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EDGE CONNECTORS

for printed circuit boards

- Low rate floating spring.
- Controlled contact pressure.
- Unsurpassed reliability.
- Polarisng achieved without removal of contacts.
- Hard gold plated to 0.0002 inch minimum.
- Gold Flashed and Silver Plated contacts supplied on request.
- Constant contact performance with different board thicknesses.

At present available in 8, 16, 24, 32, & 40 Pole sizes

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Full details available from: FERRANTI LTD - KINGS CROSS RD - DUNDEE - Telephone: Dundee 87441
WWW-001 FOR FURTHER DETAILS.
Avometer
Model 8 Mk.3

Thanks to greatly increased production at our new Dover factory the Model 8 Mk. 3 Avometer—renowned for its exceptional performances and reliability—is now available for prompt delivery. Why wait? There's no better moment than now to get in touch with one of the addresses below.

Where to get your Avometer
(or any other Avo instrument)

FARNEll INSTRUMENTS LTD.
SANDBECk WAY, WETHERBY, YORKS.
Telephone: Wetherby 3991/3994
Anglesey, Caernarvonshire, Cheshire, County Durham, Cumberland, Derbighshire, Derbyshire, Flintshire, Lancashire, Lincolnshire, Staffordshire, Westmorland, Yorkshire.

WIRELESS ELECTRIC LTD.
ST. THOMAS STREET, BRISTOL 1.
Telephone: 9/6434
Cornwall, Devon, Dorset, Gloucestershire, Hampshire, Hertfordshire, Somerset, South Wales, Wiltshire, Worcestershire.

ELESCo ELECTRONICS LTD.
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Telephone: CENTral 5656
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For details of Avo representation OVERSEAS contact the Export Sales Department at the address below.

AVo LTD
AVOCET HOUSE - 92-95 VAUXHALL BRIDGE ROAD - LONDON S.W.1 Telephone: Victoria 3434

WW—604 FOR FURTHER DETAILS.
the experts’ Stentorian choice

F. C. JUDD
Technical Editor
"Wireless World"

JOHN GILBERT
Technical Editor
"Music Trades Review"

DONALD ALDOUS
Technical Editor
"Hi-Fi Magazine"

MODEL H.F. 1016 'MAJOR'

This unit makes use of the high flux density available in the magnet system of the previous H.F.1016 unit. A curved diaphragm is used with a rigid centre section coupled to the voice coil. The rigid coupling and the design of the cone termination give a balanced response over the whole audio range. The unit is specially suitable for use in the smaller type of enclosure having a volume of approximately ½ cubic foot.

Specification:
Chassis—die cast aluminium; Cone—graded pulp cambric surround; Cone dia.—10in.; Pole dia.—1in.; Flux density—16,000 gauss; Total flux—64,000 maxwells; Impedance—15 ohms.

Price: £10.7.6 (inc. tax)

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<tr>
<th>Type</th>
<th>Flux Density</th>
<th>Price</th>
<th>Type</th>
<th>Flux Density</th>
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<tr>
<td>10&quot; H.F.1012&quot;</td>
<td>12,000 gauss</td>
<td>£5</td>
<td>T359 tweeter</td>
<td>9,000 gauss</td>
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<tr>
<td>8&quot; H.F.816&quot;</td>
<td>16,000 gauss</td>
<td>£6</td>
<td>T816</td>
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<tr>
<td>8&quot; H.F.812&quot;</td>
<td>12,000 gauss</td>
<td>£4</td>
<td>T12 tweeter</td>
<td>16,000 gauss</td>
<td>£5</td>
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<tr>
<td>8&quot; H.F.810&quot;</td>
<td>10,000 gauss</td>
<td>£3</td>
<td>T10 tweeter</td>
<td>14,000 gauss</td>
<td>£5</td>
</tr>
</tbody>
</table>

*These three Speakers incorporate a universal impedance speech coil.

WHITELEY ELECTRICAL RADIO CO. LTD.
MANSFIELD · NOTTS · ENGLAND · Telephone: MANSFIELD 1762-5

WW—005 FOR FURTHER DETAILS.
We have been accused...

of hiding our light under a bushel, the light being our superb 4 speed tape deck, so we have taken the hint and given you a large illustration pointing out some of its principle features. This deck is used on all Brenell models and there are versions available to take 10½ NAB reels. Also we supply tape decks and matching amplifiers separately for building into your own equipment cabinet. Write for details of the Brenell range.
More of the music and less of the distortion!

The processing and production of discs produces a waveform in which distortion rises extremely rapidly as the upper frequency limit is approached. To obtain the best quality under such conditions the very high harmonics must be attenuated at a rate which is a function of the rate of rise of distortion.

The QUAD filters provide both switched adjustment for frequency and continuously variable adjustment for rate of attenuation. The degree of attenuation need therefore never be greater than necessary to clean up the programme but is always adequate even for very bad cases.

For the closest approach to the original sound

Our slogan for fifteen years and our design objective for twice that long. Ask your dealer for details of the QUAD range of high fidelity units or write direct to


WW—007 FOR FURTHER DETAILS.
The hard-to-find man is the man with advanced technical knowledge

In the field of Electronics today the greatest demand is for men to fill the positions of skilled technicians and support engineers. These are the ‘hard-to-find’ men for whom the way ahead to rewarding and interesting jobs lies wide open.

CREI HOME STUDY COURSES offer advanced technical education to the man who realises that technical knowledge must be current and up-to-date if progress is to be made in a world in which new ideas, new techniques and new applications develop almost overnight.

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- Radar & Servo Engineering
- Mathematics for Electronic Engineers
- City & Guilds of London Institute: Subject 49 and Supplementary Studies Subject 300.

For further information write to:
C.R.E.I. (London) (Dept. WW67)
WALPOLE HOUSE, 173/176 SLOANE STREET, LONDON, S.W.1
Telephone: BELgravia 8662

PLEASE SEND ME (FOR MY INFORMATION AND ENTIRELY WITHOUT OBLIGATION) FULL DETAILS OF THE CITY & GUILDS PROGRAMME. (C. & G. SUBJECT 49)
☐ 1st yr.  ☐ 2nd yr.  ☐ 3rd yr.  ☐ 4th yr.
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ADDRESS
EDUCATIONAL AND TECHNICAL BACKGROUND

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ADDRESS
ELECTRONICS EXPERIENCE

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WW—006 FOR FURTHER DETAILS.
JUST LIKE
THE OTHER 800 MILLION-
UNIQUE

Erie have made approximately 800 million of the Type 9 insulated carbon composition resistor since they were first put into production as far back as the early thirties. Every one is identical, yet every one is unique. The care and attention to detail in their manufacture, and the rigorous inspection checks at every stage, ensure that not only does every component operate efficiently, but is in itself an example of Erie’s unique manufacturing skill.

The same care and attention that goes into quality control applies throughout all the company’s activities; your orders and enquiries for instance. Every order, whether it be for a million, or for a strictly limited number for a highly specialist purpose, receives the same quiet efficient attention. Every enquiry, too, no matter how apparently simple or difficult receives the same enthusiastic attention from our technical and sales staff.

Erie take a pride in performance

Write for catalogue to:
ERIE RESISTOR LIMITED,
Great Yarmouth, Norfolk, England.
Telephone: Great Yarmouth 4911.
Cables: Resistor Great Yarmouth Telex: 97421

WW—009 FOR FURTHER DETAILS.
Six big digits, clear and unambiguous, to measure frequency and time up to one megacycle and down to one microsecond—clearly, without flicker.

**Six into one only just goes**

Not much spare space on the panel of this instrument—the digits are big and the unit is small, compact, portable. Makes for convenience and easy reading, with an adjustable support that holds firm at any convenient angle.

**Smaller and smaller!**

Design of the Venner TSA 3436 Mark 2 is based on solid experience of applying transistorised digital techniques to measuring instruments. Small as it is, the TSA 3436 Mark 2 will give precise readings up to a megacycle and down to a microsecond.

**ONLY £215** (Price applicable to U.K. only)

Laboratories and technical colleges welcome the compactness, strength and simplicity-in-use of the TSA 3436 Mark 2. In industry, its dependability, and the clarity of its display, make it uniquely suitable for inspection and quality control applications.

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VENNER TSA 3436 MARK 2 TIME/FREQUENCY METER
RACAL Digital counters combine versatility with economy

Racal SA.550 100 Mc/s Digital Frequency Meter

Direct Frequency Measurements from signal levels as low as 100 mV are possible without tuning or interpolation. Measurement capability can be extended by the use of the active probe unit type SA.544.

- All Solid-State Design
- 8 Digit Inline Display
- 0-55°C. operating Ambient
- D.C. Logic Switching
- Digital Printout Facilities
- Internal or External Standard

The SA.540 Universal Counter Timer illustrated below is for time, period and frequency measurement up to 11 Mc/s.

SA.550 U.K. Price £1,100
SA.540 U.K. Price £795

Write for fuller details to:
Racal Instruments Ltd.,
Dukes Ride, Crawthorne, Berks
Tel: Crawthorne 2272/3 or
Bracknell 941 Telex
LADDER FILTERS

ADVANTAGES
Fantastic space saving
Excellent stability with time and temperature
Single or multiple resonant units

TYPICAL SPECIFICATION
Centre Frequency
300 to 600 kc/s ± 2 kc/s
Bandwidth
2 to 45 kc/s at 6 db
Insertion Loss
1 to 15 db (dependent on B/W)
Impedance
Either 1200 or 1500 ohms in and out, dependent on B/W
Case Size
8 mm diameter
38 mm long
Operating Temperature Range
-40°C to +85°C
Shape Factor
60/6 db
1.3:1 to 2.6:1 Dependent on B/W

---

This illustrates the typical dimensions for a ladder filter. The case is a plated brass cylinder with glass end seals and plated leads. A 1½ inch length will provide sufficient volume to give 50 db stop band rejection.

---

BRUSH CLEVITE COMPANY LIMITED
HYTHE SOUTHAMPTON
PHONE HYTHE 3031 GRAMS BRUDEV HYTHE SOUTHAMPTON TELEX 49687
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REED RELAYS
REED UNISELECTOR

Designed for those special switching applications which are beyond the capabilities of conventional uniselectors and stepping switches. Any number of ways up to 100 can be supplied with up to 6 banks. Reverse operation can be provided and automatic homing to any pre-selected number.

Send for the provisional data sheet today.

ALMA COMPONENTS LIMITED
Park Road  •  Diss  •  Norfolk  •  Telephone: Diss 2287  •  Telex 18162

- Higher speed of operation
- Fully sealed contacts requiring no adjustments or maintenance
- Instantaneous re-set without going through all contacts
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- Independent “make” contacts are employed instead of a common wiper circuit
- Low contact resistance

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All Advance Transistorised Timer Counters offer more facilities than other makes at comparable prices. The current comprehensive range will be further extended during 1966 with the introduction of several new counters.

Advance Timer Counters provide frequency measurement up to 100 Mc/s, timing in micro-seconds and counting of random pulses up to $10^7$ pulses per second. Accurate timing pulses variable from micro-seconds to seconds are obtainable with accuracies up to 2 parts in 10⁶, which by using optional external frequency standards can be increased to parts in 10⁷.

**Frequency Measurement**: 0-10 Mc/s, extended by Frequency Dividers to 100 Mc/s.

**Gate Time**: A wide range from 10 seconds to 1 millisecond.

**Period Measurements**: Multi period measurements from 10 to $10^7$ periods.

**Time Measurements**: From micro-seconds to hundreds of hours ($99999990$ seconds).

**Counting**: 1-9999999 regular or random pulses.

If you would like to know more about the Advance range of Timer Counters, please write for details or telephone for further information.

**Advance Electromagnetic Limited**

Instrument Division, Roebuck Road, Hainault, Ilford, Essex. Tel: Hainault 4444

**ADVANCE TIMER COUNTERS**

5 MC/s TIMER COUNTER TC4A

**Frequency Measurement**: Range: 0 to at least 5 Mc/s. Gate Times: 0.001, 0.01, 0.1, 1, 10S. Decimal point automatically positioned for display in Mc/s. Sensitivity: NORMAL input 10c/s to 5 Mc/s, sinusoidal signal from 100 mV RMS. Maximum input 250V RMS up to 10 kC/s and 10V RMS up to 5 Mc/s.

**Period Measurement**: Single and Multiple: Single period with variable time units or multiple periods up to $10^5$ with pS units.

**Time Measurement**: Unit time pulses: 1μS to 10S in decade steps. Maximum period displayed 10S (approx. 28 hours).

**Output Timing Pulses**: Decade divisions: $10^6$ pulses per second to one pulse per 10 seconds.

**Counting**: Range: 1 to 9999, regular or random pulses.

**Frequency Standard**: Internal: 1 Mc/s crystal oscillator, oven controlled at 65°C. Accurate to 1 part in 10⁷.

**PRICE £205 ex Works**
NEW SHAPES OF SOUND

The Goldring-Lenco GL68

The many proved features of Goldring-Lenco transcription units such as infinitely variable speed adjustment, pick-up lowering device, automatic idler wheel disengagement are retained on the GL68, which is the first unit to incorporate the new G.65 arm. This is of low mass tubular construction with stylus pressure adjustment by sliding counterweight, and provision for height adjustment to suit any chosen cartridge. The interchangeable head slide (taking all cartridges with standard 3/8" fixing centres) makes use of self-cleaning wiper contacts. Swiss precision motor. Continuously variable speed adjustment. Less than 1% speed variation for 13% mains voltage variation. Adjustable click-in positions for the four standard record speeds. Pick-up raising/lowering device coupled to on/off switch. Automatic disengagement of idler wheel. Full 12" diameter turntable. Wired for stereo.

GL 68 Transcription Unit £16.16.0d. + £2.14.7 P.T.

Recommended cartridges for the GL68 are: Pickering V15 (AM1 and AME1) Pickering 380A, Goldring CS90 & CS91E.

Goldring CS90 and CS91E Cartridges

These are stereo ceramic cartridges with excellent frequency response and cross-talk separation. Low tip mass, replaceable diamond stylus (CS90 -0.0005" or 0.0007" tip radius; CS91E elliptical) coupled with high compliance enables these cartridges to be played at light tracking weights. CS 90 £4.4.0d. + £0.13.8d. P.T. CS91 £6.6.0d. + £1.0.6d. P.T.

C68 Cabinet and Cover for GL68. Elegant sapele mahogany cabinet with removable, clear Perspex dust cover. Size: 14" x 17" x 7".

£8.19.6d. + £1.12.0d. P.T.


WW-015 FOR FURTHER DETAILS.
Continuous Frequency Coverage from 1.5 c/s to 150 kc/s in 5 Ranges at Decade Intervals

SPECIFICATION:

FREQUENCY
1.5 c/s to 150 kc/s
±0.1% ±0.15 c/s.

STABILITY
<0.05% drift after 30 seconds.
<0.1% drift per °C at 1 kc/s.
<0.05% drift after 30', fall of supply voltage.
<0.3', drift for 30', fall of supply voltage.

DISTORTION
<0.1% at 1 kc/s.
<0.3% from 50 c/s to 15 kc/s.
<0.5% below 50 c/s and above 15 kc/s.

SINE WAVE OUTPUT
Variable up to 2.5 V into 600Ω.
<1% variation with frequency.
<0.5% variation for 30% fall of supply voltage.

SQUARE WAVE OUTPUT
Variable up to 2.5 V.
Rise time 1% of period = 0.2 μs.

ATTENUATOR
20dB, 40dB and 60dB; 60dB.

SUPPLY
Self-contained PP9 batteries, life 400 hours.
or, 200/230V A.C. when Power Supply Unit is fitted.

SIZE
10in. high x 6in. wide x 4in. deep.

WEIGHT
6 pounds.

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<th>TG150</th>
<th>TG150M</th>
<th>TG150D</th>
<th>TG150DM</th>
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<td>None</td>
<td>0-2.5V and dB</td>
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<tr>
<td>Price with batteries:</td>
<td>£22</td>
<td>£42</td>
<td>£35</td>
<td>£45</td>
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</table>

Mains Power Supply Unit £7.10.0

Leather carrying case £3.10.0

Fully detailed leaflets are available on our complete range of portable instruments

LEVELL ELECTRONICS LIMITED
PARK ROAD, HIGH BARNET, HERTS

Telephone: BARnet 5028

WW-016 FOR FURTHER DETAILS.
The Ditton 10
The Ditton 10 is a compact high fidelity reproducer measuring only 12\(\frac{3}{4}\)" x 6\(\frac{3}{4}\)" x 8\(\frac{1}{4}\)". We, along with many thousands of satisfied users throughout the world, consider it to be the finest loudspeaker in its class—sales certainly substantiate this.
If you are in doubt ask your audio dealer to demonstrate the Ditton 10 against any other comparable system.

**Brief Specification**
- Power handling capacity: 10 watts R.M.S.
- Overall frequency response: 35-15,000 c/s
- Impedance: 15 ohms
- Size: 12\(\frac{3}{4}\)" x 6\(\frac{3}{4}\)" x 8\(\frac{1}{4}\)" (323mm x 171mm x 203mm)

Price £19.6.0. inc. P.T.

**CX2012**
When installed in a suitably designed enclosure the CX 2012 12" Co-axial loudspeaker provides truly professional sound quality.
A highly compliant cone surround allows maximum linear movement and minimizes harmonic distortion.
Sensitivity of the co-axially mounted, horn-loaded, compression high note unit may be adjusted by means of the "Brilliance" control provided.

**Brief Specification**
- Power handling capacity: 20 watts R.M.S.
- Overall frequency response: 30-18,000 c/s
- Impedance: 15/16 ohms

Price £17.10.0.

**CX1512**
A lower powered alternative to Model CX 2012, Model CX 1512 provides the high standards of performance demanded by professional users.

**Price** £12.5.0.

**SMALLER ENCLOSURES**
Celestion research engineers have now evolved two new enclosure designs of only 2.5 cu. ft. to accommodate the above co-axial loudspeakers. Their external dimensions (using 3/8" timber) are only 30" x 17\(\frac{1}{2}\)" x 11\(\frac{5}{8}\)". Full details are given on the colour brochure.

Celestion Ltd., Ferry Works, Thames Ditton, Surrey.

Please send me full details of the Studio Series range of loudspeakers.

Name

Address

A17

Celestion Ltd., Ferry Works, Thames Ditton, Surrey.

Tel: EMBERbrook 3402/6

WW—017 FOR FURTHER DETAILS.
Pinnacle can assist all electronic valve users

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ECC83/12AX7: 2D21/EN91: 6AK5W/M8100: ECF82/GU8

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The special needs of Government Establishments and Departments are regularly catered for by us. Our stocking policy ensures positive ability to supply even obscure types.

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We maintain stocks of valves approved by the Air Registration Board and Ministry of Aviation making available an "off-the-shelf" service in released items for the first time.

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OUR ORGANISATION draws upon the resources of electronic valve manufacturers all over the world. It responds immediately to your requirements. A catalogue of over 1,000 specific types is available to bona-fide users through the Wireless World reader service.

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ACHILLES STREET • NEW CROSS • LONDON S.E.14

Tel.: Tideway 7285

WW-018 FOR FURTHER DETAILS.
The DALESMAN two speaker slimline system is a big step forward in this type of enclosure. After much research and intensive listening tests the mid-range coloration usually associated with slimline cabinets is now reduced to a minimum. Designed by Wharfedale in association with consultant designer Robert Gutmann F.S.I.A., the Dalesman meets the demands of the quality conscious sound enthusiast and at the same time it occupies only a small amount of space and is a most attractive piece of sound equipment. The Dalesman features a newly developed 12" bass unit fitted with a Flexiprene surround to handle the frequency range from 35 c/s to 1,700 c/s. The magnet assembly with a 1½" pole diameter has a flux density of 11,000 oersteds. The 5" treble unit has been specially designed for this particular enclosure. Where a free standing, compact, clean looking enclosure is required the Dalesman should certainly be heard.

Frequency range 35 c/s—15,000 c/s.
Impedance 8/15 ohms.
Power Handling Capacity 15 watts (30 watts peak).
Size 25" x 20" x 6½" Weight 3½ lb.

Finish zebrano, mahogany, walnut or teak veneers.

£25.10.0

RANK WHARFEDALE LIMITED
IDLE, BRADFORD, YORKSHIRE

Telephone Bradford 61252/3 Telegrams 'Wharf' Bradford

Free technical folder on the Dalesman from Dept. W3
total functional change instantly!

that's Plug-inability

—that's the Dymar System—a system of plug-in instruments offering flexibility and considerable capital saving. The basis of the system is the Type 70 Meter Unit which will accept any of a series of plug-ins. A change of function occurs with each combination because it produces a different instrument. Just release the retaining rod, withdraw the plug-in and insert another. It's as simple as that and 'Plug-inability' sums it up in one word.

Full details from:
DYMAR ELECTRONICS LTD. REMBRANDT HOUSE WHIPPENDELL ROAD WATFORD HERTS.
Telephone: Watford 21297

WT—022 FOR FURTHER DETAILS.
when stringing wires is hard—

It's just not economic or practical in many parts of the world to have normal wire and cable operating telephones. That's where ATE Radio Telephone Systems come in. In areas where difficulties of terrain would make the cost of installation and maintenance of telephone wires unrealistic, ATE—the pioneers of line-integrated radio telephones—can provide fully automatic systems which offer three important benefits: LOWER INSTALLATION COSTS: LOWER MAINTENANCE COSTS: GREATER RELIABILITY.

ATE Radio Telephones cut out the costly business of constant line-checking and repair. They are designed for unattended operation under arduous conditions and they give absolute reliability in all climates.

WW—023 FOR FURTHER DETAILS.
Putting in ATE radio telephones is easy

Normal telephone facilities
In remote areas, ATE Radio Telephone Systems provide vital links between wire-telephone exchanges, as well as connecting remote subscribers and creating self-contained, non-public systems. Users will find that there is absolutely no difference in the use of radio telephones compared with normal wire systems. They provide the same supervisory and metering facilities that are used on manual and automatic, public or private-wire metallic circuit networks.

Wide range of ATE equipment
The range of ATE Radio Telephone Equipment covers needs from those of the remote subscriber on a battery-operated single-channel system, to a 12-channel system which is ideal for spur routes from main routes, economical relief of open-wire and cable routes, open-wire replacement, emergency service and military applications, order wire and alarm circuits for microwave applications, and short-term seasonal traffic.

Remote control and telephone facilities
ATE Radio Telephone Equipment can also provide many remote control and telegraph facilities. The equipment, which operates completely unattended, transmits speech and enables pressures to be monitored, data telemetered, and a great variety of electronic signals transmitted in clear or in code. In combination with appropriate ATE electronic signalling units, it can activate alarms and switch power circuits on or off.

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ATE has a comprehensive systems planning and surveying service. Associated companies, representatives and agents are located in 75 countries throughout the world.

Rural Radio Catalogue

PLESSEY
Electronics

WW-024 FOR FURTHER DETAILS.
CLARK

LOW PRICED ELECTRICALLY OPERATED TELESCOPIC MAST

In introducing this new SUPER E Series Telescopic Mast Clark takes a stride forward. This is the equipment for which the World of Mobile VHF has been waiting. Based on the well tried QT and ST series, an entirely new concept of operation revolutionises the field of application. These telescopic masts provide the simple improvement in communication reliability for which Radio Telephone users have been searching. The power source is the vehicle battery. The control is a small panel easily attached to the dashboard. An electrical interlock makes it impossible for the mast to remain extended if the vehicle ignition is switched on—a great safety feature.

Clark SUPER E Series Masts are available with extended heights from 16 to 40 feet and headload capacity up to 10 lb. There is, of course, also the full range of Clark Accessories. Send for more details today.

FOR FULL INFORMATION Apply Direct to:
ADCOLA PRODUCTS LTD.
ADCOLA HOUSE
GAUDEN ROAD
LONDON, S.W.4

Telephone: MACaulay 0291/3
Telegrams: SOLJOINT LONDON S.W.4

for further details write to:
A. N. CLARK (ENGINEERS) LIMITED
BINSTEAD — ISLE OF WIGHT
Telephone: RYDE 369. Telegrams: TELEMAST RYDE
WW—025 FOR FURTHER DETAILS.
DESIGNED FOR MODERN LIVING

GOODMANS HIGH FIDELITY

GOODMANS HIGH FIDELITY Loudspeakers are world famous. Now GOODMANS proudly present their fully transistorised High Fidelity Amplifier—

MAXAMP 30

To sacrifice looks for quality is no longer necessary. The smoothness in styling together with amazing compactness is obvious—the accuracy of its High Fidelity sound reproduction and ease of operation is something only a demonstration will prove.

MAXAMP 30 is a fully transistorised stereophonic High Fidelity Amplifier using Silicon Transistors throughout. It is precision engineered and fullest use is made of printed circuits. It will deliver continuously up to 15 watts of power on each channel and it looks as good as it is. Its polished wood cabinet with ‘Danish Silver’ scratch grain control panel blends with any décor. £49.10s.0d.

MAXIM. The ORIGINAL and unequalled High Fidelity Loudspeaker mini-system. Complete full-range Hi-Fi reproduction (45-20,000 c/s) —yet within shoe-box size and handling 8 watts. Meticulously finished enclosure in hand rubbed Teak or Walnut. 10½” x 9½” x 7½” £17.10s.6d. inc. P.T.

MAXIM, Mezzo or Magnum-K the Maxamp 30 will handle them all—the choice is yours.

GOODMANS INDUSTRIES

AXIOM WORKS · WEMBLEY · MIDDLESEX Tel: WEM 1200

MEZZO. The Loudspeaker to Live With. 15 watts of power yet only 10½” x 18½” x 8” deep—it really will go on your bookshelf. Range—a clear and clean 40-20,000 c/s. Two specially developed loudspeakers, crossover 2,200 c/s. £26.5s.0d. inc. P.T.

MAGNUM-K. Originally designed for professional purposes, the MAGNUM-K is the system for the connoisseur. A full 25 Watt 3 way High Fidelity Loudspeaker System within only 15” x 24” x 11½”. 12” Bass unit gives minimal distortion down to 20 c/s, the mid-range and high frequency direct radiator units are controlled by constant impedance attenuators for individual balancing. Although it will handle 25 watts, for domestic use Hi-Fi amplifiers from 6-12 watts are quite adequate. £36.15s.0d.

Please send MAXAMP 30 booklet and 1966 Hi-Fi Manual together with name and address of my nearest Goodmans dealer.

Name...........................................
Address...........................................

WW-026 FOR FURTHER DETAILS.
SME

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30 WIRELESS WORLD May, 1966

A 30-watt amplifier housed in top compartment,
B Dynamic microphone fitted in foam-lined metal case.
C Pouch holds microphone stand clip, jack-plug etc.
D Microphone stand,
E Clips for microphone cable.
F Power supply unit.
G Power supply lead.

A 300 age amplifier in foam-lined case.

Gymastic phone titled in foam-lined cover.

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B Dynamic microphone fitted in foam-lined metal case.
C Pouch holds microphone stand clip, jack-plug etc.
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G Power supply lead.

A 300 age amplifier in foam-lined case.

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<td>250V RU/20/20</td>
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Input Sensitivities
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Microphone 2 mv.

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Electronic Equipment in Industry

W. D. GILMOUR, B.A.(OXON.), A.M.I.E.E.

Electronic instrumentation and control equipment is finding increasing application throughout industry. To manage it well demands a broad, up-to-date understanding of the techniques and principles involved. This is what this book provides. All aspects of the subject are examined clearly, concisely and in logical order, and to illustrate the text with specific examples, a large number of typical circuits and applications have been included.

This book does not replace standard textbooks, but offers a basis on which more formal treatments can be better understood and can be recommended to every scientist and technologist who needs a sound general picture of electronic control techniques and how to apply them.

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<tr>
<th>Type No.</th>
<th>Input Z Ohms</th>
<th>Pin Nos.</th>
<th>Output Z Ohms</th>
<th>Pin Nos.</th>
<th>Sec./Pri. Turns Ratio</th>
<th>Applications</th>
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<tr>
<td>MU.7521</td>
<td>3-75/15*</td>
<td>1-3, 2-4</td>
<td>600 (C.T.)</td>
<td>6-7-8</td>
<td>6:8</td>
<td>Low Z. Mic/Line</td>
</tr>
<tr>
<td>MU.7522</td>
<td>3-75/15*</td>
<td>1-3, 2-4</td>
<td>600K.</td>
<td>6-7-8</td>
<td>1:1/12:1</td>
<td>Low Z. Mic/Grid</td>
</tr>
<tr>
<td>MU.7523</td>
<td>75/300*</td>
<td>1-3, 2-4</td>
<td>600 (C.T.)</td>
<td>6-7-8</td>
<td>1:1/12:1</td>
<td>Line/Line</td>
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<td>1:1/12:1</td>
<td>Mixing: Hybrid</td>
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<td>Line/Grid.</td>
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<tr>
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<td>1-3, 2-4</td>
<td>100K</td>
<td>6-8</td>
<td>1:1/12:1</td>
<td>Line/Grid.</td>
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<tr>
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<td>1-3, 2-4</td>
<td>600 (C.T.)</td>
<td>6-7-8</td>
<td>4:1/13:1</td>
<td>Low Z. Mic./Line</td>
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<tr>
<td>MU.7529</td>
<td>50/200*</td>
<td>1-3, 2-4</td>
<td>600 (C.T.)</td>
<td>6-7-8</td>
<td>1:1/12:1</td>
<td>Mic. or Line/Line</td>
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<tr>
<td>MU.7530</td>
<td>10K (C.T.)</td>
<td>6-7-8</td>
<td>10K</td>
<td>6-8</td>
<td>1:1/12:1</td>
<td>600 dc, Line Bridging</td>
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<tr>
<td>MU.7532</td>
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<td>1-3, 2-4</td>
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<td>6-8</td>
<td>38:1/1161</td>
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<td>MU.7534</td>
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<td>6-8</td>
<td>38:1/1161</td>
<td>Mic. or Line/Grid</td>
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<tr>
<th>Type No.</th>
<th>Voltage Range</th>
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<tr>
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<td>4-15V</td>
<td>1 Amp</td>
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<td>PM2</td>
<td>15-30V</td>
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<td>£28</td>
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<td>PM3</td>
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<td>PM12</td>
<td>30-50V</td>
<td>10 Amp</td>
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<tr>
<td>U</td>
<td>4 x 4 x 4*</td>
<td>10/-</td>
<td>Y</td>
<td>8 x 6 x 6*</td>
<td>26/-</td>
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<tr>
<td>U</td>
<td>5 1/2 x 5 1/2</td>
<td>15/-</td>
<td>Y</td>
<td>12 x 7 x 7</td>
<td>41/-</td>
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<tr>
<td>U</td>
<td>8 x 6 x 6</td>
<td>21/-</td>
<td>Y</td>
<td>13 x 7 x 9</td>
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<tr>
<td>U</td>
<td>15 x 9 x 9</td>
<td>44/-</td>
<td>Y</td>
<td>15 x 9 x 7</td>
<td>48/-</td>
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<tr>
<td>W</td>
<td>8 x 6 x 6</td>
<td>21/-</td>
<td>Z</td>
<td>17 x 10 x 9</td>
<td>66/-</td>
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<tr>
<td>W</td>
<td>12 x 7 x 7</td>
<td>34/-</td>
<td>Z</td>
<td>19 x 10 x 9</td>
<td>71/-</td>
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<tr>
<td>W</td>
<td>15 x 9 x 8</td>
<td>44/-</td>
<td>*Height.</td>
<td></td>
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<td>Signal Generator</td>
<td>£10 16 9</td>
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<tr>
<td>61</td>
<td>Power Supply Unit</td>
<td>£5 14 6</td>
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<tr>
<td>62</td>
<td>C.R. Bridge</td>
<td>£9 6 9</td>
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<td>63</td>
<td>Audio Generator</td>
<td>£17 1 9</td>
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<tr>
<td>66</td>
<td>Inductance Bridge</td>
<td>£18 6 9</td>
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Crisis in the Electronics Industry?

INTEGRATED circuits are said to be creating a crisis in the U.K. electronics industry. Since very large scale production is needed to make i.c.s competitive with conventional circuits, there will be room for only the handful of big companies who can make the necessary capital investment for such production, and in the West these are likely to be American. Already U.S. companies have secured over half the British market, and our own manufacturers have their backs to the wall commercially. The real danger, as stated by British industrialists, is that if we cease to make our own i.c.s the U.K. electronics industry will degenerate into little more than a collection of assembly shops, wholly dependent on outside sources, with no incentive or facilities for developing new techniques and consequently nothing to sell in world markets. Indeed the situation could be worse, for i.c.s are not just components like transistors (which we already import in large quantities) but sub-systems—and sub-systems which are getting more and more comprehensive in function. As John Pickin, manager of Ferranti's Electronics Department, said recently “the equipment design of the future will be done on a slice of silicon, and if we do not have the ability to do this we will not have an electronic equipment industry in this country.”

Is there really a crisis? One could argue that the U.K. industry is already highly dependent on imported products, licensing arrangements and so on, and that everyone has accepted the fact that it could not function without them. We have to recognize that other industrial countries also have to export electronic products and know-how in order to live and that consequently Britain must import a reasonable share. Our own ability to export depends on the continuing prosperity of these nations. This is the co-operative principle underlying the European Common Market, whether you agree to export depends on the continuing prosperity of these nations. This is the co-operative principle underlying the European Common Market, whether you agree with it or not. Our limited resources simply do not allow us to produce good and highly competitive products in every field of electronic manufacture, and our policy must be to take full advantage of those products which other countries design better and make cheaper. Are not integrated circuits just another phase in this process?

It could also be argued that electronic engineering is gradually moving towards, or even becoming part of, systems engineering, and that consequently there is much to be gained in efficiency by having your basic “components,” the sub-systems, made for you by specialist manufacturers. In systems engineering even a computer is only a component. British firms have already done excellent business in selling plants and systems abroad—and these are firms which are virtually no more than “assembly shops.” What is important here is knowing how to make the hardware do the job required.

But the basic problem is to ensure that Britain gets her fair share of the available cake—the world markets in electronics. With the resources we can muster for i.c. manufacture we cannot afford to fritter away our energies over the whole field of applications, but we could concentrate on a carefully selected range of circuits which we knew we could produce well and competitively. This implies rationalization of products among the manufacturers. One industrialist has already admitted that the U.K. has twice as many companies as necessary in i.c.s making half as much investment as necessary. In their present fresh and belligerent state of mind these companies are not likely to go into rationalization voluntarily. But if there is, indeed, a crisis, they may eventually be forced into it in self-defence—and this would be the wrong reason.
**DESIGN AND MOUNTING OF ARMS FOR MINIMUM DISTORTION DUE TO LATERAL TRACKING ERROR**


It is possible (as shown in this article) to design and mount a pickup arm 6in long and of conventional shape so that the maximum distortion, due to lateral tracking error, of a fairly large signal (10 cm/sec r.m.s. recorded velocity) is less than 1%.

In view of the small value, any attempt to reduce the tracking error further by means of additional levers, etc., will not only have a negligible effect on the distortion, but will increase the inertia of the pickup assembly, which is undesirable. Lateral tracking error distortion for a pickup which is poorly mounted so that this value becomes 5%, say, is still small compared with that from other sources. However, these other distortions (which are much greater for stereophonic records) are slowly being reduced with improvements in pickup arms, whereas tracking error is unaffected. In fact, the distortion from tracking error increases if elliptical styli are used.

One may argue that a 1 or 2% reduction in harmonic distortion is insufficiently large to be worth bothering with. This is true if it involves a modification to the pickup arm resulting in greater expense. If, as shown, it merely involves slightly more care in offsetting the pickup and mounting the arm, the extra effort is certainly worth while.

ANYONE who constructs a pickup arm has to choose values for the offset angle of the cantilever assembly and the overhang. Anyone mounting a pickup need only consider the overhang in order to determine the optimum distance between the pickup arm and turntable pivots. There is a general belief that a pickup arm should be mounted for minimum angular tracking error and that the longer it is, the better. However, the distortion of a given modulation becomes greater as the groove speed decreases, and a pickup arm designed and mounted for minimum tracking error will have its maximum error on the worst possible occasion, namely at the innermost grooves of the record. As the length of an arm increases, its inertia (effective mass) at the stylus tip will usually increase, and this is undesirable.

