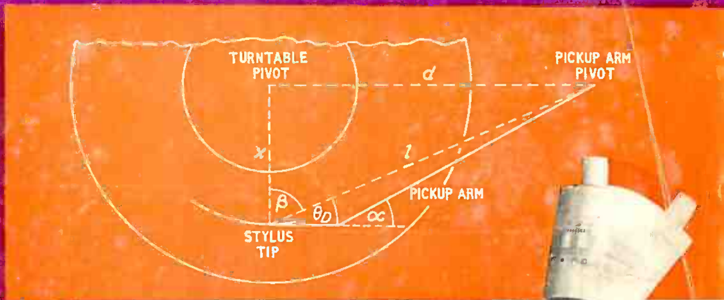
MAY 1966

Three Shillings

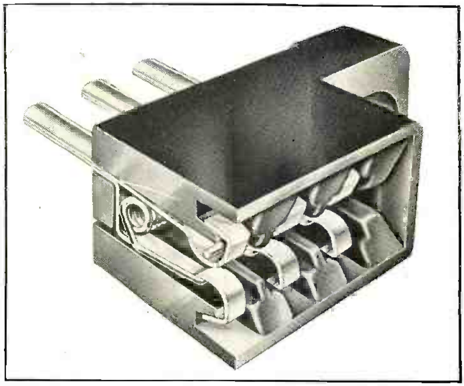
ELECTRONIC ORGAN DESIGN

Wireless World

ELECTRONICS • TELEVISION • RADIO • AUDIO



PICKUP TRACKING DISTORTION



FERRANTI

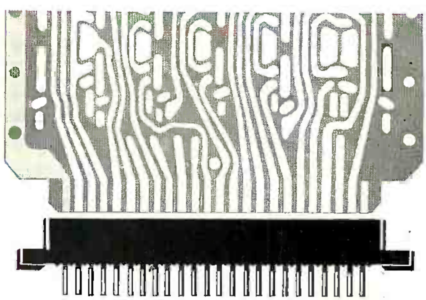
EDGE CONNECTORS

for printed circuit boards

- Low rate floating spring.
- Controlled contact pressure.
- Unsurpassed reliability.
- Polarising 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

FERRANTI *First into the Future*

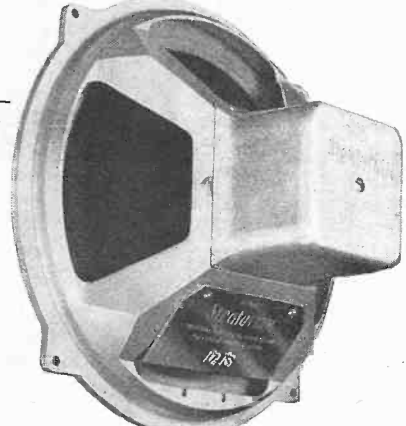


DS/T140

Full details available from: FERRANTI LTD · KINGS CROSS RD · DUNDEE · Telephone: Dundee 87141

WW—001 FOR FURTHER DETAILS.

the experts' choice *Stentorian*



F. C. JUDD
Technical Editor
Amateur Tape Recording and Hi-Fi Magazine'

JOHN GILBERT
Technical Editor
'Music Trades Review'

DONALD ALDOUS
Technical Editor
'Audio and Record Review'

See and hear us at the
AUDIO FAIR
STAND 46
Demonstration Room 204

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 $1\frac{1}{2}$ cubic feet.

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)

Other Stentorian Speakers ▶

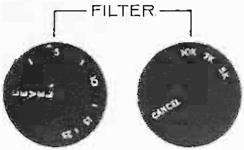
Type	Flux Density	Price	Type	Flux Density	Price
10" H.F.1012*	12,000 gauss	£5 1 3	T359 tweeter	9,000 gauss	£1 15 6
8" H.F.816*	16,000 gauss	£6 18 6	T816	16,000 gauss	£6 11 3
8" H.F.812*	12,000 gauss	£4 4 3	T12 tweeter	16,000 gauss	£15 5 6
8" H.F.810	10,000 gauss	£3 2 9	T10 tweeter	14,000 gauss	£5 2 0

*These three Speakers incorporate a universal impedance speech coil.

CROSSOVER NETWORKS:
CX3,000 £1/13/3
CX1,500 £2/2/-
CX500 £1/8/9

WHITELEY ELECTRICAL RADIO CO. LTD.
MANSFIELD · NOTTS · ENGLAND · Telephone: MANSFIELD 1762-5
London Office: 109 Kingsway, London W.C.2.

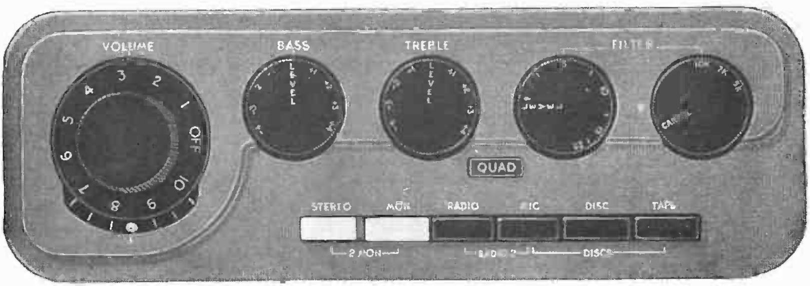
WW—005 FOR FURTHER DETAILS.



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.

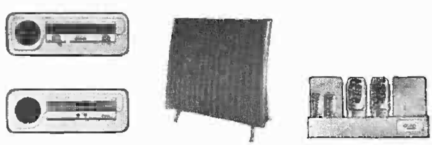
The QUAD filters provide both switched adjustment for frequency and continuously variable adjustment for rate of attenuation. The degree of attenuation need therefore never be greater than necessary to clean up the programme but is always adequate even for very bad cases.



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

Ref. W.W. Acoustical Manufacturing Co. Ltd., Huntingdon. Huntingdon 361.



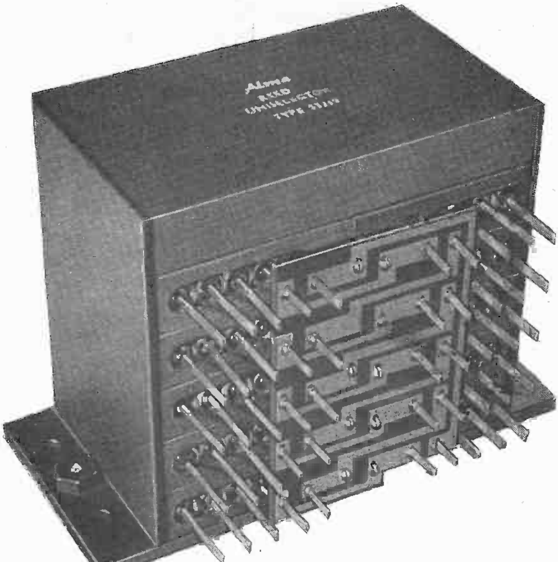
QUAD

WW—007 FOR FURTHER DETAILS.

REED RELAYS

REED UNISELECTOR

Alma



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.

- ★ *Higher speed of operation*
- ★ *Fully sealed contacts requiring no adjustments or maintenance*
- ★ *Instantaneous re-set without going through all contacts*
- ★ *Changeover or normally closed contacts can be supplied if required*
- ★ *Independent " make " contacts are employed instead of a common wiper circuit*
- ★ *Low contact resistance*

ALMA COMPONENTS LIMITED

Park Road · Diss · Norfolk · Telephone: Diss 2287 · Telex 18162

WW—013 FOR FURTHER DETAILS.

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 Kc/s. *Sensitivity:* NORMAL input 10 c/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 10^6 with µS units.

Time Measurement. *Unit time pulses:* 1µS to 10S in decade steps. Maximum period displayed 10^5S (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 10^6.

PRICE £205 ex Works

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 microseconds to seconds are obtainable with accuracies up to 2 parts in 10^8, which by using optional external frequency standards can be increased to parts in 10^9.

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 10^6 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 ELECTRONICS LIMITED

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

279

WW—014 FOR FURTHER DETAILS.

Continuous Frequency Coverage from 1·5 c/s to 150 kc/s in 5 Ranges at Decade Intervals

TRANSISTOR

R. C. OSCILLATORS

TYPES TG150, TG150M TG150D & TG150DM

SEE US AT THE I.E.A. SHOW
STAND N.815
FIRST FLOOR NATIONAL
GALLERY MAY 23-28

SPECIFICATION:

FREQUENCY
1.5 c/s to 150 kc/s
±3% + 0.15 c/s.

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

DISTORTION
<0.1% at 1 kc/s;
<0.3% from 50 c/s to 15 kc/s;
<1.5% below 50 c/s and above 15 kc/s.

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

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

ATTENUATOR
20dB, 40dB and 60dB; 600Ω

SUPPLY
Self-contained PP9 batteries, life 400 hours, or, 200/250V A.C. when Power Supply Unit is fitted.

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

WEIGHT
6 pounds.

TYPE	TG150	TG150M	TG150D	TG150DM
Output Waveforms:	Sine only	Sine only	Sine and Square	Sine and Square
Output Meter:	None	0-2.5V and dB	None	0-2.5V and dB
Price with batteries:	£32	£42	£35	£45

LEVELL
PORTABLE INSTRUMENTS

Mains Power Supply Unit **£7.10.0**

Leather carrying case **£3.10.0**

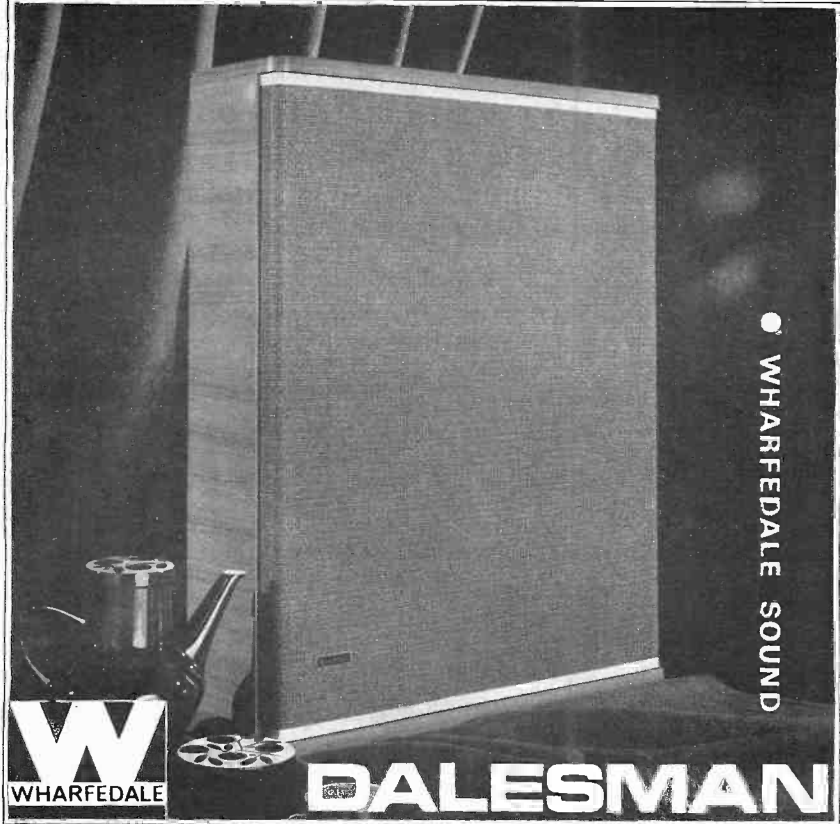
Fully detailed leaflets are available on our complete range of portable instruments

LEVELL ELECTRONICS LIMITED

PARK ROAD, HIGH BARNET, HERTS——Telephone: BARnet 5028

WW—016 FOR FURTHER DETAILS.

WHARFEDALE SOUND stereo/mono



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

- AIRTIGHT FIBRE DOME TO ISOLATE TWEETER
- 5" HIGH EFFICIENCY TWEETER
- CROSSOVER NETWORK
- BRACING STRUT TO REDUCE PANEL RESONANCE
- BONDED ACETATE FIBRE WADDING
- 12" BASS UNIT WITH FLEXIPRENE SUSPENSION
- AIRTIGHT ENCLOSURE OF MAN MADE TIMBER

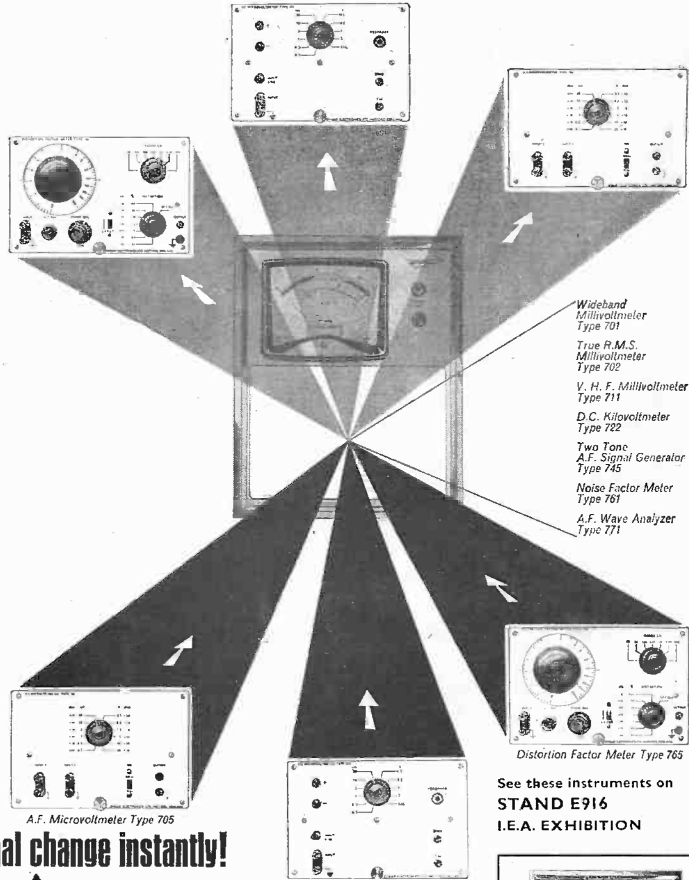
Free technical folder on the Dalesman from Dept. W.5

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 6¼" Weight 31½ lb.
Finish zebrano, mahogany, walnut or teak veneers.

£25.10.0

RANK WHARFEDALE LIMITED
IDLE, BRADFORD, YORKSHIRE
Telephone Bradford 612552/3 Telegrams 'Wharfdel' Bradford

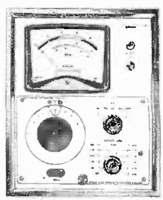
WW—019 FOR FURTHER DETAILS.



See these instruments on
STAND E916
I.E.A. EXHIBITION

total functional change instantly!

that's Pluginability



Type 70 Meter Unit with Plug-in-A.F. Signal Generator Type 741.

—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 'Pluginability' sums it up in one word.

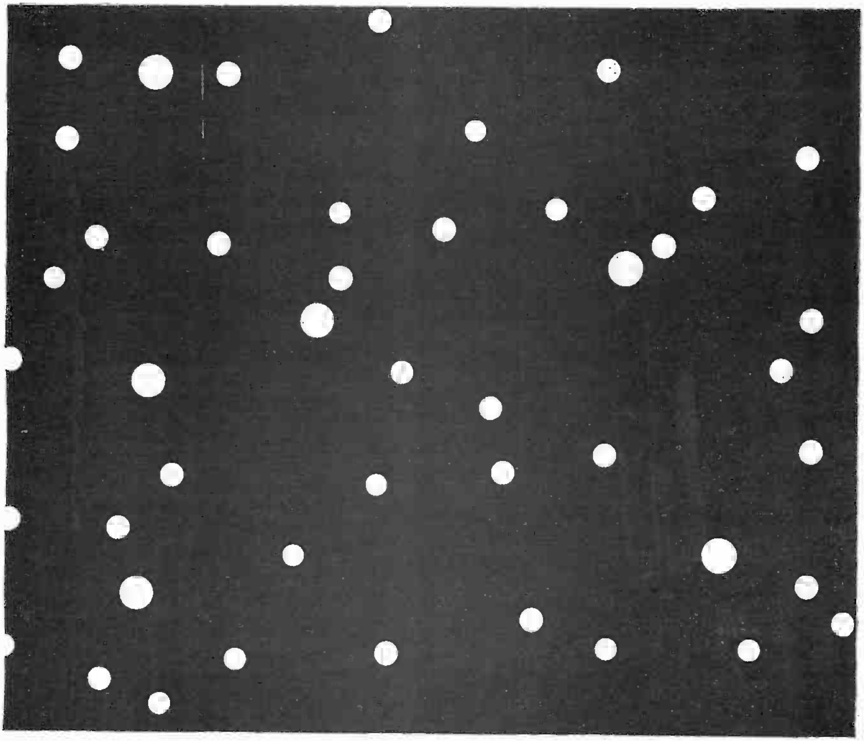
Full details from:

DYMAR

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

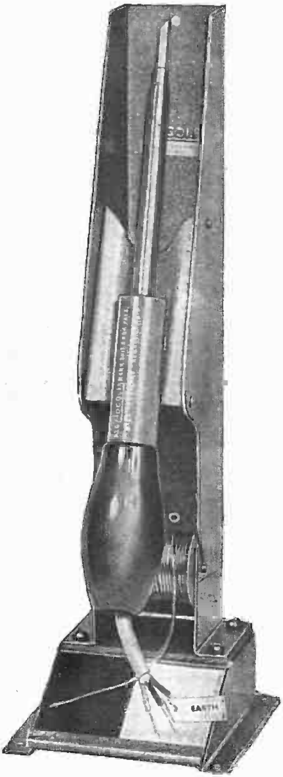
Broadway DY601

WW—022 FOR FURTHER DETAILS.



ADCOLA PRODUCTS LIMITED (Regd Trade Mark)

SOLDERING EQUIPMENT



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

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.

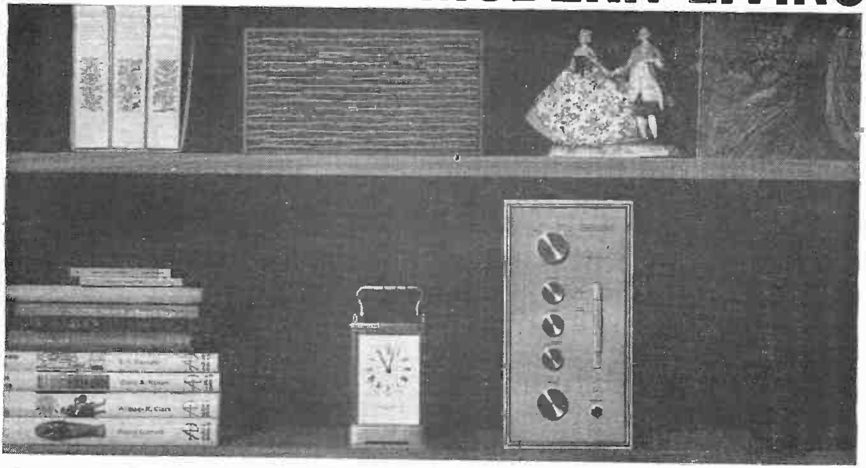
Clark SUPER E Series Masts are available with extended heights from 16 to 40 feet and head-load capacity up to 10 lb. There is, of course, also the full range of Clark Accessories. Send for more details today.

for further details write to:

A. N. CLARK (ENGINEERS) LIMITED
BINSTEAD — ISLE OF WIGHT
Telephone: RYDE 3691 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' scratchgrain control panel blends with any decor. **£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 5½" x 7¼" **£17.10s.6d.** inc. P.T.

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

MEZZO. The Loudspeaker to Live With. 15 watts of power yet only 10¾" x 18¼" 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.**

GOODMANS INDUSTRIES

AXIOM WORKS · WEMBLEY · MIDDLESEX Tel: WEM 1200

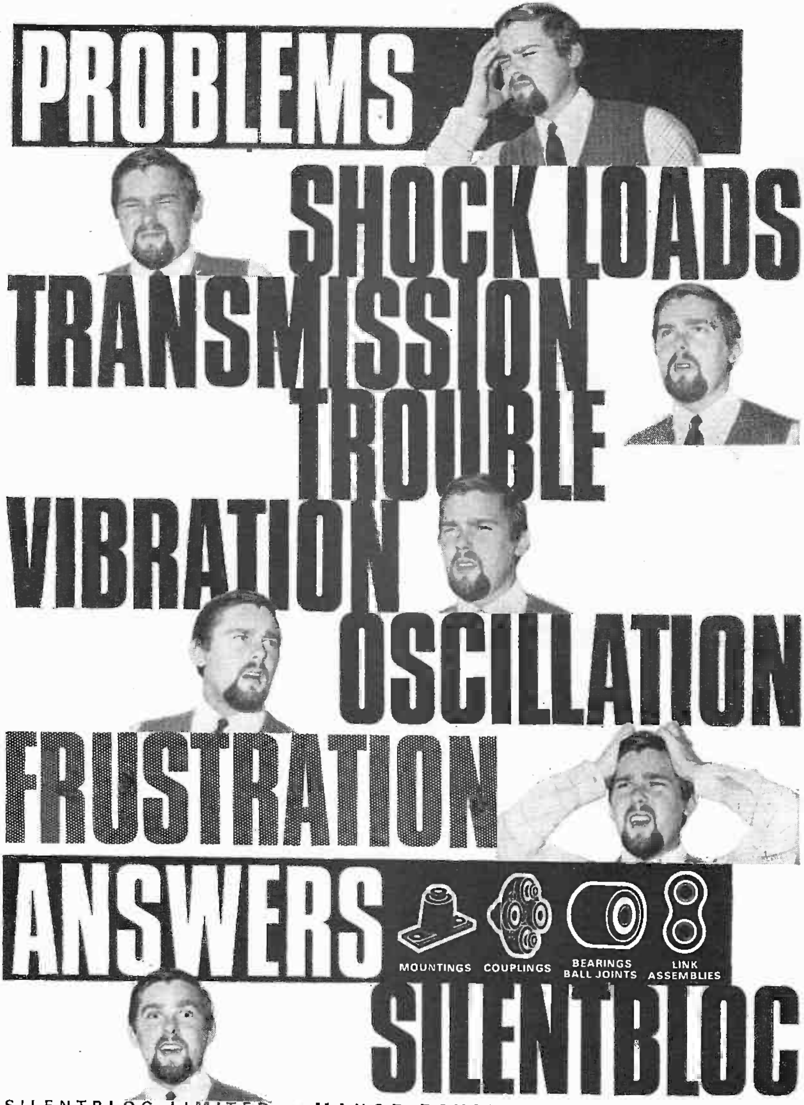
A Division of Radio Rentaset Products Ltd.

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

Name...

Address...

WWS



SILENTBLOC LIMITED · MANOR ROYAL · CRAWLEY · SUSSEX

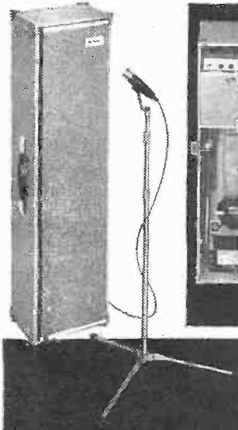
Telephone: Crawley 27733 Telegrams: Silentbloc Crawley Telex: 87177

Silentbloc products are also manufactured by Silentbloc (Australia) Pty. Ltd., Melbourne

Andre Rubber Co. Ltd. is another Silentbloc Company

Broadway/S507

WW—032 FOR FURTHER DETAILS.



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.

PORTABLE SOUND FOR ALL EVENTS

THE WHARFEDALE PA30 PUBLIC ADDRESS SYSTEM

Completely self contained — pull open the amplifier compartment—open the accessory compartment —take out the microphone—plug in — switch on and speak; it's the greatest public address idea in years.

Anyone can operate the PA30 — no technical ability required.

This completely portable sound system is housed in a single durable tan leatherette covered carrying case with vinyl grille cloth. A special loudspeaker system comprising six Wharfedale speakers is built in the front section of the case. The robust and powerful transistor amplifier operates from self contained batteries or mains at the turn of a switch.

Everything packs away neatly in sixty seconds — ready for use again at a moments notice.

Size 36¾" x 7¾" deep x 9⅞" plus ⅜" handle.

Weight 42 lb. **£69.10.0.**

FOR FULLY ILLUSTRATED LEAFLET AND DETAILS OF PA30 DEMONSTRATIONS WRITE TO (Dept WS)

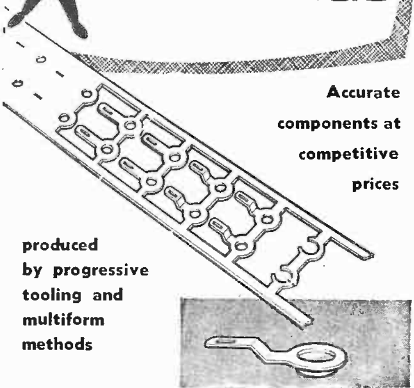
RANK WHARFEDALE LTD
IDLE · BRADFORD · YORKSHIRE
TELEPHONE BRADFORD 612552/[illegible]
TELEGRAMS 'WHARFDEL' BRADFORD

NAME ....
ADDRESS ....
....
TOWN ....
COUNTY ....

WHARFEDALE

WW—035 FOR FURTHER DETAILS.

PRECISION PRESSINGS



Accurate components at competitive prices

produced by progressive tooling and multiform methods

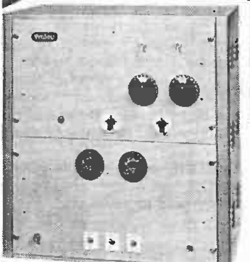
JOHN SMITH LTD.

209 SPON LANE · WEST BROMWICH · STAFFS
TELEPHONE: WES 2516 (3 lines)
WOODS LANE · CRADLEY HEATH · STAFFS. TELEPHONE: CR 69283 (3 lines)

WW—036 FOR FURTHER DETAILS.

The NEW Wolec RF GENERATOR

gives Variable IMPEDANCE MATCHED OUTPUT from 100–2,000Ω



This high performance, reliable and robust R.F. generator is specifically designed to meet the popular need for a lower power R.F. source with a variable output impedance. Three models are available, viz: 10-120 watts (output), 10-200 watts and 20-250 watts. The WOLEC is finding considerable application for laboratory use (to operate discharge tubes, etc.), in Industry, Nuclear Physics, Universities and Colleges. This extremely versatile unit can be coupled up to any equipment requiring an R.F. input with a low distortion sine-wave. Crystal controlled single frequency or variable frequency (with a high stability tuner) covers the bands 13-18 M/cs, 25/30 M/cs and 140/150 M/cs. The output can be modulated as required. Power supply (200/250V A.C.) using Silicon Rectifiers (fully smoothed). Every WOLEC is triple tested before despatch and has been designed to ensure easy maintenance. It is suitable for continuous use in temperatures up to 50°C. Circuit modification to suit customers' requirements can be incorporated.

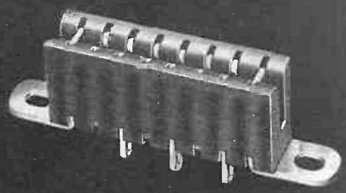
Dimensions: 21½" wide × 10½" deep × 22" high. Weight: approx. 80 lbs.

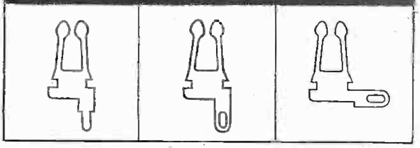
For Full Specification write to the Manufacturers, DEPT. W4.

WOLFENDALE ELECTRONICS
36A KIMBERLEY ROAD · BOURNEMOUTH · Tel: 48792

WW—037 FOR FURTHER DETAILS.

Permacon edge connectors





35

These inexpensive edge connectors feature polypropylene mouldings and brass or phosphor bronze contacts with a standard tinned finish. Silver plate, gold flash, or gold plate finishes are available to special order. .100″ contact pitches provide a maximum of 40 positions whilst the .150″ contact pitch range provides for a maximum of 26 positions. Contact tail variations (shown above) include solder slot tails projecting either vertically downwards or at 90° to the moulding, or tails for direct mounting to a "mother" printed circuit board. Mounting brackets provide "closed" or "open-ended" connectors or include contacts for direct earthing from the mating P.C. Board.

Electrical Ratings

Working voltage: 500 Volts D.C. or A.C. Peak (.150″ pitch)
350 Volts D.C. or A.C. Peak (.100″ pitch)

Current capacity: 5 amps max. per contact

CARR FASTENER CO LTD

the firm with the best connections

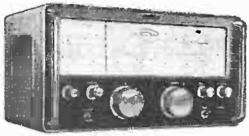
Stapleford, Nottingham. Telephone: Sandiacre 2661.
Sales Offices: Wembley, Sale.

CARR FASTENER
UNITED-CARR GROUP

WW—038 FOR FURTHER DETAILS.

EDDYSTONE COMMUNICATION RECEIVERS

For the professional or Amateur user who likes the Best.



840C
£66

Communication receiver at a moderate price. MANUFACTURING STANDARDS OF THE HIGHEST ORDER, 8 B8A valves Superhetero-dyne circuit. **FREQUENCY RANGES:**

Range 1	12.4—30 Mc/s.	Range 4	1.12—2.58 Mc/s
Range 2	5.2—12.9 Mc/s	Range 5	480—1,150 kc/s
Range 3	2.5—6.1 Mc/s		

Ranges 4 and 5 include the International Distress Frequencies.

Model No	Cash Price	Model No	Cash Price
EC10	£48 0 0	EB35	£59 7 6
840C	£66 0 0	940	£133 0 0
EA12	£185 0 0		

Hire Purchase Terms gladly arranged. Owing to frequent changes in the HP regulations we are obliged to discontinue advertising these.

Please write for current rates. A 4d stamp will bring you these and a full range of Eddystone Literature.

Carriage paid per passenger train. SATISFACTION GUARANTEED.

SEND FOR LITERATURE TO

The Eddystone Specialists

HP RADIO

SERVICES LTD.

49/51 COUNTY ROAD
LIVERPOOL, 4

Telephone: AINTREE 1445

ESTAB. 1935

WW—039 FOR FURTHER DETAILS.

JONES TYPE CO-AXIAL CONNECTORS

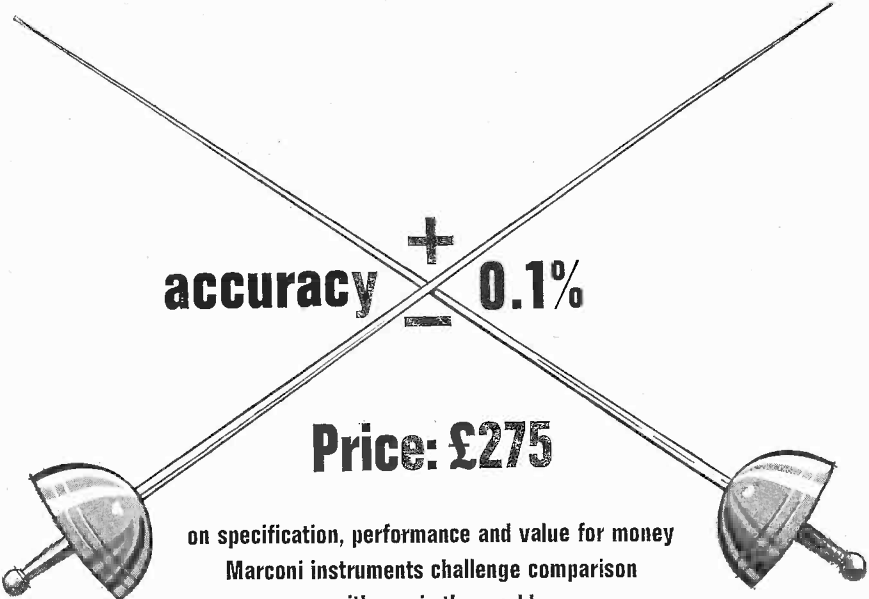
Low cost miniature co-axial with brass shells, screw thread coupling.

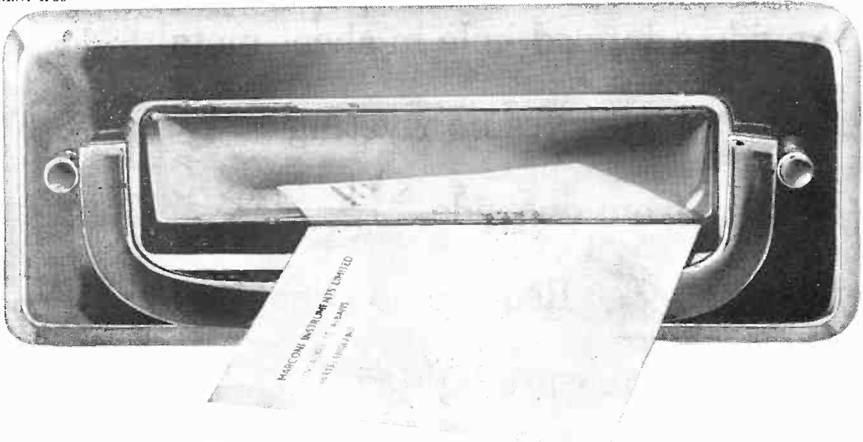
Cannon Electric (Great Britain) Ltd.,
Lister Road,
Basingstoke, Hants.
Tel: Basingstoke 3171

CANNON PLUGS
Registered Trademark

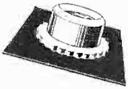
CANNON

WW—040 FOR FURTHER DETAILS.

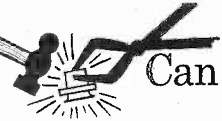




Provide a tapped hole in sheet metal

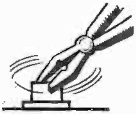


Require no riveting

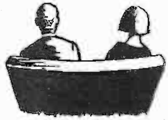


Can be fixed from one side

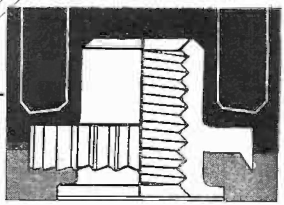
Cannot rotate



Require no clinching



are smaller · are lighter



Please send me free samples of

ROSAN PRESS-NUTS

actual size of a 4BA nut

with .... *threads*

INSTRUMENT SCREW CO. LTD., NORTHOLT RD, SOUTH HARROW, MIDDLESEX Tel: Byron 1141

WW—054 FOR FURTHER DETAILS.

THE AUDIO FIDELITY STEREO-33

A High Fidelity, All Transistor Stereo Amplifier providing 10 watts R.M.S. on each channel

OUTPUT PER CHANNEL
10 watts R.M.S. into 15 ohm load.
15 watts R.M.S. into 3.75 ohm load.

TOTAL HARMONIC DISTORTION
0.1% at 5 watts R.M.S. } Into
0.3% at 10 watts R.M.S. } 15 ohm
1,000 c.p.s. } load.

DAMPING FACTOR 20

FREQUENCY RESPONSE
± 1½ db. 20-20,000 c.p.s.

HUM AND NOISE
—80 db.

CROSS TALK
—42 db. to —53 db.

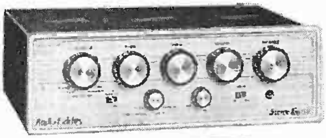
MAINS INPUT SELECTION
100-110-120-200-210-220-240 v.
50/60 c.p.s.

SEMI-CONDUCTORS (per channel)
AC107, OC44(3), OC81Z(2), OA5, OC127Z
AD149(2)

INPUT SENSITIVITIES
(for 10 watts R.M.S. into 15 ohms)
Pick-up Magnetic 3.5 mv. 33⅓ r.p.m.
7 mv. 78 r.p.m.
Pick-up Crystal/Ceramic 400 mv.
Microphone 5 mv.
Tape Head 2 mv.
Aux. (Radio, Tape, Ceramic P.U. etc.) 100 mv.
(Above sensitivities will be doubled when output load is 3-4 ohms)

BASS CONTROLS
+ 11db to — 16 db. at 40 c.p.s.

Incorporation of the very latest Mullard Transistors has made possible the really outstanding performance figures of this brilliant design.
Compare them with other leading makes currently available.



RETAIL PRICE 39 GNS

THE PRE-AMPLIFIER IS A COMPLETELY NEW DESIGN

IT ELIMINATES THE NECESSITY OF MATCHED INPUTS AND COMPLICATED SWITCHING ARRANGEMENTS. IT ALSO PRODUCES CONDITIONS OF MINIMUM NOISE AT HIGHEST SENSITIVITIES.

TREBLE CONTROLS
+ 15 db. to — 15 db. at 10 kc/s.

EQUALISATION
Gram to standard R.I.A.A. characteristic.
Tape Head to standard C.C.I.R. characteristic.

SIZE 12½ × 4 × 8¾in.

WEIGHT 12½lb.

FILTER (Steep Cut) 7 kc/s., 11kc/s., 15 kc/s.

INPUT SELECTOR
33⅓ r.p.m., 78 r.p.m., AUX., Mic., Tape Head.

INPUT SOCKETS
Magnetic P.U. Crystal/Ceramic Pick-up, Aux., Tape Head/Microphone.

Designed for ease of fitting in cabinet or for free standing use. Tested for satisfactory operation in temperatures of up to 50°C. (120°F.).

Built to highest standards employing latest materials and techniques.

PLEASE SEND S.A.E. FOR LEAFLET

EXPORT ENQUIRIES INVITED

Designed and developed by the Audio Fidelity Group of Companies.

Manufactured and Distributed by LINEAR PRODUCTS LTD. ELECTRON WORKS, ARMLEY, LEEDS.

WW—055 FOR FURTHER DETAILS.

ARE YOU DESIGNING A.F. EQUIPMENT?

EXCEPTIONALLY WIDE BAND MICROPHONE AND AUDIO LINE MATCHING TRANSFORMERS

ALL TYPES ARE NORMALLY AVAILABLE FROM STOCK

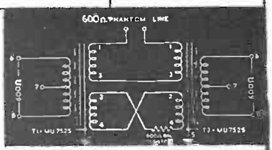
FREQUENCY RANGE
100 K.ohm models ± 1 dB 30 c/s to 20 kc/s.
All other models ± 0·5 dB 30 c/s to 20 kc/s.
MAXIMUM AUDIO LEVEL + 12 dBm (16mW)
INPUT IMPEDANCE maintained to within ± 10% (± 20% ‡) at all frequencies within the range 50 c/s to 8 kc/s (to 5 kc/s only for 100 K.ohm models).
MAGNETICALLY SCREENED
— 50 dB reduction in hum pick up.

For professional recording and broadcast transmission equipment, these Octal-based plug-in transformers have a frequency response extending well beyond the audio range. The design achieves dynamic performance with minimum distortion at all levels

Type No.	Input Z Ohms	Pin Nos.	Output Z Ohms	Pin Nos.	Sec./Pri. Turns Ratio	Applications
MU.7521	3·75/15*	1-3, 2-4	600 (C.T.)	6-7-8	6·32:1/12·64:1	Low Z. Mic/Line
MU.7522	3·75/15*	1-3, 2-4	100K.	6-8	82:1/164:1	Low Z. Mic/Grid
MU.7523	75/300*	1-3, 2-4	600 (C.T.)	6-7-8	1·41:1/2·82:1	Line/Line
MU.7524	150/600*	1-3, 2-4	600 (C.T.)	6-7-8	1:1/2:1	Mixing: Bal/Unbal.
MU.7525	600 (C.T.)	6-7-8	300/1·2K*	1-3, 2-4	1+1:1·41 (C.T.)	Mixing: Hybrid‡
MU.7526	600 (C.T.)	6-7-8	2·5k/10k.*	1-3, 2-4	2·04:1/4·08:1	Line/Grid.
MU.7527	150/600*	1-3, 2-4	100K.	6-8	13:1/26:1	Line/Grid.
MU.7528	7·5/30*	1-3, 2-4	600 (C.T.)	6-7-8	4·47:1/8·94:1	Low Z. Mic./Line
MU.7529	50/200*	1-3, 2-4	600 (C.T.)	6-7-8	1·73:1/3·46:1	Mic. or Line/Line
MU.7530	10K. (C.T.)	6-7-8	10K.	1-4	1 (C.T.):1	600 Ω Line Bridging
MU.7532	7·5/30*	1-3, 2-4	100K.	6-8	58:1/116:1	Low Z. Mic./Grid
MU.7534	50/200*	1-3, 2-4	100K.	6-8	22·4:1/44·8:1	Mic. or Line/Grid

*Denotes series/parallel connection.

