rear of the unit is confined in a small enclosure. The resulting frequency characteristics on axis and at 60° are shown in Fig. 18; with this unit the operational frequency range is 400 Hz to 3.5 kHz. It will be seen that the axial frequency characteristic over this range is smooth, but that the 60° response diverges from it. As mentioned earlier a slit of 100mm width is used to effect an improvement in this respect; the resulting characteristics are shown in Fig. 19. The cone was coated on both sides with Plastiflex 1200 P to reduce slight colouration in the 2 kHz region and in this

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**Fig. 18. Response/frequency characteristic of 200 mm diameter middle-frequency unit without slit at 0° and 60° to the axis.**

**Fig. 19. Response/frequency characteristics of 200 mm diameter middle-frequency unit with 100 mm slit at 0° and 60° to the axis.**

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regard listening tests show that the reproduction from the
carded unit is remarkably "clean."

High-Frequency Units.—The 58mm high-frequency unit
employed in the LS5/1A has a smooth response frequency
characteristic and has proved to be very repeatable in pro-
duction. At the request of the B.B.C. a further model has
been produced employing the same diaphragm, and therefore
having similar frequency characteristics, but with a stronger
magnet giving an increase in sensitivity of nearly 2 dB.

A horn-loaded unit designed for the high fidelity market
was also examined but was found to be inferior to the 58mm
unit mentioned above. A larger direct radiator was also tested
and although this had a more extended axial frequency range
than the 58mm unit, the corresponding response curve was
not so smooth and the increased size made the unit appreciably
more directional at high frequencies.

The frequency characteristics of the improved but un-
equalized 58mm unit mounted in the cabinet are shown in
Fig. 20 at 0° and 60° to the axis.

With the units available three designs were possible.
Design A was similar to the type LS5/1A construction and
employed the plastic cone 305mm unit and two of the 58mm
units; type B used the 305mm unit for the bass, the 200mm
unit for the middle frequencies and a single 58mm improved
unit for the high frequencies; type C was similar to type B
but used the 110mm unit for the middle-frequency range.
As it was not possible to determine from a study of the units
which would give the best reproduction it was decided to
build a prototype of each and carry out final listening tests.
The characteristics of the three designs will be discussed in
the final part of the article next month.

References
2. H. Levine and J. Schwinger. Physical Review, 73, No. 4, 1948,
   pp. 383-406.

APPENDIX

Musical Excerpts used for the Experiment on Bass
Equalization

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Title</th>
<th>Type of Music</th>
<th>Length of Excerpt</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Götterdämmerung (Wagner)</td>
<td>Orchestral</td>
<td>35 sec</td>
</tr>
<tr>
<td>b</td>
<td>Schwanda (Weinberger)</td>
<td>Orchestral</td>
<td>55 sec</td>
</tr>
<tr>
<td>c</td>
<td>Prelude in G (Pierne)</td>
<td>Organ</td>
<td>1 min 41 sec</td>
</tr>
<tr>
<td>d</td>
<td>Flot Lux (Dubois)</td>
<td>Organ</td>
<td>1 min 30 sec</td>
</tr>
<tr>
<td>e</td>
<td>The Gee Hen (Swinger from Seville)</td>
<td>Saturday Club</td>
<td>1 min 41 sec</td>
</tr>
<tr>
<td>f</td>
<td>Billy J. Kramer with Dakotas (It's all over now baby blue)</td>
<td>Saturday Club</td>
<td>1 min 12 sec</td>
</tr>
<tr>
<td>g</td>
<td>Billy J. Kramer with Dakotas (We're doing fine)</td>
<td>Saturday Club</td>
<td>1 min 30 sec</td>
</tr>
<tr>
<td>h</td>
<td>Mars from Planets Suite (Holst)</td>
<td>Orchestral</td>
<td>52 sec</td>
</tr>
<tr>
<td>i</td>
<td>Mars from Planets Suite (Holst)</td>
<td>Orchestral</td>
<td>25 sec</td>
</tr>
<tr>
<td>j</td>
<td>Jupiter from Planets Suite (Holst)</td>
<td>Orchestral</td>
<td>51 sec</td>
</tr>
<tr>
<td>k</td>
<td>Overture: Scapino (Walton)</td>
<td>Orchestral</td>
<td>1 min 30 sec</td>
</tr>
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</table>

A capacitor microphone with a permanent electric
charge built in has been developed as an experimental
telephone transmitter by Northern Electric Laboratories
of Ottawa, Canada. In conventional capacitor
microphones the charge is, of course, produced by some
kind of voltage source, but in this new transducer it is
provided by an electret—that is, a dielectric material
to which a permanent electric charge has been applied
during manufacture. (Electrets can be considered as
electrostatic analogues of permanent magnets.) Here the
electret takes the form of a 7.6 μm film of a granular
carbonate material (the capacitor dielectric) meta-
alyzed on one side with a 0.89 μm layer of gold (one plate
of the capacitor). In the microphone this metalized film is
placed with its insulating side in contact with the
roughened surface of a rigid perforated backplate, which
forms the other plate of the capacitor. The film has just
enough tension to prevent wrinkles. Thus, when the air
pressure on this diaphragm is varied the capacitance is
changed and, since the charge is constant and \( V = Q/C \),
there is a corresponding variation of voltage across the
capacitor—the output signal.

The transducer is a high impedance device, so its
output is matched to the low impedance of the telephone
line, and at the same time amplified, by a 20 dB
solid-state pre-amplifier built into the microphone.

One advantage of this technique, regarding its applica-
tion to telephones, is, of course, that no voltage generator
is needed for the capacitor microphone. And, because
electrets can be made from very thin dielectric films, a
higher capacitance per unit area than with conventional
capacitor microphones is possible. The rate of decay of
the charge is very slow, and the developers say that
measurements at temperatures ranging from 90°C to
170°C have indicated that an electret life in excess of 100
years can be expected at normal temperatures. As a
competitor to the carbon microphone used in telephones,
the experimental microphone has the advantage, accord-
ing to Northern Electric, that the built-in pre-amplifier
requires less current than a carbon transducer.

**Electret Microphone**

A capacitor microphone with a permanent electric
charge built in has been developed as an experimental
telephone transmitter by Northern Electric Laboratories
of Ottawa, Canada. In conventional capacitor
microphones the charge is, of course, produced by some
kind of voltage source, but in this new transducer it is
provided by an electret—that is, a dielectric material
to which a permanent electric charge has been applied
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electrostatic analogues of permanent magnets.) Here the
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of the capacitor). In the microphone this metalized film is
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the charge is very slow, and the developers say that
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years can be expected at normal temperatures. As a
competitor to the carbon microphone used in telephones,
the experimental microphone has the advantage, accord-
ing to Northern Electric, that the built-in pre-amplifier
requires less current than a carbon transducer.
Ferrograph, 1949-1967

Now, another major event

See the new Ferrographs unveiled at the Audio Fair

The Ferrograph New Generation, Series 7 — a brand new family of Ferrograph tape recorders in mono and stereo, will be shown for the first time at the Audio Fair, London, April 18th, and will be available at Ferrograph stockists from the middle of May.

BOOTH NO.53 ROOM NO.134
BBC trains TV producers from overseas...

At the BBC's Overseas Training Studio at Woodstock Grove, Shepherds Bush, London, training courses are held for television producers, vision mixers and other overseas broadcasting staff. Many of the recordings made during these courses are on Scotch Helical Scan Video Tape. The use of video tape for the recording of training productions enables them to be played back immediately. In this way students can see the results of their work and benefit from criticism by professional producers and others. While these training productions are on closed circuit television, the BBC also makes use of Scotch 'Quadrature' Tape for many of its broadcast telerecordings.

The new Helical Scan Video Tape has an improved, low noise oxide formulation designed to give broadcast quality performance on helical scan equipment. The video signal-to-noise ratio can exceed 45 db. and dropouts are considerably reduced. There are two types. Type 351 has a 1 mil. polyester backing with a 210 microinch oxide coating and is available in ½" and 1" widths. Type 350 has a 1 mil. polyester backing with a 450 microinch oxide coating and is available in 1" and 2" widths.

More details? Certainly—just complete and post the coupon below for video talk publications and for 'Scotch' video tape data sheets.
Protecting Meters with Semiconductors

A selection of simple circuits using transistors or diodes to protect moving-coil meters from electrical overloads

by T. D. Towers*, M.B.E., M.I.E.E.

MOVING-COIL meters are expensive. They are easily damaged by accidental current overload from such things as wrong circuit connections, component failures or test probe slipping. An unprotected meter may not actually burn out on overload, it may end up with a bent pointer or, even worse, it may show no visible damage but have a gross reading error.

Modern semiconductors make it easy and cheap to protect your meters against current overloads. So much so, that in well run labs nowadays it is becoming the rule to fit any meter, before putting it into service, a protection circuit similar to those to be described. It is simple insurance. A diode costing less than £s can protect a meter costing several pounds.

Moving-coil meter characteristics.—A moving-coil meter is a coil of very fine wire (down to 0.001 in. dia., 50 s.w.g.) which is suspended in the field of a strong permanent magnet and balanced on a pivot. In measurements, current passes through the coil and deflects it against the reaction of a spring. A pointer or "needle", affixed to the coil, indicates the magnitude of the current by the position it takes up over the scale. The coil, pivot, spring and pointer can each be damaged by current overload.

A meter coil must have some resistance and, at full scale deflection, the voltage drop across it usually lies somewhere in the range of 30-300 mV. Very exceptionally, values as low as 5 mV or as high as 500 mV may be met with. For ordinary, general-purpose meters used in laboratories you will find a 1 mA meter has something like a 75-ohm coil resistance (i.e. 75 mV f.s.d. voltage drop), a 100 µA meter 1,250 ohms (125 mV f.s.d.) and a 50 µA meter 2,500 ohms (125 mV f.s.d.). Typical of this is the Ammeter 8 with 125 mV f.s.d. in its lowest, 50 mA f.s.d., range.

Overload current limits.—Meter failures can arise either from extremely high current pulses of short duration or from continuous high overloads. The short pulse rotates the moving-coil assembly so violently that the assembly or the pointer is damaged. The continuous overload leads to overheating under which the restoring spring or the fine coil wire melts and opens up like a fuse wire.

How much overload can you apply to a meter without materially affecting its accuracy? Little information has been published on this subject. One authority found an overload of 140-225 times f.s.d. necessary to bend the pointer detectably in sample microammeters. I am not aware of any commonly agreed acceptable overload limit. My own practice, based on years of sometimes-bitter experience, is to try to keep meter currents down to less than 20 x f.s.d. value.

For typical 75 mV, 1 mA meters, this "20 x f.s.d. current" overload limit sets a maximum of 1.5 V permissible across the meter terminals. A good rule of thumb is thus: "Never let meter terminals see more than a volt."

Basic meter protection methods.—In essence you can shunt-or series-protect a meter.

In shunt-protection you connect across its terminals an element that passes negligible current while the needle is on scale, and bypasses most of the excess current when the meter tries to travel off scale. In series-protection you fit in one lead to the meter an element which passes current up to the meter limit with negligible voltage drop, but presents a high resistance to excess currents. Of course, there is nothing to prevent you using both methods together in "belt-and-braces" style.

Shunt-Protection Circuits

A simple, cheap and effective way to protect a moving-coil meter against reasonable electrical overloads is to connect a semiconductor diode across its terminals, polarized as indicated in Fig. 1(a). When the meter is used to read current, the voltage drop across its coil forward biases the diode. Diodes can be selected whose forward current is negligible compared with the meter current up to the f.s.d. voltage of the meter (30-150 mV as noted above). Beyond full-scale the meter current continues to increase linearly with voltage, but the bleeder current through the diode increases exponentially. Thus the diode safely shunts more and more of the applied current progressively away from the meter coil.

Shunt diode selection.—In the days before transistors, meter protection diodes were usually copper-oxide or selenium rectifiers, whose basic leakage currents were too high for low-current meters. Nowadays, germanium and silicon diodes, with their intrinsic low leakage currents, can be used with even the most sensitive microammeters.

In modern silicon and germanium small diodes, the forward current, \( I_F \), rises with voltage, \( V_D \), roughly as shown in the table. This shows that germanium can give better overload protection than silicon. For example, when the voltage across the meter coil builds up to 0.45 V, a germanium shunt diode will bleed off 10 mA, but a silicon one only 10 µA. Again on 100 mA overload, the voltage across the meter will be 0.55 V with germanium against 0.85 V for silicon.

On the other hand, on scale the higher leakage current of the germanium shunt diode is liable to give a greater error than silicon, particularly with sensitive, high-resistance microammeters. In a 50 µA meter with 125 mV f.s.d., at 10 µA reading the voltage drop across the meter terminals would be 12.5 mV. At this level, the germanium diode could have about 1 µA leakage, significantly affecting the 10 µA reading. By

Fig 1 Forward-biased diode shunt protection of moving-coil meter movements—(a) single-diode for forward overload; (b) double-diode (for forward or reverse overload); (c) transistor collector-base junction as diode; (d) transistor emitter-base as diode; and (e) transistor with collector and base swapped together.
contrast, the silicon diode would pass only 10 nA (0.01 μA) and would produce no visible error. With less sensitive meters, such as standard 1 mA movements, it is usually immaterial whether you use germanium or silicon.

Diode data sheets are oddly uninformative about forward currents at voltages below 250 mV. When you are contemplating using a shunt protection diode, you might go to the trouble of measuring the low voltage characteristics if you had suitable equipment, but this is hardly worth while. The practical answer is to pass about 1/10th full scale current through your meter and see whether the reading changes perceptibly when you connect the diode across it. Then increase to f.s.d. current and check once again by connecting and disconnecting the diode.

For any given forward voltage, the diode current rises with temperature. For most lab. requirements where meters are normally used near room temperature, generally this can be ignored. Typical readily available diodes used for simple shunt protection are OA81 germanium and 1N914 silicon.

**Shunt protection against reverse overloads.—** The simple diode circuit of Fig. 1(a) protects the meter only against forward overloads. It is equally important to protect against reverse overloads. You can do this quite simply by paralleling the first diode with a second diode oppositely polarized as shown in Fig. 1(b). This is just as important with a left-hand zero meter (where a reverse overload only drives the needle a short distance to the stop) as it is with a centre-zero meter (where overload in either direction drives full across the scale to the stop).

**Transistors as shunt protection diodes.—** Silicon transistors are now nearly as cheap as diodes and more plentiful around the bench, so engineers sometimes use one of the junctions in a transistor as a diode. Fig. 1(c) shows the collector-base junction of the popular BC108 used as a substitute for the diode of Fig. 1(a). In Fig. 1(d) the emitter-base junction is used. These substitutes are useful when you have some reject transistors to hand.

Another arrangement sometimes adopted is the "tridode" connection of a transistor shown in Fig. 1(e). Here the collector and base are strapped together and the emitter-base junction used. This has the advantage that the device has a lower voltage drop at high current than the emitter-base diode on its own.

"Breakdown" (Zener) shunt diodes.—So far, we have looked at forward-biased diode shunt protection circuits. It is also possible to use reverse-biased shunt diodes.

In Fig. 2(a) a Zener diode is shown shunted across a meter. When the forward voltage across the meter is below the Zener breakdown voltage there is negligible leakage through the diode. When the meter voltage exceeds the Zener voltage most of the overload current is shunted through the Zener. The main practical difficulty of this circuit is that Zeners working at less than 3 V are unusual and expensive.

To get round this, I use the emitter-base junction of a p-n germanium post-alloy-diffused v.h.f. transistor such as the NK767 or AF117, whose emitter breakdown voltage is between 1 and 1.5 V. The circuit is shown in Fig. 2(b). The emitter breakdown characteristic is very similar to a Zener diode, but at a lower voltage.

Using a Zener or a reverse-biased transistor emitter junction for meter protection has an additional advantage. In the earlier shunt diode protection, a second oppositely polarized shunt diode had to be used to protect against reverse overloads. With the Zener, or Zener-substitute, if a reverse current is applied to the meter, the device acts as a conventional forward-biased shunt protection diode. Therefore the one element provides both forward and reverse overload shunt protection.

**Series Protection Circuits**

The shunt protection circuits dealt with so far present to the meter a high resistance at shunt at low voltage and low resistance at high voltages. An alternative approach is to use a series element which presents a low resistance at low current and high resistance at high current. There are a number of ways of doing this.

**Simple series diode meter protection.—** Fig. 3(a) shows a simple and effective meter protection circuit I have used for years in transistor test instruments where a high voltage can fall directly on a current meter if the transistor under test fails. This uses a large-area germanium power diode junction with a high reverse saturation current. Arranged in the reverse-biased direction in series with the meter as shown, the diode acts like a low resistance up to about 1 V. Thereafter the diode current begins to saturate and remains relatively constant as the applied voltage increases. The main difficulty in using this circuit is to find a suitable diode whose saturation current is about ten times the f.s.d. current of the meter to be protected.

**Working in a transistor factory** I get round this by selecting a very high-power transistor such as the NK1405 and connecting it with base open circuit in series with the meter as shown in Fig. 3(b). Up to 60 V the leakage current of the 405 lies in the μA range, so that it is adequate to protect standard 25 to 100 μA meters.

You are probably not lucky enough to have a transistor factory at your back, and may be forced to turn to one of the f.e.t. current limiting series circuits described below.