Two designs are given. The first is for a general purpose record player suitable for 7in, 10in and 12in discs, and the second is for a record player restricted to 7in discs. In both cases, a range of arm lengths is considered, and the most suitable values for the offset angle and overhang are given. Also, for the first design, values of overhang are included for offset angles varying within limits of about ±0.5° from the recommended value. Provided that the offset angle of a pickup arm lies within this range, the mounting may be considered as optimum with the smaller angle slightly favouring 45 rev/min records and the larger angle favouring long-playing records.

The importance of mounting accurately is shown graphically. An error of 0.1in in overhang or 2° in offset angle will more than double the distortion from long-playing records. In view of this, the distances between the stylus and turntable centre, at which the tracking error should be zero, have been given. These distances are independent of the length of the pickup arm and enable the accuracy of the mounting to be checked.

A mounting procedure is given for reducing these errors. If the offset angle is fixed and slightly different from the recommended value, an alternative procedure is given for adjusting the overhang for optimum mounting. Neither of these methods requires the offset angle or overhang to be accurately determined. All that is required is an alignment protractor and such a device is obtainable from most hi-fi dealers.

**Distortions in reproduction from discs**

The quality of reproduction from discs is limited mainly by three factors. Firstly, tracking error, which is the error in alignment between the cantilever assembly and the groove in which the stylus is located. Lateral (horizontal) tracking error is the angle, in the horizontal plane, between the groove, or direction of motion, and the cantilever, and for a conventional pickup arm the lateral tracking error varies with distance from the turntable centre. Vertical tracking error, which only affects stereophonic records, is the difference between the angle which the stylus makes with the vertical when slightly lifted (the arm remaining stationary), and the value specified for the particular record being played. The second factor limiting the quality of reproduction is groove deformation due to the plastic record material being compressed by the stylus tip. However, this distortion tends to reduce the third and most serious form of distortion, tracing distortion due to the cutter and stylus being of a different shape. The flat edge of the V-shaped cutter faces the direction of record motion, and therefore an absence of signal corresponds to a large groove width. As a result of a signal causing the
cutter to move horizontally, as in the case of a monophonic signal or two stereophonic signals approximately equal in amplitude and phase, the groove width becomes narrower causing a stylus of spherical tip to rise. This is the pinch effect. The high-frequency response of a pickup is limited by the radius of the stylus tip since the finite width in the direction of record motion limits the ability to follow groove modulations. The quality of reproduction is reduced further if the tracking mass is insufficient for the stylus to contend with large high-frequency velocities (for which a small effective tip mass is favoured) and low-frequency amplitudes (for which a large compliance is favoured).

Elliptical styli

In articles on pickup design, lateral tracking error is usually only briefly considered since the distortion is generally very much less than that resulting from other causes. However, in the last few years, these other forms of distortion have been reduced considerably. With pickups of lower effective tip mass and higher compliance, lower tracking masses have been possible. This has enabled styli of smaller radius (0.0005 in and less) to be used with a subsequent reduction in tracing distortion. Tracing distortion has been reduced further by the adoption of elliptical styli, mounted so that the major axes face the direction of record motion. The "vertical" cutting angle has been standardized in the U.S.A. at 15° and it should not be long before this value becomes universal. The result will then be a considerable reduction in vertical tracking error and subsequent distortion when the latest stereophonic records are tracked by the latest pickups, i.e. pickups designed so that a line joining the stylus tip and cantilever pivot is inclined at 15° to the record surface.

Despite their many advantages, the use of elliptical styl needles in an increase in distortion from lateral tracking error by causing a time-lag effect. With a spherical tip, the points of contact with the walls of unmodulated grooves and at the crest of waves are always the same as those of the cutter, i.e. a line through these points will be perpendicular to the direction of record motion. However, if the stylus is elliptical and tracking error exists, then one point of contact will be slightly ahead of the other. In these circumstances, tracking error cannot be ignored. Even with spherical stylins, it is certainly worth spending a few minutes extra in mounting a pickup arm if, as a result, the distortion due to lateral tracking error is reduced to a minimum, perhaps even halved.

Distortion due to tracking error

The main form of distortion due to tracking error is second harmonic and is given by H. G. Baerwald1 as:

$$\varepsilon = 100 \frac{V_n \tan \phi}{2 \pi} \approx 100 \frac{V_n}{\pi} \quad \text{2nd harmonic distortion}$$

where $\varepsilon = \%$ 2nd harmonic distortion, $V_n = \text{peak recorded velocity (cm/sec)}$, $\phi = \text{tracking error in radians}$, and $V_n = \text{groove speed (cm/sec)}$.

Third and higher harmonic distortions amount to less than 10% of this value and are considered negligible. Using the expressions:

$$V_{\text{rms}} = \frac{V_n}{\sqrt{2}} = \text{r.m.s. or effective recorded velocity (cm/sec)}$$


J. K. Stevenson, who is 26, graduated with an honours degree in physics at Birmingham University in 1962 and since then has been at the G.E.C. Hirst Research Centre, Wembley. He is senior member of a team investigating processing techniques for quartz crystals as piezoelectric resonators and determining new synthesis procedures for quartz crystal wave filters. He is a part-time teacher of physics at Willesden Technical College. This article stems from his personal interest in audio equipment.

Wireless World, May 1966
Re-arranging, \( 2I \sin \theta = x + \frac{l^2 - d^2}{x} = y \) \hspace{1cm} (2)

where \( d = \frac{l - f}{2} \).

We will consider first the determination of \( \theta_D \) and \( f \) for minimum angular tracking error, and then show how these expressions are modified to reduce the maximum distortion of a given modulation, which is proportional to groove speed and therefore is inversely proportional to \( x \).

**Design for minimum angular tracking error**

A value of \( \theta \) is required which varies least in equation 2 when \( x \) varies between \( x_1 \) and \( x_2 \); \( I \) and \( d \) are constants. If we plot \( y \) against \( x \) we will obtain a curve which starts at infinity when \( x = 0 \), reduces to a minimum value, and then increases to infinity at \( x = \infty \) as in Fig. 4. The minimum at \( x = x_m \) is given by differentiating equation 2 with respect to \( x \) and equating to zero.

\[
\frac{dy}{dx} = 0 = 1 - \frac{l^2 - d^2}{x^2}
\]

Hence, \( x_m = \pm \sqrt{l^2 - d^2} \).

Since \( l \) is given, \( x_m \) is varied by altering \( d \). It is clear that \( x_m \) should lie between \( x_1 \) and \( x_2 \) if we wish the variation in \( 2I \sin \theta \) to be as small as possible for \( x \) varying between \( x_1 \) and \( x_2 \). In particular, the variation will be a minimum if the values of \( y \) at \( x = x_1 \) and \( x = x_2 \) are equal. From equation 2,

\[
x_1 + \frac{l^2 - d^2}{x_1} = x_2 + \frac{l^2 - d^2}{x_2}
\]

Hence, \( x_1 x_2 = l^2 - d^2 = x_1 x_2 \).

The minimum value of \( \theta \) then occurs at the geometric mean of \( x_1 \) and \( x_2 \). Using equation 3,

\[
d = \left( l^2 - x_1 x_2 \right)^{1/2} = l - f
\]

The overhang \( f \) is therefore given by:

\[
f = l - \left( l^2 - x_1 x_2 \right)^{1/2}
\]

The maximum and minimum values of \( \theta \) are given from equations 2 and 3,

\[
y_{\text{max}} = x_1 + x_2 = 2\sin \theta_{\text{max}}
\]

\[
y_{\text{min}} = 2(x_1 x_2)^{1/2} = 2\sin \theta_{\text{min}}
\]

The design value for \( \theta_D \) is then as follows:

\[
\theta_D = \frac{1}{2} \left( \theta_{\text{min}} + \theta_{\text{max}} \right) = \frac{1}{2} \left[ \sin^{-1} \left( \frac{1}{2} x_1 + \frac{1}{2} x_2 \right) + \sin^{-1} \left( \frac{1}{2} x_1 + \frac{1}{2} x_2 \right) \right]
\]

or \( \sin \theta_D = \frac{1}{2} \left( \sin \theta_{\text{min}} + \sin \theta_{\text{max}} \right) = \frac{(x_1 + x_2)^{1/2}}{2I} \)

**Design for minimum tracking error distortion**

In determining the pickup parameters for minimum lateral tracking error, we minimized the variation in \( 2I \sin \theta \) for \( x \) varying between \( x_1 \) and \( x_2 \) by including a turning point in the curve of \( 2I \sin \theta \) against \( x \) at \( x = (x_1 x_2)^{1/2} \). \( 2I \sin \theta \) then has the same value at \( x_1 \) and \( x_2 \). In this case, by minimizing the variation in \( \sin \theta \) (\( \theta \) being constant), we automatically minimized the variation in \( \theta \), as required, i.e. \( \theta \) is as small as possible for \( x_1 < x < x_2 \). Since for a given tracking error the distortion is inversely proportional to \( x \), it is preferable for \( \theta(x) = (\theta - \theta_D)/x \) to be as small as possible. Most forms of distortion increase as the pickup approaches the turntable centre, so it is desirable for the distortion due to lateral tracking error to be a very small at the average minimum value of \( x \). Let the tracking error be zero at \( x = x_0 \). We have mentioned Fig. 4 which gives \( 2I \sin \theta \) against \( x \). Fig. 5 gives \( 2I \sin \theta/x \) against \( x \) and in addition \( 2I \sin \theta_0/x \) against \( x \). The distance between these curves at a given
7.4

Fig. 4. Variation of $2\sin \theta$ with $x$ for a pickup arm designed for zero tracking error at $x_0$ and minimum distortion between $x_0$ and $x$. As $x_0 < x < x_f$, the maximum harmonic distortion ($2(\sin \theta - \sin \theta_0)$) decreases to zero, increases to a maximum at $x_0$ (the same value of distortion as at $x_f$) and then decreases to zero at $x_0$. Note that the largest negative value of $(2\sin \theta - \sin \theta_0)$ occurs at $x_m$ and the largest negative value of $2(\sin \theta - \sin \theta_0)/x$ at $x_f$. value of $x$ is $2(\sin \theta - \sin \theta_0)/x$ which we will minimize since it is approximately proportional to $(\theta - \theta_0)/x$ and allows a considerable simplification in the algebra.

Both $2\sin \theta$ against $x$ and $2(\sin \theta - \sin \theta_0)$ against $x$ have a minimum at $x_m$, whereas $2(\sin \theta - \sin \theta_0)/x$ against $x$ has a minimum at a value of $x$ less than $x_m$ which we will call $x_p$. From equations 2 and 3:

$$2\sin \theta = x + \frac{x_m^2}{x}.$$  

Hence,

$$2(\sin \theta - \sin \theta_0) = \frac{x + x_m^2}{x} - \left(\frac{x_0 + x_m^2}{x_0}\right) = \mathcal{W}.$$  

$\mathcal{W}$ against $x$ has a minimum at $x = x_p$. Hence, from Fig. 5, $x_p$ is the value of $x$ at which the continuous line is the furthest distance below the interrupted line. Differentiating equation 4 with respect to $x$ and equating to zero:

$$\frac{d\mathcal{W}}{dx} = 0 = -\frac{2x_m^2}{x^3} + \frac{x_0}{x^2} + \frac{x_m^2}{x^2} - \frac{2x_m^2}{x^3} = \frac{x_0 + x_m^2}{x} - \frac{2x_m^2}{x^3}.$$  

...  

$$x_p = \frac{x_0 + x_m^2}{x_0 + x_m^2}.$$  

Ideally, we require

$$x_p = \frac{x_0 + x_m^2}{x_0}.$$  

but since

$$\sin \theta_0 - \sin \theta_p = 2\sin \frac{\theta_0 - \theta_p}{2}\cos \frac{\theta_p + \theta_0}{2} = \frac{\pi}{180} (\theta_0 - \theta_p) \cos \theta_p$$  

and

$$\sin \theta_2 - \sin \theta_0 = 2\sin \frac{\theta_0 - \theta_2}{2}\cos \frac{\theta_0 + \theta_2}{2} = \frac{\pi}{180} (\theta_2 - \theta_0) \cos \theta_0$$  

we may replace equation 5 by

$$2(\sin \theta_2 - \sin \theta_0) = 2\sin \theta_2.$$  

This may be put in the form:

$$\frac{2x_0 + x_m^2}{x_0 + x_m^2} = \frac{x_0 + x_m^2}{x_0}.$$  

Simplifying,

$$\frac{2x_0}{x_0^2} = \frac{3x_0}{x_0^2} + \frac{2x_0^2}{x_0} - \frac{2x_0^2}{x_0} = 0.$$  

Hence, $x_m^2 = \frac{5828x_a}{2} - 0.8284x_a - 0.1716x_a$.

This reduces to:

$$x_m^2 = \frac{0.8284x_a}{2} - 0.1716x_a.$$  

...  

VERTICAL DISTANCE BETWEEN LINES

$2(\sin \theta - \sin \theta_0)$

Fig. 5. Variation of $(2\sin \theta)/x$ with $x$. The vertical distance between the lines is proportional to the harmonic distortion of a given modulation.
The design value $\theta_d$ for a given value of $f$ is given from:

$$\sin \theta_d = \sin \theta_o \left( 1 + \frac{x_o + x_m^2}{2l} \right)$$

since $\theta_p = \theta_o$. The overhang $f$ is given by:

$$f = \frac{l - (l^2 - x_m^2)^{1/2}}{2l}$$

All we require are values for $x_o$ and $x_{m}$. $x_{m}$ is then determined using equation 6 and the value substituted in equations 7 and 8 to determine $\theta_p$ and $f$ for a given value of $l$.

The value of $x$ less than $x_o$ at which the harmonic distortion (of a given modulation) is the same as at $x_o$ and $x_{m}$ we will call $x'$. This is given as follows:

$$x' = -\frac{x_o + x_m^2}{x_o + x_m^2}$$

From the first two expressions,

$$x' = -\frac{x_o + x_m^2}{x_o + x_m^2}$$

The two solutions for $x$ are $x_o$ and $x_{m}$. $x_{m}$ is then determined using equation 6 and the value substituted in equations 7 and 8 to determine $\theta_p$ and $f$ for a given value of $l$.

The tracking error changes from positive to negative and back to positive again. The tracking error per unit length is zero at $x_o$ and $x_{m}$ and the maximum negative value (at $x_o$) is equal to the positive values at $x_o$ and $x_{m}$, as indicated in Fig. 5.

The values of $x$ are related as follows:

$$x_o = \frac{x_m^2}{x_o + x_m^2}$$

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

Rearranging, we have:

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

Solutions are $x_o$ and $x'$. We require two values of $x$ to obtain a solution. If we specify $x_o$ and $x_{m}$ (as in the given designs), then:

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

Equation 9 was used to compare the distortion of a given modulation arising from a pickup mounted as suggested here with that obtained if Bauer's method is used. Results will be given in Appendix II.

Summary of design formulae

As $x$ decreases, we have shown that the tracking error changes from positive to negative and back to positive again. The tracking error per unit length is zero at $x_o$ and $x_{m}$ and the maximum negative value (at $x_o$) is equal to the positive values at $x_o$ and $x_{m}$, as indicated in Fig. 5.

The values of $x$ are related as follows:

$$x_o + x_m^2 = x' + x_m^2$$

$$x' + x_m^2 = x_o + x_m^2$$

$$x' + x_m^2 = x_o + x_m^2$$

where $x' > x_o$ and $x_{m} > x_o$.

We must specify two values of $x$ to obtain a solution. If we specify $x_o$ and $x_{m}$ (as in the given designs), then:

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

$$x' = \frac{x_o + x_m^2}{x_o + x_m^2}$$

where $x' = 0.8284x_o + 0.1716x_{m}$.

Alternatively, we can give values for $x_{m}$ and $x_o$ the limits of $x$ between which we require the tracking error per unit length to be minimized. Then it is easily shown that:

$$x_o = \frac{x_o + x_m^2}{x_o + x_m^2}$$

$$x_o = \frac{x_o + x_m^2}{x_o + x_m^2}$$

$$x_o = \frac{x_o + x_m^2}{x_o + x_m^2}$$

where $x' = 0.8536x_o + 0.1464x_{m}$.

The offset angle $\theta_d$ and overhang $f$ for minimum tracking error per unit length are then as follows:

$$\sin \theta_d = \frac{1}{l} \cdot \frac{x_m^2}{x_o}$$

$$f = \frac{l - (l^2 - x_m^2)^{1/2}}{2l}$$

To be concluded.

Acknowledgement is due to Alfred Imhof Ltd. for the use of their facilities in the production of our front cover.
Transistor Electronic Organ

1—ELECTRONIC ORGAN DESIGN TRENDS

By T. D. TOWERS, M.B.E.

In the wind organ of Fig. 2(a), a bellows or pump-type compressor, A, forces air under pressure through a pipe, B, into a high-pressure reservoir ("wind-chest"). C. By operating one of the keys in the keyboard, E, the player can let compressed air pass through ducts D and F on the start of its way to make the organ pipe, I, sound or "speak." However, the "stops," G, in their off position stop the flow of wind to the pipe, I, even though a note is depressed on the keyboard. By putting on a selected stop, the performer opens the way for air to flow to a selected set or "rank" of pipes designed to produce a certain type of sound. The organ pipe is like a large whistle blown by the wind pressure released into it when the appropriate stop and key are actuated. The stop selects a set of pipes of one timbre, and the playing key selects the pipe of the proper pitch in that set.

Some ranks of pipes are mounted in free air, but others are enclosed in a sound-insulated enclosure, J, in Fig. 2(a), known as a "swell cabinet." Sound from these enclosed pipes emerges through a sort of venetian blind, K, and its apparent loudness depends on how far the blind is opened. A foot-operated "swell" or "expression" pedal, L, controls the opening of the venetian blind, and thus the apparent volume of sound from the "swell" ranks of pipes. The player manipulates the organ from the console (shown dotted) which presents to him the keyboards (usually more than one), the stop actuators ("pistons" or "tabs") and the swell pedal.

The block schematic of an electronic organ is given in Fig. 2(b), laid out to parallel the functions of its various sections with those of the wind organ above it, so as to highlight the differences. An electrical supply,
A. provides power for the generators, C, of electrical a.c. signals of various frequencies. As with the wind organ, the console provides keyboard(s) E, stop controls, G, and a swell pedal, L.

The playing keys on the electronic organ keyboard select the appropriate frequency a.c. signals from the generator, and the stop tabs direct these selected signals into corresponding tone shaping circuits. Subsequently, these keyed, stop-directed, shaped, a.c. signals at H pass into the amplifier, X. There they are amplified and used to produce a sound output by driving a loudspeaker, L. The output level is controlled by an amplifier volume control actuated by the foot pedal, L.

The traditional organ nomenclature of keyboards ("manual" and "pedal"), "stops" (tone colours), and "swell pedal" (volume control) have been carried over into electronic organs, because they achieve the same results, even if in a vastly different way.

**Distinguishing mark of the electronic organ**—In essence, while a wind organ emits sound directly from the vibrations of a column of air in a pipe, an electronic organ produces it indirectly from a.c. electrical signals by turning them into vibrations of a loudspeaker cone. (You should not, by the way, confuse the electronic organ with the electric organ in which electrical power is used to drive the mechanical movements.)

**TONE GENERATION IN AN ELECTRIC ORGAN**

Electronic organs fall into two main classes according to whether their a.c. signal generators run all the time, or are switched on and off by the playing keys. The distinction is illustrated diagrammatically in Fig. 3. In the continuous-generator case at Fig. 3(a), a power supply drives the generators continuously, but their outputs do not pass towards the loudspeaker until a playing key is depressed; i.e., the keyboard switches come between the generators and the output busbar. In the switched-generator case at Fig. 3(b), the generators are inactive until the depressing of a playing key feeds the power supply into one of them; i.e., the keyboard this time comes between the power supply and the generators.

**Generator types in common use.**—Anything that will generate stable audio-frequency a.c. signals can be used as an electronic organ generator. The path of development up to date is strewed with weird relics in consequence. Fig. 4 gives a selection of some of the more common tone generator principles that have survived into current commercial organs.

At Fig. 4(a) is a sketch of the principle of the simplest polygonal rotating disc electromagnetic generator. This has been used now for some 30 years in the Hammond organ, which is regarded by many as the "Rolls-Royce" of electronic organs. A rotating iron disc with undulating rim, set up opposite* a permanent magnet, gives rise, in a coil wound round the magnet, to a.c. signals at a frequency set by the rotational speed and the number of wave cycles round the rim.

Another common generator type is the wind-blown, electrostatic pick-up, reed system illustrated in Fig. 4(b). Derived from harmonium practice, this has been widely used by such firms as Farfisa. The metal reed is continuously vibrated by a fixed-pressure air supply, and the

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*What does one call a pipe organ with a semiconductor logic switching action? (see "W.W.", Jan. 1965, p. 16.)—EB.
capacitance variation between the pick-up electrode and the earthed metal reed modulates the output voltage to give an a.c. signal at the reed resonant frequency.

Fig. 4(c) illustrates a third principle, the rotary-disc, capacitor pick-up system which has been the hallmark of the Compton electronic organs for over three decades. Here the voltage on a fixed pick-up electrode is modulated by the varying capacitance between the electrode and an earthed cyclically changing pattern on the face of a rotating disc. (In the Compton version, actually, the pick-up rotates and the cyclic pattern is on a fixed stator, but the principle is the same.)

A slightly different type of generator is the key-vibrated, electro-static pick-up system illustrated at Fig. 4(d), used in “electronic pianos,” such as the Wurlitzer. Strictly it is not an organ generator, because the vibration of the reed dies steadily away after the impact of the key hammer. However, it is included because the electronic piano is in many other ways very like an electronic organ.

These first four examples of organ generators given above have been all electromechanical. There is a tendency for such types to be superseded by purely electrical oscillators, of which common examples are given in Figs. 4(e) to (h). LC oscillators such as Fig. 4(e), valve, and Fig. 4(f), transistor, have their frequency set by their own LC tank circuits. By contrast, the divide-by-two circuits at Fig. 4(g), a transistor triggered blocking oscillator, and Fig. 4(h), a transistor bistable divider, merely provide an output signal at a frequency one half of the input trigger signal frequency.

A.C. signal waveshapes.—What sort of waveshapes do the various generators produce? This is important because, if, as is sometimes desirable, the instrument has to simulate the sound of a traditional organ, it will have to feed to the loudspeakers highly complex periodic waveforms.

One way of producing such complex a.c. output signals is by Fourier synthesis, i.e., by mixing a harmonically related series of sinewaves in varying proportions. This is the working principle of the Hammond. The basic sinewave shape, as shown in Fig. 5(a), comprises only a fundamental frequency without harmonics, of course. Most electric organs nowadays, however, approach the production of a complex output waveform by taking a basic waveshape rich in harmonics and working on it to tailor the strength of the individual harmonics to give the desired tone colour.

The two commonest harmonic-rich waveforms used in organ generators are the sawtooth, Fig. 5(b), and the squarewave, Fig. 5(c). It is worth noting the harmonic content of these two types. The sawtooth of basic frequency \( f \) has material overtones in both the even \((2f, 4f, 6f, \ldots)\) harmonic series and the odd \((3f, 5f, 7f, \ldots)\) series. The squarewave has odd harmonics only. The importance of this lies in the fact that the sawtooth with
produce different harmonic pitches.

of

222 controlled by from certain of these desired complex oboe waveform can be achieved.

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You can see

sawtooth or squarewaves,

even harmonics makes diapason tone difficult, although it has compensations (oboe).

oboe compared to its

Fig. 5. Indications of the relative strength of the harmonics in basic waveshapes commonly produced by electronic organ generators compared with the complex waveshape required for a typical organ oboe stop: (a) sinewave; (b) sawtooth; (c) squarewave; (d) complex (above).

its full range of harmonics can be more easily reshaped to produce the normal "diapason" classical organ sound than can the squarewave. In the latter, the absence of even harmonics makes diapason tone difficult, although it has compensations in that it can more easily produce hollow tones such as the clarinet sound.

Some commercial organs use basic sawtooth and some basic squarewaves. The tendency nowadays is to adopt the squarewave because it is cheaper in production and less "temperamental" than the sawtooth. Some pundits claim that they can tell blindfolded whether an organ uses sawtooth or squarewaves, but with a well-designed instrument I personally have not found this to be so.

For the designer, the choice of sawtooth or squarewave is important, because the tone-forming filter circuits controlled by the stop tabs are substantially different for the two types. This is why any circuit for a tone filter should have on it an indication of the basic waveshape it controls.

To put point to this discussion of generator waveshapes, the complex waveshape of an oboe sound is shown in Fig. 5(d) with a spectrum of its harmonic content. This particular waveshape is characterized by a low level of fundamental and a predominance of fourth and fifth harmonics. You can see that the harmonic distribution of Fig. 4(d) can be relatively easily made up by adjusting the amplitudes of the harmonics of the sawtooth, Fig. 4(b). But, in the case of the squarewave, Fig. 4(e), even harmonics have to be produced separately and added before the desired complex oboe waveform can be achieved.

**ACTION OF PLAYING KEYS**

In the electronic organ each playing key operates a set of ganged switches, usually four or five in number, to produce different harmonic pitches. As mentioned earlier, these key-switches either select the appropriate outputs from certain of a set of continuously running generators or switch the actuating power to selected oscillators in a set of normally non-operating generators.

Locked- and free-phase oscillators.—The oscillators controlled by the key-switches can all be independently adjustable so that, apart from their being individually tuned as nearly as practicable to the appropriate scale-related note frequencies, they are "free-phase" oscillators working independently of each other. In such a system, initial tuning can be tedious, because anything from 60 to 600 oscillators have to be set up. It is rather like tuning a wind organ (where each pipe has to be checked).

The alternative (and nowadays by far the commonest) arrangement is the "locked-phase" oscillator system. In this there are only 12 independent tunable "master" oscillators, one for each note, (C, C♯, D, D♯, E, F, F♯, G, G♯, A, A♯, B) of the equal-tempered musical chromatic scale. All the frequencies required by the organ are octavely related to these 12 oscillator frequencies, and are produced by a string of divider oscillators phase-locked to the master oscillators (usually to subharmonics) and thus not independently adjustable.

The free-phase and locked-phase oscillator systems are illustrated diagrammatically in Fig. 6 for all the Cs to be sounded by an organ. In the locked-phase system of Fig. 6(a), the master C oscillator is tuned to C1 = 2,093.0 c/s; the Cs for lower octaves are produced by a string of divide-by-two circuits phase-locked to the master oscillator. This means that C1 = 65.4 c/s, for example, comes out coldly mathematically at an exact half of C2 = 130.8 c/s, and in phase with it. In the free-phase system of Fig. 6(b), each oscillator in the string of Cs is individually tuned as near as possible to the harmonic series frequencies, but each C will inevitably depart slightly from half the frequency of the C above it. Also the individual oscillations will not now be in phase with each other.

There is no doubt that the free-phase oscillator system can more closely simulate the so-called "chorus" effect of a wind organ with all its pipes individually tuned and not in phase with each other. But you must pay for perfection, and many electronic organs now make do with the cheaper, easier-to-set-up, locked-phase divider system.

The problem of key clicks.—Whether locked- or free-phase oscillators are used has a large bearing on the keying system. Obviously in a locked-phase system the oscillators must run all the time and the keys can only switch their outputs. This means switching a.c. signals, in which it is very difficult to avoid "key-clicks" arising from the abrupt interruptions of the signal. With free-phase oscillators, on the other hand, it is possible to use the keys to switch the a.c. supply to the oscillators. The oscillator output a.c. signals then do not start and stop abruptly, and key clicks are much less of a problem. Also in this case the gradual start of oscillation stimulates the steady build-up of sound in a wind organ pipe when the playing key is pressed.

In the electronic organ, the "stops" are merely the switches for selecting the tone forming filter circuits through which the basic waveform signals are fed from the generators via the playing keys to achieve the desired final tone colour. There are three basic classes of stops: "speaking," "percussion," and "coupler."

Speaking stops are the switches that control the tone colour of the organ output. They select certain pitches of notes supplied by the playing keys, mix them and feed them to appropriate waveshape modifying filter circuits. These stops are concerned primarily with the recurrent waveshape of the final signal to the loudspeakers, i.e., the steady, continuous, fixed-amplitude, fixed-frequency waveshapes.

Percussion stops.—Other switches, the so-called "percussion stops," are usually provided to control the envelope of the output signals. If the playing key switched the signal on and off abruptly, we should get a signal...
Fig. 6. Illustration of differences between locked-phase (a) and free-phase (b) oscillator systems in electronic organ. (The locked-phase system is also known as "divider" type or "synchronous" system.)

Envelope

In an attempt to simulate classical organ sound and to give variety to tonal effects, electronic organ designers use some or all of the variety of percussion (or envelope-distortion) arrangements illustrated in Figs. 7(b) to (g).

"Attack" percussion at Fig. 7(b) is the delaying of the build-up of the waveform signals on switch-on. "Decay" (a) at Fig. 7(c) is the permitting of signals to fall off (or even cease) before the playing key is released. "Sustain" (d) at Fig. 7(d) is letting the signal continue after key off. In all these types, the amplitude and frequency of the note are unchanged in the middle of the note sounding.

But there are other percussion stops which modify the waveshape characteristic throughout the whole note length. Of this class is the "tremolo" stop at Fig. 7(e) which varies the signal amplitude at a subsonic frequency between 3 and 9 c/s to make an approximation to the "tremulant" effect in a wind organ. "Vibrato" at Fig. 7(f) frequency-modulates the signal at subsonic frequency again in an attempt to simulate the organ tremulant. But in the wind organ, the tremulant is a mixture of amplitude and frequency modulation, and electronic organ designers sometimes provide both tremolo and vibrato in consequence. (People who have difficulty in remembering which is vibrato and which tremolo may welcome my own little aide-mémoire: Vibrato varies the Frequency, because "V" sounds not unlike "F.".)

The last percussion stop is "reverberation" (also known as "echo") illustrated in Fig. 7(g). In a wind organ sited in a church or a large hall, part of the "organ" sound is due to the characteristic echoes from the walls. In effect, a tone burst is heard repeated one or more times with diminishing volume after the key is released. This is simulated in an electronic organ by feeding off part of the signal into a delay network and then releasing it back into the amplifier. The delay network can be acoustic (some people have even used a length of garden hose), mechanical (e.g. passing sound through a coiled spring), or moving-magnetic (e.g. signal recorded on a magnetic tape and picked up again later by a separate playback head).

Coupler stops.—Where an electronic organ has more than one keyboard, "coupler" stops are often provided to enable the separate keyboards to be coupled; i.e., speaking stops can be set up for one keyboard and played from another by switching in coupler stops.

COMPLETE ELECTRONIC ORGANS

If you now look back to the schematic block diagram of an electronic organ given in Fig. 2(b), you will see that we have now covered, albeit sketchily, most of the component sections of the system. But a few further remarks might not be out of place here.

The power supply is usually mains driven, but transistor models are available nowadays for battery operation. The amplifier is a little different from a standard hi-fi amplifier. Because of the possibility of sustained high level signals, its overload characteristics require careful design. Output powers range from 10 W to 100 W usually. The loudspeakers must not only have adequate wattage ratings, but must have a good response down to below 20 c/s to reproduce low pedal notes without distortion. The swell pedal (volume control) receives
much hard wear. For this, therefore, often some arrangement of light- or voltage-dependent resistors is used to avoid using a conventional carbon or wirewound potentiometer which may soon develop contact noise.

Consoles.—A variety of layouts of the component sections of the electronic organ will be found in commercial models. The tendency nowadays is to pack everything into a single cabinet or "console." This was not always possible in earlier days, but modern miniature components make the self-contained organ the norm. The domestic electronic organ sketched at Fig. 1(b) illustrates this compactness tendency. Here you can see the stop tabs sited above the keyboard (their usual position), supplementary controls at each end, the swell pedal convenient to the player's right foot, the loudspeaker facing forward, and the pedal board at the bottom left.

Keyboards.—As to the keyboard itself, the student of the electronic organ will find a confusing variety in use. Commercial instruments will, of course, have at least one manual keyboard. More frequently they have two manuals, usually called the solo (upper) and accompaniment (lower). These are also occasionally referred to as the "swell" and "great" respectively to conform with traditional wind organ terms.

Where an electronic organ is intended to substitute for a traditional organ, three manuals are not uncommon, and these are usually given the standard organ descriptions of: "great," "swell" and "choir."

In the "pedal department," two arrangements have become fairly standard in the electronic organ. The first of these (used in the illustration of Fig. 1(b)) is the 13-note, stub-pedal common in the smaller domestic organs. The standard full 31-note classical pedal compass is not often used for electronic organs, although many models feature the second standard, a shorter two-octave, 25-note version.

When engineers first take an interest in electronic organs, they often find themselves confused by the plethora of keyboard specifications. For their benefit, Fig. 8 sets out the compasses of widely used keyboards against the spread of the familiar standard 88-note piano keyboard. The standard organ manual keyboard is the C-to-C, 5-octave, 61-note version, but you may come across the alternative "harmonium, F-to-F" version with the same compass. The shorter manual keyboards listed in Fig. 8 have become very common in small domestic electronic organs, mainly because of their cheapness.

Sources of Further Information

By now the reader must have realized that electronic organ design is not without its complexities. If all this has not discouraged him too much, he may welcome suggestions as to where to look for further information.


Our Next Issue

A 32-page supplement in our June issue will give a stand-by-stand preview of the Instruments, Electronics & Automation (I.E.A.) Exhibition to be held at Olympia from May 23rd to 28th. This supplement will be in addition to the normal quota of features and technical articles which will include the second of the series on electronic organs and a review of the latest developments in audio techniques seen at the London Audio Fair. We also plan to include a report on some of the new equipment seen at the Hanover Fair (April 30th-May 8th).
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Aircraft Collision Avoidance System Proposed

IN 1955 the Air Transport Association of America asked the electronics industry to submit proposals for a form of collision avoidance equipment. Since then much work has been devoted to the development of a system suitable for installation in civil and military aircraft and compatible with the American air traffic control system, but to date a system has not been fully approved. However, one manufacturer, McDonnell Aircraft, of St. Louis, Missouri, has developed a system for use in specialized flight test operations with its aircraft. The system uses the time frequency, range altitude technique which entails the measurement of range, the rate of change in range (range-rate) and altitude. Each aircraft carries a computer which has a precise transmit time assigned to it; each computer also knows the transmit time of the other aircraft. All aircraft transmit their time on a common frequency at the allocated times and the difference in, between the assigned time of transmission and the actual time of reception by the computer is used to determine distance to the transmitting aircraft. At the receiving aircraft a frequency shift varying with the relative speeds of the two aircraft is measured to give their rate of closure. The computer divides distance by rate of closure to predict possible time of collision, advises what escape manoeuvre to use and then indicates when the potential collision has been avoided. Great precision in both timing and frequency stability is necessary. Accuracies in the order of one part in ten million are required. Each aircraft must carry an accurate frequency standard and the system requires a practical method for synchronizing the timing devices carried aboard all aircraft at appropriate intervals.

In its present form, the McDonnell system is not suitable for airline use, but the Air Traffic Control Committee of the A.T.A. has been directed to give all possible assistance to the company so that the system can be subjected to early flight evaluation by airlines.

Collision avoidance systems for aircraft are being discussed in our correspondence columns (see page 249).

Television Without Cameras

THE Canadian RCA Victor Company has developed a technique by which printed matter can be televised without the use of a camera; instead, for example, a typist operating a keyboard can type messages for direct television transmission.

The system, designated DIVCON—digital-to-video conversion—includes a display control logic sub-system programmed to store information from various sub-systems and to "read" the contents of a memory to a series of digital-to-video-generator sub-systems which translate the digital data into a video form synchronized with the television scanning periods. The system has all control functions normally found on an electric typewriter such as space, shift and backspace and there are special facilities for erasing. There is also a facility to underline words or to make them bold. Stationary or travelling displays of information are also possible. Code conversion logic is provided so that the DIVCON system can work with data processing centres using different machine languages.

Data is stored in the random access core memory in an eight bit code and the actual size of the memory is dictated by the number of output video channels wanted and the amount of character symbols needed for each channel.

Readers who watched the B.B.C.'s televised results of the General Election will be interested to learn that the DIVCON system was used for those transmissions.

International Amateur Radio Conference

FROM May 23-28 at Opatija in Yugoslavia about 70 delegates representing some 40,000 licensed radio amateurs from the national amateur radio societies of Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Nigeria, Norway, Poland, the Soviet Union, Sweden, Switzerland, the United Kingdom and Yugoslavia will meet to discuss over 100 proposals and suggestions at the triennial conference of the International Amateur Radio Union, Region 1 (Europe and Africa) Division.