‡ *Type MU.7525 may be used in "Hybrid" circuits, as shown, to establish phantom line operation in telephony. Accurate balancing of the windings enable guaranteed rejection of better than — 55 dB from 50 c/s to 10 kc/s. Up to — 75 dB may be expected for normal rejection levels.*



Gardners

WRITE FOR A.F. BROCHURE GT.4
giving full details of these and other types of A.F. transformers

GARDNERS TRANSFORMERS LIMITED . SOMERFORD . CHRISTCHURCH . HANTS.
TEL.: CHRISTCHURCH 1734. Telex 41276. Grams. & Cables: Radiotrans Christchurch Telex.

THE ANTEX RANGE

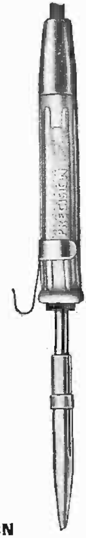
-an iron for every precision need!

F
40W. Models for 20 or 24V (mains models available shortly) 5/16" bit fitted–alternative bits available. 42/6d

ES
25W. Models for 12, 24, 110, 220 or 240V supply. 1/8" bit fitted–3 alternative bits available. 35/-

E
20W. Models for 24, 110, 220 or 240V supply. 1/4" bit fitted–8 alternative bits available. 35/-

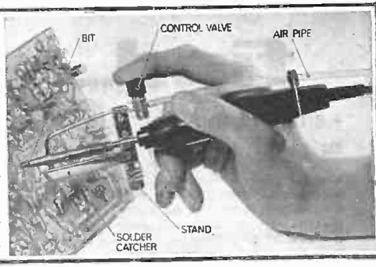
G
18W. Models for 110, 220 or 240V supply. 3/32" bit fitted — 3 alternative bits available. 32/6d



CN
15W. Models for 24, 110, 200, 220 or 240V supply. 3/32" bit fitted — 17 alternative bits available. 32/6d

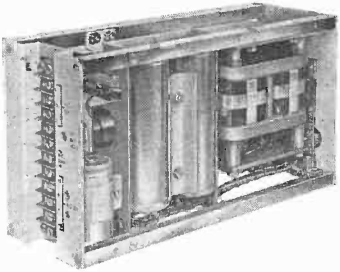
HOURS of work reduced to *SECONDS* with the new ANTEX DE-SOLDERING TOOL

Soldered joints can now be easily, speedily and neatly unsoldered. A self-cleaning nozzle, exclusive to the ANTEX de-soldering irons, sucks up molten solder into stainless steel catcher. Operates by compressed air from airline or standard footpump. Type ESS for 240, 220, 110 or 24 volts. Type GSS for 240, 220 or 110 volts. Price complete with connecting tube, flexible lead and adaptors £4. 4. 0.



ANTEX LTD
Grosvenor House, Croydon, Surrey, MUNicipal 2774

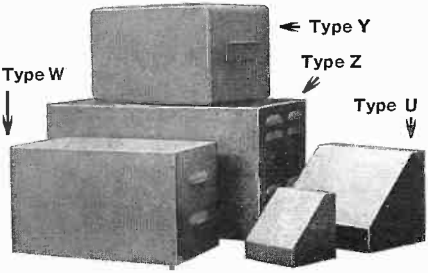
WW—073 FOR FURTHER DETAILS.



CHASSIS and CASES

by Smith's of EDGWARE ROAD

H. L. SMITH & CO. LTD.
ELECTRONIC COMPONENT DISTRIBUTORS
287/289 EDGWARE ROAD, LONDON, W.2.
Tel: PADdington 5891/7595
We shall be pleased to quote for all your component requirements



BLANK CHASSIS

SAME DAY SERVICE

Of over 20 different forms made up to **YOUR SIZE.**
(Maximum length 35in., depth 4in.)

SEND FOR ILLUSTRATED LEAFLETS
or order straight away, working out total area of material required and referring to table below, which is for four-sided chassis in 16 s.w.g. aluminium.

48 sq. in.	4/3	176 sq. in.	9/-	304 sq. in.	13/6
80 sq. in.	5/6	208 sq. in.	10/-	336 sq. in.	14/9
112 sq. in.	6/6	240 sq. in	11/3	368 sq. in.	15/9
144 sq. in.	7/9	272 sq. in.	12/6	and pro rata.	
P. & P. 2/6		P. & P. 2/9		P. & P. 3/-.	

Discounts for quantities. More than 20 sizes kept in stock for callers.

FLANGES (¼in., ⅜in.), 6d. per bend.

STRENGTHENED CORNERS 1/- each corner.

PANELS: Any size up to 3ft. at 5/3 sq. ft. 16 s.w.g.; (18 s.w.g. 4/6). Plus post and packing

CASES

ALUMINIUM. SILVER HAMMERED FINISH

Type	Size	Price	Type	Size	Price
U	4 x 4 x 4*	10/-	Y	8 x 6 x 6*	26/6
U	5½ x 4½ x 4½	15/6	Y	12 x 7 x 7	41/-
U	8 x 6 x 6	21/-	Y	13 x 7 x 9	46/-
U	15 x 9 x 9	44/6	Y	15 x 9 x 7	48/6
W	8 x 6 x 6	21/-	Z	17 x 10 x 9	66/-
W	12 x 7 x 7	34/-	Z	19 x 10 x 8½	71/-
W	15 x 9 x 8	44/-			

*Height.

Plus post and packing

Type U has removable bottom or back, Type W removable front, Type Y all-screwed construction, Type Z removable back and front.

LIVE SOCKETS

Up to 6 at a time

Instantly!

With Lexor DIS-BOARDS. Over 1,000 combinations in all types of fittings and finishes. Available from stock.

Brochure and price list from:

LEXOR DIS-BOARDS LIMITED, ALLESLEY OLD ROAD, COVENTRY. Telephone: 72614

WW—078 FOR FURTHER DETAILS.

MICROPHONES, ACCESSORIES, TRANSISTORISED "RADIOMIC" and other EQUIPMENT

Top ranking quality
Top ranking performance

LUSTRAPHONE

St. George's Works, Regent's Park Road, London, N.W.1

WW—079 FOR FURTHER DETAILS.

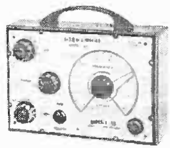
NOMBREX TRANSISTORISED INSTRUMENTATION

SIGNAL GENERATOR MODEL 27

★ Signal Generator 27	£10 16 9
★ Power Supply Unit 61	£6 14 6
★ C.R. Bridge 62	£9 6 9
★ Audio Generator 63	£17 1 9
★ Inductance Bridge 66	£18 6 9

All prices include battery, post and packing. Prompt Delivery.

S.A.E. FOR TECHNICAL LEAFLETS • TRADE & EXPORT ENQUIRIES INVITED

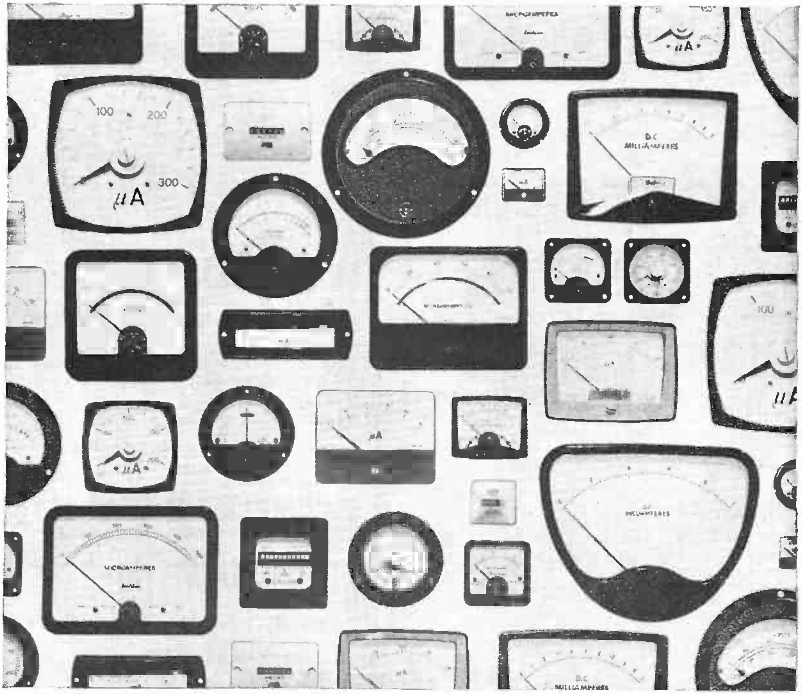


AUDIO GENERATOR MODEL 63

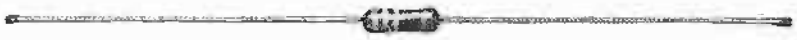
NOMBREX LTD. ESTUARY HOUSE, CAMPERDOWN TERRACE, EXMOUTH, DEVON. *Phone: 3515*

WW—080 FOR FURTHER DETAILS.

WW—081 FOR FURTHER DETAILS.


100
200
300
μA
D.C.
MILLIAMPERES

one electrosil TR resistor = 33 other types of the same value



so why is your store so full of resistors?

Send today for a remarkable leaflet which shows how *one* TR resistor can replace thirty three other makes and types of the same value. See for yourself how relatively few Electrosil TR resistors can replace the many types and styles which you have to hold in stock. TR resistors are fully approved to DEF 5115.1: pattern RFG 5 (Multiple Rating) so you can get high stability, semiprecision and general purpose ratings in *one* resistor. Over 50 million resistors have now been produced to this standard in the UK. TR resistors can save you space, time and money. You really should investigate TR resistors—can you afford not to? Get your copy of "one for thirty three", today from

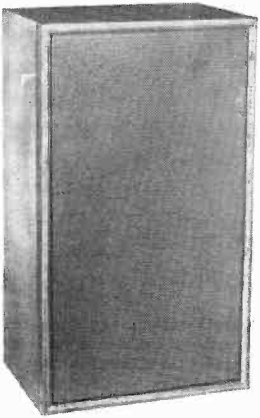
Electrosil Limited, P.O. Box No. 37, Pallion, Sunderland, Co. Durham. Tel: Sunderland 71480 (10 lines) Telex 53273

Electrosil LIMITED

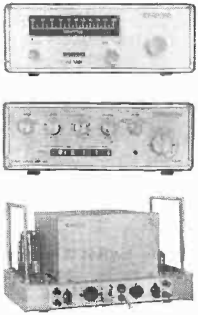
OFFICIAL STOCKISTS:	Townsend-Coates Ltd., Coleman Road, Leicester	SASCO Ltd., Gatwick Road, Crawley, Sussex	Radio Resistor Co. Ltd., Palmerston Road, Wealdstone, Harrow, Middlesex	Morris Warden & Co. Ltd., Morden House, 10 Royal Crescent, Glasgow C.3	Standard Telephones & Cables Ltd., (Electronic Services) Edinburgh Way, Harlow, Essex

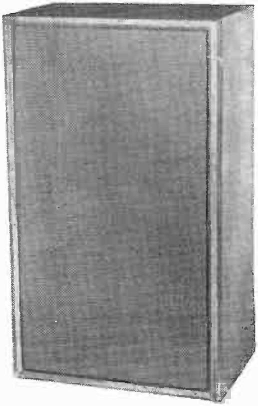
WW—094 FOR FURTHER DETAILS.

EQUIPMENT OF THE HIGHEST ATTAINABLE PERFORMANCE



RADFORD





SEND FOR DESCRIPTIVE TECHNICAL LEAFLETS GIVING FULL DETAILS

RADFORD ELECTRONICS LTD., ASHTON VALE ROAD, BRISTOL 3

WW—098 FOR FURTHER DETAILS.

FIAR

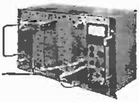
FABBRICA ITALIANA APPARECCHI RADIO

DIPARTIMENTO ELETTRONICA PROFESSIONALE

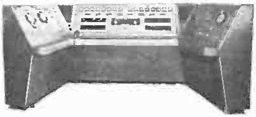
MILAN (Italy)-Via G. B. Grassi, 93-Telephone: 306241/306841-Telex: 31295

PRODUCTION

- Closed circuit television
- Sound diffusion installations
- TV transmitters
- Radio transmitter/receivers
- Radar and ancillary equipment
- Electronic military equipment
- Ancillary navigational equipment
- Antennae and accessories



Transistorised television repeater P 3149



Direction unit for large sound diffusion installations

Transistorised telecamera P 4814

WW—099 FOR FURTHER DETAILS.

"Wireless World"
Iliffe Electrical Publications Ltd.
Dorset House, Stamford Street,
London, S.E.1

Manager Director:
W. E. MILLER, M.A., M.I.E.R.E.

Editor-in-chief:
W. T. COCKING, M.I.E.E

Editor:
H. W. BARNARD

Technical Editor:
T. E. IVALL

Editorial:
B. L. SEXTON, Grad. I.E.R.E.
G. B. SHORTER, B.Sc.

Drawing Office:
H. J. COOKE

Production:
D. R. BRAY

Advertisements:
G. BENTON ROWELL (*Manager*)
J. R. EYTON-JONES

VOLUME 72 No. 5
PRICE: 3s.

FIFTY-SIXTH YEAR
OF PUBLICATION

Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

MAY 1966

SHORT ITEMS

REGULAR FEATURES

PUBLISHED MONTHLY (3rd Monday of preceding month). *Telephone:* Waterloo 3333 (70 lines). *Telegrams/Telex:* Wiworld Iliffepres 25137 London. *Cables:* "Ethaworld, London, S.E.1." *Annual Subscriptions: Home* £2 6s 0d. *Overseas:* £2 15s 0d. *Canada and U.S.A.* $8.00. Second-class mail privileges authorised at New York N.Y. BRANCH OFFICES: *BIRMINGHAM:* 401, Lynton House, Walsall Road, 22b. *Telephone:* Birchfield 4838. *BRISTOL:* 11, Marsh Street, 1. *Telephone:* Bristol 21491/2. *COVENTRY:* 8-10 Corporation Street, *Telephone:* Coventry 25210. *GLASGOW:* 123 Hope Street, C.2. *Telephone:* Central 1265-6. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. NEW YORK OFFICE U.S.A. 111 Broadway, 6. *Telephone:* Digby 9-1197

Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

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.cs 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.cs 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.cs 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 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.cs 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.

VOL 72 NO 5
MAY 1966

PICKUP ARM DESIGN—1

DESIGN AND MOUNTING OF ARMS FOR MINIMUM DISTORTION DUE TO LATERAL TRACKING ERROR

By J. K. STEVENSON,
B.Sc., Grad. Inst. P., Grad. I.E.E.

It is possible (as shown in this article) to design and mount a pickup arm 8in 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 $\pm 0.5^\circ$ 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 styli results 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 crests 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 styli, 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. Baerwald[1] as:—

$$\epsilon = 100\,\frac{V_0 \tan\eta}{u} \approx 100\,\frac{V_0\,\eta}{u} \qquad \ldots \quad \ldots \quad 1$$

where ϵ = % 2nd harmonic distortion, V_0 = peak recorded velocity (cm/sec), η = tracking error in radians, and u = groove speed (cm/sec).

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

$$V_{rms} = \frac{V_0}{\sqrt{2}} = \text{r.m.s. or effective recorded velocity (cm/sec)}$$

[1]H. G. Baerwald, *J.S.M.P.I.E.*, p.591-662, 1941.

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.

$$\phi = \frac{360\eta}{2\pi} = \text{tracking error (degrees)}$$

x = distance between stylus tip and turntable pivot (in)

s = turntable speed (rev/min),

$$\text{then } u = (2\pi\ 2.54x)\,\frac{s}{60},$$

and equation 1 may more conveniently be put in the form

$$\epsilon = 100\,\frac{\sqrt{2}}{2.54\times 6}\cdot\frac{V_{rms}\,\phi}{xs} = 9.28\,\frac{V_{rms}\,\phi}{xs}.$$

A typical maximum value for V_{rms} may be considered as 10. Therefore,

$$\epsilon_{max} = 92.8\,\frac{\phi}{xs}$$

The sign of ϕ (positive or negative) is ignored as it has no effect on the distortion. In order to prevent an excessive groove amplitude in the bass and to improve the signal to noise ratio, a gain of approximately 4 dB per octave with increasing frequency is applied to the recorded sound before it reaches the cutting heads. A reverse characteristic is used for replay. As a result, harmonic distortions are effectively reduced by 4 dB per octave. The effective maximum second harmonic distortion ϵ'_{max} is as follows,

$$\epsilon'_{max} = 10^{-4/20}\,\epsilon_{max} = 0.631\,\epsilon_{max} = 58.5\,\frac{\phi}{xs}$$

since the variation in pickup voltage is proportional to the recorded velocity. Hence,

$$\epsilon'_{max} = 1.76\,\frac{\phi}{x} \ \ldots\ldots\ldots\ 33\tfrac{1}{3}\ \text{rev/min}$$

$$= 1.30\,\frac{\phi}{x} \ \ldots\ldots\ldots\ 45\ \text{rev/min}$$

The values for harmonic distortion in this article are for spherical styli: other distortions due to tracking error are considered in Appendix I (in the next issue). The important point is that the distortions depend on ϕ/x.

Therefore, in a design ϕ/x should be minimized, and not ϕ alone.

Design procedure

Fig. 1 shows tracking errors for a straight pickup arm. By offsetting the pickup the errors are reduced considerably as shown in Fig. 2. Using the symbols in Fig. 3, we wish to determine the optimum values of θ_D and f when x lies between given limits. We therefore require a value of θ which will remain almost constant as x varies within this range.

From Fig. 3:—

$$d^2 = x^2 + l^2 - 2xl\cos\beta = x^2 + l^2 - 2xl\sin\theta$$

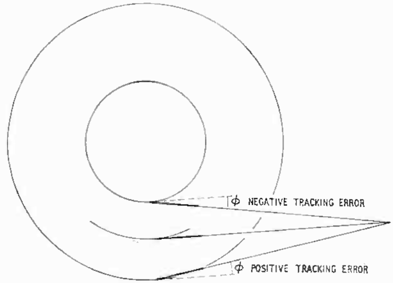


Fig. 1. Showing tracking errors for a pickup arm without offset.

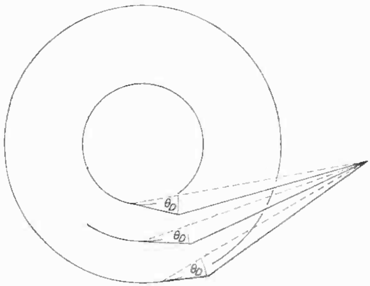


Fig. 2. Pickup arm with offset, θ_D. By offsetting the pickup, tracking errors are reduced considerably. Note that the stylus moves very slightly in the direction of the record motion.

l = EFFECTIVE LENGTH OF PICKUP ARM
d = DISTANCE BETWEEN TURNTABLE AND PICKUP ARM PIVOTS
$f = l - d$ = OVERHANG
x = DISTANCE BETWEEN STYLUS TIP AND TURNTABLE PIVOT

$\theta = 90^\circ - \beta$ = OFFSET ANGLE FOR ZERO TRACKING ERROR—VARIES WITH x
θ_D = DESIGN VALUE FOR OFFSET ANGLE
$\phi = \theta - \theta_D$ = TRACKING ERROR —VARIES WITH x
$= 90^\circ - (\beta + \theta_D)$

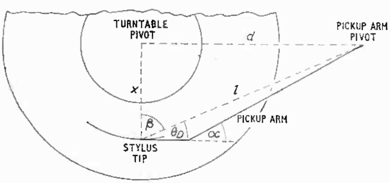


Fig. 3. Key to symbols used. The tracking error is zero when $\beta + \theta_D = 90^\circ$. Optimum values for offset, θ_D, and overhang f for x between giving limits are derived in the text. The offset angle of the pickup should not be confused with α, the angle through which the arm is bent.

Rearranging, $$2l \sin\theta = x + \frac{l^2 - d^2}{x} = y \quad .. \quad (2)$$
where $d = l - f$.

We will consider first the determination of θ_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 θ is required which varies least in equation 2 when x varies between x_1 and x_2: l 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, $x_m = \sqrt{(l^2 - d^2)}$.

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 $2l \sin\theta$ 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, $x_1 x_2 = l^2 - d^2 = x_m^2$ 3

The minimum value of y then occurs at the geometric mean of x_1 and x_2. Using equation 3,

$$d = (l^2 - x_1 x_2)^{\frac{1}{2}} = l - f$$

The overhang f is therefore given by:—

$$f = l - (l^2 - x_1 x_2)^{\frac{1}{2}}$$

The maximum and minimum values of y are given from equations 2 and 3,

$$y_{max} = x_1 + x_2 = 2l/\sin\theta_{max}$$
$$y_{min} = 2(x_1 x_2)^{\frac{1}{2}} = 2l/\sin\theta_{min}$$

The design value for θ_D is then as follows:

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

or $\sin\theta_D \approx \frac{1}{2}(\sin\theta_{min} + \sin\theta_{max}) = \dfrac{(x_1^{\frac{1}{2}} + x_2^{\frac{1}{2}})^2}{4l}$

Design for minimum tracking error distortion

In determining the pickup parameters for minimum lateral tracking error, we minimized the variation in $2l\sin\theta$ for x varying between x_1 and x_2 by including a turning point in the curve of $2l\sin\theta$ against x at $x = (x_1 x_2)^{\frac{1}{2}}$. $2l\sin\theta$ then has the same value at x_1 and x_2. In this case, by minimizing the variation in $\sin\theta$ (l being constant), we automatically minimized the variation in θ, as required i.e. ϕ 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 $\phi/x = (\theta - \theta_D)/x$ 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 $2l\sin\theta$ against x. Fig. 5 gives $2l\sin\theta/x$ against x and in addition $2l\sin\theta_D/x$ against x. The distance between these curves at a given

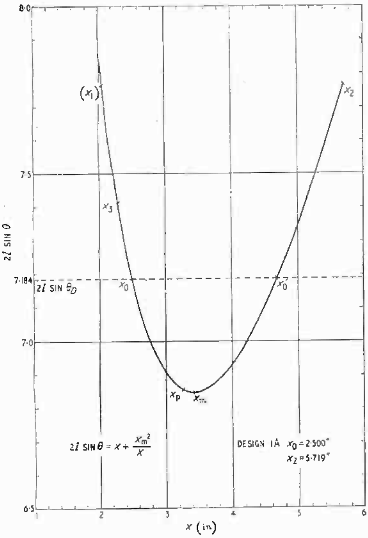


Fig. 4. Variation of $2l \sin\theta$ with x for a pickup arm designed for zero tracking error at x_0 and minimum distortion between x_0 and x_2. As $x_2 < x < x_0$ the maximum harmonic distortion ($\propto |\theta-\theta_D|/x$) decreases to zero, increases to a maximum at x_p (the same value of distortion as at x_2) and then decreases to zero at x_0. Note that the largest negative value of $(2l \sin\theta - \sin\theta_D)$ occurs at x_m and the largest negative value of $2l(\sin\theta-\sin\theta_D)/x$ at x_p.

value of x is $2l(\sin\theta-\sin\theta_D)/x$ which we will minimize since it is approximately proportional to $(\theta-\theta_D)/x$ and allows a considerable simplification in the algebra.

Both $2l\sin\theta$ against x and $2l(\sin\theta-\sin\theta_D)$ against x have a minimum at x_m, whereas $2l(\sin\theta-\sin\theta_D)/x$ 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:

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

Hence,

$$\frac{2l(\sin\theta-\sin\theta_D)}{x} = \frac{x+\frac{x_m^2}{x}-\left(x_0+\frac{x_m^2}{x_0}\right)}{x} = W \quad .. \quad .. \quad 4$$

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:

$$\frac{dW}{dx} = 0 = -\frac{2x_m^2}{x^3} + \frac{x_0}{x^2} + \frac{x_m^2}{x_0x^2} = \frac{1}{x^2}\left(x_0+\frac{x_m^2}{x_0}-\frac{2x_m^2}{x}\right)$$

$$\therefore\ x_p = \frac{2x_m^2}{x_0+\frac{x_m^2}{x_0}} = \frac{2x_0x_m^2}{x_0^2+x_m^2}.$$

Ideally, we require $\dfrac{\theta_0-\theta_p}{x_p} = \dfrac{\theta_2-\theta_0}{x_2}$, ... 5

but since
$$\sin\theta_D - \sin\theta_p = 2\sin\frac{\theta_D-\theta_p}{2}\cos\frac{\theta_D+\theta_p}{2} \approx \frac{\pi}{180}(\theta_D-\theta_p)\cos\theta_D$$
and
$$\sin\theta_2 - \sin\theta_0 = 2\sin\frac{\theta_2-\theta_0}{2}\cos\frac{\theta_0+\theta_2}{2} \approx \frac{\pi}{180}(\theta_2-\theta_0)\cos\theta_0$$

we may replace equation 5 by

$$\frac{2l(\sin\theta_0-\sin\theta_p)}{x_p} = \frac{2l(\sin\theta_2-\sin\theta_0)}{x_2}.$$

This may be put in the form:

$$\frac{x_0+\frac{x_m^2}{x_0}-\left[\frac{2x_0x_m^2}{x_0^2+x_m^2}+\frac{1}{2}\left(x_0+\frac{x_m^2}{x_0}\right)\right]}{\frac{2x_0x_m^2}{x_0^2+x_m^2}} = \frac{x_2+\frac{x_m^2}{x_2}-\left(x_0+\frac{x_m^2}{x_0}\right)}{x_2}.$$

Simplifying,

$$x_m^4\left(\frac{2x_0}{x_2^2}-\frac{2}{x_2}-\frac{1}{2x_0}\right)+x_m^2\left(3x_0-\frac{2x_0^2}{x_2}\right)-\frac{x_0^3}{2}=0.$$

Hence, $$x_m^2 = \frac{x_0^2\,x_2(5{\cdot}828x_2-4{\cdot}828x_0)}{x_2^2+4x_0x_2-4x_0^2}$$

This reduces to:

$$x_m^2 = \frac{x_0^2\,x_2}{0{\cdot}8284x_0+0{\cdot}1716x_2} \quad .. \quad .. \quad .. \quad 6$$

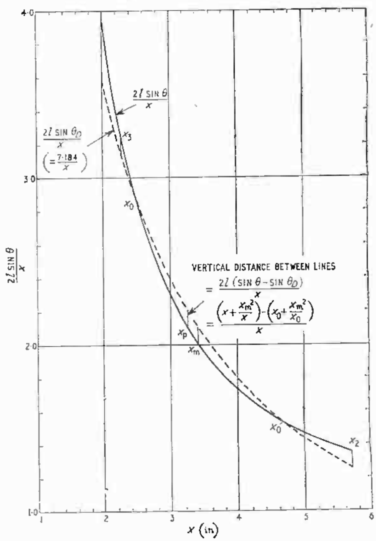


Fig. 5. Variation of $(2l \sin\theta)/x$ with x. The vertical distance between the lines is proportional to the harmonic distortion of a given modulation.

The design value θ_p for a given value of l is given from:

$$\sin\theta_p = \sin\theta_o = \frac{1}{2l}\left(x_o + \frac{x_m^2}{x_o}\right) = \frac{1}{l}\,\frac{x_m^2}{x_p} \qquad \ldots \quad 7$$

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

$$f = l - (l^2 - x_m^2)^{\frac{1}{2}} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad 8$$

All we require are values for x_o and x_2. x^2_m is then determined using equation 6 and the value substituted in equations 7 and 8 to determine θ_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_p and x_2 we will call x_3. This is given as follows:

$$\frac{\left(x + \frac{x_m^2}{x}\right) - \left(x_o + \frac{x_m^2}{x_o}\right)}{x} = \frac{\left(x_2 + \frac{x_m^2}{x_2}\right) - \left(x_o + \frac{x_m^2}{x_o}\right)}{x_2} = \frac{\left(x_o + \frac{x_m^2}{x_o}\right) - \left(x_p + \frac{x_m^2}{x_p}\right)}{x_p}$$

From the first two expressions,

$$\frac{1}{x_2}\left(x_o + \frac{x_m^2}{x_o} - \frac{x_m^2}{x_2}\right)x^2 - \left(x_o + \frac{x_m^2}{x_o}\right)x + x_m^2 = 0$$

The two solutions for x are x_2 and x_3.

$$\therefore \quad x_2 + x_3 = \frac{x_o + \frac{x_m^2}{x_o}}{\frac{1}{x_2}\left(x_o + \frac{x_m^2}{x_o} - \frac{x_m^2}{x_2}\right)}$$

$$\text{Hence,} \quad x_3 = \frac{x_m^2}{\left(x_o + \frac{x_m^2}{x_o}\right) - \frac{x_m^2}{x_2}}$$

The tracking error changes from positive to negative between x_2 and x_p. Let it be zero at a value of x which we will call x'_o

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

$$\text{Rearranging,} \quad x^2 - \left(x_o + \frac{x_m^2}{x_o}\right)x + x_m^2 = 0$$

Solutions are x_o and x'_o.

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

$$\text{so } x'_o = \frac{x_m^2}{x_o}, \text{ as expected.}$$

Note that whatever design method is used to obtain θ_p and f, the tracking error at a given value of x is given by:

$$\phi = \sin^{-1}\left[\frac{x}{2l} + \frac{f(2l-f)}{2lx}\right] - \theta_p \qquad \ldots \quad \ldots \quad 9$$

i.e. $\phi = \theta - \theta_p$

where θ is given from equation 2 rewritten in the form:

$$\sin\theta = \frac{x}{2l} + \frac{f(2l-f)}{2lx}.$$

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_o' and the maximum negative value (at x_p) is equal to the positive values at x_2 and x_3, as indicated in Fig. 5.

The values of x are related as follows:

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

$$\frac{\left(x_2 + \frac{x_m^2}{x_2}\right) - \left(x_o + \frac{x_m^2}{x_o}\right)}{x_2} = \frac{\left(x_3 + \frac{x_m^2}{x_3}\right) - \left(x_o + \frac{x_m^2}{x_o}\right)}{x_3} = \frac{\left(x_o + \frac{x_m^2}{x_o}\right) - \left(x_p + \frac{x_m^2}{x_p}\right)}{x_p}$$

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

where $x'_o > x_o$, $x_2 > x_3$.

We must specify two values of x to obtain a solution. If we specify x_o and x_2 (as in the given designs), then:

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

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

$$x_3 = \frac{x_m^2}{\left(x_o + \frac{x_m^2}{x_o}\right) - \frac{x_m^2}{x_2}}$$

$$\text{where } x_m^2 = \frac{x_o^2\,x_2}{0{\cdot}8284x_o + 0{\cdot}1716x_2}$$

Alternatively, we can give values for x_2 and x_3, the limits of x between which we require the tracking error per unit length to be minimized. Then it is easily shown that:

$$x_o = \frac{x_2\,x_3}{0{\cdot}8536x_2 + 0{\cdot}1464x_3}$$

$$x'_o = \frac{x_m^2}{x_o} = \frac{x_2\,x_3}{0{\cdot}1464x_2 + 0{\cdot}8536x_3}$$

$$x_p = \frac{2x_2\,x_3}{x_2 + x_3}$$

$$\text{where } x_m^2 = \frac{8x_2^2\,x_3^2}{x_2^2 + x_3^2 + 6x_2\,x_3}$$

The offset angle θ_p and overhang f for minimum tracking error per unit length are then as follows:—

$$\sin\theta_p = \frac{1}{l}\cdot\frac{x_m^2}{x_p}$$

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

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.

THE electronic-organ-building bug is a curious one. Bitten by it, many thousands have become afflicted with *dementia organistra*. The first clinical signs displayed by the victim of the disease (now assuming epidemic proportions) is a delusion that without substantial mechanical, electronic and musical skills he can construct one of these complex mechanical, electronic, musical instruments. This article is written with compassion for those who feel the first stirring of the *dementia organistra* fever in their blood, and cannot bring themselves to accept the sage advice from the pundits (usually reserved for those contemplating marriage!) . . . "Don't." It tries to give the happy victim some helpful guidance by setting out the main design features of present day electronic organs.

WHAT AN ELECTRONIC ORGAN IS

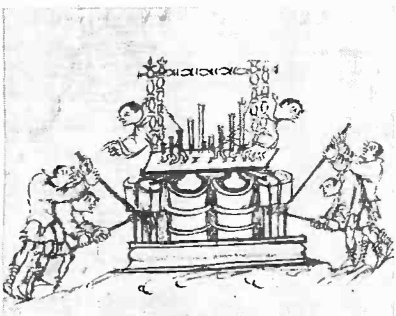
Organs have been around for a long time now. My favourite illustration of this is the ancient organ pictured in Fig. 1(a). This appeared in a famous medieval Psalter, the "Utrecht," and different musicologists have ascribed various dates from A.D. 600 to A.D. 1000 to the instrument. It may seem a far cry from it to the modern domestic electronic organ, which nowadays often takes a form somewhat like Fig. 1(b). Yet both belong to the same organ class of instrument; i.e., they are keyboard instruments in which a note sounds when a playing key is depressed and continues to sound until the key is released.

"Electronic" v. "wind" organs.—How an electronic organ differs in fundamentals from a classical "wind" organ is illustrated schematically in Fig. 2.

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,



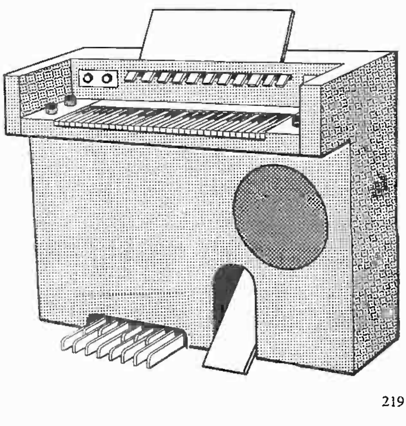


Fig. 1. The organ over the years: (a) illustration from early Psalter of pre-A.D. 1000 organ, well-known to organ antiquarians; (b) sketch of typical modern domestic electronic organ.

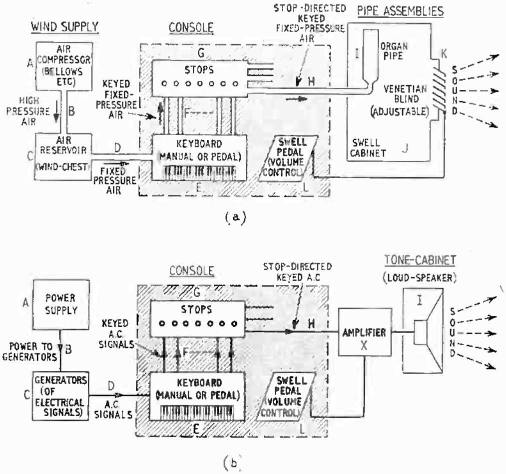


Fig. 2. Diagrammatic illustration of the essential differences between a traditional "wind" organ (a) and an electronic organ (b).

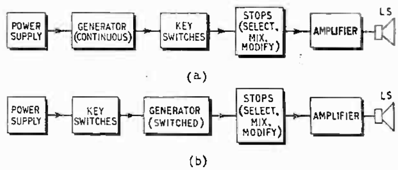


Fig. 3. Basic differences between two main classifications of electronic organs: (a) continuously-running generators and (b) switched generators.

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, I. 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 diagramatically 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 strewn 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 time-proved 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

*What does one call a pipe organ with a semiconductor logic switching action? (see "W.W.," Jan. 1965, p. 16).—ED.

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 ($2f$, $4f$, $6f$, . . .) harmonic series and the odd ($3f$, $5f$, $7f$, . . .) series. The squarewave has odd harmonics only. The importance of this lies in the fact that the sawtooth with

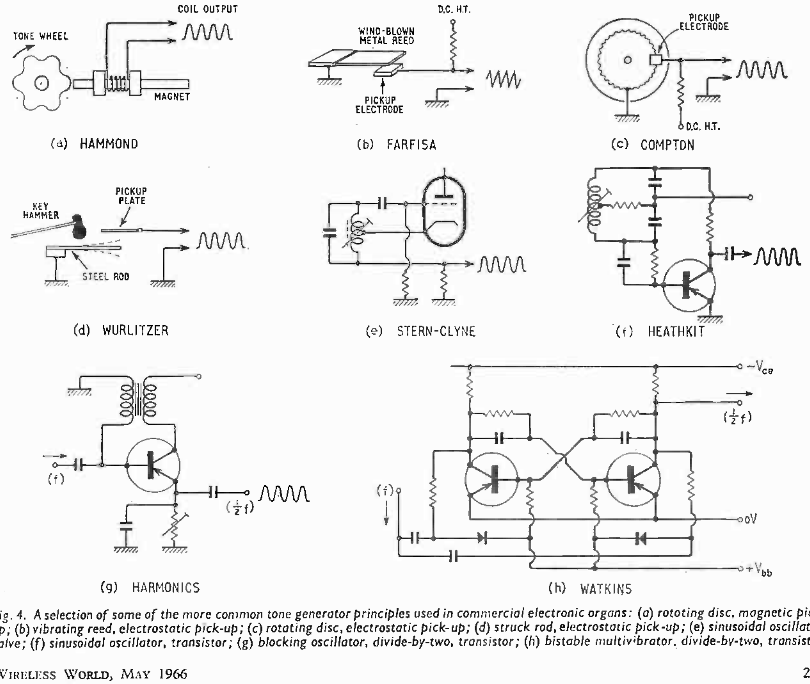


Fig. 4. A selection of some of the more common tone generator principles used in commercial electronic organs: (a) rotating disc, magnetic pick-up; (b) vibrating reed, electrostatic pick-up; (c) rotating disc, electrostatic pick-up; (d) struck rod, electrostatic pick-up; (e) sinusoidal oscillator, valve; (f) sinusoidal oscillator, transistor; (g) blocking oscillator, divide-by-two, transistor; (h) bistable multivibrator, divide-by-two, transistor.

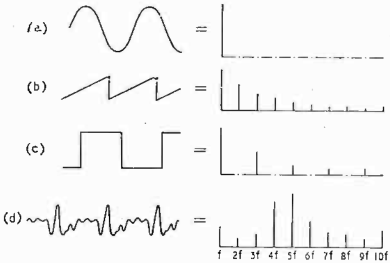


Fig. 5. Indications of the relative strength of the harmonics in basic waveshapes commonly produced by electronic organ generators compared with the complex waveshape required for a typical organ oboe stop: (a) sinewave; (b) sawtooth; (c) squarewave; (d) complex (oboe).

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(c), 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 C6 = 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 of 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 d.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

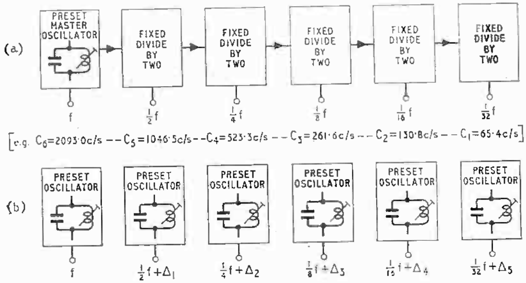


Fig. 6. Illustration of differences between locked-phase (a) and free-phase (b) oscillator systems in electronic organ. (The locked-phase system is also known as "divider" type or "synchronous" system.)

envelope like Fig. 7(a). 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" at Fig. 7(c) is the permitting of signals to fall off (or even cease) before the playing key is released. "Sustain" 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*: *V*ibrato varies the *F*requency, 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).

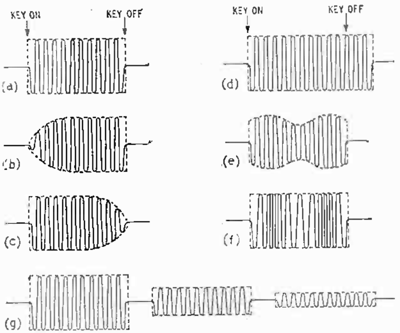


Fig. 7. Modifications of fixed-amplitude, fixed-frequency, waveshape to achieve various special "percussion" effects: (a) No percussion—instant start, instant stop, constant-amplitude, constant-frequency. (b) "Attack"—varying rate of increase of amplitude on switch on. (c) "Decay"—amplitude falling off before key off. (d) "Sustain"—signal continues after key off. (e) "Tremolo"—signal frequency constant but amplitude varied at low frequency (amplitude modulation about 6 c/s). (f) "Vibrato"—signal amplitude constant but signal frequency varies at low frequency (frequency modulation about 6 c/s). (g) "Reverberation"—signal repeated one or more times after key off, with progressively reduced amplitude.