**Simple f.e.t. series meter protection.—** If the source and gate of an f.e.t. transistor are strapped together, the output current—voltage characteristics are such that up to near the pinch-off voltage, $V_T$ it acts like a simple resistance. Above $V_T$ it acts like a constant current device up to the drain breakdown voltage. These quasi-pentode characteristics are most useful, particularly nowadays, when low $V_T$ and low series resistance, $r_{ds}$, are readily available.

Fig. 3(c) shows an n-channel f.e.t. (with its gate and source strapped) in series with the meter to be protected. Fig. 3(d) shows a similar arrangement for a p-channel f.e.t. In the second case you will note that the source connection is reversed from that of the left.

The characteristic requirements for such series-protection f.e.t.s are that the pinch-off voltage should be less than 1 V and the $I_{s1}$ approximately ten times the meter f.s.d. current. The higher the drain voltage rating the better, because the f.e.t. protects the meter only up to the rated drain voltage. As an example, a protected 25 μA meter, I use an NK70213 n-channel f.e.t. ($I_{s1}$=1000 μA and $V_{BN}$=1 V typical). With this protection I have been able to connect the meter directly across 12-V car battery terminals without damage.

**Multiple series element protection.—** In the case of diode or f.e.t. series circuits above, if you wish to protect against reverse overloads, you can add another diode or f.e.t. in series with the first but with opposite polarisation. This corresponds to adding an opposite-polarity device in parallel in shunt protection circuits.

For one-way protection, other multiple series element arrangements are possible. Fig. 4(a) shows as f.e.t. with an adjustable resistance in the source lead by which you can preset the limiting current in the f.e.t instead of having to select a suitable f.e.t. with the right $I_{s1}$.

Fig. 4(b) shows an arrangement of a transistor biased in a constant current mode by means of a battery which fixes the emitter current to a constant value given approximately by the battery voltage divided by the emitter resistance, always provided that the collector-base voltage is more than a fraction of a volt positive. As soon, therefore, as the total voltage across the circuit exceeds $V_B$ by about 250 mV, the emitter (and therefore the meter) current limits to $I_{d1}=V_{e1}/R_e$. For a sensitive 25 μA meter, for example, a 1 V mercury cell can be used limiting the emitter current to around 200 μA. If this is done, the drain on the battery is so low that no on/off switch need be provided. A practical multirange circuit using the above technique was described in "Meter Protection Circuit."
it to insert some protection device at the junction of the two resistors.

Zener voltmeter protection.—One example of this is shown in Fig. 5(a) where the series resistor is made up of $R_{51}$, $R_{52}$, and a Zener is connected from their common point to the negative meter terminal. The necessary resistance and Zener values can be calculated quite simply. Firstly $R_{51} + R_{52} = E_u/I_u$ where $E_u$ = f.s.d. voltage to be measured, $I_u$ = f.s.d. current of the meter and $R_m$ = meter coil resistance. Select a Zener of approximately $E_u$ breakdown voltage. Make $R_{52}$ approximately 20% of $R_{51} + R_{52}$. This will mean that when the voltage applied to the voltmeter is more than about 25% above the voltmeter f.s.d. voltage, the Zener will begin to conduct and limit the current through the meter to some 25% above its f.s.d. value. Of course, when the meter is used with a series multiplier resistor in the lower voltage range of the voltmeter (e.g. 125 mV in the 50µA range of the Avo 8), this method of protection cannot be used as it clearly depends on having a multiplier resistance that can be split to insert the Zener.

Transistor voltmeter protection.—Fig. 5(b) shows another voltmeter protection circuit that I use which depends on the fact that a silicon transistor does not begin to conduct until its base-emitter voltage approaches 500 mV. Here again $R_{51} + R_{52}$ represents the voltmeter series-multiplier resistance whose total value is fixed as in the previous example. The individual resistor values are chosen so that the voltage across $R_{52}$ is about 400 mV for the f.s.d. meter current. Beyond this current, the BC108 transistor is biased more and more fully on and shunts off most of the excess current away from the meter movement on an overload.

An interesting meter protection arrangement used by Yates for pen recorder protection is shown in Fig. 5(c). In this the base of the transistor, whose collector and emitter are placed across the recorder terminals, is held at a small positive voltage. So long as the f.s.d. voltage of the recorder is not exceeded, the base-emitter junction of the transistor is reverse biased and the transistor is cut off. When the positive terminal of the recorder rises above this threshold voltage, the transistor begins to conduct and bypass excess current away from the movement. In Fig. 5(d) the arrangement is shown fitted as a protective measure to a common type of pen recorder valve drive circuit.

Miscellaneous Matters

The various protective circuits have been shown above in circuit diagram form, but there are some practical points to be considered.

Mounting meter protection circuits.—With modern semiconductors, the devices are so small that in the case of passive networks (with no separate power supplies required) the circuits can be easily fitted permanently inside the meter case. An alternative is to mount them on a small printed circuit board with holes to fit the meter terminal spacings, so that the board can merely be slipped over the terminal screws and bolted into place. Another approach is to "pot" the elements in some compound leaving only the two meter lead wires exposed. In the case of the common protection circuit, two parallelled opposite-polarity shunt diodes, "potting" can consist merely of strapping the two diodes together with Sellotape and twisting the leads together.

Other protection methods.—All or any of the various circuits described earlier can be used singly or together. However, they all require in the end a sufficiently high voltage to limit an overload is applied. The only sure way of fail-safe protection is to incorporate either a mechanical cut-out or a fuse in series with the meter. Unfortunately, it is difficult to find readily available fuses below about 60 mA, but, provided a shunt diode is used across the meter with such a fuse, it can be most effective.

If you wish to go into more detail on semiconductor meter protection circuitry, you will find much relevant material in the following references:


Books Received

Precision Electronics by G. Klein and J. J. Zaalberg van Zelst (from the Philips Technical Library). The reader is presented with the basic principles of electronics design and with a number of worked examples. The most common components, methods of calculation and basic circuits in electronics are described and general principles and methods are dealt with, particular attention being given to the limits in the design of electronic measuring equipment. Pp. 446. Price 13s.6d. Macmillan & Co. Ltd., Little Essex Street, London W.C.2.

Electrical and Electronic Trader Year Book, prepared in collaboration with the staff of our sister journal Electrical and Electronic Trader. All sections of this, the thirty-ninth edition of the year book, have been revised and brought up to date and provide a wealth of information for all in the radio, television and domestic electrical fields. The first section of the book gives principal trade organization addresses, licence details, legal information, addresses of electricity boards, intermediate frequencies of commercial receivers, a comprehensive guide to the field strengths of f.m. and television transmissions and much other information. Other sections separately cover valve base diagrams, trade addresses and telephone numbers and the manufacturer's or agent's names of proprietary equipments and components. The technical literature section contains an index of all the Trader Service literature available and brief details of the contents of about 250 books are given. Other sections include classified buyers' guides for components and domestic radio, television and electrical equipment. Pp. 495. Price 35s. Iliffe Technical Publications Ltd., Dorset House, Stamford Street, London, S.E.1.
"Portable 1-MHz Frequency Standard"

The recent article by L. Nelson-Jones (February issue) has been studied with interest. Although the instrument described is a useful one, its performance could perhaps be improved with the consideration of several factors.

In the receiver circuitry itself, limiting is used to "remove residual modulation". This, in fact, cannot be done generally. No matter how much or how little one retains an amplitude-limited function which will have a time-varying nature due to the amplitude modulation imposed upon the original carrier. For that matter, amplitude variations in the entire signal due to variable propagation factors will also exhibit much the same effect. The time variation of the cyclic function after limiting can only approach zero if the points in time when the waveform first limits symmetrically approach the time when the value of the original function is zero. This may be seen in Fig. A.

The time-response of a phase-locked loop—particularly one in which a quartz resonator is included—is not, in fact, arbitrarily small due to the narrow bandwidth of the piezoelectric element.

The precise behaviour of an arbitrarily-defined phase-locked system is not generally known; in any case, an approximate analysis would involve many pages. However, this is not to say one cannot combine the rudiments of servomechanism theory and quartz resonator behaviour to a useful end.

The oscillator used in the standard described is a Colpitts type, with the typical inductor replaced by a quartz resonator and its associated series tuning capacitor. One could therefore argue that the resonator is operating in a quasi-parallel mode. However, using conventional circuit theory, the resonator and its associated circuitry may be represented as a series equivalent circuit in Fig. B, where L, R, and C represent the time-invariant elements in the oscillator circuitry and C<sub>T</sub> represents the time-variable tuning capacitor. Since the crystal Q is very high and its series motional arm capacitance is very small, it is in keeping with an approximate analysis to assume the values of L and C are within perhaps an order of magnitude of the resonator values alone.

The resonant angular frequency may be shown to be

\[ \omega_0 = \frac{1}{\sqrt{L/C + L/C_T}} \]  

For elimination of modulation effects, \( t_2 = t_1 + \Delta t \). Hence the rate of change of angular frequency is not only considerable for a corresponding change in tuning capacitance, but what is most important of all, directly proportional to the rate of change of tuning capacitance.

The application of this analysis here establishes that the quartz resonator will not, in fact, remove much of the time-varying component of the locking signal fed to the tuning element in the oscillator.

Philosophically, this is what one would expect; the quartz resonator, when held at a fixed frequency and presented with an input of varying frequency, will remove much of the time-varying components of the waveform (they may be regarded as sidebands which are "filtered out"). However, when the quartz resonator is placed in a circuit with a varying reactive component, the entire oscillatory circuit surely can be only as stable as the most unstable element.

If one considers the d.c. amplifier portion of the phase-lock loop one may deduce the open-loop time constant to be of the order of five to fifteen milliseconds; thus, when the loop is closed, if the gain is sufficient and the transfer function of the time-variable capacitor allows, the crystal resonator will be subject to perturbations in its frequency at a maximum rate of, say, rather more than five or ten hertz and to an extent determined by the capacitor.

The suggestion that this does, in fact, happen is reflected in the performance of the unit. The author quotes, during the condition of phase lock, a short-term stability (one second) of less than one part per million. In fact, a crystal resonator alone should, if placed in an oscillatory circuit with perhaps drive not exceeding five microwatts or so, exhibit a figure of the order of 0.01 part per million.

It is perhaps a pity that Mr. Nelson-Jones did not include a simple filter in the receiver portion of the device to remove the sidebands which, when present, perturb the frequency of the phase-lock loop. The device, however, achieves a most useful end in that the output has a long-term stability which is roughly that of the received signal.

A similar device was constructed here a year or so ago; it uses an LC oscillator locked to Drolitch via a ± 5 hertz bandwidth receiver. Its short-term stability (one second) is less than 0.01 part per million.

LEWIS E. SCHNURR
Mid-Essex Technical College, Chelmsford.

The author replies:
I agree with much of what Mr. Schnurr has said, and indeed it is mostly in accord with my own understanding of the operation of the type of circuit described.

With regard to the ability of the crystal resonator to reject sideband interference in such a phase-lock loop system, I would agree that the degree of filtering is much less than would be expected from consideration of the crystal response bandwidth alone.

I think it is important to define the time scale within which one is speaking when talking about accuracies with this type of instrument, for instance, if one were to consider the pulse-to-pulse accuracy then the time scale would be 1 μs and say a 10 ns shift of a single pulse would represent an accuracy of only 1 in 100 parts. However, such a shift of a single pulse in a period of 1 second would represent an accuracy of 1 in 10<sup>5</sup>. It is therefore true that Mr. Schnurr's mathematical treatment may
how an instantaneous frequency shift of many Hz, but averaged over 10⁵ or more cycles this may not represent any great error as measured say on a digital frequency meter.

Assuming that limiting is taking place as shown in Fig. 4 of my article (Fig. A of Mr. Schnurr's letter), the sampling pulse will stay within the time duration of the rise time of the trapezium waveform if phase lock is to be retained. In fact the pulse does stay within this time interval in practice despite residual modulation. The total rise time of this waveform is approximately 1μs; therefore the maximum error that can occur in one second is 1 part in 10⁵.

I agree with Mr. Schnurr that a very narrow band filter would achieve the desired effect if placed in the receiving chain, but I would not agree that such filters are necessarily simple (or cheap) if a bandwidth of only a few Hz is to be obtained at 200 kHz. The suggested modification shown in Fig. 6 of my article achieves the same end, since it increases the time constant of the phase-lock loop from a few milliseconds to around 1 second. With such a long time constant the phase-lock loop is not disturbed by frequencies above 1 kHz.

As I said in the article it is not possible to achieve automatic phase lock with a long time constant when switching on, so that it is necessary to switch this extra capacitor into circuit after the phase lock is established.

The only comparable commercial equipment to my own uses a phase-lock loop with such a large time constant. The loop is opened on switching on, and the lock indicator is used to show the difference frequency between the crystal oscillator and the received carrier. This frequency has to be reduced to a very low value (less than the cut-off rate of the phase-lock loop) or phase lock cannot be established. With respect to the makers of an otherwise excellent instrument, I personally found it to be a very "fiddling" method of setting up the equipment. To set up my own instrument it is only necessary to switch on and set the phase lock (if it has been disturbed)—only a few seconds is taken to do this. A period of 30 seconds is allowed for the time constant to charge up and then the switch is closed bringing in the larger capacitance.

My thanks to Mr. Schnurr for his most interesting comments, but we must agree to differ: he prefers to use a narrow band filter, and I prefer to use a long time constant. "You pay your money—you take your choice." I think, however, that you will pay less my way.

L. Nelson-Jones.

Bournemouth, Hants.

Supply of Components to the Home Constructor

For three years I have been trying, without success, to obtain certain components, in particular dual potentiometers with particular resistance values. At last an apparent source came into view through a Distributor's advertisement in Wireless World. Neither the catalogue nor the advertisement offering it mentioned anything about restrictions on the type of would-be customer to be supplied. However, my order and cheque were returned with a printed letter suggesting that I obtain the parts via my "local television/radio dealer who will be pleased to help!" A letter to the firm in question produced an apologetic reply with the information that certain retailers will be glad to order the components for me.

When searching for components, retailers have offered me stock parts distributed by a service and distribution organization, but of unknown origin, at times dubious quality, and, I feel, at high prices. Manufacturers and importers are reluctant to supply small quantities to large account customers and small cash customers alike, this is reasonable. It seems that the stockist/distributor has grown up to fill the gap thus created, carrying extensive stocks of branded, high-quality components, and distributing them quickly to large areas of the country by post or van at reasonable prices. Most of these firms are very cooperative when asked to supply in small quantities to a private individual components not normally found in retail shops.

When faced with an unco-operative distributor of British components, what am I to do? Should I try to persuade my retailer to order the parts (and thus make it more expensive for me to buy them, yet probably not giving the retailer an adequate recompense for the trouble involved in dealing with a "special"), or should I turn once again to the Americans and have the parts imported because a distributor is clinging to distinctions between trade and general public, which to most people are as out-dated and restrictive as resale price maintenance and "who does what?" industrial disputes? It would at least be some help if advertisers would indicate if they are "Trade only", but it would be much more helpful if they would be willing to supply to private individuals catalogues and a list of retailers who regularly deal with them.

P. W. Tomlinson

Leeds 16, Yorks.

Electronic Music

I was surprised and pleased to see a review of the Queen Elizabeth Hall electronic music concert in the March issue of Wireless World. It is encouraging to find the subject treated seriously in a scientific journal; the people who are generally the most reactionary with regard to electronic music are electronics experts and musicians.

Your reviewer mentioned that the Royal College of Music is starting a pilot course on electronic music. I should like to add that we have already set up an Electronic Music Workshop at Goldsmiths' College, and that some 40 people have been attending courses here since January, these include established composers, students from the main London music colleges, and people from other arts and sciences.

The workshop is designed both for the production of electronic music on tape and for the performance of live electronic music (which has so far been scarcely explored in this country). This latter genre was not represented at the above-mentioned concert, but a concert of electronic music to be given at the London Planetarium on March 22nd (organized jointly by the Society for the Promotion of New Music and the Park Lane Group) will include a new composition combining tapes with live electronic performance, the first work realized in our workshop.

Hugh Davies

Electronic Music Workshop,
University of London Goldsmiths' College

Corrections

Under our new printing arrangements the final checking of material is one stage earlier than under the old system and it is regretted that several errors crept into the March issue. Some cannot be remedied, as for instance the "geranium" transistor on p. 6 (which one reader has suggested was for "flower power") but others must be corrected.

It is ironical that a major error occurred in Mr. Soutball's article "Electronics in Typesetting!" In the fifth paragraph from the end the sentence beginning "One, from the width tables stored in the" should continue "main part of the memory, gives the character's width in half relative units (713 does all its calculations in half relative units)."

In Mr. Short's article (pp. 24/5) the end of the paragraph following the heading "oscillators" should read "measurements in a working low-frequency circuit show Vc/Vce ≈ 100."

It will be obvious from Fig. 1 that the low-pass switch connection to the common input-output line was omitted in preparing the drawing for Fig. 5.