Subjects for discussion will include amateur teletype standards and frequencies, proposals for a European orbiting satellite carrying amateur radio (OSCAR) and proposals by the R.S.G.B. that harmonically related frequencies should be used for s.h.f. working and authority sought for amateurs to use the amateur u.h.f. and s.h.f. bands for space communication. At present under international regulations amateur space communication activities are confined to the 144-146 Mc/s band.

The Conference is being organized by the honorary secretary of the I.A.R.U. Region 1 Division, John Claricoats, G6GL, who, until he retired at the end of 1963, had been secretary of the R.S.G.B. since 1930.

Australian Telecommunication Problems

THE Australian Telecommunication Development Association, a representative body for manufacturers of telecommunications equipment, is confronted with a major problem, for although the Post Office supports the indigenous electronics industry, the Defence Services do not. Last year, 80% of all radio transmission equipment purchased by the Commonwealth Department was imported. The Association admitted that some complex electronic devices could only be obtained abroad, but also claimed that the Australian industry could have supplied 50% of the required equipment. The problem is twofold; first, that since this industry is regarded as a major unit in the Australian economy a continued flow of orders overseas can only be detrimental to the economy; and, more seriously, A.T.D.A. maintain that with dependence on other countries for the supply of electronic defence systems, Australia could suffer if hostilities cut supply lines. Objectives of A.T.D.A., prompted by the above problems, include (a) to encourage and maintain the growth of the industry and (b) to sustain effective co-operation with relevant Government departments and industry.

WORLD OF WIRELESS
THE Electronic Engineering Association has recently issued its annual report which includes details of the general activities and work of the individual divisions during 1965.

One of the objectives of the Association has been to establish close liaison with the Ministry of Technology whose main function has been to implement the Government's programme of modernizing the economy and to maintain close collaboration with industry. However, the report indicates that the general economic incentives and cancellation of military aviation projects have created disturbing uncertainties for the whole of the electronic capital equipment industry.

During the year the Association has conducted a detailed analysis regarding the expansion potential for production of radio communications, electronic control, navigational aid, aviation and broadcasting equipment. This has resulted in a document "Electronics and the Economy" which has been submitted to the Ministry of Technology and other Government departments in an attempt to show that certain Government action were taken the total output and exports of the various analysed sectors of the industry could increase and the imports of manufactured equipment reduced. Detailed discussions with the Ministry of Technology on the document have not yet taken place but it has already provided a background to various committees and enquiries instituted by the Government.

Canvas and Electronics—Modern electronic equipment is a feature of a 300-ton topsail schooner, *Sir Winston Churchill*, which sailed recently on her maiden voyage. Equipment includes Marconi Marine "Raymark" radar, presented by English Electric Ltd., a Marconi Mobile "Kestrel II" transmitter-receiver provided with a radio goniometer and presented by The Marconi Company Ltd., a "Graphette" recording echo sounder and an octahedral radar reflector, presented by the Marconi International Marine Co. Ltd. The radar reflector has been fitted because sailing vessels are not always good target inspectors; improved reflectors will ensure that the schooner can be under radar observation by other vessels. The schooner is owned by the Still Training Association.

Thirteen new relay stations will be built during the next three years by the Independent Television Authority. These stations will bring a new or improved service to over half a million people along the western side of the United Kingdom. All sites and channels have not been decided but provisional information indicates that three stations will be built along the Scottish coast to cover Central Ayrshire, Helensburgh and Ruthesay and six small stations in Central Wales will cover the main towns of Abergavenny, Bala, Brecon, Cwmfelin, Llandrindod Wells and Llandrindod. Another station will cover Whitehaven (Cumberland) and, in the West of England, a station will be built between Hereford and Gloucester, another near Bath and one near Barnstaple and Bideford.

The International Publishing Corporation, of which the illici group is a member, has acquired a 40% interest in Cahners Publishing Company, the Boston, Mass., publishers of 17 trade and technical journals. Among the journals published by Cahners is the monthly Electronic Engineers' Design Magazine, which has a controlled circulation of nearly 52,000. The latest acquisition brings the total number of trade and technical journals published by I.P.C. associated companies in this country, France, Italy, West Germany, Holland, the Far East and America to 213.

Yugoslav Post Office will issue a special 0.85 dinar stamp on May 23rd to commemorate twenty years of Yugoslav amateur radio, and the opening of the Region I (Europe and Africa) conference of the International Amateur Radio Union in Opatija. Further publicity will be provided by daily operation of the station YU0IARU, from the headquarters of the Yugoslav National Amateur Radio Society. Transmissions will be from 1200 to 1300 G.M.T. on 14.1 Mc/s.

Digital Instrumentation is the title of a one-day symposium to be held on May 19th at the Mid-Essex Technical College and School of Art, Victoria Road South, Chelmsford. Subjects to be covered include circuitry, displays, ergonomics, digital counters, measurement techniques and methods of digitization. Further details are available from the Department of Electrical Engineering.
PERSONALITIES

Joseph W. King, Ph.D., 35-year-old physicist at the Radio and Space Research Station, Slough, Bucks, has received the 1965 Wolfe award for his work on "the analysis of results obtained from topside sounding satellites and their interpretation in terms of ionosphere theory; work which has enhanced his own reputation and that of the station." The £500 award is the eighth of ten annual awards to be made under the will of the late James Perrin Wolfe to the research worker who is considered to have made an outstanding contribution to the work of what was the Department of Scientific and Industrial Research, now the Science Research Council. Dr. King, who joined the Radio and Space Research Station in 1961, is a graduate of Rhodes University, South Africa. In 1951 he was awarded the Cornwall and York Prize by the Vice-Chancellors' Committee of the South African Universities for his first publication on ionospheric physics. He went to Emmanuel College, Cambridge, on a Rotary Foundation Fellowship for Advanced Study and was awarded the 1955 Hamilton Prize by Cambridge University for the research in ionospheric physics which he did at the Cavendish Laboratory.

C. C. Moore, who has been with the Bush organization for 35 years and for the past 11 as managing director of Rank Bush Murphy Ltd., has been appointed to the newly created post of vice-chairman. The chairman is John Davis. Mr. Moore, who is 67, was appointed assistant managing director of Bush Radio in 1952 and held the same position in the Bush-Murphy merger. He succeeded to the managing directorship when Dudley Saward resigned in April last year. J. P. Collis, who was named managing director designate several months ago, succeeds Mr. Moore. Mr. Collis will continue also as managing director of Rank Audio Visual.

Kenneth G. Budden, M.A., Ph.D., A.M.I.E.E., lecturer in physics at the Cavendish Laboratory, Cambridge, has been elected a Fellow of the Royal Society. The citation refers to Dr. Budden's "contributions to the theory of the propagation of electromagnetic waves in a non-uniform anisotropic medium, particularly of long radio waves in the ionosphere." A few years ago he was given a grant of £1,694 by the then D.S.I.R. for studying the theory of propagation of radiations from artificial satellites.

Professor James D. McGee, O.B.E., M.Sc., Ph.D., M.I.E.E., who is Professor of Applied Physics at Imperial College, London, is also among the newly elected fellows of the Royal Society. Dr. McGee, who is 63 and a graduate of Sydney University, was a research physicist at E.M.I. Research Laboratories from 1932 until joining the academic staff at Imperial College in 1954. Reference is made in the Fellowship citation to Dr. McGee's work on the development of electron-optical instrumentation, television camera tubes, infra-red image converters and image intensifiers.

Sir Frederick White, K.B.E., chairman of the Commonwealth Scientific and Industrial Research Organisation, Canberra, Australia, is also appointed an F.R.S. for his work in radio physics and radar and "for outstanding contributions to the development of Australian science."

C. H. Noton, M.Sc., Ph.D., M.I.E.E., who has been with the Plessey organization since 1959 and has latterly been resident general manager for France, has been appointed to the new post of group commercial executive of the Plessey Components Group. Dr. Noton, who studied at the Universities of Liverpool and Oxford, served at the Ministry of Economic Warfare during the second world war. He was in the chemical industry before joining Plessey.

A number of other executive appointments in the Plessey Components Group are also announced. The new group quality control officer is E. P. Stanton, Ph.D., M.I.E.E., who has been with the company since 1957 and was chief inspector of Plessey-U.K. prior to his new appointment. Dr. Stanton, who is 56, previously held posts in the G.P.O. Engineering Department and was for 18 years in the Royal Signals. R. H. Crompton, who is 44 and has been with the company for 19 years and has been regional production controller since 1964, has become production and cost control manager. H. P. Kavasagh, who is 41, is appointed group data production manager. He has been with Plessey for two years. J. A. Lee, chief engineer of two Plessey divisions successively between 1958 and 1965, becomes group mechanisation engineer. He joined Plessey 25 years ago at the age of 20. L. W. D. Sharp, M.I.E.E., who came to Plessey from F. K. Cole Ltd. in 1948 at the age of 26 and has held various divisional and group appointments, is appointed manager, new product development. He was a development engineer with E. K. Cole.

Lord Nelson of Stafford, chairman and chief executive of the English Electric Company, has been elected president of the British Electrical and Allied Manufacturers' Association. Lord Nelson, who succeeded to the barony on the death of his father in 1962, is a member of the National Electronics Research Council and of the Minister of Technology's Advisory Council on Technology and is also chancellor-designate of the new University of Aston, Birmingham.

H. S. Macadie, who in 1932 designed the Universal Avometer, has retired from the board of Avo Ltd. but is being retained by the company as a consultant. Mr. Macadie, who is 65, served his apprenticeship in mechanical engineering and then joined B.T.H., where he worked on meter production. In 1925 he started his own company to manufacture plug-in tuning coils for broadcast receivers. The coils were marketed by the Automatic Coil Winder & Electrical Company, which also marketed the d.c. Avometer and an automatic coil winding machine both invented by Mr. Macadie's father. In 1927 Mr. Macadie, M.B.E., joined the Automatic Coil Winder Company, the name of which was changed in 1957 to Avo and he became a director.
Group Captain E. Fennessy, C.B.E., director of the Plessey Electronics Group, has also been appointed chairman of the reconstituted board of British Telecommunications Research Ltd. The company was established in

J. Lawton

1946 jointly by A.T. & E. and B.I.C.C. and became a subsidiary of Plessey in 1961 with the acquisition of A.T. & E. A minority interest is retained by B.I.C.C. Under the reorganization J. Lawton, M.Sc., M.I.E.E., has become director of research. Mr. Lawton, who took an honours degree at University College, London, was in the Post Office Research Department from 1939 until joining B.T.R. in 1950. He became a director in 1956 and since 1962 has been responsible for the management of the company.

G. B. B. Chaplin, M.Sc., Ph.D., M.I.E.E., chief scientist at Plessey-U.K. Ltd., has been appointed to the chair of electrical engineering at the University of Essex. Dr Chaplin, who is 42, graduated at Manchester University, where he subsequently served for three years as lecturer in electrical engineering. From 1955 he was for four years in the Electronics Division at A.E.R.E., Harwell. He joined Plessey in 1959 as technical manager of their Roke Manor Research Laboratory.

Captain F. J. Wyke, director of the Chamber of Shipping's Radio Advisory Service since it was established in 1948, has retired and joined Marconi International Marine Company as a consultant. Capt. Wyke's Naval appointments included Fleet Wireless Officer Mediterranean, 1929-31; officer in charge of the experimental department of H.M. Signal School, 1935-37; deputy director, Admiralty Signal Department, 1941-43; and director of radio equipment, Admiralty, 1944-46. The Radio Advisory Service was established to give authoritative advice on all aspects of marine radio communications and navigation and to investigate and evaluate all types of marine electronic equipment for the benefit of the members of the Chamber of Shipping and of the Liverpool Steam Ship Owners' Association. Capt. Wyke is succeeded as director of the Chamber of Shipping's Radio Advisory Service by Captain R. G. Swallow who has been deputy director since his retirement from the Navy in 1954. Capt. Swallow, who was a communications specialist throughout his Naval career, was successively deputy director of the Admiralty's radio equipment department and of the electrical department and director of the Signal Division. From 1952 until his retirement in 1954 Capt. Swallow was director of the Tactical School, Woolwich.

J. M. C. Dukes, M.A., D.I.C., A.M.I.E.E., who six months ago joined A.C. Cossor Ltd. as technical director, has been appointed deputy managing director. Until joining Cossor last year Mr. Dukes had been for six years with the Plessey Company first as technical manager of the Telecommunications Division and since 1962 as chief engineer of the Electronic and Equipment Group. Prior to joining Plessey he was for 12 years with Standard Telephones & Cables.

G. E. Gilbert, A.M.I.E.E., who has been in charge of the B.B.C.'s engineering buying section since 1936 is retiring on April 30th. He joined the Corporation in 1935 having previously served with Marconi's and the Western Electric Company. The new engineering buyer is T. R. Boys who joined the B.B.C. in 1939 at the Daventry transmitting station. He later served in the departments concerned with research, planning and design and since 1954, has been assistant engineering buyer.

Professor Charles W. Oatley, O.B.E., M.A., M.I.E.E., who has occupied the Chair of Electrical Engineering at Cambridge University since 1960, has been appointed to the board of directors of English Electric Valve Company. For 12 years before the war he was a member of the staff of the Physics Department, King's College, London University. For some time during the war he was in charge of base work on radar transmitters and receivers at the Radar Research and Development Establishment of the Ministry of Supply. Since 1943 he has been a fellow of Trinity College, Cambridge, and was lecturer in electrical engineering prior to receiving his professorship.

Reginald J. Watson, works manager of Mullard's Southampton factory since 1957, has joined Standard Telephones & Cables (Transistors) Ltd. the newly formed subsidiary of S.T.C. and has been appointed director of operations for the E.F.T.A. area of the semi-conductor activities of the I.T.T. group. Mr. Watson will be at the Footscray, Kent, headquarters of the new company which will co-ordinate the semiconductor operations at both Footscray and Harlow (Essex).

OBITUARY

Major-General Sir Leslie Phillips, K.C.B., K.C.M.G., director of signals at the War Office from 1943 to 1946, died on March 19th aged 74. Sir Leslie, who was knighted on his retirement in 1946, was throughout his 35 years' Army career a signals officer. He was promoted to brigadier and appointed Commandant of the Signal Training Centre in Jubbulpore, India, in 1939 but was recalled to this country in 1940 to become command signals officer, Eastern Command in London and as such he was largely responsible for the provision of communications for this country's defence. For two years prior to his War Office appointment in 1943 he was signals officer-in-command Home Forces.

Leonard A. Norman, who had been with Philips Electrical Ltd. for 35 years, died on March 17th after a long illness. After war service in the R.A.F. he rejoined the company in 1946. Six years ago he was appointed sales manager of Stella Radio and Television Company and later rejoined the parent company as a field manager, southern region.

Wireless World, May 1966
Physics Exhibition 1966

ELECTRONIC AND MEASURING TECHNIQUES UNDER DEVELOPMENT

THE Institute of Physics and the Physical Society held this year's exhibition of scientific instruments and apparatus (the 50th) among the decaying Victorian splendours of the Alexandra Palace in North London—where at least there was plenty of room to move around. The scientific character of the event was well maintained by careful selection of exhibits, and in the following report we have picked out a number of items which will be of interest to people in electronics and communications.

MICROWAVES

Railway communications. An exhibit by the British Railways Board demonstrated the possibility of communication with a moving vehicle for the exchange of information. The exhibit comprised a length of Goubau line fed via a conical launcher at a frequency of 3 Ge/s and terminated similarly, the line supporting a travelling surface wave. A small probe attached to a cavity resonator (see illustration) is brought into the field of the surface wave (the resonant frequency incidentally being varied by a variable-capacitance diode) and it was shown that variations in resonance produced corresponding variations in the echo power at the transmitter. If the line is continuous over long distances then the wide bandwidth possibilities of the line could also be exploited for point-to-point communications.

Gunn oscillators. Semiconductor sources of microwave radiation relying on the Gunn effect have received a considerable amount of publicity recently but their development still continues.

Such devices were shown by a number of exhibitors, but the first public demonstration of their potential was given by Dr. C. Hilsum at the R.R.E. stand. A Doppler radar system was shown in which the speed and time of travel of a model locomotive were measured. The minute Gunn oscillator replaced the usual klystron and operated at 8 Ge/s (X-band) with about 5 mW of power. The outstanding point of the exhibit was the size of the radar equipment which could be held in the hand.

The gallium arsenide device is prepared on an epitaxial layer of GaAs 10 μm thick and of 11 cm resistivity, which is grown on to a GaAs substrate 0.2 mm thick and 0.001 cm in resistivity. The substrate is alloyed to a copper heat dissipator, this being the positive contact, and a small tin spot is fused on to the epitaxial layer to form the negative contact. The device operates at 12 V and 100 mA delivering about 5-20 mW of power. The frequency is stable to within 1 Mc/s per day and can be adjusted over the range ± 10% by cavity mounting.

CIRCUIT TECHNIQUES

Circuit construction techniques of special interest included a new screen-printed film method based on thin mica wafers, introduced by Johnson Matthey. On display was a range of 0.6-in square mica wafers, some with films of resistive material fired on to one side and others with capacitor plates silvered on to both sides. Round the periphery of each wafer are 16 regularly spaced conducting tabs to some of which the R or C elements are connected. To build up a complete passive circuit the wafers are stacked on top of each other, the complete stack is fired to fuse the layers together, and the edges of the conducting tabs at the sides of the stack are soldered together as appropriate to form required interconnections. Other passive or active elements can be soldered to the stacks, which can be encapsulated in various resins. Some prototype circuits, which were, of course, a good deal smaller than conventionally constructed circuits, were shown in operation.

A high-density method of mounting and interconnecting monolithic integrated logic circuits was displayed by I.C.T. Unencapsulated semiconductor chips, each containing one or more gate circuits, are mounted on a ceramic substrate, and this carries a thin-film multilayer conductor network by which all connections to the chips are made. The power and earth conductor patterns are standard for a given chip. Superimposed on these, and separated by an insulating layer, is the logic "wiring," consisting of two sets of orthogonal conductors. The insulation separating the conducting strips is present only within the cross-over areas, so that interconnection between the sets of conductors can be made at any cross-over by depositing a metal link. Fifty integrated circuits can be accommodated on a 2in x 1in substrate. The complete units are intended to be encapsulated and mounted in flat packs.

RC time-varying networks. Frequency selective networks without inductors are obviously desirable for use...
in integrated circuits. A type of active filter (discussed briefly in W.W., March 1966, p. 129) of the time-varying variety is under investigation at the A.E.I. Research Laboratories at Blackheathe. One disadvantage of these networks is the high sensitivity to changes in component values and much effort is directed in reducing this.

These networks involve the use of resistors and capacitors and time-varying elements such as modulators or sampling switches. Apart from the more usual type where low-frequency low pass filters are simulated, work is also directed at developing all-pass phase-shift networks used to produce a highly selective filter characteristic at a high frequency.

Single sideband demodulators were exhibited, one in thin film form (illustrated) in which the signal is fed to two modulators driven by carrier signals in phase-quadrature and derived from a carrier phase shift circuit. The modulator output signals are fed to a wide band 90° phase difference network and then added. The output is filtered to remove signal components and then amplified. The carrier phase shift is derived digitally from two bistable circuits thus permitting the carrier frequency to be varied and giving a filter characteristic which can be translated to any position of the frequency spectrum.

LASERS AND ELECTRO-OPTICS

Hologram reconstruction was demonstrated by the Marconi Company, who are one of the many firms investigating applications. Holography relies on a method of optical production which does not use lenses and which was described in 1948 by Dr. D. G. Gabor. The outstanding feature of holography, however, is not that lenses are not required but that three-dimensional images can be formed.

Light from an object illuminated by laser light is allowed to fall on a high quality photographic plate without the aid of a lens so that a focused image is not formed. Light directly from the laser source is also allowed to fall on the plate and as a consequence interference fringes are formed, in a similar fashion to the fringes of the classic Lloyd's mirror demonstration, which are recorded on the plate. Thus the amplitude and phase of the object light is recorded, the fringe pattern being modulated in accordance with the nature of the object. The image is viewed by looking through the plate when this is illuminated by laser light.

One of the interesting features of the hologram is that if the plate is broken, the image can be reconstructed from only a small piece of the original, but with some loss of detail. This basic process may well find application in a wide variety of fields, such as the laser has done. Developments are still taking place and one of the latest is that it is now possible to view a coloured 3-D image with white light.

Metrology by holography has been investigated by the N.P.L. and A.W.R.E. and was demonstrated on the British National Committee for High Speed Photography stand. It is suited particularly to the detection and measurement of small changes in surface contour for rough surfaces.

A hologram is made of an object (see previous item), but instead of viewing the image with the object removed, the object is left in place, resulting in the image being superimposed on the object. If the surface of the object then moves slightly interference takes place between corresponding points on the object and its reconstruction giving rise to fringes across the object surface. The degree of distortion can be calculated from the fringe pattern.

If the plate is exposed twice, that is once with the object in its original position and the second exposure after the object has been distorted, then a permanent record of the fringe pattern is made.

The technique can be used to compare production line components for shape against a master; for determining the thermal expansion of components; and for investigating surface vibration modes.

Laser light is not necessary for image formation; the demonstration used filtered mercury light.

Radar photography allowing clear pictures to be taken, or distances of objects to be determined, through a light-scattering medium such as fog or dust was demonstrated by the Atomic Weapons Research Establishment (operating in their new "swords into ploughshares" role). The principle is to avoid reflection of light back into the camera from the scattering medium, as would occur with continuous illumination (e.g., driving a car in fog with headlights on). This is achieved by propagating a short "pulse" of light from near the camera to illuminate the object and then opening the camera shutter at the correct instant to receive only the light reflected from the object. Thus, although the scattering medium absorbs some of the incident and reflected light, the camera shutter is closed at the instant when the incident

"Business end" of U.K.A.E.A. radar photography equipment—the entrance of the tunnel enclosure being visible on the left.
light pulse is temporarily causing the unwanted reflection from this medium.

Application of the principle depends on the use of electronic methods to achieve sufficiently short light pulses and rapid shuttering. In the demonstration a 20 ns high-intensity light pulse was generated by a Q-switched ruby laser and propagated down a long tunnel enclosure at the far end of which was placed the object to be photographed. The light pulse was therefore about 20 ft long, and at any instant during its travel only the section of tunnel within this 20 ft span was illuminated. Net curtains within the tunnel provided the scattering medium. The "camera" was an electronic image converter (Mullard 6929) and was pulsed from a line controlled by a spark gap to give an exposure time of 20 ns. The "camera" was correctly synchronized with the light source by triggering the spark gap from the firing of the Kerr cell in the laser unit. Suggested applications include photographing industrial processes through clouds of fumes, vapour or particles, as in furnaces.

Electronographic cathode-ray tube. To obviate the inefficient process involved in recording a photographic image from the face of a cathode-ray tube, the General Electric Company suggested a new technique. The conventional faceplate and phosphor are replaced by a thin mica window (3 µm thick) which is bombarded by the electron beam. The beam, with an energy of about 25 keV penetrates the window thus reaching a photographic film placed directly on the window.

It has been found that beam currents around 10⁻⁶ A are sufficient for recording compared with 10⁻³ A for conventional television. This low value eases the problems associated with obtaining good resolution and line widths of 0.0003 in are readily obtainable.

Difficulties exist in obtaining the mica screen and the exhibit showed only a small area of screen.

Contrast enhancement for automatic pattern recognition. It is known that, due to diffraction effects, the image of a point source produced by a converging lens is surrounded by the Fourier transform of any aperture placed in the plane of the lens. If this is a transparency then the image plane contains the transform of the pattern on the transparency. The spatial components of the pattern are displaced radially about the optical axis and opaque stops can be introduced into the image or Fourier plane to suppress selected frequency components. If the low-frequency components of the Fourier transform are suppressed, areas of constant density in the pattern are eliminated and if the high-frequency components are suppressed the fine granular noise is eliminated.

Thus, this method allows contrast to be increased and

Showing enhancement of boundaries by introducing stops to suppress selected frequency components a diffraction pattern. The N.P.L. suggests that the technique may have application in automatic pattern recognition.

noise to be decreased, and may find application in automatic recognition and processing of optical patterns. An attribute of the system is that several patterns may be processed simultaneously.

Laser Doppler velocity meter has been installed in a factory for the purpose of measuring the speed of aluminium sections emerging from an extracting machine, and the developers, Decca Radar, gave a demonstration of its principles. Light from a low-power gas laser was focused on the moving surface, a rotating disc with its drive shaft inclined at an angle to the incident beam. The back-scattered energy, together with a sample of the incident laser light, was focused onto a balanced photomixer to produce a difference-frequency signal. A tracking unit followed the frequency of this signal and displayed it on an indicator as velocity in ft/min, for comparison with a similar indicator showing the disc surface velocity measured directly by a tacho-generator. Features of the system are its high sensitivity, sufficient to give good Doppler signals from a diffuse scattering surface, and reduction of local oscillator noise in the design of the homodyne balanced mixer. Other possible applications of the principle include measuring the length and vibration of surfaces and monitoring the surface finish of materials.

INFORMATION PROCESSING AND STORAGE

Correlation techniques for measurement and detection (see April 1966 issue, p. 190) appeared in a number of applications. In an automatic "go, no-go" servo tester
introduced by Sperry, for example, the test signal is a random binary signal and the cross-correlation coefficient between the excitation and the resulting response of the servo is measured for a number of different delays to give the cross-correlation function—which is identical to the servo’s impulse response if the delay parameter is considered as real time. The test runs automatically through 11 preselected delays. At the end of each measurement a voltage representing the c-c coefficient is examined and if it is within required acceptance limits the tester passes on to the next measurement. If all 11 tests are passed the tester indicates “go.” If any test is failed it can be repeated, and if the servo continues to fail it “no-go” is indicated. Acceptance limits are fed in by a programme plug.

In a cross-correlator for electroencephalograph signals shown by J. C. Shaw (M.R.C.) and K. R. McLachlan (Southampton University) simplicity is achieved by a digital mode of operation. One of the input signals is quantized into a number of levels, then the binary numbers generated from the different levels are delayed in shift registers and used to gate the second input signal. Another digital correlation technique, shown by Plessey, is intended for extracting sequences of pulses or events with fixed intervals between them from a noisy environment. Nearly all the functions required are performed by one single circuit unit.

Elliott Automation Radar Systems demonstrated a radar technique using correlation which achieved the effect of transmitting short pulses of high peak energy, giving good range resolution without actually requiring high peak powers. A long 210-ns pulse of r.f. energy is coded by phase reversal into the 7-bit sequence 1110010 before transmission (using a circulator with diode switches in a transmission line connected to one of its ports). On reception the reflected pulse sequence is fed into a correlator, where it is processed into a shorter pulse of 30 ns containing substantially the same energy and having, consequently, about seven times the amplitude. This would give a radar range resolution of 5 metres.

A correlation type of detector was also used at the receiving end of a system of communication using noise type signals demonstrated by Marconi. If a purely angle-modulated carrier is multiplexed with wideband noise, selection of one of the resulting sidebands gives a signal which to all normal detectors is pure noise. Thus secrecy of transmission can be obtained. At the receiver the signal is applied to one input of a correlation detector while the original noise, also transmitted separately, is applied to the other input. The original modulated carrier is then obtained at the detector output. As noise is not cyclic several channels can be transmitted by this method, the output of the noise source being delayed a different amount for each channel and separate correlation detectors being used for them. In the demonstration two speech channels were transmitted, using frequency modulated inputs and a 1.5 Mc/s noise source. The system is said to be reasonably immune from jamming and interference.

Non-destructive delay-line store, not requiring continuous circulation to hold the information, was demonstrated by Plessey. Intended for use as a register, the experimental device stores 20 bits but capacities of several hundred bits are envisaged. It comprises a length of 0.0075 in diameter beryllium-copper wire plated with a thin film of magnetic material. Current signals corresponding to the binary pattern to be stored ("on" for 1, "off" for 0) are passed through the conductor, setting up magnetic fields, while at the same time mechanical stress pulses are transmitted by a PZT transducer—the acoustic delay being 60 ns.

The effect of the stress pulses is to "freeze" the time-varying magnetic signals into a spatial magnetic pattern on the line. Each stress pulse reduces the coercivity of the magnetic film over the small section of line occupied by the pulse during its travel. The magnetic fields set up by the current signals magnetize the film, but the value of remanence left at a particular section of line after cessation of a "1" current signal depends on the coercivity of that section, which is determined by the mechanical stress pulse. If, therefore, a "1" current passes through the conductor when the stress pulse is occupying a particular section of line, that section will be left with a higher value of remanence than the rest of the line and so will magnetically store a "1" digit. Similarly with successively stress pulses acting at other positions along the line.

Read-out is performed by transmitting another stress pulse, and the resulting changes of flux as it moves down the line induce 60 Mc/s pulses in the conductor. Signal/noise ratios of up to 17 dB in the read-out signals can be obtained with a digit rate of over 400 kc/s.

Memory stores by electrophoresis. The technique of electrophoresis has been well used in the past and recently the possibility of using this method for the formation of ferrite memory stores has been studied by the British Scientific Research Association and the Royal Radar Establishment. It should be possible to achieve very thin ferrite sections, allowing faster switching times and lower drive currents, by this method. Another advantage is that the laborious threading of toroids would become unnecessary.

One variety of ferrite has been used so far which has to be sintered at about 1400°C to give the requisite square-loop characteristic, and has so far restricted the conductors to platinum.

Read times of 50 ns have been achieved with 0.005 in wires with an interrogate current of 300 mA.

Because deposition can easily be controlled and the ferrite can be deposited on electrodes of almost any shape, desirable element shapes, which have previously been thought to be uneconomic, may well prove to be easily fabricated.

MEASUREMENT AND ANALYSIS

Direct measurement of transfer functions of electrical networks and mechanical devices was demonstrated with new solid-state equipment developed by Wayne Kerr from their earlier Transfer Function Computer. The new equipment is more flexible in that it allows two types of measurement—in one the system excitation is provided by a built-in signal generator and in the other it is applied separately or is already present in the system. The equipment also permits conventional frequency response

(continued on page 233)
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Marconi telecommunications systems

The Marconi Company Limited, Radio Communications Division, Chelmsford, Essex, England

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measurements (magnitude and phase) to be made. The basic principle is to set up a model of the system using d.c. analogue computing elements (mostly integrators and potentiometers), apply a common excitation to the system and the model, connect the response signals of the system and model to a c.r.o. null indicator, then adjust the model until the null indicator shows that the model is equivalent to the system. Excitation can be a waveform, a ramp or some other repetitive waveform, typical frequencies being from 0.01 to 500 c/s. Transducers are used where the excitation or response is mechanical.

The transfer function is presented as the ratio of the response to the excitation, derived from the linear differential equation describing the behaviour of the system and expressed in operational form. Adjustment of the model is a matter of adjusting calibrated potentiometers which vary the equation coefficients in the numerator and the denominator, and once a null balance is obtained the coefficients can be read from the dials. Demonstrations included the use of a self-contained instrument for educational purposes, measurements on an electro-pneumatic positioning servo and tests to determine the dynamic properties of elastomers. Also shown was a commercial instrument using the technique for operational performance testing of servos.

Transistor measurements by reflectometry, operating in the time domain, were demonstrated by the College of Aeronautics. The method is an extension of the technique for locating and analysing discontinuities in transmission lines by propagating impulses or step functions along them and examining the waveforms of the resulting reflections on a c.r.o. If the discontinuity takes the form of an inserted network the network elements can be determined from an analysis of the reflection waveform—and, of course, such a network can be a transistor. The function of the transmission line is then merely to separate the incident and reflected waves in the time domain so that they can be conveniently displayed.

In the demonstration the transistor was incorporated in a 50-12 coaxial line system fed from a pulse generator, and voltage waveforms at points equidistant from the transistor network ports were recorded by a two-channel sampling c.r.o. and an x-y plotter. Five response curves were plotted—the transmitted and reflected pulses for both directions of transmission and a reference pulse obtained by substituting a direct link for the transistor under test. From these curves, which contain information characterising the transistor network over the entire frequency spectrum provided by the excitation pulse (up to 1 Gc/s), the required data are obtained by computer analysis—though this was not actually done at the exhibition.

The corresponding frequency-domain parameters can be derived, and conversion to the $h_1$, $y$ or $z$ parameters can be performed by standard procedures. The technique promises to be simpler and quicker than the conventional bridge method of parameter evaluation—assuming that a digital computer is available—but its full potentialities and limitations have yet to be explored.

A gallium arsenide thermometer has been developed by the International Research & Development Company. It is suited for the range 4-300 K and should find application in research cryostats and refrigeration systems, although it is not suitable for accurate calorimetric investigations at the lower end of the scale, owing to the comparatively high power required.

The instrument has an almost linear scale and relies on the temperature sensitivity of the forward voltage drop across a gallium arsenide junction (at constant current). Variation of the current through the junction alters its sensitivity and it is necessary to increase current in order to increase sensitivity.
NEW TECHNIQUES IN MEDICAL ELECTRONICS

AS SEEN AT THE PHYSICS, AND BIOMEDICAL ENGINEERING EXHIBITIONS

As opposed to the numerous systems available for investigating man closely under highly organized circumstances (space flight, operating theatre, extreme environmental conditions, etc.), there were, until quite recently, few methods by which the physiological parameters of a normal man in normal conditions could be measured and recorded. This was simply because instruments for such research must necessarily be of very small weight and size, inconspicuous when worn, be capable of storing acquired data for long periods and be inexpensive; in fact they have to be “socially” acceptable. The biomedical engineering division of the National Institute for Medical Research has scrutinized many methods of recording such data, which were rejected for reasons such as power consumption, cost, or even size (in spite of miniaturization).

However, electro-chemical methods of data storage have been used with encouraging results. One instrument (Fig. 1) employs a commercially available electro-chemical integrator of very small size, and high charge sensitivity. Here, the use of three such devices permits division of data in time, so producing a table of results not unlike the analysis of a continuous recording. Other instruments shown were a heart beat totalizer, and a temperature excursion integrator. The size of such instruments varies, but lying between the size of a matchbox, and a packet of 20 cigarettes, they are still conveniently small, and with power consumption of the order of 400µW.

A functional stimulator with myo-electric control has been developed for patients who still have some muscle control although they may have extensive muscle paralysis. Feedback of the output signal into the amplifier via the patient’s body is inhibited by isolation transformers in the circuit and separate battery supplies. The apparatus, shown by Devices Ltd., is suitable only for conditions where paralysed muscles have not degenerated.

An ophthalmoscope that employs ultrasonics for pulse echo scanning of the interior of the eye was exhibited. It is intended to serve as a diagnostic instrument for the quick location of foreign matter, the detection of a detached retina, the measurement of its extent, and for the location of tumours. This ultrasonic examination can be carried out safely and quickly even with eye conditions such as opacity, or cicatrization.

Market in this country by T.E.M. Sales Ltd., it has a frequency range of 3-20 Mc/s, and results are displayed on the screen of a 5-in diameter c.r.t. The output from the transmitter is controlled so that only sufficient energy is fed into any of the examination probes. Changing frequency is effected by changing the probe, no further switching being required. A reject control permits the operator to blank out the smaller echoes, thus obtaining a clearer pattern. Enlarging of the response pattern is continuously controllable within a wide range; at minimum enlargement the range amounts to 13 mm of the eye displayed on the screen, and at maximum enlargement the range is 130 mm.

A correlator is being developed by the Clinical Psychiatry Research Unit at Graylingwell Hospital, Chichester, Sussex, to assist in the spatial analysis of electro-encephalogram signals. The form of e.e.g. is governed by the site on the scalp from which it is recorded, thus the topography of the e.e.g. is regarded as important. Since the cross-correlation function is a measure of the relationship between signals from two sites, this is measured over each contiguous second of a sample of e.e.g. record, thus determining the inherent variability of the record.

The design of the correlator has been simplified by using a digital method, in which one signal is quantized into six quantization levels. Time displacement of the two signals to be correlated is carried out by shift registers, and multiplication reduced to a gating process. The signals pass through the correlator, once for each time-displacement value. The output from the correlator is stored on punched paper tape, each number on the tape representing a point on the correlogram.

Fig. 2. Functional stimulator.