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 handle low pedal notes without distortion. The swell pedal (volume control) receives

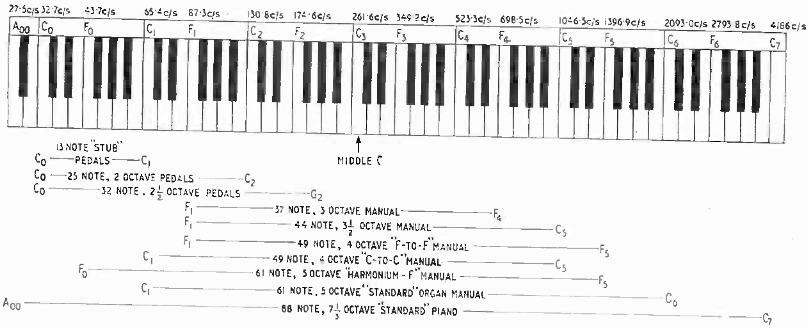


Fig. 8. Compasses of keyboards in various commercial organs compared with standard piano keyboard.

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 verw 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.

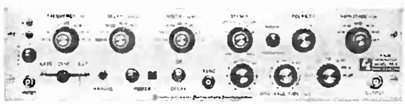
For basic principles and general reading, I can heartily recommend "Electronic Musical Instrument Manual," Pitman, 1961, and "Electrical Production of Music," Macdonald, 1957, both by A. Douglas. No textbooks exist covering current practice in this rapidly changing field, but some useful information can be gleaned from such books as "Electronic Organ Handbook," H. E. Anderson, Sams, 1962, and "Servicing Electronic Organs," C. R. Pittman and E. J. Oliver, Sams, 1962.

And for the "antiquarian," interested rather in the development of the electronic organ, recommended reading "musts" are "Electronic Music and Instruments" by B. J. Miessner, *Proc.I.R.E.*, Vol. 24, No. 11, Nov., 1936, and "Electronic Musical Instruments and the Development of the Pipeless Organ" by G. T. Winch and A. M. Midgley, *Journal I.E.E.*, Vol. 86, No. 522, June, 1940.

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).

The world's most versatile 1c/s to 16Mc/s solid-state Pulse Generator



made in England

The INTERCONTINENTAL PG-2 Pulse Generator is extremely versatile, ideally suited for a wide range of measuring applications—from testing amplifiers, radar, computers, memory cores, semiconductors, and A.C. coupled logic circuits to nuclear instrumentation. Panel height is only 3½".

ADVANTAGES:

- ☐ Repetition rate 1 c/s to 16 Mc/s
- ☐ Single or double pulse
- ☐ Positive or negative and complementary pulse
- ☐ One shot pushbutton
- ☐ Adjustable offset, delay and width
- ☐ No duty cycle limitations
- ☐ Linear rise and fall times variable from 12 nanoseconds to 20 milliseconds
- ☐ DC coupled output
- ☐ Adjustable trigger sensitivity, threshold and slope
- ☐ All solid state ☐ Price £380

The Intercontinental PG-2 Pulse Generator offers a combination of advantages unobtainable hitherto in any other instrument produced in this country.

Now that it is being made in England by the Instruments Division of Claude Lyons Limited, customers will, of course, benefit in many ways—not the least of which is the elimination of tedious duty-free formalities.

CLAUDE LYONS LTD
Instruments Division, Hoddesdon, Herts.
Tel: Hoddesdon 67161 Telex: 22724.
76 Old Hall Street, Liverpool 3.
Tel: MARitime 1761. Telex: 62181.

3771

WW—110 FOR FURTHER DETAILS.

JD 10

WORLD OF WIRELESS

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 altitude on a common frequency at the allocated times and the difference in μs, 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 flash. 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 these 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 Clarricoats, G6CL, 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.

E.E.A. Annual Report

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 inhibitions 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 if 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 "Raymarc" radar, presented by English Electric Ltd., a Marconi Marine "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 radar targets; improved reflections will ensure that the schooner can be under radar observation by other vessels. The schooner is owned by the Sail 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 Rothesay and six small stations in Central Wales will cover the main towns of Abergavenny, Bala, Brecon, Ffestiniog, Llandrindod Wells and Llandovery. 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 Iliffe 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 YUØIARU, 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 digitalization. Further details are available from the Department of Electrical Engineering.

Royal Society Awards.—Three awards of unstated value under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been made. To Dr. A. R. H. Cole (University of Western Australia) to enable him to gain experience in high resolution electronic spectroscopy; to Professor E. O. Hall (University of Newcastle, New South Wales) to enable him to gain experience in the use of thin film electron microscopy and to Professor E. R. Love (University of Melbourne) to assist him to continue work on integral equations and integral transforms. An award under the Paul Instrument Fund Committee worth £3,250 has been made to Professor A. F. Gibson (University of Essex) for work on the application of infra-red lasers.

A visit of a "**Spacemobile**" to this country is being arranged by the British Interplanetary Society and the National Aeronautics and Space Administration of America. The "Spacemobile" is a vehicle containing models, films and other visual aid equipment for demonstrating astronautics and will be on a three-month tour of the U.K. Schools, colleges, universities, adult education centres, industrial, service establishments and other organizations who wish to be included in the tour should contact the Society at 12 Bessborough Gardens, London, S.W.1.

The second session of the **Aeronautical Radio Conference** convened by the I.T.U. commenced on March 14th for a period of eight weeks at the Maison des Congrès in Geneva. The main purpose of the Conference is to draw up a new world-wide plan for h.f. long-range communications for aircraft flying on national and international civil air routes. This will be considered in conjunction with the development of v.h.f. communications to reduce the use of high frequencies for short-range communication in many parts of the world.

Radio Nepal.—A gift of a 100 kW Marconi h.f. transmitter, costing with associated equipment about £145,000, is being made to the Nepalese government by the Ministry of Overseas Development as part of the £1M capital grant made by the British Government to Nepal in 1960. With the new transmitter, Radio Nepal will be receivable in all parts of Nepal.

This year's **National Mobile Rally** organized by the Radio Society of Great Britain will be held on Sunday, May 1st, at the Bedford headquarters of Texas Instruments Ltd. The talk-in stations will be GB3BS on 160 and 180 meters s.s.b. and GB2VHF on 2 and 4 metres.

An **exhibition of educational equipment** arranged by Educational Instruments Ltd., is being held on May 9th and 10th at the Embassy House Hotel, 31 Queens Gate, London, S.W.7. Admission to the exhibition is free to all those interested in educational equipment.

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

Dr. J. W. King

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 year has been 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 Organization, 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 manager 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. Crampton,** who is 44 and has been with the company 27 years and has been regional production controller since 1964, has become production and cost control manager. **H. P. Kavanagh,** 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 E. 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

H. S. Macadie

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, jnr., 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 science 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. Wylie, 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. Wylie'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. Wylie 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 basic work on radar transmitters and receivers at the


Prof. C. W. Oatley

Radar Research and Development Establishment of the Ministry of Supply. Since 1945 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-


R. J. Watson

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.B.E., C.B., M.C., 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 37 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.

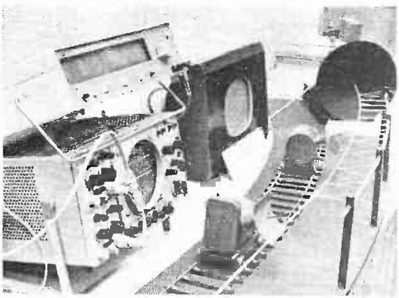
Physics Exhibition 1966

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 Gc/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



An exhibit illustrating how communication with moving trains can be achieved using guided surface waves of about 3 Gc/s.

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 Gc/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.

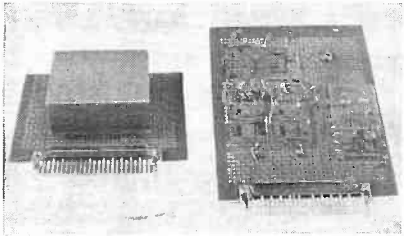
The gallium arsenide device is prepared on an epitaxial layer of GaAs 10 μm thick and of 1 Ωcm resistivity, which is grown on to a GaAs substrate 0.2 mm thick and 0.001 Ωcm in resistivity. The substrate is alloyed to a copper heat dissipator, this being the positive contact, and a small tin spot is fused 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 × 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



An example of frequency selective RC time-varying networks. The thin-film unit shown is a single sideband demodulator developed by A.E.I.

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 Blackheath. 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 these 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, much 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.

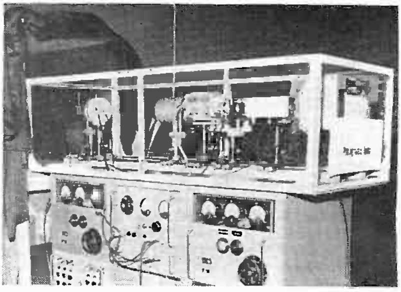
A hologram is made of an object (see previous item), but instead of viewing the image with the object removed, the object is left in place, resulting in the image being superimposed on the object. If the surface of the object then moves slightly interference takes place between corresponding points on 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

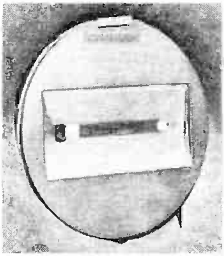


"Business end" of U.K.A.E.A. radar photography equipment—the entrance of the tunnel enclosure being visible on the left.

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.



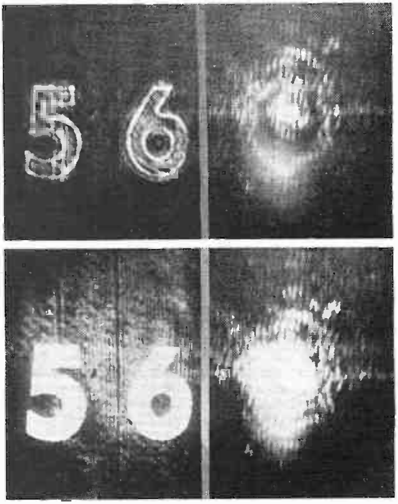
A small electronographic c.r.t. which uses a mica faceplate to enable direct photographic recording of images and eliminating the losses associated with a phosphor screen (G.E.C.)

It has been found that beam currents around 10^{-9} A are sufficient for recording compared with 10^{-6} A for conventional oscillography. 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 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.



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.

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 on to 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 tester 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 simple 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.

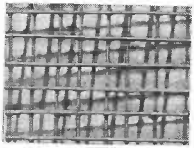
A correlation type of detector was also used at the receiving end of a system of **communication using noise type** signals demonstrated by Marconi. If a purely angle-modulated carrier is multiplicatively mixed with wideband noise, selection of one of the resulting sidebands gives a signal which to all 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 15 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 60μs.

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 successive 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 μV 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.



Illustrating the deposition of ferrite computer stores by electrophoretic deposition.

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.

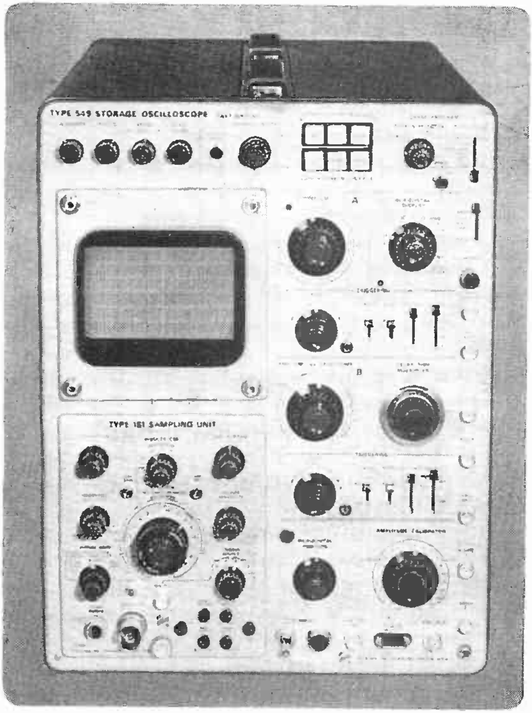
Read times of 50ms have been achieved with 0.005 in wires with an interrogate current of 300 mA.

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)



SEE US AT THE
I.E.A. EXHIBITION
STAND E553

The TEKTRONIX 549

has a dual personality

AS A **STORAGE** SCOPE

Enables holding single-shot events, and low duty cycle waveforms, for detailed analysis.
features include:
High writing speed—up to 5 cm/μsec, with enhancement, split-screen storage—storage on either upper or lower half of crt (with other half for conventional displays, if desired), automatic erase feature—with selectable viewing times from 0.5 seconds to 5 seconds. Storage feature adds a new dimension to sampling applications and spectrum analysis — permitting displays not possible with any other oscilloscope.

AS A **CONVENTIONAL** SCOPE

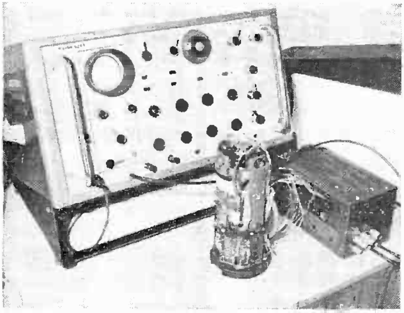
Accepts more than 20 plug-ins—either the Tektronix letter-series units or the newer 1-series units.
features include: calibrated sweep delay from 1 microsecond to 10 seconds, single sweep, 5X sweep magnifier, and full-passband triggering facilities.
The Type 549 can handle almost any laboratory application in the DC to 30 Mhz range.

PLUS ALL THESE APPLICATIONS: low-level differential-input · wide-band · sampling multi-trace · spectrum-analyzer · strain-gauge.
Type 549 Oscilloscope (without plug-ins) £981. Free of duty—subject to Treasury direction.

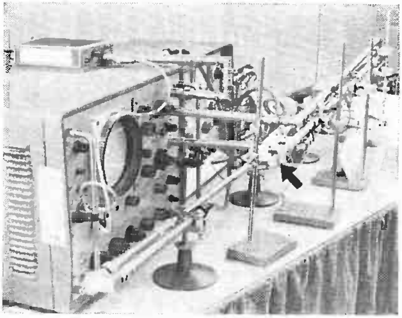
Tektronix U.K. Ltd. Beaverton House · Station Approach · Harpenden · Herts
Telephone: Harpenden 61251 · Telex: 25559

For overseas enquiries:— TEKTRONIX Ltd . Albany House . St. Peter Port . Guernsey . C.I. . TEKTRONIX CANADA LTD . Quebec . Toronto (Willowdale) . Ontario . TEKTRONIX AUSTRALIA PTY Ltd. P.O. Box 488 . Sydney . New South Wales . TEKTRONIX INTERNATIONAL A.G. P.O. Box 57 . Zug . Switzerland . TEKTRONIX INC · P.O. Box 500 . Beaverton . Oregon . U.S.A.

WW—112 FOR FURTHER DETAILS.



Wayne Kerr instrument for direct measurement of transfer functions, with electro-pneumatic servo unit in front.



Apparatus for reflectometry transistor measurements (College of Aeronautics, with black arrow showing coaxial line link containing transistor under test.

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.t. null indicator, then adjust the model until the null indicator shows that the model is equivalent to the system. Excitation can be a sinewave, 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.

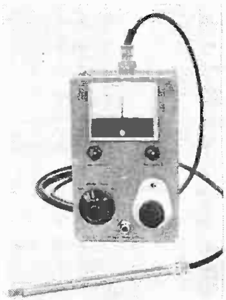
Transistor measurements by reflectometry, operating in the time domain, were demonstrated by the College of Aeronautics. The method is an extension of the technique for locating and analysing discontinuities in transmission lines by propagating impulses or step functions along them and examining the 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-Ω 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, 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.



Gallium arsenide thermometer using the temperature dependence of the forward voltage drop across a GaAs junction and developed by I.R.D.C.

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

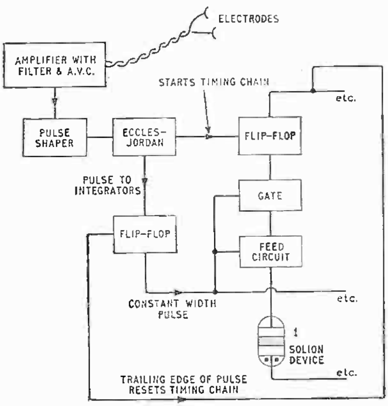


Fig. 1. Heart rate integrator.

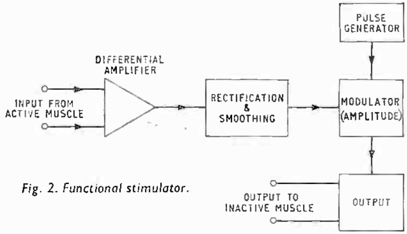


Fig. 2. Functional stimulator.

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.

Marketed 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 cleaner 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.

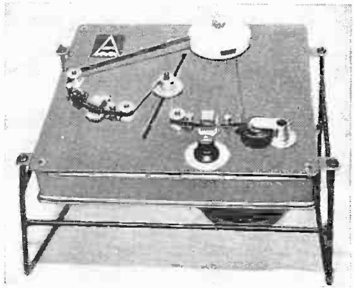
A correlator is being developed by the Clinical Psychiatry Research Unit at Graylingwell Hospital, Chichester, Sussex, to assist in the spatial analysis of electro-encephalogram signals. The form of e.e.g. is governed by the site on the scalp from which it is recorded, thus the topography of the e.e.g. 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.

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 250 mW 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?



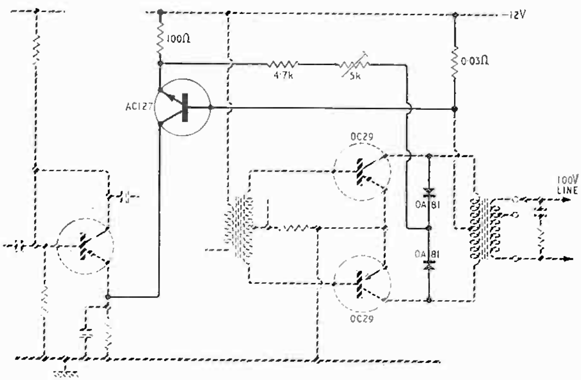
A tape transport mechanism developed by Planet Projects. This illustrates a simple method of obtaining a variable delay between recording and playback.

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 μV 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 μV and a distortion of 8%. 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



Protection circuit for Mullard 50W amplifier design to give protection against short circuited load. Rising current in the output stage causes the a.f. drive to be reduced by tending to cut off a transistor (OC71 on left).

A photograph which arrived too late for last year's display of early p.a. equipment. The transmitter-size amplifier (a W.E. No. 1 amplifier) was rated at 40 W and dates back to 1919.

The first microphone to be produced by the London Microphone Co. This moving-coil microphone is suitable for domestic tape recorder use and costs about £3 (retail).

includes the usual feature of automatic switching from mains to battery in the event of mains failure.

Armstrong have entered the p.a. field by modifying their 227 tuner-amplifier for 100 V line working. A version is available with a balanced 30 Ω input. As a high quality amplifier the distortion will be considerably less (0.5% at 8 W) than the average p.a. amplifier.

Microphones

Although a number of new types of microphone are under development (e.g. semiconductor and electret types) is it not expected that these will appear for some time in the p.a. field. Two of the new mikes 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 Ω is 300 μV/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 Reslo 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.

Some portable equipment

Of the mixers shown, the EMT104, shown by F. W. O. Bauch, was perhaps the most interesting. This robust portable transistor mixer includes a battery casette taking either primary or secondary cells and a charging unit. Some of its features are a peak programme meter, monitor loudspeaker, tone generator, rumble filter on each channel and a switchable limiter and compressor.

Two new portable transistor p.a. systems by the French firm of Bouyer were shown by Claude Lyons and Associates. In the smaller (5 W) version which measures about 22 × 5 × 3 in the amplifier is enclosed together with batteries and a number of loudspeakers. A stand mounting version is also available with a longer loudspeaker column.

A small sound level meter was shown by Cosmocord covering the range 60-95 dB s.p.l, with "A" weighting.

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); bandspread 3.5-30 Mc/s (calibrated for amateur bands).

Receiving Modes s.s.b., a.m., c.w.

Impedances 52-600 Ω (I/P) 3 and 500 Ω (O/P).

Sensitivity and (S+N)/N Average 1.5 μV for 10:1 s/n on a.m. and 0.7 μV on s.s.b. and c.w.

Selectivity Selectable sidebands, u.s.b. 1, 2 and 3 kc/s; l.s.b. 1, 2 and 3 kc/s; d.s.b. 0.5, 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.

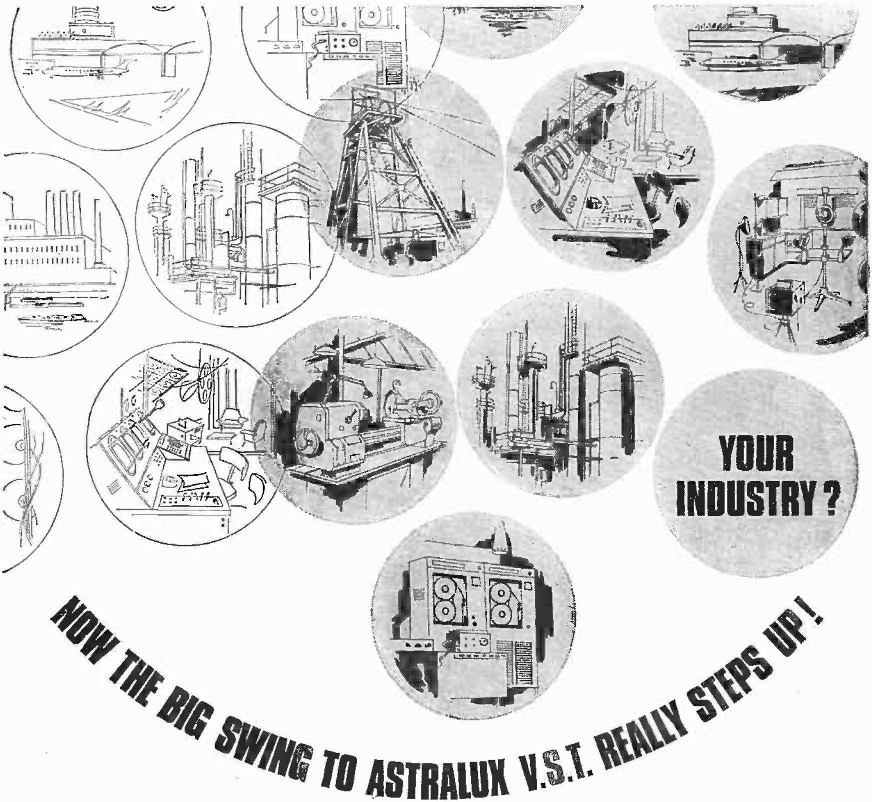
Local Oscillator 1st tunable; 2nd 2,580 kc/s (xtal); 3rd 395 kc/s. The receiver also incorporates a xtal filter (on 0.5 kc/s selectivity); b.f.o.; a.n.l.; xtal calibrator; power unit.

Gain Controls a.f., r.f.

Valves 18.

Semiconductors 2.

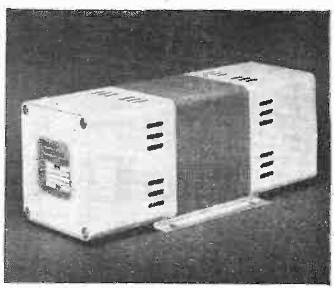
Additional Information Product detector, vernier tuning, aerial trimmer, calibrated "S" meter, 14 controls.



Everywhere Astralux Voltage Stabilising Transformers outperform and outdate conventional C.V.T. systems

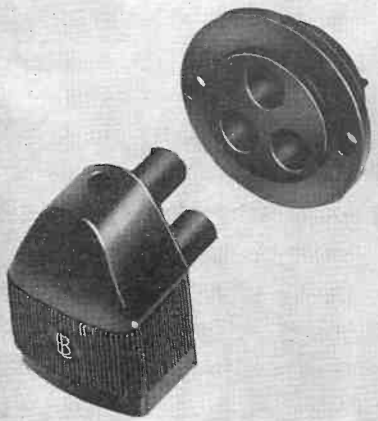
HERE'S WHY ASTRALUX V.S.T. IS REPLACING C.V.T. IN INDUSTRY AFTER INDUSTRY:

Better Performance. That means improved Output Voltage Stability—output voltage maintained within ± 0.5% for input voltage changes of + 10% — 20%. Even when the voltage fluctuation is as great as + 10% to — 30% the V.S.T. will maintain the output voltage to within ± 1%. ● **Latest Materials.** High temperature (Class F) materials give optimum reliability and increased safety margins on operating temperatures. ● **Low external field.** The latest techniques in magnetic core design give improved performance, coupled with high efficiency, while still offering low external fields. ● **Stable Voltage—Stable Prices.** ASTRALUX prices remain stable over long periods, so costing a job ahead is facilitated with this advanced system. ● **Over 10,000 models!** The ASTRALUX V.S.T. Standard Range consists of ten basic models with over a thousand variations on each. *No other manufacturer* offers such a choice, or can offer such economical prices. ● **Low Cost Specials.** You can order V.S.T. 'specials' at little more than the cost of standard units. Our design department will be happy to prepare prototypes to your specification, for incorporation into equipment under development.
Free illustrated booklet giving full details of ASTRALUX V.S.T. from



ASTRALUX *dynamics limited* TRANSFORMER DIVISION · BRIGHTLINGSEA · COLCHESTER · ESSEX · TEL: BRIGHTLINGSEA 417

WW—114 FOR FURTHER DETAILS.

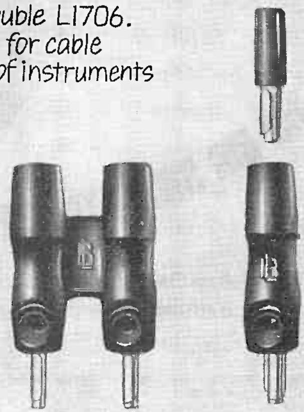


3 POLE POWER CONNECTOR L1722 P&S

finger-proof shrouds on plug and socket contacts. Rating 7amp AC 5 amp DC 250 volts.
Send for Leaflet P703

STACKING PLUGS

4 mm. 'OZ' contacts – single L1708 double L1706.
provide fully shrouded tap-off points for cable and plug-in connections on all types of instruments
Send for Leaflet P676



YOU SHOULD KNOW ABOUT THESE **NEW**

BELLING-LEE components

Write for leaflets mentioned above or telephone Miss Woolgar at Enfield 5393 Ext. 27

Belling & Lee Limited · Great Cambridge Road · Enfield · Middlesex · Telephone: Enfield 5393 · Telex: 263265

WW—115 FOR FURTHER DETAILS.

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. Capab lity 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 valves grid being held at a fixed potential V_B.

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,

$$V_{op} = \delta I_a \cdot R_L = V_{ip} \cdot g_{m1} \cdot R_L$$

$$G = \frac{V_{op}}{V_{ip}} = g_{m1} R_L \quad \ldots \quad (1)$$

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.

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_k in its cathode, its anode impedance is increased by a factor: $(1 + g_m R_K)$.

We can write for the cascode:—

$$r_a = r_{a2}(1 + g_{m2} r_{a1}) \quad \ldots \quad (2)$$

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

$$\mu = r_a g_m = r_{a2} \cdot g_{m1}(1 + g_{m2} r_{a1}) \quad \ldots \quad (3)$$

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

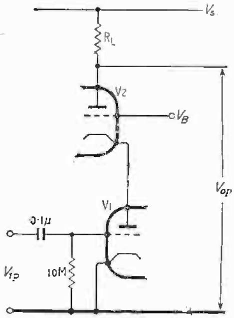


Fig. 1. Basic cascode circuit.

with r_a = 100 kΩ and μ = 70 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

SYMBOLS

g_{m1} g_{m2} g_m	Mutual conductance of V1, V2 and combination respectively.
r_{a1} r_{a2} r_a	Anode impedance of V1, V2 and combination respectively
μ_1 μ_2 μ	Amplification factor of V1, V2 and combination respectively
G_1 G_2 G	Voltage gain of V1, V2 and combination respectively
G	Overall gain after application of negative feedback.
V_{ip}	Signal input voltage
V_{op}	Signal output voltage
R_L	Anode load
V_{k3}	The d.c. voltage at the cathode of V3
Z_o	The output impedance at the anode of V2
C_M	Effective Miller capacitance at the grid of V1
β	The fraction of the signal voltage at the cathode of V3, which is fed back to the grid of V2

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 V2, and the g_m of V1.

Suppose now in Fig. 1 that a resistor was inserted between the anode of V1 (and cathode of V2) and the h.t. rail V_S. This would mean that V1 could be taking a reasonable current and so have a good g_m, whilst V2 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 V2 can now be cut-off without affecting the working conditions of V1, the bias of V2 (V_B) must be derived *via* potential divider of some sort from the anode of V2.
2. The anode load for V1 is the cathode of V2 and so is equal to $1/g_{m2}$ and when the mutual conductances of both valves are equal, the gain of V1 is equal to -1 and the Miller capacity at the grid of V1 is only about 3 pF (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 V1. 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 earthed grid of V2.

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 V2, and hence its cathode, is stabilised by the action of a potential divider from its anode, the effect of changes of bias on V1, 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 for the whole audio amplifier in which the cascode is incorporated is applied to a small resistor in the cathode of V1 (about 100 Ω, which has little effect on the parameters of the circuit); then, the 0.1 μF capacitor and 10 MΩ resistor in the grid circuit are outside the feedback loop, and so do not affect the phase shift over the cascode. Similarly, since V2 is drawing very low anode current the voltage feed, V_B, to its grid can be supplied by another 10 MΩ resistor and 0.1 μF capacitor, so giving virtually no l.f. phase shift down to very low frequencies.

The bias voltage, V_B, can be supplied in one of two ways:—

1. By direct potential divider from the anode of V2. This method has two disadvantages, the maximum value of resistance usually made in standard ranges is 10 MΩ, 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_L is too high cut off V2 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_L, although when R_L is around 1 MΩ 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 V2 the above drawbacks disappear.

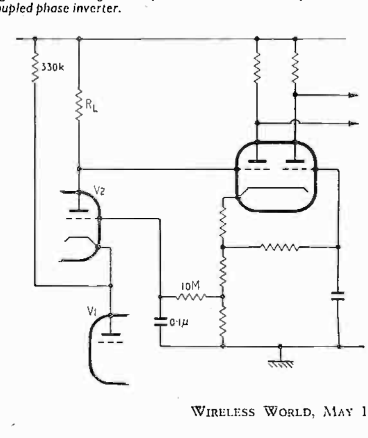
Usually in modern audio amplifiers the trend is to follow the input voltage amplifier with a directly coupled phase splitter, of the cathode-coupled variety, in this case the cathode resistor of the phase splitter may be replaced by two other resistors so forming the necessary bias network for V2, as 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 kΩ current bleed resistor was found experimentally for an anode load of 10 MΩ and on altering the load the value still seemed about optimum and so no experiments were conducted using values other than this.

S1 and R_2 were used to determine the output impedance of the circuit, R_2 being altered until closing S1 reduced the

Fig. 2. Bias arrangement of the cascode circuit to feed a cathode-coupled phase inverter.



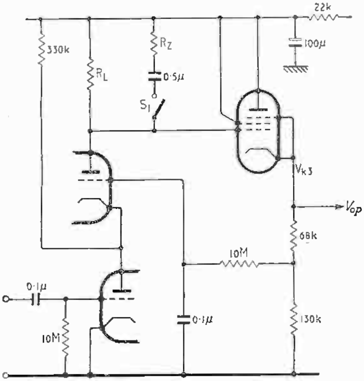


Fig. 3. Circuit used for measurements incorporating the cathode biasing method. Results are shown in Table I and Figs 6 and 8.

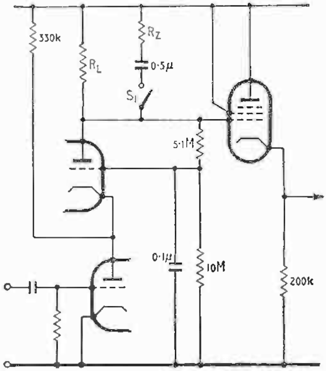


Fig. 4. Test circuit used for measurements. S_1 and R_2 were used to determine the output impedance. Results are shown in Table I.

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 V1, was also measured for different loads, this giving the measure of Miller capacity on the input, and also the gain of the cascode if:—

1. The grid of V2 is not decoupled to earth; or
2. The effect of putting a frequency sensitive network between the cathode of V3 and the grid of V2 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_L being the measured values of standard resistors.

As can be seen, when the anode load is in the order of 10 MΩ the output impedance is 3.5 MΩ. In the test circuit 3 the stray capacity at the anode of V2 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_o 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 V2, the total stray capacitance should not exceed 16 pF and so the 3 dB upper

TABLE I

				FIG. 3 Cathode follower bias					FIG. 4 Potentiometer bias				
RL	V_{k3}	C_M	G_1	G	G(dB)	Z_o	G_2	G/Z_o	G	G(dB)	Z_o	G_2	G/Z_o
16 MΩ	153V	103pF	68	4,800	73.5	3.8 MΩ	70	1.26	Cut-off				
13 MΩ	153	103	68	4,800	73.5	3.67 MΩ	70	1.26	940	59.5	2.58 MΩ	13.8	0.365
10 MΩ	153	90	60	4,400	72.8	3.52 MΩ	73	1.25	2,350	67	2.2 MΩ	39	1.02
6 MΩ	154	75	50	3,750	71.3	2.48 MΩ	75	1.52	2,500	68	1.73 MΩ	50	1.44
3 MΩ	157	53	35.6	2,850	69.0	1.72 MΩ	80	1.64	2,100	66	1.35 MΩ	59	1.55
1.5 MΩ	161	34	22.5	1,850	65.2	1.13 MΩ	82	1.62	1,480	63.5	940 kΩ	66	1.58
1 MΩ	165	24.5	16.3	1,325	62.5	790 kΩ	81	1.67	1,130	61	693 kΩ	69	1.63
620 kΩ	173	16	10.8	900	59.0	540 kΩ	83	1.67	815	58	493 kΩ	77	1.66
400 kΩ	184	11.5	7.6	632	56.0	370 kΩ	83	1.71	610	55.5	334 kΩ	80	1.83
253 kΩ	195	8.5	5.6	423	52.5	235 kΩ	75	1.80	418	52	203 kΩ	75	2.03
137 kΩ	217	5.5	3.6	251	48.0	130 kΩ	70	1.93	250	48	125 kΩ	70	2.0
91 kΩ	232	4.4	2.9	176	45.0	87.5 kΩ	61	2.01	175	45	86 kΩ	61	2.03
52 kΩ	253	3.1	2.1	98	40.0	51.1 kΩ	47	1.92	98	40	50 kΩ	47	1.96
30 kΩ	260	2.5	1.7	56.5	35.0	28.8 kΩ	33	1.96	56.5	35	28 kΩ	33	2.02

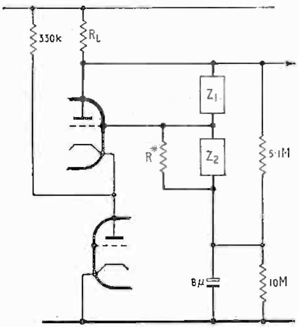


Fig. 5. Use of the cascode for equalization by frequency selective feedback. R^* is only required to provide bias if Z_2 is blocked to d.c.

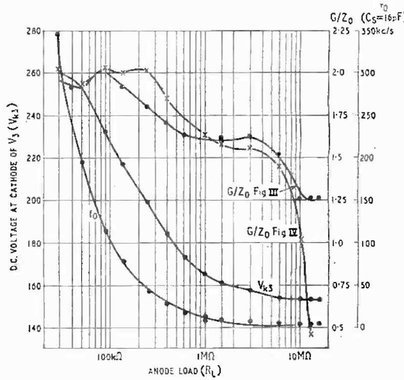


Fig. 8. Some of the results, listed in Table 1, obtained from the circuits shown in Figs 3 and 4.

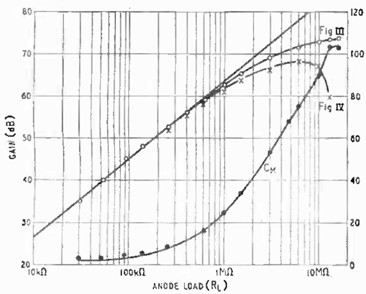


Fig. 6. Some of the results of Table 1 obtained from the circuits of Figs 3 and 4.

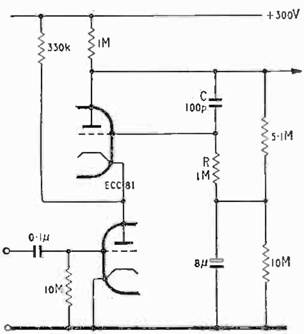


Fig. 7. Particular case of Fig. 5 for use as a tape playback equalizer.

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_o 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 μ 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_{k3}) were investigated by putting seven different new valves in the V1 and V2 position. The total gain variation was 10%, 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. 5, then the overall gain is a function of frequency.

The circuit now behaves with V1 as a pre-amplifier with gain G_1, and V2 as a frequency-selective feedback amplifier. The gain of V2 as a feedback amplifier is given by:—

$$G'_2 = \frac{G_2}{1+G_2\beta} \text{ where } \beta = \frac{Z_2}{Z_1 + Z_2}$$

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 lift supplied by the overall circuit, but for values of R_f greater than about 1 MΩ 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:—

$$G' = G_1 \cdot G'_2 = \frac{G_1 G_2}{1+G_2\beta} = \frac{G}{1+G_2\beta} = \frac{G(Z_1+Z_2)}{Z_1 + Z_2(G_2+1)}$$

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 μs with a total top cut of about 36 dB, the l.f. gain being 60 dB, dropping to 24 dB at h.f.

Ceramic Cathode-ray Tube

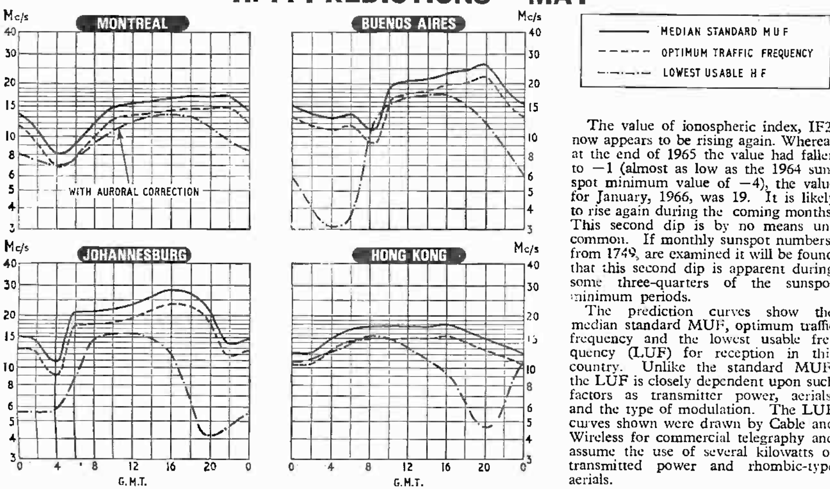
Cathode-ray tubes can be a relatively unreliable part of the electronic equipment of many aircraft, space and defence systems, and in order to achieve great reliability a ceramic c.r.t. (for magnetic deflection) has been produced. The device has been developed by Elliott-Automation to meet a need for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

Magnetically focused ceramic c.r.t. developed by Elliott-Automation.

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.

H. F. PREDICTIONS — MAY



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.

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 on 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 and if necessary moniter 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.

A "patient" demonstrates the new Marionette 10in X-ray image intensifier.

New S.T.C. Subsidiary.—The activities in the semiconductor field of the S.T.C. plants at Footscray and Harlow 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 Electrosil Ltd. have been able to effect price reductions in the Signetics range of integrated circuits. All 14-lead flat package items in the SE1000 military D.T.L. (Diodes Transistor Logic) are reduced by between 30% and 40% and those in the NE100 industrial D.T.L. range by approximately 40%. Of the other military ranges, all packages in the SE400J low-power T.T.L. (Transistor Transistor Log 16) range have been reduced by between 25% and 35% 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 net sale or return figures 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.