The upper frequency limit of the d.c. converters and inverters described by Mr. Nowicki (p. 38) should, of course, have been given as 50 kHz in the subtitle and introduction. In equation (3) the term Vc should read VceSat. Square brackets were omitted from the expression (lμ + R1/μ) in equation 8 and the author omitted to define lμ, which is five times lμ. In Fig. 11 component references R2 and R3 should be transposed, and, correspondingly, in the text describing the circuit. Definitions of R4, and Φ4 are given in the author's earlier papers (References Nos. 3 and 4).

In the first line of the caption to the flight deck mock-up (p. 12) for "left" read "right".

A Disclaimer

Mr. D. W. Stebbings has asked us to let it be known that he is not the author of the article "Doctoring Recorded Sound" published in the March issue (p.9).
London Audio Festival

Hotel Russell, April 18—21

The annual festival of sound, which opens at the Hotel Russell, London, on April 18th for four days, has attracted even more exhibitors than last year's record breaking Fair. An additional area of the Hotel is being used to accommodate the extra booths necessary for the 98 exhibitors, the majority of whom will also mount demonstrations in private rooms. These demonstrations, many of which are given in rooms furnished to simulate the domestic atmosphere, are an essential part of the International Audio Festival & Fair which has become the Mecca of the ever-growing number of audio enthusiasts.

As is usual, the Fair will hold some interesting surprises for visitors. First, the number of new participants; secondly that several manufacturers have diversified their interests—as for instance Audio & Design who have entered the pickup cartridge field; and thirdly the considerable quantity of imported equipment which will be on show. The Fair has indeed become international; about a third of the exhibitors will be showing or demonstrating equipment from overseas.

We list below the names of the exhibitors and where overseas manufacturers are represented by their U.K. agents we give the latter's name in parentheses. We plan to include in our June issue a review of some of the latest developments in audio equipment as seen by members of the staff of Wireless World at the Fair. As a preliminary we illustrate on these pages some of the equipment which will be seen or demonstrated.

The Fair will open daily at 11.00 but admission on the opening day will be restricted to specially invited guests until 16.00. It will close at 21.00 except on the last day when it will end an hour earlier.

Tickets, which will admit two people at any time after 16.00 on the opening day, are obtainable from exhibitors, audio dealers or the editorial offices of Wireless World. Please send a stamped addressed envelope large enough to accommodate the 5 x 3-inch tickets.

As with all major shows some companies, for one reason or another, prefer to hold their own exhibition and during the Audio Fair there will be independent shows at the Tavistock Hotel, Tavistock Square (B & O, Radford and Sony) and the Grand Hotel, Southampton Row (Heathkit).

LIST OF EXHIBITORS

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LIST OF EXHIBITORS

One of the new Series 7 Ferrograph tape recorders. F.E.T. input stages are employed in the all-transistor amplifier. Separate motors are provided for each of three speeds.

A new single record playing unit (AP 75) introduced by Garrard Engineering. Fitted with a non-magnetic turntable and aluminium pickup arm with slide-in cartridge carrier.

Sennheiser MD 409 super-cardioid microphone, introduced by Audio Engineering, provides steep attenuation at the sides as well as the back.

Rogers Developments' Ravensbourne 2 f.m. receiver, featuring an f.e.t. front end, is available with or without decoder.

Grundig's RTV600 tuner-amplifier, which employs 53 transistors and 31 diodes, covers the v.h.f./f.m. band, the s.w. bands from 3.15-22.5 MHz, and the m.w. and l.w. bands. It incorporates a stereo decoder (with automatic mono/stereo switching) and has an output of 20 W per channel.
Illegal Walkie-Talkies

In agreement with the Board of Trade, the Postmaster General has made an Order under Section 7 of the Wireless Telegraphy Act 1967, the effect of which is that the authority of the P.M.G. will be required, as from April 1st, by any person who wishes to manufacture or import radio equipment capable of transmitting on any frequency between 26.1 and 29.7 MHz or between 88 and 108 MHz. Some of the frequencies covered by the Order are used by radio amateurs and they will be authorized to build their own apparatus for use within the terms of their licence. The Order is aimed at putting an end to the indiscriminate sale to the public of small imported transmitters such as the 27 MHz walkie-talkies. The Post Office has warned in the past that the use of these sets cannot be approved in the United Kingdom because they are liable to interference with authorized services and numerous people have been prosecuted for using them without a licence. The purpose of the Order is to deal with the matter at source and to protect the public from being offered sets which they cannot legally use.

E.M.E Test.—An Earth-Moon-Earth Test is due to take place during the period April 12th-14th, on 1296 MHz ± 5 Hz when the Crawford Hill V.H.F. Club station W2NFA, located at Holmdel, New Jersey, U.S.A., will transmit with an output power of at least 200 watts into a 60-ft parabolic reflector. The aerial has an estimated gain of 44 dB. Echo-testing will commence at moon-rise and continue for 30 minutes prior to any schedules. Moon-rise to moon-set times (G.M.T.) at W2NFA during the test period are 23.00 April 12th to 10.28 April 13th, and 00.18 April 14th to 10.57 April 14th. All correspondence concerning the tests is to be sent to Mr. R. Turrin, W2IMU, Box 45, R.R.2 Colus Neck, New Jersey, U.S.A. 07722. The official liaison station WB2NDH will operate on 14.235, 21.385 and 28.690 MHz.

U.K. Successes in International V.H.F. Contest.—The German National Amateur Radio Society (D.A.R.C.), organizers of the 1967 I.A.R.U. Region 1 V.H.F. Contest held last September, report the receipt of 924 logs, including 831 from 2-metre stations, 81 from 70-cm stations and 12 from 24-cm stations. Section 1, for 2-metre fixed station operation, was won by I1CZE (Italy) with a score of 44563 points and Section 2, for 2-metre portable operation, by GC3WMS/P (Channel Islands) with a score of 52340 points. Another U.K. operator G3CMS (Leicester) with a score of 4022 points led in the section for 70-cm fixed stations, while in the section for 70-cm portables, U.K. operators occupied the first three places—GC3VXK/P (Channel Islands), 12118 points, G3NNG/P (Berkshire), 6991 points and G3MAR/P (Birmingham), 6419 points. In the section for 24-cm fixed stations, G3CMS (Leicester) achieved his second success of the Contest by leading the field with a score of 1351 points. In the section for 24-cm portables, U.K. operators—G3NNG/P (1003 points), G3MAR/P (878 points) and G3OBD/P of Dorset (845 points)—occupied the first three places.

Amateur Radio Licences.—At the end of December the number of amateur radio transmitting licences in force in the U.K. was as follows: Type A sound licences 15034 (including 2407 mobile); B licences for telephony only on 420 MHz 722 (22 mobile); and 177 television licences making a total of 15933—an increase of 553 during the preceding six months. At the end of the year there were 12658 model radio control licences in force; a 1037 increase in six months.

Amateur Facsimile now Authorized.—Following discussions between the Radio Society of Great Britain and the Post Office it has been decided that any licensed U.K. radio amateur may apply to the Radio and Broadcast Dept., G.P.O., Armour House, London, E.C.1, for permission to transmit facsimile (A4, F4 and allied modes). In the past this mode of transmission has not been among those permitted by the terms of Amateur Sound Licences. Recently there has been increasing interest in facsimile brought about by the availability of reproduction equipment.

Derby and District Amateur Radio Society, which incorporates the Derby Wireless Club, now boasts 178 members including 86 holders of transmitting licences. The first wireless club in the United Kingdom was formed in Derby during 1911 and an experimental station was established that year in Old Bank Chambers, Irongate, with the call sign QIX. Mr. Fred Ward, G2CVV, secretary of the present go-ahead society, has produced a short history of the original Derby Wireless Club, a copy of which he will send on receipt of a stamp for postage to anyone interested in the early days of wireless and the club movement. Mr. Ward's address is 5 Uplands Avenue, Littleover, Derby, DE3 7GE.

Iceland on 2 metres.—Mr. D. B. Collins, K2LME, of Paramus, New Jersey, has set up a 2-metre amateur radio station in Keflavik on the south west coast of Iceland from where he hopes to maintain schedules with amateur stations in Great Britain and other parts of Europe. The aerial is a 7-element horizontally polarized Yagi, 30 feet above ground. The station is operating from a site close to the ocean with no obstructions looking east south-east. The transmit frequency is within 50 Hz of 144.1 MHz. Telegraphy will be used unless propagation supports the use of the single sideband mode. Mr. Collins is monitoring as much as possible for auroral occurrences and will appreciate receiving information on aerial headings used by U.K. operators during auroral QSOs. Transmissions take place for 15 minutes each evening from 20.00 G.M.T. on 144.1 MHz followed by a listening period for the next 15 minutes. The array is beamed on the U.K. and schedules for any hour of the day or night will be welcomed by Mr. Collins whose full address is c/o F.E.C./DYE 5, Box 4, U.S.N.S., Keflavik, Iceland.

R.F.C. Wireless Operators' Reunion.—The Annual Reunion of Royal Flying Corps Wireless Operators will be held at the Victory Ex-Services Club, Edgware Road, on Saturday, March 30th. Information is obtainable from Mr. E. J. Hogg, M.B.E., 57 Hendham Road, London, S.W.17.

The Tenth Annual Reunion of the Radio Amateur Old Timers' Association is to be held at The Horse Shoe Hotel, Tottenham Court Road, London, W.1, on Friday, May 3rd. Membership of the Association is open to any radio amateur who has held a United Kingdom amateur transmitting licence for an unbroken period of 25 years (including the war years) at the time of his application for membership. Further information from the Founder-Secretary, 16 Ashridge Gardens, London, N.13.

Amateur Radio Teleprinting is well catered for in the U.K. by the British Amateur Radio Teletypewriter Group who, through the medium of a quarterly News Letter, provide members (315 at the last A.G.M.) with up-to-date information on all aspects of the subject. Editor of the News Letter is Mr. A. W. Owen, G2FUD, 184 Hale Road, Hale, Cheshire, and the secretary is Mr. D. G. Goacher, G3LZJ, 51 Norman Road, Swindon, Wilts. The annual subscription is 15s.

Look out for EA6ITU.—During the Interim Meetings of the International Radio Consultative Committee (C.C.I.R.) to be held in Palma, Majorca, from April 29th to May 10th, an amateur radio station will be operated under the call sign EA6ITU.
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WW-111 FOR FURTHER DETAILS
There's a BRIMAR tube to meet the needs of every oscilloscope designer—ranging from general purpose tubes of medium bandwidth to tubes designed specifically for exacting applications requiring features such as short length, wide bandwidth or dual phosphors. Face plates range from 8½” large displays to 1” types for numerical and indicator presentations including the latest 7 x 5 cm rectangular size.

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New Products

Toggle Switch
Rated at 30,000 operations at 24 V d.c. 3 A this single-pole changeover switch (type TS/1) combines small physical size with high reliability. The body of the switch is 0.375 inches in diameter and protrudes 1 inch behind the panel on which it is mounted. It has an initial contact resistance of 5 mΩ and the insulation resistance between the contacts and other parts of the structure is 10 GΩ, the open voltage between open contacts is 1.5 kV and between contacts and structure 2 kV. When used in a.c. applications the maximum current that can be handled is 1.5 A. Rendal Instruments Ltd, Victoria Road, Burgess Hill, Sussex.

WW 335 for further details

Digital R. F. Power Meter
An instrument that offers an instantaneous digital display of r.f. power on a linear or logarithmic scale has been announced by Pacific Measurements Incorporated, Palo Alto, California. The new instrument (Model PM 1009) is designed for both swept- and single-frequency power measurements from 10 MHz to 12.4 GHz. The three-digit standard readout is augmented by an over-range numeral, a unit annunciator and decimal-point indicator that minimize the likelihood of operator error. An analogue output is available for driving either an oscilloscope or X-Y recorder. Five linear and three logarithmic operating modes are provided. Linear ranges are from 1 µW to 10 mW full scale. Logarithmic modes are dBm, DB, and DB NULL. All are selected using pushbuttons. In the DB and DB NULL modes an offset control allows the analogue output to be adjusted to zero for any input power level. Thus, any desired reference level can be established so that the gain of the oscilloscope or recorder can be increased to permit a very small signal riding a large signal to be expanded and analysed in detail. The DB NULL mode is used for sweep-frequency measurements where a d.c. coupled oscilloscope is used to display the response curve. Digital readout indicates the difference in dB between the reference and NULL OFFSET. These two offsets can be used to bracket perturbations on the sweep display and the digital readout will indicate directly in dB the magnitude of these perturbations. Outputs on the rear panel coded in b.c.d. are available. For computer use, the digital display may be triggered from an external source over a range of zero to 1,000 readings/sec. An auxiliary input is provided so that frequency markers may be added to the swept-frequency display or two instruments may be connected together to make ratio measurements. An internal calibrator provides precise power levels of 1mW and 10 µW at 30 MHz for calibrating the instrument and verifying its operation. A thermistor in the detector mount provides temperature compensation from 15 to 45°C.

The high-gain direct-coupled input amplifier is chopper stabilized and temperature-sensitive components are oven mounted to ensure negligible drift. A non-linear noise filter may be connected ahead of a "d.v.m." input by means of a front-panel switch. This filter insures a clean display of noisy signals, yet allows relatively rapid response for large changes in signal level.

WW 306 for further details

Ladder Network
The cermet thick-film Series 811 ladder networks are designed for digital-to-analogue conversion applications over a wide temperature range. Eight standard models are available, depending on accuracy and temperature range required, with standard resistance values of 5, 10, or 20 kΩ. Tracking is better than 1 p.p.m./°C and settling time is typically less than 50 ns. Maximum output voltage ratio error is ±122 p.p.m. over the operating temperature range of −55 to +125°C. The units are less than 0.1 inch high, occupy one square inch of board space, and are fully sealed. The networks are constructed of cermet thick-film resistors of glass and precious metal fused to a 96% alumina substrate at temperatures above 1500°F. The identical material and processing for all resistors ensures uniform electrical characteristics and high stability. Because of the high thermal conductivity of the alumina substrate, low thermal gradients are maintained throughout the network. All the passive elements are protected from moisture by a polymer conformal coating. Beckman Instruments Ltd, Queensway, Glenrothes, Fife.

WW 318 for further details

Word Generator
Many digital systems can be tested using a repetitive pulse train which simulates the data normally handled by the system. The word generator WG 320 provides such pulse trains in a wide variety of different formats. Word length can be from one to sixty-four bits made up of four words of sixteen bits, or two words of thirty-two bits, or one word of sixty-four bits. Four channels each with two outputs are provided, the actual outputs being available in a number of different formats. (1) RZ fixed; return to zero after half basic bit spacing. (2) RZ variable; return to zero after a switch-selected interval, which must be less than 0.7 bit spacing; intervals available are 0.1, 0.5, 5 and 50 µs and 0.5, 5, 50 and 500 ms. (3) NRZ; Non-return to zero. Three operating modes are available and each may be used with the internal or an external source of clock pulses. These are (A) Continuous mode; all outputs generated repeatedly. (B) Single bit mode; upon operation of a single-shot control or upon application of a negative pulse of 2 V minimum to the "EXT TRIGGER" socket, all words progress by one bit. Reset to first bit of word is achieved manually. (C) Single word mode; operation of the single-shot control or the application of a pulse to the "EXT TRIGGER" socket generates one complete word at all outputs. Output four may be delayed relative to the other outputs provided the delay is less than 0.7 bit spacing, delay intervals available are 0, 0.1, 0.2, 2 and 20 µs, and 0.5, 2, 20 and 200 ms. Individual data bits are set in to the registers by means of two-position toggle switches. The following internal clock rates are available (switch selected on front panel) 2 MHz, 1 MHz, 100, 10 and 1 kHz and 1 Hz. External clock inputs can be up to 2 MHz and can take the form of either sine or square waves. Output impedance is 50 Ω and the rise and fall times of the output pulses are less than 15 ns. Two versions of the instrument are available the difference being in the polarities of the various pulses available. Price £475. Feedback Ltd, Crowborough, Sussex.

WW 310 for further details

Phase-Sensitive Detector
A set of measuring equipments known as the 400 range, is being introduced by Broodkeal Electronics Ltd, Myron Place, London S.E.13, at the rate of one a month during 1968, following a two-and-a-half year feasibility study. Each instrument will be fully compatible with all the others and will take the form of a system building brick, each brick being a complete instrument in itself. The first of these instruments is the phase-sensitive detector type 411. This instrument is built...
around a full-wave balanced gate covering a frequency range of 1 Hz to 1 MHz. Zero drift has been kept to a low level and very linear operation ensures that zero errors due to asynchronous signals are no greater than the drift (d.c. drift of zero level referred to f.s.d. × 0.005%/°C and with an in-phase input d.c. zero drift is <0.02%/°C). This has been achieved by employing error-compensating circuitry and by applying a high degree of feedback at d.c. and over the frequency range rendering tuning unnecessary and making swept measurements possible. The reference input signal can be varied over a 30-DB range (<3 V peak-to-peak into <10 kΩ) with an output change of less than 0.01% f.s.d. Mark-space ratio changes similarly have little effect on the output. The instrument requires 1 V r.m.s. input into 0.25 MΩ for a 10-V d.c. output that can be used for driving digital voltmeters, analogue-to-digital converters, potentiometric recorders, trigger units and galvanometric recorders.