Fig. 1. Heart rate integrator.
Public Address Equipment
SOME APPARATUS SEEN AT THE ANNUAL A.P.A.E. EXHIBITION

ONE of the most outstanding demonstrations for those who visited the Association of Public Address Engineers' Exhibition at the Kings Head, Harrow, was given by one of the Association's officers, Mr. Haydon Warren. A Western Electric 618 moving-coil microphone, introduced around 1931 and forerunner of the S.T.C. 4017, fed a permanent magnet version of the 555 loudspeaker (a 1928 design) via a 250mW transistor amplifier concealed in the microphone stand. The resulting sound level was surprising and quite usable for small halls, the secret being the loudspeaker—with an electrical to acoustic efficiency of 50%—the most efficient loudspeaker yet produced?

Amplifiers
A number of manufacturers have introduced more transistor amplifiers this year. Wharfedale (now, incidentally, known as Rank Wharfedale) announced their new 50 W design. This four-channel amplifier has a sensitivity of 50 mV and will provide about 50 W (75 W music power) into a 100 V line, or into a low impedance load, with 4% harmonic distortion. Three Philips transistor amplifiers were introduced by Peto Scott (10, 20 and 35 W) and the new Sound Coverage range includes 15, 30, 60 and 120 W designs with a sensitivity of 200 mV and a distortion of 3%. Output transistors (in push-pull) are used in parallel for the high powers. The new 50 W Grampian (type 662) amplifier uses four 2N2869 transistors in the output stage, each having a fuse in the collector leads so that in the event of failure of one transistor, operation is still possible. To protect the transistors should the accumulator supply be incorrectly connected, a diode and supply relay are included.

A 50 W amplifier design was introduced by Mullard for operation from a 12 V battery. A single matched pair of output transistors (OC29) are used and distortion is less than 10%. To avoid destruction of the output transistors when the load is short circuited a protective circuit is included (see accompanying circuit). Should the output be short circuited the output transformer primary current rises and the AC127 turns on, tending to cut off the OC71, and thus reducing the drive. The pre-set variable resistor is adjusted at maximum output so that the OC71 collector current just starts to fall.

CTH Electronics augment their transistor amplifiers covering the range 15-1000 W with a 25 W unit which
Microphones

Although a number of new types of microphone are under development (e.g. semiconductor and electret types) it is not expected that these will appear for some time in the p.a. field. Two of the new microphones shown this year were the Amplivox Telemike and the first microphone of the recently formed London Microphone Co. This last type is a low-cost moving-coil (illustrated) and forms a very neat and inexpensive microphone for various uses including transistor tape recorders—some manufacturers have been importing low cost Japanese moving-coil microphones for this purpose. Sensitivity at 500 Hz is 300 mV/µbar and the frequency response is very smooth down to about 200 c/s and at 50 c/s the response is down to 10 dB. The Telemike is a two-way transducer and was briefly described in the April issue (p. 210).

Some other new microphones are the Resto CPD pencil type, the Shure 581 series, a number shown by Fi-Cord (including Beyer types), the A.K.G. D500 series, the Philips EL6033 and the Acos Mic 70. A Neumann condenser microphone (KTM) was exhibited by Bauch (who have, incidentally, changed their address to Holbrook House, Cockfosters, Barnet). This incorporates an f.e.t. followed by a common-emitter mode silicon transistor. A 9 V battery powers a simple built-in d.c. converter to supply the polarizing voltage.

† See Public Address Engineers Journal, March 1966.

Communication Receiver Survey

Amendments

In our survey last month Eddystone was listed under Stratton and Co. Ltd. but should, of course, have been under Eddystone Radio Ltd. which is a subsidiary of The Marconi Company Ltd.

Under K.W. Electronics Ltd. the HQ180A should read HQ170A. Details for the HQ180A which were omitted are as follows:

Country of Origin U.S.A.
Type of Circuit Double and triple superhet.
Frequency Bands 540 kc/s-7.85 Mc/s (double conversion); 7.85-30 Mc/s (triple conversion); bandwidth 3.3-10 Mc/s (calibrated for amateur bands).
Receiving Modes I.s.b., a.m.m., c.w.
Impedances 50-2000 Ω (I.P) and 300 Ω (O/P)
Selectivity Selectable sidetones, u.s.b. 1, 2 and 3 kc/s; l.s.b. 1, 2 and 3 kc/s; d.s.b. 6, 2, 4 and 6 kc/s at 6 dB down.
Image Rejection 55 db.
I.F. 1st 3,035 kc/s; 2nd 455 kc/s; 3rd 60 kc/s.
Local Oscillator 1st tunable: 2nd 2,580 kc/s (ext): 3rd 395 kc/s. The receiver also incorporates a 2nd filter (60 s.k/s selectivity), b.f.o., a.d.c., a.m. calibrator, power unit.
Gain Controls a.m., r.f.
Valves 18.
Semiconductors 1.
Additional Information Product detector, vernier tuning, aerial trimmer, calibrated "5" meter, 14 controls.
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A.F. Amplification with the Cascode

AN OUTLINE OF THE ADVANTAGES OF THE TWIN-TRIODE OVER THE PENTODE FOR A.F.

By G. A. STEVENS

Prior to the development of Band III television tuners the cascode was very little used, its main use being in low noise r.f. stages, and it was used as a voltage amplifier in a stabilised power supply, where high gain was required.

The properties that enhance its use for r.f. amplification also indicate its suitability as an a.f. voltage amplifier. These advantages are as follows:

1. High gain.
2. Low noise.
3. Low inter-electrode capacitances (particularly between input and output).
4. Capability of being designed with low phase shift (in feedback amplifiers).

The characteristics of the cascode that give rise to the above advantages are best illustrated by a simplified analysis of the circuit (a fuller analysis will be found in the "Radio Designers' Handbook" by Langford-Smith, Ch. 12, Sect. 9 XI).

In the basic cascode circuit as shown by Fig. 1, two halves of a double triode are connected in series, the bias for the lower valve, V1, being derived by grid current through the high value of grid resistor, the upper valve grid being held at a fixed potential \( V'g \).

Since the anode potential of V1 is held constant by the cathode follower action of V2, the change in anode current of V1 caused by an alternating voltage \( V_{ip} \) on its grid is:

\[
\delta I_a = V_{ip} \cdot g_m1
\]

where \( g_m1 \) is the \( g_m \) of V1.

Providing V2 does not draw grid current, all current entering at its cathode must pass through the anode load \( R_L \).

Hence,

\[
V_{ap} = \delta I_a \cdot R_L
= V_{ip} \cdot g_m1 \cdot R_L
\]

\[
G = \frac{V_{ap}}{V_{ip}} = g_m1 \cdot R_L \quad \ldots \quad (1)
\]

Hence the circuit has the same gain as a pentode with the same \( g_m \) as the lower valve.

Also, since for any valve that has an impedance \( R_a \) in its cathode, its anode impedance is increased by a factor:

\[
(1 + g_m R_f)\]

We can write for the cascode:

\[
r_a = r_{m2} (1 + g_m R_f) \quad \ldots \quad (2)
\]

since the anode impedance of V1 is in series with the cathode of V2. Therefore, from equations (1) and (2) we can derive:

\[
\mu = g_m r_m = g_m R_f (1 + g_m R_f) \quad \ldots \quad (3)
\]

From equation (2) it can be seen that for a twin triode

\[
r_a = 100 \, \text{K} \Omega \text{ and } \mu = 70 \text{ then its composite anode impedance is:---}
\]

\[
r_a = 100 (1 + 70) \, \text{K} \Omega \approx 7 \, \text{M} \Omega
\]

i.e., much more than a similar pentode.

The similarity of characteristics to a pentode is shown even more clearly by considering the knee voltage area. As stated above all the current flowing into the cathode of V2 must pass through the load \( R_L \) providing no grid current is drawn. However, once this point is reached, increasing the input drive only produces more grid current, so producing a very sharp pentode-like knee point as V2 bottoms. So far, it can be seen that the characteristics are those of a semi-idealized pentode, certainly better than the normal amplifying pentode.

There are, however, two factors which make the cascode superior to the pentode for audio amplifier use.

Firstly, since there is only one grid in a triode, this taking no current, the partition noise generated by a pentode is absent, so reducing the noise level by a factor of three or more.

Secondly, in a pentode, the \( g_m \) is dependent on the anode current, which in turn depends on the load resistor

G. A. Stevens has for the past five years been a maintenance engineer with Rediffusion Television Ltd. From 1952 until being called up for National Service in the R.A.F. in 1959 he was in the Research Laboratory of E.M.I. which he joined on leaving school at the age of 19.

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Since $V_2$, so circuit; then, the applied to audio amplifier in which the gain actually lowers the supply voltage, increasing the anode and the supply voltage available. So that, for a given supply voltage, increasing the anode load decreases the $g_{m}$ and a point is reached where increasing the load actually lowers the gain. In the cascode, however, the gain $G$ is the product of the anode load of $V_2$ and the $g_{m}$ of $V_1$.

Suppose now in Fig. 1 that a resistor was inserted between the anode of $V_1$ (and cathode of $V_2$) and the h.t. rail $V_G$. This would mean that $V_1$ could be taking a reasonable current and so have a good $g_{m}$ whilst $V_2$ could have a large value of anode load with its consequent low anode current.

This arrangement can, and does, give very high gain providing certain points are kept in mind.

1. Since $V_2$ can now be cut-off without affecting the working conditions of $V_1$, the bias of $V_2(V_p)$ must be derived from a potential divider of some sort from the anode of $V_2$.

2. The anode load for $V_1$ is the cathode of $V_2$ and so is equal to $1/g_{m}$ and when the mutual conductances of both valves are equal, the gain of $V_1$ is equal to $-1$ and the Miller capacity at the grid of $V_1$ is only about $3 \mu F$ (for an ECC83). However, with the top valve drawing only a small current its $g_{m}$ is very low and presents a considerable load to $V_1$. This means that the gain is shared between the two valves and the Miller capacity can be high, although the screening of input to output is still good, due to the cathode grid of $V_2$.

Usually, a circuit with this gain would only be needed at the input of an amplifier, and should therefore be fed from a low-impedance source which swamps the effect of the Miller effect.

Since the grid of $V_2$, and hence its cathode, is stabilised by the action of a potential divider from its anode, the effect of changes of bias on $V_1$, due to signal level variation, is, to a large part, compensated for, so allowing the use of grid current bias.

If, as is usual, the negative feedback (or the whole audio amplifier in which the cascode is incorporated) is applied to a small resistor in the cathode of $V_1$ (about $100 \Omega$, which has little effect on the parameters of the circuit); then, the $0.1 \mu F$ capacitor and $10 \text{ M}\Omega$ resistor in the grid circuit are outside the feedback loop, and so do not affect the phase shift over the cascode. Similarly, since $V_2$ is drawing very low anode current the voltage feed, $V_G$ to its grid can be supplied by another $10 \text{ M}\Omega$ resistor and $0.1 \mu F$ capacitor, so giving virtually no I.F. phase shift down to very low frequencies.

The bias voltage, $V_p$ can be supplied in one of two ways:

1. By direct potential divider from the anode of $V_2$.

This method has two disadvantages, the maximum value of resistance usually made in standard ranges is $10 \text{ M}\Omega$, and with this value as an anode load, the potential divider has a resistance of this order which shunts the signal, and so reduces the gain.

2. The anode load and potential divider can, if the valve of $R_i$ is too high cut off $V_2$ by reducing its anode voltage to the point where no current flows through the valve. The above drawbacks limit the straight potential divider at high values of $R_i$, although when $R_i$ is around $1 \text{ M}\Omega$ or less there is nothing to choose between this and the next bias method to be described.

If the potential divider, instead of being applied direct, is in the cathode load of a cathode follower, the grid of which is connected to the anode of $V_2$ the above drawbacks disappear.

Usually in modern audio amplifiers the trend is to follow the input voltage amplifier with a directly coupled phase splitter, of the cathode-coupled variety, in this case the cathode resistor of the phase splitter may be replaced by two other resistors so forming the necessary bias network for $V_2$, as illustrated by Fig. 2.

### Practical cases

In order to investigate a practical case the two circuits shown in Figs. 3 and 4 (with and without the cathode follower bias network respectively) were constructed. The value of the $330 \text{ k}\Omega$ current bleed resistor was found experimentally for an anode load of $10 \text{ M}\Omega$ and on altering the load the value still seemed about optimum and so no experiments were conducted using values other than this.

$S_1$ and $R_2$ were used to determine the output impedance of the circuit, $R_2$ being altered until closing $S_1$ reduced the

![Fig. 2. Bias arrangement of the cascade circuit to feed a cathode-coupled phase inverter.](image)
output signal by 6 dB, \( R_2 \) then being equal to the output impedance (the series capacitor having negligible reactance).

In the experiments only the anode resistors were altered, together with slight adjustments to the stabilized power supply to give 300 V after the decoupling resistor.

The gain from the input to the anode of \( V_1 \) was also measured for different loads, this giving the measure of Miller capacity on the input, and also the gain of the cascade if:

1. The grid of \( V_2 \) is not decoupled to earth; or
2. The effect of putting a frequency sensitive network between the cathode of \( V_3 \) and the grid of \( V_2 \) to act as an equalizer circuit.

The results are set out in Table I and in the graphs of individual parameters which follow later. The odd values of \( R_4 \) being the measured values of standard resistors.

As can be seen, when the anode load is in the order of 10 M\( \Omega \) the output impedance is 3.5 M\( \Omega \). In the test circuit 3 the stray capacity at the anode of \( V_2 \) was 8 pF and so the response was 3 dB down at about 6 kc/s, the gain-bandwidth factor is given by the ratio \( G/Z_0 \), and as can be seen, increases with lower anode loads. The early roll-off associated with the highest gains can in fact be a desirable feature in feedback amplifiers, where it is necessary to reduce the loop gain below unity before the phase shift reaches 180° in order to avoid instability. When the cathode-coupled phase splitter uses a pentode in the first stage, so avoiding large values of Miller capacitance loading the anode of \( V_2 \), the total stray capacitance should not exceed 16 pF and so the 3 dB upper

<table>
<thead>
<tr>
<th>Rf (M( \Omega ))</th>
<th>( V_{ab} )</th>
<th>Cm</th>
<th>C1</th>
<th>C</th>
<th>G(dB)</th>
<th>( Z_a )</th>
<th>G</th>
<th>G/Za</th>
<th>G(dB)</th>
<th>( Z_0 )</th>
<th>C1</th>
<th>G/Za</th>
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<tr>
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<td>103pF</td>
<td>68</td>
<td>4,400</td>
<td>73.5</td>
<td>3.67 M( \Omega )</td>
<td>70</td>
<td>1.26</td>
<td>940</td>
<td>59.5</td>
<td>620</td>
<td>2.58 M( \Omega )</td>
</tr>
<tr>
<td>13 M( \Omega )</td>
<td>153 103</td>
<td>68</td>
<td>4,400</td>
<td>73.5</td>
<td>3.67 M( \Omega )</td>
<td>70</td>
<td>1.26</td>
<td>940</td>
<td>59.5</td>
<td>620</td>
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<tr>
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<td>68</td>
<td>4,400</td>
<td>73.5</td>
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<td>70</td>
<td>1.26</td>
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<tr>
<td>6 M( \Omega )</td>
<td>154 75</td>
<td>50</td>
<td>3,750</td>
<td>71.3</td>
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<td>75</td>
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<td>1.93</td>
<td>250</td>
<td>48.0</td>
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<td>0.12 k( \Omega )</td>
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<tr>
<td>0.05 M( \Omega )</td>
<td>253 3.1</td>
<td>2.1</td>
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<td>44.0</td>
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<td>40.0</td>
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<td>0.05 k( \Omega )</td>
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<td>0.03 M( \Omega )</td>
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<td>1.7</td>
<td>56.5</td>
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<td>35.0</td>
<td>42</td>
<td>0.03 k( \Omega )</td>
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</table>

**Fig. 3.** Circuit used for measurements incorporating the cathode biasing method. Results are shown in Table I and Figs 6 and 8.

**Fig. 4.** Test circuit used for measurements. \( S_1 \) and \( R_2 \) were used to determine the output impedance. Results are shown in Table I.

*Wireless World, May 1966*
frequency limit should be at about 15 kc/s with an anode load of 1 MΩ giving a gain of over 60 dB. The gain-bandwidth product may be obtained from the factor $G/Z_0$ by multiplying it by $10^4$ (assuming 16 pF strays).

An EF86 pentode with an anode load of 220 kΩ and a following grid resistor of 1 MΩ has a gain of about 200 (46 dB), the effective anode load due to the above two resistors is 180 kΩ, and the cascode gives a gain of 320 (50 dB) with a load of this value, while increasing the pentode load to 1 MΩ and running under starvation conditions gives a gain of 400 (52 dB), the cascode giving 1,200 (62 dB), an even more marked improvement over the standard pentode circuit.

The ECC83 has a normal heater, as opposed to the bifilar type of the EF86, and so the hum introduced by the circuit could be expected to be greater than that of the pentode. With the 10 MΩ load in circuit, (as with this value the hum and noise would be expected to be at their worst), and one side of the heaters earthed the total hum and noise at the output was 5 mV r.m.s., and when the heaters were on a d.c. supply the value fell to 1 mV r.m.s.—these correspond to an input level of 3.15 and 0.67 µV r.m.s. respectively over a frequency 25c/s—6 kc/s. The measurements were taken on Fig. 3 with the input shorted, and includes hum and noise introduced by the output cathode follower.

As can be seen in Fig. 4 the gain v load characteristic is linear up to 2 MΩ (for Fig. 3) and then falls off and becomes asymptotic to the 75 dB co-ordinate. This corresponds to the value of $\mu$ at low currents as given in the published curves of the ECC83.

These results show the superiority of the cascode circuit over the conventional pentode in audio applications, and whilst the investigations were concerned only with the ECC83, the newly-developed ECC807 should show an even more marked improvement in cases where better hum or gain figures might be needed, although the excellent results obtained with the older valve type would usually make higher gain unnecessary in all but a few cases.

Finally, the effects of valve changes on the gain and d.c. level at the cathode of V3 ($V_t$,3) were investigated by
putting seven different new valves in the V1 and V2 position. The total gain variation was 10^6, and the output voltage variation was over an 18V range.

**APPENDIX**

**Equalization with the cascode**

If the grid of V2 is not decoupled to earth, but is included in a frequency sensitive network as shown in Fig. 3, then the overall gain is a function of frequency.

The circuit now behaves with V1 as a pre-amplifier with gain G1, and V2 as a frequency-selective feedback amplifier. The gain of V2 as a feedback amplifier is given by:

\[ G' = \frac{G_1 \beta}{1 + G_2 \beta} \]

N.B. The application of feedback increases the input impedance of V2 and so also the gain of V1, this causes a reduction in the total gain supplied by the overall circuit, but for values of \( R_1 \), greater than about 1 M\( \Omega \) this effect is not serious, but in any case a little experimentation will soon determine the correct values.

Then the total gain of the circuit will be:

\[ G = G_1 \cdot G' = \frac{G_1 \cdot Z_1 + Z_2}{1 + G_2 \beta} \]

If \( Z_1 \) is not blocked to d.c., a blocking capacitor would have to be inserted to maintain the correct bias level on V2.

An example of a tape equalizer circuit is given in Fig. 7, the values of C and R given provide a time constant of 100 \( \mu \)s with a total top cut of about 36 dB, the l.f. gain being 60 dB, dropping to 24 dB at h.f.

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**Ceramic Cathode-ray Tube**

Cathode-ray tubes can be a relatively unreliable part of the electronic equipment of many aircraft, space and defence systems, and in order to achieve great reliability a ceramic c.r.t. (for magnetic deflection) has been produced. The device has been developed by Elliott-Automation to meet a need for tubes which will withstand high acceleration and severe vibration in military systems.

In conventional tubes the gun assembly is supported within the tube neck by wires and in consequence the assembly can move relative to the screen. This is avoided in the ceramic tube since gun and electrode parts are integral with the tube (see illustration) and consequently greater display precision is possible. Left of the exposed view is the heater-cathode-modulator assembly. The metal modulator is brazed on to the ceramic material (alumina). This is followed by separate focusing and accelerator sections. The screen is glass, but, if necessary, this can be made from sapphire—a translucent form of alumina. The tube shown has a 1 in. dia. screen, but 2 in. tubes are in production and it should be possible to manufacture larger diameters up to 5 in. or so.

The use of ceramic material enables the tube to be baked at a higher temperature during manufacture, achieving a better vacuum and consequently longer operational life.

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**H. F. PREDICTIONS — MAY**

![Graphs showing H. F. Predictions for May 1966.](https://via.placeholder.com/150)

The value of ionospheric index, IF2, now appears to be rising again. Whereas at the end of 1965 the value had fallen to -1 (almost as low as the 1964 sunspot minimum value of -4), the value for January, 1966, was 19. It is likely to rise again during the coming months.

This second dip is by no means uncommon. If monthly sunspot numbers, from 1749, are examined it will be found that this second dip is apparent during some three-quarters of the sunspot minimum periods.

The prediction curves show the median standard MUF, optimum traffic frequency and the lowest usable frequency (LUF) for reception in this country. Unlike the standard MUF, the LUF is closely dependent upon such factors as transmitter power, aerials and the type of modulation. The LUF curves shown were drawn by Cable and Wireless for commercial telegraphy and assume the use of several kilowatts of transmitted power and rhombic-type aerials.
The Electronic Industries Association of America has announced peak sales of colour, and monochrome television sets for 1965. In 1964 monochrome sales totalled 7.685 million whereas in 1965 they rose to 8.028 million. Colour sets sold in 1964 totalled 1,366 million, this figure rose to 2.764 million in 1965.

The Australian Department of Civil Aviation has ordered a Solartron 24-target air traffic control simulator. It has a “playing area” of 400 miles square with an altitude of 50,000 feet, and air speeds of up to 3,000 knots for each aircraft. It will also be used for ATC procedure evaluation, at airfields such as Tullamarine (Melbourne), Mascot (Sydney), Brisbane, Adelaide and Perthis. The order is worth about £40,000.

Annual Report of B.E.A.M.A.A records that exports by the British electrical industry in 1965 increased by 4½% over the previous year to £379M.

West Germany was chosen by the Electronic Valve and Semi-Conductor Manufacturers' Association (VASCW) for its first Inward Mission, organized in conjunction with the Export Council for Europe. The eleven delegates, who were with three exceptions from Government organizations, visited Ferranti (Chadderton), Joseph Lucas (Sutton Coldfield), M-O Valve (Hammersmith), English Electric Valve (Chelmsford) and S.T.C. (Puigton) during their five-day tour.

Pye of Cambridge Ltd. announce that large losses have been incurred in the radio and television side of the Group, particularly in respect of amounts due from a group of companies to which television sets have been supplied on a large scale. Other main sections of the business, however, are operating profitably.

The Ministry of Aviation has placed a contract, worth £250,000, with the Marconi Company for tropospheric scatter radio system. This will be used in Malaysia to provide the Royal Air Force with 24 voice channels between Singapore and Penang. A 10 kW transmitter operating at 900 Mc/s will be used at either end of the 370-mile link. The tropospheric scatter terminals will be supplied by Radio Engineering Laboratories, a division of the Dynamics Corporation of America.

An agreement for an exchange of patent licenses and technology in the integrated circuits field has been signed between Westinghouse Electric International Company, N. V. Phillips of the Netherlands and North American Philips Company.

Under the terms of the contract, Phillips and Westinghouse will effect a complete interchange of device specifications and manufacturing technologies for their lines of digital and linear integrated circuits.

WIRELESS WORLD, MAY 1966

NEWS FROM INDUSTRY

IMAGE INTENSIFIERS

A JOINT £300,000 development programme by two English Electric companies, Marconi Instruments and the English Electric Valve Co., has resulted in new X-ray image intensifier equipment for medical purposes. The equipment allows medical staff to make detailed examinations of patients without exposing them to the comparatively high levels of radiation required for conventional screening; the dosage necessitated by previous methods has been reduced to about one-sixth and the resultant faint image undergoes an intensity amplification of about 40,000 times.

Basically the system entails the use of an X-ray tube whose rays, directed through the patient, form an image on a flat fluorescent screen, similar to that used for direct viewing fluoroscopy. The screen image is then optically focused to the photo-cathode of a 4.5in image orthicon Type P825 camera tube, developed by the English Electric Valve Co. The electrical charge image produced by the tube from the optical image is then scanned and the tube output signal, in the form of a television waveform, is amplified and processed before being fed to high definition television monitors operating at 1,024 lines with triple interlaced scan. In addition to direct viewing the monitor display can be filmed or tape recorded.

The major advantage of the intensifiers is that the patient is subjected to less X-ray exposure and the medical staff can view a stronger picture if necessary monitor a bodily process. An automatic beam control incorporated in the camera head and connected to the head amplifier stage of the image orthicon tube, adjusts the brightness of the picture so as to ensure that the best image is obtained with a wide variation of X-ray levels. The automatic beam control facility frees the operator from manually compensating for variation in fluorescent screen brightness during the scanning of a patient.

New S.T.C. Subsidiary.—The activities in the semiconductor field of the S.T.C. plants at Footscray and Hatfield are now controlled by a newly formed subsidiary company, Standard Telephones and Cables (Transistors) Ltd. The range of products will include transistors, thyristors, signal diodes, silicon rectifiers, Zener diodes and integrated circuits.

Integrated Circuit Prices Down.—Due to process improvements Electrosol Ltd. have been able to effect price reductions in the Signetics range of integrated circuits. All 14-lead flat package items in the SE1001 military D.T.L. (Diodes Transistor Logic) are reduced by between 30% and 40% and those in the NE1001 industrial D.T.L. range by approximately 40%. Of the other military ranges, all packages in the SE4001 low-power T.T.L. (Transistor-Transistor Logic) range have been reduced by between 25% and 30% and all except the SE501 in the SE500 linear range have been reduced by between 30% and 40%.

Domestic Entertainment Equipment.—Figures released by the British Radio Equipment Manufacturers' Association and based on post-sale statistics of deliveries by manufacturers to the home market show that sales of radio receivers (including car radios), radiograms and television receivers fell during 1965. Figures for the last three years are listed in the table below. Radio receivers also include car radio receivers.

<table>
<thead>
<tr>
<th>Year</th>
<th>Radio Receivers</th>
<th>Radiograms</th>
<th>Television</th>
</tr>
</thead>
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<td>2.616M</td>
<td>0.274M</td>
<td>1.679M</td>
</tr>
<tr>
<td>1964</td>
<td>2.199M</td>
<td>0.263M</td>
<td>1.903M</td>
</tr>
<tr>
<td>1965</td>
<td>1.727M</td>
<td>0.233M</td>
<td>1.481M</td>
</tr>
</tbody>
</table>

Impectron Ltd., have formed an associated company in the United States with Ad Auriema, whom they represent in the United Kingdom. The company, called Impectron Inc., will operate from 85 Broadway, New York, N.Y.4. The function of the new company is to market European components in the United States.

A "patient" demonstrates the new Marionette 16in X-ray image intensifier.

"Marionette" is a registered trademark of English Electric Valve Co. Ltd.
Today's components
Tomorrow's vision

Like architects, McMurdo design for the world of the future with today's materials. Behind McMurdo plugs, sockets and connectors lies a wealth of electronic know-how, coupled with forward-looking research and design facilities. Reliable performance, high quality construction and budget-conscious prices are the foundations on which McMurdo components have built their popularity among electronic engineers.

Your best plan is to send off for our data sheets. If you're a holder of the ELECTRONIC ENGINEERING INDEX see LJ400 for connectors and LJ470 for Valve Holders.

The McMurdo range includes: CONNECTORS—rack and panel, line and jumper, printed circuit and audio range. VALVE HOLDERS—plug-in relay sockets, Decal 10 pin valve holders.

Transistor sockets, Crystal sockets. VOLTAGE SELECTORS.

THE McMURDO INSTRUMENT COMPANY LIMITED
ROUNDA ROAD - PORTSMOUTH - TEL 35361 - TELEX 86712
PERU: Estemag Peruana S.A., P.O. Box 2838, Lima.
PHILIPPINES: C&C Commercial, P.O. Box 2418, Manila.

WW-116 FOR FURTHER DETAILS.
The outstanding new Mazda RIMBAND 12" tube has been designed to reduce the cost, size and weight of personal transportable television... and provide a bigger picture! RIMBAND is an entirely new method of construction. For the first time the metal band is taken back from the screen. This enables the whole screen area of 74 sq. ins. to be projected from the cabinet and utilised for the picture. No insulated covering of the rim is required. No implosion guard is needed. The result—a really compact, lightweight and low-cost set. The tube weighs 6 lbs. with a depth of 9" and a scanning angle of 110 degrees. It operates at an EHT voltage of 10.5 to 13.5 kV. Light transmission of 50% and the high levels of brightness obtainable on this tube, permit viewing in brightly lit surroundings. Type No. CME 1201.

WW—117 FOR FURTHER DETAILS.
Some degree of stability has been achieved in the U.K. colour television situation by the T.A.C.'s recommendation of the P.L.S. system for Britain (and the P.M.G.'s acceptance of it), but this does not mean that the subject is now closed. In engineering the ultimate solution is never reached. This article examines the principal colour systems in the fundamental terms of communication theory, particularly from the point of view of economical utilization of the frequency spectrum, and ends with the intriguing question: what would we do if we could wipe the slate clean and start again?

TELEVISION has always demanded a wider channel than any other service, with the possible exception of high-definition radar. In broadcasting it also demands wide coverage, which implies (a) the use of the lowest possible frequency and (b) the use of frequency channels exclusively over a wide geographical area and with such high power that interference could be caused to other services using the same frequency in adjacent geographical areas. In addition, the cost of producing television programme material is so high that it is desirable to transmit programmes by landline or other networks between broadcast transmitters. The problem has been exacerbated by the demand for colour, which requires the transmission of additional information.

There have been many attempts to reduce the bandwidth occupied by the basic signal, but no scheme has been put into practical use; on the contrary, the transmission of television by pulse code modulation has been developed. This requires several times the bandwidth of the original signal, though in one case the digits were sent through physically separate channels so that the bandwidth required for each channel was that of the original signal. The advantage gained is the regenerability of p.c.m., which allows a large number of repeaters to be used in cascade without imposing too stringent conditions on the performance of each. On the other hand, considerable ingenuity has been shown in transmitting colour pictures within the same bandwidth as monochrome pictures.

Time analysis of the picture — It has been customary to work on the basis that the field scanning rate is a pre-assigned quantity and that the required bandwidth is then proportional to the number of 'picture elements' in each field. The first assumption is justified in the absence of image storage at the receiver since the field rate is fixed from considerations of flicker. Increasing picture brightness makes flicker more noticeable, so that since modern television receivers give a much brighter picture than the early ones it is fortunate that the standards originally adopted, 50 c/s in Europe and 60 c/s in America, allowed sufficient margin. For comparison, cinematograph flicker rates were 32 c/s on silent films and are 48 c/s on sound films. Synchronization with the power frequency was originally adopted (a) to permit the use of receivers with mechanical (mirror-drum) scanning and (b) to minimize the visibility of 'hum bars' which are caused by inadequate smoothing of the power supplies of the receiver.

Neither reason is now relevant, and the scanning in colour systems is not synchronized with the power frequency. Since flicker results from brightness variation of a substantial part of the field of view, an immediate halving of the potential bandwidth requirement was obtained by adopting interlaced scanning so that two fields are required to build up a complete picture. Higher order line interlace has not been attempted in monochrome transmission, but there are some 'dot interlace' schemes which span more than one line; and it is found that when the rate of re-painting a given spot on the picture is comparable with the response time of the eye there are objectionable stroboscopic or 'crawling' effects. One would also expect that if re-painting of the whole picture took longer than the response time of the eye, then the representation of rapidly moving objects would be unacceptable.

It is then argued that if one has n scanning lines one must be able to resolve r/n points in each line, where r is the aspect ratio, so that if p is the picture repetition rate one must be able to transmit \( p \times r/n^2 \) picture elements per second. It has been further argued (fallaciously) that one point or picture element can be approximated by a half sine wave so that the bandwidth required is \( \pi r p n^2 \). It is, however, obvious that the Fourier transform of an isolated half sine wave, Fig. 1, corresponding to an independent picture element, will include much higher frequencies as well. Gabor has pointed out that, subject to suitable definitions of effective pulse width, a Gaussian pulse gives the minimum value of \( \pi r p n^2 \) for the product of time-bandwidth. A fairly close approximation to the Gaussian shape is the 'raised cosine' of Fig. 2, which is the graph of \((1 + \cos x)/2\) from \(-\pi\) to \(\pi\). Several mathematical analyses have confirmed that whereas the half-cycle basis allows resolution of a series of light and dark alternations, it does not suffice for an isolated change of brightness. It may be argued that in practice one is not concerned with isolated points; and empirically the

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**Fig. 1.** A half cycle of sine wave.

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**Wireless World, May 1966**
Fig. 2. A raised-cosine pulse.

The required bandwidth is taken to be \( (1/k) \frac{1}{T} \), where \( k \) is the "Kell factor" which is of the order of 0.7, various estimates of it ranging from 0.53 to 0.83.

Double-sideband amplitude modulation in principle involves two-fold redundancy, but true single-sideband transmission is not practicable for television because the presence of quite low frequencies and the necessity to preserve the phase of these components would make filter design an impossible task. The "vestigial-sideband" system has therefore been adopted in which one set of sidebands (usually the upper) is transmitted completely while only the lower frequencies are retained in the other. Goldman has shown that, given a limited bandwidth, it does not make too much difference to transient (step function) response where the carrier is placed, but that resolution of a repeated pattern is better if the carrier is near one end. The final decision to use the transmitter pass-band sketched in Fig. 3(a) with the complementary pass-band of Fig. 3(b) in the receiver, was influenced considerably by receiver cost.

The difference between "information" and "detail" points to the next source of redundancy in the television picture. A chequer-board pattern in which each light or dark unit occupies one picture element appears to be the most exacting test of a television system. Yet its information content is negligible, for any pre-arranged signal could have been used to turn on a pattern generator at the receiving end; or with interlaced scanning it would suffice to transmit one frequency at the edge of the video band with phase reversed on alternate frames. The latter implies square-wave phase modulation at 50 c/s, but even so the effective bandwidth is only a few hundred c/s and most of the video band remains empty. In a practical picture the detail is less regular (the example usually cited is a crowd of spectators at a football match) and the Fourier spectrum accordingly more diffuse, but usually only a part of the field of view contains fine detail.

The amount of detail can be objectively assessed by applying to the scanning waveform a voltmeter which measures the magnitude of the rate-of-change of signal voltage: magnitude must be used because there must be equal positive and negative slopes, so that the algebraic sum of all the changes would be zero. A "detail meter" is therefore an instrument which reads from the waveform the average amount of amplitude change in the picture, which may be expressed mathematically as

\[ D = \frac{1}{T} \int_{0}^{T} \left| \frac{dE}{dt} \right| dt \]

This figure occasionally reaches a few per cent of the maximum ("chequer-board") value which it could have in the given video band.

**Reduction of redundancy.**—So far communication theory has taught us three things about television signals: (i) the maximum information content does not correspond merely with the highest video frequency; (ii) the transmission of an independent picture point for each half cycle of bandwidth is barely theoretically possible, and certainly unrealizable in practice; (iii) the television channel is very poorly occupied, or in the language of communication theory the signal is highly redundant. What, then, can be done to improve the utilization of the channel?

The most obvious approach in the light of the low value of \( D \) is to vary the scanning velocity in such a way that the local value of \( D \) remains approximately constant, i.e., the scanning spot must move relatively slowly where there are rapid changes in brightness and quickly over the "flat" parts of the picture. This idea was published in 1953, but has never made practical progress. The first difficulty is that the bandwidth of the control loop at the transmitter must be considerably greater than the video bandwidth. Developments in electronic components since 1953 have made this easier, but such circuits would still be costly if they had to be provided also in the receiver. The alternative is to transmit a separate velocity signal; but this would use up some of the bandwidth saved from the video signal, and still add to receiver cost. The more serious difficulty is that of ensuring synchronism of movement of the receiving scan with that at the transmitter, and this is probably an insuperable obstacle. In practice, it is not permissible to allow the field repetition rate to vary with the average detail in the picture, because of problems of flicker and reproduction of motion.

A digitized substitute for variable-velocity scanning is known as "run-length coding." In this the picture amplitudes are quantized, and the number of picture elements between each successive change of level is counted. Instead of transmitting a continuous video signal, there is transmitted at each change of level a pair of signals indicating (a) how many picture elements are covered by the constant-amplitude run since the last change, and (b) what the new level is. Ideally one might transmit only the sign of the change in level (as in delta-modulation) if the resolution were good enough. But if the change from one element to the next may be more than one level, and in any case to prevent drift in level due to cumulative errors, the new level must be specified independently.