Year	Radio Receivers	Radio-grams	Tele-vision
1963	2.616M	0.274M	1.678M
1964	2.139M	0.282M	1.903M
1965	1.73M	0.233M	1.681M

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 Broad Street, New York, N.Y.4. The function of the new company is to market European components in the United States.

The Electronic Industries Association of America have announced peak sales of colour, and monochrome television sets for 1965. In 1964 monochrome sales totalled 7.685 million, while 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 Perth. The order is worth about £40,000.

Annual Report of B.E.A.M.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 (VASCA) 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. (Paignton) 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 a 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. Philips of the Netherlands and North American Philips Company.

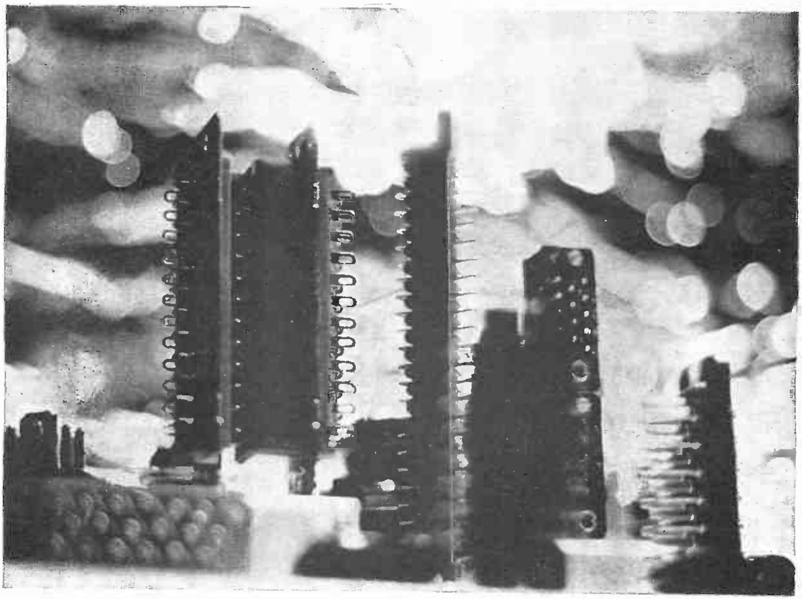
Under the terms of the contract, Philips and Westinghouse will effect a complete interchange of device specifications as well as process specifications and manufacturing technologies for their lines of digital and linear integrated circuits.

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.



McMURDO ELECTRONIC COMPONENTS

THE McMURDO INSTRUMENT COMPANY LIMITED
RODNEY ROAD · PORTSMOUTH · TEL 35361 · TELEX 86112

AGENTS—NORWAY: J. M. Feiring A/S, Lilletorvet 1, Oslo.
PERU: Estemag Peruana S.A., P.O. Box 2838, Lima.
PHILIPPINES: C&C Commercial, P.O. Box 2419, Manila.

WW—116 FOR FURTHER DETAILS.

the tube that makes the "portable" all picture

new MAZDA RIMBAND 12 inch T.V. TUBE

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.

For full technical details, please write to:

Thorn-AEI Radio Valves & Tubes Limited

7 Soho Square, London W1.
Telephone: GERrard 5233

TA3323

WW—117 FOR FURTHER DETAILS.

By

H. O. CODON

Communication Theory and Colour Television

Some degree of stability has been achieved in the U.K. colour television situation by the T.A.C's recommendation of the PAL 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[1,2,3]. This requires several times the bandwidth of the original signal, though in one case[2] 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 coloured 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 $p \times rn^2$ 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 $\frac{1}{2}prn^2$. 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[4] that, subject to suitable definitions of effective pulse width, a Gaussian pulse gives the minimum value of $\frac{1}{2}$ 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 $(1+\cos x)$ from $-\pi$ to $+\pi$. Several mathematical analyses[5,6] 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

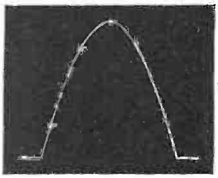


Fig. 1. A half cycle of sine wave.

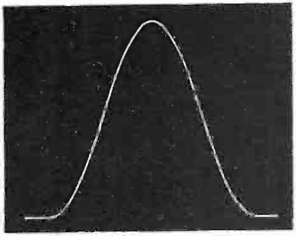


Fig. 2. A raised-cosine pulse.

required bandwidth is taken to be $(1/k)\ \frac{1}{2}\ p.\ rn^2$ where k is the "Kell factor" which is of the order of 0.7, various estimates of it ranging from 0.53 to 0.85.

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[5] 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 publicized in 1953[7,8], 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[9] 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 [1,2] have suggested at least 32 levels.) The trouble is that long runs at uniform brightness are not so common: the orders of magnitude

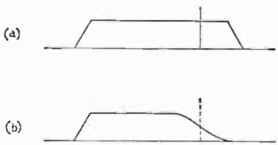


Fig. 3. (a) Transmission characteristic of vestigial-sideband transmitter; (b) transmission characteristic of vestigial-sideband receiver.

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[10], 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 leads ultimately to the use of within-band sub-carrier for colour, 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[8, 12]. 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 exactly half-way between two frame-multiple 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[13] 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-interlace has also been tried as a means of reducing the bandwidth required for colour[14], but appears to have been abandoned.

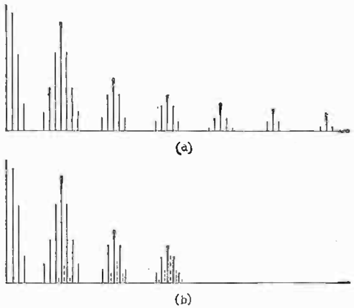


Fig. 4. (a) Schematic spectrum of television signal; (b) result of "folding" the spectrum in order to reduce bandwidth.

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, θ 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 θ 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-

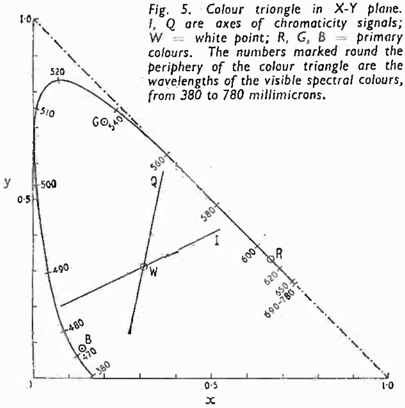


Fig. 5. Colour triangle in X-Y plane. I, Q are axes of chromaticity signals; W = white point; R, G, B = primary colours. The numbers marked round the periphery of the colour triangle are the wavelengths of the visible spectral colours, from 380 to 780 millimicrons.

city components $a = A/(A + B + C)$, $b = B/(A + B + C)$ and $c = C/(A + B + C)$. But it is obvious that $a + b + c = 1$ so one need specify only two chromaticity components; and these can be represented by the x and y co-ordinates in Fig. 5 and may be regarded as the normalized contributions from two of a set of imaginary primaries X, Y, Z such that the triangle XYZ encloses the whole 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. are ready for direct application to the colour tube in a receiver.) The two components of modulation applied to the sub-carrier are:—

$$E'_Q = 0.41(E'_B - E_Y') + 0.48\,(E_R' - E_Y')$$
$$E'_I = -\,0.27\,(E_B' - E_Y') + 0.74\,(E_R' - E_Y')$$

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_Y', E_Q' and E_I'.

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[15], 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_I 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_Q 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 3.6 Mc/s in a nominal 4 Mc/s channel, E_Q may be approximately double-sideband but E_I 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[17] (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_I tends to convey hue, rather than saturation, because it is based on the difference between red and blue signals. It is E_Q which has the smaller bandwidth of the two in N.T.S.C.) It follows that E_I vanishes from the sum of successive lines, leaving E_Q, while similarly E_Q alone is recovered from their difference. If a phase-sensitive detector is used, an error ϕ in the reference phase will only reduce the amplitude of the colour signal by cos ϕ.

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 NIR 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 store is thus able to bring together simultaneously the modulated sub-carrier and the reference oscillation, 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 of 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 [18] 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 cause trouble.

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 poorly utilized channel for most of the time, or average over such a long sequence of fields that video tape recording seems the only available means of storage.

On the choice of modulation for radio transmission, there are ample theoretical studies showing that the present vestigial-sideband system is a good compromise between the minimum redundancy of a single-sideband system and the requirements of simple receiver design. From the point of view of monochrome signals only, communication theory suggests that most of the video band should be subjected to a pre-emphasis of nearly 6 dB per octave, so that the signal transmitted should have a flat spectrum, rather than a falling one. Looked at in another way, this is approximately equivalent to differentiating the video signal before transmission, to be followed by integrating in the receiver, which (a) in the transmitted signal gives prominence to the edges and boundaries which convey most information and (b) in the receiver reduces random noise. However, this would be incompatible with present colour systems, which only work because the monochrome spectrum is of low intensity at the frequency of the sub-carrier.

There is a degree of asymmetry in present colour systems, since horizontal resolution is reduced by a factor of two or three for E_I and about six for E_Q but vertical resolution is unchanged for colour in N.T.S.C. or reduced by two in SECAM and PAL. Since flicker is such a powerful factor in setting frame frequency, one wonders whether whole fields could somehow be interlaced in colour. Obviously the transmission of a colour signal cannot be delayed for a whole frame, since this woud lead to colour trails behind moving objects, so one then comes to the dot-interlace scheme of colour television[15]. Just as line interlace is normally used, so each line can be broken up into groups of say three dots, which are transmitted in only one colour at a time, red, green or blue. Thus if one used in three successive scans the sequences RGB, GBR and BRG, super-position of the three scans would give all three colours for all three points.

The main trouble is that in this form the system makes use of the wrong tolerance in colour: it reduces bandwidth by allowing the formation of colour to be extended in time, instead of by degrading the spatial resolution in colour. It is also rather inflexible in the sharing of bandwidth between the three colours; unequal allocation is possible by giving two scans of green to one each of red and blue, but only such integral proportions are possible. The practical stumbling block is that dot systems are not immediately compatible with simple monochrome reception, and the more one refines the dot system the worse is the compatibility problem. To set against the pattern which can be created by the sub-carrier in the N.T.S.C. system, there is the break-up of the picture into dots, though this is theoretically at a higher frequency.

One is forced to the conclusion that although sub-carrier colour systems have no fundamental merit, and work only by virtue of the inefficient use of the channel by monochrome signals, they have great practical merit. Whether communication theory will guide anyone to a system having sufficient advantages to justify abandoning direct compatibility with existing receivers must remain an open question.

*It has been suggested that only the centre of interest of the picture should be scanned in full detail: a spiral scan could be made to give fine detail in the centre of the picture and coarser coverage of the outer parts.

REFERENCES

1. "Television by Pulse Code Modulation," by W. M. Goodall. *B.S.T.J.*, vol. 30, p. 37 (Jan. 1951).

2. "Video Transmission over Telephone Cable Pairs by Pulse Code Modulation," by R. L. Carbrey. *Proc. I.R.E.*, vol. 48, p. 1545 (Sept. 1960).

3. "Digital Television Transmission." *Wireless World,* March 1966.
4. "Theory of Communication," by D. Gabor. *J.I.E.E.,* vol. 93, Part III, p. 429 (1946).
5. "Television Detail and Selective-sideband Transmission," by S. Goldman. *Proc.I.R.E.,* vol. 27 p. 725 (1939).
6. "Influence of Transmission Bandwidth on Television Picture Quality," by J. Schunack. *Archiv. Elekt. Ubertragung,* vol. 3 p. 301 and p. 323 (1949); and vol. 4, p. 75 and p. 113 (1950).
7. "Some Possibilities for the Compression of Television Signals by Re-coding," by E. C. Cherry and G. G. Gouriet. *Proc.Inst.Elect Engs.* vol. 100 Part III, p. 9 (1953).
8. "*Information Theory and its Engineering Applications,*" by D. A. Bell. Pitman, London, 3rd edition, 1962.
9. "Run-length Coding of Television Signals, by J. O. Limb and I. G. Sutherland *Proc.I.E.E.E.* vol. 53 p. 169 (Feb. 1965).
10. "Some Properties of Digital Television Systems with a Variable Number of Lines and Fields," by V. P. Mandrakzi and D. A. Novik. *Radiotekhnika* (U.S.S.R.) vol. 17 no. 10, p. 35 (Oct. 1962).
11. "A Theory of Scanning and its Relation to the Transmitted Signal in Telegraphy and Television," by P. Mertz and F. Gray. *Bell Syst. Tech. J*, vol. 13 p. 464 (1934).
12. "Spectrum of Television Signals," by D. A. Bell and G. E. D. Swann. *Wireless Engr.,* vol. 33 p. 253 (1956).
13. "Reduction of Television Bandwidth by Frequency Interlace," by E. A. Howson and D. A. Bell. *J.Brit.Inst.Rad. Engrs.,* vol. 20, p. 127 (1960).
14. "Dot Systems of Colour," by W. Boothroyd. *Electronics,* vol. 22, no. 12, p. 88 (Dec. 1949); and vol. 23 no. 1 p. 96 (Jan. 1950).
15. "Frequency Interlace Colour Television," by R. B. Dome. *Electronics,* vol. 23 no. 9, p. 70 (Sept. 1950).
16. "Henri de France Colour Television System," by R. Chaste and P. Cassagne. *Proc.I.E.E.,* vol. 107B, p. 499 (1960).
17. "PAL," by M. Cox, *Wireless World,* vol. 69, p. 584 (Dec. 1963).
18. "A Single-Carrier Colour Television System," by E. J. Gargini. *Wireless World,* vol. 71 p. 210 (May 1965).
19. "From Russia with Love." *Wireless World,* Feb. 1966 p. 73.

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 322 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 323 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 324 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 (90.0/200.0) listing the company's semiconductor application notes, article reprints, manuals and papers. Requests should be made to the General Electric Company, Distribution Services, Building 6, 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 Brüel and Kjær,** 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 327 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 "slimline" 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 329 for further details

Autospec Success is the title of publication SP149 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 330 for further details

Transet Variable Ratio Transformers is the title of a 6-page folded leaflet describing a new range of transformers manufactured by Smith Hobson Ltd., Hersham Trading Estate, Walton-on-Thames, Surrey.
WW 331 for further details

British Insulated Callender's Cables Ltd., 21 Bloomsbury St., London, W.C.1, announce a new publication No. 508, **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 332 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 333 for further details

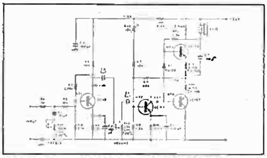
Circuit diagram available for each type of pack

Pre-selected for performance to cut development and production costs!

The transistors are arranged in sets and carefully graded for performance characteristics in a range of standard audio amplifiers of different outputs. This means improved, predictable performance for amplifiers in industrial equipment – with reduced production and development time, and lower overall costs.

BRIMAR Transistor Packs offer you:

- Audio amplifier circuit designs.
- Balanced characteristics, giving a narrower spread of performance than could be obtained from a random selection of transistors.
- Packaged sets for convenience of assembly.
- Coloured sleeves for easy identification.
- Lower production costs.



See these and other BRIMAR semiconductor devices at the THORN-AEI

STAND G109

I.E.A. OLYMPIA

Selection of Transistor Packs and Circuits available

For audio amplifiers

LP15	0·4W Class B push-pull amplifier, 9V supply.
LP17	1·5W complementary single-ended Class B output stage, 25V supply.
LP19	3W Class B single-ended push-pull output stage, 25·5V supply.
*YP56	8W Class B push-pull output stage, 25V supply.

For tape recorders

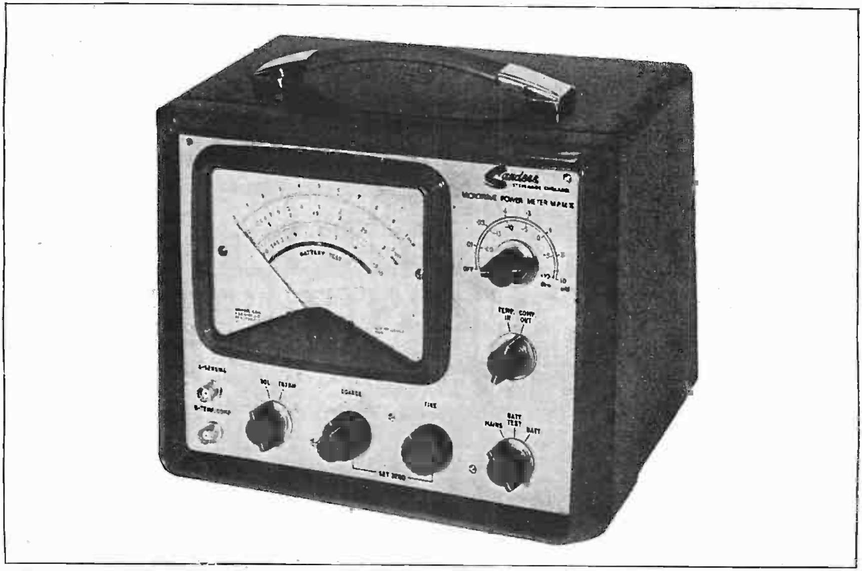
*YP54	Educational tape recorder, microphone input—headphone output, 24V supply.

* *Development packs.*

Thorn-AEI Radio Valves & Tubes Limited

7 Soho Square, London W.1.
Tel: GERrard 5233

WW—118 FOR FURTHER DETAILS.



SEE THE LATEST ADDITIONS AND CURRENT RANGE OF SANDERS MICROWAVE EQUIPMENT ON

STAND N 403 I.E.A. EXHIBITION

● Attenuators ● Bench Supports Clamps & Carriages ● Bends & Twists ● Crystal Detectors & Mixers ● Directional Couplers ● Educational Microwave Equipment ● Ferrite Isolators ● Waveguide Horns ● Junctions ● Loads ● Oscillators & Signal Generators ● Phase Shifters ● Power Meters ● Power Supplies ● Short Circuits ● Standing Wave Detectors ● Transitions ● Tuners & Variable Impedances ● Wavemeters ● Flexible Waveguides

Sanders are one of the leading European manufacturers of microwave equipment and, in the U.K., exclusive representatives for:— **Weinschel Engineering Co., INC. Gaithersburg, Maryland, Santa Monica, California, U.S.A.**

Sanders

MICROWAVE

W. H. SANDERS (ELECTRONICS) LTD.
A SUBSIDIARY OF MARCONI INSTRUMENTS LTD.

GUNNELS WOOD ROAD, STEVENAGE, ENGLAND.
Tel: Stevenage 2311 Telex 82159
Cables Sandelect Stevenage.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

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.

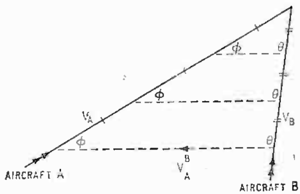
(b) The successful operation of the equipment depends on complete serviceability of *both* units in *both* aircraft. Things like this go "on the blink" with monotonous regularity. One fault in either system and all is useless.

(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 aerial moves transversely (i.e. spherically) in following the stranger, the two aircraft are designed to miss each other. If the aerial stays geometrically stationary in following the other aeroplane the relative velocity is through the two aircraft with no angular component, and a collision course exists.

Warning of an impending collision could either be presented to the pilot or arranged to tweak the autopilot so that the relative velocity changes into one with an angular component subtended at the aerial and collision is avoided. The presentation of range and velocity information to the pilot as a bonus presents no problem, using the Doppler effect mentioned by Mr. Gilmour.

Where several aircraft are within range the locking radar would investigate each in turn, the nearest first. Once the aerial has locked on and moved while following its target it has satisfied itself that no danger exists and goes on to the next trace. This would only take a few seconds; no problem at 100 miles range even at closing velocities of 1,200 m.p.h.

This system, though idealistic, has none of the immediate snags prevalent in Mr. Gilmour's:—

(i) The system is positive for all straight line flying, and takes account of rates of climb and descent.

(ii) The system is entirely self-contained. One's own careful airline has no need to trust the servicing and operating integrity of a small airline operating across the Atlantic at the "lowest fare ever."

(iii) If both aircraft have the system, one unserviceable is still a safe state of affairs.

(iv) The pilot is not bothered until something threatens, which is as it should be.

In conclusion, I am delighted to see this subject coming up in other than aeronautical circles. The evolution of the supersonic transport and proposed narrower air corridors demand the rapid development of such a device.

G. L. PERRY

Officers' Mess,
R.A.F. College, Cranwell.

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. Milligan 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 manufacture 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 Misnomer?

THE letter from Mr. P. S. Pinder in your April issue can only produce my complete agreement, but what a shame that 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"!

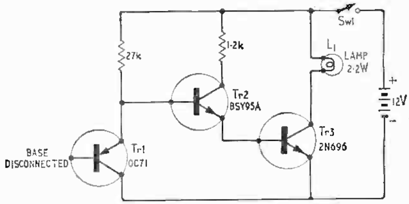
However, I will come down on Mr. Pinder's side—after all, why should the bistable be so privileged above members of its own family?

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-flip' and an astable a 'flop-flop.'"—Ed.

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 inoperative 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

$$= \frac{2.2 \times 10^3}{12 - V_{SAT}} = \frac{2.2 \times 10^3}{11.7} = 188\text{mA}$$

current required to saturate Tr3

$$= \frac{188}{\beta(\text{min})\text{ of Tr3}} = \frac{188}{20} = 9.4\text{mA}$$

As Tr2 and Tr3 form a darlington pair and Tr2 remains saturated when circuit is in use, therefore current in

$$\text{Tr2} = \frac{12 - V_{SAT} - V_{be}}{1.2} = \frac{12 - 0.3 - 0.7}{1.2} = 9.2\text{mA}$$

This current is enough to saturate Tr3 which requires

$$\frac{9.2}{\beta\,(\text{min})\text{ of Tr2}} = \frac{9.2}{30} \simeq 0.3\text{mA}.$$

Current of about 0.45mA is enough in the 1st stage. For Tr2 to saturate V_{b1} must rise to at least 1.6V with respect to negative earth. The impedance of Tr1 is about 3.5k in the dark. Therefore $V_{b1} = 0.45 \times 3.5 = 1.57$ 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, Essex. — S. K. CHAWLA

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 thermistor 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

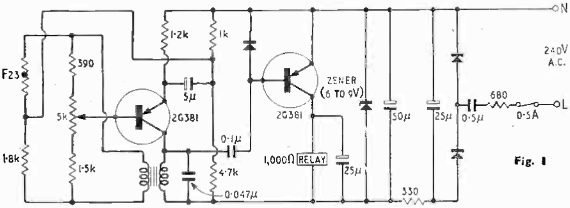


Fig. 1

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 2,000 Ω 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

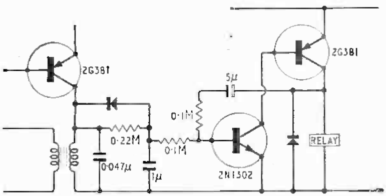


Fig. 2

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 2 V 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 (1,000 V 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.

Bexhill-on-Sea, Sussex. C. Q. KEILLER

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 240 V 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.

Stroud, Glos. JOHN WEBSTER

* Make sure the mains supply is a.c.—ED.

"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.

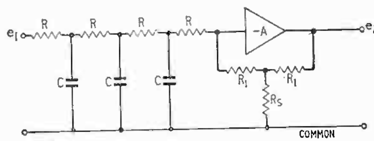
It may be shown that if the amplifier has zero input impedance (i.e. virtual earth) the fundamental frequency of oscillation is given by

$$f = \frac{\sqrt{10}}{2\pi CR} \quad \left\{ \text{c.f.} \; \frac{\sqrt{6}}{2\pi CR} \right\}$$

and the amplifier output voltage by

$$e_2 = \frac{1{\cdot}274 e_1}{56R} R_1 \left(2 + \frac{R_1}{R_s}\right)$$

where e_2 is the sine wave peak-to-peak amplitude and e_1 is the square wave peak-to-peak amplitude. This output amplitude may readily be adjusted by varying R_s.

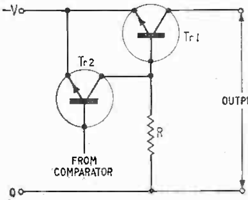


By using an operational amplifier a high open-loop gain may be achieved together with a low output impedance, thus ensuring a true virtual earth input and eliminating the need for a buffer between oscillator and load.

Basingstoke, Hants. J. W. HARMAN

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 30 W, is only required to dissipate around 1 W.



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 ~ 100 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 Tr1/Tr2 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 15s 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.

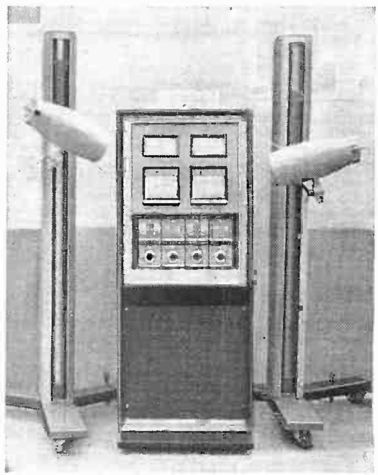
The prism is a lens-like structure comprising a volume of liquid enclosed between two transparent plates and a bellows. In normal operation the two plates are parallel and no deflection of the light rays occurs. When a displacement signal is received, however, the plates are moved at an angle to each 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. for the American manufacturers, Dynasciences Corporation, by the Livingston 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

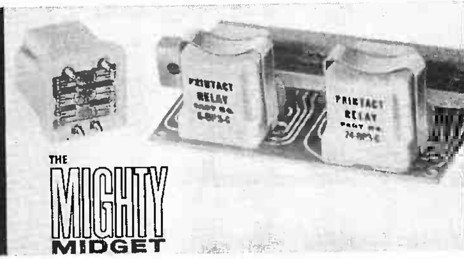
KIDNEY function studies employing radioactive isotope tracers will be assisted by a specially developed renal function analyser with two separate channels. This equipment, made by Isotope Developments Ltd., employs two scintillation counters, which are so positioned on two vertical columns that the patient 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.

RELAYS—
Immediate Delivery

PRINTED CIRCUIT RELAY



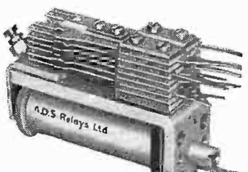
G & R and LATCHING RELAYS

PRINTACT miniature relays are designed solely for printed circuits. 6, 12 and 24 volts; 500 mW; 5,000,000 operations; Palladium contacts; — 30 C. to + 95 C. 3 to 7 millisecs. ⅞in. cube; 0.8 oz.; 1000 V. insulation; Bifurcated double break contacts; Balanced armature; Enclosed housing; Plug-in application; Encapsulated coil; Self-wiping contacts; Inherent snap-action, greater switching versatility—

***and still the* MINI-Q** **the economical 4 pole miniature plug-in relay.** High Sensitivity, Twin contacts to switch 1a. at 100 V.

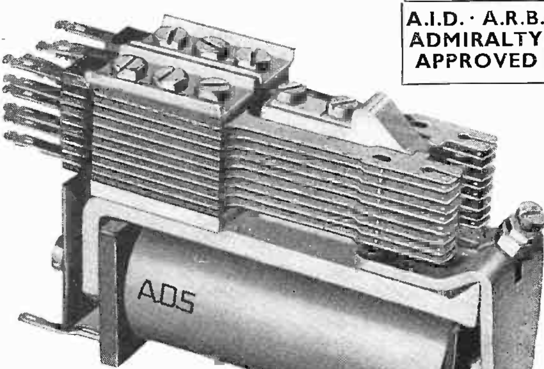
MINI G.P.

S1500 PO. Miniature General Purpose relay. Miniaturised version of P.O. 600 type with identical specification. ¾in. × 1¼in. × 2¼in. plus tags.
Ideal for printed circuits



Illustrated ¾ of actual size

A.I.D. · A.R.B. ADMIRALTY APPROVED



14 Days' Delivery
of 3000, 600 & MINI G.P. types

Continuous expansion now means 2 weeks' delivery of standard 3000, 600, MINI G.P types. Variants available: PLUG-IN, TWIN RELAY, 30A, REMANENT, LATCHING, TIMER, TRANSISTORISED.

48 HOURS' PROTOTYPE SERVICE

Mark ***URGENT*** enquiries 'E.M.S.' for EXPRESS MANUFACTURING SERVICE'

A.D.S. RELAYS LIMITED

97 ST. JOHN STREET, London, E.C.1. Phone: CLErkenwell 3393. Cables: ADSRELAYS, LONDON, E.C.1.

WW—120 FOR FURTHER DETAILS.

5–Experiments and Decisions

(*Concluding the series*)

By D. A. BELL,* M A., B.Sc., Ph.D., M.I.E.E., F.Inst.P.

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 irreversible. 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[1]) 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 will 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.

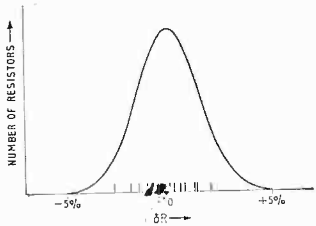
*University of Hull.

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 teleprinter 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



The short vertical lines indicate by their positions along the scale of R the differences from nominal value of fifteen resistors. It is reasonable to assume that the bulk quantity of resistors, from which these fifteen were drawn, have the gaussian distribution centred on the correct value, which is represented by the curve?

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%, 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*.

$$t = \frac{(\bar{x} - \bar{X})}{{}_c\sigma_s} \sqrt{n} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where $\bar{x}$ is the mean of the sample, $\bar{X}$ the mean of the whole population, n the number in the sample, and ${}_c\sigma_s$ is related to the variance of the sample:

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

The quantity $m = n - 1$ is said to be the number of " degrees of freedom " of the sample parameter ${}_c\sigma_s$: 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, $\bar{x} - \bar{X} = 0.012$, $n = 15$, and ${}_c\sigma_s = (1/14)\ \Sigma\ (x - \bar{x}^{2})$ which for 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 Burington 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 60% 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

	Obtain O.N.C.	Do not succeed	Total enrolled students
Engineering	539 (542)	561 (558)	1100
Building	54 (51)	48 (51)	102
Totals	593	609	1202

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 4×3 table). The statistician can then write into each cell the difference δ 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 $\pm$ ambiguity is eliminated by squaring δ, and that in general the square of δ is likely to be proportional to the independence value m; so we derive a measure

$$\chi^2 = \Sigma\,(\delta^2/m)$$

where the summation is taken over all cells in the table. There are tables of χ^2 showing for various degrees of freedom the probabilities of various values of χ^2 arising by chance. If the value of χ^2 is greater than could occur by chance with an acceptable degree of probability, 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 δ is the same in all cells, but of course there are different values of m,

so that $$\chi^2 = 9\left(\frac{1}{542} + \frac{1}{558} + \frac{2}{51}\right) = 0.386$$

Now looking in the table of χ^2 under one degree of freedom we find $\chi^2 = 0.148$ 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 χ^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 of 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 to all colleges, (b) they refer to a single year and (c)

*This is the form given by Yule and Kendall in " An Introduction to the Theory of Statistics." Burington and May, in " Handbook of Probability and Statistics, give the algebraically equivalent and apparently simpler formula $t = (1/{}_c\sigma_s)\,(\bar{x} - \bar{X})\sqrt{(n-1)}$ where σ_s is the ordinary variance of the sample. It is less easy to explain the factor $n-1$, rather than n, in this form.

†Based on figures given on p. 356 of the Crowther Report, "15 to 18," H.M.S.O., 1959.

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 times of 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* α and a *lost-signal risk* β, a terminology which is applicable to many situations including radar. In the b.s.c. one makes the false-alarm risk ($0 \rightarrow 1$) equal to the lost-signal risk ($1 \rightarrow 0$) 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 false alarm subject to 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 β necessarily fixes also the value of α. 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 α against the change in β 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 (BMEWS) 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 α rather less than β, i.e. set the threshold a little higher than half way between space and mark. So let π_0 and $\pi_1 = 1 - \pi_0$ 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 π_0 (the frequency of occurence of spaces) by α (the proportion of mistakes made on spaces) and C_0 (the cost of each such mistake) one finds $\pi_0\, \alpha\, C_0$ as the cost arising from false-alarm errors, and $\pi_1\, \beta\, C_1$ for lost-signal errors. The total cost $R = \pi_0 \alpha C_0 + \pi_1 \beta C_1$ is minimized if for every signal y one computes the likelihood ratio $L(y)$ and sets the dividing line in L at the value

$$K = \frac{\pi_0 C_0}{\pi_1 C_1}$$

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 $\pi_0 = 0.6$ and $\pi_1 = 0.4$ (compare the teleprinter mark/space ratio) and that the error costs are the same, $C_0 = C_1$. Hence in this example $K = \pi_0 / \pi_1 = 1.5$. 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

$$\alpha = \frac{1}{\sqrt{(2\pi N)}} \int_{y'}^{\infty} \exp. \frac{(-y^2)}{2N}\, dy$$

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

$$\beta = \frac{1}{\sqrt{(2\pi N)}} \int_{-\infty}^{y'} \exp. \left(- \frac{(y-m)^2}{2N} \right) dy$$

The slopes $d\alpha/dy$ and $d\beta/dy$ are the integrands, so the likelihood ratio is

$$L(y') = \frac{\exp. \left(- \frac{(y'-m)^2}{2N} \right)}{\exp. \left(- \frac{y'^2}{2N} \right)}$$

$$= \exp. \left[- \frac{m}{n} \left(\frac{m}{2} - y' \right) \right]$$

$$= \exp. \left[- k \frac{P}{N} + \frac{my'}{N} \right]$$

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 $\alpha(y')$ 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 *minimax* test. The simple Bayes test requires a knowledge of the signal parameters π_0 and π_1, but in fact these may be uncertain. Therefore one picks out the worst-case values of π 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 π it will be less efficient than a Bayes test constructed for the specific value of π.

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.[2]

REFERENCES

(1) "Communication in the Presence of Noise," by C. E. Shannon. *Proc. I.R.E.*, vol. 37, p. 10, 1949.

(2) "Detection Theory," by I. Selin. Princeton University Press, 1965.

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 then 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 37s 6d. Distributed by Macmillan & Co. Ltd., Little Essex 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 £9. Pergamon Press Ltd., 4 and 5 Fitzroy Square, London, W.1.

A new British Standard, BS3934, "**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.

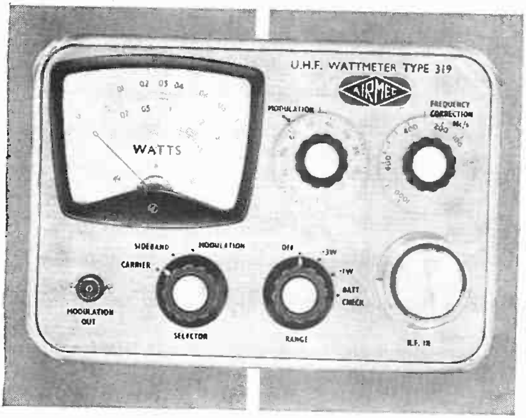
Electrical & Electronic Trader Year Book 1966.—As usual this book, compiled in collaboration with *Electrical & Electronic Trader*, is a mine of information covering most of the general important aspects of the trade. The publication is divided into eight sections—Valve base diagrams—Specifications—Technical literature—Wholesalers—Proprietary names—Buyers' guide, radio and television—Buyers' guide, domestic electrical—Trade addresses—identified by thumb index tabs which facilitate rapid reference. Additional general information contains a legal guide which includes details of aerial erection, hire purchase and credit sales, noise abatement, tenancies of business premises and the Wireless Telegraphy Act. Pp. 480. Price 35s (plus postage). Iliffe Books Ltd., Dorset House, Stamford St., London, S.E.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. Lad., 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 paper back form from Constable & Co. Ltd., 10-12 Orange St., London, W.C.2. They are:— **Computing Mechanisms and Linkages,** by Svoboda, 18s; **Microwave Antenna Theory and Design,** by Silver, 24s; **Microwave Transmission Circuits,** by Ragan, 24s; **Pulse Generators,** by Glasoe & Lebacqz, 24s; **Principles of Microwave Circuits,** by Montgomery, Dickie & Purcell, 18s; **Propagation of Short Radio Waves,** by Kerr, 24s; **Radar System Engineering,** by Ridenour, 24s; **Theory of Servomechanics,** by James, Nichols & Phillips, 18s; **Threshold Signals,** by Lawson & Uhlenbeck, 18s; **Vacuum Tube Amplifiers,** by Valley, Wallhman & Henry, 24s.; **Waveforms,** by Chance, Britton, Hughes, Vernon, MacNichol, Sayre, David & Williams, 26s; **Waveguide Handbook,** by Marcuvitz, 18s.

To measure C. W. Power . . . Sideband power . . . Modulation depth



- ★ 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

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 1-1000Mc/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.

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

Airmec UHF Wattmeter Type 319

Airmec for peak performance — CONSISTENTLY

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.

AP286A

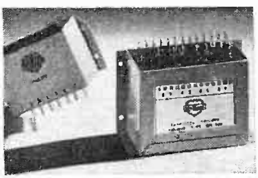
NEW PRODUCTS

equipment systems components

THYRISTOR POWER CONTROL SYSTEM MODULES

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 ensapsulation.

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 load 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 MY5051 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.

WW 301 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., Cradock Road, Luton, Beds.

WW 302 for further details

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 0.02in 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.

WW 303 for further details

PANORAMIC MICROWAVE RECEIVER

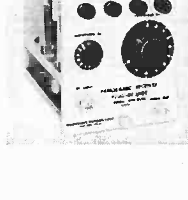
THIS receiver, from Microwave Physics (U.S.A.), is for use in the design and testing of harmonic generators, solid state signal sources, transmitters, and other signal generators, where observation of spurious and harmonic signals is desirable. The circuit uses an electronically swept yttrium iron-garnet 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).

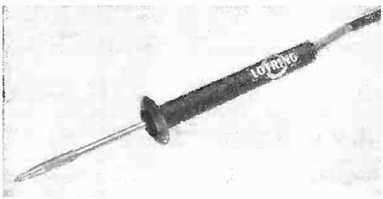
Marketed by Microwave Systems Ltd., 9-10 River Front, Enfield, Middx.

WW 304 for further details



NICKEL BIT SOLDERING IRONS

SOLDERING irons with bits of solid nickel are now being produced by the West Germany company, Lotring Werner Bittman, 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 for further details

Capacitance Tester

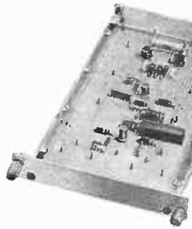
FOUR-DIGIT in-line readout is utilized on the Model 1201 Digital Capacitance Tester manufactured by the American company of Micro Instrument Co. and marketed by Claude Lyons Ltd., Ware Road, Hoddesdon, Herts. The instrument has been designed for two- or three-terminal measurements and uses a 1 Mc/s, 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_{ob} (capacitance between base and collector with emitter o/c) and C_{ib} (capacitance between base and emitter with collector o/c) measurements. Overall accuracy is a combination of measurement accuracy, which is $\pm\frac{1}{2}\%$, and a readout 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 £1,078 with print out. A transistor jig for TO-5 and TO-18 cans with C_{ob} and C_{ib} switch and 30 in coaxial leads is available for £40.

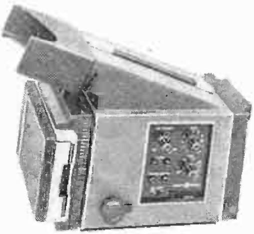
WW 306 for further details

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 tag-ended components. The board mounts on two tie rod supports behind indvidual 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

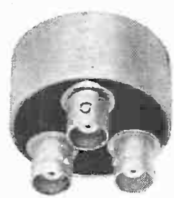


OSCILLOSCOPE CAMERA

THE Hewlett-Packard model 197A camera uses an electronically controlled shutter calibrated in nine even steps from 1/30 to 4 s. 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 ohms 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.

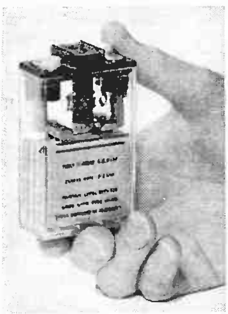
WW 309 for further details

Unspillable Lead Acid Cell

THE compact 2 V Exide cell MRP7 which weighs 12oz filled and measures $1\frac{5}{32}$in $\times$ $2\frac{13}{32}$in $\times$ $3\frac{3}{4}$in 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 4 Ah at a 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.