A wide range of fixed time constants is available (suitable plastic film capacitors) and zero offsets is possible with a ten-turn potentiometer making slide-back measurements possible. Other features include a peak-reading overload indicator; two switched reference channels; a two-stage ladder filter for I.F. operation; provision for use as a balanced demodulator; sockets duplicated on rear panel for system use; and a reference-channel neon that indicates if sufficient amplitude of reference is being applied.

WW 328 for further details

Thump-wheel Switches

A range of decimal and binary-coded thumb-wheel switches available with ten positions engraved 0-9 or intermediate numbers of positions, in straight decimal or with any binary code (standard or special) are available from Kynmore Engineering Co. Ltd, 19 Buckingham Street, London W.C.2. Stops are fitted to customers’ specification. According to the manufacturers, an improvement has been made in the contact material. A layer of nickel is placed on the copper base and then a layer of gold, electrolytically bonded and stabilized. Thus a hard surface is combined with low and constant contact resistance. For computer programming circuits, speeded bridging or muting contacts are available as an overriding device. These contacts block the memory store during transient conditions and therefore prevent disruption of information when switching from one position to another. Alternatively they may be used to initiate another process. The units are available with standard or extended 0.156-inch printed circuit board terminations, with or without provision for diodes. Roller-tuned terminations are available to order. The delivery time for special codes is within four weeks.

WW 319 for further details

Gunn Effect Source

A GaAs Gunn effect X-band source that provides an output in the 7–12 GHz range is being manufactured by the Plessey Company, Edge Lane, Liverpool 7. The power output is 2mW minimum with a typical value of 5 mW. Current drain is approximately 70 mA and bias voltage may be varied to allow a maximum dissipation of 1 W. Operating temperature range is −55 to +85 °C.

WW 322 for further details

Pulse Generator

Repetition rates of 5 Hz to 50 MHz, positive or negative d.c. coupled outputs from 10 mV to more than 10 V and single- or double-pulse operation are features of the pulse generator model 110B being manufactured by Datapulse Inc., 10150 West Jefferson Blvd, Culver City, California, a subsidiary of the System-Donner Corporation. Rise and fall times of the instrument are independently variable from 4 ns, d.c. baseline offset is variable over a 12-V range and is held constant by a closed-loop system which detects and regulates the offset at the output of the instrument. The generator may be triggered externally or internally, synchronous and asynchronous gating is available and a synchronizing trigger output is supplied for all modes of operation. Pulse delay is variable from 15 ns advance to 50 ms delay, pulse width is variable from 10 ns to 5ms. Repetition rate, delay and width jitter errors are less than 0.05%, while overshoot, undershoot, ringing and top slope aberrations are less than ±3% at amplitudes of 300 mV and higher. Output stages cannot be damaged by any combination of panel-control settings, open or short circuits or back voltages of up to 10 V.

WW 327 for further details

Data Transmission

Test Set

The Datel Tester 1B has been designed under contract to the G.P.O. and is used for testing modems in the Datel service, checking data-transmission equipment and computer data links. It comprises a transmitter and receiver of d.c. signals in which the transmitter generates a range of test patterns and the receiver synchronizes those patterns to display peak distortion, bias distortion and error count. Peak distortion is indicated on a digital display from 0 to 49% early or late with an accuracy of ±1% ±1 digit. Bias distortion is indicated on a separate meter to an accuracy ±3% with the scale indications in 2% steps. Any signal element greater than 49% is considered an error. These are totalized and the stored count displayed up to a maximum of 2,047 counts. The error counter may be switched to display element counts or 511-bit pseudo random blocks in error. Trend Electronics Ltd, St. John’s Works, Tyders Green, Nr. High Wycombe, Bucks.

WW 314 for further details

Microcircuit Matched Transistor Pairs

DIFFUSED on a single silicon chip, using the planar process, this temperature stabilized matched transistor pair is intended for low drift d.c. amplifier applications. The device (μA726) is held at a constant temperature by a built-in active temperature regulator circuit that obviates the need for external ovens and individual heaters. Input offset voltage, at collector currents from 10 to 100 μA, is 1 mV. Input offset current, at a collector current of 10 μA and a VCE of 5 V, is 10 nA. Input voltage offset is 0.2 μV/°C; current offset drift being 10 pA/°C. The built-in temperature regulator consists of a transistor which acts as a heating element controlled by an amplified signal from a chip temperature sensing element. The system, which has a low standby dissipation, maintains the chip temperature at 130°C (+3°C) at ambient temperatures between 0 and 85°C. Applications of the μA726 include servo-amplifiers, instrumentation amplifiers, low level and low noise amplifiers and transducer amplifiers. It has been pointed out that the device may be used in conjunction with the SGS-Fairchild μA709 to produce a high performance amplifier with a gain in excess of 3,000,000. The μA726 is contained in a low-profile TO5 encapsulation. SGS-Fairchild, Planar House, Walton St., Aylesbury, Bucks.

WW 331 for further details

Delay-line Module

A small-capacity memory module for data processing applications with integrated-circuit compatibility has been developed by Sealectrọ Co Ltd, Farlington, Portsmouth, Hants. Designated Del-time Model 175A/RZ–90. The new module requires a gating signal, clock and power supply for operation. Information re-circulates serially, and in the absence of an erase signal, reads out
Instruments, Hainault, A push button. If being read rise time
Wide
WW 315
employs
dual
transmitters
and
receiver and pulse systems. Significant figures from the published specification are output power at 1-dB gain compression point +27 dBm minimum, temperature range –20 to +71 °C, power input is 28 V d.c. at 360 mA and the case size is 3.5 x 9 x 1.75 inches.
WW 315 for further details

Wide Range Oscillator
A low-cost (£35) oscillator that covers 10 Hz to 1 MHz in five ranges is being produced by Advance Instruments, Hainault, Essex. The generator, type SG67, will supply sine- or square-wave outputs at up to 2.5 V r.m.s.—the square-wave rise time is typically 50 ns. The output level is selected by a four-position push-button attenuator or a variable control, the output frequency being read on a horizontal "easy-to-read" scale. Two internal PP9 batteries provide the power and these can be checked by means of a front-panel push button. If mains operation is required a battery eliminator is available for £7 10s.
WW 311 for further details

Dual Standard V.T.R.
This outfit consists of a video tape recorder model CV–2100CE, a dual-standard 19-inch monitor model CVM2000, this also doubles as a normal dual-standard tv receiver, and a 625-line camera model CVC 2000 CE. The retail price of the complete system is £685. The tape deck uses 0.5-inch tape running at 11.25 i.p.s. (+ 2%) and employs helical scanning. One tape roll will run for 40 minutes and will rewind in 7 minutes. The tape speed settles down within six seconds of switch on. The recorder requires a composite video signal of 1.3 V peak-to-peak, negative sync. into 75 Ω. A choice of random or 2:1 interface is available; signal-to-noise ratio is better than 40 dB and the resolution is better than 240 lines on 625 and 360 lines on 405. The audio section has two inputs, Mic, at 600 Ω unbalanced (–60 dB), and line—10 kΩ balanced (–20 dB). The output is 5 kΩ unbalanced (0 dB). Frequency response, signal-to-noise ratio, and wow and flutter are: 80–100,000 Hz, ±6 dB, 5% and less than 0.25% r.m.s. respectively. The recorder incorporates 69 transistors and 34 diodes. Facilities include still frame, sound dubbing, duplication of tapes and automatic sound and vision level control. The camera is supplied with an f/1.9 25-mm lens and a tripod. Other accessories included are tape, carboindent microphone, desk stand, mains and microphone extension leads, lavalilier cord and a carrying case. Sony U.K. Division, Eastbrook Road, Gloucester.
WW 320 for further details

Miniature Trimmers
Using a high-permittivity film dielectric, a new range of miniature trimmer capacitors, type 809, announced by Mullard have a maximum capacitance of 20 pF within a body only 6 x 7 x 8 mm. Connections to the rotor are made by self -cleaning, silver -plated contacts; and the rotor and stator tags are spaced to match a 2.54-mm (0.1-in.) grid on printed -circuit boards. An asymmetric outline ensures correct orientation. Change of capacitance is made via a slotted adjuster head. Three versions are available with maximum capacities of 4, 10.8 and 20 pF; all have a 50-V d.c. rating and operate in the temperature range –40 to +120 °C. Mullard Ltd, Torrington Place, London, W.C.1.
WW 316 for further details

Standby Power Units
Two inverter standby power units for supplying 250 V at 30 Hz from 12- and 24-V batteries are being produced by Ekco Electronics Ltd, Southend-on-Sea, Essex. These units, which have sine-wave outputs, will supply signal generators, oscilloscope recorders and other laboratory equipment for mobile use. Provision is made for supplying the load directly from the mains with automatic changeover to inverter operation in the event of a mains-supply failure. Type E236 is available for 12- or 24-V battery operation, having a power output of 120 W. The 12-V unit will also reverse to operate as a battery charger with manual selection of the charge rate. Type E239 operates from a 24-V battery and has a power output of 200 W. Current drawn from the batteries is switched by power transistors and fed to the mains output at any load up to full rating. The inverter circuit is protected against damage if the output is short -circuited.
WW 308 for further details

Wire Stripper
The stripper consists basically of two articulated levers, operating against a return spring, one of which manipulates the cutting and stripping blades, and the other the gripping jaws. The cutting and stripping blades can be infinitely adjusted to strip wires from 0.3 mm to 4.0 mm O.D. The setting, by trial and error, is achieved with a simple lock nut and screw. The stripping blades are of toughened steel and are replaceable. A stripped length of up to about 15 mm can be obtained. The Six-In hand wire stripper weighs 5 oz and costs 50s. Henri Picard & Frere Ltd, 34/35 Purnell Street, London, E.C.A.
WW 313 for further details

Oscillator and Selective Level Measuring Set
Two instruments have been introduced by the Testing Apparatus and Special Systems Division of Standard Telephones and Cables Ltd. Known as the 74308 Oscillator and 74309 Selective Measuring set, they are companion instruments for testing a wide range of telephone transmission systems. Spanning the frequency range 250 Hz to 1620 kHz they may be used on audio, open -wire, balanced -pair, and coaxial systems of up to 300 circuits. One of the aims of the design has been to eliminate unnecessary switching when testing a particular system, and the five frequency bands have been chosen for this purpose; thus, audio and broadcast frequencies are covered in one band, coaxial supergroup No 1 in another, basic supergroup No 2 in a third and so on. Similarly three output impedances are available to cater for
the requirements of different systems. An automatic tracking signal from the oscillator can be used to obviate manual tuning of the s.l.m.s. when making loop measurements. During end-to-end measurements, or when an external signal source is used the automatic tracking facility is not available. In these circumstances, a slight change of frequency in the signal being measured would normally seriously affect the level as measured by the equipment in the selective condition, owing to the steep slope of the narrow-band filters in its input circuit. An automatic-frequency-control circuit is therefore provided. If this is selected and the equipment has been tuned to the signal, it will remain tuned even if the signal drifts by ±300 Hz from its original frequency. In addition to making selective in-channel measurements in the presence of traffic in adjacent channels, the s.l.m.s. can also be used for making wideband measurements; e.g., for fault location on carrier systems taken out of service. An optional accessory is also available for making return-loss measurements. The oscillator has a slow-motion drive, and built-in frequency checking circuit for checking the calibration at intervals throughout the range. A further feature is the provision of an off-cycles facility which permits the frequency to be set accurately between the calibration points. Both instruments are portable and operate from either a.c. mains or an external d.c. supply of 19 to 21 V. Their dimensions are 22 × 15 × 83 inches (559 × 381 × 222 mm); their weights are 40 lb (18 kg) for the oscillator and 50 lb (22.7 kg) for the s.l.m.s. Standard Telephones and Cables Ltd, STC, House, Strand, London W.2.

**WW 317 for further details**

### Illuminated Pushbutton Switch

The Licon 02–800 range of illuminated pushbutton switches, manufactured by the Plessey Components Group's Microswitch Unit, Titchfield, Hampshire, is an extension of the 01–800 series, and offers four additional features. These are, two stationary lamps which can be independently connected if required, horizontally or vertically split lens caps; "snap-on" switch modules, with momentary or maintained action; and "snap-on" solenoid units. The new series will fit the panel cut-out for the type 01–800. The new push-button switch has snap-in mounting and a combination bezel-barrier presentation and a choice of seven screen colours is offered. The switches are suitable for horizontal or vertical matrix mounting requiring individual rectangular holes 1.00 in. by 1.14 in. for single units and additional 1.250 in. per switch for matrix mounting. One to four-pole momentary or maintained snap-on switch modules are available as standard, each pole being s.p.d.t. or two circuit. The basic two-circuit microswitches are rated at 10 A, 125/250 V a.c., 30 V d.c.

**WW 324 for further details**

### Rotary Edge Switch

Low cost, coded in binary or decimal, legend to customers requirements, with or without internal illumination, modular design and simplicity of installation are features of a ten-way thumbwheel switch announced by Argos Instruments Ltd. The body of the switch is moulded in Styron 45 and measures 2.09 × 0.433 × 2.09 inches. It has a life expectancy in excess of 100,000 operations and a one-off price of 22s. Argos Switches Ltd., Island Farm Avenue, West Molesey Trading Estate, Molesey, Surrey.

5% Zener Range

A Family of zener diodes encapsulated in hard thermosetting epoxy resin, complementary to their glass encapsulated BZ188 series, has been recently introduced by Mullard. The diodes, BZX61 series, have a rating of 400 mW at temperatures up to 50°C and nominal voltages between 33 and 75 V following the logarithmic series of preferred values. With a junction temperature of 25°C the devices will withstand a surge of 50 W for a maximum of 100 μ sec. Other maxima from the specification include a zener current of 250 mA and a junction temperature of 175°C. The case outline is similar to the DO-7 but with 0.03 inch diameter leads to reduce the thermal resistance, the cathode connection being at the "coned" end of the encapsulation. It is of interest to note that this type of package has recently been granted CV approval. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

**WW 312 for further details**

### Medium Torque Potentiometers

The Potentiometer Division of S.T.C. has announced a new range of medium torque potentiometers in six sizes ranging from 1.5 to 4.5 watts. Designed to conform fully with international frame size requirements, the new QR series makes use of a circular section former and offers many improvements over conventional types. A new dished slip-ring wiper contact is housed in an "L"-shaped insulator which ensures rigidity and gives an operating life of better than 5 × 10^6 sweeps of the winding. Starting torque for the scaled types is 8.5 Ncm (12 oz. in.) and 0.305 Ncm (0.4 oz. in.) for unsealed types. Mounting is by means of servo, bush or three-hole fixing and a chromodized finish is standard. S.T.C. Potentiometer Division, Broad Lane, Leeds 13.

### Digital Readout

A monolithic silicon integrated circuit performs the decoding and indicator driving functions in the type TNR 70A readout unit produced by Litton Precision Products International Inc., 503 Uxbridge Road, Hayes, Middx. Measuring only 1.75 inches high, 1 inch wide and requiring 1.4375 inches behind the panel, the unit requires an n.b.c.d. (1, 2, 4, 8) input using the negative logic convention, 0 to +0.4 V for a 1
Logic Interface Elements

High voltage logic interface elements that translate standard 5 V logic levels to levels up to 30 V are available from the Microelectronics Division of Electrol Inc. The three elements, just introduced, consist of the 8T18 dual two-input Nand gate, the 8T80 quad two-input NAND gate, and the 8T90 Hex inverter. All are available in either 14 leads glass flat packages in two temperature ranges, 0° to +70°C or -55 to +125°C. The 8T18 is a high input voltage element that will accept input voltage swings of between 8 and 30 V and provide an output in standard 5 V logic. This gate operates from two power supplies, 20–30 V for the input stages and 5 V for the output stage, which has the active pull-up pull-down type of circuit making it suitable for line driving applications. The 8T80 and 8T90 are the low to high voltage interface elements. Microelectronics Division, Electrol Inc., Lakeside Estate, Colnbrook, Bucks. WW 330 for further details.

Tell-tale Temperature Detector

A small disk, no larger than 0.25 inches in diameter, that turns permanently black if exposed to a temperature within 1% of given value is available from A. Levermore & Co. Ltd, Broadway House, Broadway, Wimbledon, S.W.19. The disks, called Tem-plates, can easily be mounted within a product or externally as part of a nameplate, they are available in 42 increments between 100 and 500°F. Picture shows disk with a match-head. WW 303 for further details.

16-Bit Memory

Housed in a standard hermetically sealed dual-in-line flat-pack, the MuL 9033 micrologic memory cell consists of 16 r.s. flip-flops arranged in an addressable four-by-four matrix. The main application for this device is in high-speed "scratch pad" memory systems. It has a typical access time of 15 ns and requires a write pulse of 25 ns duration. Delay between addressing and reading a previously stored bit is less than 20 ns and not greater than 35 ns between reading and writing. Up to four locations may be simultaneously addressed without destroying the stored information. The component dissipates 310 mW and the output is capable of sinking up to 40 mA. Word expansion is relatively easy as the wired or connection is possible (one external resistor being required to "pull up" linked outputs). SGS-Fairchild Ltd., Planar House, Walton Street, Aylesbury, Bucks. WW 333 for further details.

Wireless World, April 1968
April Meetings

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

LONDON


2nd. I.E.E.---Discussion on "Microwave electronic wattmeters" opened by Prof. H. E. M. Barlow at 17.30 at Savoy Pl., W.C.2.