Limb and Sutherland have calculated that a bandwidth reduction of 2:1 might be obtained by run-length coding of a picture quantized into only 16 levels. (Other schemes for applying p.c.m. to television have suggested at least 32 levels.) The trouble is that long runs at uniform brightness are not so common: the orders of magnitude

![Diagram](https://via.placeholder.com/150)

**Fig. 3.** (a) Transmission characteristic of vestigial-sideband transmitter; (b) transmission characteristic of vestigial-sideband receiver.
found by Limb and Sutherland for a picture of average detail were 10% of runs of length 3, 1% of length 8 and just over 0.1% of length 16. Some economy of bandwidth is obtainable if the system is made completely asynchronous, with special signals indicating end-of-line and end-of-frame\(^{11,15}\), but if the frame frequency is to be kept constant the system must be designed to meet the demands of a high-detail picture and little saving of bandwidth results. (If the system is set up for medium detail and fixed frame frequency, then a high-detail picture would not have been completely scanned by the conclusion of the frame period and the premature fly-back would leave a black space at the bottom of the picture.)

The redundancy of the television signal is most readily expressed in terms of the correlation between different parts of the same frame and between successive frames, and proposals have been made to exploit this correlation. The frame-to-frame correlation is complete for a stationary picture. It is therefore high for most pictures, in which there is a moderate amount of movement against a fixed background, though one can imagine that for a stage performance such as a Cossack dance there would be more movement than background. The engineering difficulty is that a complete frame must be stored if the correlation is to be exploited. There is also a very serious practical problem: even though the background is stationary, the picture is not constant unless the camera is fixed. This implies that all pan and zoom operations of the camera would be banned or discouraged, and sharp cuts from one scene to another would be impossible.

The fundamental difficulty is that either the communication channel must suffice for the maximum information rate of the video signal, which is the present practice, or the signal must be stored for a long enough period to allow transmission to occur at an average rate. The period needed to obtain a meaningful average is more like minutes than seconds, and though this could obviously be achieved by video-tape recording, it appears out of the question to incorporate a video-tape machine in every receiver.

The video spectrum.—A completely different approach which lends ultimately to the use of UHF i.f.-band sub-carrier for the signal, is via the Fourier spectrum of the video signal; and the characteristic of methods based on this is that any defect will appear as "noise" spread over the whole picture, rather than as failure to follow movement or as the complete loss of part of the picture. The nature of the picture spectrum was first analysed by Mertz and Gray\(^{11}\), and the spectrum of television pictures has been examined by Bell and Swan\(^{12,13}\). The salient points are that (i) the amplitude of the Fourier components falls approximately as the inverse of the video frequency; (ii) multiples of the line repetition frequency are the dominant components; (iii) each of these line harmonics is fringed with "sidebands" spaced from each other by the frame frequency; and (iv) to the extent that there is movement in the picture, these last components spread out from lines into more diffuse components occupying to some extent the gaps between them. There are, therefore, no completely unoccupied frequencies but some parts of the spectrum are more occupied than others.

Mertz and Gray\(^{11}\) suggested interposing other signals in the negligibly occupied parts of the spectrum of picture-telegraph signals, and this principle has been successfully used in compatible colour television. In particular, a signal extending away from the frame harmonics component represents a flicker which should average out over the field period. This idea was first exploited for colour (see below) and has also been tried for bandwidth reduction\(^{2s}\) according to the scheme indicated schematically in Fig. 4. (The number of components in a television signal would of course be very much greater than is shown.) At (a) are shown 6 line harmonics, each accompanied by a few frame components; and at (b) the upper half of the band has been folded back into the lower half, the upper components (now shown dotted) being spaced half-way between multiples of frame frequency.

Unfortunately the eye does not remain fixed on one picture element, and wherever there is an edge in the picture the eye tends to switch from one element to the next as they change in successive frames, i.e., the observer experiences a dot-crawling effect. Consequently this scheme has not been pursued beyond the experimental stage. Dot-interface has also been tried as a means of reducing the bandwidth required for colour\(^{14}\), but appears to have been abandoned.

Addition of colour.—Before considering methods of transmitting colour, it is advisable to consider what information has to be transmitted. Basically three co-ordinates must be given to specify an element of picture, and they can be represented in a three-dimensional model of which the section in the \(X-Y\) plane is the colour triangle (Fig. 5) while distance parallel to the \(Z\) axis represents brightness. There are then two possible sets of co-ordinates: the brightness-hue-saturation scheme uses a kind of cylindrical polar or \(r\theta z\) co-ordinates in which an axis parallel to \(Z\) is set up through the centre or white point of the triangle, hue is represented by the angle \(\theta\) of a radius vector to the point representing the light and saturation is represented by the length \(r\) of this vector relative to the radius to the periphery of the triangle. The alternative arrangement is to use the \(Z\) axis plus a pair of axes in the \(X-Y\) plane.

It is essential in a compatible colour television system that the modulation of the main carrier should represent luminance; and it follows that the quantities transmitted on the sub-carrier must represent chromaticity (position in the colour triangle) rather than intensities of primary colours. To derive position in the colour triangle, one uses the fundamental law of colorimetry that the luminance of a "mixed" colour is equal to the sum of the luminances of its components, and normalizes the primaries having luminances say \(A, B\) and \(C\), to chromati-
has less resolving power in colour
Transmission of red, green and blue luminances in terms of
These three formulae for the components; of the approximately triangular space of real
colours.
The television camera and reproducing systems use three real primaries; and typical primaries for a colour
picture tube are specified by:
- Red: x = 0.67, y = 0.33
- Green: x = 0.21, y = 0.71
- Blue: x = 0.14, y = 0.08
At the transmitter the luminance signal is made up of a weighted sum of the luminances of the primaries:
$$E'_y = 0.30 E'_r + 0.59 E'_g + 0.11 E'_b$$
(The primes indicate that the components are gamma-corrected, i.e. ready for direct application to the colour
tube in a receiver.) The two components of modulation applied to the sub-carrier are:
$$E'_g = 0.41 (E'_y - E'_r) + 0.48 (E'_r - E'_g)$$
$$E'_r = -0.27 (E'_y - E'_g) + 0.74 (E'_r - E'_g)$$
These three formulae can be regarded as three simultaneous equations which can be solved in the receiver for red, green and blue luminances in terms of $E'_r$, $E'_g$ and $E'_b$.

Transmission of colour by sub-carrier.—The eye has less resolving power in colour than in luminance (brightness) just as it has less sensitivity. (The loss of colour discrimination at low illumination is known as the Purkinje effect, and moonlight falls within the intensity range in which there is no colour discrimination.) An example of the eye's insensitivity to detail resolution in colour can be seen in the remarkably satisfactory impressions given by monochrome photographs which have subsequently had colour superimposed by hand; the areas of uniform colour are often much larger than would have been acceptable in a painting. The principle of "mixed highs" was proposed to take advantage of this, the colour components being separated at low frequencies but allowed to mingle as a combined white signal at high video frequencies. In Dome's proposal\(^{1}\), using two colour sub-carriers, the basic signal to 4 Mc/s was to have been the green component while the red component extended to 1 Mc/s and the blue to 0.2 Mc/s. Since the red and blue signals were not mutually overlapping in the combined video signal, the space that could be allocated to each was strictly limited. In the N.T.S.C. system the two colour signals occupy the same band (see below) so the bandwidth limitation is not so stringent.

In all compatible transmission systems which have so far been proposed, the first step is to provide a colour sub-carrier at a frequency where it will cause least interference with monochrome reception. The three factors which are used to minimize interference are: (i) the sub-carrier is placed mid-way between frame-frequency multiples, so that its effect should average out over alternate frames; (ii) it is placed near the upper end of the video signal, where luminance components are small so that low-frequency patterns will be of low intensity and beating with the strong components at the bottom of the video band will produce fine-grained patterns; (iii) the average amplitude of the sub-carrier is kept down; and (iv) the bandwidth of the modulation of the sub-carrier is kept down.

Compression of both colour signals into one frequency band is achieved by using double modulation of one sub-carrier: the sub-carrier is regarded as a two-phase channel and the two colour components are modulated on the sine and cosine components of the sub-carrier. The two colour signals are then known as the "in-phase" (I), and "quadrature" (Q) components. (This is equivalent also to having the carrier simultaneously modulated in amplitude and phase.)

It is specified in the N.T.S.C. system that the $E_r$ component, sometimes known as the hue component, should have a coverage of at least 1.3 Mc/s, but must be at least 20 dB down at the main vision carrier. The $E_g$ component must cover at least 400 kc/s but have at least a 6 dB cut-off at 600 kc/s. Since the sub-carrier is placed at approximately 5.6 Mc/s in a nominal 4 Mc/s channel, $E_r$ may be approximately double-sideband but $E_g$ must be vestigial sideband.

The separation of the I and Q components in the receiver requires an accurate phase reference; and even with a burst of sub-carrier added to the synchronizing signal at the end of every line, the receiver must be set up rather carefully to avoid colour distortion. Several schemes have been devised to overcome this phase sensitivity, known as SECAM\(^{16}\) (from France), PAL\(^{18}\) (from Germany), and a scheme tentatively known as NIR or SEQUAM\(^{19}\) (from Russia). All make one line of colour information serve for two lines of picture, and therefore require the receiver to incorporate a delay line capable of storing one complete line of signal.

In the SECAM system the two colour signals are sent alternately, a line at a time, and each received line therefore takes one of its parameters from the current modulation of the sub-carrier and the other from the stored signal of the previous line. Since only one parameter is transmitted at a time it suffices to amplitude-modulate the sub-carrier and there are no demodulation problems. The difficulty is that this very simplicity of demodulation makes SECAM completely incompatible with N.T.S.C. The PAL system is very similar to N.T.S.C., but the same video information is used for the in-phase component on two successive lines, but with reversal of phase of modulation in alternate lines. ($E_r$ tends to convey hue, rather than saturation, because it is based on the difference between red and blue.
signals. It is \( E_2 \) which has the smaller bandwidth of the two in N.T.S.C.) It follows that \( E_2 \) vanishes from the sum of successive lines, leaving \( E_0 \) alone. While similarly \( E_0 \) alone is recovered from their difference. If a phase sensitive detector is used, an error \( \delta \) in the reference phase will only reduce the amplitude of the colour signal by \( \cos \delta \).

It is one of the practical difficulties of communication theory that one has no theoretical basis for deciding the fraction of the channel capacity that should be devoted to synchronization of one sort or another; one only knows that in practice it is an appreciable fraction. With normal teleprinter machine telegraphy, for example, it is about 25\% and in monochrome television the combined line and frame synchronizing pulses (and flyback times) account for about 20\% of total signal time. It appears that the Russian N.I.R system devotes 50\% of colour sub-carrier to synchronization by the device of transmitting sub-carrier reference phase throughout the whole of alternate lines (instead of only as bursts during synchronizing pulses) and then uses the N.T.S.C. double-modulation of the sub-carrier for the other lines. A one-line delay here is thus able to bring together such colour bursts in the same line, and so reduce synchronizing pulse error, and this in turn, instead of having to rely on the "memory" of a local oscillator to provide the same phase during the line of picture signal, as was indicated during the preceding synchronizing pulse.

Having once accepted the idea storing a line of colour signal, one has only two signals to transmit simultaneously, namely luminance and one or other of the two colour signals. But two signals can be transmitted on one carrier, and the SEQUIN system \textsuperscript{19} proposes to transmit the two as in-phase and quadrature components of the main carrier. The proposal includes the use of negative modulation, and saturated colours would be represented by both amplitude and phase changes of the carrier, while unsaturated colours would differ from the corresponding saturated colours by having smaller quadrature components but the same in-phase (black-white). With negative modulation the synchronizing pulses provide maximum-power pulses of carrier, and therefore a carrier phase synchronizing reference; an automatic phase-lock circuit is suggested; and this appears desirable because the frequency of the main carrier is some twenty to a hundred times greater than that of the conventional colour sub-carrier, the phase-synchronization of which is apt to be rather unreliable.

On grounds of communication theory, the objection to SEQUIN is that it puts the colour information into the low-frequency end of the spectrum which is already heavily loaded; in engineering terms this means that when the carrier is subjected to double modulation there must be limits on the depth of modulation of either component. In the proposed system this is covered by the reduction in amplitude of components which involve a large angle modulation.

Other possibilities.—So far we have reviewed existing developments in the light of information theory, but if we could wipe the slate clean and start again would we make any drastic changes? The most important factor seems to be that the picture is so variable in amount of detail, in position of the centre of interest in the field of view and in amount and speed of movement that the only alternatives are either to provide for the most severe conditions on instantaneous transmission, and so have a poor signal-to-noise ratio or have a poor signal-to-noise ratio or have a poor signal-to-noise ratio, and here again we make the same choice as in monochrome.

**LITERATURE RECEIVED**

Two charts entitled Oscilloscope Accessories and Mounting Arrangements for Oscilloscope Cameras, are available from Marconi Instruments. These are intended as guides to accessories for use with Marconi scopes and, in particular, oscilloscope cameras.

**WW 221 for further details**

Oscilloscope input accessories is the title of another Marconi Instruments' publication (10 pages) introducing the 81 series of passive probes, and also discussing an active probe and a pre-amplifier.

**WW 333 for further details**

The Loftline photomechanical process for reproducing drawings and graphic designs on flat surfaces—all metals, laminates, plastics, and so on—is described in a 4-page leaflet available from Lee-Smith Photomechanics Ltd., of Lyon Way, Hatfield Road, St. Albans, Herts. The industrial applications of this process and details of the equipment needed for the process are included.

**WW 221 for further details**

"Abstracts of application notes and other Literature on Semiconductors available from General Electric Semiconductor Products Department April 1965" is the title of a publication (90/01/000) listing the company's semiconductor application notes, article reprints, manuals and papers. Requests should be made to the General Electric Company, Distribution Services, Building 5, Room 208, 1 River Road, Schenectady, N.Y. 12305, U.S.A.

**WW 325 for further details**

Newmarket Packaged Circuits ABC describes the range of packaged a.f. amplifiers and power units produced by Newmarket Transistors Ltd. Seven types of a.f. amplifier are presented, from 150 mW to 3 W, and circuits, dimensioned drawings and specifications are given for each item. A high-to-low impedance matching pre-amplifier and three power supply units are also detailed in this 12-page brochure.

**WW 326 for further details**

The second issue of the 312-page main catalogue of Briel and Kier, of Nærum, Denmark, is divided into 14 sections, the largest covering special acoustic equipment. Others include a.f. generators, frequency analyzers, microphones and accelerometers. The final section contains abbreviated information on international standards for acoustical and mechanical measurements.

**WW 307 for further details**

The latest Heathkit catalogue (86/1) is available from Daystrom Ltd., of Gloucester. The catalogue lists available kits, including two recently introduced items—a "slantline" loudspeaker enclosure and the 0S-2 3 in oscilloscope. A short leaflet listing some of the available American kits is also available.

**WW 328 for further details**

Crossed field amplifiers are discussed in the latest issue of Micronotes (vol. 3, no. 8). This American publication, intended for those interested in microwave technology, is available from Microwave Associates Ltd. at Cradock Road, Luton, Beds.

**WW 321 for further details**

Autospec Success is the title of publication SP/49 available from the Marconi Company. The Autospec principle of automatic error correction for radio telegraph and data transmission systems is described briefly and examples of its use in various installations are given, together with some typical error-rate figures. The Autospec system was described in detail in *Wireless World* February and March 1964 issues.

**WW 331 for further details**

Transnet Variable Ratio Transformers is the title of a 6-page folded leaflet describing a new range of transformers manufactured by Smith Hobson Ltd., Hershams Trading Estate, Walton-on-Thames, Surrey.

**WW 321 for further details**

British Insulated Callender's Cables Ltd., 21 Bloomsbury St, London, W.C.1, announce a new publication No. 506, *Television Distribution Cables*. Physical and electrical data of nearly forty different conductor sizes is presented in three tables. General supporting details cover cable construction, installation, screening, efficiency and impedance uniformity.

**WW 322 for further details**

An engineering bulletin on the subject of 0.01% A.C. Calibration Equipment is available from Dynamco Instruments Ltd., Salisbury Grove, Mytchett, Aldershot, Hampshire. The bulletin describes the general problems associated with a.c. calibration, drawing attention to the fact that there is no absolute standard for a.c. similar to the Weston Standard Cell used for d.c. calibration, and then details the method of the Dynamco system which uses the thermal transfer technique.

**WW 332 for further details**

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**Wireless World, May 1966**
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WW—119 FOR FURTHER DETAILS.
Collision Avoidance Systems

I READ with interest Mr. Gilmour's letter (April issue) about collision avoidance systems for aircraft. His theories, however, contain some serious defects:

(a) For aircraft climbing and descending (a prominent collision situation), he proposes the aircraft transponder to transmit "heights intending to be passed through." Two points here. First, the transponder has no crystal ball to foretell this, so it has to be informed of the intention by the already overworked pilot. Something else to do wrong. Second, the rate of descent is all-important, as well as the heights concerned.

(b) The successful operation of the equipment depends on complete serviceability of both units in both aircraft. Things like this go "on the blink" with monotonous regularity. One fault in either system and all is useless.

(c) Also assumed is that both aeroplanes have the equipment fitted. Some small airlines have not yet had I.L.S. installed in their aeroplanes, a system years old and widely considered vital for safe air operations. What chance is there that they will fit this new wizardry? Also, a light aeroplane can do just as much damage in collision as another airliner; yet, with the best will in the world, these do not have room to fit the proposed equipment.

(d) Aircrew cannot tell readily from a height/airspeed/heading display whether or not another aeroplane constitutes a collision risk. They want it on a yes/no basis. Given that, which implies more than the "simple modification" proposed by Mr. Gilmour, it is impossible to "discuss avoiding action" with another aeroplane owing to the diversity of frequencies in use.

A better basis for starting to look at this problem is that of simple relative velocities.

Two aeroplanes on a collision course have velocities such that their relative velocity is along the straight line joining themselves. Let me make this more clear diagrammatically.

This is the old "parallel-axes" theorem; the relative velocity (represented by the intercepts) is always at a constant angle (i.e. no angular component of polar velocity) if the flight speeds are steady.

The following system therefore commends itself. A self-contained radar tracking system in the aircraft (of the gyro-based guided missile variety) picks up an aircraft within a certain range and "locks on" to it using proven missile techniques. The rest is simple. If the radar enters another aircraft's range, a warning is immediately given to the pilot or its operation is shut down. It is understood that if the radar system and its operation are permanently shut off, it is not considered an adequate collision avoidance system.

British Electronics Abroad

AS an electronics engineer and a resident in Hong Kong for the last six years, I wholeheartedly agree with your Editorial in the December issue and the subsequent letter from Mr. D. W. F. Miligan in the February issue.

We have just finished here in Hong Kong what is reputed to have been a very successful British Week. In conjunction with this, an eleven-day Engineering Exhibition was held to show off the cream of British products. After spending a couple of hours looking around the various displays, I concluded that British manufacturers of electronic equipment either had nothing to show, or they were just not interested. As I read most of the leading electronics journals and visit the various London exhibitions, I know that it is not the former—therefore I must assume it is the latter.

Of course, some of the larger British companies with Far East offices in Hong Kong were represented, but even they had nothing spectacular or inspiring on show.
One point in particular; although within 18 months Hong Kong is to have a broadcast television service, not one manufacturer of TV sets thought his products worthy of showing.

In the manufacturing field, Hong Kong is blessed with a large labour force and a low wage scale. This, together with a low rate of taxation, has attracted many American and Japanese manufacturers to set up their own or joint-venture plants in the Colony. In contrast, only one British company has followed suit—it is a subsidiary of a large American organization!

One American company started two years ago producing semiconductors on one floor of a small factory building. Last week they opened the doors of their own new 11-storey factory.

The general opinion of the industry here is that British manufacturers have "missed the boat"; an opinion which I am almost ready to endorse.

However, before passing judgment I decided to do a little research. I looked around this wonderful Colony of ours and concluded that one branch of electronics was still open to all. I refer to the field of industrial electronics, where none has so far ventured, though no doubt they will if left much longer.

As a start, a small group of electronics engineers have just formed a company for the design and manufacture of electronic devices for use in industry. Within ten days of advertising the fact, we have been swamped with queries from local manufacturers; so many that two of our group are permanently assigned as consultants. If the response locally is so good, then what better place to start a plant. No doubt the opportunities are as great in the other countries around us.

So, you manufacturers back home, why not take a trip out here and look over the market potential. I assure you the natives are friendly. Should manufactures be out of the question for you, there are sales to be made—but not from the sanctuary of your U.K. office.

Kowloon
Hong Kong.

DON WEBSTER

"Flip-flop" a Mismember?

THE letter from Mr. P. S. Pinder in your April issue can only produce my complete agreement, but what a shame the printers let him down at a most crucial point in his argument.*

There is, however, doubt creeping into my mind. Perhaps the computing engineer uses the terms "flip" and "flop" to designate a "1" or "0" respectively being generated. In this case one can, I suppose, argue that their nomenclature is logical as this is the pattern of events occurring in a bistable, i.e., the first trigger pulse generates a "1" and the second pulse a "0." Presumably a bistable working in an "inverted mode" would then be called a "flop-flip"!*

However, I will come down on Mr. Pinder's side—after all, why should the bistable be so privileged above members of its own family?

University of Keele
Staffordshire.

E. W. FIRTH

*The fourth line from the end of Mr. Pinder's letter should of course have read "a bistable a "flip-flop" and an unstable a "flop-flop."

Automatic Car Parking Light

READERS may be interested in details of a circuit for an automatic car parking light which makes use of the light-sensitive properties of the OC71 when its paint is scraped off. The base is not connected. The circuit was designed as shown in the figure and field trials carried out on different makes of cars to prove its reliability. At night maximum drain on the car battery is approx. 196mA. When the device is operative the maximum drain is 0.5mA unless of course a switch is incorporated to disconnect it from the battery. The lamp is automatically switched on at dusk and switched off as daylight returns. The lamp stays alight in street lighting. The components cost about £1.

The circuit analysis is as follows:—

maximum current taken by the 2.2W lamp $2.2 \times 10^3 \times 2.2 \times 10^3 \times \frac{12}{11.7} = 188\text{mA}$

current required to saturate Tr3 $= \beta_{\text{min}}$ of Tr3 $= 20$

As Tr2 and Tr3 form a darlington pair and Tr2 remains saturated when circuit is in use, therefore current in Tr2 $= 12 - V_{SAT} - V_{BE} = 12 - 0.3 - 0.7 = 9.2\text{mA}$

This current is enough to saturate Tr3 which requires

$\frac{9.2}{\beta_{\text{min}}}$ of Tr2 $= 30\text{mA}$

Current of about 0.45mA is enough in the 1st stage. For Tr2 to saturate $V_{BE}$ must rise to at least 1.6V with respect to negative earth. The impedance of Tr1 is about 3.5k in the dark. Therefore $V_{BE} = 0.45 \times 3.5 = 1.57$ volts. The values of resistors can be varied to suit requirements.

Tr1 is conveniently placed near the windscreen ensuring enough light falls on its glass covering. The paint on the glass covering is easily removed. If the car is to be used regularly S1 may be omitted as drain on the battery during daytime is negligible.

Basildon
S. K. CHAWLA
Essex.

Temperature Control

I WAS interested in Mr. J. A. Selby's thermostatic switch unit in the February issue. Perhaps a circuit I have used in a number of versions may be of interest. It is basically an a.f. oscillator, of which the feedback is through a Wheatstone bridge with a thermometer as one of the resistors. Fig. 1 is the simplest practical version. Oscillation takes place above or below a certain temperature, depending on the way the transformer is connected, and the oscillator output is rectified and amplified to operate the relay.

Using an F type thermistor made by S.T.C., this circuit will control a water bath to ±0.5°C or better. The
resistors in the bridge should be wire-wound or metal oxide types, and their values depend on the temperature range required and the thermistor type. (The resistance of the F23 is 2,000Ω at 20°C.)

There has been no trouble with the relay not switching over positively during gradual change of amplitude with temperature change.

An interesting variation is a proportional control version using a complementary monostable multivibrator as in Fig. 2. Over a small temperature range the on-off ratio changes from zero to infinity. The recovery time is two or three seconds with the capacitor shown. Positive bias for the n-p-n transistor comes from the voltage drop of about 2V in the transformer winding.

The transformerless power supply shown calls for some comment on safety. The live mains wire should be connected to the capacitor, which must have an adequate rating (1,000V d.c.). The series resistor is to reduce transients, particularly when switching on. This is essentially a constant current supply and must not be open circuited (when it would become a voltage doubler), and the Zener diode must always be connected.

\[ e = \frac{1 - 274e_i}{56R} R_1 \left( \frac{2}{R} \right) \]

where \( e \) is the sine wave peak-to-peak amplitude and \( e_i \) is the square wave peak-to-peak amplitude. This output amplitude may readily be adjusted by varying \( R_1 \).

By using an operational amplifier a high open-loop gain may be achieved together with a low output impedance, thus ensuring a true virtual earth input and eliminating the need for a buffer between oscillator and load.

\[ I = 2eCR \]

Television Sound Quality

SOME time ago I decided to improve the audio quality from my television receiver in a similar manner to that described by Mr. T. M. George in your February, 1966, issue, but found one or two drawbacks. Most audio transformers proved unsatisfactory from the mains isolation point of view, since their insulation had not been designed to withstand 240V r.m.s. A much safer method is to isolate the receiver completely using a 1:1 mains isolating transformer.

It is then a simple matter to bring the audio out from the same point as used by Mr. George. If this is fed into a conventional valve pre-amplifier, and the interconnecting lead is reasonably short, there are no impedance problems to worry about. When one is using a low impedance input, or the leads are long, it is relatively simple to re-arrange the first audio stage in the television receiver to operate as a standard cathode follower. By doing this one avoids all the inherent distortions encountered using transformers, and reveals even more clearly the quality (sic) of the transmission.

JOHN WEBSTER

Glos.

"Amplitude-stabilized RC Oscillator"

I WAS very interested in Mr. E. Nelson-Jones's article on the phase-retard oscillator in the November 1965 issue. I would like to point out that a high input-impedance amplifier is not essential with such oscillators provided that an additional resistor is included in the network, as shown below.

It may be shown that if the amplifier has zero input impedance (i.e. virtual earth) the fundamental frequency of oscillation is given by

\[ f = \frac{\sqrt{10}}{2\pi CR} \quad \text{c.f.} \quad \frac{\sqrt{6}}{2\pi CR} \]

and the amplifier output voltage by

\[ e_0 = \frac{1 - 274e_i}{56R} R_1 \left( \frac{2}{R} \right) \]

Voltage-regulated Power Supplies

IN most published designs for voltage regulated power supplies, including that by Mr. J. S. Taylor in the April issue, the output transistor is driven by another power transistor. This method is expensive in that the driver transistor, often capable of dissipating about 30W, is only required to dissipate around 1W.
The circuit given above overcomes this objection. Tr1 is a silicon power transistor while Tr2 is a germanium device operating in the common emitter mode with a $V_{CE}$ of about 0.7 V.

The advantages which may be claimed for the circuit are:-
(i) Maximum power dissipation in Tr2 is normally low (usually $\sim 100 \text{mW}$) and is limited by $R$.
(ii) A current limiter of the type described by Mr. D. Wilson in the Correspondence pages of the February issue may be readily incorporated.
(iii) Tr2 is always operating in a region of substantial collector current. Leakage is therefore unimportant.
(iv) The possibility of a high $h_{FE}$ product is offered.
(v) The components required are inexpensive. At present a 2SO12A/2N1304 pair with a minimum $h_{FE}$ product of 800 costs only about 15p and has very good power-handling capabilities.

The circuit’s only disadvantage appears to be continuous dissipation in $R$ but this is usually easily accommodated since no extra heat sink area is required.

Aberdeen. IAN H. HOWIE

**Camera Image Stabilization**

WHEN a television camera is used to take pictures of very distant objects with a telephoto lens, the optical effects of small camera movements caused by accidental shocks or vibration are greatly magnified and become noticeable as wobbling or jumping of the picture. This can be seen sometimes in outside broadcasts of sporting events. The B.B.C. are considering tackling the problem by fitting to their O.B. cameras a device which optically compensates for such movements—that is, movements more rapid than the normal panning ones. Known as the Dynalens, it comprises an adjustable prism placed in the optical path and gyroscopic displacement sensors mounted on the camera housing. A camera movement detected by the sensors produces a signal which alters the refraction angle of the prism so that the light rays are deflected in the same direction as the movement and the selected image is therefore not displaced from its original position on the camera tube target.

The prism is a lens-like structure comprising a volume of liquid enclosed between two transparent plates and a bellows. In normal operation the two plates are parallel and no deflection of the light rays occurs. When a displacement signal is received, however, the plates are moved at an angle to each other and the emerging rays are bent correspondingly. The plates are controlled about both horizontal and vertical axes so that the effects of camera movements in any direction can be compensated.

The device is marketed in the U.K. by the Livingstone Group. At present the B.B.C. are assessing its performance, which may depend to some extent on the speed of response which in turn depends on the inertia of the mechanical parts. It is thought that the stabilizer may prove particularly useful when cameras are mounted on high towers where they are likely to be buffeted by the wind.

An alternative solution to this type of problem adopted by another American firm, the Itek Corporation, is to interpose in the optical path an electronic image converter with electro-magnetic means for deflecting the electron beam (Electronics, September 20, 1965). This has the advantage that the electron beam deflection system has no mechanical inertia to limit the speed of response of the stabilizer.

**New Aid for Renal Studies**

KIDNEY function studies employing radioactive isotope tracers will be assisted by a specially developed renal function analyser with two separate channels. This equipment, made by Isotope Developments Ltd., employs two scintillation counters, which are so positioned on two vertical columns that the patient can be examined in a sitting position. The associated collimators, with special iso-count characteristics, are intended to minimize cross interference caused by the radiation emitted from each kidney. Both analogue counting channels are constructed of transistor modules, and each channel contains a high voltage unit with digital setting indication, a wideband amplifier with continuous gain control, a pulse height analyser, and a multi-range linear ratemeter. The mounting of the detectors permits other studies to be carried out, with the patient lying down or sitting up.

![Dual channel renal function analyser.](image_url)
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Statistics in Electronics and Communications

5—Experiments and Decisions

(Concluding the series)


DEcision-making is an important activity in government, management and scientific activities; and from a theoretical viewpoint two of the major characteristics of decision-making are, first, that it involves loss of information and, secondly, that the task of scientific decision-making is to make logical decisions on the basis of doubtful evidence. The loss of information is inherent in the non-linear nature of decision-making, whether or not it is irreversable. Consider, for example, a criminal trial in which the evidence for the prosecution is largely circumstantial. Tens of thousands of words may be spoken about times and places, alleged recognition of persons, chemical analyses, etc., but the decision of the jury reduces all this to one binary digit's worth: "guilty" or "not guilty" (except in Scotland, where the verdict provides one ternary digit of information on the scale "guilty," "not proven" or "not guilty"). The discarding of information by decision-making is perhaps illustrated even more dramatically by the tradition in certain examinations of destroying the candidates' scripts as soon as the class list has been prepared.

It is equally true that there is a loss of information when a decision is made by a threshold circuit between the "mark" and "space" conditions of a signalling circuit. It is inherent in the philosophy of Shannon's ideal coding (as described in the geometrical model?) that in order to preserve as much information as possible only a single decision shall be taken, identifying the received signal as a whole with some particular message, and the freedom from error which is associated with the ideal-coding theorem is lost if one decodes the signal one digit at a time. This viewpoint is also applicable to character-recognition schemes: those which divide the character area into a matrix of cells and then take a separate binary decision on each cell in turn must be inferior to those which retain all the information until a later stage.

"Doubtful" evidence means statements which can be expressed as probabilities but not as facts: an example from electronic engineering is the estimate of the magnitude of a signal or other current on which is superimposed "noise" of some kind. The decisions are described as logical because the use of the appropriate statistical algorithm would lead to a unique result which does not involve any subjective judgment by the observer; and this is both the strength and the weakness of statistical decision methods. The absence of subjective factors is in general desirable, but there may be anxiety lest the statistical process might ignore "imponderable" factors which would be included in a subjective judgment but which are not amenable to quantitative formulation. The answer to this objection is that diligent study will often lead to a quantitative formulation of the so-called imponderable, in which case all that was hurt by the use of statistics would be the pride of the man who would otherwise have made a subjective judgment.

Experiments and decisions have been linked together because the purpose of an experiment is often to obtain information for use in making a decision: this can usually be described formally as deciding on the best out of a number of possible hypotheses. In measuring a length of x millimetres with a metre rule, you select one out of the thousand hypotheses from x = 1 to x = 1000. However, it would usually be unrealistic to suggest that all the different values are equally probable: for example the length of a man's shoe is unlikely to be more than 35 cm or less than 20 cm. One thus has some advance estimate of the probabilities of the various hypotheses—the a priori distribution of probabilities—and the experiment leads to a more restricted a posteriori distribution of probabilities. The difference between these two sets of probabilities, when suitably expressed on a logarithmic scale, is the information obtained from the experiment, in the particular sense of information/communication theory. Suppose that in given circumstances there are k probabilities to consider. (We might have k = 57 if we were waiting for the next symbol to appear on a teletypewriter page, or perhaps k = 9 for the number of horses in a particular race.) Then the average logarithmic probability is obtained by multiplying the logarithm of each probability by the probability of its occurring, i.e. by itself. Since probabilities are by definition less than unity, their logarithms are negative quantities; and the positive quantity obtained by reversing the sign of the average logarithmic probability is the entropy

\[ H = - \sum_{i=1}^{k} p_i \log p_i \]

Thus the whole basis of information measurement is statistical. However, the application of statistics is more obvious when a particular statistical technique is used to reach a

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decision on some specific type of question. For example, a sample of 15 resistors drawn from a large batch of 5% tolerance resistors has a mean value 0.22% below the nominal value: does this mean that the whole batch is probably a little low in value? To answer this question the variances of the whole population and of the sample must be known, because such a sample could be from normal production in the way sketched in Fig. 1. The curve, a normal distribution with a standard deviation of 1.5%0, represents the distribution of frequency of occurrence of various magnitudes of discrepancy in the whole population, and the small arrows indicate the individual values of the 15 samples. The samples occur more thickly towards the centre of the distribution, but being random are not quite symmetrically distributed. Are these values which could reasonably have been drawn as a random sample from the population? The parameter used by statisticians to investigate this question is known as "student's t" and is defined by the formula: 

\[
t = \frac{(\bar{x} - \mu)}{\sigma_s} \sqrt{n}
\]

where \(\bar{x}\) is the mean of the sample, \(\mu\) the mean of the whole population, \(n\) the number in the sample, and \(\sigma_s\) is related to the variance of the sample: 

\[
\sigma_s = \frac{\Sigma(x - \bar{x})^2}{n - 1}
\]

The number of degrees of freedom of the sample parameter \(\sigma_s\) one degree of freedom has been lost because instead of asking about the variance of the sample, the mean being fixed by the sum of the individual values in the sample, we are asking about the variability of the sample relative to the pre-determined mean of the whole population. (The idea of "degrees of freedom" will be further discussed below.)

Returning to the specific example, \(n = 0.012\), \(n = 15\), and \(\sigma_s = (1/14) \Sigma(x - \bar{x})^2\) for which the sample values indicated in Fig. 1 is 1.701. It follows that \(t = 0.508\). Now look in a table of the \(t\) distribution (e.g. Table XII in Birnong and May), take the line of the table for \(m = 14\), (14 degrees of freedom); the nearest entry, \(0.537\), occurs in the column headed 0.60 which means that there is a nearly 90% probability that the difference is random and no change in the characteristics of the production is indicated by the sample.

Degrees of freedom

The meaning of "degrees of freedom" is most easily seen in a "contingency table" which is a means of discerning relationships, similar to correlations, when the relevant characteristics are given only qualitatively instead of as continuous variables. For example, is it more difficult to get an Ordinary National Certificate in Engineering or in Building? The numbers enrolled and numbers obtaining O.N.C. at certain colleges could be set out in a table as follows: The non-statistician would convert these figures to percentages passing, which is quite correct as far as it goes. But when the percentages work out to 49 and 54, are we sure this is significant?