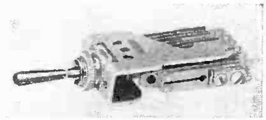
WW 310 for further details



Miniature Lever Switches

THE 5000 and 5100 BECUWE 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 0.325in (8.2mm) diameter single hole fixing, while the 5100 series have 2 fixing screws for 2 side holes 0.09in (2.3mm) diameter.

The cam is made of the hard plastic DELRIN, 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 Charing Cross Road, W.C.2.

WW 312 for further details

MICRO-CIRCUIT WELDER

A COMPACT multi-purpose micro-circuit bonding system, capable of welding, brazing, parallel-gap soldering and thin film diffusion bonding, is available from Hughes International (U.K.) Limited, Heathrow House, Bath Road, Cranford, Hounslow. Occupying only 20 inches of bench space, the system includes a power supply (MCW 550), two sizes of bonding heads, micro-positioning apparatus and accessories, and a stereozoom microscope. The smaller head, designated Model VTA-90, is designed for ultra-fine materials and can be adjusted to apply bonding pressures as light as 10 grams. The larger head, VTA66, is used for parallel-gap welding or soldering of flat packs, memory plane matrixes and other surface bonding applications.

WW 311 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 1% 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 300μs, 0 to 300ms, and 1 to 10s. Readings are $\pm$2% 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: $5\frac{3}{4}$in (14.5cm) $\times$ $3\frac{3}{4}$in (9.5cm) $\times$ $1\frac{3}{4}$ (4.5cm). Weight 1lb 4oz (0.6kgm) unpacked. Batteries B121, U10 (1 of each).

From A. G. Brown Electronics Ltd., Lower Mills, Busby, Glasgow.

WW 313 for further details

INFORMATION SERVICE FOR PROFESSIONAL READERS

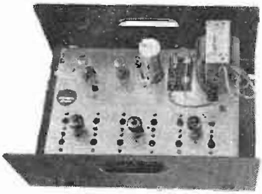
To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 16 and 19.

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.

COMMUNAL AERIAL AMPLIFIERS

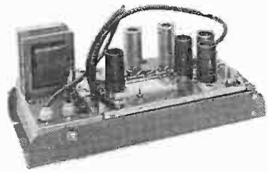
NEW communal aerial amplifiers for television and sound signals and combined u.h.f. and v.h.f. crystal controlled converters have been introduced by Teleng Ltd. The design of the new



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 "U" 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 produce 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.

WW 314 for further details

Rectifier Bridges for Printed Circuits

THESE bridges by Pirelli (Milan) are single phase, resin cast units, with a body length of ¼in, and ⅜in diameter.

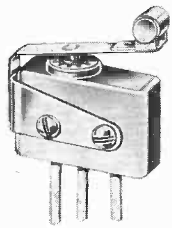
The WO2, WO4 and WO6 bridges which respectively have a p.i.v. of 200, 400 and 600 V, possess these principal ratings.—Max. average rectified output at 50°C, 1.5 A, at 100°C, 1 A; peak single-cycle surge current 50 A; max. forward voltage drop at 1 A and 25°C, 2 V; and max. leakage at rated p.i.v. and 25°C 10 μA. 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.

WW 316 for further details

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 oils and fuels. Basically, the switch comprises a standard 11SMI-T micro switch sealed in epoxy resin in a corrosion-resistant case 0.6×0.876×0.34 in. The cable connections are covered by an outer sheath of extruded p.t.f.e. which affords good protection against heat and abrasion. 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

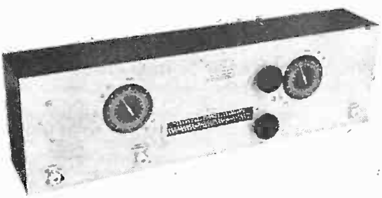


means the switch can be operated from cams, slides or other devices which are not in line with the motion of the switch plunger. The illustration shows a roller leaf actuator, JE-5, for applications involving rapid cam or slide operation.

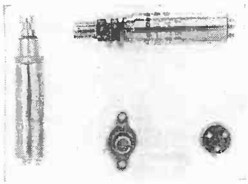
WW 317 for further details

R.F. Piston Attenuator

A PISTON attenuator giving an attenuation range of 100 dB at frequencies from 1 Mc/s to 2 Gc/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 attenuation 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 0-100dB in 2dB 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 Gc/s. For the highest accuracy measurements small setting corrections have to be made as the measurement frequency deviates from the design frequency (60 Mc/s), but a correction curve is supplied.



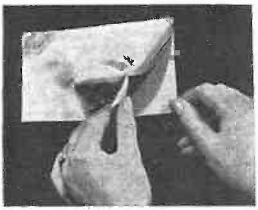
WW 315 for further details



HELICAL POTENTIOMETER

A TEN turn potentiometer with a resistence 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 318 for further details



Copper Sheet for Printed Circuits

MANUFACTURED by Peak Sound (Harrow) Ltd., and marketed under the name "Cir-Kit" this adhesive copper sheet is intended for constructing prototype circuits.

The sheet (0.002 in thick) is coated on one side with a heat resistant adhesive, which, in turn, is protected by a paper backing. Offered in ⅛ in wide strip (at 7s 6d for 24 feet) that can be cut to length, or in 6 in wide sheets (6s for 1 foot) permitting required dimensions to be drawn on the backing paper, and cut out with scissors or knife. The paper is stripped off, and the shape pressed firmly on a laminated board. Normal drilling and soldering may be carried out.

From Peak Sound (Harrow) Ltd., 10 Asher Drive, off Mill Ride, Ascot, Berks.

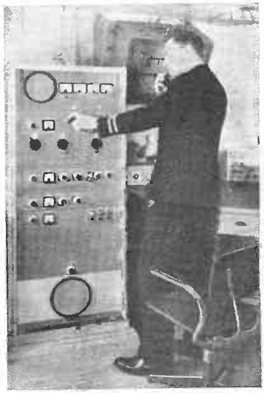
WW 319 for further details

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 1939) 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 320 for further details

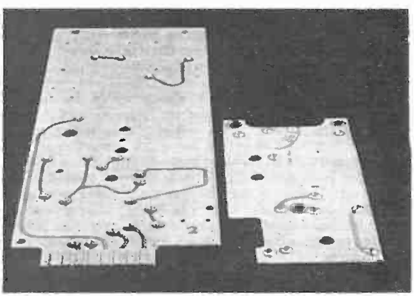
Cored Preform Washers

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 minimizing 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 321 for further details



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 stripling 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 stripling into something approaching the size of the opposition, starting with that genesis of exportable products, the research laboratories. Mass attack 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 on this mass attack business.

This realistic approach brings results. The recruitment scheme donates 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 multitest 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 overstaffed, his particular domain is well below skeleton level and only functions as well as it does by reason of genius at the helm.

Baffled 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 langorous 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 voluble 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 restyled 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 quota. 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.

described as self-oscillating, using paper-work 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? . . . er . . . 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.

10th. I.E.E.—"Automatic control in railway systems" by S. Jones at 5.30 at Savoy Pl., W.C.2.

11th. I.E.E.—"Holography" by Prof. D. Gabor at 6.0 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.R.E.—Discussion on "Electrical aids to the handicapped" at 10 a.m. at Savoy Pl., W.C.2.

23rd. I.E.E.—Colloquium on "A new look at energy storage" at Savoy Pl., W.C.2.

BIRMINGHAM

18th. Television Soc.—"Take 625 lines" by L. Marsland Gander at 7.0 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 6.0 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. television networks" by R. J. Seacombe at 2.30 at the I.E.E., Savoy Pl., W.C.2.

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 1000°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 800 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 circuitry 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 at short wavelengths 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 2-9 — Olympia
Numerically Controlled Machine Tool Exhibition
(Machine Tool Trades Assoc., 25-28 Buckingham Gate, S.W.1)

May 10-20 — Earls Court
Mechanical Handling Exhibition
(*Mechanical Handling*, Dorset House, Stamford St., S.E.1)

May 23-28 — Olympia
I.E.A.-Instruments, Electronics & Automation Exhibition
(Industrial Exhibitions, 9 Argyll St., W.1)

BRIGHTON

May 15-19 — Hotel Metropole
R.T.R.A. Conference
(Radio & Television Retailers' Assoc., 19 Conway St., W.1)

EASTBOURNE

May 3-5 — Congress Theatre
British Joint Computer Conference
(Joint Conference Secretariat, I.E.E., Savoy Pl., London, W.C.2)

SALFORD

May 5-6 — Royal College of Advanced Technology
Ultrasound in Medicine
(Dr. Basil Brown, Dept. of Physics, Royal College of Advanced Technology, Salford, Lancs.)

OVERSEAS

Apr. 29-May 15 — Oslo
Britain 66
(British Overseas Fairs, 21 Tothill St., London, S.W.1)

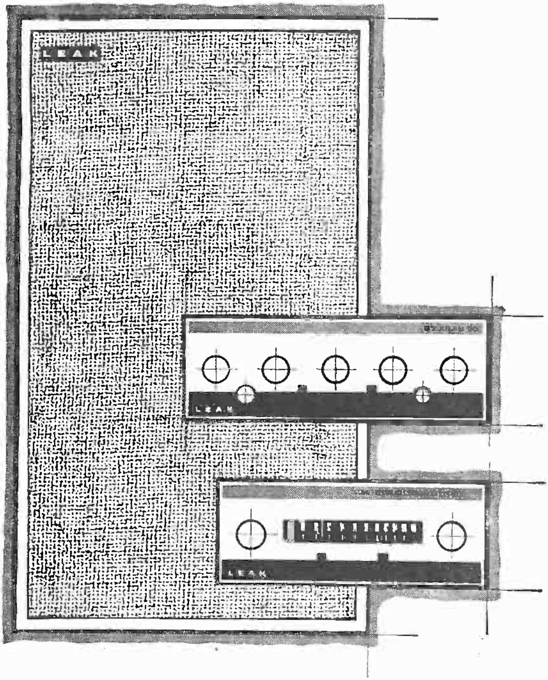
Apr. 30-May 8 — Hanover
Hanover Fair
(Schenkers Ltd., 13 Finsbury Sq., London, E.C.2)

May 2-4 — Washington
Communications Satellite Systems Conference
(I.E.E.E., 345 East 47th St., New York, N.Y. 10017)

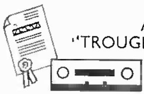
May 4-6 — Washington
Electronic Components Conference
(I.E.E.E., 345 East 47th St., New York, N.Y. 10017)

May 10-12 — Boston
National Telemetering Conference
(I.E.E.E., 345 East 47th St., New York, N.Y. 10017)

May 22-26 — Sydney
Radio & Electronics Engineering Convention
(Instn. of Radio & Electronics Engrs., Box 3120 G.P.O., Sydney, N.S.W.)

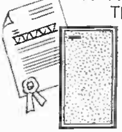


A TRIPLE FIRST FOR LEAK



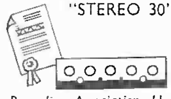
A SUCCESSOR TO THE FAMOUS "TROUGHLINE II" : FM "TROUGHLINE 3"
Price £31 : 14 : 6d.

HI-FI NEWS—"*To sum up the Leak Troughline II belongs to the very limited class of aristocrats in the tuner world.*"



A MAJOR LOUDSPEAKER INVENTION THE "SANDWICH" Price £39 : 18 : 0d.

AUDIO AND RECORD REVIEW—"*. . . This design must be regarded as a breakthrough of fundamental and far-reaching importance.*"



ANOTHER MILESTONE IN AUDIO ENGINEERING "STEREO 30" TRANSISTORISED AMPLIFIER
Price: £49 : 10 : 0d.

WIRELESS WORLD Editorial, May 1963—"*Last autumn during his presidential address to the British Sound Recording Association, H. J. Leak demonstrated a prototype high-quality transistor amplifier which gave results indistinguishable from those of his valve amplifiers . . .*"

"*People sometimes ask why there is any necessity to change to transistors. The elimination of the output transformer is, in our view, sufficient reason now that solutions of the problem of linearity in the response of the rest of the transistor circuit have been found. As additional bonuses we get smaller size, cooler running and the prospect of longer life.*"

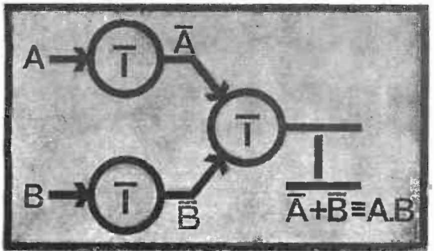
If you are interested in Hi-Fi equipment combining faultless presentation with audio engineering to impeccable standards offering studio quality reproduction at reasonable cost . . .

WRITE NOW FOR FULLY ILLUSTRATED AND DETAILED LITERATURE

LEAK . . . the first name in High Fidelity since 1934

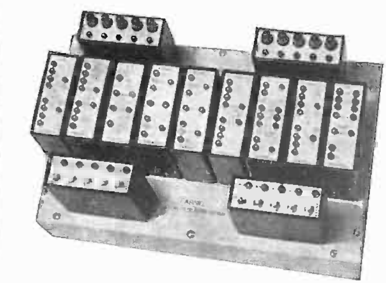
H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, LONDON, W.3.

Telephone: SHEpherds Bush 1173 (PBX). Telegrams: Sinusoidal, London, W.3



DIGITAL LOGIC

INSTRUMENTATION KITS



AN EDUCATIONAL SYSTEM FOR TEACHING LOGIC AND CONTROL TECHNOLOGY WITH PRACTICAL APPLICATIONS IN INDUSTRY

A modular digital system with patching lead connections designed to teach Engineers of any science or Technology the essential requirements of Logic design and digital control techniques.

The equipment is accompanied by a comprehensive instruction manual giving an introduction to logic, with terms employed, and detailing 15 of the many experiments which can be carried out. Using the input and output units, designed systems can be proved in operational form by utilising the complete equipment as a control device.

LOGIC KIT (25 modules)	£125
NOR KIT (13 modules)	£83
POWER SUPPLY (will drive six kits)	£26

FARNELL INSTRUMENTS LTD.
Sandbeck Way,
Wetherby, Yorkshire
Telephone 2691/2/3/4

WW—126 FOR FURTHER DETAILS.

USED SCIENTIFIC, ELECTRONIC, LABORATORY & INDUSTRIAL EQUIPMENT

TEMPERATURE
Recorders from **£50** to **£120**, meters from **£5**, controllers **£15** to **£30** by Kent, Electroflo, Cambridge, Ether, Bristol, etc.

VACUUM PUMPS
Rotary pumps from **£12**, diffusion pumps from **£12**, valves and accessories, etc. by Edwards, N.G.N., Leybold, etc.; e.g. ISP30 at **£22** to Kinney GKD110 at **£160** and N.G.N. OP25 at **£12** to Edwards 9B3 at **£100**.

LABORATORY
Flasks, pipettes, burettes, filter papers and thimbles, etc. Large quantity (list price over £400). Bargain **£100** only.

PYE PANCHROMATOGRAPH
Complete with sample injector, operating manual and the following detectors: Gas density balance and Katharometer with power supply control unit. Only 3 years old, original cost £917. Special offer, only **£400**.

CLOSED CIRCUIT TELEVISION
E.M.I. (modified outside broadcast unit) 625 lines, type 10307 CPS Emitron pick-up tube. Only **£500** o.n.o.
Pye (modified underwater unit) Image Orthicorn Industrial Camera 2063, C.C.U. 2327, only **£250**, o.n.o.

ELECTRONICS
Universal Bridge Marconi TF868, **£45**
Guard circuit Muirhead D-140-10, **£45**.
Capacitance bridge Muirhead A-168-A, **£45**.
Oscilloscopes ex government research type **T200, £75**
KX30, £35
E.M.I., WM2, £80
Oscilloscope cameras (without lens) of various makes, from **£5**.
Scan generator Type T5007, **£20**.

PROCESS TIMERS
Chamberlain & Hookham type P.O-10 secs., 0-30 secs., 0-30 mins, etc., each **£8**.

Please let us have your requirements. Catalogue available.

V. N. Barrett & Co.
18 Sherwood Rd., Addiscombe, Croydon, Surrey
ADDISCOMBE 6470

Build the smallest radio set in the world!

the inimitable

sinclair MICRO6

SIX-STAGE POCKET RECEIVER

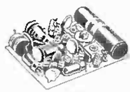
Anyone can build it in an evening!

$1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$

● **FANTASTIC RANGE AND POWER**

● **PLAYS ANYWHERE**

The wonderful Micro-6 brings in stations all round the medium waveband and has bandspread to bring in Luxembourg like a local station. The Sinclair Micro-6 has power, range and quality yet is actually smaller than a matchbox. Batteries and ferrite-rod aerial are contained within the minute white, gold and black case, and the set will play virtually anywhere. Building the Micro-6 is easy, and when completed, it will delight and enthral you with its fantastic performance, to bring an intriguing new personal approach to radio listening.



This remarkable set has two stages of R.F. amplification, double diode detector and 3 stages of audio amplification with powerful A.G.C. to counteract fading from distant stations. Slow motion tuning makes station separation easy. Kit complete with transistors, case, dial, lightweight earpiece and instructions manual.

59/6

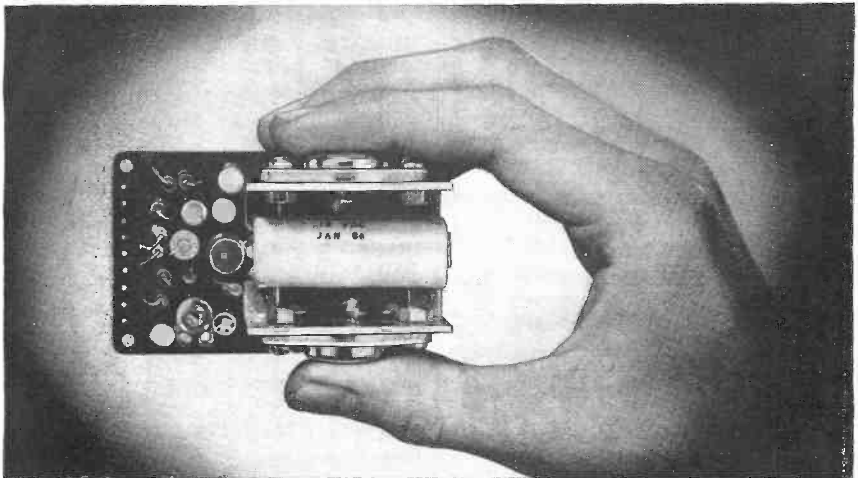
MALLORY MERCURY CELL ZM. 312 (2 required) 1/11 ea. Pack of Six 10/6

FULL SERVICE FACILITIES AVAILABLE TO SINCLAIR CUSTOMERS.

● **MICRO FM & Z.12**
See pages 86/87

SINCLAIR RADIONICS LTD.
22, NEWMARKET ROAD, CAMBRIDGE
Phone - OCA3 - 52731

WW—127 FOR FURTHER DETAILS.



More power per square inch than any other amplifier in the world!

The Z.12 has quality. The Z.12 has power, and it is certainly marvellously compact. In fact, this wonderful unit which is complete with its own high gain pre-amplifier and ready to connect to any input will give you an output of up to SIX WATTS PER SQUARE INCH of its total size—a standard of performance unequalled by anything in its class. And because of its size and excellent circuitry, you can now use quality amplification in applications never before possible.

The Sinclair Z.12 uses 8 special H.F. transistors with generous negative feed back and ultralinear class B push-pull output to achieve the highest possible standards of quality. The unit can be powered from 6 to 20 v. d.c. and for those not using a battery, the new PZ.3 will be found ideal. Signal to noise ratio is better than 60dB, and the output may be fed directly into any load from 3 to 15 ohms, or two 3 ohms speakers may be used in parallel. The Manual included with the Z.12 gives full details of matching tone and volume control circuits for mono and stereo, together with multi-input switching facilities.

- **12 WATTS R.M.S. OUTPUT**
  Continuous Sine Wave (24 w. Peak)
  15 Watts R.M.S. Music Power (30 w. Peak)
- **SIZE 3″ × 1¾″ × 1⅓″**
- **IDEAL FOR 12 V. OPERATION**
- **INPUT 2mV. INTO 2K OHMS**
- **RESPONSE—15 TO 50,000 c/s ±1dB**
- **SUITABLE FOR HI-FI, TUNER, GUITAR, P.A., INTERCOM, ETC.**

PROMPT DELIVERY IS OFFERED TO MANUFACTURERS WISHING TO ORDER IN QUANTITY AT COMPETITIVE PRICES. ENQUIRIES INVITED FOR THIS AND AMPLIFIERS TO SPECIFICATION.

If you prefer not to cut this page, please refer to W.W.5 when writing your order.

sinclair Z.12

COMBINED 12 WATT HI-FI AMPLIFIER AND PRE-AMPLIFIER

A NEW POWER UNIT

SINCLAIR PZ.3

The PZ.3 used new circuitry based on advanced transistorised techniques to achieve phenomenally good smoothing, making it ideal for the Z.12, two of which it will power with ease. Ripple is a barely measurable 0.05 v. Output 20 v. D.C. for A.C. mains operation 200/250 v. 50-60 c/s. **79/6**

Ready-built, tested and guaranteed, with Z.12 manual.

89/6

Guarantee

Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full and at once without question.

ORDER FORM

To SINCLAIR RADIONICS LTD.,
22 NEWMARKET ROAD, CAMBRIDGE.

Please send ....

....

....

for which I enclose

....

CASH/CHEQUE/MONEY ORDER for £ s. d.

NAME ....

ADDRESS ....

....

.... WW.5

SINCLAIR MICRO-6—*the world's smallest radio*

SEE PAGE 85

WW—129 FOR FURTHER DETAILS.

TS 36AP POWER METER, with accessories, used for checking radar outputs, £5 each, 10/- carr.

DE-ICER, Controller Mk. 3. Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20-30 volts 12 R.P.M.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay, etc., sealed in steel case, size 4×5×7in., £3 each, post 5/-.

GEARED MOTORS (Reversible).
28 v 150 r.p.m., 25/-, post 2/6.
24 v Open gears with governor approx. 10 r.p.m., 25/-, post 2/6.
24 v. D.C. 1.4 r.p.m., reversible with two micro switches inside gear box, silent operation, £2 each, post 5/-.
A.C. Motor 115v. 50 c/s 1/300 H.P., 3000 r.p.m. Capacitor 1 mfd. 25/-, post 3/-. Dalmotor SC5, 28 v. D.C. at 45 amps.; 12,000 r.p.m., output 750 w. (approx. 1 h.p.), brand new, £2/10/- each post 7/6.

AZIMUTH INDICATOR UNIT ID-260/GRD 115v. 50 c/s., complete with Azimuth Bearing Indicator and suitable for aerial direction control, 2" tube with shield suitable for modulation percentage indicator or oscilloscope and 3" speaker that can be utilised as a sidetone monitor. With all valves, in excellent condition, price £8 15/-, carriage 15/-.
CRD6 DIRECTIONAL ANTENNA for use with the above Instrument, £5 each, carriage £1.
CM23 COMPARATOR SIGNAL UNIT, £4/10/-, carriage 15/-.

MARCONI V. LVE VOLTMETERS TF428-B/1. Ranges: 0 to 1.5, 5, 15, 50 and 150 volts. Fitted with probe unit for RF measurements. 230 v. mains input. Brand new, £12/10/- each, carr. 10/-.
TCS MODULATION TRANSFORMER 20 w. Pri., 6,000 ohm C.T. Sec., 6,000 ohm. 25/- each, post 3/6.
MICROPHONE TRANSFORMER. Pri., 75 ohm. Sec., 125,000 ohm. 10/- each, post 2/6.

OUTPUT TRANSFORMER. Pri., 7,500 ohm. Sec., 500 ohm. C.T., 2.5 w. 12/6 each, post 3/-.

CONDENSERS. 150 mfd., 290 volts A.C. £5 each, post 12/6. 50 mfd. 330 volts A.C. 40/-, post 4/-. 10 mfd., 1,000 v. 12/6, post 2/6. 8 mfd., 1,500 volts, 17/6, post 2/-. 8 mfd., 1,200 volts, 12/6, post 3/-. 8 mfd. 600 volts, 8/6, post 2/6. 0.25 mfd., 2 kv. 4/-, post 1/6.
Vacuum condenser 50 pf. 32 kv. 30/-, post 1/6. 6 pf. 20 kv. 22/6, post 1/6. All the above are new in cartons.

TX DRIVER UNIT. 100-156 Mc/s. Ideal for two meters, Valves 3C24, in excellent condition, fits 19in. rack. £5 each, carr. 20/-.

CONTROL UNIT. 230 v. A.C., output 24 v. 2 amps., 230 v. A.C. solenoid switch 15 amps.. plus relays and switches, etc., £2/10/-, carr. 12/6.

HEADPHONES. DLR.5, 10/- pair, 2/6 post. No. 10 headset and microphone, 15/-, post 2/6. M/C phones, with chamois ear muffs and jack plug, 17/6 pair, post 2/6.

AUTOMATIC PILOT UNIT Mk. 2. This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price £7/10/-, £1 carriage.

U.S.A. DESK MICROPHONE CRV/51018/A. Complete with 7 yards of screened cable and universal jack (adjustable). 10/- each, post 3/-.

VARIABLE MASTER OSCILLATOR TYPE 115 MODEL 1. Principally used in diversity, reception to supply variable or crystal H.F.O. voltage to the receivers. Its variable freq., has a stability equivalent to that obtained by non-temperature controlled crystal oscillators. It also provides three H.F.O. crystals for operation of diversity receivers where fixed frequencies are required and two F.V.O. crystals. Freq. 2-32 Mc/s. Power supplies 100/220 v. A.C., 50/60 cys., £30 each, carr. 30/-. Wt. 80 lb.

ANAPIN-9 LORAN INDICATOR UNIT. As used for ships and aircraft to provide accurate means of position by the reception of a known Loran transmitter. Power supplies, external X Inverter. This unit will make a very good Oscilloscope, £8/10/- each, carr. £1.

RADIO TELEPHONE GR300 V.H.F. 75 Mc/s two channels, complete with control box and 12 v. D.C. supply, as new, £50, carr. £1. Control unit for the GR300, £3 each; also power supply unit 12 v. D.C., £3/10/-, carr. 10/-.

AVO METER MODEL 7 with test leads and case, £12/10/- each, post 7/6.

BLOWERS MOTORS. 115 v. A.C., 50 or 60 c/s., 1/80 h.p., 0.2 amps. 3,200 r.p.m., cont., duty new in cartons £2/10/- each, post 5/-. Smaller type blower 24 v. D.C., 15/-, post 2/6.

RELAYS SEMI ROTARY. 3 pole DT., contacts suitable for 10 amps. (silver), coil 12 volts D.C., new in cartons 12/6 each, post 2/6.

TRANS/RECEIVER UNIT Mk. 3. Freq. 2 to 8 mc/s., RT or CW., MCW., requires external power supply. Complete station £9. Trans-rec. only £3/10/-, carr. 15/-.

RESISTORS. Variable 3 ohm. 10 amps., 25/-, post 4/-.

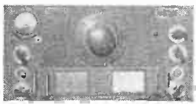
ROTARY TRANSFORMERS. 24 v. input, 175 v. at 40 ma. output 25/-, plus 2/- post. EICOR type, 12 v. input, 400 v. at 180 ma. output, 30/-, plus 4/- post. 12 v. input, 225 v. at 100 ma. output, 25/-, plus 3/- post. (All the above are D.C. only).

MICROPHONES Type T50. Fits the palm of hand with on/off switch and lead (Electro Dynamic) 35/- each, 2/6 post. Type T17 with lead and PL55 plug, 45/-, 3/- post.

PLUGS. Standard two-way jack plug PL55 with 6ft. lead and transformer, low to high impedance, 7/6 each, plus 1/6 post. PL68 plug and switch lead assembly, 5/- each, plus 1/6 post.

CANADIAN C52 TRANS. REC., Freq. 1.75 to 16 mc/s. on three bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12 volts D.C., new condition complete set £50, carr. £2/10/-. Used condition in working order £25, carr. £2/10/-. C52 receiver only (less outer case), £8/10/-, carr. 15/-. Transmitter only £7/10/-, carr. 15/-. Power unit C52 rec., new £3/5/-. Used power units in working order £2/5/-, carr. 10/-.

TRANSFORMERS. 230 to 115 v., isolation 300 va, £3 each, plus 5/-. 230/115 auto 300 watts, £2, post 6/-. 230 v. pri., 24 v. at 2 amp., 22/6, post 5/-. 230/115 v. pri., 275-0-275 v. at 120 ma., 6.3 v. at 4 amp., 6.3 v. at 1 amp., 25/-, post 5/-.



HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW., and MCW., reception crystal filter, with phasing control. AVC., and signal strength meter. Freq., range 50 kc/s. to 30 mc/s., with set of nine coils. Receiver only in working order, £18/10/-, carr. 15/- each. Set of nine coils £12/10/-, available only with set. Power unit for HRO., 100/240 v. A.C., £2/15/-, carr. 10/-.

CONVERTERS. Type 8a, 24 v. D.C., 115 v. A.C. at 1.8 amps 400 cycles, 3-phase, £6/10/- each, post 8/-.

SCANNER UNIT. AS 596 APQ.13. This modern piece of equipment made by a well-known American firm, normally for aircraft use, has a 30in. diameter parabolic reflector adjustable 180 deg. vertical and horizontal and is complete with standard waveguide couplings and rotary joints. Three powerful D.C. motors by Dalmoter Company, i.e. Types SC.5, SR.2 and PM.4. Three geared motors 0-6 r.p.m. and 0-150 r.p.m., also Kollsman Magslip motor type TY.971C-0460. Two solenoid contactors, small compressor unit with pressure gauge 0-30 and dehydrator unit. All the above is mounted in an aluminium casting, approx. weight 120-125 lbs. 4 Relays d.p. c/o. 24 v. 235 ohms., 4 Relays 4 p., c/o, 24 v. 235 ohms., Mechanical Counter 0-9999, 2 20K ± 0.15% Linear Potentiometer, 1,400 ohms ± 3% Suppressors, Switches, Plugs, Sockets and assorted gears. Price £17/10/-, £2 carr. and £5 deposit for returnable container.

TRAN/REC 510/A. This is a lightweight transmitter/receiver principally used for long range communications. Frequency, tunable 2-10 Mc/s. and has facilities for "VOICE" or "CW" working. The operator can set up 4 crystal controlled channels within this band and select the required frequency by means of a switch on the panel of the transmitter. Power requirements 1½ v. and 90-7½ v. The power output is approx. 0.2 watts for "VOICE" (unmodulated) and 0.5 watts for "CW." Suitable for mobile units or can be used as a base station with improved aerial system. In excellent condition. £15 each, carr. 10/-.

DESK TELEPHONE. 30/- each or £2/15/- per pair, post 5/-.

MARCONI TYPE TF-144G SIGNAL GENERATOR. Freq. 85 Kc/s.-25 Mc/s., internal and external modulation, power supplies 200/250 v. A.C., price £25, carr. 30/-.

RDO RECEIVER has complete metering of both RF and Audio Circuits. Calibrated Accuracy: 1% approx., Video Output: 25mv into 50 ohms. It utilizes the same plug in RF tuning units as the AN/APR-4 Receiver, and is ideally suited for monitoring and measuring signals in the 38-4,000 mc range. Receiver with three tuning units covering 38-1,000 mc/s. and Panoramic Adaptor. Price £150 carr. 30/-.

1154TX UNIT freq. 200-500 kc/s., 2.5-16.7 mc/s., complete with all valves, suitable for CW, MCW, and RT, output approx. 25 watts. Price £4 each, carriage 15/-. (No power supplies available.)

TS535A/U, Hewlett Packard Co. Signal Generator: freq. on 4 bands, 7-16 kc/s., 15-36, 34-80, 70-160 kc/s., with 400 cys. external mod., microvolts 0-10 and 0-20 Db., with a 2 inch cathode ray tube for visual indication. Power Supplies 115 v. A.C. Price £75 each, carriage £1.

MUIRHEAD AUDIO FREQ. OSCILLATOR TYPE A-706-B. 4 ranges, 15-160 c/s., 0.15-1.6 kc/s., 1.5-17 kc/s., 15-120 kc/s. 230 v. A.C. Price £30, carriage 15/-.

MARCONI SIGNAL GENERATOR NO. 13. 2 bands, 20-40 mc/s and 40-80 mc/s. FM., AM., and CW. Mod. freq. 300/1000/1600/3000 and external mod. Output voltage is 0.1-10. Power Supplies 110 v. or 250 v. A.C. Price £50, carriage £1.

AUTOMATIC STABILISED P.U. Input voltage 200/245 A.C., Output 230 v. at 2.17 amps. Made by Claude Lyons & Co. Price £8 each, carriage 12/6.

POWER UNIT GR.49. 100/240 v. A.C. Outputs voltages 500-0-500 at 400 mA., 250-0-250 v. at 100 mA., 28 v. at 0.3 amp., 13-0-13 at 1.1 amp., 13-0-13 at 0.8 amp. and 5.25 v. at 6 amps. Two 5U4G and one 35Z4. Fully smoothed with output terminated into a Jones plug, £8/10/- each, carr. £1.

OSCILLOSCOPES. Type 1035, Cossor Mk. 1, in very good condition, £35, carr. £1. Hartley type 13a, £25, carr. £1.

CONTROL MOTORS. 115/115 v., 2 pole 60 cys., output 5 watts, the tachometer 115v. 1 ph., output volts per 1,000v. = 6 v., £3/10/- carr. 4/- each. Type R110-2B-B, 115/115 v. 400 cys., £2/10/-, carr. 4/- each.

TELEPHOTO UNITS (Trans-ceiver) Type CNP. Complete with tuning fork and power supplies 115 v. 50 or 60 cys., £30, carr. £2 each.

TELETYPEWRITERS. TT-4 TGXc-2. Also AN/PGC-1 and AN/PGG-2, £35, carr. £1 each.

TERMINAL UNITS. Type A.C.T. P.W.R. line feed unit and amplifier units YB 07606-7-8, £25 each. Repeater unit TG-30, £25 each. CF.2-B, £75 each, carr. £5.

Complete installations can be quoted for. Please write further details. List available 6d. S.A.E. for all enquiries.

W. MILLS

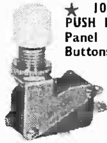
3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: Tottenham 9213 & 9330

TIMERS MICRO SWITCHES
IMMEDIATE DESPATCH

S5G

★ 1 MILLION OPS. 5 amp. c/o Sub-miniature Micro-switch.

2/3 each per 1,000.



VAQ

★ 10 amp. c/o PUSH BUTTON. Panel mounting. Buttons in six colours.

5/4 each per 500.

C-5

★ LOW TORQUE PRECISION ROTARY SWITCH.

★ 5 amp. c/o.

★ ½ milops

6/3 each per 1,000.

VV-15-IA

★ 15/10 amps. c/o.

★ 100,000 ops.

1/8 each per 1,000

Single Throw 1/6 each

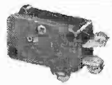
LIMIT SWITCH WL 10 FCA2

★ 10 amp. 2 circuit

★ CASED FOR USE UNDER ARDUOUS CONDITIONS. MECHANICAL HANDLING, MACHINE TOOLS, LIFT GEAR.

ROLLER LEVER AS ILLUS.

As low as **41/1** each



V-10-1B

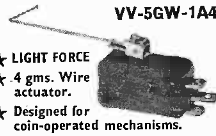
★ 1 MILLION OPERATIONS.

★ 10 amp. c/o.

★ COMPARE OUR SPEC. & OUR PRICES WITH OTHER SIMILAR TYPES.

Screw Terms **2/2** each per 1,000

V-10-1A Solder Tags 1/11 each per 1,000



VV-5GW-1A44

★ LIGHT FORCE

★ 4 gms. Wire actuator.

★ Designed for coin-operated mechanisms.

2/4 each per 1,000.

U.L. APPROVED (Appr. No. 32667)
U.S. MIL. SPEC.
ALWAYS AVAILABLE FROM STOCK.

PROCESS TIMERS

611 T Delay Relay

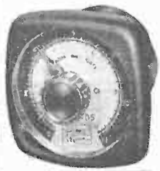
★ 2 secs. to 25 secs. Delay.

★ 15 amp. c/o micro-switch fitted.

★ LARGE RANGE OF A.C. & D.C. OPERATIONS.

From **26/11** each.

SYT MINI-TIMER



★ DIAL RANGES 10 secs. to 6 hours.

★ Mains operation.

★ 5 AMPS. DOUBLE POLE, DOUBLE THROW SWITCHING INCORPORATED. Accuracy ½%.

From **£8.14.5** each.

STP Sub-Mini Process Timer

★ Plug-in Octal base.

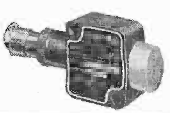
★ Mains operation.

★ Built-in 2 amp. c/o switching.

★ 10 secs. to ½ hour.

From **£5.0.0** each.

PROXIMITY SWITCH—TL 2 GNA



★ FOR BATCHING, CONVEYORS, MACHINE TOOL CONTROL, PACKAGING, SORTING, etc.

★ SENSES FERROUS & NON-FERROUS OBJECTS.

★ NEEDS NO MECHANICAL FORCE OR PRESSURE TO OPERATE.

★ SOLID STATE SENSING HEAD, plus Power Pack.

From **£6.14.5** each.

FLOATLESS LIQUID LEVEL CONTROLS

★ To control or record liquid levels.

★ Stainless Electrodes switching minute current to Master unit for:

★ Pumps, Motors, Alarms, etc.

★ No moving parts. Single and multi switching.

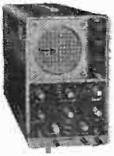
From **£4.19.7** each

SEE US AT THE I.E.A. EXHIBITION. STAND No. G259. 23-28 MAY.

(Dept. W.W.1) **OMRON** PRECISION CONTROLS
313 Edgware Road, London, W.2 **Tel.: Paddington 2370**

See **DAYSTROM** Industrial Products and **HEATHKIT** models at the
International Instruments, Electronics, Automation **EXHIBITION**
OLYMPIA, LONDON. 23-28 MAY. Stand No. 768

MODERNISE YOUR SERVICE DEPT. OR WORKSHOP WITH THESE INSTRUMENTS

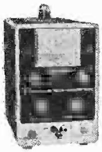


5in. Flat-face GENERAL PURPOSE OSCILLOSCOPE Model IO-12U

An outstanding oscilloscope

"Y" sensitivity 10 mV. r.m.s. per cm. at 1 kc/s. Bandwidth 3 c/s-4.5 Mc/s. Frequency compensated input attenuator X1, X10, X100. T/B. 10 c/s.-500 kc/s. in 5 steps. Two extra switch selected pre-set sweep frequencies in T/B. range. T/B. output approx. 10 v. peak to peak. Built-in 1V calibrator. Facility for "Z" axis modulation. Electronically stabilised power supply. Power req. 200-250 v. A.C. 40-60 c/s. 80 watts. Fused. Front panel silver and charcoal grey. Cabinet, charcoal grey, size 8¾ × 14 × 17in. deep. Net weight 23lb. 56-page construction and operation manual.

Kit............£35.17.6 Assembled £45.15.0

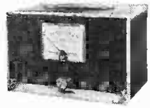


Transistorised REGULATED POWER SUPPLY Model IP-20U

Tremendous value! 0.5-50 volts D.C. output at up to 1.5A. Voltage or current monitored on easy-to-read meter. Adjustable current limiter.

Relay protected against overload. Less than 150 microvolts ripple. Regulation less than ± 15 millivolts. Output impedance less than 0.1 ohm. Compact 9½in. × 6½in. × 11in. Weight 11lb. net. Full details on request.

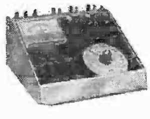
Kit............£35.8.0 Assembled £47.8.0



HARMONIC DISTORTION METER Model IM-12U

Will give fast, accurate noise and distortion measurement in amplifiers, receivers, transmission lines, speakers, etc. Measurements are read directly on large meter. High input impedance, precision components and Wien bridge circuit design assure excellent sensitivity and high accuracy in all applications. Freq.: 20 cycles to 20,000 cycles. Distortion: 1, 3, 10, 30, 100% f.s.d. Voltmeter: 0, 1, 3, 10, 30 volts f.s.d. Input resistance 300kΩ. Dimensions 13in. × 8½in. × 7in. deep. Weight 11lb.