2nd. I.E.R.E. & I.E.E.---Discussion on "Assessing computer performance" at 18.00 at the London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

2nd. S.E.R.T.---"Field effect transistors" by E. F. Munro at 19.00 at Carshalton College of Further Education, Nightingale Rd., Carshalton.

4th. I.E.E.---Graham Clark Lecture "Place of engineering in relation to society as a whole" by Lord Jackson of Burnley at 17.45 at Savoy Pl., W.C.2.


17th. I.E.E.---Discussion on "Views on relativity and gravitation" opened by Dr. L. Essen at 14.30 at Savoy Pl., W.C.2.


23rd. I.E.R.E.---"Simulation safety and the air traffic engineer" by P. C. Haines at 18.00 at 9 Bedford Sq., W.C.1.

25th. I.E.E.---"Recent developments in meteorology and the world weather watch" by Dr. B. J. Mason at 17.30 at Savoy Pl., W.C.2.

25th. I.E.R.E.---"A realistic appraisal of the higher national certificate" by Dr. H. L. Haslergrave at 18.00 at 9 Bedford Sq., W.C.1.


29th. I.E.E.---"Magnetic equivalent circuits for electrical machines" by Prof. E. R. Laithwaite at 17.30 at Savoy Pl., W.C.2.

29th. I.E.E.---"Revital ideas" by Dr. D. E. N. King at 17.30 at Savoy Pl., W.C.2.


ABERDEEN


BELFAST

28th. I.E.E.---Faraday Lecture "Medical Electronics" by D. W. Hill at 19.30 at the Sir William Whitla Hall, Queen's University.

BIRMINGHAM

17th. R.T.S.---"Further thoughts on colour television" by C. B. Wood at 19.00 at the Medical Inst., Harborne Rd., Edgbaston.


29th. I.E.E.---"Current developments in the deep sea fishing industry" by R. Bennett at 18.00 at the M.E.B. Offices, Summer Lane.

BRISTOL

9th. R.T.S.---"B.B.C. Colour TV—review of the first six months" by T. H. Bridgeswater at 19.30 at the Reception Rooms BBC, Whiteladies Rd.

10th. I.E.R.E. & I.P.P.S.---"Gunn effect phenomena" by B. R. Pampolin at 19.00 at the University.

CARDIFF

5th. I.E.R.E.---"Deca system of navigation" by J. Davies at 19.30 at Llandaff Technical College, Western Ave.

COLEGHESTER

24th. I.E.R.E.---"M.O.S. transistors" by G. G. Bloodworth at 19.00 at the University of Essex, Wivenhoe Park.

CRAWLEY

25th. I.E.E.T.E.---"Electronic control in industry by Woodenridge at 19.30 at the Lecture Theatre, the College of Further Education, College Rd.

DUBLIN

24th. I.E.E.---Faraday Lecture "Medical electronics" by D. W. Hill at 18.00 at Trinity College.

DUNDEE

11th. I.E.E.---"Post Office towers and trunks" by J. H. M. Merriman at 19.00 at the University.

EDINBURGH

9th. I.E.R.E.---"Electronic testing and control in the wool industry" by B. Hegly at 19.00 at the Dept. of Natural Philosophy, the University.

EVECHAM


GLASGOW

10th. I.E.R.E.---"Electronic testing and control in the wool industry" by B. Hegly at 19.00 at the Insts. of Engrs. and Shihbids, 39 Elmbank Cres., C.2.

HARLOW

3rd. I.E.R.E.---"Industrial design in the electronics industry" by M. Rowlands at 19.00 at the Technical College, The High.

LINCOLN

2nd. I.E.E.---"Semiconductors in television receivers" by P. L. Moseholme at 19.15 at the E.M.E.B. Showrooms.

LIVERPOOL

1st. I.E.R.E.---Demonstration and lecture on "Colour television" by J. R. Sanders at 18.30 at the University.

MANCHESTER


29th. I.E.E.---"Lecture/Discussion "The future education of electronic engineers" by Prof. G. D. Sims, Prof. W. A. Gambling and B. H. Venning at 18.15 at the College of Science & Technology, Altrincham St.

MIDDLESBROUGH

19th. I.E.E.---"Sound about the home" by D. Cook at 18.30 at the Cleveland Scientific Inst.

NEWCASTLE-UPON-TYNE

1st. I.E.E.---"Applications of electronics to medical automation" by H. S. Wolff at 18.30 at the Rutherford College of Technology.

10th. I.E.R.E.---"Half megabit data transmission system" by R. E. Ross at 18.00 at the Inst. of Mining and Mechanical Engrs., Neville Hall, Westgate Rd.

NORTHWICK

23rd. I.E.E.---"Blind landing of aircraft" by G. Harrison at 19.30 at the Assembly House.

READING

30th. I.E.R.E.---"Modern techniques in digital voltmeters" by G. W. Bolton at 19.00 at the J. J. Thomson Physical Lab., the University.

ST. AUSTELL


SALISBURY

2nd. I.E.E.---"Electromagnetic levitation" by Prof. E. R. Laithwaite at 18.30 at the Salisbury & South Wilts College of Further Education.

SHEFFIELD

10th. I.E.E.---"The origins and growth of electronics" by F. A. Benson at 18.30 at the Royal Victoria Hotel.

STONE


WOLVERHAMPTON

3rd. I.E.E.---"Specialised application of electronics in medicine" by J. G. Davies and R. L. Howard at 19.15 at the College of Technology, Wolverhampton.

April Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses.

LONDON

Apr. 8 & 9 I.E.R.E., 9 Bedford Sq., London W.C.1

Apr. 18-21 Hotel Russell

Apr. 22-24 I.E.E. Savoy Pl.

Thick Film Technology (Rex Hassan, 42 Manchester Sq., London W.1)


Heavy Particle Collisions (I.P.P.S., 47 Belgrave Sq., London S.W.1)

Cardiff Radio (I.E.R.E., 47 Belgrave Sq., London S.W.1)

Cathays Park

Audio Visual Aids Conference and Exhibition (National Committee for Audio Visual Aids in Education, 33 Queen Anne St., London W.1)


DURHAM

Apr. 2 & 3 The University

Semimetals and Narrow Gap Semiconductors (I.P.P.S., 47 Belgrave Sq., London S.W.1)

Oxford

Apr. 1-4 Playhouse Theatre

Properties and Metrology of Surfaces (Inst. of Mech. Engrs., 1 Birdcage Walk, London S.W.1)

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PIDAM (Plug-in Digital and Analogue Modules) perform all the usual logic functions, but, unlike other units, can be plugged into their BPA and can be quickly connected to the required system. To help learning, the plug-in covers are easily removable for circuit examination and sets of components are available. The 16 modules have an enormous range of use, from a single MONO for a rachometer, to over 300 units in a computer interface; nevertheless, their greatest asset is extreme simplicity. Design time is cut and elaborate boardworks superfluos and any reader of "World" could with PIDAM, build up a low cost system for his own needs.

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Printed circuits chassis type "A" which fit into 1277 or 1617/2 case, or type "Q" which are mounted on an aluminium chassis. Both types take up to 20 boards and connectors on j/n centres. Prices from 45/6 down to 37/- for quantities.

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Wireless World, April 1968
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Wireless World, April 1968

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WIRELESS SET No. 76
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A compact CW only crystal controlled transmitter. Consists of a Pierce crystal oscillator (807) and a Power Amplifier (807). Both are cathode keyed by means of a relay. Six switched crystal channels are included in the frequency range of 2 to 12 Mcs. (Crystals not included.) Aerial current is indicated on a panel meter and two spare ones are supplied. Operation from 12 v. car battery via internal rotary transformer. RF output 9 watts. Contained in steel case 12x12x8 in. Weight 30 lbs. Ideal for surplus, BRAND NEW, in all original sealed carton. Carr. 10/-, extra per item. Special offer of 10% for schools and technical colleges, etc.

WIRELESS SET No. 76
A compact CW only crystal controlled transmitter. Consists of a Pierce crystal oscillator (807) and a Power Amplifier (807). Both are cathode keyed by means of a relay. Six switched crystal channels are included in the frequency range of 2 to 12 Mcs. (Crystals not included.) Aerial current is indicated on a panel meter and two spare ones are supplied. Operation from 12 v. car battery via internal rotary transformer. RF output 9 watts. Contained in steel case 12x12x8 in. Weight 30 lbs. Ideal for surplus, BRAND NEW, in all original sealed carton. Carr. 10/-, extra per item. Special offer of 10% for schools and technical colleges, etc.

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VAN DAM ELECTRONICS—ROTTERDAM, HOLLAND

MOS-FIELD EFFECT TRANSISTORS

| 3N128 | N     | 20 | 20 | 8.0 | 5-30 | 0.05 | 100 | 5,000-12,000 | 800 | 5.8/0.2 | £1 0 4 |
| 3N140 | N dual gate | 20 | 20 | 8.0(8) | 5-30 | 1 | 150 | 6,000-18,000 | 300 | — | £1 2 2 |

Thyrists

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<th>If peak</th>
<th>Ig peak</th>
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<td>100</td>
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Silicon Diodes

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<td>1(0.7)</td>
<td>30</td>
<td>0.05</td>
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LINEAR INTEGRATED CIRCUITS


CA 3012 High Frequency Amplifier, TO-5. Bandwidth 100 KHz-20 Mhz. Gain 55-61 dB/10, 7 Mhz. Price £1/18/-.


CA 3020 Low frequency amplifier Bandwidth 6 Mhz, TO-5. Gain max. 52-58 dB. Sensitivity 35 mV. Output max. 700 mW. Input Impedance 40 Kohm. Output impedance 65 + 65 ohm (push pull). Price £2/6/6.


uA 703 TO-5 High Frequency Amplifier, bandwidth 150 Mhz. Gain 36 dB/10, 7 Mhz. Gain 20 dB/100 Mhz. Price £2/16/-.  

MIC 709 c TO-5 Differential amplifier, bandwidth 0-500 Khz. Voltage gain 45,000 typ. Output voltage max. 13 V pp. Price £4/6/-.  

DIGITAL INTEGRATED CIRCUITS. (All circuits dual-in-line)

<table>
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<tr>
<th></th>
<th>Resistor-transistor-logic</th>
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<th>DTL-series (diode-transistor-logic)</th>
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<td>£1 3 0</td>
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<td>MC 718 P</td>
<td>dual 3-input gate</td>
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<td>MC 719 P</td>
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<td>£1 3 0</td>
<td>MC 832 P dual buffer</td>
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<td>MC 788 P</td>
<td>dual buffer</td>
<td>£1 9 1</td>
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<td>MC 789 P</td>
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<td>£1 6 0</td>
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<td>MC 790 P</td>
<td>dual J/K Flip-Flop</td>
<td>£2 3 0</td>
<td>MC 846 P quad 2-input gate</td>
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<td>MC 792 P</td>
<td>triple 3-input gate</td>
<td>£1 6 0</td>
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RTL-series (TO-5 case)

uA 923/926 J-K flip flop | £1 1 5 |

SPECIAL OFFERS:


Silicon Transistors: BC 171 b Vce 45 Volt. Ie 100 mA. Pce 200 mW. Hfe 250-500 Fs 300 Mhz. Price 2/6  


Both types pro 100 pieces. Price £10/15/-.  

The noted prices include all taxes etc.
**NEW! SOLID STATE HIGH FIDELITY EQUIPMENT**

**POWER AMPLIFIERS—PRE-AMPLIFIERS**

**POWER SUPPLIES—BRITISH MADE**

<table>
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<th>TRANSISTORS—SEMICONDUCTORS</th>
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<td><strong>COMPLETE NEW 1988 LIST OF 1000 VALUES SUBMITTED FROM VARIOUS MANUFACTURERS</strong></td>
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<tr>
<td>B</td>
<td>13 watt mono for 3 to 5 ohm speakers</td>
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<tr>
<td>C</td>
<td>25 watt mono for 12 to 16 ohm speakers</td>
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<td>D</td>
<td>24 watt mono two channel for 12 to 16 ohm speakers</td>
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<td>E</td>
<td>20 watt mono/mono for 12 to 16 ohm speakers</td>
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<tr>
<td>F</td>
<td>24 watt mono/mono for 3 to 5 ohm speakers</td>
</tr>
<tr>
<td>G</td>
<td>40 watt mono/mono for T1 to 16 ohm speakers</td>
</tr>
</tbody>
</table>

| MANY OTHERS AVAILABLE | Send for full details |

**AUTO-RAN TRANSISTOR CAR RADIO. British Made**

- 6-Transistor MV/LW Car Radio. 12 volt operated. 3 watt output.
- De Luxe Five Push-button service with instruction on £9/19/6. P.P. £4.4.

**BUILD A QUALITY TAPE RECORDER WITH MARTIN RECORDAKITS**

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- Today’s Value £55.

**GARRARD DECKS**

All the Latest Models

**COMPLETE RANGE IN STOCK FROM £15.15.6**

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**GRANVILLE FIREFIGHTER UNIT**

Containing 931A Phono McPhilect and Network with Cold Cathode Relay—totally enclosed in metal case £4 £3 £2

**OUR PRICE, BRAND NEW £6 each, with data sheet. Limited quantity available.**

**40 WATT AND 15 WATT INVERTER KITS**

15 WATT

- Input 12/14 volts D.C. at 2 amps.
- Output 240 volts 50 c/s 40 watts or 300 volts about 7.8 watts.

Transformer type T751.

40 WATT

- Input 12/14 volts D.C. at 5 amps.
- Output 240 volts 50 c/s 40 watts or 300 volts about 7.8 watts.

Transformer type T757.

**MAYFAIR PORTABLE ELECTRONIC ORGAN**

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- Valve Free Phono Amplifier.

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- Fully TRANSISTORISED POLYFONIC British design.
- On APPLICATION EXPENSES AVAILABLE.

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**IMMEDIATE DESPATCH**

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**VARIABLE VOLTAGE TRANSFORMERS**

Modern styling for modern equipment

*SLIDE-TRANS* & *SLIDUP* MODELS

Fully rated current consistent at all points along the winding

AVAILABLE ONLY FROM I.M.O.

- **SMOOTH CONTINUOUS ADJUSTMENT**
- **ALL MODELS SHROUDED FOR SAFETY** (IDEAL FOR EDUCATIONAL AUTHORITIES)
- **BENCH OR PANEL MOUNTING**
- **UP TO 260V. AVAILABLE FROM ALL MODELS**

All models 230V, A.C. 50/60 c.p.s. Input

- 1 Amp. £5.15.0
- 2.5 Amp. £6.17.6
- 5 Amp. £9.19.0
- 8 Amp. £14.15.0
- 10 Amp. £18.10.0
- 12 Amp. £21.10.0
- 20 Amp. £38.10.0

C. & P. EXTRA

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**TRANSISTORISED MEGOHMETER**

**PUSH BUTTON TO READ**

500 v. - 1,000 Megohms. Superb portable instrument. Supplied c/w batteries, probes and carrying case.

**ONLY £25.0.0** C. & P. 74.

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**36 FT. AERIAL MAST**

**NEW LATEST PATTERN TUBULAR MAST**

Check these vital points:

- Made from 6 x 1/16. Shergal steel sections, for durability and strength.
- Extra strong locating cap.
- Top cap with fitted pulley and halyard.
- 3 sets (B) Retaproof Guys.
- Rustproofed steel picketing stakes.

**ONLY £15.0.0** ex works

Carry 30 ft. Returnable wooden case 40 ft.

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**VARIABLE HIGH VOLTAGE SAMPLING TESTER**

**DIELECTRIC BREAKDOWN TESTER**

- **Range:** Infinitely variable up to 3,000 volts 0.1 amp.
- **Entirely suitable for continuous testing**
- **Automatic safety cut-out. Input:** Mains voltage. Input and test leads with clips.

Model T30 C. & P. 25.0

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**CONSTANT VOLTAGE TRANSFORMERS**

**AUTOMATIC MAINS STABILISER**

- **No attention**
- **No Maintenance**
- **No Moving Parts**
- **Corrected Wave**


**£12.10.0** C. & P. 20.

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**LATEST SOLID STATE VARIABLE VOLTAGE CONTROL**

- **COMPLETELY SEALED**
- **COMPACT AND COMPLETE**
- **PANEL MOUNTING**

230 volts A.C. Input 25-230 volts output.

5amp. model £6/7/6
10amp. model £13/6/6

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**PORTABLE VARIABLE A.C. POWER SUPPLY UNIT**

Designed for engineers whose requirements call for a visual indication of volts applied.

**OUTPUT:** 0-250 v. 15 amps.

**INPUT:** 230 v. A.C. 50/60 c.p.s.

Fitted with fuse, voltmeter, safety indicator on/off switch and lead.

Size 8 x 5 x 3 in. High.

**PRICE £9.2.6** C. & P. 12/6

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**PORTABLE TRANSISTOR TESTER**

SUITE FOR PRODUCTION & LABORATORY USE

**SPECIFICATION:**

- Alpha 0.7 to 0.997
- Beta 5-300
- ICO 0.50uA. 5mA.

Capable of measuring GERMANIUM AND SILICON DIODES.

**DESIGNED WITH RESISTANCE SCALE 200 ohms to 1 Megohm as an ADDED FEATURE.**

Housed in heavy duty plastic case, c/w internal battery.