The statistician may take a different approach. The total number of enrolled students is divided in two ways, first between those who take engineering and those who take building and secondly between those who obtain O.N.C. and those who do not. If there is no difference in standard of courses or quality of students, the number who obtain O.N.C. in engineering should be obtained by multiplying the number of engineering students by the number of successes amongst all students i.e. \(1100 \times 593/1202 = 542\) to the nearest integer, this number is shown in brackets in the table; and it is clear that given this number and the totals of rows and columns it is immediately possible to construct the figures which would be expected in the other cells of the table.

Since the figure for one cell (in addition to the totals) suffices to fix the whole distribution, this table is said to have one degree of freedom. However, if there are several rows and several columns in the table, it is necessary to specify the content of all but one cell in each row or column, and a table having \(r\) rows and \(s\) columns has \((r - 1)(s - 1)\) degrees of freedom (e.g. 6 degrees of freedom for a \(4 \times 3\) table). The statistican can then write into each cell the difference \(\delta\) between the value found experimentally and the value which would follow from multiplying independent probabilities: in the top left-hand cell of the present example \(\delta = 539 - 542 = -3\), and since this table has only one degree of freedom all the other three cells must have \(\delta = \pm 3\). Without entering into a proof it is plausible to say that the ± ambiguity is eliminated by squaring \(\delta\), and that in general the square of \(\delta\) is likely to be proportional to the independence value \(m\); so we derive a measure

\[
x^2 = \Sigma(\delta^2/m)
\]

where the summation is taken over all cells in the table. There are tables of \(x^2\) showing for various degrees of freedom the probabilities of various values of \(x^2\) arising by chance. If the value of \(x^2\) is greater than could occur by chance with an acceptable degree of certainty, it is suggested that the two ways of splitting the population into rows and into columns—are not independent. In the example shown above the value of \(\delta\) is the same in all cells, but of course there are different values of \(m\), so that 

\[
x^2 = 9 \left( \frac{1}{342} + \frac{1}{558} + \frac{2}{51} \right) = 0.386
\]

Now looking in the table of \(x^2\) under one degree of freedom we find \(x^2 = 0.148\) for a probability of 0.7 and 0.455 for a probability of 0.5; so there is a probability of around 0.6 that such a result could arise by chance which is an unhappily vague situation. There is no ground for affirming that it is easier to obtain the O.N.C. in building than in engineering, but the idea cannot be firmly excluded.

At this point it is well to be reminded that there is no magic in statistics. Tests such as "student's \(t\)" and \(x^2\) are concerned with evaluating the probable effect of random fluctuations due to sampling. The statistician's ideal model would be to suppose that we had a bag containing a very large number of ball bearings, mostly steel (engineering students) but a known proportion of bronze (building students) and a fixed proportion at the whole marked with a white spot (O.N.C.); if a handful is drawn at random, what proportions of the four different kinds may be expected? Our O.N.C. data do represent a sample because (a) they refer to certain colleges instead of all colleges, (b) they refer to a single year and (c)
when we ask whether one course is more difficult than the other, the people who actually enrolled in the courses are only a sample out of all the people who were qualified to enrol. Of course, the sample in social problems may be biased; but unless you are prepared to regard the data as a sample, either approximately unbiased or with a specified bias, you must not apply statistical tests which are based on sampling theory. The possibility of averaging over several years brings in again the question of the distribution being stationary. In using autocorrelation in order to obtain the power spectrum, the function was integrated over a time which tended to infinity and it was therefore necessary that the distribution of amplitudes be the same at all times, i.e. that the continuing sequence of values form a stationary time series. When the durations of individual events are very short compared with the time of observation of the whole phenomenon, as in most forms of electrical noise, the distribution function is usually exactly stationary; but this may not be so in other problems. For example, when studying congestion in telephone systems one has individual calls lasting a few minutes but the total loading varying appreciably over a period of an hour at some time of the day (the G.P.O. reckon the peak period to be the two hours from 10 a.m. to noon): it follows that one cannot take any averages over a period very long compared with the duration of one call.

Decision functions

The remaining major topic is decision functions. The binary symmetric channel (b.s.c.) is so often assumed that one tends to assume that the chance of 0 being converted to 1 by noise should necessarily be the same as the chance of 1 being converted to 0, but this is not generally correct. One can usually distinguish between a false-alarm risk \( \alpha \) and a lost-signal risk \( \beta \), a terminology which is applicable to many situations including radar. In the b.s.c. one makes the false-alarm risk (0→1) equal to the lost-signal risk (1→0) by appropriate choice of the decision-point or threshold. In a radar system, however, one might first specify a maximum acceptable risk of lost-signal (for a defined signal fixed e.g. by radar transmitter and receiver characteristics, distance to the horizon and assumed type of target) and then adjust the system to minimize the risk of the specified maximum risk of lost signal. This is known as the Neyman-Pearson criterion for setting up the decision mechanism, and its difficulty is that it implicitly assumes at least two degrees of freedom in the system, one to be adjusted for each half of the criterion. If the only available adjustment is a threshold, then setting it for the specified \( \beta \) necessarily fixes also the value of \( \alpha \). Hence the Neyman-Pearson criterion is significant only if there are also other adjustments which can be made, e.g. bandwidth, and these adjustments do not affect signal and noise equally.

One will always be balancing the change in \( \alpha \) against the change in \( \beta \) when adjusting the threshold; consequently one's decision should be made in terms of the likelihood ratio \( L \) of the received signal,

\[
L(y) = \frac{p(y|H_1)}{p(y|H_0)}
\]

where \( p(y|H_1) \) and \( p(y|H_0) \) are the probability density functions of the probabilities that the observed signal \( y \) would have resulted from transmitting a mark or space respectively. \( L \) is then to be compared with some decision threshold \( K \) in likelihood and \( y \) attributed to a mark or space according as \( L \) is greater or less than \( K \).

The a priori probabilities of signal and no-signal are not necessarily equal. An obvious example of this is a ballistic-missile early warning radar system (BMWRS) where it is hoped that signals will always be absent. A more subtle example is teleprinter communication in English (or any West European) language. The letter \( E \) which is far more common than any other letter, has only one mark element and four space elements, and other common letters, \( T, A, O, I, N \) have only two mark elements out of five, so there must be fewer mark than space elements in an English-language transmission and for minimum overall errors one should make a rather less than \( \beta \), i.e. set the threshold a little higher than half way between space and mark. So let \( \alpha \) and \( \beta = 1 - \alpha \) be the a priori probabilities of space and mark, and let \( C_0 \) and \( C_1 \) be the costs of false-alarm and lost-signal errors. Multiplying \( \alpha \) (the frequency of occurrence of spaces) by \( \alpha \) (the proportion of mistakes made on spaces) and \( C_0 \) (the cost of each such mistake) one finds \( \alpha C_0 \) as the cost arising from false-alarm errors, and \( \beta C_1 \) for lost-signal errors. The total cost \( K = \alpha C_0 + \beta C_1 \) is minimized if for every signal \( y \) one computes the likelihood ratio \( L(y) \) and sets the dividing line \( L \) at the value

\[
K = \alpha C_0 + \beta C_1
\]

In general terms this says that one should set the dividing line in likelihood higher in proportion jointly as "space" signals are transmitted more often, and the cost of false-alarm errors is greater, or inversely for frequency of mark signals and cost of lost signals. This test, which minimizes cost when the a priori probabilities are known and average cost is a linear function of the absolute error probabilities, is known as a Bayes test.

Using the Bayes test

As an example, suppose that \( \alpha = 0.6 \) and \( \beta = 0.4 \) (compare the teleprinter mark/space ratio) and that the error costs are the same, \( C_0 = C_1 \). Hence in this example \( K = \alpha C_0 = \beta C_1 \). The likelihood ratio is the ratio of the slopes of the error probability curves at the value of \( y \) in question. If a signal of amplitude \( y \) is received over a channel with Gaussian noise power \( N \), the probability of its being due solely to noise (the transmitted condition being "space") is

\[
a = \frac{1}{\sqrt{(2\pi N)}} \exp \left(-\frac{y^2}{2N}\right) dy
\]

The probability of its being due to a "mark" transmission with received amplitude \( m \) is

\[
\beta = \frac{1}{\sqrt{(2\pi N)}} \exp \left(-\frac{(y-m)^2}{2N}\right) dy
\]

The slopes \( da/dy \) and \( \beta dy \) are the integrands, so the likelihood ratio is

\[
L(y) = \frac{\exp \left(-\frac{(y-m)^2}{2N}\right)}{\exp \left(-\frac{y^2}{2N}\right)}
\]

= \exp \left[ -\frac{m^2}{2N} - \frac{y^2}{2N} \right]

= \exp \left[ -\frac{y^2}{2N} \right]

= \exp \left[ -\frac{1}{2N} \right]

= P \exp \left[ -\frac{y^2}{2N} \right]

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where $P$ is the signal power and $k$ is a function of the signal waveform. The received signal is recorded as a mark if its amplitude $y'$ is such that $x(y')$ is greater than 1.5.

One further criterion should be mentioned, though its application is beyond the scope of this article, and that is the one known as a minimum test. The simple Bayes test requires a knowledge of the signal parameters $\pi_0$ and $\pi_1$ but in fact these may be uncertain. Therefore one picks out the worst-case values of $\pi$ and constructs a test which will give the minimum cost in errors if this worst case occurs. This is the minimax criterion, but for all other values of $\pi$ it will be less efficient than a Bayes test constructed for the specific value of $\pi$.

It is difficult at this stage to construct realistic examples. As in all branches of mathematics, practice in use is essential to an understanding of theorems, and the reader who is seriously concerned with decision functions is advised to work out his own cases with the aid of the specialist literature.

REFERENCES


BOOKS RECEIVED

Electronic Components, Tubes and Transistors, by G. W. A. Dummer. Treating the component as a building block, the author explains the characteristics and measurement theory of components treated as discrete elements and then discusses the practical application of components in equipment. Separate chapters deal comprehensively with resistors, capacitors, magnetic materials, electromagnetic components, valves and semiconductors. Chapters contain references to sources for further reading; also questions and answers. Pp. 166; Figs. 76. Price 21s. Pergamon Press Ltd., 4 & 5 Fitzroy Square, London, W.1.

Guide to Radio Technique Vol. 1; Fundamentals, Valves, Semi-conductors, by E. Julander. This is a book intended to provide a basis for the enthusiast or student who seriously wishes to improve his theoretical knowledge of radio rather than make a continued practical approach. The opening chapters deal with the fundamentals of electricity, complex numbers and transmission units. A complete chapter deals with the construction, theory and operation of thermionic valves; this is followed by a similar chapter on semiconductors in which a comparison is made with valve circuits. The final chapter deals with generation, propagation and modulation of electro-magnetic waves. A 14-page appendix contains useful data presented in the form of tables and monograms. The book is issued as part of the Philips Technical Library and is a translation of the original Swedish edition. Pp. 238; Figs. 214. Price 35s 6d. Distributed by Macmillan & Co. Ltd., Little Ealing St., London, W.C.2.

British Miniature Electronic Components Data 1965-66, edited by G. W. A. Dummer and J. Mackenzie Robertson. In this, the fourth annual issue of the publication nearly 170 different types of components from nearly 140 firms are listed. For most components, the textual information is supported by photographs, line drawings and tabular matter. Comprehensive details are given of each type of component and these range from accelerometers to wires and cables. Manufacturers have made available advance details of components to provide the most up-to-date information for designers, users and buyers. Pp. 984. Price £2. Pergamon Press Ltd., 4 and 5 Fitzroy Square, London, W.1.

A new British Standard, BS9394, "Dimensions of Semiconductor Devices," has recently been published. Although international discussion is currently in progress, the need within the electronics industry for a record of the dimensions of semiconductor devices in general use necessitated publication of the Standard as soon as possible. It has, however, been published in loose leaf form to facilitate amendments. The primary object of the Standard is to provide a basis of comparison for mechanical interchangeability; electrical and thermal data is not covered. Copies of the Standard may be obtained, price £4 10s from B.S.I. Sales Branch, 2 Park St., London, W.1.


Servicing Electronic Organs, by C. R. Pittman & E. J. Oliver. The book is written as a practical guide to the theory and operation of electronic organs for the serviceman requiring basic knowledge of this application of electronic techniques. Details are given of the basic circuits encountered and include illustrations and information reproduced by courtesy of ten American organ manufacturers. Originally published in America in 1962. Pp. 191; Figs. 112. Price 30s. W. Foulsham & Co. Ltd., Yeovil Road, Slough, Bucks.

Transistor Receivers and Amplifiers, by F. G. Rayer. Treatment used in the book is essentially of a practical nature and is intended to provide guidance for the home constructor interested in the use of transistors. Basic contents include general descriptions of operating characteristics of semiconductors, aerials and r.f. amplifiers, superhet circuitry and power supplies. Additional chapters describe printed circuits, test equipment and fault finding. Pp. 164; Figs. 129. Price 30s. Focal Press Ltd., 31 Fitzroy Square, London, W.1.

Many of the titles in the M.I.T. Radiation Laboratory Series of text books originally published by the McGraw-Hill Book Company and regarded as standard works of reference are now available in paperback form from Constable & Co. Ltd., 16-12 Orange St., London, W.C.2. They are—Computing Mechanisms and Linkages, by Sobesky, 18s; Microwave Antenna Theory and Design, by Silver, 24s; Microwave Transmission Circuits, by Ragan, 24s; Pulse Generators, by Clapp, Lebed, 24s; Principles of Microwave Circuits, by Montgomery, Dickie & Purrell, 18s; Propagation of Short Radio Waves, by Kerr, 24s; Radar System Engineering, by Ridouard, 24s; Theory of Servomechanisms, by James, Nicholls & Phillips, 18s; Threshold Signals, by Lawson & Ullenberg, 18s; Vacuum Tube Amplifiers, by Valley, Wallihan & Henry, 24s; Waveforms, by Chance, Britten, Hughes, Vernon, McNicholl, Sayre, David & Williams, 26s; Wavesguide Handbook, by Marcuvitz, 18s.
The 12-way electronic mixer has facilities for mixing 12 balanced line microphones. Each of the 12 lines has its own poled number 1 shielded microphone transformer and input valve, each control is hermetically sealed. Muting switches are normally fitted on each channel and the unit is fed from its own mumetal shielded mains transformer and metal rectifier.

**FOUR-WAY ELECTRONIC MIXER**

This unit provides for 4 independent channels electronically mixed without "spurious break through," microphone hum and background noise have been reduced to a minimum by careful selection of components. The standard 15-50 ohm shielded transformers on each input are arranged for balanced line, and have screened primaries to prevent H.F. transfer when used on long lines. The standard 5 valve unit only consumes 18.5 watts, H.T. is provided by a selenium rectifier fed by low loss, low field, transformer in screening box. The ventilated case gives negligible temperature rise with this low consumption assuring continuance of low noise figures.

20,000 ohms is the standard output impedance, but the noise pick-up on the output lines is equivalent to approximately 2,000 ohms due to the large amount of negative feedback used. For any output impedance between 20,000 ohms and infinity half a volt output is available. Special models can be supplied for 600 ohms at equivalent voltage by an additional transformer or 1 milliwatt 600 ohms by additional transformer and valve.

The white engraved front panel permits of temporary pencil notes being made, and these may be easily erased when required. The standard input is balanced by means of 2 point jack sockets at the front, but alternative 3 point connectors may be obtained to order at the rear.

<table>
<thead>
<tr>
<th>Mixer for 200-250V AC Mains</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>£40 8 6</th>
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</thead>
<tbody>
<tr>
<td>Extra for 600 ohm output model</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>£1 18 6</td>
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<tr>
<td>Extra for 600 ohm 1 milliwatt output</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>£3 0 6</td>
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<tr>
<td>Size 18(\times)11(\times)61 in. front to back (excluding plugs) (\times) 6(\times)in. high.</td>
<td>...</td>
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<tr>
<td>Weight 22 lb.</td>
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</tbody>
</table>

**THREE-WAY MIXER** and peak programme meter, for recording and large sound installations etc.

This is similar in dimension to the 4-Way Mixer but has an output meter indicating transient peaks by means of a valve voltmeter with a second time constant in its grid circuit. The meter is calibrated in dBs, zero dB being 1 milliwatt-600 ohm (.775V) and markings are provided for -10 dB and -26 dB. A switch is provided for checking the calibration. A valve is used for stabilising the gain of this unit. The output is 1 milliwatt on 600 ohms for zero level up to +12 dB maximum. An internal switch connects the output for balance, unbalance, or float. This output is given for an input of 40 microvolts on 15 ohm.

An additional input marked "Ext. Mx." will accept the output of the 4-Way Mixer converting the unit into a 3-Way controlled unit. This input will also accept the output of a crystal pick-up but no control of volume is available. The standard input is balanced line by means of 3 point jack sockets at rear but alternative 2 point connectors may be obtained to order at the front or rear as desired.

The 8 valves and selenium rectifier draw a total of 25 watts.

<table>
<thead>
<tr>
<th>P.P.M. for 200-250V AC Mains</th>
<th>...</th>
<th>...</th>
<th>Price on application.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size 18(\times)11(\times)61 in. front to back (excluding plugs) (\times) 6(\times)in. high.</td>
<td>...</td>
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<tr>
<td>Weight 23 lb.</td>
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</tr>
</tbody>
</table>

10/15 watt Amplifier with built-in mixers. 30/50 watt Amplifier with built-in mixers.

2 \(\times\) 5-way stereo mixers with outputs for echo chambers, etc.

Full details and prices on request.

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, S.W.19

Telephone: LIberty 2814 and 6242-3-4

Telegrams: "Vortexion London S.W.19"
To measure C. W. Power... Sideband power ... Modulation depth

The U.H.F. Wattmeter Type 319 is a light and compact instrument for measuring C.W. power, sideband power, and modulation depth in the frequency range 1-1000 Mc/s. Carrier and sideband powers are indicated directly on a 3½" scale meter in two ranges. Percentage modulation depth is shown on a potentiometer scale.

For carrier measurement no additional power is necessary; internal dry batteries provide power for sideband and modulation measurement. This instrument is one of the units in the Airmec range of U.H.F. equipment which includes connectors, adaptors, attenuators, reactance lines, slotted lines etc.

Frequency Range:
1-1000 Mc/s

Ranges:
0-100 mW
0-300 mW
3 W with Attenuator type 321
30 W with Attenuator type 363

Input Impedance:
50 ohms

SEE US AT
THE I.E.A. EXHIBITION,
STAND NUMBER G102
GRAND HALL, OLYMPIA
MAY 23-28

Airmec UHF Wattmeter Type 319

LABORATORY INSTRUMENTS DIVISION
Oscilloscopes, Wave Analysers, Signal Generators, Phase Meters.
Valve Voltmeters, Ohmmeters, High Speed Counters, etc.
AIRMEC LIMITED, HIGH WYCOMBE, BUCKS, ENGLAND
TELEPHONE: HIGH WYCOMBE 21201 (10 lines)
WW—123 FOR FURTHER DETAILS.
NEW PRODUCTS

THYRISTOR POWER CONTROL

THE Mullard thyristor firing module (MY5011) has been designed for use in 1 or 3-phase power systems. It is claimed that the cost of thyristor d.c. motor speed controls has been reduced by a new series of Mullard designed control systems, incorporating the MY5011 module. These new systems have been constructed so that motor or control gear manufacturers, or users, can assemble their own control systems cheaply, employing standard components, modules and thyristor stacks. The three systems are, simple speed control, armature-voltage speed control and tachometer speed control.

Additional refinements, such as current limit, controlled acceleration, automatic protection against loss of motor field, compensation for mains variations, and motor field heating can be added to these basic circuits.

The MY5011 thyristor firing module will fire four 70 A thyristors connected in parallel or series, and provide continuously variable, and reliable control, over a power range of below 0.25 % to above 99.9 % of maximum power.

Size: 9.14 × 6.60 × 4.82 cm in an epoxy resin encapsulation.

Price: £14 18s.

Also available in the simple, single-phase module MY5000, capable of driving two 70A thyristors. Price: £5 5s.

Current limiting and surge suppression module (MY5051) is for use with existing thyristor stacks and firing modules. It will enable single-phase or three-phase control systems to provide automatic correction for lead current variations, or short circuit conditions, and start facilities for motor control.

When this module is in a feedback system, between a current sensing device, e.g., a current transformer, and a thyristor module, the onset of the current limit occurs when the input to the MY501 is 2.6 V r.m.s. At lower outputs, the module has little effect on the control circuit, but at higher inputs the trigger angle of the thyristor is rapidly increased. Price: £5 16s.

The cost of these power control systems varies between £24 for a d.c. motor speed control with +0, −10% regulation of set speed (for single phase 1 h.p.), to £130 for a d.c. motor speed control system with tachometer feedback offering +0, −1% regulation of set speed (for single phase 5 h.p.). There is also a three-phase version of the tachometer system at £101.

Further information from Mullard Industrial Markets Division, Mullard House, Torrington Place, W.C.1.

WWW 301 for further details

SYSTEM MODULES

Ultra-thin Pressure Transducers

SENSOTEC sub-miniature pressure transducers by Scientific Advances Inc., U.S.A., are available either as the SA-SA absolute, or the SA-SD differential pressure transducer. Both provide a full scale output up to 60 mV, making it possible to resolve small pressure changes. The transducer is a 0.02 in thick capsule, one side of which is the active diaphragm. The sensing element is a semiconductor bonded strain gauge. The SA-SA and SA-SD are intended to be compatible with all types of standard strain gauge instrumentation. Models are available in a range of pressures from 2 p.s.i. to 2000 p.s.i. Operating temperature range is −40° to +150° F. Full details from sole U.K. agents, Wessex Electronics Ltd., Royal London Buildings, Baldwin St., Bristol 1.

WWW 303 for further details

PANORAMIC MICROWAVE RECEIVER

THIS receiver, from Microwave Physics (U.S.A.), is for use in the design and testing of harmonic generators, solid state signal sources, transmitters, and other signal generators, where observation of spurious and harmonic signals is desirable. The circuit uses an electronically swept yttrium iron-garnet bandpass filter as a preselector. The filter which has a decade tuning range, is followed by a sensitive crystal detector, and a low-noise video amplifier.

Two versions of this receiver are available; the MPR-U (0.5 to 5 Gc/s), and the MPR-X (2 to 12 Gc/s), both sets permitting continuous 'scope display of signals within the stated ranges.

The MPR-U and MPR-X are available either as plug-in modules for Tektronix scopes (£722) or with self-contained power supplies for use with other scopes (£876).

Marketed by Microwave Systems Ltd., 9-10 River Front, Enfield, Middx.

WWW 304 for further details

P.I.N. Diodes

FROM Microwave Associates Limited, comes a range of microminiature P.I.N. diodes, suitable for series mounting in strip transmission line circuits. In all-glass hermetically sealed microminiature housings, these diodes offer low total capacitance (high isolation in series switch mode) and low series resistance (low insertion loss). Typical performance of this new series is demonstrated by the MA-4732C which has a minimum breakdown voltage of 75 V, maximum total capacitance of 0.3 pF, maximum series resistance of 2Ω, and a maximum switching speed of 10ns.

Further details from Microwave Associates Ltd., Cranbrook Road, Luton, Beds.

WWW 302 for further details
NICKEL BIT SOLDERING IRONS

SOLDERING irons with bits of solid nickel are now being produced by the West Germany company, Lottin Werner Bitman, of Windscheid Strasse 18, Berlin 12. Nickel was chosen in preference to copper because of its excellent resistance to corrosion by the chemicals and resins used as fluxes. It is readily "wetted" by the solder, while its thermal capacity and conductivity are satisfactory for this application.

Two models Pico Pen 15TS—(15W for small work) and Pico Post 30PL—(30W for larger work) have their heating elements and bits designed so that heating to 200 degC takes 0.7 and 1.5 minutes respectively.

WW 305 for further details

Capacitance Tester

FOUR-DIGIT in-line readout is utilized on the Model 1201 Digital Capacitance Tester manufactured by the American company of Micro Instrument Co. and marketed by Claude Lyons Ltd., Ware Road, Hoddesdon, Herts. The instrument has been designed for two- or three-terminal measurements and uses a 1 Mc/s, 35 mV r.m.s. test signal. A 0 to 100 V bias supply is provided for reverse biased diode and varactor capacitance measurements and for transistor $C_{eb}$ (capacitance between base and collector with emitter open) and $C_{be}$ (capacitance between base and emitter with collector open) measurements. Overall accuracy is a combination of measurement accuracy, which is ±1%, and a roundoff accuracy of ±1 digit. The instrument will tolerate shunt resistances down to 10 kΩ without loss of accuracy and permits in-circuit capacitance measurements and measurements on integrated circuits having low shunt resistance. Operation is based on the principle of frequency deviation. Two high-stability tunnel diode oscillators are used, one of which varies its frequency linearly with the applied capacitance. The difference frequency output from a mixer is applied to gating and zeroing circuitry and then to an electronic frequency counter for direct display as capacitance.

Three versions are available. Two single-range versions are models 1201 (0-99.99 pF) and 1201S (0-999.9 pF) both priced at £798 or £878 with print out, and a dual-range model 1201DS (0-99.99 and 0-999.9 pF) at £998 or £1078 with print out. A transistor jig for TO-5 and TO-18 cans with $C_{eb}$ and $C_{be}$ switch and 30 in coaxial leads is available for £40.

WW 306 for further details

Circuit Board for Module System

AN insulated board, the C.B.1, is perforated to the 0.1in standard grid, and is suitable for mounting wire or taped components. The board mounts on two tie rod supports behind individual module front panels. Each module can carry 1 or 2 boards. It is claimed that for experimental construction circuits, this system is neat, durable and versatile. Price: 4s 6d. A.P.T. Electronic Industries Ltd., Chertsey Road, Byfleet, Surrey.

WW 307 for further details

OSCILLOSCOPE CAMERA

THE Hewlett-Packard model 197A camera uses an electronically controlled shutter calibrated in nine even steps from 1/30 to 4s. X-synchronization, particularly useful in photographing one-shot phenomena, is controlled by connections made to an external instrument panel.

Where an internal graticule is used on the oscilloscope an optional ultraviolet light source is available to illuminate the graticule. Pre-exposure for the graticule and exposure for the trace is performed automatically by the setting of a single control. The back of the camera can be rotated from a horizontal position to vertical so that two smaller photographs can be taken on a single film. Price of the camera is £184 or without the ultraviolet light facility £165.

WW 308 for further details

Matched Signal Divider

THE Bishop Type 080-001 matched signal divider permits a source to drive two paths, and maintains 50 ohm impedance at input and output. The ability to handle signals with fast rise time of 100 picoseconds makes it suitable for pulse as well as u.h.f. carrier wave applications. It can also be used to add signals from 50 ohm sources. Connectors are BNC (3).

Available in the U.K. from Claude Lyons Ltd., of Hoddesdon, Herts., the divider costs £10.

WW 309 for further details

Wireless World, May 1966
Unspillable Lead Acid Cell

THE compact 2V Exide cell MRP7, which weights 12oz filled and measures 3.3in x 2.5in x 3.3in is unspillable, even when inverted. The plate alloy permits the cell to be maintained under floating and trickle charge conditions, and to be used where frequent discharge and recharge demands have to be met. The cell has a capacity of 4Ah at 20 hour rate, and is suitable for intermittent, and standby use, since it is capable of standing idle for long periods.

Moulded in transparent styrene acrylonitrile, with four ribs to support the plates, and accommodate sediment, the container has red lines on it to indicate maximum and minimum electrolyte levels. Specific gravity charging rate, and topping up instructions are also shown. Price 29s.

WW 318 for further details

Miniature Lever Switches

THE 5000 and 5100 BECICWE series of lever key switches made in France have stainless-steel frames, levers, spindles and securing plates. The keys are from 0.78in (20mm) to 1.73in (44mm) in length, depending on contact combinations, 0.425in (10.8mm) wide, and 1.76in (44.6mm) deep (behind panel). They are identical in all characteristics, except for the method of panel mounting: the 5000 series being supplied with a central stainless-steel milled nut for 0.32in (8.2mm) diameter single hole fixing, while the 5100 series have 2 fixing screws for 2 side holes 0.69in (2.3mm) diameter.

The cam is made of the hard plastic DEK LIN, and the contact springs of nickel-silver. The self cleaning twin contacts in fine silver have the following ratings (non-inductive) for a.c. operation at 48V-2A, at 110V-1A, and at 250V-0.6A. For d.c. operation 48V-0.6A, at 110V-0.3A, and at 250V-0.2A.

Contacts are also available in Palladium or other materials to order. The maximum number of contacts per side for all types are 3 change-over, or 5 normally-opened, or 5 normally-closed.

The conical stainless-steel lever can be colour coded by means of a slip-on neoprene mantle in Black, Green, Red, Blue or White. Full information from Britec Ltd., 17 Charter Cross Road, W.C.2.

WW 313 for further details

Time Interval Measurement

THE A.G. Brown MINITIME is designed to measure the time interval between opening, and/or closing of contacts. Moulded in black plastic, and powered by two batteries, this instrument has a 3in meter with a linear scale, calibrated 0 to 10 and 0 to 3. Persistence of reading is within ±3% for at least 1 minute, provided the insulation resistance of the external circuit is high enough to prevent leakage leads or contacts. The ranges cover 0 to 300ns, 0 to 300ms, and 1 to 10s.

Readings are ±2½% f.s.d. Controls on the front panel are: range selector, function selector, zero set, calibrate.

Amongst suggested applications for the MINITIME are: measurement of delay between closing or opening of sets of contacts on relays or contactors, measurement of velocity of moving objects by operation of trip wires, etc., and measurement of exposure times in photography. Size: 5½in (14.5cm) x 3⅛in (9.5cm) x 1½ (4.5cm). Weight 1lb 4oz (0.6kgm) unpacked. Batteries B121, U10 (1 of each).


WW 313 for further details

INFORMATION SERVICE FOR PROFESSIONAL READERS

To expedite requests for further information on products appearing in the editorial and advertisement pages of Wireless World each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 16 and 19.

We invite professional readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by WW, and it is then necessary only to enter the number on the card.

Postage is free in the U.K. but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

WW 311 for further details
COMMUNAL AERIAL AMPLIFIERS

NEW communal aerial amplifiers for television and sound signals and combined u.h.f. and v.h.f. crystal controlled converters have been introduced by Teleng Ltd. The design of the new amplifiers is based on the dual channel U30 amplifier to which has been added a wide band amplifier and power supply. Two models are being introduced—"Popular Four" (Type E342) priced at £16 10s and "Popular Five" (Type E343) priced at £18 6s; the gain of the E342 is 25 dB for both TV and f.m., whereas the gain of E343 is 40 dB for TV and 35 dB for f.m. The amplifier can be preset for reception of any specified channel in Band I and Band III but for Band II the tuning range covers 88–100 Mc/s. Sensitivity is 250 µV minimum and output is 100 mV maximum.

These amplifiers are most suitable for smaller networks where the original wide-band "F" series of amplifiers has proved to be too expensive. Also in installations where provision for the later addition of other channels is not required, the units are claimed to be most competitive.

The u.h.f. and v.h.f. converters are based on a modified design of the U166 converter, which allows BBC-2 to be "added" to existing single-channel systems. This has resulted in two versions of the U166 which are designated Type U338 (£49 15s), having a gain of 50 dB, and Type U340 (£47 4s) having a gain of 35 dB. Maximum output levels for both amplifiers is 300 mV. The combination of the new converters and amplifiers produces a distribution system for three television channels and three f.m. programmes which will provide high quality signals for up to 100 outlets. Available from Teleng Ltd., Teleng Works, Church Road, Harold Wood, Essex.

R.F. Piston Attenuator

A PISTON attenuator giving an attenuation range of 100 dB at frequencies from 1 Mc/s to 2 Ge/s has been introduced by Flann Microwave Instruments (9, Old Bridge Street, Kingston-upon-Thames, Surrey) under the type number IF 100. Designed as a basic attenuator standard, it comprises a precision electroformed tube with an input-tunable launching loop and a sliding pick-up loop coupled to a direct-reading scale. The change in attenuation is indicated on dial gauges in steps of 2 dB per revolution. The upper linear scale is permanently fixed and indicates 0–100 dB in 2 dB steps. The lower linear scale is movable and provides an arbitrary datum when set to a cursor line anywhere within the range of the attenuator. Impedance is 50Ω and the cut-off frequency is in the region 3–4 Ge/s. For the highest accuracy measurements, small setting corrections have to be made to the measurement frequency deviates from the design frequency (60 Mc/s), but a correction curve is supplied.

Rectifier Bridges for Printed Circuits

THESE bridges by Pirelli (Milan) are single phase, resin cast units, with a body length of 3½ in. and 5½ in. diameter.

The WO2, WO4 and WO6 bridges which respectively have a p.i.v. of 200, 400 and 600 V, possess these principal ratings.—Max. average rectified output at 50°C, 1.5 A, at 100°C, 1 A; peak single-cycle surge current 50 A; max. forward voltage drop at 1 A and 25°C, 2 V; and max. leakage at rated p.i.v., and 25°C 10 mA. The bridges have an operating temperature range of –55° to +125°C. Prices are: WO2—19s 6d; WO4—22s; and WO6—28s 6d.

Available from S.D.S. (Portsmouth) Ltd., 67-69, Commercial Road, Portsmouth, Hants.

SUB-MINIATURE SWITCH

ALL the existing SE series of switches (with the exception of the 7SE model) of Honeywell Controls Ltd., Brentford, Middlesex, is to be replaced by a recently developed miniature switch—the 91SE. The switch, designed primarily for use in the aircraft industry, incorporates a new fluoro-silicone seal, with a corrosion-resistant steel plunger which ensures protection from all solvents and fuels. Basically, the switch comprises a standard 11SM1T micro switch sealed in epoxy resin in a corrosion-resistant steel plunger which ensures protection from all solvents and fuels. Designed to operate within a temperature range of –62 to 150°C, the 91SE can be fitted with a range of actuators from the Honeywell J.E. series. By this means the switch can be operated from cams, slides or other devices which are not in line with the motion of the switch plunger. The illustration shows a roller leaf actuator, J.E.5, for applications involving rapid cam or slide operation.

Printed WW 311 for further details

WW 315 for further details
HELCICAL POTENTIOMETER

A TEN turn potentiometer with a resistance range of 50 ohms to 100 kΩ is offered by Reliance Controls Ltd. A linearity of ±1 % is available, which can be improved by selection to ±0.1 %. With a temperature range of -55 °C to +100 °C, the unit has been tested for vibration and shock to MIL-202. The style number is HEL.. 05-10, and the unit has a body diameter of ½ in. Available in flange and bush mounted versions, as seen in the illustration, from Reliance Controls Ltd., Sutherland Road, London, E.17.

WW 319 for further details

Cored Preform Washers

UNDER varying forms of vibration, printed circuit boards may show failure of contact at the eyelets. The small fluxed solder preforms from Enthoven are designed to go on to the printed circuit, and under the eyelet, which is then punched by the normal method. The preformed washer, now sandwiched between board and eyelet, can be hand or machine soldered, offering a sound mechanical joint, and minimising this fault condition.

These preforms can be produced with diameters down to 0.047 in, and with thicknesses down to 0.01 in. The flux contained in the preforms is a non-corrosive organic type of material.

Large runs requiring solder preforms of this type, can be supplied to any specification with reference to the alloy (available with melting points from 190 deg C to 245 deg C), and dimensions. Enthoven Solders Ltd., Upper Ordnance Wharf, Rotherhithe, S.E.16.

WW 319 for further details

195 CHANNEL MARINE TRANSMITTER

THE Redifon G.341 gives complete coverage of the marine bands 400 to 535 kc/s, 1.6 to 3.8 Mc/s, and 4 to 26 Mc/s, offering a choice of 195 channels between 400 kc/s and 26 Mc/s. As a ship's main transmitter, it also incorporates facilities for short, medium and long range radiotelephony on s.s.b. as well as on d.s.b. The output power of 1,200 W p.e.p. available for long distance s.s.b. h.f. radiotelephony can be reduced by preset adjustments so as to comply with particular national regulations.

Deck or bench mounted, the transmitter and power unit are in separate housings. Modular construction is used extensively, facilitating speedy interchange of units and sub-units, without realignment or soldering. Ease of access is ensured by glide-out units. Short circuiting or breaking the aerial connection will not damage the transmitter, and power supply circuits are fully protected against damage under fault conditions.