Kit..........£24.15.0 Assembled £34.0.0



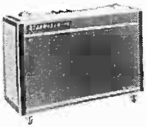
TRANSISTOR TESTER Model IM-30U

Unmatched for quality and performance at the price.

Provides a complete d.c. analysis of PNP and NPN transistors and diodes. D.C. gain (Beta, Alpha) is read direct on calibrated scales. Four lever switches facilitate fast, easy, test selection. Internal batteries for tests up to 9 v. Provision for connection to ext. power supply for higher voltage and current tests. Modern functional styling. Size 5½in. high × 10½in. deep × 10¾in. wide.

Kit..........£24.18.0 Assembled £35.10.0

OUTSTANDING EQUIPMENT FOR THE DISCERNING HI-FI ENTHUSIAST



Castors or legs available as optional extras.

"STARMAKER 33" TRANSISTOR PA/GUITAR AMPLIFIER Model PA-2

This is a high performance amplifier whose size and weight allows easy transportation. Ideal for vocal and instrumental groups, P.A., electronic organs, guitars, etc.

Features include: 20w. amplifier (33 watts. I.H.F.M.), two heavy duty speakers, 4 inputs on two channels, variable tremolo, modern elegant cabinet. Size: 18in. h. × 29in. w. × 10in. deep. Wt. 51 lb.

Kit..........£44.19.0 Assembled £59.10.0

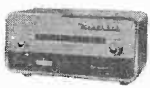
The BERKELEY Slim-line SPEAKER SYSTEM

A new concept in Heathkit loudspeaker design. The cabinet shell is assembled and finished in superb Queensland walnut veneer. Two specially designed speakers, a 12in. bass unit and 4in. mid/high frequency unit and an L.C. cross-over network provide the smooth 30-17,000 c/s. frequency response. Its professional cabinet styling will blend with both traditional and contemporary decors. 15 ohm nominal impedance. Size 26" × 17" × 7¾" deep.

Kit........£18.10.0 Assembled £23.0.0

MODELS FOR THE MUSIC LOVER AND FOR FAMILY ENTERTAINMENT

A WELL DESIGNED F.M. TUNER Model FM-4U



Tuning range 88-108 Mc/s. Flywheel tuning. Attractive Plastic Front Panel in two-tone grey with golden trim surround and motif. Thermometer type visual tuning indicator. Pre-aligned. I.F. transformers. Three I.F. stages. Wide-band low distortion Ratio Detector. R.F. Unit, wired, tested and pre-aligned. Printed circuits for I.F. amplifiers and ratio detector. Built-in power supply. Output socket for stereophonic adaptor (for stereo transmission when available).

TUNER UNIT Model FMT-4U with 10.7 Mc/s. I.F. output. £2/15/- (inc. P.T.). **I.F. AMPLIFIER and power supply Model FMA-4U** complete with case and valves, £13/13/-. Sold separately.

Kit Total £16.8.0

"OXFORD" LUXURY TRANSISTOR PORTABLE Model UXR-2

This superb transistor radio is the ideal domestic or personal portable Medium and Long Wave receiver. Solid leather case and handle. Easy-to-read tuning scale. Extra large loudspeaker. Push button L, MW and tone. 10 semi-conductors (7 transistors plus 3 diodes). Sockets for personal earphone, tape recorder, car aerial. Internal 9-volt battery (not supplied), lasts for months. Latest printed circuit techniques. Comprehensive easy-to-follow, fully illustrated instruction Manual.

Kit..........£14.18.0 incl. P. Tax.

Prices quoted above are Mail Order prices • *Prices include free delivery in U.K.*

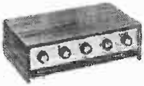
DAYSTROM LTD.

DEPT. W.W.5, GLOUCESTER, ENGLAND

FREE BROCHURE AVAILABLE ON THE BRITISH INSTRUMENT RANGE OF MODELS
ALSO "AMATEUR" RADIO BROCHURE COVERING BRITISH & AMERICAN MODELS

WW—130 FOR FURTHER DETAILS.

So easy to build **Heathkit** DAYSTROM So easy to use



TRANSISTOR MIXER
Model TM-1

"A must for the tape enthusiast"

Four channels with individual, continuously variable controls, plus a master volume control allows model to be used for recording from a wide variety of sources, e.g. dynamic and crystal microphone, radio tuners, record players, etc.

- ★ 7 transistor circuit and internal 9 v. battery (not supplied) allows unit to be used " in the field " as well as in the home, studio, etc.
- ★ Printed circuit board ensures consistent performance, easiest possible construction.
- ★ Professional, modern, compact, low silhouette styling.
- ★ Beautiful walnut veneered, fully finished cabinet.
- ★ Attractive anodised aluminium front panel.
- ★ Size: 11$\frac{11}{16}$in. x 7$\frac{1}{4}$in. x 3$\frac{3}{4}$in. high.

KIT **£11.16.6** incl. cabinet Assembled **£16.17.6** incl. cabinet

Full specification leaflet sent on request.

The Outstanding 20+20 WATT TRANSISTOR STEREO AMPLIFIER
Model AA-22U

This " International Class " amplifier offers you a realism and beauty of music never before obtainable at such a competitive price.

- ★ Professional, elegant, compact, slim-line styling.
- ★ The best of American transistor techniques in a British amplifier.
- ★ Beautiful walnut veneered, fully finished cabinet available as an optional extra.
- ★ 5 stereo inputs (five on each channel) accommodate pick-up, radio tuner, tape and two other sources.
- ★ 20 transistor 10 diode circuit.
- ★ Dimensions: 15$\frac{5}{16}$in. wide x 3$\frac{3}{4}$in. high x 12$\frac{1}{4}$in. deep.

Kit **£39.10.0** less cabinet

Walnut cabinet for free standing use £2.5.0 extra.

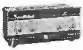
COMPARE ANY HEATHKIT MODEL FOR PRICE, PERFORMANCE, QUALITY

3+3 W HI-FI STEREO AMPLIFIER KIT Model S-33H

An inexpensive stereo-mono amplifier with the high sensitivity necessary for lightweight miniature ceramic pick-ups (e.g., Decca Deram). De luxe version of the S-33 with attractive two-tone grey Perspex panel.

Kit **£15.17.6** Assembled **£21.7.6**

5 W HI-FI MONO AMPLIFIER KIT Model MA-5



A low-priced general purpose Hi-Fidelity amplifier based on the popular S-33 for those who do not require a stereophonic system. Separate bass and treble controls. Gram and Radio inputs. Suitable for most crystal pick-ups. A printed circuit simplifies construction.

Kit **£10.19.6** Assembled **£15.10.0**

HI-FI MONO POWER AMPLIFIER KIT Model MA-12

A compact Hi-Fidelity power amplifier (including auxiliary power supply). 12 watts output. Wide frequency range and low distortion. A variable sensitivity control is fitted enabling it to be used with an existing amplifier in a stereophonic system. Other applications include sound reinforcement systems, transmitter modulators, for use with tape recorders, also as a general purpose laboratory amplifier.

Kit **£11.18.0** Assembled **£15.18.0**

STEREO CONTROL UNIT KIT Model USC-1

Incorporates all worthwhile features for Hi-Fidelity stereo and mono. Push-button selection, accurately matched ganged controls to ±1 dB. Negative feedback rumble and variable low-pass filters. Printed circuit boards. Accepts inputs from most tape-heads and any stereo or mono pick-up.

Kit **£19.10.0** Assembled **£26.10.0**

HEATHKIT-THOMAS (Transistorized) ELECTRONIC ORGAN KIT (with Color-Glo) Model GD-325E

Can be built with no knowledge of electronics.

Kit **£205.0.0** Bench **£14.10.0**

(Price includes carriage and duty)

HI-FI EQUIPMENT CABINETS

A range of equipment cabinets is now available. Designed for maximum operating convenience or for where room space is an over-riding consideration, this range includes easy-to-build kits or ready-assembled cabinets in the white for finish to own requirements.

" MALVERN " (*Illustrated*) Kit. £18.1.0 (inc. P.T.) Assembled (left in the white) £23.6.0.

" GLOUCESTER " for Tape Deck and Record Player. Kit £18.10.0 (inc. P.T.). Assembled £23.15.0

" CHEPSTOW " for Record Player or Tape Deck. Kit £11.12.6 (inc. P.T.) Assembled £16.17.6

How to install Hi-Fi in YOUR home

If you are planning to install a Hi-Fi system in your home, and are uncertain of the type of equipment to use, our widely experienced technical staff will with pleasure put forward recommendations. All you have to do is state the type of installation contemplated, the price you are prepared to pay and give details of existing equipment you wish to include, if possible.

HI-FI STEREO AMPLIFIER KIT Model S-99

18 w. output (9 per channel with 0·2 per cent. distortion at 9 w. per channel). It has ganged controls. Stereo/Mono gram, radio and tape recorder inputs and push-button selection. Ultra-linear push-pull output. P.C. boards. Attractive Perspex front panel with golden surround and grey metal cabinet.

Kit **£28.9.6** Assembled **£38.9.6**

INTERNATIONAL MAIL ORDER SCHEME

Covering the American Heathkit range of 250 models

Direct from U.S.A. to your U.K. address. Illustrated American catalogue and full details can be obtained from us for 1/- post paid.

● Deferred Terms available on orders above £10 ●

MONO CONTROL UNIT KIT Model UMC-1

Ideal for use with MA-12 or similar amplifier. Output 0.25 v. *Send for full details.*

Kit **£8.12.6** Assembled **£13.12.6**

HI-FI SPEAKER SYSTEM KIT Model SSU-1

Ducted-port bass reflex cabinet " in the white." Frequency response is 40-16,000 c/s. Power rating 10 watts. Matched speaker units 8in. high flux (12,000 lines) with hyperbolic cone and 4in. wide angle dispersion type for higher frequencies.

Kit (with legs) **£12.12.0** (less legs) **£11.17.6** (inc. P.T.)

" COTSWOLD " SPEAKER SYSTEM KIT

This acoustically designed enclosure measures 26 x 23 x 14$\frac{1}{2}$in., and houses a special 12in. base speaker with 2in. 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.

Kit **£25.12.0** Assembled **£33.17.0**

" COTSWOLD M.F.S." SPEAKER SYSTEM KIT

This model, based on the standard Cotswold, measures only 36in. high, 16$\frac{1}{2}$in. wide by 14in. deep. Particularly recommended to those who require the best results in small rooms.

Kit **£25.12.0** Assembled **£33.17.0**

DAYSTROM LTD.

DEPT. W.W.5, GLOUCESTER, ENGLAND

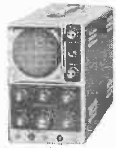
Member of the Schlumberger Group including the Heath Company.

MANUFACTURERS OF THE WORLD'S LARGEST-SELLING ELECTRONIC KIT-SETS

See HEATHKIT at the
International Instruments, Electronics, Automation EXHIBITION
OLYMPIA, LONDON. 23-28 MAY. Stand No. 768

AN OUTSTANDING LOW-COST 3in. OSCILLOSCOPE Model OS-2

★ Vertical amplifier 2 c/s to 3 Mc/s.
★ Modern professional styling.
★ Vertical sensitivity 100 mV/cm.
★ Compact size 5in. × 7⅜in. × 12in.



★ Light weight—under 10lb.
★ Time base range 20 c/s to 200 kc/s.
★ Horizontal input 100 mV/cm.
★ Mumetal c.r.t. screen.

This compact oscilloscope offers excellent performance, is professional in appearance and is an instrument you will be proud to own. Apart from its obvious uses by radio/TV engineers, etc., it is ideal for construction, study and use by workshop apprentices and by students in schools, technical colleges and universities.

Kit £22.18.0 Assembled £30.8.0

MULTIMETER KIT Model MM-1U

Provides wide voltage, current, resistance and dB ranges to cover hundreds of applications. Sensitivity 20,000 ohms/volt D.C. and 5,000 ohms volt A.C. Ranges: 0-1.5 v. to 1,500 v. A.C. and D.C.; 0-150μA to 15 A. D.C. Measures resistance from 0.2Ω to 20MΩ. 4½in. 50μA meter. A polarity reversing switch eliminates transferring test leads when alternatively measuring + and − voltages

Kit £12.18.0 Assembled £18.11.6

OSCILLOSCOPE TRACE DOUBLER KIT Model S-3U

This device will extend the use of your single-beam oscilloscope and, at a nominal cost, will give you the advantages of a double (or other multiple) beam 'scope.

Kit £12.18.0 Assembled £18.10.0

R.F. SIGNAL GENERATOR KIT Model RF-1U

Provides extended frequency coverage on six bands from 100 kc/s. to 100 Mc/s on fundamentals and up to 200 Mc/s on calibrated harmonics.

Kit £13.8.0 Assembled £19.18.0

DECADE RESISTANCE BOX KIT

Model DR-1U. Range 1-99,999Ω in 1Ω steps. Ceramic switches throughout. Current rating from 500 mA. to 5 mA, according to decades in circuit. Polished wooden cabinet supplied complete.

Kit £16.8.0 Assembled £14.8.0

RESISTANCE-CAPACITANCE BRIDGE KIT Model C-3U

Measures capacitance 10pF. to 1,000μF. Power-factor and resistance 100Ω to 5M ohms. Test voltages 5-450 v. Safety switch provided.

Kit £10.10.0 Assembled £16

AUDIO SIGNAL GENERATOR KIT Model AG-9U

10 c/s. to 100 kc/s., switch selected. Distortion less than 0.1%. 10 v. sine wave output metered in volts and dB's.

Kit £22.10.0 Assembled £30.10.0

A.M./F.M. TUNER KIT

Tuning range 88-108 Mc/s. (FM) 16-50, 200-550, 900-2,000 m. Flywheel tuning. Attractive Perspex front panel in two-tone grey with golden trim. Thermometer type tuning indicator, pre-aligned I.F. transformers. Switched wide and narrow A.M. bandwidths.

TUNING HEART Model AFM-T1 £4/13/6 (inc. P.T.) **I.F. AMPLIFIER and Power Unit Model AFM-A1.** Complete with metal cabinet and valves £22/11/6. Sold separately.

Kit Total £27.5.0

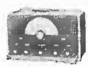
DUAL-WAVE TRANSISTOR PORTABLE RADIO KIT Model UXR-1

Presented in elegant real hide case with tasteful gold relief. Can be assembled in 4 to 6 hours and you have a set in the top flight of transistor portables. Pre-aligned I.F. transformers, printed circuit and a 7in. x 4in. high flux speaker.

Covers both Long and Medium waves. Dimensions 9¼in. × 7¼in. × 3¼in.

Kit £12.11.0 (Inc. P.T.)

SINE/SQUARE GENERATOR Model IG-82U



Covers 20 c/s.-1 Mc/s. in 5 bands. Simultaneous Sine and Square Wave outputs. Less than 0.15μS rise time and on Square Wave. Less than 0.5% distortion on Sinewave. Up to 10 volts output. This attractively styled generator is designed for maximum operating convenience. Size 13in. × 8½in. × 7in. deep.

Kit £24.10.0 Assembled £36/10/0

ELECTRONIC WORKSHOP KIT EW-1

20 exciting experiments can be made with this one kit.

Kit £7.13.6 (incl. P.T.)

4½in. VALVE VOLTMETER KIT Model V-7A

The world's most popular valve voltmeter with printed circuit and 1 per cent. precision resistors to ensure consistent laboratory performance. It has 7 voltage ranges measuring respectively D.C. volts to 1,500 and A.C. to 1,500 r.m.s. and 4,000 peak to peak. Resistance measurements from 0.1 ohm to 1,000 megohms. with internal battery. D.C. input resistance is 11 megohms and dB measurement has a centre-zero scale. Complete with test prod, leads and standardising battery. Power requirements, 200-250 v. 40-60 c/s. A.C. 10 watts.

H.V. and R.F. Probes available at optional extras.

Kit £13.18.6 Assembled £19.18.6

6in. VALVE VOLTMETER Model IM-13U

Modern styling. Many extra features. Unique gimbal bracket allows bench, shelf or wall mounting. Measures A.C. and D.C. volts 0-1.5, 5, 15, 50, 150, 500, 1,500. Resistance 0.1 to 1,000MΩ. Size 5in. × 12$\frac{1}{16}$in. × 4¾in. Complete with test prod and leads.

Kit £18.18.0 Assembled £26.18.0

DECADE CAPACITOR KIT Model DC-1

Capacity values 100μμF to 0.111μF in 100μμF. steps. Precision silver-mica capacitors and minimum loss ceramic water switches ensures high accuracy.

Kit £7.5.0 Assembled £10.8.0

TELEVISION ALIGNMENT GENERATOR KIT Model HFW-1

Offers the maximum in performance, flexibility and utility at the lowest possible cost. Several outstanding features have been incorporated in this model which are unusual in instruments in this price range. Frequency coverage 3.6 Mc/s. to 220 Mc/s. on fundamentals. Unique non-mechanical sweep oscillator system. High level output on all ranges. Sweep deviations up to 42 Mc/s. Built-in fixed and variable marker generators (5 Mc/s. crystal supplied).

Kit £37.18.0 Assembled £47.10.0

AUDIO SINE-SQUARE WAVE GENERATOR KIT, Model AO-1U

Covers 20 c/s to 150 kc/s in four ranges with choice of sine or square waves. The latter up to 25 kc/s. Output 10 v. max. and distortion less than 1%. Ideal for audio testing. Size 9½ × 6½ × 5in.

Kit............£14.15.0 Assembled £21.5.0

OSCILLOSCOPE ACCESSORY KITS

Demodulation Probe kit 337-C £2.7.6
Low-cap Attenuator Probe kit Pk-1 £3.2.6

● Prices quoted are Mail Order Prices. ● ● Deferred Terms available on all orders above £10. ● ● Prices include Postage U.K. ●

DAYSTROM LTD.

DEPT. W.W.5, GLOUCESTER, ENGLAND

SEND FOR FREE CATALOGUE OF INSTRUMENT RANGE

WW—132 FOR FURTHER DETAILS.

Thoroughly **Heathkit** DAYSTROM *dependable*

AMATEUR TRANSMITTER KIT
Model DX-40U

Covers all amateur bands from 80 to 10 metres, crystal controlled. Power input 75 watts C.W. 60 watts peak controlled carrier phone. Output 40 watts to aerial. Provision for VFO. Filters minimise T.V. interference. Modulator and power supplies are built-in. Single knob band switching is combined with a pi-network output circuit for complete operating convenience. A high-grade moving-coil meter indicates the final grid or anode current. Provision is made for the use of 3 crystals with access through a trap-door in the back of the cabinet. A 4-position switch selects the appropriate crystal or a jack for external VFO which can be used instead of the crystal(s).

Kit .. £33.19.0 Assembled .. £45.8.0

SINGLE SIDEBAND ADAPTER KIT
Model SB-10U

May be used with most A.M. transmitters with certain provisions. Allows full use of existing equipment for SSB facilities. Band coverage: 80, 40, 20, 15, 10 m. Unwanted sideband suppression; better than 30 dB. Carrier suppression: better than 40 dB. Power requirements: 300 v. D.C. 85 mA. (average) 30 mA (standby). 140 mA (transmit), 6.3 v. A.C., 3.5 A. Meter: 2½in. Scale edge reading, 200μA movement, indicates carrier null and relative power output. Cabinet 11in. high × 8in. wide × 14½in. deep.

Kit .. £39.5.0 Assembled .. £54.18.0

GENERAL COVERAGE RECEIVER KIT
RG-1

An inexpensive communications type receiver specially designed for the short wave listener with many refinements found only in receivers costing much more. Freq. coverage 32 Mc/s-1.7 Mc/s in 5 ranges also M.W. band.

Kit .. £39.16.0 Assembled £53.0.0

Optional extras available.

GRID-DIP METER KIT. Model GD-1U

Functions as oscillator or absorption wavemeter. With plug-in coils for continuous frequency coverage from 1.8 Mc/s. to 230 Mc/s.

Kit .. £10.19.6 Assembled .. £13.19.6

Additional Plug-in Coils Model 341-U extend coverage down to 350 kc/s. With dial correlation curves, 17/6.

TRANSISTOR INTERCOM KITS
Models XI-1U and XIR-1U

9 v. battery operated. Up to five remote stations can be operated with each Master. The Master unit can call any one, any combination, or all five Remote stations and any Remote station can call the Master. A private call to any

Model XI-1U (Master)
Kit .. £10.19.6 Assembled .. £16.19.6

Model XIR-1U (Remote)
Kit .. £4.7.5. Assembled .. £5.16.0

AMERICAN MARINE MODELS

Prices include carriage, duty, import levy, etc.

DIRECTION FINDER, MR-21A
3WB transistor circuit. Kit .. £61.10.0

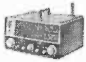
DEPTH SOUNDER MI-11A
Soundings to 200ft. Kit .. £38.10.0

FUEL VAPOUR DETECTOR MI-25
Transistor circuit. Kit .. £23.10.0

TACHOMETER MI-31A
6, 12, 24 or 32 v. D.C. Kit .. £14.0.0

Please send for details.

"MOHICAN" GENERAL COVERAGE RECEIVER KIT
Model GC-1U



This fully transistorised receiver which includes 4 piezo-electric transfilters, is in the forefront of receiver design. It is an excellent portable or fixed station receiver. The R.F. "front-end" is supplied as a pre-assembled and pre-aligned unit. Its many features include a 10-transistor circuit, printed circuit board, telescopic whip antenna, tuning meter, and a large slide-rule dial giving a total length of approximately 70 inches. Housed in a steel cabinet and powered by two 6 volt dry batteries (not supplied), mounted internally, it gives frequency coverage from 580 kc/s. to 30 Mc/s. in five bands; thus enabling world-wide reception. Electrical bandspread covers the amateur bands from 80 to 10 metres—each band having a scale length of approximately 8 inches. BFO tuning and Zener diode stabiliser. Size 6⅞ × 12in. × 10in.

Please write for specification leaflet.

Kit .. £37.17.6 Asmbld. .. £45.17.6

STABILISED POWER PACK
Models MSP-1M and MSP-1W

Specially recommended for industrial and laboratory use, meeting the need for a reliable and versatile stabilised power pack capable of a very high performance. Input 200-250 v. 40-60 c/s., A.C., fully fused. Outputs: H.T. 200-410 v. D.C. at 0-225 mA. in 3 switched ranges. Unstabilised A.C., 6.3 v. at 4.5 A. centre-tapped. Two 3in. "easy-to-read" meters for reading voltage and current simultaneously. Separate L.T. and H.T. supply transformers. All output circuits are isolated. Size 13in. × 8¼in. × 9¼in.

MSP-1M (with meters)
Kit .. £36.12.6 Asmbld. .. £43.12.6

MSP-1W (less meters)
Kit .. £29.17.6 Asmbld. .. £36.17.6

BALUN COIL UNIT KIT

Model B-1U. Will match unbalanced co-axial lines to balanced lines of either 75 or 300Ω impedance. Frequency range 10-80 m., input up to 200 watts.

Kit .. £4.15.6 Asmbld. — £5.8.0

TAPE PRE-AMPLIFIER KITS
Models TA-1M and TA-1S

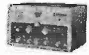
The Combined Tape Record/Replay Amplifier is available in both monophonic and stereophonic models. Model TA-1M can be modified to the stereo version with modification kit TA-1C.

TA-1M Kit £19.8.0 Asmbld. £28.18.0
TA-1S Kit £25.10.0 Asmbld. £35.18.0
TA-1C Kit .. £6.15.0

All prices are mail order and include free delivery in the U.K.

Deferred Terms are available on all orders above £10

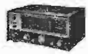
AMATEUR TRANSMITTER KIT
Model DX-100U
The World's most popular Amateur TX Kit



- Completely self-contained. 150 w. D.C. input.
- Built-in highly stable VFO and all Power Supplies.
- The KT88 high-level anode and screen modulator stage gives over 100 watts of audio from less than 1.5 mV. input.
- Keying on CW is via the VFO and buffer amplifier cathodes; the other RF valves are biased beyond cut-off.
- Provision has been made for remote control operation.
- Covers all Amateur bands up to 30 Mc/s. 'phone or CW.

Kit .. £79.10.0 Assembled .. £104.15.0

AMATEUR BANDS RECEIVER KIT



Model RA-1 The ideal economically priced fixed station, portable or mobile receiver covering the Amateur bands from 160-10 m., each band separately calibrated on a large illuminated slide-rule dial. Features: Signal strength meter, tuned RF amplifier stage, half-lattice filter, adjustable noise limiter. Freq. coverage 160, 80, 40, 20, 15, 10 metre bands. I.F. 1620 kc/s.

Kit .. £39.6.6 Assembled .. £52.10.0

AMERICAN HEATHKIT SINGLE SIDE BAND EQUIPMENT

Transmitters, Receivers, Transceivers. Send for details of models. Fully illustrated American Catalogue of Heathkit range sent for only 1/- post paid.

REFLECTED POWER METER KIT

Model HM-11U Indicates, reliably but inexpensively, whether the R.F. power output of your transmitter is being transferred efficiently to the radiating antenna.

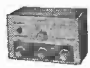
Kit .. £8.5.0 Assembled .. £10.10.0

VARIABLE FREQUENCY OSCILLATOR KIT. Model VF-1U

Specially designed to meet the demand for the maximum possible flexibility from an amateur Transmitter which would otherwise be subject to certain limitations imposed by crystal control. Calibrated for all Amateur bands 160-10 metres, fundamentals on 160 and 40 m. Ideal for Heathkit DX-40U and similar transmitters.

Kit .. £10.17.6 Assembled .. £15.19.6

Q MULTIPLIER KIT. Model QPM-1



A reasonably priced Q Amplifier for the amateur and short-wave enthusiast. This self-powered unit (200-250 v. 50/60 c/s.) may be used with communications receivers to provide both additional selectivity and signal rejection.

Models QPM-1 for 470 kc/s. IF. QPM-16 for 1.6 Mc/s. I.F.

Kit, either model £8.10.0
Assembled £12.14.0

AERIAL TOWER KITS. Model HT-1, HT-1G

Height 32ft., sq. section 3ft. × 3ft. at base (no stays required). Accessories available as extras.

HT-1G Kit (galvanised) £40.15.0
HT-1 Kit (red oxide) £34.15.0

WELCOME TO OUR LONDON HEATHKIT CENTRE

See the British Heathkit range and a selection of American models etc.

233 TOTTENHAM COURT ROAD, W.1 Tel: MUSeum 7349

We open MON.-SAT., 9 a.m.—5.30 p.m. THURSDAY 11 a.m.—2.30 p.m.

When you are in town we hope that you will visit us there.

Please send me FREE CATALOGUE (Yes/No)........

Full details of Model(s) ....

NAME..
(Block Capitals)
ADDRESS ....

.... WW5

DAYSTROM LTD., Dept. WW5, GLOUCESTER, ENGLAND.

WW—133 FOR FURTHER DETAILS.

LASKY'S RADIO

LONDON'S LARGEST STOCKISTS OF HI-FI AUDIO EQUIPMENT

BY ALL THE WORLD'S FAMOUS MANUFACTURERS

DEMONSTRATION STUDIOS

VISIT OUR NEW HIGH FIDELITY CENTRE AT:

42 TOTTENHAM COURT ROAD, LONDON, W.1.

Tel: LANgham 2573

This branch is devoted exclusively to quality High-Fidelity equipment—Tape recorders, Record Reproducers, Radios, Tuners, etc. Custom built installations provide balanced comparisons of the best in Hi-Fi in ideal surroundings. Open all day Thursday, early closing Saturday.

Visit our other spacious showrooms at 33 Tottenham Court Road, 207 Edgware Road or 152-3 Fleet Street, whichever is most convenient. In our Demonstration Studios you can see, examine, hear and compare the very latest products in the realm of high-fidelity reproduction by all the well-known makers.

If you cannot call please send us details of your choice of equipment and we shall be pleased to quote. See Complete Systems. "Purchase tax-free Plan" for overseas visitors. H.P. Terms available.

RECORD PLAYERS

4-SPEED AUTOCHANGERS

B.S.R. AUTOCHANGERS AT LOWEST EVER PRICES!

All brand new and fully guaranteed complete with cartridge and stylus.

UA14 4-speed mains model	£4 9 6
UA16 4-speed mains model	£4 19 6
UA16 9v battery model	£5 19 6
UA20 4-speed mains model	£5 19 6

Add 5/- Post on each.

GARRARD

Auto-slim Mono	£4 19 6	A70 less cartridge	£19 19 0
AT6 Mono	£8 19 6	A50 less cartridge	£9 14 6
AT6 Stereo	£9 9 0	A1000 with GC8 cartridge	£6 6 0
3000LM with stereo cartridge	£8 8 0	A2000 with GC8 cartridge	£7 7 0
AT60 less cartridge	£10 19 6		

Postage on all above 5/-.

SPECIAL OFFER—GARRARD AT5 AUTOCHANGERS

4-speed mains model—brand new and fully guaranteed.

LASKY'S PRICE with Mono Crystal Cartridge £5 19 6
with Stereo Cartridge .... £6 9 6 Post 5/-.

TRANSCRIPTION MOTORS		LENCO GL58	£17 1 9
GARRARD 401	£32 10 0	LENCO GL68	£19 10 7
GARRARD Lab. 80, less cart.	£24 19 6	LENCO G88	£15 15 0
GARRARD 301 (Strobe)	£22 19 6	LENCO GL70	£29 18 8
GARRARD Lab. A Mono/Ster.	£14 19 6	LENCO G99	£21 19 5
GARRARD Lab. A on plinth	£15 19 6	THORENS 135	£35 8 4
GARRARD SP25 Mono	£9 19 6	THORENS TD124	£38 7 4
GARRARD SP25 Stereo	£10 19 6	THORENS TD150	£20 13 2
PHILIPS AG/1016	£12 12 0	**SINGLE PLAYERS**	
BRAUN PC4L Stereo	£8 19 6	Auto. start and stop. With pick-up and crystal cartridge.	
CONNOISSEUR		EMI with Stereo cartridge	£3 19 6
Craftsman II	£17 2 11	COLLARO JUNIOR 4-speed motor and pick-up	£3 9 6
Craftsman III	£22 19 6		
Model B	£25 4 0		

All other current models available. Postage on all above 5/- extra.

GREENCOAT RECORD PLAYER

3 speed model for 33⅓ and 45 r.p.m. 6 v. Battery operated. Complete with pick-up and fitted with crystal cartridge. Size only 7½ × 6in. Fitted with auto. stop and start.

LASKY'S PRICE 59/6 Post 2/6

AMPLIFIERS

STOP PRESS AM/FM TUNER/AMPLIFIER SCOOP

LOEWE OPTA L040 Spec.: Valve Stereo Tuner and IF Amp. (incl. Multiplex). Transistorised Twin channel pre-amps. and power amps. 20 watts per channel. LW-MW-SW and VHF/FM (switched AFC). Superb modern styling-beautiful veneered cabinet. Large tuning scale-11 push button controls. Orig. list price **84 Gns.**

LASKY'S PRICE 59 GNS. Write for details and illustration. Limited quantity only. Carriage & Ins. 21/- extra

ARMSTRONG EQUIPMENT

All the latest models in stock— H.P. Terms available.

Model 227M	£36 15 0	T.4c	£17 19 0
Model 223	£28 15 0	T.4.b	£20 8 0
Model 227	£52 15 0	127M	£26 10 0
Model 226	£61 0 0	127	£37 10 0
Model 222 Amplifier	£27 10 0	A.20 Stereo Amp.	£23 12 6
Model 224	£22 10 0	P.C.U. 25 Stereo Pre-amp.	£21 0 0
Model 221	£33 15 0	Optional cases	£3 10 0
		Stereo Multiplex Decoder	£14 10 0

MARTIN HI-FI AUDIOKITS

Using specially developed circuits, the very latest transistors and printed circuits—these kits are all fully checked and tested before leaving the factory.

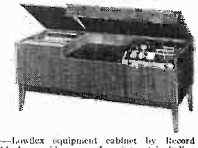
KIT 1.	5 stage Matching Input Selector Unit	LASKY'S PRICE £2 7/6
KIT 2.	Pre-amplifier with volume control	LASKY'S PRICE £1/17/6
KIT 3.	3-Channel Mixer, with plug-in adaptors for individually matching each circuit. Adaptors 8/6 each	LASKY'S PRICE £3/19/6
KIT 4.	Pre-amplifier with tone/volume control stages	LASKY'S PRICE £3 2/6
KIT 5.	10 and 3 watt Main Amplifier	LASKY'S PRICE £5/12/6
KIT 6.	Power supply Converter Unit	LASKY'S PRICE £2 12/6
KIT 7.	15 ohm version of Kit 5	LASKY'S PRICE £6/12/6
KIT 8.	Power supply for Kit 7	LASKY'S PRICE £2/15/-

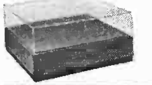
COMPLETE SYSTEMS

A Lasky's "Privilege Parcel Package Deal" allows you to purchase the complete Audio System of your choice at a worthwhile cash saving. We shall be pleased to quote our "Privileged Parcel Package Deal." Prices for any selection of equipment of your own choice. Send us details of your requirements. **H.P. Terms can be arranged on "Privilege Parcel Package Deals."**

HI-FI FURNITURE

Choose from our extensive range of equipment cabinets and speaker enclosures by Record Housing, Fisher, G.K.D., Design Furniture, etc. A full range is in stock to suit all types of equipment, furnishing styles, etc. Complete installations can be supplied to your choice, and our expert staff will be pleased to advise you.



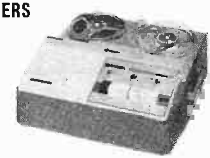


Shown above—Lowline equipment cabinet by Record Housing suitable for a wide range of equipment including space for record and tape storage.

Shown left—"Clearview" cabinet suitable for most types of motor/turntable units.

TAPE RECORDERS

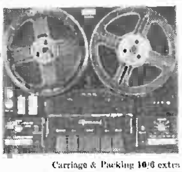
SPECIAL BARGAIN!! COSSOR CR.1604 PORTABLE TAPE RECORDERS



These recorders are extremely high quality and are brand new and unused. Many superb technical features include: simple push button operation; uses both valves and transistors; 4 track; parallel track switching on play back; 2 speeds—1⅞ and 3¾ i.p.s.; takes 7in. spools; radio and gram inputs—can be mixed with separate mic. input, 6½in. speaker; provision for foot switch; monitoring with headphones or through speaker; fast forward and rewind. Other features include: 4 digit position indicator; outputs for extra amplifier, external speaker, headphones and stereo socket; record level indicator—can be adjusted with tape stationary. Cabinet with carrying handle finished in two tone beige polystyrene, size 14 × 14 × 7in.—space for mic. Supplied with moving coil microphone, 5in. tape and empty spool. Fully guaranteed. **Maker's List Price 39 gns.**

LASKY'S SPECIAL PRICE 29½ GNS. C. & P. 15/- extra.

JUST ARRIVED-THE NEW GARRARD STEREO DECK

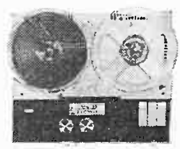


Carriage & Packing 10/6 extra

Now available from stock—superb specification. Three ¼ track stereo/ mono heads; 3 speeds—1⅞; 3¾, 7½ i.p.s.; takes 7in. spools; fast forward and rewind; tape position indicator; pause control; separate record, replay and erase heads—4 tracks; piano key controls interlocked for all functions; stop/start can be remotely controlled; auto., tape-end stop. Heavy duty motor, capacitor start and run, large dynamically balanced flywheel. Deck finished in grey plastic, size: 14½ × 12 × 6in., depth below plinth 4in. For 110 v. 50 c.p.s. Mains operation. Auto-transformer for 200/250 v. included free.

LASKY'S PRICE 29½ GNS.

MAGNAVOX-COLLARO 363 TAPE DECKS



The very latest 3 speed model—1⅞, 3¾, 7½ i.p.s., available with either ¼ track or ½ track head. Features include: pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate 13½ × 11 × 5¾in. deep below unit plate. For 200/250 v. A.C. mains, 50 c.p.s operation. New unused and fully guaranteed.

LASKY'S PRICE ½ track model £10.10.0

LASKY'S PRICE ¼ track model £13.9.6

Carriage and Packing 7/6 extra.

SPECIAL FOR OVERSEAS CUSTOMERS—the new Magnavox-Collaro 363 Deck for 110/125 v. 50 or 60 c.p.s. mains now available, prices as above. Post to any part of the world **35/-.**

MARTIN TAPE RECORDER AMPS.

Designed for use with Collaro Studio Tape Deck. In sub-assemblies for immediate installation 6-valve circuit. Comprehensive instructions make final assembly as simple as possible. Everything supplied including valves, etc. Monitoring facilities. 3 ohm output, speed equalising, etc. For 200-250 v. A.C. mains. **PRICES:** ½ track Model **£11/11/-**. ¼ track Model **£12/12/-**. Post 2/6. Portable carrying case designed to take the Collaro Studio Tape Deck and the Martin Tape Amplifier. Fitted with 9 × 5in. speaker. Price complete with speaker **£5 5/-**. Post 5/-.

Note: These Amplifiers can be used that the Magnavox 363 deck by a simple alteration to the mounting of the record/play switch assembly.

LASKY'S RADIO FOR FINEST VALUE and COURTEOUS SERVICE

WW—134 FOR FURTHER DETAILS.

TRANSISTOR RECEIVERS & CONSTRUCTORS BARGAINS

LASKY'S RADIO

THE WIDEST RANGE AVAILABLE TODAY

CONSTRUCTORS BARGAINS

We consider our Construction Parcels to be the finest value available on the home construction market. If on receipt you feel not competent to build the set, you may return it as received within 7 days, when the sum paid will be refunded less postage.

THE SKYROVER AND SKYROVER DE LUXE

GENERAL SPECIFICATION

7 transistor plus 2 diode superhet, 6 waveband portable receiver.

The SKYROVER and SKYROVER DE LUXE cover the full Medium Waveband and Short Waveband 31-49M and also 4 separate switched band-spread ranges, 13M., 16M., 19M., and 25M., with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our easy to follow, stage by stage instructions. Superhet, 470 Kc/s. All Mullard Transistors and Diode. Uses 4 U2 batteries. 5in. Ceramic Magnet P.M. Speaker. Easy to read Dial Scale, 500 MW Output. Telescopic Aerial and Ferrite Rod Aerial.

NEW! SKYROVER MK. III (Illustrated). Now supplied with redesigned plastic cabinet, finished in black and grey with chrome trim, edgewise controls. Controls: Waveband Selector, Volume Control with on/off switch. Tuning Control. In plastic cabinet, size 10 × 6½ × 3¼in. with metal trim and carrying handle.

Can now be built for **£8.19.6**	Post 5/- extra	H.P. Terms: 45/- deposit and 11 monthly payments of 13/9.	Total H.P.P. £9/16/3.

The SKYROVER De Luxe Tone Circuit is incorporated with separate Tone Control in addition to Volume Control. Tuning Control and Waveband Selector. In a wood cabinet, size 11¼ × 6½ × 3in. covered with a washable material, with plastic trim and carrying handle. Also car aerial socket fitted.

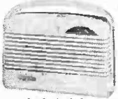
Can now be built for **£10.19.6**	Post 5/- extra.	H.P. Terms: 55/- deposit and 11 monthly payments of 16/11.	Total H.P.P. £12/1/1.

Data for each receiver: 2/6 extra. Refunded if you purchase the parcel. Four U2 batteries 3/4 extra. All components available separately.

★ LONG WAVEBAND COVERAGE IS NOW AVAILABLE FOR THE SKYROVER & SKYROVER DE LUXE A simple additional circuit provide coverage of the 1100/1950M band (including 1500M, Light programme). This is in addition to all existing Medium and Short wavebands. All necessary components with construction data. Only 10/- extra. Post Free.

This conversion is suitable for Skyrover and Skyrover De Luxe receivers already constructed.

THE "REALISTIC" SEVEN



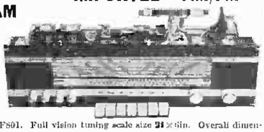
Fully tunable over long and medium wavebands. Uses 7 Mullard Transistors, plus Diode OA70. STAR features: ★7 Transistor Superhet. ★350 Milliwatt output 4in. high flux speaker. ★All components mounted on a single printed circuit board, size 5¼ × 5¼in. in one complete assembly. ★Plastic cabinet, with carrying handle, size 7 × 10 × 3¼in. In blue/grey. ★Easy to read dial. ★External socket for car aerial. ★I.F. frequency 470 Kc/s. ★Ferrite rod internal aerial. ★Operates from PP9 or similar battery. ★Full comprehensive data supplied with each receiver. ★All coils and I.F.s, etc., fully wound ready for immediate assembly. An outstanding Receiver.