**Only £6.19.6**

Plus 7/4 C. & P.

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(I.ELECTRONICS) LTD.

(Dept. W.W.7), 313 Edgware Road, London, W.2.

Wireless World, April 1968
Lasky's Radio

DON'T MISS THIS!

Lasky's Birthday Draw
The following 65 numbers have been drawn for our 50th Birthday Draw. Please refer to Parts 3, 5, 7, 10, and 12 of your Catalogue for details of our 10th Birthday number (on the Front Face of your Catalogue). 19 numbers have been drawn and are as follows:
00899 00320 00133 00721 00841 00646 00341 00140 00974 00510 00458 00762 00442 00920 00491 00771 00533 00919 00264 00922

The first 10 correct entries to be opened will receive 5 Lasky's Gift Vouchers. The next 25 will receive £1 Vouchers and the last 30 a complimentary 10% Voucher.
Post: Messrs Lasky's Radio, 25 Market Place, Newbury

COMMUNICATION RECEIVERS

TRIO JR-500GE
This high performance receiver is a monaural type capable of receiving the amateur bands and utilises a crystal controlled tuning system. It is fitted with a 9 inch screen and has volume and sensitivity control. Limited stock.

Lasky's Price £61.19.0
Carriage and Packing Free.

TRIO 9R-59DE
A really first-class HI-FI Stereo Amplifier Kit. Uses 14 transistors giving a watts push pull output from push-pull 12W transistors. Integrated circuit. Hi Fin, 12W output, 2 watts from each channel. Suitable for any speakers from 3 to 12 ohms. Unbeatable deal, all parts supplied including metal case. 6314 Base, attractive front panel, knobs, wires, solder, nuts, etc., no extra to buy. Simple to assemble with step instructions enable any constructor to build an amplifier to be proud of. Direct Amplifica- tion: Pre, crossover, 12W output. Mono or stereo output. Circuit and layout diagrams. 

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Designed for HI-FI reproduction of records. A.C. coupled output. Heavy built on panel heavy gauge metal chassis. 6W, 1.5W, 4W. (See chart. Separate pre-amp, heavy built on panel heavy gauge metal chassis. 6W, 1.5W, 4W. (See chart. Separate base. Treble and volume controls, giving fully variable boost and cut with negligible hum. Heavy negative feedback loop over 2 stages. 2x12W output at excellent quality with very low distortion factor. Suitable for use with polar, omnidirectional or record player. Provision for remote mounting of control or direct on cabinet. All the electrolytics on to a class b size only 7W, 2 for 4.4m. Overall height 4W. All components and valves are heavy duty. Very close and uniform instructions enable even the new constructor to build with confidence, 6 power transistors, 16 stages, 12W output, 2W output per channel. New HA34 circuit. 

BRAND NEW 3 OHM LOUDSPEAKERS

BRAND NEW 3 ohm 125W. M.D. Specials. 3 or 12 inches. Complete to loudspeaker box and included accessories. Offer of 6 for £21.42. P. & P. included. 

BRAND NEW 3 ohm 125W. M.D. Specials. 3 or 12 inches. Complete to loudspeaker box and included accessories. Offer of 6 for £21.42. P. & P. included. 

DE LUXE QUALITY PORTABLE RECORD PLAYER CABINET

SERVICE TRADING CO.

LIGHT SENSITIVE SWITCHES
Kit and parts including ORP-12 Cadmium Sulphide Photocell, Relay Transformer and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt set-up. Prices 35c, plus 1/2 P. & P. ORP-12 and Circuit 150c. plus 1/2 P. & P. A.C. MAINS MODEL incorporates mains transformer rectifier and special Circuit. New in pack. Controls include circuit, 47c, plus 1/2 P. & P.

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Can be set for counts of up to 500 per minute. 2-1/2 X 205 v. Also 12 volt units, including photo cell, high speed non-resettable counter, transformer, relay & complete circuit diagram. 3/34, plus 1/2 P. & P. With resettable counter, 4/24, P. & P. 3/4.

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Precision manufactured light source with adjustable lens assembly and ventilated lamp housing to take 120 volt. Separate photo cell mounting assembly for ORP-12 with potted window. Both units are single hole fixing. Price per pair 6/19.50 plus 1/4 P.

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A complete composite apparatus, comprising a robustly built Transformer and electro-magnet with removable coils and pole pieces, coil tapped for 230 v., 220 v., 110 v., 115 v. and 100 v. A.C. These coils are also used for D.C. experiments. Complete with all accessories as shown. 6/19 plus 1/4 P. Extras as required.

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Type CV337. Supersedes Blue-3a, complete with special P.T.F.E. drift tube and divider network, 57c, incl. P. & P.

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3 figure, 24 v. D.C. operation (Illustrated). Similar style with 5 or any number up to 999 reducing to zero. Extra 2/34, P. & P. 2/16.

LATEST HIGH-SPEED MAGNETIC COUNTERS (non-resettable)
4 figure, 10 impulses per second. Type 100A, 500 ohm coil. Either 15c each, plus 1/2 P. & P.

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These fantastic ex WD magnets weighing only 81b. will lift weight over 100 lb. Fitted with swivelled handle and rubber grip. 4 x 7 x 1in. 3 x 1/2 x 1/2in. Packed in original maker's cases of 2. Price 25c per pair, plus 3/4 P. & P.

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SUPER SPEED MORSE KEY
2 adjustable positions, press adjustable w/ p.m.o. to set high as you like. A useful key for Morse practice. 24 c. plus 1/2 P. & P.

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Fitted 24m. Moving Coil Speaker. Uses type PF7 or equivalent. Available without long design Morse key. 22/4, plus 1/2 P. & P. 3/4.

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4 x 4.5 volt units connected series, output up to 2.8-3.0 m.a. in sunlight. 30 times the efficiency of selenium cell. As used in power supply for Telephones.

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Teaches the principles of light sensitive devices and their applications.

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R.S.C. AI15 15 WATT HIGH FIDELITY ALI (P.A.)

DUAL PURPOSE P.A. or HI-FI SOLID STATE CIRCUIT

- FM/AM Tuner - 5 Band Stereo - 100W True RMS - 48 Volt/Input

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Shipping: Free

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FULLY TRANSISTORIZED 250/600 v. A.C. OUTPUT 15 WATT S.M.A. into 8 ohms. 15 WATT S.M.A. into 4 ohms. 15 WATT S.M.A. into 150 ohms.

Price: £19.99

Shipping: Free


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Price: £50

Shipping: Free

R.S.C. SUPER STEREO AMPLIFIER


Price: £50

Shipping: Free

R.S.C. TA12 12 WATT STEREO AMPLIFIER

FULLY TRANSISTORIZED, SOLID STATE CONSTRUCTION, HIGH FIDELITY. OUTPUT OF 4 WATTS PER CHANNEL (2 ohms) at 1% distortion with any crystal or ceramic gram. P.C.U. (Pre-Cable Input Unit) for Tone-Transformer, Tape Recorder, "Mike," etc. 3 separate switches for Tone-Transformer (with BASS, TREBLE and MID-FREQUENCY control), 30W/60W/120W. Switch for mono use.

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Shipping: Free

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MODEL: RL3000. P.A. 30 WATT OUTPUT (15 WATTS/CHANNEL). BUILT IN CROSS OVER CIRCUIT. HARMONIC DISTORTION 0.2% AT 150 WATT OUTPUT (15 WATTS/CHANNEL). ELECTRO-SHIELDED CHASSIS. TONE CONTROL. CROSS OVER CIRCUIT FOR USE WITH 15 WATT SPEAKERS.

Price: £60

Shipping: Free

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PLUS FULL REPAIR DATA FOR
800 POPULAR
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Big time-saving repair library
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Including—Integrated Tuners, Stereo Multiplex Broadcasting—The Zenith—G.E. System, Receiver and decoder and adjustments, Aerial, etc. Colour TV Receivers, Colour TV Test Card F, Servicing Transistor Equipment, Chemical Aids to Servicing, Batteries and Rechargeable Cells, Sound-on-Sync, Double Line Sync, Silicon Transistors, etc.

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If you are under 21 your father must fill in coupon.

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RV3/35B1

WIRELESS WORLD, April 1968
LIND-AIR

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For model makers, model engineers, radio, television and electronics enthusiasts.

Motor

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Wireless World, April 1968

www.americanradiohistory.com
Complete Hi-Fi Stereo System

ALL TRANSISTOR & WATS PER CHANNEL STEREO HI-FI SYSTEM OFFERING A PERFORMANCE EQUAL TO IF NOT BETTER THAN NAME BRAND SYSTEMS COSTING UP TO DOUBLE THE PRICE. Modern styling plus all modern circuitry using latest silicon transistors throughout. The famous LINDAIR EIGHT RENCH Changeable light bright tubes with MONOFORE STEREO & MONO DIAMOND CARTRIDGE will play all sizes of records. (4 speeds 7S, 45, 331/3, 18) r.p.m. will play up to 3 records automatically, also player for manual play. Amplifiers and motors are mounted below record player and stereophonic. Bass, Treble, Balance, Tuning, Stereo switch. TWO IDENTICAL LOUDSPEAKER SYSTEMS each having own treble, mid and bass drivers. Distance controls separate bass speakers and tweeters.全て立体声放音機。スピーカー2つ個別に調整。簡単な操作で高音、中音、低音を調節。Diode pri.. $32.25 - Car. 7/6. tomb. $31.50 - 10/-.

All D.C. 600, 120, 300, 62/6. ELECTRONIC KIT part. 5 P. 5/6. Stethoscope, 5 P. 5/6. FANTAVOX MARVELLOUS HI-FI STEREO SYSTEM. Only 59*. plus 50/- Carriage and Insurance. (Reserved Satin $ 3 extra.) (Perspex Cover 3 extra, extra.

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LIND-AIR PRICE £9 19.6 Carr., Pkg. & Ins. 5/-
ELECTROLYTIC CONDENSER FANTASTIC SELECTION:

<table>
<thead>
<tr>
<th>Value</th>
<th>Metering</th>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6µF 273 volts</td>
<td>1/2</td>
<td>$0.60</td>
<td>brand new</td>
</tr>
<tr>
<td>12µF 200 volts</td>
<td>1</td>
<td>$0.40</td>
<td>brand new</td>
</tr>
<tr>
<td>33µF 200 volts</td>
<td>1 1/2</td>
<td>$0.20</td>
<td>brand new</td>
</tr>
<tr>
<td>47µF 500 volts</td>
<td>2</td>
<td>$0.10</td>
<td>brand new</td>
</tr>
</tbody>
</table>

PAPER CONDENSERS:

<table>
<thead>
<tr>
<th>Value</th>
<th>Metering</th>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002µF 1000 volts</td>
<td>1/2</td>
<td>$0.05</td>
<td>brand new</td>
</tr>
<tr>
<td>0.005µF 250 volts</td>
<td>1</td>
<td>$0.03</td>
<td>brand new</td>
</tr>
<tr>
<td>0.01µF 500 volts</td>
<td>1 1/2</td>
<td>$0.02</td>
<td>brand new</td>
</tr>
<tr>
<td>0.02µF 500 volts</td>
<td>2</td>
<td>$0.01</td>
<td>brand new</td>
</tr>
</tbody>
</table>

MILLARD POLYESTER CAPACITORS. ALL HALF PRICE:

<table>
<thead>
<tr>
<th>Value</th>
<th>Metering</th>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 volts</td>
<td>1/4</td>
<td>$0.01</td>
<td>Mint</td>
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<tr>
<td>630 volts</td>
<td>1/4</td>
<td>$0.01</td>
<td>Mint</td>
</tr>
<tr>
<td>1000 volts</td>
<td>1/4</td>
<td>$0.01</td>
<td>Mint</td>
</tr>
<tr>
<td>1500 volts</td>
<td>1/4</td>
<td>$0.01</td>
<td>Mint</td>
</tr>
</tbody>
</table>

VARY SPECIAL VALUE! Silver Minx Ceramic. Polypropylene Condensers. Well assorted. Mixed pairs at 25c each. Mixed Bag of 100 only 10c.

RESISTORS. Give-away offer! Mixed types and values, 1 to 11.

<table>
<thead>
<tr>
<th>Value</th>
<th>Metering</th>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8 to 100,000</td>
<td>1/2</td>
<td>$0.01</td>
<td>brand new</td>
</tr>
<tr>
<td>1/16 to 1000</td>
<td>1</td>
<td>$0.005</td>
<td>brand new</td>
</tr>
</tbody>
</table>

WIRE-WOUND RESISTORS:

<table>
<thead>
<tr>
<th>Value</th>
<th>Metering</th>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 watt, 8 watt, 12 watt, 25 watt, 35 watt, 100 watt</td>
<td>1/2</td>
<td>$0.05</td>
<td>brand new</td>
</tr>
</tbody>
</table>

CONNECTING WIRE. THIN, P.F. INSULATED:

<table>
<thead>
<tr>
<th>Size</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>19/24</td>
<td>1 foot</td>
<td>$0.05</td>
</tr>
<tr>
<td>22/24</td>
<td>1 foot</td>
<td>$0.05</td>
</tr>
</tbody>
</table>

VALVES. BRAND-NEW AND BOXED. ROCK-BOTTOM PRICES:

<table>
<thead>
<tr>
<th>Valve</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>D87</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
<tr>
<td>EAC700</td>
<td>Brand new</td>
<td>$0.05</td>
</tr>
<tr>
<td>EAC500</td>
<td>Brand new</td>
<td>$0.05</td>
</tr>
<tr>
<td>ECC90</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
<tr>
<td>ECC93</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
<tr>
<td>ECL70</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
<tr>
<td>ECL80</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
<tr>
<td>EP30</td>
<td>Brand new</td>
<td>$0.05</td>
</tr>
<tr>
<td>EP30</td>
<td>Brand new</td>
<td>$0.05</td>
</tr>
<tr>
<td>EP35</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
<tr>
<td>EP40</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

RECORD PLAYER CARTRIDGES:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

RECORD PLAYER TONECARTRIDGE:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 / 600</td>
<td>Brand new</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

BARGAIN OFFER!

We sell the following, 1,000 volt, 45c; 20,000 volt, 85c.

Orders by post to:

G. F. MILLWARD, 17 PEEL CLOSE, DRAYTON BASSETT, Staffs.

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111, 1007s. Accuracy 0.2 Minimum output 2w into 8000 ohms above 20 c/s 50mW into
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750-750 A, 2 in. round panel
1mA, 2 in. round panel sealed. 5mA, 2 in. round panel
5mA, 2 in. round clip-in panel or plug. 5-50mA, 1 in. round panel
10-100 mA, 2 in. round panel
20-30 mA, 2 in. round panel
10mA, 2 in. square panel
2.5 mA, 2 in. square panel
100mA, 2 in. square panel
75mA, 2 in. plug-in
100mA, 1 in. plug-in
100mA, 1 in. round panel
100mA, 2 in. round panel
2 amperes, 2 in. round panel
25 amp, 3 in. round panel
30 amp, 3 in. round panel
35 amp, 3 in. round panel
50 amp, 2 in. round panel
100VDC, 2 in. round panel
80VDC, 2 in. round panel
150VDC, 4 in. round panel
1.5 amp, 4 in. round panel
D-1500, 2 in. elects. plug-in, round panel
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15 VAC 2 in. round panel
500 VAC 2 in. round clip for

METERS. 4 in. x 4 in. 4 in. long.
Mirror scale panel mounted, calibrated
0-1 mA, 55% P. & P. 50
Laboratory TYPE VOLT.
METERS, 150 A. Mirror scale
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5 in. with carrying handle, brand new
22-24%, P. & P. 3.

MINIATURE METERS. General
Electric 1 in. round flush, clip mounted.
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150 mA, D.C. 15-26, P. & P. 50

S" METER FOR H.R.O.
RECEIVERS. Brand new, £2-10-0, Carriage
paid U.K.

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SIZE" METERS. 1 in. round, flush
mount not mounted 50p.A, P.S. cali- 
brated 0-1 mA, 55% P. & P. 50

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Instrument. Field Mag. 1 in. x
6 in. with switching dials. 22-
24%, P. & P. 3.

COMPLETE V.F.O. UNIT from
5x315 Ltd. Range 12,000 to 17,500 Mc/s.
Two Y.T. 500s as oscillator and buffer. 607 or
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Slow motion drive directly calibrated
Mc/s. Provision for crystal control, metering of
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meter in excellent condition as
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with specially built PSU for mass.
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SPARES FOR A.R.B. RECEIVERS.
For your needs from our huge
selection.

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P. & P. 2.6

VARIOMETER for No. 19 sets, 17/6
P. & P. 2.

TELEPHONE HANDSETS. Stand-

INSET MICROPHONE for tele-

LIGHTWEIGHT, LOW RESIST-
ANCE, HEADPHONES. Type H.S.
33-. Largely used by pilots. Brand new.
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Mounted in portable wooden cases.
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wire on drum. Completely new.
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Ray Tubes and Specialised Tubes. C.A.}

TRANISTORS ZENER DIODES ETC

P. C. RADIO LTD.
170, GOLDHAWK RD., W.12

Wires World, April 1968

www.americanradiohistory.com
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An extremely reliable general purpose valve amplifier, suitable for use with the use of separate instruments at the same time. All these are connected directly across the input sockets. The input impedances of all the amplifiers are also specified, with the volume controls of each channel being adjusted directly above the corresponding input sockets.