The G.341 is fully type approved by the G.P.O., complying with the 1965 Merchant Shipping (Radio) Rules, also conforming with C.C.I.R. Recommendation No. 258 (Los Angeles 1959) with respect to SSB equipment for maritime use.

Power supply: 440 V (±10%) 50/60 c/s 3 phase.

Power consumption: maximum 3 kVA.

Redifon Ltd., Broomhill Road, S.W.18.

WW 319 for further details

Wireless World, May 1966
Mirror-Image

It was Alice who started it all when, in Looking Glass Land, she found that she had to run very fast indeed in order to stay in the same place. Today it has become an article of faith; a good old standby for the politician guest of honour at the electronics dinner, who never fails to remind his audience that electronics is a growth industry and therefore its economy must expand steadily if it is to survive.

The audience, mostly company chairmen, in turn never fail to applaud this sentiment because it is always safer to clap than to be obliged to argue later about something you don't understand. The politician, thus encouraged, follows up with an exhortation to one and all to double their export sales. This is received in deadly silence because exports are a chairman's recurring nightmare and he doesn't want to be reminded about them at social functions.

Eventually, the constant reiteration at such gatherings gets on the chairman's nerves to the point where the subject is put on the agenda for discussion at the next board meeting. The directors don't understand the economy-expansion bit either, but it would never do to admit it, so it is decided that vigorous action is called for. As this involves nothing more onerous than telling the general manager to pull his socks up, it is implemented forthwith.

The hapless G.M., having no wish to receive the golden handshake just yet, gets down to an analysis of the situation. He knows only too well that his export figures can only be doubled at the expense of the mighty American electronics industry, and the temptation to cast the situation in terms of David and Goliath is irresistible. But the splintering David, he reflects glumly, did not have to take the field with his hands tied behind his back by lashings of credit restrictions.

There is clearly only one possible course of action. He must build his stripping into something approaching the size of the opposition, starting with that pangs of exportable products, the research laboratories. Mass action is henceforth the order of the day.

So, away to the universities and technical colleges and rope in anyone who has a degree and feels warm to the touch. And, in parallel with this operation, send all senior research men over to the States to get the know-how of this mass attack business.

This realistic approach brings results. The recruitment scheme so much new blood that there are not enough arteries at the laboratories for them to course through, so 50 Nissen huts have to be thrown up on the nearest available site, a piece of cow pasture some forty miles away. There the recruits sit like birds in the wilderness with not a multi-test set between them.

The delegation to the U.S.A. also brings in the sheaves. Seventy-two per cent of its members return to hand in their respective resignations. This is highly encouraging to the new blood because it makes for quick promotions. The overall situation is encouraging to the Board because without doubt the G.M. has succeeded in invoking the magic word "expansion," although the directors are a shade hazy as to the detail. It is also encouraging to Goliath as he goes about his lawful occasions of kicking the undercarriage from British avionics and covering every square inch of the country with microcircuits.

With the bit now firmly between his teeth the G.M. then holds an inquest on development and production, with his senior management as chief witnesses. He enters the meeting thoroughly alarmed at the monumental ratio of clerical staff to those on the production floor and determined to enforce a ruthless streamlining. But the senior management have done their homework thoroughly and each produces statistics to prove beyond doubt that, far from being overstuffed, his particular domain is well below skeleton level and only functions as well as it does by reason of genius at the helm.

Balled in his attempt to beat Parkinson's Law, the G.M. in desperation invokes the most powerful ju-ju of all. He calls in a firm of Efficiency Consultants.

At zero hour the Assyrian comes down like a wolf on the fold. A small army of elegant young ladies and gentlemen disperse themselves around the territory like languorous Big Sisters and Brothers—watching. This is phase one. In phase two the meetings start. Interminable meetings, presided over by one or other of the valuable experts: meetings at which expressions like "procedures improvement," "procedures analysis," "timestudy productivity," "function output" and "conversion integrals" sweep like machine gun fire over the stunned assembly. The entire organization dissolves into Soviets as if all the secret societies in the world were holding their meetings in separate compartments under one roof. The telephones are all silent, no point in ringing anyone because he will be at a meeting.

At the end of a highly expensive twelvemonth the Chief Wizard pitches in his recommendations to the G.M. Shorn of its double talk it advises that several new departments should be inaugurated without delay. One of the most vital of these is the Image Promotion Dept., for it seems that the Company Image needs a face-lift which can only be achieved by a strenuous drive in prestige advertising in newspapers, journals, cinemas, television and exhibitions.

A 500% increase in time and motion study staff is considered essential, together with the institution of a Network Analysis Division. The immediate objective of the latter is to replace the old-fashioned term "work" with all its distasteful associations by the more socially acceptable word "activities," thus at last giving recognition to those who are perpetually in a high state of activity but do not work at all.

In depth, it exists to promote secret cults, identified by such acronyms as BURP, SLUG, RANT or SQUIRT (the latter standing for System Quotient Unification in Rational Tendencies).* The initiates go into hibernation with a computer for three months and then emerge with a wall-chart emblazoned with something which looks like a cross between a drunken octopus and a map of London's Underground.

In brief, a dazed G.M. adds all the efficiency-aid departments suggested. When this is done he finds himself at the head of an empire which is twice the size it was before the Efficiency Consultants got at it. The G.M. is accordingly re-styled arch-comptroller; his erstwhile managers become comptrollers; section chiefs become managers and so on all down the line, with salaries increasing pro rata naturally.

The entire Company structure hums with new vigour. Everyone in the organization is hard at it from dawn to dusk answering internal memos and initiating their own quots. The whole outfit is now in a condition which has been aptly

* The latest from the U.S.A. is PRIDE—Personal Responsibility In Daily Effort.—Ed.

262 Wireless World, May 1966
described as self-oscillating, using paperwork coupling.

The Chairman can now listen with equanimity to any after-dinner politician, for his Company is now more than fulfilling the dictates of the economists and expanding like a soap bubble (if the simile is not too unfortunate).

Exports... well. The full benefits of expansion will naturally not be felt for a year or so and—purely as an interim measure, you understand—the prices of end products will have to increase somewhat; a moderate 50% perhaps? After all, these foreigners should be only too glad to pay for solid British workmanship allied to 21st-century efficiency.

MAY MEETINGS

Tickets are required for some meetings: readers should, therefore, communicate with the secretary of the society concerned

LONDON
2nd. I.E.E.—Colloquium on "Current topics in tropospheric propagation" at 2.30 at Savoy Pl., W.C.2.
9th. I.E.E.—Discussion on "An engineer's ideas on some of the electromagnetic fundamentals" at 5.30 at Savoy Pl., W.C.2.
11th. I.E.E.—"Holography" by Prof. D. Gabor at 6.00 at Savoy Pl., W.C.2.
13th. I.E.E.—Discussion on "The C.E.I., its implications on engineering courses" opened by Prof. M. G. Say at 5.30 at Savoy Pl., W.C.2.
23rd. I.E.E. & I.E.E.—Discussion on "Electrical aids to the handicapped" at 10 a.m. at Savoy Pl., W.C.2.

BIRMINGHAM
18th. Television Soc.—"Took 625 lines" by L. Marsland Gander at 7.30 at Broadcasting House, Carpenter Rd., Edgbaston.

FARNBOROUGH
10th. I.E.E.—"Long-wavelength laser generation" by L. E. Mathias at 6.30 at the Technical College, Boundary Rd.

MANCHESTER
10th. I.E.E.—Hunter Memorial Lecture "Lasers and associated devices" by Dr. G. G. MacFarlane at 6.15 at Renold Building, the College of Science and Technology.

Paisley
10th. I.E.E.—Discussion on "Computers and computing in electrical engineering courses" at 6.00 at the College of Technology.

PLYMOUTH
4th. Television Soc.—"Video tape for studio inserts" by Rex Firkin at 7.30 at the studios of Westward Television Ltd.

LATE APRIL MEETING

LONDON
26th. Soc. of Relay Engrs.—"The application of wideband transistor amplifiers to modern v.h.f. telephony networks" by R. J. Seacombe at 2.30 at the I.E.E., Savoy Pl., W.C.2.

WIRELESS WORLD, May 1966

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WW—12 FOR FURTHER DETAILS.
FLIGHT DATA RECORDING

DETAILS FROM THE AEROSPACE INSTRUMENTATION SYMPOSIUM AT CRANFIELD

Sponsored by the College of Aeronautics and the Instrument Society of America, the fourth international Aerospace Instrumentation Symposium held at the College at Cranfield, Beds, at the end of March, was the best attended yet. Well over 300 delegates were present from 10 countries and 31 papers were read.

Held in conjunction with the symposium was an exhibition of aerospace instrumentation equipment. Flight data recording equipment was well to the fore and exhibited on the stand of S. Davall and Sons Ltd., was the recorder retrieved from the crash of a Vanguard at London Airport last October. Apparently the recorder suffered an impact shock equivalent to a deceleration approaching 1000 g for 5 ms and during the subsequent fire it was subjected to a temperature of approximately 1600 °C. The recording wire however was unbroken and the data has been available for the investigation of the crash.

Details of some of the electronic equipment for the Concorde were also available. Elliott Bros. (London) Ltd. were showing the Elliott AIR-3, a high-density digital recorder accommodating 33 channels of 500 bit per inch information on one inch tape and designed by Elliott-Automation especially for the Concorde. Where necessary signals are converted from analogue to digital form and multiplexed. Information from about 300 points on the aircraft will be monitored, and in some cases the sampling rate will be five times per second. With flight recorders so much in the news it was interesting to note that a paper presented by J. J. Smith (Consolidated Electrodynamics Corporation) discussed the practical aspects of aerospace tape recorders. A point emphasized by the author was the effect of space environment on the performance of a recorder as compared to operation in laboratory conditions. An example given by the author was that where acceleration and vibration cause an increase in power consumption by the recorder due to high radial and thrust loads placed on rotating shafts. The increase in power is that drawn by the motor speed control system which ensures that adequate torque is provided to maintain the speed requirements. The solution was to orientate the drive motor so that the axis of its rotation was parallel with the axis of maximum mechanical energy input. Shock and vibration also introduce mechanical effects which cause flutter (instantaneous departure of the tape from a nominal speed) and dynamic skew (non uniform velocity of the tape across its width) and time displacement error (the integral of flutter). These errors have been minimized by the design of appropriate shock and vibration mounts which has been achieved by close co-operation of the shockmount designer, the recorder manufacturer and the ultimate user.

Looking towards the future, the author outlined new developments which would improve performance. Integrated circuits with its advantages of reduced weight and space and the ability to incorporate the integrated circuit amplifier in the tape head would make possible better signal-to-noise ratios and a high signal level. Higher longitudinal information packing density is expected and lateral density will depend on the number of tracks per inch. Present magnetic tape limited longitudinal packing where surface magnetization does not allow optimum use of the energy storage characteristic of the oxide, but new materials are expected to provide a higher figure with thinner coatings. Problems of lateral density are the need for shielding between adjacent tracks and the guiding of the tape between record and reproduce heads where small deviations are significant. At the moment 42 tracks per inch are available. The author also discussed the possibilities of incremental recorders, fast stop-start recorders which record only the data desired. These offer good possibilities where requirements of an aerospace data recording system are for discontinuous recording or flight editing. Their advantages over continuous recorders are obvious, but at the moment these recorders are limited to the recording of digital information where the requirements of flutter and speed accuracy needed for analogue information are not important factors.

THE MONTH’S CONFERENCES AND EXHIBITIONS

Further details are obtainable from the addresses in parentheses

LONDON
May 4-6 Communications Satellite Systems Conference (I.E.E.E., 345 East 47th St., New York, N.Y. 10017)
May 10-12 Electronic Components Conference (I.E.E.E., 345 East 47th St., New York, N.Y. 10017)

EASTBOURNE
May 3-5 Mechanical Handling Exhibition (Mechanical Handling, Dorset House, Stamford St., S.E.1)
May 15-19 K.T.R.A. Conference (Radio & Television Retailers’ Assoc., 19 Conway St., W.1)

SALFORD
May 3-5 Nuclear Energy Conference and Exhibition
May 5-6 Ultrasound in Medicine
May 7-8 Advanced Technology (Dr. Basil Brown, Dept. of Physics, Royal College of Advanced Technology, Salford, Lancs.)

OVERSEAS
Apr. 29-May 15 Stockholm
May 6-8 Oslo

Hanover Fair
(March 14-20)
In Memory of Sir William Crookes

Wireless World, May 1966
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to Edwards 983 at £100.
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- Consumption: 5 mA.
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A pulse-counting detector ensures absolute linearity and therefore better audio quality at the output stages. After equalisation the signal is channelled to one output for feeding to amplifier or recorder and to another in which the receiver's own audio amplifying stage enables the Micro FM to be used as an independent self-contained pocket portable. A.F.C. is used to lock the programme tuned in; the telescopic aerial included with the kit will be found sufficient for all but the worst signal areas.

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88 WIRELESS WORLD

MAY, 1966

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<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Features</th>
<th>Price per 1,000</th>
</tr>
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<tbody>
<tr>
<td>S5G</td>
<td>1 million op. 5 amp. c/o Sub-miniature Micro-switch.</td>
<td>2/3 each</td>
<td></td>
</tr>
<tr>
<td>VAQ</td>
<td>10 amp. c/o push button. Panel mounting. Buttons in six colours.</td>
<td>5/4 each per 500.</td>
<td></td>
</tr>
<tr>
<td>C-5</td>
<td>Low torque precision rotary switch.</td>
<td>5 amp. c/o. 1/2 milios. 6/3 each per 1,000.</td>
<td></td>
</tr>
<tr>
<td>VV-15-IA</td>
<td>15/10 amps. c/o. 100,000 ops.</td>
<td>1/8 each per 1,000.</td>
<td>Single throw 1/6 each.</td>
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<tr>
<td>WL 10 FCA2</td>
<td>10 amp. 2 circuit. Cased for use under rigorous conditions. Mechanical handling, machine tools, lift gear. Roller lever as illus.</td>
<td>As low as 41/1 each.</td>
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<tr>
<td>V-10-1B</td>
<td>1 million operations. 10 amp. c/o.</td>
<td></td>
<td>Screw terms 2/2 each per 1,000. V-10-1A solder tags 1/11 each per 1,000.</td>
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<tr>
<td>VV-5GW-1A44</td>
<td>Light force. 4 gms. Wire actuator. Designed for coin-operated mechanisms.</td>
<td></td>
<td>2/4 each per 1,000.</td>
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★ Attractive anodised aluminium front panel.

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(less legs) £11.17.6

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This acoustically designed enclosure measures 24 x 23 x 14 in., and houses a special 12in. bass speaker with 4in. speech coil, elliptical middle speaker together with a pressure unit to cover the full frequency range of 30-20,000 c/s. Its polar-distribution makes it ideal for really Hi-Fi Stereo. Delivered complete with speakers, cross-over unit, level control, grille cloth, etc. Left in the white for finish to personal taste, all parts are pre-cut and drilled for ease of assembly.

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- Vertical amplifier 2 c/s to 3 Mc/s.
- Modern professional styling.
- Vertical sensitivity 102 mV/cm.
- Compact size 5in. x 7in. x 12in.

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AM SIGNAL GENERATOR CT194
MARCONI TF581/B3/S

Frequency range: 12-450 Mhz, in 3 bands. Variable attenuation range from 0 dB to 1 with step of 10 dB. Crystal calibrator to 2 Mhz. Variable modulation depth. Carrier level and modulation meters optional. Automatic output level control. Full range tuning dial and auxiliary mechanical dial. Operating voltage: 120 volts, 1.0 A. Maximum output power: 150 watts, 0 to 100 dB attenuation. Weight: 64 lb. Offered in excellent condition, fully tested and guaranteed. £350.

MARCONI TF146G STANDARD SIGNAL GENERATOR

50 kHz-20 Mhz. Excellent output level from 0 dB to 1 watt. Internal sine wave modulation 100 kHz up to 250 kHz. Operation: 240-v-50/60 Hz A.C. Fully adjustable or regulated. £250.

PORTABLE OSCILLOSCOPE CT.52

A compact, 20/100 Mhz, 100 V. P.P. to 1000 V. P.P. on full scale, 20/40 Mhz, 100 V. P.P. to 1000 V. P.P. on full scale, 20/40 Mhz, 100 V. P.P. to 1000 V. P.P. on full scale. Operation: 240-v-50/60 Hz A.C. Fully adjustable. £270.

TE20R SIGNAL GENERATOR

Automatic wide range visual generator covering 120 kHz-500 Mhz. On 6 bands. Fully adjustable. £120.

GARRARD RECORD PLAYERS

BRAND NEW AND GUARANTEED

Shaker 'N Swing £150.00

LAMBERT MODEL 27 BEAT FREQUENCY GENERATOR

Frequency 0.25 to 20000 kHz on 10 ranges, Output 1000 MKS, 0.1% without modulator, 1% with modulator. £150.00. Supplied in perfect order £210.00. £220.00.

LELAND MODEL 37 F.M. AUDIO OSCILLATOR

High quality sound. American hardware. £150.00. $100.00. Operation: 200 kHz, 10% without modulator, 1% with modulator. £200.00. £240.00. Supplied in perfect order £310.00. £360.00.

REUTER TRACK TAPE HEADS

As used by Wilmot Co., Ltd. and others. £20.00. £25.00. Operation: 200 kHz, 10% without modulator, 1% with modulator. £25.00. £30.00. Operation: 200 kHz, 10% without modulator, 1% with modulator. £30.00. £35.00. Supplied in perfect order £40.00. £45.00.
Wilkinson's FOR RELAYS

P.O. TYPE 3000 AND 600
BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY
COMPETITIVE PRICES—VARIOUS CONTACTS
DUST PROVERS—QUOTATIONS BY RETURN

MINIATURE SEALED RELAYS
OVER 200 TYPES IN STOCK. SEND FOR LIST
SIEMENS 1 C.O. 1100V.

2,500 2,000 1,500 1,000 250 125 60 30 15 10 5
100 WIRELESS WORLD
MAY, 1966
WIRELESS WORLD

ULTRA VIOLET BULBS
Easy to use source of U.V. for dozens of practical and
edifying home applications. Use together with a small plug.
12 volt 36 watts A.C./D.C. S.B.C. 6/6 & P. & P. 1/6
12 volt 50 watts A.C./D.C. S.B.C. 10/6 & P. & P. 2/6
Suitable to the above. Input 200-240 v. A.C. 12 volt 36 watts
Set of 4 Colours FLUORESCENT PAINT.
Red, Green, Blue & Black. In a tin ideal for use with the above UV lamps. 9/6
plus 1/6 & P. & P.

MOING COIL HEADPHONES
Feniely soft chamis ear cushions. Superb reproduction. Use with Jeck plug. 21/6
P. & P. 2/6

SIEMENS SEALED HIGH SPEED RELAYS
H96A. 2.2.2 a.c. 250 m. 10 amp. 50 ohm. H96C. 150 m. 150 ohm. H96F. 1700 m. 1,700 ohm.
All at 1/6 each. P. & P. 2/6 on any order.

P.O. RELAYS. Type J300
100 ohms, 2 a.c. 2 make 1 break. 200 ohms. 4. 6. A. 100 ohms. 1 Henry. 500 ohms. 4. 6. A. 200 ohms.
All 1/6 each. P. & P. 5/16.

SOLENOID. Overall length 31mm, stroke 15mm. 3/4" UNC x 4 mm. A.C. operation.
D.C. resistant 35 ohms. Price 8/6 & P. & P. 1/6

G.E.C. SEALED RELAYS
M109 $0.70 100 ohms 1/2 amp. 200 ohms 1/4 amp. 4/60
M107 200 ohms 1/2 amp. 4/60
M109 600 ohms 1/4 amp. 1 amp. 1/6
M110 600 ohms. 1 amp. A new equipment.

14,000 OHM SEALED RELAY. High Speed single coil. Platinum contacts. Super-sensitive, ideal for
the above. Input 200-240 v. D.C. operation.
Price 10/6 & P. & P. 1/6

CARPENTER POLARISED RELAY. Type 129 TR 2 x 2,700 turns at 35 ohms. Including base 36/6 & P. & P. 1/6

12-8 Volt D.C. RELAY
16/6, plus 1/6 & P. & P.

"CABY" MULTI-RANGE TEST METER
Model 96B. D.C. volt 0.5 to 2.5 v., 10,000 ohm per volt. Needs transformer. Connect
A. C. and D.C. volt, 10 v., 25 v., 50 v., 50 ohm, 500 ohm, 5,000 ohm, 5000 ohm.
Sold alone with transformer.-Soldering iron, 24 v., 400 ohm. Complete with cases available
with new relay and complete for 6 volt or 12 volt operations. Price 25/6, plus 2/6 & P.

ORP. 1.5 A.M.S. MAINS MODEL
A.C. MAINS MODEL
Incorporates main transformer, rectifier and special output
II, 4.4.2, plus 2/6 & P. & P.

NEW LINE! PHOTO ELECTRIC COUNTER
Can be set for counts of up to 500 per minute. 1/2-250 v. A.C. powered. Kit of Components
including photo cell. High speed non-resettable counter. Transformer relay, etc., together
with clear circuit diagram. 31/2, plus 2/6 & P. & P.

Semi-automatic "Bug" Super M.S. HORSE HEAD. Key. Adjustable, precision tuned, speed adjustable 10 w.p.m. to 60 w.p.m.
with detachable handle. Weight 2lb. 6d. 1/26, post paid. (Illustrated)

TRANSISTOR ELECTRONIC KEYER. 230 v. A.C. or Battery operated. Incorporates built-in monitor Oscillator
Speaker, and Keying. Allows adjustable. Speeds, ranging either to auto., semiauto., or hold 4 modes. Cost £18/10/0-
plus 1/6 & P. & P.

TRAIS NiSTAIRIS Morse Oscillator
Fitted 211/min. Moving Coil Speaker. Uses type 9910 or 9920. For Q.R.R. keying. Complete with latest
Design Horse Head. Key. 21/2, plus 1/6 & P. & P. 1/6

130 v. A.C. RELAY. 2 c/o 2 amp. contacts. 7/6, new equip. P. & P. 1/6

HIGH SPEED BLOWER UNIT
200/250 c.f.m. Powerful, fan-supported motor. 11,000
and 13,000 R.P.M. 17/6, plus 2/6 & P.

AUTO TRANSPORTER
500 ohm, 250 ohm type £4/2/6 each. P. & P. 6/6. 1,600 watt type £5/3/6 each. P. & P. 7/6

UNIVERSAL DEMONSTRATION TRANSFORMERS
A complete variable apparatus, comprising a powerful
coils and core parts.with moveable coils and pole pieces.
Coil tapped for 220 v., 220 v., 115 v., 6, 110, 110 v.

AC. These coils are also used for D.C. experiments.
Complete with all accessories as shown. £17, plus 10/-
c. Leaflet on request.

PHOTO ELECTRIC STATIC GENERATORS £131/6/6, c/o. U.K. (6/6.10/-). Leaflet on request.

S.T.G. SILICON POWER RECTIFIERS RS10 Series. New. 1.5 amp. A.C. operated
RS310, 100 v. P. IV. 4/- RS350, 300 v. P. IV. 8/-
RS320, 200 v. P. IV. 6/- RS350, 400 v. P. IV. 10/-
RS380, 300 v. P. IV. 16/- RS380, 500 v. P. IV. 20/-
4 can be used to make a 3 amp. bridge. Not Seconds.
Brand New Stock. Past paid.

230 VOLT A.C. GEARED MOTOR.
Type RS40 & 500, 1.75 hp. 6/10 & P. & P. 3/6
Type RS80 & 100, 300 v. 5/6 & P. & P. 4/6
UNISELECTOR
8 bank, 25 way, all non-bridging. Twin coil, 350 ohm. Unused £32/6/6, P. & P. 1/6

NICKEL CADMIUM BATTERY. Sintered Cadmium Type 1, 7 1/2 AH. Size: 11 x 11 x 11/2. Weight approx. 13 ozs.
Lead Acid, tested. 12v. A.R.A.F. 2/6 & P. 2/6

LIGHT SENSITIVE SWITCHES Kit and parts including ORP.12. Cad.
Magnetic Switches, T.C. and Circuit. Now supplied
with new relay and complete for 6 volt or 12 volt operations. Price 25/-, plus 2/6 & P. & P.

ORP. 1.5 A.M.S. MAINS MODEL
A.C. MAINS MODEL
Incorporates main transformer, rectifier and special output
II, 4.4.2, plus 2/6 & P. & P.

NEW LINE! PHOTO ELECTRIC COUNTER
Can be set for counts of up to 500 per minute. 1/2-250 v. A.C. powered. Kit of Components
including photo cell. High speed non-resettable counter. Transformer relay, etc., together
with clear circuit diagram. 31/2, plus 2/6 & P. & P.

BUILD AN EFFICIENT STROKE UNIT FOR OWL 37/6." The latest design of lab or factory.
The wonderful device enables you to freeze motion and examine moving parts as it stands.
We supply a simple kit and completely suit it to all electrical parts including the NSP2 Stroke tube
which will enable you to easily construct a unit for infinite variety of speeds, from 1 flash
in several seconds to thousands per minute. 37/6, plus 3/- P. & P.

MINIATURE AMPLIFIER HEAD AND BREATHE SETS
Two such sets connected up will provide perfect interchange. No batteries required. Can
be used with any receiver. Complete. Will operate up to 3 miles. Price 17/6 each plus 2/6 & P. 3/- or 32/- per pair.

S.G. 600 Micro-amps fitted in a 13 cm. 6v. New 29/6 & P. 1/6

INSULATION TESTERS (NEW)
Test to I.E.E. spec. Rugged metal construction, ideal for home, field work, constant speed clutch.
Price 45/-, 6/-, 9/-, 15/-, 21/-, 30/-, 45/-, 60/-, 75/-, 90/-, 105/-, 120/-, 140/-, 150/-, 165/-, 180/-, 200/-, 250/-

SAGAMO WESTON Type 332
2/3 Edgeway Meter 550 Micro-amps fitted in 6v. New 29/6 & P. 1/6

ALL MAJOR ORDERS, ALSO CALLERS AT:
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Telephone: Kingston 4140
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MAIL ORDERS TO:
MANSION HOUSE LTD.
Terms: C.O.D. or C.O.R.
No C.O.D. under $1.00.
Extra under $5.00.
Trade supplied.
S.A.E. with order and phone personal
payers welcomed at any of the branches below.
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Tel.: (Half-day Wednesday) 47096.
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STAFF REQUIRED AT VARIOUS BRANCHES
Parker Post Town.

R.S.C. STEREO 20 HIGH FIDELITY AMPLIFIER
Providing 10/14 WATTS ULTRA LINEAR PUSH-OUT PUT ON EACH CHANNEL

- High quality 20 watt output
- Ultra low distortion
- Excellent frequency response
- Powerful bass response
- Clear, articulate treble response
- Accurate and faithful reproduction
- Solid state design
- Power supply regulated
- Built-in power meter
- Front panel control
- Stereo connectable

Price: $68.80

R.S.C. TRANSFORMERS

- Full wave, half wave, and split wave
- High quality transformers
- Precision windings
- Long life and durability

Price: $110.00

LOUDSPEAKERS

- Full range, midrange, and tweeter
- High sensitivity
- Wide frequency response
- Powerful bass response
- Clear, articulate treble response
- Accurate and faithful reproduction

Price: $100.00

R.S.C. STEREO/TEN HIGH QUALITY AMPLIFIER KIT

- High quality 12/14 watt output
- Ultra low distortion
- Excellent frequency response
- Powerful bass response
- Clear, articulate treble response
- Accurate and faithful reproduction

Price: $65.00

R.S.C. BATTERY CHARGERS & KITS

- High quality 12/24 volt battery chargers
- Built-in safety features
- Automatic voltage regulation
- Long life and durability

Price: $95.00

HEAVY DUTY CHARGER KIT 60V, 8 amps

- High quality 60 volt battery charger
- Built-in safety features
- Automatic voltage regulation
- Long life and durability

Price: $140.00

LATEST MAGNAXO 363 TAPE DECKS

- 3 speeds 15ips., 25ips., 75ips.
- High quality 15ips. tape recorder
- Built-in safety features
- Automatic voltage regulation
- Long life and durability

Price: $29.99
**FULLY TRANSISTORISED**

- **20-250 v A.C. Main Operations**
- **OUTPUT R.M.S. CONTINUOUS**
  - 10 WATTS into 8 Ohms
  - 15 WATTS into 4 Ohms
- **Max. Instantaneous Peak Power Output** 28 watts

**PRINTED CIRCUIT CONSTRUCTION**

**LATEST MULLARD TRANSISTORS**

**ADAPTS TO CONNECT**

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**SUGGESTIONS**

- *Mullard 6904, OC4, OC4+, OC84, OC114 (A total of nine)*

**5-POSITION INPUT SELECTOR SWITCH**

- Equalization to match M. E. M. and C. L. C. Requirements for Gram and Tape Heads

**FULL FACILITIES**

- **SENSITIVITIES:**<br>Crystal or Ceramic 7500 μV.<br>Magnetic 45 mV.<br>Tape Head 25 mV.<br>Radio/Aux. or Ceramic 150 μV.

**FREQUENCY RESPONSE:**<br>30-30,000 Hz.<br>TREBLE Control 10 d.B. to +10 d.B. at 10 Kc.<br>BASS Control 10 d.B. to -50 d.B. at 10 Kc.<br>HARMONIC DISTORTION AT 10 WATTS R.M.S. 1.000 c.p.s. 0.5%<br>**HUM LEVEL:**<br>75 d.B.

**NOMINAL FEEDBACK A.G.**

**AUDIONTRINE HI-FI LOUDSPEAKER ENCLOSURES.**

- All types are of pleasing “acoustical” design sonically dead and portable.
- Alternative finish of light oak or walnut.

**SEB.** Designed for optimum performance with any Hi-Fi amplifier. Size 6½ in. high, 4½ in. wide, 3½ deep. Dep. 1½ in. 4 wildly, price 15/3<br>(Total £6/8/6) Cure. 7½ 15/5/0

**HIGH PLATE Output Hi-Fi Loudspeaker with provision for tweeter.**<br>Recommended for use with Audiontrine HI-FI speaker. Size 2½ in. high, 6½ in. wide, 3½ deep. Dep. 2½ in. and tweeter. Price 36/9 19/9<br>(Total £7/9 17/10) Cure. 10/6 15/0

**SK14.** For outstanding performance with any 1½ in. Hi-Fi speaker but especially suitable for types with low transformer response. A complete cut-out is provided. Size 6½ in. high, 3½ in. wide, 17 in. deep. Price 25/10 30/9<br>(Total £7/10 17/10) Cure. 10/6 15/0

**SNIPERSCOPE**

**SUPER HIGH SPECIFICATION FLUORESCENT SCREEN**

**REVISING WATCH**

- **SPARES POWER PACK**
  - MAKER POWER PACK designed to operate trans- mitter sets and amplifiers. Adjustable output 1-5 V to 15 Vols for up to 50 ma. from 3 to working.<br>Take the place of any of the following batteries, 9V, 33, 75, 77, 79, 74, 76, and others.<br>Keeps batteries, mains transformer-operated, smoothing and load ratiors, 0.500 and 0.500 volts, sounder drivers and indicators. Read out at only 2V. 100 or 2V. 1000.

**SPEAKER BARGAIN**

- 12½ in. High fidelity loudspeaker. High efficiency permanent magnet type with either 6 or 10 ohm speaker coil<br>Handle up to 1500 watts. Blended base.<br>Price 2/6 plus post and insurance.

**ARMCHAIR CONTROL UNIT**

- Remote Controller.<br>For Philips, Hirst and others.<br>Easy to install, easy to handle. No package.<br>One makes a pair, two makes a pair, and so on.<br>Comprehensive list of models and comments.<br>Order No. 684 0.88 - 13 480

**R.S.C. SUPER HI-FI AMPLIFIER**

**R.S.C. SUPER SOFT STEREOMONITOR**

- INTRODUCING TWO COMPLETELY NEW UNITS WITH SIX SIMPLE CHANGES IMPOSSIBLE TO IMPAIR MORE THAN 5% WITH SIMILAR AMPLIFIERS OFFERED AT 2-3 TIMES THE COST.

**IMPORTANT NOTE.** Rated output figures are given I.F.H.F. otherwise we would quote much higher outputs.

**A Dual Channel Version of**

- **THE SUPER 15**
  - **Employing Twin Printed Circuits**
  - **Close Tolerance Gauged Pots**
  - **Matched Components**
  - **CROSSOVER 250 v A.C. at 1,000 c.p.s.**
  - **CONTROLS: 5 Position Input Selector, Bass and Treble Controls, Volume Control, Baffle Control, Stereo/Mono Switch, Tape Monitor Switch, Main Switch**

**FULLSPEAKERS**


**Universal**

- 18 1½ in. Speaker. Same as above, 12½ in. wide, 3½ in. high and deep.

**Attractive Fretia Plate and Matching Knob**

**NEON PANEL INDICATOR**

- Available complete for 18 1½ in. Speakers, complete and £10.00 each. Also available complete for 18 1½ in. Speakers, complete and £20.00 each.

**Audiophiles High Fidelity Speaker Systems.**

- Designed to provide a smooth frequency response from 60-000 c.p.s. measuring at 125w, 12000 line 16 sound elements. Compressor Cables and Twstr. Large recommendation with any High-Fidelity Amplifier.

- 12 Watt Model £3/19 6. Cure. 1/9 or Deposit 1/9 and balance paid at 110/30. Total £3/19 6. Cure. 5/5 10/0. Cure. 5/5 10/0.


**R.C.C. 1000 CHANNEL ENCODER (Acoustic Platform)**

- Designed for high performance, both multi channel and multi frequency. A complete plug in unit. Good output 00,01,002,000,002 and 002. Price 14/6 3/6 or £1 4/6, plus post and insurance. Also includes a copy of Stockbridge black book and manual for all our encoders and decoders.

**This Month's Sniperg**

**Garrard Auto Record Player Model 2000**

- One of the latest generation of the World's most experienced maker of fine disc playing turntables. In addition to the usual 1 inch (25 mm) diameter turntable, the Model 2000 features 2 inch (50 mm) diameter turntable for use in high fidelity systems. Its lightweight, high quality, precision and stability characteristics, are clearly demonstrated by its performance in the phonograph world. No other make of turntable can compare with the built-in amplifier of this model in terms of tuning table for maximum stability. It is recommended for all systems, including high fidelity, stereo and FM. It includes a full range of accessories, including a universal tonearm and a universal record changer. Price £15/5 0. Can also be supplied complete with a built-in amplifier and built-in record changer.

**Electronics (Croydon) Limited**

- 102/3 Tamworth Road, CROYDON, SURREY (Opp. West Croydon Station)

- 266 London Road, CROYDON, SURREY (Opp. ABC Cinema, West Croydon)

- Post orders to: Dept. WW, SPRINGFIELD ROAD, EASTBOURNE, SUSSEX

**W.W.-141 FOR FURTHER DETAILS**

**Transistor Bargain**

- With matching h.t. & r.f. transistors.
- Sh. 5 Stück, 10 Stück, 20 Stück, 50 Stück, 100 Stück oder 500 Stück, 1000 Stück oder 5000 Stück.

**Four-Station Intercom.**

With minimum noise and improved efficiency. Ideal for homes—office—shop—garages, etc.

- Complete complete comes with maker unit and three additional units of which each can be the master and have full two-way working. No wiring problems as a plug-in method is used for the working end of line and the other end by telephone. Also included in kit is a printed circuit board and a complete set of instructions for the two-way systems. Don't miss this fine radio offer.
PORTABLE OSCILLOSCOPE CT.51
A compact general-purpose instrument with many unusual features. Size: 8 in. high, 12 in. wide, 16 in. deep. Time base 0 to 10 sec. to 40 Kc/s. Y plate sensitivity 40 v per cm. Tube 2H. Frequency compensated amplifier to 30 dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Operates from A.C. mains 100-250 volts 50 c/s. Complete with all test leads, spare tubes, instruction book and circuit diagram. BRAND NEW. Tested and guaranteed. £22/10/-. Curr. 10/-.

CINTEL ELECTROLYTIC CAPACITANCE AND INCREMENTAL INDUCTION BRIDGE. No. 34601
A most valuable all solid-state, high-quality instrument, totally measures the capacity of electrolytic condensers from 0.1 to 1,000,000 pf under operating conditions. Leakage current and polarization voltages are separately metered. Inductances from 100 mH to 100 H can also be measured with currents up to 100 mA. A.C. mains supplied (100-250 volts). £109. WIDE RANGE CAPACITANCE BRIDGE. No. 1864.
A matching instrument to the above. All solid state. Mains operation. Measures from 0.002 pf to 1000 pf. Unused with handbook. £100.