Can be built for **£5.19.6** Post 4/6.

REALISTIC SEVEN De Luxe Same specification as standard model—PLUS A SUPERIOR WOOD CABINET covered in washable material, with chrome trim and carrying handle. Also full vision circular dial. **ONLY £1 EXTRA.**

Both models: Battery **3/9** extra. (all components available separately.) Data and instruction separately **2/6**, refunded if you purchase parcel.

THE LATEST "KUBA" IMPORTED AM/FM STEREO RADIOGRAM CHASSIS



Long, medium and short waveband coverage, plus V.H.F./F.M. Piano-key wavechange. Separate fly-wheel tuning on A.M. and F.M. Bass, treble and balance controls. Magic-eye tuning indicator. Ferrite rod aerial. The very latest printed circuitry. Provision for multiplex. 5 valves: line-up: ECC85, ECH81, ECC83, EL84, EAF801. Full vision tuning scale size 24 × 6in. Overall dimensions 21 × 6½ × 8in. Made to the very highest standards. Output: 5 watts per channel.

LASKY'S PRICE 29½ GNS, Carriage Free.

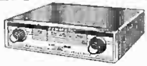
"SPECIAL PRIVILEGE PARCEL PACKAGE DEALS"

1. The "Kuba" A.M./F.M. Stereo Chassis with 2 Pamphonic S1 Speaker Systems and Garrard AT6 Stereo Autochanger. **PACKAGE PRICE £49.**
2. As above but with two 10in. P.M. Speakers. **38½ GNS.**
3. As above but with two 10in. P.M. Speakers and attractive 4 speed Autochanger. ..... **37 GNS.** Carriage FREE

Our branch at **33 Tottenham Ct. Rd., W.1,** has been appointed an **"International Semi-conductor Centre."** We now stock the complete range of these products for the development engineer, experimenter and service man. Send 6d. to 3-15 Cavell St., E.1, for full catalogue.

TRANSISTOR PORTABLES

FAMOUS BRITISH MAKE TRANSISTOR CAR RADIO



Uses 6 high quality transistors and one diode. Covers full Medium waveband and 1,250 to 1,600 M. on Long waveband. High output suitable for most private vehicles. Illuminated dial—7in. × 2in. front panel will fit all standard cut-outs; only 4in. front to back. Fused for use on 12 v. positive earth systems. Complete with 6in. × 4in. speaker and baffle, fixing brackets and full fitting and operating instructions. Brand new, unused and fully guaranteed.

Maker's List Price was £14/19/6.

LASKY'S PRICE £9.19.6 Including wing mounting car aerial. Post 5/-.

TRANSISTOR POCKET RADIOS

A wide range always in stock. All supplied complete with personal earpiece, battery and carrying case. Fully guaranteed—ready to use. **POST FREE.**

EXAMPLE—FIDA 6 TRANSISTOR MODEL

Fully built in plastic case, 4in. × 2¾in. × 1in. with 2¼in. speaker. Uses single PP3 type battery. Tunable over full medium waveband. **LASKY'S PRICE 49/6**

THE "TRANSWAVE" DE LUXE 8 TRANSISTOR TWO WAVE-BAND RADIO

8 Sony transistors give super sensitive reception over the full Medium and Long wavebands. Internal ferrite and detachable chrome telescopic aerials, 2¼in. p.m. Speaker. Smart black plastic cabinet with metal trim—size 6½ × 3¾ × 1½in. Uses 3 penlight batteries. Complete with leather case and shoulder strap, earpiece and batteries. **LASKY'S PRICE 95/-** Post 2/6

2 WONDERFUL SETS FROM THE U.S.S.R.

THE "CONVAIR 700" 7 TRANSISTOR RADIO

High sensitivity circuit gives excellent reception over full Medium waveband and powerful volume. P.M. Speaker. Uses PP3 type battery. Black and ivory plastic cabinet size 7 × 4 × 2in. Socket for external aerial. Complete with solid hide case and shoulder strap, earpiece and battery.

LASKY'S PRICE £5.9.6 Post 2/6

THE "CONVAIR 800" 7 TRANSISTOR TWO BAND RADIO

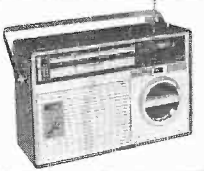
Super quality receiver covering the full Medium and Long wavebands with exclusive rechargeable battery which can be recharged from any 110/250 v. A.C. mains supply. Also operates on PP3 type dry battery. P.M. Speaker. Ivory and black plastic cabinet: 6 × 3½ × 1½in. Socket for external aerial. Complete with real leather case, rechargeable battery and charger, dry battery and earpiece. **LASKY'S PRICE £6.9.6** Post 2/6.

SPECIAL BARGAIN — THE "DICTORETTE" PORTABLE DICTATION/TAPE RECORDER

High Quality British Manufacture with many super quality features and de luxe accessories: Fully transistorised ● Battery operated ● Simple Cassette loading and single control lever (cassette takes 3in. spools giving 2 × 22mins. twin track recording and 3¼in. spools giving up to 2 × 30 mins.) ● Volume control on playback ● Accidental erasure safety device on replay ● Fast rewind operates on 4 economical, easy to get, U2 type batts. ● Strong two-tone plastic case size 9in. × 6in. × 3½in., with transparent cover. ● Fully guaranteed ● *Complete with all these accessories:* 1. Cassette with 3in. spools and tape. 2. Microphone with lapel clip and remote pause control (doubles as speaker on replay). 3. Stethoscope type headset. 4. Telephone adaptor. 5. Foot switch. 6. Desk speaker. 7. Reference pad—*ALL INCLUDED IN OUR OUTSTANDING VALUE PRICE.* List price £31.

LASKY'S PRICE 12 Gns. Carriage FREE. 4 long life Rayovac Batt. 6/-ex

SPECIAL PURCHASE OFFER— FAMOUS MAKERS SURPLUS PORTABLE TRANSISTOR RECEIVERS



7 transistor plus 2 diode superhet, 6 waveband portable receiver. Covers the full Medium waveband and Short waveband 31-94M., and also, 4 separate switched band-spread ranges, 13M., 16M., 19M., and 25M., with Band Spread Tuning. All Mullard Transistors and Diode. Uses 4 U2 batteries. 5in. Ceramic Magnet P.M. Speaker. 500 MV output. Telescopic aerial and Ferrite rod aerial. Plastic cabinet, size 10 × 6½ × 3¼in., finished in mid-fawn with metal trim and carrying handle. Fully built and factory tested.

LASKY'S PRICE £10.19.6

4 U2 batteries 3/4 extra. Post 5/-.

TRANSISTORISED BABY ALARM/INTERCOM

Fully transistorised miniature intercom. that has all the features of sets many times its size. Battery consumption is exceptionally low and makes this system particularly suitable for use as a Baby Alarm. Specification: 2 transistor; Sensitivity; more than 55 dB. Power: one 9 v. PP9 or equiv. (approx. life 50 hours). Size of units 4 × 2¼ × 1¼in. The sturdy plastic cabinets are finished in ivory and silver with chrome stands. P. & P. 2/6. **LASKY,S PRICE 54/6**

LASKY'S FOR D.I.Y. CONSTRUCTION BARGAINS P.T.O. FOR MORE NEWS

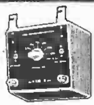
FOR THE FINEST VALUE & SERVICE IN GREAT BRITAIN

LASKY'S RADIO

HUGE STOCKS OF COMPONENTS, TEST GEAR ETC.

TEST EQUIPMENT

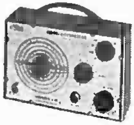
TEST METER ADAPTOR



Type PE 220— this is a fully transistorised device which enables any 50 microamp D.C. Multimeter to be used in place of a valve voltmeter On the 1 v. range an impedance of 1 megohm is offered which increases on the 1,000 v. range to 100 megohms. 7 ranges: 1 to 1,000 v. Designed for immediate connection to Avo 8 and similar size meters but quite suitable for use with any other 50 microamp meter. Size 6 × 6 × 5in. New and boxed. List Price 7 Gns.

LASKY'S PRICE 39/6 Post 2/6. Set of batteries 7/5 extra.

NOMBREX TEST EQUIPMENT



MODEL 27 TRANSISTORISED SIGNAL GENERATOR (illustrated)
Wide range—150 kc/s. to 350 Mc/s. Accuracy better than 2%. Direct calibration. AF, RF and MOD. Battery operated. Light weight and strongly made. Complete with test leads and batt.

LASKY'S PRICE £9.16.9 Post Free.

OTHER NOMBREX MODELS AVAILABLE.

MODEL 63. Wide range AUDIO GENERATOR 10-100 Kc/s. £16/15/0.

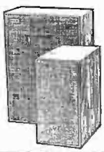
MODEL 66. Wide range INDUCTANCE BRIDGE. 1μH to 100H in 4 ranges. Measures Q. £18 0'0.

POWER SUPPLY UNIT 1 to 15 v. D.C. up to 0·1 amp. 230/250 v. A.C. mains. £6.10.0

MODEL 62 RESISTANCE CAPACITY BRIDGE £8.5.0

SPEAKERS

SPECIAL BARGAINS FROM SCANDINAVIA - S.H.B. SPEAKER SYSTEMS



Extremely advanced design and miniatureisation of components pioneered by this well-known Swedish manufacturer has made possible these wonderfully compact speaker systems, with a performance previously impossible in such small enclosures. Both utilise a double layer cone drive system contained in a hermetically sealed cabinet, giving a very sensitive and smooth response at all levels. Individual details: **Mini-B,** power handling 8 watts undistorted; impedance 15/16 ohms; frequency response 50-15,000 c/s.; superbly made cabinet size 10 × 5¾ × 7in., finished in Scandinavian Teak—*list price* £11/13/8. **Model B-7,** as Mini-B but frequency response 45-15,000 c.p.s., and size 16¾ × 11¾ × 3¾in.—*list price* £12/5/5.
Brand new and fully guaranteed.

LASKY'S PRICE Mini-B £6.19.6 Model B-7 £7.19.6 Carriage

CONSTRUCTORS BARGAINS

SINCLAIR SUPER MINIATURES *We stock the complete range*

The Micro-6 miniature radio....	£2 19 6
THE SLIMLINE 2 transistor radio	£2 9 6
THE MICRO-FM (tuner/receiver)	£5 19 6
THE X-20 20 watt P.W.M. amp...	£7 19 6
THE X-10 10 watt amplifier and pre-amp.	£5 19 6
THE Z-12 12 watt amp. and pre-amp., fully built	£4 9 6

Write for details of package deals.

TRANSISTORS

ALL BRAND NEW AND GUARANTEED

GET 81, GET 85, GET 86 2/6; 837A, 874P 3/6; OC45, OC71, OC81D, 4/6; OC44, OC70, OC76, OC81 (match pair 10/6): 5/6; AF117, OC75, OC200, 6/6; OC42, OC43, OC73, OC82D, 7/6; OC201, OC204, 15/-; OC205, OC206, 19/6; OC28, 24/6.

TRANSFILTERS

By BRUSH CRYSTAL CO. Available from stock.

TO—01B 465 kc/s. ± 2 kc/s.
TO—01D 470 kc/s. ± 2 kc/s.
TO—02B 465 kc/s. ± 1 kc/s.
TO—02D 470 kc/s. ± 1 kc/s.
TF—01B 465 kc/s. ± 2 kc/s.
TF—01D 470 kc/s. ± 2 kc/s.

7/6 EACH Post 6d.

GORLER UT 340 FM/VHF TUNING HEART

Permeability tuned—covering 87 to 108 Mc/s. Designed for use with one ECC85 valve. Built in cast metal case, size 3 × 2¼ × 1½in. Circuit supplied.

LASKY'S PRICE 15/11 ECC85 valve, 9/- extra. Post and Packing 2/-.

TAPE DECK MOTORS

High quality tape deck capstan motor made by E.M.I. Holland. Bi-directional. Size 4in. dia. × 2in. high, 1in. × ⅛in. spindle.

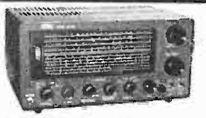
LASKY'S PRICE 15/11 Post 3/6.

HI-FI TAPE RECORDER HEADS—*SPECIAL OFFER*

¼ track Stereo record/replay Tape Heads. High Imp. Size $\frac{7}{16}$in. wide × ¾in. high × ⅜in. deep. Fixing is by single 8 B.A. screw. New and unused. LASKY'S PRICE 25/-. Post free.

COMMUNICATION RECEIVERS

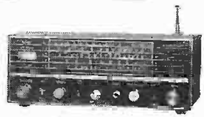
MODEL KT 320 KIT



Supplied in sub-assemblies for easy building. Covers range from 540 Kc/s to 30 Mc/s Ham Band is provided with a scale for direct reading and can also be band spread. 9 valves. Facilities: A.N.L., A.V.C. and M.V.C. Q Multiplier also serves as B.F.O. H.F. stage and two I.F. stages ensure high sensitivity and selectivity (all coils and I.F.s are supplied pre-aligned). 2 Aerial Sockets. Stand-by position for use with a transmitter S meter fitted. 200-250 v. A.C. mains. Steel cabinet, grey crackle finish. Size 15 × 8 × 10in. Dial 12 × 4in. All parts new and fully guaranteed. Complete with full construction data and operating manual.

LASKY'S PRICE 25 GNS. POST FREE. Also available ready built and tested 29 gns. H.P. Terms Avail. on Kit and Built versions.

NEW MODEL SR 150



Covers full medium waveband and 1.6-4.4 Mc/s. 4.5-11.0 Mc/s. and 11.0-30.0 Mc/s. in separate switched band spread ranges. Two aerials are fitted an internal loop and external telescopic. Controls include: B.F.O. Sensitivity, C.W., A.N.L., tone switch, receive/stand-by, S meter. Easy to read illuminated dial with logging scale. For 200/250 v. A.C. 4 valves plus rectifier. Fitted with internal speaker and socket for phones or external speaker. Cabinet size 13¾ × 8¼ × 5¾in. Complete with full instruction manual.

LASKY'S PRICE 20 GNS. H.P. Terms £5 5/- dep. and 11 monthly payments at £1/11/6. Total H.P. £22/11/6. Post 10/-.

STILL A FEW AVAILABLE · FULLY BUILT

MODEL HE30. 33 Gns. MODEL HE40. 18¾ Gns. MODEL HE80. 59 Gns.

WE WILL ACCEPT YOUR OLD SET IN PART EXCHANGE

SPECIAL INTEREST ITEMS!

INTERNATIONAL TAPE

Fully Guaranteed at record low prices.

3in.	Message tape, 150ft.	2/6
3in.	Message tape, 225ft.	3/9
3in.	Message Tape, 300ft.	7/6
3¼in.	Triple play, 600ft. Mylar base ..	15/-
4in.	Triple play, 900ft. Mylar base ..	17/6
5in.	Double play, 1,200ft. Mylar base	15/-
5in.	Long play 900ft. Acetate base....	10/-
5in.	Standard play, 600ft. P.V.C. base	8/6
5in.	Triple play, 1,800ft. Mylar base..	35/-
5¾in.	Double play, 1,800ft. Mylar base	22/6
5¾in.	Long play, 1,200ft. Acetate base	12/6
5¾in.	Standard play, 850ft. P.V.C. base	11/6
5¾in.	Triple play, 2,400ft. Mylar base..	45/-
5¾in.	Long play, 1,200ft. Mylar base..	15/-
7in.	Standard play, 1,200ft. Acetate base	10/-
7in.	Standard play, 1,200ft. Mylar base	12/6
7in.	Long play, 1,800ft. Mylar base..	19/6
7in.	Double play, 2,400ft. Mylar base	25/-
7in.	Long play, 1,800ft. Acetate base	15/-
7in.	Triple play, 3,600ft. Mylar base ..	58/6

1/- Post extra per reel; 4 reels and over Post Free.

CRYSTAL PICK-UP CARTRIDGES—LOWEST PRICES EVER!

All complete with Styli L.P. and Standard, fully guaranteed. Standard Fitting will fit most P.U. Arms and Heads. Post 1/-.

Garrard GC2	17/6
Garrard GCS	15/-
Garrard EV26A	19/6
Acos G.P. 67/1	10/6

STEREO

Ronette Stereo O.V. Turnover with 2 sapphires ..	25/-
Ronette Stereo type 105 and 106 with 2 sapphires	25/-
Ronette Stereo Type 105 and 106 with diamond LP/Stereo and sapphire standard	35/-

Full range of Goldring and Philips cartridges stocked.

AND EVEN LOWER PRICES Save Money! Some of these cartridges are cheaper than styli

C.T.I. Mono 2 sapphires	4/11
Collaro 2 sapphires, stereo	16/-
Collel SCI diamond LP, stereo	10/6
Sonotone 8T, stereo	19/10
Sonotone 2TA mono	15/-

Postage 1/- extra each.

LIMITED QUANTITY ONLY—EXPORT MODEL TV

625 line T.V. chassis (Export Model). For 200-250 v. A.C./D.C. mains. Fitted with Bands I-III turret tuner. Fully loaded with 12 sets of coils for all CCIR channels in these bands. F/M sound. Made by famous British manufacturer. 16 Mullard valves. Electrostatic focus/magnetic deflection. Will take 17in., 19in., 21in. or 23in. CRT. All controls fitted. Supplied new and unused with all valves (less CRT speaker and cabinet). Circuit data included.

LASKY'S PRICE £14.19.6 Carr. & packing in U.K. 10/-. Anywhere overseas 50/-.

THE HARROW POWER PACK

Battery eliminator for portable radios, etc. Converts your Battery radio to A.C. mains. Replaces 4½ v., 6 v. and 9 v. batts. Size only 3in. × 2in. × 2¼in. State Voltage required when ordering.

LASKY'S PRICE 29/6 Post 2/-

TAPE POSITION INDICATOR

Open type—as used by most makers. With reset knob. 3 DIGIT 7/6. 4 DIGIT 10/6. post 9d. each

207 EDGWARE ROAD, W.2.

Tel.: PADdington 3271. Open all day Saturday. Close 1 p.m. Thursday.

33 TOTTENHAM COURT ROAD, W.1.

Tel.: MUSeum 2605. Open all day Saturday. Close 1 p.m. Thursday.

42 TOTTENHAM COURT ROAD, W.1.

Tel.: LANgham 2573. Open all day Thursday. Close 1 p.m. Saturday.

ELECTRONICS (FLEET ST.) LTD. **152/3 FLEET STREET, E.C.4.**

Tel.: FLEet St. 2833. Open all day Thursday. Close 1 p.m Saturday.

ALL MAIL ORDERS AND CORRESPONDENCE TO OUR HEAD OFFICE:—3-15 CAVELL STREET, TOWER HAMLETS, LONDON, E.1. Tel: STE 4821/2

P.T.O. FOR MORE NEWS

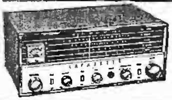
LASKY'S FOR SPEEDY MAIL ORDER SERVICE

WW—136 FOR FURTHER DETAILS.

P.C.R.3 RECEIVERS

Absolutely brand new. 3 waveband 190-550 metres and 2.2-23 Mc/s. With circuit. **£8/19/6.** Carr. 10/6.

Plug in power supply 12v. D.C. **19/6**; 230 v. A.C. **35/-**.

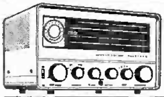


HAM-1. 4 BAND COMMUNICATION RECEIVER

4 wavebands covering 535 kc/s.-30 Mc/s. 5 valve superhet circuit. Incorporates S meter, B.F.O., BANDSPREAD TUNING, BUILT-IN 4in. SPEAKER, FERRITE AERIAL AND EXTERNAL TELESCOPIC AERIAL. Operation 220/240v A.C. Supplied brand new with handbook. **£16/16/-.** Carr. 10/-.

HA-55 AIRCRAFT RECEIVER

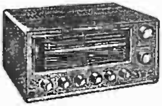
108-136 Mc/s. High selectivity and sensitivity. Incorporates 2 RF stages including 6CW4 Nuvistor, 8 tubes for 11 tube performance, solid state power supply, adjustable squelch control, slide rule dial, built-in 4in. speaker and front panel phone jack. 220/240 v. A.C. Supplied brand new and guaranteed. **£19/17/6.** Carr. 10/-.



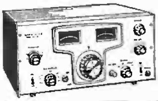
HA-63A GENERAL COVERAGE RECEIVER

7 valves + Rectifier. 4 Bands 550 kc/s.-31 Mc/s. "S" Meter-BFO-ANL-Bandspread Tuning 200/250 v. A.C. Brand new **24 GNS.** Carr. paid.

HA.230 DE-LUXE GENERAL COVERAGE RECEIVER



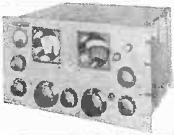
Wonderful value. 8 valves + rectifier. Coverage 550 kc/s.-30 Mc/s. 1 R.F. and 2 I.F. stages, 'Q' multiplier, B.F.O., A.N.L., 'S' meter, electrical bandspread, aerial trimmer etc. Brand new and guaranteed. **£33.** S.A.E. for full details. Also available in easy to assemble Semi-kit form at **25 GNS.**



H.A. 350 10-80 METRE AMATEUR RECEIVER

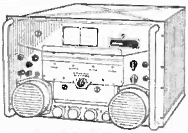
A superb receiver. Dual conversion with mechanical filter. 12 valves, crystal controlled osc., product detector. 100 kc/s. crystal calibrator, crystal B.F.O., A.N.L., 'S' meter, Rock like stability. Brand new and guaranteed. **75 GNS.** S.A.E. for full details.

HAMMARLUND SP600JX COMMUNICATION RECEIVER



High Quality professional dual conversion communication receivers available for the first time in this country at a reasonable price. Frequency range 540 kc/s-54 Mc/s. in 6 bands, variable tuning or 6 channel crystal controlled. 2.5 watt output into 600 ohms. Input 110/230v. A.C. 20 valve circuit incorporating: Xtal filter, B.F.O., A.N.L., Xtal calibrator, S meter etc. Size 19 x 12 x 22in. (List £520). Offered in excellent condition fully tested and checked. **£100** each.

R-278/GR RADIO RECEIVER



U.H.F. receiver designed by Collins Radio. Provides reception of A.M. and C.W. signals on any one of 1750 channels in the frequency range of 225 to 399.9 Mc/s. and simultaneously on one fixed tuner channel in the frequency range of 238-248 Mc/s. Power requirements 115/230 v. 50/60 cps. Size 13in. x 19in. x 20in. Output 3 watts into 600 ohms. High quality modern equipment originally costing hundreds of pounds. Available in as new condition, fully tested, complete with all crystals. **£60.** Carr. 50/-.

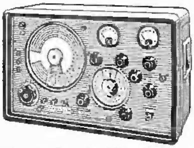
PRECISION MECHANICAL FILTER

As used in HA. 350 Receiver For superb selectivity For 455 kc/s. I.F. provides 60db attenuator at 2.5 kc either side. Complete adjacent channel rejection **£9 19 6.** post paid.

NUVISTOR GRID DIP METER

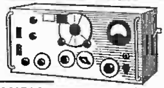
Compact true one hand operation. Frequency range 1.7-180 Mc/s. 230 v. A.C. operation. Supplied complete with all coils and instructions. **£12/10/-.** Carr. 5/-.

AM SIGNAL GENERATOR CT394 MARCONI TF801B/3/S



Frequency range: 12-485 Mc/s. in 5 bands. Variable attenuation from .1µV to 1 volt into 50 ohms. Crystal calibrator every 5 Mc/s. Variable modulation depth. Carrier level and modulation meters fitted. Automatic output level control. 70in. main tuning dial and auxiliary incremental dial. Operating voltage A.C. 100 to 150 and 180 to 250 volts. 40 to 100 c/s. Size 14½in. x 23½in. x 10½in. Weight 67 lbs. Offered in excellent condition, fully tested and guaranteed. **£85.**

MARCONI TF144G STANDARD SIGNAL GENERATOR



85 kc/s.-25 Mc/s. ± 1%. Output variable from 1µV to 1 volt. Internal sine wave modulation 400 c/s. up to 75% depth. Operation 200/250 volts A.C. Offered in really excellent condition, fully tested and guaranteed. **£25.** carr. 30/-.

PORTABLE OSCILLOSCOPE CT.52

A compact (9 x 8 x 16½in.) general purpose 'scope. T/B 10 c/s.- 40 kc/s. Bandwidth 1 Mc/s. Mullard DG7/5 2½ CRT. For operation on 200/250 v. A.C. Supplied complete with metal transit case, strap, test leads, and visor hood. Brand new and guaranteed. **£22/10/-.** Carr. 10/-. Supplied complete with instructions.

AUDIO TRANSFORMERS

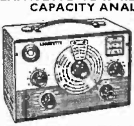
Step up or Step down. Tapped 0-115-200-230-250 volts.

Unshrouded: 20w. **9/-.** P.P. 2/-; 60 w. **12/6.** P.P. 2/6. 75 w. **15/6.** P.P. 2/6; 150 w. **18/6.** P.P. 3/6; 200 w. **27/6.** P.P. 3/6; 300 w. **42/6.** P.P. 4/-; 500 w. **59/6.** P.P. 5/-.

Fully shrouded: 300 w. **42/6.** P.P. 4/-; 500 w. **67/6.** P.P. 5/-; 1,000 w. **90/-.** P.P. 5/-; 1,500 w. **£6/19/6.** P.P. 5/-; 3,000 w.* **£7/10/-.** Carr. 12/6; 7,500 w.* **£15.** Carr. 20/-.

(*Tapped 0/115/230 v. only).

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER



2 PF-2,000 MFD. 2 ohms-200 megohms. Also, checks impedance, turns ratio, insulation 200/250 v. A.C. Brand New **£15.** carr. 7/6.

TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s.-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. **£12/10/-.** P. & P. 7/6.

S.A.E. for details.

GARRARD RECORD PLAYERS

BRAND NEW AND GUARANTEED

	£	s.	d.
SRP-12 Player	£4	7	6
AUTOSLIM Changer	£4	19	6
1000 Changer	£5	19	6
2000 Changer	£6	19	6
3000 Changer—Stereo	£8	8	0
SP25 Player—Stereo	£9	19	6
AT60 Changer Stereo	£9	19	6
A70 (less cart.)	£21	10	0
LAB80	£25	0	0
301 Transcription	£30	0	0

All plus P. & P. 5/-.

NOMBREX

TRANSISTORISED EQUIPMENT

ALL Post Paid

With battery

Transistorised Audio Generator 10-100,000 cs/- Sine or square wave. **£16 15/-.**
Transistorised Signal Generator 150 kc/s. 230 Mc/s. **£10.**
Transistorised resistance capacity bridge 1Ω. 100 Meg. Ω. 1 pf-100µF. **£9/10/-.**
Transistorised Induction bridge 1µH-100H., **£18.** Mains operated Transistor power supply unit, output 1-15 v. up to 100 mA. **£6 10/-.**

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities.

3in. 225ft. L.P. acetate	4/-
3¼in. 600ft. T.P. mylar	10/-
5in. 600ft. std. plastic ..	8 6
5in. 900ft. L.P. acetate	10/-
5in. 1,200ft. D.P. mylar ..	15/-
5in. 1,800ft. T.P. mylar	35/-
5¾in. 1,200ft. L.P. acetate	12/6
5¾in. 1,800ft. D.P. mylar	22/6
5¾in. 2,400ft. T.P. mylar	45/-
7in. 1,200ft. std. mylar ..	12/6
7in. 1,800ft. L.P. acetate	15/-
7in. 1,800ft. L.P. mylar	20/-
7in. 2,400ft. D.P. mylar ..	25/-
7in. 3,600ft. T.P. mylar	58/6

Postage 2/-. Over £3 post paid.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0-20 Kc/s. on 2 ranges. Output 500Ω or 5kΩ. Operation 200/250 v. A.C Supplied in perfect order **£12/10/-.** Carr. 10/-.

TS-382 F/U AUDIO OSCILLATOR

High quality modern American instrument. Frequency coverage on 4 bands. 0-200 Kc/s. Output impedance 1,000Ω. Output monitoring meter. 7 range output attenuator from 12 micro-volts to 12 volts. Operation 115 v. 50-1,000 cps. Supplied as new. **£40.** Carr. 20/-.

SINCLAIR TRANSISTOR AMPLIFIERS All Post Paid

Z12 amplifier **89/6.** Power pack **£2/14/-.**
X10 amplifier built **£6 19/6.** Kit **£5/19/6.**
X10 Power pack **£2/14/-.**
X20 amplifier built **£9/19/6.** Kit **£7/19/6.**
X20 power pack **£2/14/-.**
Micro FM radio kit **£5/19/6.**
Micro 6 **59/6**; TR750 amp. kit **39/6**; Micro Amp. **28/6**; Micro Injector **27/6**; all post paid.

REUTER ¼-TRACK TAPE HEADS

As fitted to Collaro Mk IV and Studio Decks. High imp. record/play back, low imp. erase. Brand new. **19/6** pair. Also Miniflux ¼ track, set of 3, **29/6**; Bradmatic ¼ track, set of 2 **92/6.** Post extra.

ALSO SEE NEXT PAGE

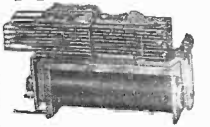
G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

Open 9 a.m.—6 p.m. every day Monday to Saturday. Trade supplied.

Wilkinsons FOR RELAYS

P.O. TYPE 3000 AND 600



BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY
COMPETITIVE PRICES – VARIOUS CONTACTS
DUST COVERS – QUOTATIONS BY RETURN

MINIATURE SEALED RELAYS
OVER 120 TYPES IN STOCK. SEND FOR LIST

SIEMENS 1 C.O.				
	2.2Ω + 2.2Ω		H96A	18/6
	50Ω + 50Ω		H96B	19/6
	145Ω + 145Ω		H96C	19/6
	1,000Ω + 1,000Ω		H96F	21/–
	1,700Ω + 1,700Ω		H96E	22/6
G.E.C.	2,500Ω	4CO	M1008	19/6
	2,500Ω	1CO	M1002	15/–
	5,000Ω	2CO	M1052	17/6
	670Ω	2m2bHD	M1095	17/6
	2,500Ω	2C2K	M1417	18/6
	5,000Ω	2CO	M1452	17/6
	2,500Ω	2mHD	M1458	15/–
	2,500Ω	1m1bHD	M1462	15/–
	40Ω	2CO2K	M1482	19/6
	180Ω	1CO	M1486	15/–
	180Ω	2m2bHD	M1487	17/6
	180Ω	2C2K	M1490	19/6
	670Ω	2C2K	M1493	19/6
	670Ω	4K	M1567	19/6
S.T.C.	45Ω	1mHD	4186EB	19/6
	170Ω	1mHD	4186EC	19/6
	700Ω	2COMD	4190HD	19/6
	2,500Ω	2CO	4184GE	19/6
ERICSSON	7,500Ω	2CO	N22365AZ1	17/6
	7,500Ω	2m2b	N22360AZ1	17/6

RECTIFIER UNITS. Input 230/440 v. A.C. output 50 v. 16 amps. D.C. **£35.**

FREQUENCY METERS 45-55 cycles per second, 230 v., 6in. dia. Flush Round. Brand new, **£10/10/-.**

ROTARY VANE VACUUM PUMPS. Romec B3 Mark 3. Brand new 7 cu ft per min 10 p.s.i. at 1,200 r.o.m. size 6in. × 4in. splined shaft 2in. × ½in. Inlet and outlet ⅜in. dia. internally screwed **95/-** ea., **post** 5/-.

RELAYS. 24 volt D.C. 4 Make, 4 Break, 10 amp. 5C/3944 with Dust Cover, **12/6** each.

SIEMENS MINIATURE RELAYS Type TRLS 154d.. 24 volt, 2 change-over contacts, heavy duty with transparent dustproof cover and base, **17/6.**

SIEMENS HIGH SPEED OPEN TYPE RELAYS with usual adjustments. 1,700Ω, 1 change-over, **17/6** each.

FANS INDUSTRIAL TYPE. 230/240 v. 16in. blades in housing, adjustable louvres, filter, brand new, **£20,** carr. 15/-.

ONE HOLE FIXING SWITCHES
SINGLE POLE Double Throw. 3 amp. 250 v. A.C. can be used as ON/OFF or CHANGE-OVER switch.
12/- per dozen, 75/- per 100

VEEDER-ROOT MAGNETIC COUNTERS WITH ZERO RESET 800 COUNTS PER MINUTE. COUNTING TO 999,999. 230 volts A.C., **65/-.** Post 2/9.

PRECISION SILVER MICA CAPACITORS. 0.1 mfd. ½%, **10/-**; 1%, **7/6**; .02 mfd. 1%, **5/-**; 0.05 mfd. 1%, **5/-**; 0.15 mfd. 2%, **7/6**; **0.25** mfd. 2%, **15/-.**

METERS GUARANTEED Complete list available

2in. Moving Coil Flush Round
Microamps 0/500, **25/-.**
Milliamps 0/1 or 0/10.
Volts 0/20 or 0/30.
Amps 0/5. All D.C., **27/6** ea.
2½in. Moving Coil Flush Round.
Microamps 0/50, unsealed **70/-.** 0/100, **40/-**; 0/150, **70/-.**
Milliamps 0/2, **50/-**; 0/50, **35/-.**
Amps 0/30, **42/6**; 0/250, **60/-.**
Volts 0/2, **46/-**; 250-0-250, **60/-.**

3½in. MC FLUSH ROUND. 0/500 Microamps, **70/-.** 0/2 Milliamps, **60/-**, 0/500 Milliamps, **54/-**, 0/10 amps, **45/-**, 0/40 amps., **72/-.** A selection of our stocks.

M.C. RECTIFIER A.C. METERS. 3½ FR10 Milliamps, **70/-**, 50 or 100 v., **72/-**; 200 volts **65/-.**

MOVING IRON A.C. AMMETERS. 0/10 2½in. fr. **44/-.** 0/60in. Projection Round, **90/-.**

DIRECT ON STARTERS by Crabtree B15, **95/-.**

WEE MEGGER INSULATION TESTERS 500 VOLT SERIES 3. BRAND NEW in leather case, £18/10/-.

AVOMETER POWER FACTOR WATTAGE UNIT, £7.

MEGGER, Series 2. 500 volt 100 megohms, leather case, leads, key, etc. **Brand new, £37/10/-.**

AVOMETERS MODEL 7, £13/10/-. Post 7/-.

VOLTAGE REGULATOR with Current Limiting Reactor. Input 230v. Output 230 57.5 to 230 v. 21 amps controlled by 16 Step Rotary Stud Switch "English Electric," **£20.**

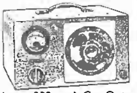
SUBMINIATURE MICRO SWITCHES HONEYWELL 11 SM1-TN13 S.P.D.T. 6/0 ea.

L. WILKINSON (CROYDON) LTD.
LONGLEY HOUSE LONGLEY RD. CROYDON SURREY
Phone: THO 0236 Grams: WILCO CROYDON

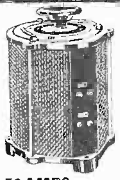
NO EXCUSES! NO DELAYS! FROM STOCK!

VARIABLE VOLTAGE TRANSFORMERS

PORTABLE



Input 230 v. A.C. Output variable 0-260 v. A.C. at 2.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle, **£9/17/6.P.& C.5/-.**



50 AMPS.

1 AMP.

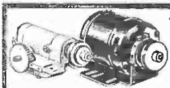
INPUT 230 v. A.C. 50/60~.
BRAND NEW. Carriage Paid. Buy direct from the importer, keenest prices in the country. All Types (and Spares) from ½ to 50 amp. available from stock.

	£	s	d
0–260 v. at 1 amp.	4	10	0
0–260 v. at 2.5 amps.	5	17	6
0–260 v. at 4 amps.	8	7	6
0–260 v. at 5 amps.	9	0	0
0–260 v. at 8 amps.	13	10	0
0–260 v. at 10 amps.	17	0	0
0–260 v. at 12 amps.	19	10	0
0–260 v. at 15 amps.	22	0	0
0–260 v. at 20 amps.	32	10	0
0–260 v. at 37.5 amps.	65	0	0
0–260 v. at 50 amps.	85	0	0

15 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.

INSULATED TERMINALS available in black, red, white, yellow, blue and green. New 15/- per doz. P. & P. 1/-.

★230v. A.C. MOTOR★ & REDUCTION GEAR BOX



Reversible 1/12th h.p. 1,450 r.p.m., ⅜ in. dia. 1in. long shaft. Mounted in anti-vibration cradle. **Supplied complete with precision 20-1 reduction gear box, and pulleys.**

Made to highest standard for computer work. Ex equip. First class condition.

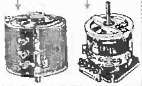
Price **£3/5/0** P. & P. 7/6 extra.

OPEN TYPES

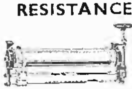
Designed for Panel Mounting
Input 230 v. A.C. 50/60 ~. Output variable. 0-260 v.

½ amp.	....	£3	3	0
1 amp.	....	£4	17	6
2½ amp.	..	£5	12	6

½ AMP. 1 AMP.

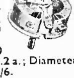


SLIDER RESISTANCES



1 ohm, 12 amp. 17/6; 1.2 ohm.14 amp. 27/6; 75 ohm. 2 amp. 37/6; 200 ohm. 1.25 amp. 37/6; 36 ohm. 6.5 to 2.8 amp., tapered winding, geared drive (less knob) 37/6. P. & P. 3/6.

100 WATT POWER RHEOSTATS (NEW)

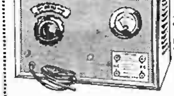


Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 9 VALUES:** 10 ohm 3 a.; 25 ohm 2 a.; 50 ohm 1.4 a.; 100 ohm 1 a.; 250 ohm .7 a.; 500 ohm. .45 a.; 1,000 ohm. 280 mA.; 1,500 ohm. 230 mA.; 2,500 ohm, .2 a.; Diameter 3½in. Shaft length ⅞in., dia. ¼in. 27/6. P. & P. 1/6.

NOW ALSO AVAILABLE IN 25 WATT

10 ohm, 1.5 a.; 25 ohm, 1 a.; 50 ohm, .75 a.; 100 ohm, .5 a.; 250 ohm, .3 a.; 500 ohm, .2 a.; 1,000 ohm, .15 a.; 1,500 ohm, .12 a.; 2,500 ohm, .1 a.; all at 14/6. P. & P. 1/6.

7 Amp. A.C./D.C. Variable Output Power Unit



Input 230 v. A.C. Output continuously VARIABLE from 0 to 260 v. A.C. OR 0 to 230 v. D.C. at 7 a. Robustly constructed in metal case, complete with safety fuse, neon indicator and voltmeter. Size 17 × 12 × 7in. Weight 36 lb. Price £34/10/-. Carriage 20/-.

SERVICE TRADING COMPANY →

SERVICE TRADING CO

Postage and Carriage shown below are inland only. For overseas please ask for quotation. We do not issue a catalogue or list.

ULTRA VIOLET BULBS

Easy to use source of U.V. for dozens of practical and experimental uses.
12 volt 36 watts A.C./D.C. SBC. 6/6. P. & P. 1/-.
12 volt 60 watt A.C./C.D. SBC. 8/6. P. & P. 1/-.
Transformer to suit the above. Input 200-240 v. A.C., 12 volt 36 watts, 16/6. P. & P. 2/6. Input 200-240 v. A.C. 12 volt 60 watt, 22/6. P. & P. 3/6.
Set of 4 Colours FLUORESCENT PAINT. Red, yellow, green and cerise. In $\frac{1}{2}$ oz. tins. Ideal for use with the above Ultra Violet Bulbs, 9/6. plus 1/6 P. & P.

MOVING COIL HEADPHONES

Finest quality soft chamois earmuffs. Superb reproduction. complete with Jack plug, 25/6. P. & P. 2/6.

SIEMENS SEALED HIGH SPEED RELAYS
H96A, 2.2 ohm+2.2 ohm, H96G, 50 ohm+50 ohm, H96C, 145 ohm+145 ohm, H96E, 1,700 ohm+1,700 ohm. All at 12/6 each. P. & P. 1/- on each Relay.