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  - **Channel 1:** 4mV at 470Ω.
  - **Channel 2:** 4mV at 450Ω.

- **Input Sensitivity:**
  - **Relatively low to 4W output:**
  - **Tone Controls are common to all inputs.**

- **Bass Boost:**
  - **12dB at 60Hz.**

- **Treble Control:**
  - **13dB at 60Hz.**

- **Output:**
  - **27 dB**
  - **Sensitivity:**
    - **M.W.:** Intermediate
  - **Price:**
    - 27 gns. [P. & P. 20%]

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**NEW! THE DORSET TRANSISTOR PORTABLE RADIO**

With **BABY ALARM FEATURES**

- **High Q internal ferrite rod aerial.**
- **Class “B” modulated output stage with transistor-controlled heat stabilization.**
- **Class “B” output stage ensures long battery life.**
- **Current drain is proportional to the output level.**
- **Total current drain under the receiver is 1.2 mA.**
- **Extension sockets for earphone input.**
- **Speaker output.**
- **All components (except speaker) mounted on printed circuit board.**
- **Fasten to follow instructions.**

**PRICE:**

- **£5.50** + 7/6 P. & P.

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**BREGES GEARED MOTOR**

- **240 V. A.C.**
- **Mains:** 50 Hz, 0.49 amp (60C). Unregulated speed, 3.750 R.P.M.
- **Gear speed:** 80 R.P.M. Constant gear ratio: 31.4:1. Reversible. Spindle dia. 12 mm (0.472in). Spindle length 1.4 in. 7.5 in. x 4 in. wide x 4 in. deep. Cost £0.20, our price £7/19/6. 7/6 P. & P.

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**SPECIAL OFFER**

- **De luxe wooden cabinet size 12 in X 8 in. X 3 in.**
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- **6.7 Hz. neutralisation on each separate stage.**
- **D.C. coupled push pull output stage with separate A.C. negative feedback.**
- **Room filling output 350 mV.**
- **Rats nested and drawn printed circuit board back printed for foolproof construction.**
- **Full comprehensive polarisation and point-to-point wiring diagram.**
- **Aerial aerial.**
- **Fully tunable over medium and long wave.**
- **Sensitivity:** 3.5 microvolts and 1,500-2,000 microvolts.
- **Price:**
  - 27 gns. [P. & P. 20%]

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**FIRST QUALITY PVC TAPE**

- **POST & P. K.**
- **5in. Std. 850ft. 9½ in. Lin. L. 850ft. 11/6 in. H. 750ft.**
- **1/2 in. 650ft. 10/6 in. Lin. 650ft. 11/6 in. Lin. 600ft. 7½ in. Lin. 500ft.**
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- **5 in. 340ft. 36/6 in. Lin. 300ft. 37/6 in. Lin. 250ft. 42/6 in. Lin. 200ft.**
- **300ft. 28/6 in. Lin. 150ft. 32/6 in. Lin. 100ft.**

**8 WATT (RMS) SOLID-STATE HI-FI AMP.**

**WITH INTL. GROUNDED, PRE-AMP.**

**STANDARD: 350 VAC., 50Hz.**

- **Power Supply:**
  - **6 Volts @ 500 mA.**
- **Price:**
  - £4.96. + 7/6 P. & P.

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**4-TRANSISTOR AMPLIFIER**

- **Frequency response:** 250 to 10,000 cycles.
- **Features:**
  - **NPN and PNP complementary circuitry.**
  - **Output Stage:** 2X X 1 in.

**3 TO 4 WATT AMPLIFIER**

- **Features:**
  - **NPN and PNP complementary circuitry.**
  - **Output Stage:** 2X X 1 in.

**24 WATT ALL TRANSISTOR AMPLIFIER**

- **A.C. mains:**
  - **240V. 50Hz.**
  - **Price:**
  - £14.00. + 7/6 P. & P.

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**AC MAINS MOTOR**

- **Type TD16.**
  - **Speed:** 3 and 4 rpm.

**BSR TAPE DECKS 200/250v.**

- **Applications:**
  - **A.C. mains:**
    - **Type TD16.**
      - **Speed:** 3 and 4 rpm.

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**Radio and T.V. Components (Acton) Ltd.**

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**Early Closing Wednesday.**

**Terms:** C.O.D. Goods not despatched until cleared. Stamped addressed Envelope.

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**Early closing Thursday.**

**Personal Shoppers Only.**

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Dynamic type. Jaw-like movement.1

Ideal for use with either hand, with a microphone coupling to barrel. Rivals small size but very sensitive. 287 Vola Yonders with button release—p重新发布The 287 Vola Yonders at $17.50. 1/4 x 7/8 x 1/2. Each. 

Franklin R.P. Molder. 240 V. N.O. 1/60—open circuit to operate. Ideal for ventilation fan, blowers, etc. 

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Pneumatic Dual Transmitter 125 220—110 v.c.m. synchronous—stabilizing 45/60. Required for dual operation. 1/10. Each. 

Nose Mason Tester 11/2 1/60. 1/16. 

Power Pack Transformer. 1 1/3 x 1 3/4 x 1/4. 

MAINS TRANSFORMER

Ideal mounting with primary connection. 

100 W. Transformer for 220 v.c.m. in glass holder. 1/2 x 1/4. Each. 

15 W. A.C. Transformer for 220 v.c.m. in glass holder. 1/2 x 1/4. Each. 

15 W. A.C. Transformer for 220 v.c.m. in glass holder. 1/2 x 1/4. Each. 

15 W. A.C. Transformer for 220 v.c.m. in glass holder. 1/2 x 1/4. Each. 

15 W. A.C. Transformer for 220 v.c.m. in glass holder. 1/2 x 1/4. Each.

FLUORESCENT CONTROL

Each kit comprises seven items— habits, 2 bakelite ends, starter holder and 2 tube clips, with wiring instructions. Suitable for normal domestic wiring. 150 W. A.C. in mains. 

Note 175 W. at 175 W.— 1/4 x 1/4. Each. 

Each kit comprises seven items— habits, 2 bakelite ends, starter holder and 2 tube clips, with wiring instructions. Suitable for normal domestic wiring. 150 W. A.C. in mains. 

Files are cut and started in such a way that the circuit will function instantly. 

RELAY SWITCHES

These simple micro switches, eliminate thermostat or other low current devices to control up to 20 amperes. To switch thermal hearing features, etc. made by the famous A.E.I. group these items are listed at each price. Each price on order or 3 for $1.75. 

Mains Motor Precision made— used in record decks and tape recorders. Exceedingly quiet. 


ALL PRICES GREATLY REDUCED

CASSETTE LOADED DICTATING MACHINE

Battery Cells. Automatic on- or-off switch. Batteries new or used. 

$15.00. Each.

$5.00. Each.

$5.00. Each.

$5.00. Each.

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(Dept. W.W.), 1023 TAMWORTH RD., CROYDON, SURREY, 

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Standard type and size. Made to order for Laboratory use. 

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(p. & p. 126)
In kit form with chassis, knobs, plugs, etc.
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5 valve 10 watt basic amplifier, complete with
valves and instructions.
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<td>Germanium Diode</td>
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1-BANK UNSELECTIVE SWITCHES. 25 switches, alternate, chrome, 1 1/2" size. £2 15s. 6d. per set. 6/- 5s. 6d. per set.

DESK PHONES. Black Balsatele case, complete with hand set and internal bell with 0-1 dial. 4/- 3s. 9d. per set.

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DESK PHONES from 35/- Various types in stock. Final End Selectors. Raylite, various callers, also 19 Receivers in stock. All law callers only.

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Suitable for navigation or amateur version, price from £5. S.A.E. for details.

AN/ARC-33 Transceivers 225/399.9 Mc/s.


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TS-47 Test Oscillator 40-500 Mc/s.

£5.

T-216/GR XA-Synthesizer Signal Generator 225/399.9 Mc/s.

AN/UPM-11A X Band Range Calibrators.

AN/USM-244A Measuring Oscilloscopes.

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TELEPHONE AMPLIFIER

Why not increase efficiency of Office, Shop and Warehouse with this incredible De LUXE Portable Transistor TELEPHONE AMPLIFIER which enables you to take down long telephone messages or conversations without holding the handset. A useful office aid. A must for every office. Also ideal for use in hospitals for fear of hearing persons. On/off switch. Volume Control. Operates on one 9 v. battery which lasts for months. Ready to operate. P. & P. 3/6 in U.K. Add 2/6 for Battery. Full price refunded if returned in 7 days.

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Originally £9 Gns.

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TELEPHONE AMPLIFIER

Weekly Special

59/6
**CLASSIFIED ADVERTISEMENTS**

**DISPLAYED SITUATIONS VACANT AND WANTED**

**LINES ADVERTISEMENTS (run-on):** 7/ per line (approx. 7 words), minimum two lines.

**WANTED: **

- Wireless operators (count as 2 words).
- **SERIES DISCOUNT:** 15%, is allowed on orders for twelve monthly insertions provided a complete project is being advertised.

**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.

**SITUATIONS VACANT**

**TV Post Office:** Required. Applications to Miss A. W. Kendall, 53-street, London 3W. 6 (extension for Forces and Overseas Civil Service).

**FULL-TIME**


**REPAIRS**

**THE Royal Free Hospital, Gray's Inn Rd., London.**

**W.C.1**

**Electronic equipment required to run course of electronic workshops. Duties will be to maintain and develop radio and electronic equipment used in the Laboratory and to build new apparatus for clinical projects. Further particulars may be obtained by telephoning Dr. Williams 857-6111. Ext. 12. A knowledge of electronic troubleshooting, testing and servicing, together with experience in the maintenance of electronic apparatus is required. Non-contributory pension scheme. Non-resident accommodation available in London W.1. For application form, outline the names of two referees and forward to: The Assistant Administrator, Royal Free Hospital, Gray's Inn Rd., London, W.C.1.

**TELEPHONE:** 01-247-3094.

**The Agricultural Research Council Radiobiological Laboratory** has a vacancy for a Junior Assistant Research Chemist. The salary will be £545 per annum, with the possibility of a rise to £630 after six months. Good working conditions, free canteen for staff, and sports facilities. For full particulars about the work and the laboratory, and a description of the position, please apply to: The Director, Radiobiological Laboratory, R.A.C., Aldington, Filsham, East Sussex.

**BOOKS, INSTRUCTIONS, ETC.**

**MANUALS, circuits of all British Ex.W.D. radio receivers and transmitters.** Instructions will be issued in blocks with the code number of the set. Payable on receipt. Please write: Col. A. E. Ford, P.O. Box 100, York Lap, S.E.1.

**RECORDING ETC.**


**SERVICE & REPAIRS**

**REPAIRS**

- Our modern service department equipped with the latest test equipment including a wave analyser and a modern oscilloscope. A special team for Service work is available to manufacturers standard—Empire Ltd., 71, Dovers Rd., London, S.E.10.
**Product Test Technicians**

**Career Opportunities with IBM Manufacturing**

We need high calibre men to fill vacancies created by promotion and programme expansion.

**The Job**
Is to commission the latest IBM products and systems in production at the Scottish plant near Greenock, and requires an intimate knowledge of the equipment under test, which can include computers, punched card and tape peripherals, magnetic disk and tape storage, high and low speed printers, visual display units and multiplexors. The products have to be tested thoroughly, and all faults traced and rectified. The work is interesting and absorbing, and the prospects for the right man are good.

**Training**
Will be a mixture of formal and "on the job" instruction. We will teach you all you need to know about IBM equipment—providing your basic knowledge is to the required level.

**Pay and conditions**
Men selected for this work will start at not less than £1,050 per annum. We can pay more for proven ability and good relevant experience.

Benefits include a non-contributory pension, immediate free life assurance and full sickness pay for up to 26 weeks in any 12 months. The 254,000 square feet plant is modern and situated in a pleasant rural valley. There is a subsidised restaurant.

Working conditions are excellent and there are good recreational facilities in the area. IBM will help you find somewhere to live and pay your removal expenses.

**The man**
Will be at least 18 and probably less than 30 and have a strong electronic background, with experience in, for example, the testing of electronic products, maintenance of radio, radar or TV similar work in the armed forces.

He will probably have, or be near to attaining, a qualification such as HNC, ONC, first class PMG, final RTEB, or final City and Guilds (Course Nos. 47, 48, 49, 57, 200). A knowledge of transistor circuitry and the use of oscilloscopes will be a distinct advantage.

If you have what we want, and are keen to join a vigorous, expanding and up-to-the-minute industry, please write, giving details of your age, experience and qualifications, and quoting ref No. PT/WW/336 to: Personnel Selection Officer, IBM United Kingdom Limited, P.O. Box 30, Spango Valley, Greenock.
**Wireless World, April 1968**

**36th (Eastern) Signal Regiment (Volunteers)**

**T & AVR WANSTEAD E II**


Tel. 01-989-5131. Similar vacancies exist at CAMBRIDGE, BRENTWOOD, GILLYNHAM, NORWICH, BEDFORD and COLCHESTER.

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**RADIO TECHNICIANS**

A number of recently-qualified candidates are required for communication work. Candidates holding 18 months school or workshop employment in electronics and other parts of the U.K. are preferred. There are also opportunities for other walks.

Applicants must be 19 or over and be familiar with the use of test gear, and have had practical hands-on experience. Preference will be given to candidates who can offer "A" level and GCE passes in English language, Maths, science, Physics, or hold the City and Guilds Telecommunications Technical Intermediate Certificate or equivalent technical qualifications.

Pay according to age, e.g., 19-20f.50, 20-21f.75 (limiting age pay on entry).

Proposals of promotion to grades in salary range £1,100-£1,900. There are a few posts carrying higher salaries.

Annual leave allowance of 5 weeks, plus 1 week per 5 years. Normal Civil Service sick leave regulations apply.

Applications forms available from:

Recruitment Officer (RT),

Governing Communications Headquarters,

Oakley, Peterborough,

Cambridgeshire.

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**BOROUGH POLYTECHNIC**

**Borough Road, London, S.E.1**

The Borough Polytechnic is centrally situated in London, between Waterloo and London Bridge stations. It is in association with other colleges, it has been proposed for designation as "The Polytechnic of the South Bank, London."

Applications are invited for the appointment of:

**TWO SENIOR LECTURERS**

in the Department of Electrical and Electronic Engineering. This Department will be completely rehoused in the summer of 1969 in a large building currently nearing completion.

It is intended that appointments shall date from 1st September, 1968. Candidates should hold honours degrees in Electrical Engineering and preferably also be corporate members of the I.E.E. or I.R.E. They should have relevant industrial or research experience in addition to teaching experience.

Candidates able to offer the following subjects, up to at least final degree level, are particularly sought:

**HIGH VOLTAGE ENGINEERING** (Ref. E.13)

**COMMUNICATION ENGINEERING** (Radio and Line Communication) (Ref. E.14)

**SALARY SCALE** (for Senior Lecturers in London):—

£2,360 p.a. rising by annual increments of £60 and £65 to £2,665 p.a.

Further details and application forms are obtainable from The Clerk to the Governing Body, Borough Polytechnic, Borough Road, London, S.E.1. Those with completed applications should be lodged within two weeks of receipt, but not later than 15th April, 1968.

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**ENGINEERS**

IBM will train you for a responsible career in data processing

To become a successful IBM Data Processing Customer Engineer, you need more than engineering qualifications. You need to be able to talk confidently and well to any level of customer management, and to have a pleasing personality in your work. As a DPCE, you work in direct contact with your customers, on some of the world’s most advanced data processing equipment.

You must have a sound electronic and electromechanical background, such as ONC/HNC Electronic or Electrical, or Radar/Radio Instrument Fitters course in the Armed Services.

You will get thorough training on data processing equipment throughout your career. Starting salaries depend on experience and aptitude, but will not be less than £1,100 a year. Salary increases are on merit—you could be earning £1,900 within 3-5 years. Drive and initiative are always well rewarded at IBM; promotions are made on merit and from within the company.

If you are between 21 and 31 and would like this chance to become part of a rapidly expanding and exciting computer industry, write to IBM.

However, if you are between 18 and 21, IBM can offer you the chance of a challenging career as a Junior Customer Engineer.

You need five G.C.E. 'O' levels, an aptitude for mechanics, a good understanding of electrics, a clear logical mind, and the ability to get on well with people.

Send details of training, experience and age to Mr. D. J. Dennis, IBM United Kingdom Limited, 389 Chiswick High Road, London W4, quoting reference E/WW/262.
REDIFFUSION

TELEVISION FAULTFindERS

We have vacancies for experienced television faultfinders in our Production Test Departments. R.T.E.B. Final Certificate or equivalent qualifications or experience are required, a knowledge of transistor circuitry will be an advantage. These positions will be staff appointments with all the expected benefits.

Applications to:

Works Manager,
Rediffusion Vision Service Ltd.,
Fullers Way South,
Chessington, Surrey (near Ace of Spades).
Phone: 01-397-5411

THE CITY UNIVERSITY

Applications are invited for the post of EXPERIMENTAL OFFICER in the LASER APPLICATIONS GROUP

Applicants should possess at least a Higher National Certificate and have considerable practical ability. The officer will be responsible for the practical development of electro-optic crystal modulators under a research contract and will receive full initial training in the laser field.