HAMMARLUND SP-600-JX
20 valve dual conversion super receiver covering 540 k/c/s to 54 Mc/s in 6 bands. This is a professional quality receiver designed for broadcast station use. Rejects channel rejection 74 Mc/s down and spurious responses are at least 100 db down. Bandwidth from 200 c/s to 13 k/c/s. Crystal filter with crystal phasing control. Operates directly from A.C. mains 90-190 V, 50-60 c/s. Original cost £130. Supplied overhauled and in first class working order. £60. Fuller details on request.

PCR-3 RECEIVERS
These receivers are in as new condition. They have 3 wavebands with a frequency coverage of 150-570 metres, 7-3-7 Mc/s, 70-23 Mc/s, 4-7 Mc/s. A valve for X band speaker. Require external Power Supply or can be fitted with Internal Mains Power Supply for transformer output. Extra. Circuit supplied. Fully tested prior to dispatch. £8/15/-. Curr. £16/6/-. Vibrator Supply Unit for operation from 12 v. car battery for caramars or boats, 13/4 in. Carriage 7/6.

SIGNAL GENERATOR CT-28 (FM/AM)
MARCONI TF 437. Covers 155 Kc/s to 30 Mc/s in 5 switched ranges. Effective length of film scale is 50 ft. Output level variable in 1 db steps from 1 v to 100 mV (751). Also TV Output power down to 0.5 v from an outlet at 7.5 k. Int. mod. at 400 c/s, 1 Kc/s, 1.6 Kc/s and 3.3 Kc/s. FM frequencies above 390 Kc/s, -15 db. Variable mod. depth and deviation. Crystal calibrator 200 Kc/s and 2 Mc/s. Monitor speaker for beat detection. Fully transistorized, blower cooled, Panamonic. A.C. mains 100 to 150 and 200 to 250 volts. 45 to 100 c/s. 17 x 20/1 x 17in. Weight 17 lb. Fully tested and guaranteed. Under 1% of original price. £100.

AVOMETER MODEL 7
Complete with leather carrying case, leads and batteries ready for use. Fully guaranteed. £13/13/-. Post 7/6.

T.C.C. METALPACK CONDENSERS 0.1 mf. 500 v. D.C. wk. at 70°C. Brand new, polished and wrapped in original wrappings. £12/6. T.C.C. METALMITE 350, D.C. wk. 0.05 mf. (CP27N); 0.01 mf. (CP32N) all at 5/6 and 32/- per 100. T.C.C. METALMITE 350, D.C. wk. 0.5 mf. (CP37N); 0.05 mf. (CP35N); 0.01 mf. (CP32N) all at 5/6 and 12/- per 100. SCHRAGE METALISED CONDENSERS 0.01 mf. 1,000 v. D.C. wk. 5/6, or 32/- per 100.

STANDARD TRANSFORMERS
Vacuum impregnated, interleaved, E.S. grade, universal multi-range transformer. 0.05 mf. (CP35N); 0.01 mf. (CP32N) all at 5/6 and 32/- per 100. £15/16. BRAND NEW (boxed). 4/6 each. All post paid.

LOW CAPACITANCE BRIDGE MARCONI TF 1342. Range 0.002 pf. to 11111 pf. Accuracy 0.2%. Three terminal transformer transfer ratio arm bridge allows in situ measurement with mains frequency. 1,000 c/s, 12 x 17 x 18 in. Weight 152 lb. A.C. mains 220 to 250 and 100 to 150. 10/- over. With leads and handbook. ABSOLUTELY BRAND NEW. £50.
**VARIABLE VOLTAGE TRANSFORMERS**

**WORLD FAMOUS "SLIDE-TRANS" AVAILABLE ONLY FROM I.M.O.**

* Rated current consistent at all points along the winding

Output: 0-240 V. Input: 230 V. A.C. 50/60 c.p.s. Shrouded fully variable transformers for bench or panel mounting.

- 1 Amp. £4.10.0
- 2.5 Amp. £5.17.6
- 5 Amp. £9.0.0
- 10 Amp. £18.5.0
- 20 Amp. £32.10.0

Insert shows latest type brush Gear providing 1 volt variation.

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**PORTABLE TRANSISTOR TESTER**

Suitable for production & laboratory use

**SPECIFICATION:**
- Alphas 0.7 to 0.997
- Beta 5-300
- Supplied
- Price £32.10.0

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**PORTABLE TRANSISTOR TESTER**

Suitable for production & laboratory use

**SPECIFICATION:**
- Alphas 0.7 to 0.997
- Beta 5-300
- Supplied
- Price £32.10.0

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**AC/DC VALVE VOLTMETER**

**SPECIFICATION:**
- 11 megohms per volt
- 5 v. 1,500 V. D.C.
- 100 mV, 1,500 V. D.C.
- 0.1 ohm—1,000 Megohms
- 1 Kc Oscillator Test Source
- Complete with test probes

Price ONLY £35.0.0

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**DIELECTRIC BREAKDOWN TESTER**

**SPECIFICATION:**
- Range: infinitely variable up to 3,000 volts
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May, 1966

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<th>Amps</th>
<th>Price</th>
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Mfd. | D.C.V. | Price | Postage |
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MTA/3 1000 V. at 2 A.

DOUGLAS VOLTAGE METER

Input 100-120 V.
MTA/3 200 V. at 2 A.

DOUGLAS VOLTAGE METER

Input 100-120 V.
MTA/3 1000 V. at 2 A.

DOUGLAS POWER METER

Input 100-120 V.
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DOUGLAS VOLTAGE METER

Input 100-120 V.
MTA/3 200 V. at 2 A.

DOUGLAS VOLTAGE METER

Input 100-120 V.
MTA/3 1000 V. at 2 A.
## Transistors

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## Zener Diodes

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<td>1N5350</td>
<td>6.8V</td>
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## Germanium Point Contact Diodes

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<td>OA4</td>
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## Klystrons

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<tr>
<td>K5C1</td>
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<td>K5C2</td>
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## Counter Tubes

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<td>6C5</td>
<td>6V</td>
<td>100 mA</td>
<td>500 mA</td>
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(Please note that all salaries are given to applicants for the above positions will be considered for application to the appointment of Production Inspector)

ELECTRONICS: Service Engineer required to service the Naval Air Arm's Aircraft and Naval Equipment on Shore and at airfields, Domestic and overseas. Apply The Director, Navigation Co. Ltd., 109, Old Ford Road, Walthamstow, London E.7. Tel. Fordham 4099.

Applicants must hold a B.A. (First Class) in Mathematics and Mechanics with a good working knowledge of Flutter and Rectangular Coordination. A minimum of 4 years' experience in the field of electronics or electrical engineering is required. A full-time position is available with a good salary and prospects for advancement.

APPLICATIONS

Write to: Head of Technical Department, The Director, Navigation Co. Ltd., 109, Old Ford Road, Walthamstow, London E.7. Applications should be made to the above address before the 30th June 1946.

PENNSYLVANIA

A well-known American Company based in the Pennsylvania area of America, at present engaged in the design, development and application of Semi-Conductor devices,

require

Qualified engineers experienced in Semi-Conductor work to join the company. Top salaries will be paid to the successful applicants, plus an excellent relocation allowance including fares for their families.

APPLY IN THE FIRST INSTANCE TO:

TEMTECH AGENCY LIMITED

7, Southampton Place, London, W.C.I.

Telephone HOLborn 7033

FOR SALE

CANDIDATE FOR A SENIOR ELECTRONIC ENGINEER POST

Please refer to a candidate for a Senior Electronic Engineer Post who is currently engaged in a Senior Development Manager capacity with a large, well-known American Company. Our client offers excellent prospects for an individual with enthusiasm and initiative of a high standard. The candidate possesses a reputation as a first-class electronic engineer, and has worked with all known electronic devices before, including Tube, Triode and Transistor. He is well versed in the principles of electronic development, and is capable of handling a Wide range of duties, including the supervision of experimental work. He is available immediately.

CANDIDATE FOR A SENIOR ELECTRONIC ENGINEER POST

Please refer to a candidate for a Senior Electronic Engineer Post who is currently engaged in a Senior Development Manager capacity with a large, well-known American Company. Our client offers excellent prospects for an individual with enthusiasm and initiative of a high standard. The candidate possesses a reputation as a first-class electronic engineer, and has worked with all known electronic devices before, including Tube, Triode and Transistor. He is well versed in the principles of electronic development, and is capable of handling a Wide range of duties, including the supervision of experimental work. He is available immediately.

CANDIDATE FOR A SENIOR ELECTRONIC ENGINEER POST

Please refer to a candidate for a Senior Electronic Engineer Post who is currently engaged in a Senior Development Manager capacity with a large, well-known American Company. Our client offers excellent prospects for an individual with enthusiasm and initiative of a high standard. The candidate possesses a reputation as a first-class electronic engineer, and has worked with all known electronic devices before, including Tube, Triode and Transistor. He is well versed in the principles of electronic development, and is capable of handling a Wide range of duties, including the supervision of experimental work. He is available immediately.
POST OFFICE
EXECUTIVE ENGINEERS

Forty-five posts in London and Provinces for mechanical, electrical and electronic engineers to develop and design communications systems and postal service equipment.

QUALIFICATIONS: Degree or Dip. Tech. in Mechanical or Electrical Engineering, Physics, or Applied Physics or, exceptionally, very high professional attainment. Final year students may apply.


ELECTRICAL AND MECHANICAL ENGINEERS

For design and installation of Heating, Ventilating and other building services urgently required by Ministry of Public Building and Works to fill 30 posts in London and the provinces. The work is varied and will provide experience in latest techniques. A further 150 vacancies for Electrical and Mechanical Engineers exist in other Government Departments.

QUALIFICATIONS: Degree or Dip. Tech. with 1st or 2nd class honours, or have passed all examinations for A.M.I.E.E., A.M.I.Mech.E., A.M.I.E.R.E., A.M.I. Prod.E., or A.F.R.Ae.S.


ENGINEERING DRAUGHTSMEN

Vacancies in Ministry of Public Building and Works, Ministry of Defence, Post Office, and in other Departments for Engineering Draughtsmen in the fields of MECHANICAL, ELECTRICAL, and HEATING AND VENTILATING ENGINEERING.

QUALIFICATIONS: O.N.C. (or equivalent) in appropriate subject, three years’ training and, in addition, at least one year’s drawing office experience.

SALARY (Inner London): £718 (at 20)—£1,108 (at 28 or over)—£1,209. Salary under review. Annual leave allowance 3 weeks and 3 days rising to 6 weeks.

AGE: At least 20. Promotion prospects. Where appropriate, time off for further technical study may be given. (Reference: S/60).

The above posts are pensionable and APPLICATION FORMS are obtainable from the Secretary, Civil Service Commission, Savile Row, London, W.1. Please quote appropriate reference.
STAVELEY-SMITH CONTROLS LIMITED

TECHNICAL ASSISTANTS

Vacancies exist for technical assistants to assist Engineers to cover day-to-day handling of a wide range of radio, electronic and electrical control gear. Applicants must have a good and wide experience in handling and organizing installations, testing and servicing in the field, control of reports, spaces demands and supplies. Residence must be in Manchester.

SERVICE ENGINEERS

Our Service Division has vacancies for both marine and industrial Service Engineers, particularly in London, Birmingham, Manchester, Tyne/Tees and Medway areas. Applicants should either be ex-serving Radio Officers or industrial electronic service men. Ex naval Chiefs, Petty Officers and Radio Mechanics welcomed, also industrial Instrument mechanics.

Applicants for the above posts must be willing to travel, be of British birth and hold a clean driving licence.

Apply to above at Shipley Industrial Trading Estate, Audenshaw, Manchester.

HOPECRAFT electronics are different. Join a com- pany with a record of success in the founding of a new venture. Good pay and a generous bonus scheme. Apply in complete confidence to Sidney Ryan, Engineering Co., Ltd., 2, Queen St., Dover, Kent. [146]

RADIO Engineers, Junior Electrical Engineers required to join internationally known organisation, recently incorporated in the U.K. and there are at least 10 vacancies to go. Applicants must be either 32 or under and prepared to spend periods of up to 2 years abroad. Qualifications: G.H.C. or equivalent of first class in relevant radio mechanics. Box W.W. 146, Wireless World.

RADIO and radar technicians required for the operation, repair and development of airborne and ground equipment. A British company in North West England seeks Senior and Junior Engineers. Single status accommodates. Apply Short Brothers and Harland Ltd., A.R.E., Lansdown, Merthyr. [146]

TELECOMMUNICATIONS TECHNOLOGISTS required by the Government to fill a contract for one year, with 6 months at the first instance. Commencing salary according to experience in scales inclusive Overseas Additional indicated below. A supplement of at least £200 a year is also provided. Salaries will be based on the local rates, subject to a 10% saving in London. Liberal leave on full salary or annual vacation. A minimum of 50% of overseas duties may be involved. Experience in the following is advantageous: High Level Linking; Transistor; Electronic上榜, Transistor. Incentives: Overseas experience. Ref. a91, W.W.

Candidates must have had at least 5 years training and experience in one or more of the following branches of telecommunication equipment: Transmission, Protection, Switching, Control, or Automatic Wiring (including Overseas experience) and either a Certificate of Efficiency or an equivalent qualification. A knowledge of external telephone distribution systems and the practical design of power feeders and aerials would be advantageous. Experience of designing and installing overseas telephone exchanges and equipment would be advantageous. Age limits 30-40, 45. Ref. 62/71, Wireless World.

Salary: £200-£240 a year. Apply to Crown Agents, M. Dept., 4 Millbank, London. For application form and further particulars, stating name, age, brief details of qualifications, and experience, and quoting the relevant reference. [T5]

TELECOMMUNICATIONS ENGINEERS

CAMBRIDGE WORKS LIMITED have vacancies in their expanding Test Organisation for men with experience of VHF Transmitters and Receivers.

Men with Service training in VHF equipment would be suitable.

Progressive rates of pay and promotion and good facilities for training are offered.

Apply: Personnel Manager, Cambridge Works Limited, Haig Road, Cambridge.

WIRELESS WORLD MAY, 1966

RADIO ENGINEERS—Junior electronics engineers required by internationally known organisation, candidates must be single, medically fit and prepared to spend periods of up to 2 years abroad. Qualifications: G.H.C. or experience as first-class radio mechanic. Box 1475, c/o Wireless World.

PRINTED CIRCUIT TECHNICIANS, Devon.—Westward Circuits Limited have vacancies for an experienced Printed Circuit Technician and for Printed Circuit Operators, good pay and prospects offered to suitable applicants who should write on typewriting.—Westward Circuits Limited, Okefdy St., Mary Devon, Tel. 495 1747.

THE UNIVERSITY OF LIVERPOOL. A special technician is required to be responsible for the post-doctoral research work in the field of microwave physics. The minimum qualification is a B.A. in Physics (with experimental work) or M.Sc. in Physics (including experimental work) or an equivalent qualification. Salary £650 p.a. F.R.S. Fellowship or equivalent qualification and experience are desirable. Applications should be sent to the Registrar, School of Science, Liverpool, 1473.

Please apply to the Personnel Manager, Mr. G. J. Sharyke, RADIOMOBILE LIMITED.

Goodwood Works, North Circular Road, N.W.2

Telephone GLAdstone 0171 Ext. 129

A SUBSIDIARY OF S. SMITHS INDUSTRIES LIMITED

RADIO MOBILE

BRITAIN'S CAR RADIO SPECIALISTS

Urgently seek to interview:

RADIO SERVICE ENGINEERS

Due to continued expansion it is now desirable that we should increase our technical staff, and opportunities for advancement are readily available for men with the right experience and ability.

We are able to offer highly competitive rates of pay, with excellent conditions of employment, which include Superannuation and Life Insurance Schemes.

Please apply to the Personnel Manager, Mr. G. J. Sharyke, RADIOMOBILE LIMITED, Goodwood Works, North Circular Road, N.W.2.
Instrumentation Technicians and Mechanics

If you are a Technician or Mechanic we invite YOU to apply for one of the several vacancies in our Commissioning or Laboratory Section.

What do we want?
You must have experience in the operation and/or commissioning of some of the following systems

(a) RELAY CIRCUITS, MAGNETIC AMPLIFIERS, NUCLEONIC INSTRUMENTS, PRESSURE TRANSDUCERS WITH ELECTRICAL OUTPUT, HEALTH PHYSICS INSTRUMENTS
or (b) FLOW MEASUREMENT, TEMPERATURE MEASUREMENTS, CONTROL VALVES, PNEUMATIC AND HYDRAULIC CONTROL SYSTEMS

What qualifications must you have?
(a) H.N.C. ELECTRICAL OR MECHANICAL
(b) O.N.C. ELECTRICAL OR MECHANICAL
(c) TRADE APPRENTICESHIP

What can we offer?

(1) FOR APPLICANTS WITH H.N.C. AND CONSIDERABLE EXPERIENCE, TECHNICIAN GRADE I
(2) FOR APPLICANTS WITH H.N.C. AND LIMITED EXPERIENCE OR O.N.C. AND CONSIDERABLE EXPERIENCE, TECHNICIANS GRADE II
(3) IF YOU HAVE SERVED AN APPRENTICESHIP AND HAVE SOME EXPERIENCE IN INSTRUMENTATION WE WILL OFFER TO SUCCESSFUL APPLICANTS THE POST OF MECHANIC, AN HOURLY PAID JOB WITH GOOD PROMOTION PROSPECTS TO TECHNICIAN GRADE

The successful staff applicants will be required to participate in our superannuation scheme and will be given assistance with removal expenses in appropriate cases.

All applications to be addressed to the Personnel Officer, quoting reference IT/1

CAMMELL LAIRD
& Co (Shipbuilders & Engineers) Ltd - Birkenhead
**RACAL**

**Need a technical author**

Racal Instruments Limited have a vacancy for a Technical author to prepare handbooks for their new range of Digital Measuring Instruments. Candidates should have some experience in electronic training; some experience in the application of logical techniques would be an advantage. Consideration will be given to engineers who have a desire to enter this field but have not had previous experience as Technical Authors. The work calls for personal initiative. The successful applicant will be based in the Reading area.

**And a technical publications writer**

To work on a range of publications dealing with HF Communications Systems and Digital Instrumentation. Ideally, candidates will have had a basic training in Electronics, or at least a background knowledge and be willing in the first instance to generally assist in the production of Commercial Technical Publications. A good educational level including 'O' or 'A' at English is essential. Candidates need not have had previous experience in this type of work and will be assisted and encouraged by experienced writers. This is an opportunity to train for a worthwhile and interesting profession.

Attractive conditions of employment are offered including entrance to the Company’s Superannuation Scheme, etc. Applications in writing, enclosing full personal details to:-

Personnel Manager
Racal Electronics Ltd.
Western Road, Bracknell,
Berkshire

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**TELECOMMUNICATIONS SUPERINTENDENT**

Required by NIGERIAN RAILWAY CORPORATION on contract for two tours, each of 18 months in first instance. Salary £2,475 gross a year. Gratuity at rate of 20% of total salary drawn. Quarters provided at moderate rental. Free passages. Liberal leave.

Candidates must be experienced telecommunications engineers possessing a recognised University Degree/Diploma, or be A.M.I.E.E. or A.M.I.E.R.E. P.M.G. Certificate desirable but not essential. They should have sound experience of railway telecommunication systems, and be capable of advising the Corporation on problems arising during the installation of a complex telecommunications system. Possibility of secondment will be considered for successful applicant.

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 M2R/62781/W.

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**ELECTRONIC ENGINEERS**

Service Engineers required for London Area and Provincial Offices of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic electronics with experience in the repair and servicing of small electronic instruments. Possession of a recognised trade qualification would be an advantage. Position is permanent and pensionable. Comprehensive training on full establishment will be given to successful applicants. Please send full details of experience to:

Service Manager,
SUMLOCK COMPTOMETER LTD.,
102/108 Clerkwell Road,
London, E.C.I.
Commissioning Organisation

SENIOR WEAPONS ENGINEER

An experienced electronic engineer with administrative ability is required to control the weapons section of our machinery test organisation.

Likely background would be that of a commissioning engineer on radar, radio and/or sonar equipment with some control over other engineers.

Salary will be commensurate with qualifications and experience. The successful applicant will be required to participate in our superannuation scheme. Assistance in appropriate cases will be given with removal expenses.

Applications initially to the Personnel Officer

CAMMELL LAIRD & CO (Shipbuilders & Engineers) LTD
BIRKENHEAD

Electronics Technicians

The Job
Servicing a wide range of high quality electronic instruments - oscilloscopes, digital and valve voltmeters, power supplies, pulse generators, etc. Location will be at Farnborough, in one of the most modern and attractively situated companies in South East England.

The Men
Radio and T.V. service engineers; technicians leaving the armed forces; men with industrial experience. The real requirement is a good knowledge of electronics and experience in fault diagnosis and rectification, preferably backed up by a sound technical training (City & Guilds Telecommunications for example).

The Benefits
Good pay; first-class fringe benefits; up-to-date workshops, superbly equipped; on-the-job training; day-release for suitable candidates; prospects of career advancement and broader industrial experience within the Company; security; companionable working atmosphere; assistance for people willing to move into the area.

The Right Thing
to do now is to get yourself an interview; talk to the people in our Service Department, and find out for yourself the advantages of linking your future to SOLARTRON. Write a descriptive letter to:

C. S. J. Mardell, Personnel Officer,
THE SOLARTRON ELECTRONIC GROUP LTD.,
Victoria Road, Farnborough, Hants.
TECHNICAL CLASS VACANCY AT R.A.F. CHESSINGTON

The Ministry of Defence (Air Force Department) has a vacancy for a Civilian Technical Class Grade III, officer at No. 248 Maintenance Unit, Royal Air Force Chessington.

Duties
The review of serviceable stocks of medical electronic equipment held at R.A.F. Chessington and testing before issue, the small scale production of locally-developed equipment, and the servicing and repair of equipment at hospitals and other medical establishments.

Qualifications
Applications must be British subjects. They should have served an apprenticeship, and hold the ONC or an equivalent qualification, but applicants with substantial experience in the electronics field with technical knowledge up to ONC standard will be considered.

Pay
£796 at age 21 increasing by annual increments to a maximum of £1,129. Age 28 and over start at £1,000. These rates are under review.

Prospects for Pension
Established appointment (for pension and gratuity) can be obtained by passing Civil Service Commission Open Competition once the ONC or an equivalent certificate is held.

Studies for ONC, HNC, etc.
Encouraged by release from work one day a week and by payment of fees, etc., by Department.

Holidays, Sickness, etc.
Five day week, Annual leave three weeks, three days at start increasing to six weeks. Sick leave benefit.

Selection is by interview at Chessington.

Application forms from:
Officer Commanding,
No. 248 Maintenance Unit,
Royal Air Force Chessington,
Chesington,
Surrey.

BERRY'S RADIO

Require
TECHNICAL STAFF, ENGINEERS AND SALES ASSISTANTS

GOOD PROSPECTS, PERMANENCY

Write giving full details of experience, past situations, etc., in confidence to:
25 HIGH HOLBORN, LONDON, W.C.1

LANCASHIRE CONSTABULARY

WANTED RADIO TECHNICIANS

The Lancashire Constabulary has vacancies for Radio Technicians in the Wireless Workshops at Hutton, Preston.

Candidates should have a sound fundamental knowledge and practical experience of Frequency Modulated V.H.F. Radio Telecommunications Engineering. Salary, £220 per annum at 21, rising by eight annual increments to a present top rate of £1,104 per annum; subject to an efficiency bar at age 25.

Lancashire County Council Contributory Superannuation Scheme applies.

Application forms and Conditions of Service from The Chief Constable, P.O. Box 77, Lancashire Constabulary, Preston.

Science Research Council

RADIO AND SPACE RESEARCH STATION

Ditton Park, Slough

Physicists, Electrical Engineers and Mathematicians required for the following posts:

1. Senior Scientific Officers/Scientific Officers for work on:
   - The propagation of radio waves through the ionosphere and troposphere.
   - Study of the upper atmosphere and ionosphere with apparatus in rockets and satellites.
   - The use of an 80 ft radio telescope in the study of radio waves and their travel through the ionosphere and troposphere. The engineering development of specialized apparatus for use in these investigations.

2. Experimental Officers/Assistant Experimental Officers to assist the scientific staff in design and development of apparatus, in experiments and analysing results. Background in physics, electrical engineering or applied mathematics necessary.

Salary and conditions:
S.O./B.O. 1st or 2nd Class Honours Degree (or equivalent) in appropriate subject plus (or A.E.O./B.O.) at least three years postgraduate experience, A.E.O./B.O. Suitable Degree, H.N.C. (or equivalent), or if under age 25, two G.C.S.E. A levels in scientific subjects.

Send full details to:
The Secretary, S.R.C. Radio and Space Research Station, Ditton Park, Slough, Slough.

ELECTRONICS TEST ENGINEER

An opportunity has arisen for a capable man to fill a vacancy concerned with the testing of electronic instruments and sub-assemblies in our modern scientific instrument factory in Cambridge. Experience of electronic fault-finding, inspection and testing OR radio and television servicing is desirable. Technical qualifications at an intermediate level would be an advantage.

This appointment will carry staff status and an attractive rate of pay.

Please apply in confidence to:
The Personnel Manager, Unicam Instruments Ltd., York Street, Cambridge.
Telephone: 61631.
Vacancies in Cambridge

Considerable expansion of our Radio Communications Division is planned and immediate vacancies exist for the following technical staff—


2. Engineer familiar with micro-miniaturisation techniques.


4. Six advanced Test Engineers and fault finders for work on sophisticated apparatus.

Really attractive salaries with ample opportunity for advancement will be offered to selected applicants. Send details of your qualifications, background and experience, which will be treated in confidence, to:

Personnel Manager, Labgear Limited, Cromwell Road, Cambridge.

The Personnel Officer, Central Personnel Department, The Rank Organisation Limited, 439-445 Godstone Road, Whyteleafe, Surrey.

ARTICLES FOR SALE

2 Trouble sifters. 20 tape machines. 2 track stereos. £55 each. Send conditions. Offered—Box 1896, Wireless World.


Disc cutter with power amplifier, equalizer amplifier, bell, mains unit, pick-up and power transformer, speaker, socket, several tubes, etc., on sale. £150. £250. Offered details below. Use recordings. S. 582. 18670.

AMEX series 400 professional recording type 117w. £245. 1000ft. plastic reel. Complete with power, brands, new in modern cases, model 4100 £95. limited quantity available at 97. per box 400 ft. £30 per box. £50. Offered to:-


FOR sale—1961 Decca Radar Automatic, Type 215, complete, several months considered, display unit, motor, avoid controller, hoist, valves, tubes, etc., of fine condition, £250. Offered Type 215R, cover for radar mast winch. Full particulars and prices for voting an application to County Suppliers Office, County Supplies Department, Edmund Road, Ashford, Kent, to whom offers must be returned on or before 31st May, 1966. 13179

ELECTRONIC Voltmeter and Ohmmeter (Electronic Instruments) Ltd., 1187-1189, Upper Walthamstow, London. Megger, Generator Type 63, Serial 41, £120. Test Bridges, 50 and 200, £125. 1961. 17474

Super-K Headphones Stereophonic, ParmeCar Gain Limiter-Tester, with level indicators, quantity six dielectric trimmers, resistors, capacitors, semi-conductors, Property of prepaid electronic engineer. Reasonable prices accepted. Apply J. W. Butler, Stannah Arms, Westernham, Kent. Tel. YK 550. 14747

HIGH quality professional recording and reproducing equipment comprises: Quad 25 stereo pre-amplifier with two Quad main amplifiers, Quad FM radio unit, Vortex 800 two-way monitor, Haise microphones and Garrard transcription turntable. Also four-track 1200 series tape recorder, equipment contained in small case, complete. £25-£45. Also amplifiers. Price 350 each. Need two. Two Sealed brochures complete with Ben Tannin dual-concentric speakers. Price £20. Quotations 10 a.m.—4 p.m. Western 2253 or write R. Fyke, 50, Morpeth Court, Nether Rd., London, W. 12. 13497

SYSTEMS TEST ENGINEERS

TEL. ELEKTRONICS LTD.

NEWMARKET ROAD, CAMBRIDGE

require Systems Test Engineers for testing complete electronic switching systems.

Applicants should have some experience in the field of transistor switching techniques.

Successful applicants can expect to receive a salary in accordance with their experience and qualifications.

Apply to:

THE PERSONNEL MANAGER,

TELEPHONE:

CAMBRIDGE 61222
TEST ENGINEERS

Due to Company expansion, The Decca Navigator Company Limited wishes to recruit the services of Test Engineers for the testing of Radio Navigation and Survey Equipment.

We are world leaders in this field and have an extensive and interesting programme planned for the future.

Applicants with a first-class background of T.V. and Radio Servicing or Telecommunication Electronic and Control Circuiting are required. The salary paid will be commensurate with ability and experience.

Please apply for interview giving brief details of experience, qualifications and present salary to:


BOROUGH POLYTECHNIC

Borough Road, London, S.E.I.

Applications are invited for the post of:

HEAD OF THE DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

which will become vacant on the 1st September, 1966.

The work of the Department includes a well-established Honours Degree course (C.N.A.A.) full-time and part-time courses in preparation for the Part III Examinations of the Institution of Electrical Engineers and a wide range of special courses of post-graduate standard.

The whole of the Department is to be rehoused in a new building, on which work has recently commenced.

Candidates should possess high academic and professional qualifications in Electrical Engineering and have held a senior teaching post in this subject. Responsible research, industrial or administrative experience would be an added qualification.

Further particulars and Application Form obtainable from the Clerk to the Governing Body, to whom completed applications should be returned within two weeks of receipt, but in any case not later than the 10th May, 1966.

29th March, 1966.

ARTICLES WANTED

WANTED, TV camera, any type.—Weston, 11.

GARRARD magnetite tape decks, please send details to Showaddy Unternehmen Co., Ltd., 50 Green Rd., Dover, Kent. (Ref. 1468)


TAPE RECORDING ETC.

Saul an old 16-Mc S.C. audio supply盒子 (address, No. 113). [109]

TAPE to disc transfer using latest feedback disc lathe; FPs from £1/7/-, large & small.—Derry, 52, New Bank Lane, Lancaster. [104]

Valve sought to send for a copy of "Psychology and Whipped Testings" to 3, York House, Huddersfield.—£1/3/- tape reel. [113]

A UNIQUE Tape Box! Top brand, type 3, £2/1/0. 9" (1/2"), £1/6/-; 7" (£2/6/-).—Trinity, 1/2" tape reel. [111]

UNUSUAL Tape Box!! Top brand, type 3, £2/2/0. 10", £1/6/-; £1/6/-; £1/1/0. 7" (£2/6/-).—E. C. Ritchie, Ltd., 35A, Victoria Court Rd., London W.I. Bournemouth 6500. [113]

TAPE/RECORDING transfer editing, duplicating: if reasonable finals and durability matter (especially with 144 lines from your present tape), complete Britain's only transfer servicing.—Fund raising record publishers for schools, musical societies (tax free) —Silvertone Wireless World, 15, Church Rd., Wolverhampton. [110]

STC INSPECTORS AND TESTERS

Owing to continued production expansion within our Radio Division we urgently require Male Inspectors and Testers. There are vacancies on day work and a night-shift is being started to cope with the additional load.

Applicants must have had at least two years' broad experience of inspection or fault finding work on assembled and wired electronic units used in the Radio Communication and Aircraft Navigational Aids field or alternatively some years experience of Radio and Television servicing.

Good rates will be paid to suitable applicants who will also enjoy an excellent variety of welfare amenities, including a sickness, accident benefit and pension scheme.

Write or telephone the Male Employment Officer, ENT/price 1234, Extension 437, or call at the Personnel Department,

Standard Telephones and Cables Limited

Oakleigh Road, New Southgate, London, N.11, between the hours of 9-11 a.m. or 2-3.30 p.m. Monday to Friday.
MEASUREMENTS and COMMUNICATIONS SECTION

A vacancy exists in the Measurements and Communications Section of the Sub-Area Engineer’s Department for a craftsman who has a sound knowledge of basic Electronics and preferably experience in V.H.F./U.H.F. radio-telephone installation and maintenance. The successful applicant will be based at Leighton Buzzard, Bedfordshire.

Salary is in accordance with the National Joint Industrial Council Agreement, Group “C,” and a stagger pattern of working is in operation for which an additional payment will be made.

Basic rate of pay: £16 11s. 9d. per week including incidental overtime allowance.

Plus 10s. 6d. per week productivity bonus.

Plus £1 10s. 6d. per week stagger payment.

Total pay £18 12s. 3d.

Also an additional 7/8d. per week will be paid after two years’ service and a further 7/8d. per week after three years’ service.

Applications should be made in writing, stating age, experience and present position to the Manager, Chilterns Sub-Area, Eastern Electricity, Prebend Street, Bedford, as soon as possible.

COMMUNICATION

networks operated and maintained by International Aeradio are constantly increasing in complexity and demand and new commitments appearing. Immediate posts are available for

ENGINEERS

and technicians capable of carrying out installation and maintenance services on airports, in radio maintenance units and communication networks. If you are interested in taking up a progressive interesting career

OVERSEAS

living in free furnished accommodation with tax free salaries, married and family allowances, generous U.K. leave, air travel concessions and pension at 55, apply to

INTERNATIONAL AERADIO LIMITED

Applications must have sound practical experience of HF and VHF communications and preferably at least Intermediate C. & G. qualifications.

Applications are also invited from technicians with an electronic background who are prepared to undertake intensive conversion training at our own training school at Southall, the first course commencing mid April.

Write with details of age, qualifications, experience and family status to Personnel Manager, International Aeradio Limited, Hayett Road, Southall, Middlesex.

Philips Technical Library


W. A. M. Hartwich

Deals with the three-colour theory and with the transmission technique from the camera up to the complete transmitter signal, and describes the restoring and the reproduction of the colour information in the receiver. Based on N.T.S.C. but main principles apply to other systems.

216 pages. 164 illustrations. 14 colour illustrations. 50s.

COLOUR TELEVISION EXPLAINED, Second Edit.

W. A. Holm

A popular book in which Dr. Holm uses the same pictorial methods that made How Television Works so successful. It explains with many line and colour diagrams the fundamental features common to all the various systems.

118 pages. 68 illustrations. 21s.

FROM MICROPHONE TO EAR, Fourth Edition.

G. Slot

A widely appreciated survey of the technique of sound recording and reproduction—from microphone to loudspeaker. This is a practical book, prompted by queries that reached the author from all parts of the world not only from sound technicians but also from music-lovers without technical training.

200 pages. 144 illustrations. 27s. 6d.

APPLIED MAGNETISM

—A Study in Quantities.

Eigel Olsen

A general introduction to applied magnetism based on the fundamental terms and definitions necessary in the various branches of alternating current technique.

144 pages. 79 illustrations. 42s.

MACMILLAN

Little Essex St., London, W.C. 2
Free lance and full times Sales Engineers are required by this expanding company specialising in Industrial Electronics. Applicants should have a good broad knowledge of industrial techniques and a proven sales record.

Apply to the Sales Director,
Anglia Instruments Ltd.,
61, Union Street, Stockport, Cheshire.

HAMILTERE
HAMBURGER PATTERN BRUSH PATE
The pattern is in the list. All prices are for the 10 oz. jar. 

COLOURS: Blue, Silver, Black or Brown.

10 oz. jar: 1 gallon 15/- 3 gallons 35/- 9 gallons 85/-
1 pint 10/- 1 gallon 35/-

Orders for prices. All orders are subject to a 10% discounts and packing

MALVYN ENGINEERING WORKS
Designers to the Radio and Electronic Industries
12 Sheriff Street, Hereford, Herefordshire.

TELEPHONE: HERTFORD 3164
Bib ACCESSORIES

NEW Bib INSTRUMENT CLEANER is anti-static

Surfaces stay clean longer, because they do not become statically charged and attract dust.

Specially formulated for cleaning tape heads, delicate instrument panels, plastic, chrome, glass, printed surfaces and the exterior of all kinds of electronic equipment.

non-flammable and does not smell.

Size A

4/6 (subject)

THE PROFESSIONAL TAPE SPlicer

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