The appointment will be for three years with a prospect of permanency.

Salary scale: £1,300 x £75 to £1,450 p.a.

Apply in writing, stating qualifications and experience, to Professor P. F. Soper, Department of Electrical and Electronic Engineering, The City University, St John Street, London, E.C.1.

WESTMINSTER 10 upholds fully automatic trans-
sistor television recording and provision for inserting offices without cutting blade, exceptional condition; very reasonable.—102

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A better deal for cash customers. We do not provide interest free credit but offer a generous discount of 13% for cash. Equipment delivered brand new in sealed cartons on receipt of remittance with order. Agents for all leading makes. Demonstrations and advice.—Write or phone. Callers welcome. Open all day Saturday, Thursday half day.—Audio Services, Ltd. 82, East Barnet Rd., New Barnet. Herris. Tel. Barnet 66 874.

ARTICLES WANTED

RETAILER requires surplus items.—Lists to Henkner & Kerr, 44, Ashley Terrace, Boltonbury, 214.

WANTED privately, an Edystone communications receiver, preferably model WRF but consider other model.—Tel. 874 8535 evenings. 736 4834 daytime.

WANTED, all types of communications receivers and test equipment.—Details to R. F. & I. Electronics Ltd., Ashville Old Hall, Ashville Rd., Lon-

GRANADA TELEVISION

Electronic Engineers for Operational Television

We have a number of vacancies at the TV Centre in Manchester for men with a good knowledge of television engineering to work in all aspects of Granada’s production and transmission operations.

These cover studio sound and vision, videotape, telex, transmission switching and maintenance of equipment.

Entry points and salaries depend on experience and qualifications and the grades open are Assistant Engineer at £1566 pa and Engineer at £1857 pa.

We will also consider as Technical Assistants, young men with the right qualifications and the ability to learn. This is a training grade with a salary of £1282 pa.

Housing prospects in the Manchester area are excellent and we will give assistance with housing and removal expenses. Generous Granada Group Pension and Life Assurance Scheme.

Write full details age and experience and qualifications to Andrew Quinn, Granada Television Manchester 3
A PERMANENT OVERSEAS CAREER

RADIO TECHNICIANS

You will be interested in the following facts.


2. Our staff has increased by 74 technicians in the last two years and we need a further 72 skilled technicians in 1968 alone to meet our expansion requirements.

Our business is telecommunications. We are a thriving company covering the fields of communication, aviation services and Air Traffic control with over 50 bases throughout the world.

The men we seek will be preferably qualified to C. & G. level. You should have a sound practical experience of HF and VHF communications. Knowledge of Navigational aids and RTT would be an advantage. Every encouragement will be given to you to continue your studies. Could you be one of the men for us? If so don't delay. Write now for application form. You will receive a prompt reply.

General Manager, Personnel (WW/RT),
International Aeradio Limited,
Aeradio House, Hayes Road,
Southall, Middlesex.

WANTED

By manufacturer of Tape Recorders,
Record Players and Radios.

YOUNG CAPABLE AUDIO DESIGN ENGINEER

Must have experience of low cost design on Mono and Stereo amplifiers.

Salary according to experience, in the range of £1,000 to £1,500 per annum.

Very good prospects.

Apply to the Managing Director,
FIDELITY LIMITED,
OLAF STREET, LONDON, W.11. PARK 0131.

Project

As a result of the steady expansion of our Radar Simulation business we are about to embark on the design and construction of digitalised electronic systems. We are therefore looking for a project manager, project engineers and systems design engineers with the following qualifications.

PROJECT MANAGER

The chosen man will have a sound engineering background and will be expert in one of the following fields. System design involving radar techniques, digital computers and interface design, or simulation. He must be able to plan and manage a complex electronic project within a well defined budget.

PROJECT ENGINEERS

We are looking for engineers with a sound knowledge of electronics and experience of radar techniques and analogue or digital computers. They must be able to organise the paperwork and be responsible for the detailed execution of contracts on the project from the planning through to the commissioning stage.

SYSTEMS DESIGN ENGINEERS

We require Senior and Junior design engineers to devise electronic systems for the simulation of radar effects. They should have experience in the use of linear and logic integrated circuits, and be familiar with digital or analogue computing techniques and interface problems. Recent work on Air Traffic Control or Marine Radar techniques would be an advantage.

The team chosen for this project will be working for a Company producing sophisticated electronic equipment in an assured and expanding market. The Company offers good conditions of service, including contributory pension scheme and a free life assurance.

Applications to: General Manager,
REDFON LIMITED
RADAR SIMULATOR DIVISION
Kelvin Way, Crawley, Sussex. Phone: Crawley 23422
A Member Company of the REDIFFUSION Group
RADIO OPERATOR preferably with PMG 2 Certificate required immediately for duty on Meteorological Office Ocean Weather Ships.

Salary scale £792-£1,230 per annum according to age, plus £143 overtime allowance. Free food and accommodation provided on board ship. Applicants must be natural born British subjects. Full details from Shore Captain, Ocean Weather Ship Base, Great Harbour, Greenock. Telephone Greenock 24291.

ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic electronics with experience in electronics, Radar, Radio and TV or similar field. Position is permanent and pensionable. Comprehensive training, on full pay, will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

Airborne Electronics

SERVICE TECHNICIANS

RCA Great Britain Limited, is an International Electronics Company with diverse interests in the field of electronic engineering. Our Service Division operating at A & AEE, Boscombe Down, Wiltshire is engaged on servicing and maintaining airborne electronic equipment, particularly AIRBORNE RADARS, ELECTRONIC NAVIGATIONAL AIDS, and HF, VHF and UHF COMMUNICATIONS.

A number of interesting vacancies have arisen which offer excellent opportunities for developing the initiative and fostering the career of young men between 22 and 35. They must have relevant experience preferably on the specific equipment mentioned above.

These positions carry monthly paid staff status with excellent fringe benefits, including three weeks paid holiday each year. A competitive salary will be paid and there are excellent promotion prospects.

Please write or phone for an application form to:-

Mr. A. Freemantle, RCA Great Britain Limited, Lincoln Way, Windmill Road Sunbury on Thames, Middlesex. Telephone Sunbury on Thames 855111, Ext. 105.

A SUBSIDIARY OF RADIO CORPORATION OF AMERICA.

UNIVERSITY OF STIRLING

Electronics Technician

Applications are invited for the post of Electronics Technician, to assist the University electronics engineer with maintenance of equipment and in the development of new equipment. This post is the first technical appointment in this section and while qualifications to O.N.C. level or equivalent are desirable, preference will be given to applicants with proven experience and ability in the general field of electronics.

Salary on or within scale £653 rising to £968 (bar at £760), placing according to age, qualifications and experience; pension scheme.

Applications by letter, giving names and addresses of two referees, to the Secretary, (W.W.), University of Stirling, Stirling, by 29th March.

KINGSTON-UPON-HULL Education Committee, College of Technology, Principal E. John, M.Sc., F.R.I.C.

FULL-TIME courses for P.M.G. certificates and the radar maintenance certificate, also in electrical and electronics engineering—Information from College of Technology, Queen's Gardens, Kingston-upon-Hull.

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**Government of Malawi**

**REQUIRES**

**TELECOMMUNICATIONS ENGINEER**

on contract for one tour of 24-36 months in the first instance. Commencing salary according to experience in scale (including overseas addition) £1195 rising to £1905 a year. A supplement of £100 a year is also payable. Gratuity (free of Malawi tax) 25% of total salary drawn for tour of 30 months or over or 15% for a tour of 24 but less than 30 months. Outfit allowance £30. Free passages. Liberal leave on full salary. Generous education allowances. Quarters at low rental. Contributory pension scheme available in certain circumstances.

Candidates, preferably aged 25-45 years, must have at least 5 years experience in either of the following branches of telecommunications engineering, after completion of two years' approved training: Carrier and V.H.F. Equipment; HF Radio and A.R.Q. Equipment. They must possess at least one appropriate City and Guilds Certificate. Previous overseas experience and experience in training and supervision of subordinate staff would be advantageous.

Apply to CROWN AGENTS, M. Dept., 4 Millbank, London, S.W.1. for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference M3B/6254/ W.F.

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**Government of Swaziland**

**REQUIRES**

**TELECOMMUNICATIONS TRAINER**

For the Posts and Telecommunications Department, on contract for one tour of three years in the first instance. Commencing basic salary according to qualifications and experience in scale Rands 2540 rising to Rands 3003 a year (£165-£194) plus Inducement Allowance Rands 318 rising to Rands 450 a year (£190-£225). Gratuity 25% of total salary drawn. Free passages. Liberal leave on full salary. Quarters provided at low rental (or allowance paid in lieu). Generous education allowances. Contributory pension scheme available in certain circumstances. Candidates must possess a City and Guilds Intermediate Group Certificate or equivalent.

Experience in another African Telecommunications Service would be an advantage. The duties will involve the training of local students in theoretical subjects up to level of 1st Year City and Guilds in Engineering Service, Elementary Telecommunications Practice, etc., and the supervision of the practical application of elementary Telecommunications practice in laboratory and field.

Apply to CROWN AGENTS, M. Dept., 4 Millbank, London, S.W.1. for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference M3B/6255/ W.F.
TELEPHONE EXCHANGE OVERSEAS

**TECHNICIANS & ENGINEERS**

required for an overseas tour of 2 years to carry out Clerk of Works functions on telephone switching installations. Ideal applicants would be 30/50 years of age, have experience in Strowger, step-by-step or cross bar. Generous overseas allowances and travelling expenses for applicants and families.

Applications in writing please to: Stan Yates, STC, Chester Hall Lane, Basildon, Essex

**STC**

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**ELECTRONIC SYSTEMS SERVICE ENGINEERS**

**THE JOB**
Systems Service Engineering on Advanced Training Aids for Aircraft, Radar Networks, Nuclear Reactors and Submarines.

**THE MAN**
Electronic Engineer preferably with O.N.C. or H.N.C., having had practical experience of electronic devices with a keen desire to learn new techniques and applications.

**THE REWARDS**
A salary within a range of £950-£1,450. 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 equipment. High quality training will also 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 travel at home and overseas

Apply: Personnel Manager,

**REDIFON LIMITED**
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Gatwick Road, Crawley, Sussex. Phone: Crawley 28811

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**CAMBRIDGE**

**PYE T V T LIMITED**

Can offer the following opportunities:

**INSTALLATION ENGINEERS**
Senior and Assistant Engineers to install and commission Colour T.V. Transmitting equipment at home and abroad. The posts offer opportunities for travel.

Applicants for the SENIOR ENGINEER posts should have an H.N.C. or equivalent, but candidates without such qualifications who have considerable experience of installation of T.V. broadcasting or other transmitting equipment will be considered.

Applicants for the ASSISTANT ENGINEER posts should have an O.N.C. or equivalent trade or services qualification in electronic engineering. Some experience of installation work on electronic equipment would be an advantage.

Attractive salaries will be paid, according to experience and qualifications. Traveling expenses are paid in addition.

**ELECTRONIC DEVELOPMENT ENGINEERS**
Engineers for development of Colour Television Transmitters and associated equipment. The vacancies fall into two categories:

Applicants for the first category are expected to be aged between 24 and 34, with H.N.C. or equivalent qualifications and design experience in at least one of the following activities:

1. Video and radiofrequency amplifiers up to 1 GHz using solid state and microwave tube techniques.
3. High power coaxial networks and feeders.
4. Other work connected with television transmitters.

Applicants for the second category will be aged between 20 and 26, with O.N.C. or equivalent, with some experience in the electronics industry.

Attractive salaries will be paid to Engineers able to provide immediate contribution to a comprehensive work programme.

**TRANSMITTER TEST ENGINEERS**
Senior and Assistant Engineers to test Colour T.V. Transmitting equipment. This includes a wide range of U.H.F. Transmitters of powers up to 40 kW.

Applicants for the SENIOR ENGINEER posts should have an H.N.C. or equivalent, but candidates without such qualifications who have considerable experience of T.V. Broadcasting or other Transmitting equipment will be considered.

Applicants for the ASSISTANT ENGINEER posts should have an O.N.C. or equivalent trade or services qualification in electronic engineering. Some experience of test work on electronic equipment would be an advantage.

Attractive salaries will be paid, according to experience and qualifications.

Enquiries should be addressed to the Personnel Officer, Pye T V T Limited, Coldham's Lane, Cherry Hinton, Cambridge. Write or telephone Cambridge 45115.

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Wireless World, April 1968
Government of MALAWI
REQUIRES
RADIO
TECHNICIAN

to serve as Inspector of Police (Signals) on contract for one tour of 24-36 months in the first instance. Commencing annual salary according to experience in scale rising to £1,590 (including overseas add). A supplement of £100 a year is also payable. Gratuity (free of Malawi tax) 25% provided a tour of at least 30 months is served, otherwise 15%. Outfit allowance £30. Free passages, Liberal leave on full salary. Generous children's education allowances. Contributory pension scheme available in certain circumstances.

Candidates, up to 45 years, should have at least 5 years practical experience in radio, preferably in a Police Force or the armed forces. Preference will be given to candidates who possess City and Guilds Intermediate Telecommunications Certificate or equivalent. A good knowledge of transistor circuitry, multi-channel carrier telephone equipment and/or diesel plant and petrol/electric alternators would be an advantage.

Apply to CROWN AGENTS, M. Dept., 4, Millbank, London, S.W.1, for application form and further particulars, stating name, age, brief details of qualifications and experience, and quoting reference M38/64949/...
Trained in electronics? Interested in aircraft?

Combine both these interests at the Marconi London Airport Service Depot.

Technicians at the depot undertake major servicing of all types of Marconi airborne electronics equipment including navigational aids and V.H.F and U.H.F communication systems. During 1968 there will be an expansion into a new building giving excellent opportunities for rapid promotion.

Applicants should possess a City and Guilds Certificate in telecommunications, equivalent qualification or experience.

Marconi

Please write quoting reference WW/AV/7, giving details of age, qualifications and relevant experience to: Mr B K Overy, Divisional Personnel Officer, c/o Directorate of Personnel, English Electric House, Strand, London WC2.

The Marconi Company Limited

AN ENGLISH ELECTRIC COMPANY

TECHNICAL JOURNALIST/WRITER

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Wireless World, Swan 230-EC FH-K.W. Lalayette Communications CC.40 Swaoao /CSE SWANCO PRODUCTS Joystick std. -700 Une Equipment: Aircraft Communications Transmitter. Antennas "slit" permits M. in Mohican, receiver receiver or another, "NI'11 128 Microphones: LUDO, SELMER ££ Performance of Transistor STELLA RECORD PLAYER SELMER ££ Size: 30 × 35 × 15 Cash by Ericsson 5,10, 15, 20, 25, 30, 35, 40, 45 12.5, 15, 17.5, 20, 22, etc. 10.6 12.5, 15, 17.5, 20, 22, etc. 10.6
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SOLDERING INSTRUMENTATION

HIGH EFFICIENCY INSTRUMENTS

1. DIA.--3.12 mm dia. detachable.
   Special centre temp. 250 c. 900 c.
   Weight 1.5 oz. 40 grams.

2. DIA.--3.75 mm dia. detachable.
   Special centre temp. 250 c. 1000 c.
   Weight 2 oz. 70 grams.

3. DIA.--4.56 mm dia. detachable.
   Special centre temp. 250 c. 410 c.
   Weight 3 oz. 110 grams.

4. DIA.--5.08 mm dia. detachable.
   Special center temp. 250 c. 410 c.
   Weight 3.5 oz. 110 grams.

5. DIA.--6.35 mm dia. detachable.
   Special center temp. 250 c. 410 c.
   Weight 5 oz. 160 grams.

6. DIA.--7.93 mm dia. detachable.
   Special center temp. 250 c. 410 c.
   Weight 7 oz. 200 grams.

WE HAVE, FOR YOUR CONVENIENCE, A HIGHLY SPECIALISED SERVICE SECTION, SO ORGANISED AS TO MAINTAIN A PROMPT EXECUTION OF ALL REPAIRS OF EQUIPMENT OF OUR MANUFACTURE.

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Wireless World, April 1968

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In some of these 60 countries cored solder is produced locally. However, it is the consistent high quality of ERSIN MULTICORE SOLDER, that provides the utmost reliability of soldered joints, making it advantageous for manufacturers to import this British made product.

If in Britain or overseas you make or service any type of equipment incorporating soldered joints and do not already use ERSIN MULTICORE SOLDER, it must be to your advantage to investigate the wide range of specifications which are available.

Besides achieving better joints – always – your labour costs will be reduced and substantial savings in overall costs of solder may be possible.

Solder Tape, Rings, Preforms and Pellets – Cored or Solid – and an entirely new type of cored disc, can assist you in high speed repetitive soldering processes. If you solder printed circuits, our complete range of chemicals, fluxes and extra pure alloys can help you.

Engineers are invited to apply on their Company’s notepaper for a comprehensive copy of the 30 page, seventh edition, of “Modern Solders”. Ask us to help you with your soldering problems.

See us at the Paris Electronics Component Show, where our technical staff will be happy to give you full information on interesting new developments applicable to soldering.

April 1st–6th, Section 2, Allée 9, Stand 11.