P.O. RELAYS, Type 3000
100 ohm, 8 c/o, 2 make, 2 break. 200 ohm, 6 c/o. 500 ohm, 1 Heavy duty c/o. 500 ohm, 4 Heavy duty make. 2,000 ohm, 4 make, 4 break. 10,000 ohm, 2 make, 2 break. All at **12/6** each. 20,000 ohm, 2 Heavy duty make. Plus 1/- P. & P.

SOLENOID. Overall length $3\frac{5}{8}$in., stroke $\frac{1}{8}$in. to $\frac{1}{2}$in. Maximum push 8 oz. 12-24 v. D.C. operation. D.C. resistance 35 ohm. Price 8/6. P. & P. 1/6.

G.E.C. SEALED RELAYS
M1069 5,000 ohms, 2 c/o. M1084 180 ohm, 4 c/o.
M1092 670 ohm, 4 c/o. M1095 670 ohm, 2 m, 2 b.
M1100 670 ohm, 2 c/o. Ex new equipment.
All at 12/6 each, plus 1/- P. & P.

14,000 OHM SEALED RELAY. High Speed single c/o. Platinum contacts. Super-sensitive, ideal for Transistor circuitry. Will operate, on 1 milliamp, 25/-. P. & P. 1/-.

CARPENTER POLARISED RELAY. Type SA7 TR 2×1,900 turns at 55 ohms. Including Base 25/-. P. & P. 1/-.

12-18 VOLT D.C. RELAY
168 ohm coil, 3×5 amp. N.I. c/o contacts. New, 16/6. plus 1/- P. & P.

"CABY" MULTI-RANGE TEST METER

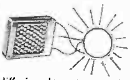
Model B40. D.C. volt 0.5 v. 2.5 v. at 10,000 ohm per volt. Ideal for transistor circuit testing. A.C. and D.C. volt. 10 v., 50 v., 250 v., 500 v., 1,000 v. at 4,000 ohm per volt. Resistance, 2K ohm, 200 K ohm, 2 megohm, 20 megohms. Complete range of spares available from stock. Price includes Test Leads. Battery. Instruction book. Packing and Post (U.K.) Price £6/2/6. Three additional models available. Prices from 54/- to £14/14/-. Leaflet gladly sent on request.

LATEST HIGH SPEED MAGNETIC COUNTERS
4 figure 10 impulses per second. Types 100D. 4.1 ohm coil, 3-6 v. D.C. operation. Type 100A, 500 ohm coil, 18-24 v. D.C. operation. Type 100B, 2,300 ohm coil, 36-48 v. D.C. operation.. Any type, 15/- each, plus 1/6 P. & P.

RESETTABLE HIGH SPEED COUNTER
4 figure 1,000 ohm coil, 36-48 v. D.C. operation. £3/10/-. P. & P. 1/6.

FIRST AGAIN!

TYPE 34R SILICON SOLAR CELL



Four .5 volt units series connected in high impact polystyrene case, flying lead connections. Specially designed diffusing lens system to ensure maximum light pick-up. Output—up to 2 v. at 16-20 mA. in bright sunlight. Wider spectral response, and thirty times the efficiency of selenium cells. As used to power earth satellites. 37/6 and 1/- P. & P.
JUST PUBLISHED "SOLAR CELL & PHOTO-CELL EXPERIMENTERS' GUIDE." Teaches the principles of light sensitive devices and their application. 26/-, post paid.

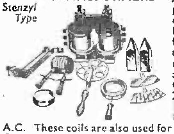
MINIATURE IMMERSION HEATER. 6in. × $\frac{1}{2}$in., 240 volt, 120 watts, 6/6, plus 2/- P. & P.

230 v. A.C. RELAY. 2 c/o 2 amp. contacts, 9/6, ex new equip. P. & P. 1/6.

HIGH SPEED BLOWER UNIT
200/250 volt A.C. Powerful 2-speed motor, 11,000 and 13,000 R.P.M. 17/6, plus P. & P. 2/6.
AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3 each. P. & P. 4/6. 500 watt type £4/2/6 each. P. & P. 6/6. 1,000 watt type £5/5/- each. P. & P. 7/6.

UNIVERSAL DEMONSTRATION TRANSFORMERS

Stenzyl Type



A complete composite apparatus, comprising a robustly built Transformer and electro-magnet with removable coils and pole pieces. Coil tapped for 230 v., 220 v., 110 v., 115 v.; 6, 12, 36, 110 v. A.C. These coils are also used for D.C. experiments. Complete with all accessories as shown. £17, plus 10/- carr. Leaflet on request.

WIMSHURST ELECTROSTATIC GENERATORS
£13/17/6, carr. U.K. (B.R.S.) 10/-. Leaflet on request.

S.T.C. SILICON POWER RECTIFIERS
RS300 Series. All types 1.5 amp. wire ended.
RS310, 100 v. P.I.V. 4/- RS350, 500 v. P.I.V. 8/-
RS330, 300 v. P.I.V. 6/- RS360, 600 v. P.I.V. 9/-
RS340, 400 v. P.I.V. 7/- RS380, 800 v. P.I.V. 10/-
4 can be used to make 3 amp. bridge. Not Seconds. Brand New Stock. Post paid.

230 VOLT A.C. GEARED MOTORS
Type D15G 5 r.p.m. 1.7lb. inch £2/9/6. P. & P. 2/6.
Type D18G 13 r.p.m. 1.45lb. inch £2/12/6. P. & P. 2/6.
Type B16G 80 r.p.m. .26lb. inch £2/2/-. P. & P. 2/6.

UNISELECTOR 8 bank, 25 way, all non-bridging, full wipers, twin coil, 950 ohm. Unused £3/2/6. P. & P. 4/6.

NICKEL CADMIUM BATTERY. Sintered Cadmium Type, 1.2 v. 7 AH. Size: height $3\frac{1}{2}$in., width $2\frac{3}{4}$ × $1\frac{11}{16}$in. Weight: approx. 13 ozs. Ex-R.A.F., tested. 12/6. P. & P. 2/6.

LIGHT SENSITIVE SWITCHES

Kit and parts including ORP.12. Cadmium Sulphide Photocell. Relay. Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price 25/-,** plus 2/6 P. & P.
ORP.12 and Circuit 8/6, post paid.
A.C. MAINS MODEL
Incorporates main transformer, rectifier and special relay with 3×5 amp. mains c/o contacts. Price inc. circuit 47/6, plus 2/6 P. & P.

NEW LINE! PHOTO ELECTRONIC COUNTER
Can be set for counts of up to 500 per minute. 210-250 v. A.C. powered. Kit of Components including photo cell. High speed non-resettable counter. Transformer relay, etc., together with clear circuit diagram. £3/2/6, plus 2/6 P. & P.

ELECTRIC CHECK METER (Sangamo Weston), 200/240 volt A.C., 40 amp. As new 35/- plus 3/6 P. & P.

SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY. 7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight $2\frac{1}{4}$lb. £4 12/6, post paid. (Illustrated)
TRANSISTORISED FULLY AUTOMATIC ELECTRONIC KEYER. 230 v. A.C. or Battery operated. Incorporates built-in monitor Oscillator Speaker, and Keying Lever. Adjustable speeds. Keying either auto., semi-auto. or hold 4 diodes, 7 transistors. Price £16/10/- plus 4/6 P. & P.

TRANSISTORISED MORSE OSCILLATOR Fitted $2\frac{1}{2}$in. Moving Coil Speaker. Uses type PP3 or equiv. 9 v. battery. Complete with latest design Morse Key. 22/6, plus 1/6 P. & P.

1st grade	TRANSISTORS	Brand new
OC29* .. 18/-	OC139 .. 12/-	AF115 .. 10/-
OC41 .. 7/-	OC140 .. 19/-	AF116 .. 10/-
OC44 .. 6/6	OC171 .. 9/-	AF117 .. 9/6
OC45 .. 5/-	OC200 .. 10/6	BCZ11 .. 10/-
OC71 .. 5/-	Get 104 6/-	
OC72* .. 7/-	Get 104 6/-	**DIODES**
OC73 .. 6/-	Get 105 10/-	
OC75 .. 7/-	Get 573 12/6	OA91 .. 3/-
OC76 .. 6/-	25019 .. 30/-	SX781 .. 4/-
OC81 .. 8/-	AC107 .. 14/6	IS111 .. 4/-
OC83* .. 6/-	AF114 .. 11/-	ZS10B .. 3/-

*Available in Matched Pairs.

ZENERS 5%
All $\frac{1}{4}$ watt 5% at 10/- each, 4.3 v., 4.7 v., 5.1 v. 5.6 v., 6.2 v., 6.8 v., 7.5 v., 8.2 v., 9.1 v., 10 v., 12 v., 15 v., 16 v., 22 v.

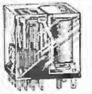
L.T. TRANSFORMERS
All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Carr.
1	30, 32, 34, 36 v. at 5 amps	£2/19/6	6/-
2	30, 40, 50 v. at 5 amps	£4/15/-	6/-
3	10, 17, 18 v. at 10 amps	£3/2/6	4/6
4	6, 12 v. at 20 amps	£3/12/6	6/6
5	17, 18, 20 v. at 20 amps	£5/2/6	6/6
6	6, 12, 20 v. at 20 amps	£4/15/-	7/6
7	24 v. at 10 amps	£3/9/6	5/6
8	28, 29, 30, 31 v. at 21 amps	£6/15/-	10/-

A.C. AMMETERS 0-1, 0-5, 0-10, 0-15, 0-20 amp. F.R. $2\frac{1}{2}$in. dia. All at 21/- each.
A.C. VOLTMETERS 0-25 v. 0-50 v., 0-150 v. M.I., $2\frac{1}{2}$in. Flush round all at 21/- each. P. & P. extra.
0-300 v. A.C. Rect. M-Coil $2\frac{1}{2}$in. 29/-
0-300 v. A C. Rect. M-Coil $3\frac{1}{2}$in. Type W23.. 55/-

D.C. AMMETERS
0-5 amp. D.C. M.I. $2\frac{1}{2}$in. Rnd. 11/6
0-500 Microamp. sub-min. $1\frac{1}{4}$in. dia. Scaled 0-1 milliamp .... 21/- Postage extra.

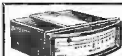
VAN DE GRAAF ELECTROSTATIC GENERATOR, fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £6/6/- plus 4/- P.&P. Lft. on request.



Latest type **SIEMENS MINIATURE RELAY** in Transparent Case. 2 c/o 700 ohm coil, size $\frac{7}{8}$ × $\frac{3}{4}$ × $1\frac{3}{8}$in. 15/- including base.
Similar to above. Mfg. by GRUNER 4 c/o, 2,400 ohm coil. New, 12/6, less base.

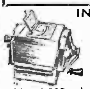
SOLENOID OPERATED MAGNETIC RELAY
Type Sc/3944, 4 pole c/o, 10 amp. contacts, 24 volt D.C. operation. 12/6 each. P. & P. 1/6.

BUILD AN EFFICIENT STROBE UNIT FOR ONLY "37/6." The ideal instrument for workshop lab. or factory. This wonderful device enables you to "freeze" motion and examine moving parts as if stationary. We supply a simple circuit diagram and all electrical parts including the NSP2 Strobe tube which will enable you to easily and quickly construct a unit for infinite variety of speeds, from 1 flash in several seconds to several thousands per minute. 37/6, plus 3/- P. & P.



SANGAMO WESTON
Type S32
$2\frac{1}{2}$ Edgewise Meter
250 Micro-amp., scaled in dB.'s. New 29/6, P. & P. 1/-.

INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volt 500 megohms. Price £22, carriage paid. 1,000 volts, 1,000 megohms, £28, carriage paid.

NEW SOUND POWER OPERATED EX-ADMIRALTY HEAD AND BREAST SETS

Two such sets connected up will provide perfect intercom. No batteries required. Will operate up to $\frac{1}{2}$ mile. Price 17/6 each plus P. & P. 3/- or 32/6 per pair. P. & P. 4/-.

ALL MAIL ORDERS. ALSO CALLERS AT:
47-49 HIGH STREET, KINGSTON-ON-THAMES
Telephone: KINgston 9450
Closed Saturdays.

PERSONAL CALLERS ONLY: **9 LITTLE NEWPORT STREET, LONDON, W.C.2.** *Tel.: GER 0576*
(OFF LEICESTER SQUARE)
Open till 1 p.m. Thursday and all day Saturday.

R.S.C. (MANCHESTER) LTD.

MAIL ORDERS TO: Dept. W., 102 Henconner Lane, Bramley, Leeds, 13

Terms: C.W.O. or C.O.D. No C.O.D. under £1. Postage 2/9 extra under £2. 4/6 extra under £5. Trade supplied. S.A.E. with all enquiries please. Personal shoppers welcomed at any of the branches below. OPEN ALL DAY SATURDAY

BRADFORD 10 North Parade. Tel.: 25349. (Half-day Wed.)
BRISTOL 14 Lower Castle Street. (Half-day Wed.). Tel.: 22904
BIRMINGHAM 30/31 Gt. Western Arcade. Opp. Snow Hill station. Tel.: CENtral 1279. (No half-day). Larger premises now open.
DERBY 26 Osmaston Rd. The Spot. (Half-day Wed.). Tel.: 41361.
DARLINGTON 13 Post House Wynd Tel.: 68043. (Half-day Wednesday)
EDINBURGH 133 Leith Street, (Half-day Wed.)
GLASGOW 326 Argyle Street. Tel.: CITy 4158 (No half-day)
HULL 51 Savile Street (Half-day Thursday). Tel.: 20505.
LEICESTER 32 High Street (Half-day Thurs.). Tel.: 56420
LEEDS 5-7 County (Mecca) Arcade (No Half-day). Tel.: 28252.
LIVERPOOL 73 Dale St. (No Half-day) Tel.: CENtral 3573
LONDON 238 Edgware Road, W.2 (Half - day Thursday). Tel.: PADdington 1629.
MANCHESTER 60A-60B Oldham St. (No Half-day). Tel.: CENtral 2778.
MIDDLESBROUGH 106 Newport Road. (Half-day Wednesday). Tel.: 47096
SHEFFIELD 13 Exchange Street, Castle Market Bldgs. Tel.: 20716. (Half-day Thursday.)

STAFF REQUIRED AT VARIOUS BRANCHES Full or Part Time. Experience unnecessary.

R.S.C. 4 watt GRAM AMPLIFIER KIT

Complete set of parts to build a good quality compact unit suitable for use with any record playing unit. Mains isolated chassis. Separate Bass and Treble controls. Output for 2-3 ohms speaker. For 200-250 v. A.C. **59/9**

POWER PACK KITS

Fully smoothed output 250 v. 60 mA. H.T. and L.T. 6.3 v., 1.5 amps. Consists of chassis, mains trans. 200-250 v. Double wound, Rectifier, Choke, Electrolytics and circuit. **19/11**
Or with case in lieu of chassis 25/-.

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

Valves EZ81, ECC83, ECC83, EL84, EL84. Separate bass and treble controls giving "cut" and "boost" Sensitivity 50 mV. 5 watts high quality output on each channel. Can be used as straight 10 watt amplifier. Controls: Stereo/Monaural switch, ganged volume, ganged treble, ganged bass and balance. Output for 3 ohms speaker. Point-to-Point wiring diagrams and instructions. Illustration full wiring details and priced parts list 1/9. **8 GNS.** Carr. 10/-
Or supplied assembled and tested 59/6 extra. Deposit 2 gns. and 9 monthly payments of 24/2 (Total £12/19/6).

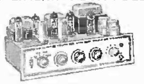
Full range of Hi-Fi equipment. Cash or Terms.
ARMSTRONG, LINEAR, LEAK, TRUVOX, TANDBERG, JASON, FANE, FERROGRAPH, RESLO, GARRARD, GOLDRING, W.B., CONNOISSEUR, GOODMAN, GRAMPIAN, WHARFEDALE, ROGERS, QUAD.

HEAVY DUTY SELENIUM RECTIFIERS
12 V. 15 AMPS. F.W. (BRIDGE) **19/9**

FANE 122/10 20 WATT HEAVY DUTY LOUDSPEAKERS 12in. 15 ohm. With exceptionally robust 2in. diameter voice coil assembly. **5 GNS.** Post 5/6
Model 122/10A with Dual Cone 6 Gns.

R.S.C. STEREO/20 HIGH FIDELITY AMPLIFIER

Providing 10/14 WATTS ULTRA LINEAR PUSH-PULL OUTPUT ON EACH CHANNEL

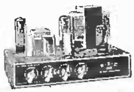


Features include:
★ Four-position tone and compensating Input Selector switch.
★ Stereo/Mono switch so that peak monaural output of 28 watts can be obtained.
★ Separate Bass "lift" and "cut" and treble "lift" and "cut" controls.
★ Neon panel indicator.
★ Handsome Perspex Frontplate. Send S.A.E. for illustrated leaflet.

Complete set of parts with point-to-point wiring diagrams and instructions. Carr. 12/6. **13 Gns.** or Factory assembled, tested and supplied with our usual 12 months' guarantee for 18 gns. or DEPOSIT £2/17/- and nine monthly payments of 39/10 (Total £20/15/6). SUITABLE for "MIKE," GRAM., RADIO OR TAPE. INTENDED FOR HOME OR STUDIO. Employing valves ECC83, ECC83, ECL86, ECL86, ECL86, ECL86, EZ81. Output transformers are high quality sectionally wound to required specification. Output matchings for 3 and 15 ohms speakers on each channel. FREQUENCY RESPONSE ±2 D.B. 30-20,000 c.p.s. HUM LEVEL 65 D.B. down. SENSITIVITY: 15 millivolts maximum. HARMONIC DISTORTION (each channel) 0.2 per cent. For operation on 200/250 v. A.C. mains.

R.S.C. A10 30 WATT AMPLIFIER

HIGH FIDELITY ULTRA LINEAR PUSH-PULL OUTPUT



SIX VALVES EF86, EF86, ECC83, 807, 807, GZ34. Tone Control Pre-amp stages are incorporated. Sensitivity is extremely high. Only 12 millivolt minimum input is required for full output. THIS ENSURES THE SUITABILITY OF ANY TYPE OF MICROPHONE OR PICK-UP. Separate Bass and Treble controls give both "lift" and "cut." An extra input with associated vol. control is provided so that two separate inputs such as "mike" and gram., etc. can be simultaneously applied for mixing purposes. AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 A. FOR A RADIO TUNER. Price in kit form with easy to follow wiring diagram, ONLY **12 Gns.** Carr. 10/-. Or factory built using latest EL34 output valves with 12 months' guarantee. 15 GNS. TERMS ON ASSEMBLED UNITS. DEPOSIT £2/8/- and 9 monthly payments of 33/3 (Total £17/7/3). Protective cover with handles available for 21/-. Type 807 output valves are used with High Quality Sectionally Wound output transformer specially designed for Ultra Linear operation. Negative feedback of 20 D.B. in main loop. CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE. Frequency response ± 3 D.B. 30-20,000 c/s. Tone Controls +12 D.B. at 50 c/s. +12 D.B. to −6 D.B. at 12,000 c/s. hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish gold hammer. Overall size 12×9×9in. approx. Power consumption 150 watts. For A.C. mains 200-250 v. 50 c/s. Output for 3 and 15 ohms speakers. EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS, OR OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS, SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc., etc. We can supply Microphone, Speakers, etc. etc. at keen cash prices or on terms with amplifiers. EXPORT ENQUIRIES INVITED.

R.S.C. A11 12-14 WATT AMPLIFIER

HIGH FIDELITY PUSH-PULL ULTRA LINEAR OUTPUT

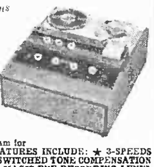
"BUILT-IN" TONE CONTROL PRE-AMP STAGES

Two input sockets with associated controls allow mixing of "mike" and gram. etc. High sensitivity. Includes 5 valves ECC83, ECC83, EL84, EL84, EZ81. High quality sectionally wound output transformer specially designed for Ultra Linear operation. Reliable components. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut." Frequency response ± 3 D.B. 30-20,000 c/s. Six negative feedback loops. Hum-level 60 D.B. down. ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and mikes. Comparable with the very best designs. For gram., radio or tape. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc.
OUTPUT SOCKET with plug provides 300 v. 30 mA. and 6.3 v. 1.5 a. For supply of a RADIO TUNER. Size approx. 12×9×7in. For A.C. mains 200-250 v. 50 c/s. Output for 3 and 15 ohms speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied (or factory built £10/19/6). TERMS: DEPOSIT 33/3 and 9 monthly payments of 24/1 (Total £12/10/-. **8 Gns.** Carr. 10/-
If required louvred metal covers with 2 carrying handles can be supplied for £1.

AUDIOTRINE HI-FI TAPE RECORDER KIT

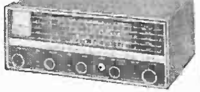
Only 4 pairs of soldered joints plus mains

Build a high quality recorder in the £50 class for only **25½ Gns.** Carr. 18/6.



Can be assembled in one hour. S.A.E. for leaflet. 4 track 3 gns. extra OR DEPOSIT 4 gns. and 9 monthly payments of 56/- (Total 28 Gns.). Cash price if settled in 3 months. INCORPORATING THE LATEST MAGNAVOX TAPE DECK THE AUDIOTRINE HIGH QUALITY TAPE AMPLIFIER, A HIGH FLUX 7×4in. LOUDSPEAKER. Reel of Best Quality TAPE. Spare Tape Spool, a Portable Cabinet, size approx. 17¼×14½×8½in., finished in complementary shades of Rexine and Vynair. Connection diagram for wiring amplifier to transcriptor provided. FEATURES INCLUDE: ★ 3-SPEEDS ★ FREQUENCY RESPONSE 50-11,000 cps ★ SWITCHED TONE COMPENSATION FOR EACH SPEED ★ OUTPUT 4 WATTS ★ MAGIC EYE RECORDING LEVEL INDICATOR ★ HEAVY DUTY MOTOR ★ TAPE MEASURING & CALIBRATING DEVICE ★ TAKES FULL 7in. DIAMETER REELS OF TAPE ★ NEGLIGIBLE HUM ★ ENTIRELY EFFECTIVE AUTOMATIC ERASURE.

COMMUNICATION RECEIVER RX 60 DE-LUXE



4 Band 535 Kc/s to 30 Mc/s. Slide Rule Tuning Dial with Bandspread and "S" Meter. A.V.C. Noise Limiter, B.F.O. Phone Jack. Built in speaker. Stand-By Switch with terminal for transmitter. Built in Antenna for long range reception. High Sensitivity. For 200-250 v. A.C. mains. Handsome chrome decorated cabinet. 13¾in. × 5¾in. × 8¾in. **19 Gns.** Or Deposit £5. and 9 monthly payments 37/8 (Total £21/19/-) Carr. 10/-.

R.S.C. TRANSFORMERS

Fully Guaranteed. Interleaved and Impregnated.

MAINS TRANSFORMERS. Primaries 200-250 v. 50 c/s.

MIDGET CLAMPED TYPE 2½×2½×2¼ins.
250 v. 60 mA., 6.3 v., 2 a. 13/9
250-0-250 v. 60 mA., 6.3 v. 2 a. 14/9

FULLY SHROUDED. UPRIGHT MOUNTING
250-0-250 v. 60 mA., 6.3 v. 2 a. 0-5-6.3 v. 2 a. 2½-3-3in. 18/9
250-0-250 v. 100 mA., 6.3 v. 5 a., 0-5-6.3 v. 3 a. 29/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 29/9
300-0-300 v. 130 mA., 6.3 v. 4 a. c.t., 6.3 v. 1 a. For Mullard 510 Amplifier 36/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 29/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 36/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 5 v. 3 a. 59/9
425-0-425 v. 200 mA., 6.3 v. 4 a., 6.3 v. 4 a., 5 v. 3 a. 63/9
450-0-450 v. 250 mA., 6.3 v. 4 a. c.t. 5 v. 3 a. 69/9

TOP SHROUDED DROP-THROUGH TYPE
200-0-250 v. 70 mA., 6.3 v. 2 a., 0-5-6.3 v. 2 a. 17/9
250-0-250 v. 100 mA., 6.3 v. 3.5 a. 19/9
250-0-250 v. 100 mA., 6.3 v. 2 a., 6.3 v. 1 a. 21/9
350-0-350 v. 80 mA., 6.3 v. 2 a. 0-5-6.3 v. 2 a. 21/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 28/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 28/9
300-0-300 v. 130 mA., 6.3 v. 4 a., 0-5-6.3 v. 1 a. suitable for Mullard 510 Amplifier 35/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 28/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 0-5-6.3 v. 3 a. 37/9

FILAMENT TRANSFORMERS
12 v. 1 a. 7/11 6.3 v. 1.5 a. 6/9; 6.3 v. 2 a. 7/6; 6.3 v. 3 a. 9/9; 6.3 v. 6 a. 17/9; 12 v. 3 a. or 24 v. 1.5 a. 17/9.

AUTO (Step UP/Step DOWN) TRANSFORMERS
0-110/120 v.-200-230-250 v. 50-80 watts 14/9
150 watts 29/9, 250 watts 49/9, 500 watts 99/9

CHARGER TRANSFORMERS
0-9-15 v. 1½ a. .... 12/9 — 0-9-15 v. 5 a. 19/9
0-9-15 v. 2½ a. .... 14/9 — 0-9-15 v. 6 a. 23/9
0-9-15 v. 3 a. .... 16/9 — 0-9-15 v. 8 a. 28/9

OUTPUT TRANSFORMERS
Standard Pentode 5,000Ω to 3Ω or 7,000Ω to 3Ω 6/6
Push pull 8 watts EL84 to 3Ω or 15Ω 9/9
Push pull 10-12 watts 6V6 to 3Ω or 15Ω 18/9
Push pull 10-12 watts to match 6V6 to 3, 5, 8 or 15Ω 19/9
Push pull EL84 to 3 or 15Ω 10-12 watts 18/9
Push pull Ultra Linear for Mullard 510, etc. 29/9
Push pull 15-18 watts, sectionally wound 6L6, KT66, etc., for 3 or 15Ω 29/9
Push pull 20 watt high-quality sectionally wound. EL34, 6L6, KT66, etc. to 3 or 15Ω fully shrouded.. 49/9

SMOOTHING CHOKES
250 mA., 5 H., 100 Ω 11/9 — 80 mA., 10 H., 350Ω 5/9
150 mA., 7-10H, 250Ω 11/9 — 60 mA., 10 H., 400Ω 4/11
100 mA., 10 H., 200Ω 8/9 — 1 amp. 0.5Ω L.T. type 6/8

LOUDSPEAKERS IN CABINETS

12in. 10 WATT. Walnut Veneered Cabinet. Size 15×14×8in. approx. High quality 12in. 10 watt 12,000 line speaker, 3 ohms or 15 ohms £4 13/6. Carr. 5/6. Or Deposit 15/- and nine monthly payments 10/10 (Total £5/12/6).

12in 20 WATT. High Quality 15,000 line l/speaker 15 ohms in Cabinet, finished as above. Size 18×18×8in. **£7/19/6.** Carr. 8/6. Or Deposit 24/6 and 9 monthly payments of 17/- (Total £8/17/6).

12in. 30 WATT. 17,000 lines, in walnut finished cabinet Terms: Deposit 32/- and 9 monthly payments of 22/-. Total £11/10/-. **10 Gns.** Carr. 10/-.

All above available in Rexine covered cabinets for £1 extra.

R.S.C. BATTERY CHARGERS & KITS

FOR A.C. MAINS: 200/250 v. 50 c/s. *ASSEMBLED* 4 amps 6/12 v. Fitted Ammeter and variable charge rate selector. Also selector plug for 6 v. or 12 v. charging. Steel case with stoved grey hammer finish. Fused and ready for use with mains and output leads and battery clips. **59/9** Carr. 4/6. Terms: Deposit 15/- and 5 monthly payments of 12/- (Total £3/12/-).

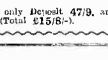
HEAVY DUTY CHARGER KIT 6/12v., 6 amps, variable output
Mains transformer 0-200-230-250 v. F.W. (Bridge), Selenium Rectifier, Ammeter, Variable Charge Rate Selector panels, Plugs, Fuses, Fuse-holder and circuit. Carr. 6/-. **59/9**

R.S.C. BATTERY TO MAINS CONVERSION UNITS.

Type B.M.1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supply 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. For all battery portable receivers requiring 1.4 v. and 90 v. Complete kit with diagram **39/9** or ready for use **49/9**

LATEST MAGNAVOX 363 TAPE DECKS

3 speeds 1⅞in., 3¾in., 7½in. per sec. A robust high quality Deck with high fidelity recording heads. Includes: Digital Counter, pause control, Heavy 4 pole fully screened motor, Record Interlock to prevent accidental erasure. For 200-250 v. A.C. mains.



Two Track Model **10 Gns.** Carr. 7/6
Four Track Model **£13/19/6** Carr. 7/6
Terms on 4 Track Model only Deposit 47/9. and 9 monthly payments 28/11 (Total £15/8/-).

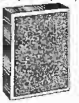
R.S.C. SUPER 15 HI-FI AMPLIFIER | R.S.C. SUPER 30 STEREO AMPLIFIER

FULLY TRANSISTORISED

- ★ 200-250 v A.C. Mains Operation
- ★ OUTPUT R.M.S. CONTINUOUS 10 WATTS into 15 ohms, 15 WATTS into 3 ohms.
- ★ Max. instantaneous Peak Power Output 28 watts.
- ★ PRINTED CIRCUIT CONSTRUCTION
- ★ LATEST MULLARD TRANSISTORS AD149, AD149, OC127Z, OC81Z, OC44, OC44, OC81Z, OC44, AC107 (Total of nine)
- ★ 5-POSITION INPUT SELECTOR SWITCH EQUALIZATION to Standard R.I.A.A. and C.C.I.R. Characteristics for Gram and Tape Heads
- ★ FULL TAPE MONITORING FACILITIES
- ★ SENSITIVITIES: Magnetic P.U. 4 m.v. Crystal or Ceramic P.U. 400 m.v. Microphone 4.5 m.v., Tape Head 2.5 m.v. Radio/Aux. or Ceramic P.U. 110 m.v.
- ★ FREQUENCY RESPONSE: 20-20,000 c.p.s. ± 2 d/B
- ★ TREBLE Control +15 d.B. to −14 d.B. at 10 Kc/s.
- ★ BASS Control +12 d.B. to −15 d.B. at 50 c/s.
- ★ HARMONIC DISTORTION AT 10 Watts R.M.S. 1,000 c.p.s. 0.35%. ★ HUM LEVEL: −75 d.B.
- ★ NEGATIVE FEEDBACK 52 d.B.

AUDIOTRINE HI-FI LOUDSPEAKER ENCLOSURES. All types are of pleasing modern "slim-line" design acoustically lined and ported. Alternative finishes of light teak or medium walnut.

SE8. Designed for optimum performance with any Hi-Fi 8in. speaker. Size 22in. high, 15in. wide, 7in. deep. Dep. 18/-, 9 mthly. pyts. 12/3 (Total £6/8/3) Carr. 7/6. **£5/15/0**

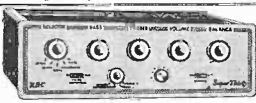


SE10. For 10in. High-Fidelity Speaker with provision for tweeter. Especially recommended for use with Audiotrine HF100D speaker. Size 24in. high, 15in. wide, 7½in. deep. Carr. 10/-. Or Dep. 21/- and 9 monthly payments 15/- (Total £7/16/-.) **£6/19/9**

SE12. For outstanding performance with any 12in. Hi-Fi speaker but especially suitable for types with low fundamental resonance. A tweeter cut-out is provided. Size 24in. × 20in. × 7½in. approx. Deposit 27/- and 9 monthly payments 17/10 (Total £9/7/6). Carr. 10/-. **Only 8 Gns.**

INTRODUCING TWO COMPLETELY NEW UNITS WITH TECHNICAL SPECIFICATIONS COMPARING MORE THAN FAVOURABLY WITH SIMILAR AMPLIFIERS OFFERED AT 2-3 TIMES THE COST.

IMPORTANT NOTE. Rated output figures are given in R.M.S. and not speech and music or I.H.F.M. otherwise we could obviously quote much higher outputs.



Complete Kit of parts with full constructional details and point-to-point wiring diagrams. **10½ Gns.** Carr. 10/-.

If preferred printed circuit can be supplied with parts soldered in and tested for **30/-** extra. Terms on Kit with wired printed circuit Deposit **72/-** and 9 mthly. pyts. **22/6** (Total **£13/14/6**). Handsome Wooden Cabinet, beautifully finished in walnut or teak **5 gns.** Or unit factory built and tested, with our usual 12 months' guarantee and fitted Cabinet mentioned above. **18½** gns. Carr. 12/6. Deposit **£3/9/-** and 9 mthly. pyts. **£2** (Total **£21/9/-**).

All parts point-to-point wiring diagrams and detailed instructions. Carr. 12/6. **18 Gns.**

Printed circuits supplied with appropriate components assembled, soldered and tested for **£3** extra. Terms: Deposit **6 gns.** and 9 mthly. pyts. of **38/6** (Total **£23 12 6**). Walnut or Teak finished cabinet **5 gns.** Or Deposit **17/-** and 9 monthly pyts. **11/-** (Total **£5/16/-**). Or unit completely assembled ready for use, fitted cabinet as above. Carr. 15/-. **29 gns.** Or Deposit **£4/12/-** and 9 monthly payments **64/-**. (Total **£33/8/-**).

A DUAL CHANNEL VERSION OF THE SUPER 15 Employing Twin Printed Circuits

Send S.A.E. for leaflet.

- ★ Close Tolerance Ganged Pots
- ★ Matched Components
- ★ CROSS-TALK −52 d.B. at 1,000 c.p.s.
- ★ CONTROLS: 5 Position Input Selector, Bass Control, Treble Control, Volume Control, Balance Control, Stereo/Mono Switch, Tape Monitor Switch, Mains Switch.
- ★ INPUT SOCKETS (Matched Pairs) (1) Magnetic P.U. (2) Ceramic or Crystal P.U. (3) Radio/Aux. (4) Tape Head Microphone.
- ★ Operation of the Input Selector Switch assures appropriate equalization.
- ★ Rigid 18 s.w.g. Chassis. Size approx. 12in. wide, 3in. high and 8in. deep.
- ★ Attractive Facia Plate and Matching Knobs.
- ★ NEON PANEL INDICATOR.

Above facilities etc., except for Ganging and Balance Control, apply also to Super 15. ALL COMPONENTS ETC ARE OF A HIGH STANDARD AND SUPPLIED BY LEADING BRITISH MANUFACTURERS. THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Moving Coil, Ribbon), REGARDLESS OF THE COST. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USING WITH FIRST RATE ANCILLARY EQUIPMENT.

AUDIOTRINE HF100D 10in. 15 watt HI-FI SPEAKER

Heavy cast construction. 2in. Diameter VOICE COIL. Dual Cone, plastic treated surround, smooth frequency response 20-20,000 c.p.s. Speech Coil 3 ohm or 15 ohm. **£5/15/0**

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS. HF1012. 10 watts rating. Where a really good quality speaker at a low price is required, we highly recommend this unit. Please state whether 3 ohm or 15 ohm required. **£4 19 9.**

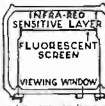
Audiotrine High Fidelity Speaker Systems

Designed to provide a smooth frequency response from 40-20,000 c.p.s. consisting of 12in. 12,000 line 15 ohm speaker. Crossover Unit and Tweeter. Highly recommended for use with any High-Fidelity Amplifier. **10 Watt Unit. £4/19 9.** Carr. 5/6, or Deposit **15/-** and 9 monthly payments of **10/10** (Total **£5 12 6**); **20 Watt Unit £6/19/9.** Carr. 7/6, or Deposit **21/-** and 9 monthly payments of **15/-** (Total **£7/16/-**).

R.S.C. JUNIOR BASS REFLEX CABINET. Designed for above speaker, but suitable for any good quality 8in. or 10in. speaker. Acoustically lined and ported. Medium walnut veneer finish. Size 18in. × 12in. × 10in. Strongly made. Handsome appearance. Ensures superb reproduction for only **£4 7 6.** Dep. **14/6**, 9 mthly. pyts. of **10/4** (Total **£5/7/6**).

WW—141 FOR FURTHER DETAILS.

SNIPERSCOPE

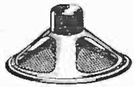


Famous war-time "cats eye" used for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. With carrying strap, a golden opportunity for some interesting experiments. **5/-** each, post 2/-. Data will be supplied with cells if requested.

MAINS POWER PACK

MAINS POWER PACK designed to operate transistor sets and amplifiers. Adjustable output 6 v.-9 to 12 volts for up to 500 mA (class B working). Takes the place of any of the following batteries, PR1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer-rectifier, smoothing and load resistor, 5,000 and 500 mfd. condensers, zener diode and instructions. Real snip at only **14/6**, plus 2/6 post.

SPEAKER BARGAIN



12in. High fidelity loudspeaker. High flux permanent magnet type with either 3 or 15 ohm speech coil. Will handle up to 10 watts. Brand new, by famous maker. Price **29/6**, plus 3/6 post and insurance.

ARMCHAIR CONTROL UNIT

Remote Controller—for Philips, Stella and Cossor T.V. sets but adaptable to most others, and to model control. Comprises 3 rock switches, two variable resistances and components including Mullard OA81 - Knobs - 10 way plug—11 ft. 7 way cable etc., etc. List price £3/9/-, yours for only **12/6**, plus 2/- post and insurance.

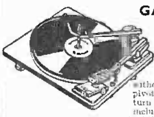
STUPENDOUS OFFER—£11 for £2

The Princess superhet described below is a very fine little set that has been carefully designed for high performance. Only recently (under another name of course) this was on offer in many radio shops, for £10/19/6, but we have been fortunate in obtaining the parts at a very low price and now pass this saving on to you. If you act quickly you can purchase this for only **39/6** plus 3/6 post and insurance. Note these features: ● Long and Medium Wave ● Long clear dial with travelling pointer and slow motion drive ● Push pull output approximately 350 m.w. ● A.V.C. and feed back ● Dust cored H.Q. I.F. transformers ● High selectivity ferrite aerial ● Six tested and guaranteed transistors ● Printed circuit board for fool-proof assembly ● Economy output circuit gives long life from PP3 battery ● Permanent magnet moving coil speaker ● Cabinet size 4¾in. × 3in. × 1¼in.

You get over 100 parts (list value over £10). In fact everything you need and easy to follow wiring and aligning instructions. Don't miss this wonderful offer. Make up several while you have the chance. Use them as presents and you'll be loved for ever. Battery **1/9** extra.

THIS MONTH'S SNIP

GARRARD AUTO RECORD PLAYER Model 2000



This is one of the latest products of the World's most experienced maker of fine record reproducers—its superior features include—automatic playing of up to 8 mixed size records—stopping and starting without rejecting—manual playing—pick-up pivots to give low stylus pressure—large diameter turn table for max. stability—adjustments include pick-up height—pick-up dropping position and stylus pressure. Size is 13¾ × 11¾ clearances 4¾ above, 2¼ below—fitted with latest hi-compliance cartridge for stereo—and mono. L.P. and 78. Supplied complete with mounting template and service sheet.

Offered this month at the Special Snip price of **£6/9/6**, plus 7/6 carr. & ins.

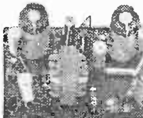
TRANSISTOR BARGAIN

With carrying handle size 10in. × 8in. × 3in. strongly made from best plywood and covered two-tone fabric—looks very smart, suitable for receiver — amplifier — extension speaker, etc.—Originally listed at 29/6—but offered this month at only **15/-** plus 2/- post and insurance: also given free with it is a printed circuit board to suit it and building instructions for fine two-wave radios. **Don't miss this grand offer.**

FOUR-STATION INTERCOM.

Will save time and improve efficiency. Ideal in home—office—shop—surgery, etc. Complete outfit comprises Master unit and three substations each of which can call the master and have full two-way working. No wiring problems as subs fitted with 60ft. twin flex and they plug into sockets. Also included is packet of staples—and battery. **Nothing else to buy—£7/15/-**, plus 4/6 post and insurance.

750 mW TRANSISTOR AMPLIFIER



4 transistors including two in push-pull - input for crystal or magnetic microphone or pick-up—feed back loops — sensitivity 5 m/v. Price **19/6**. Post and Ins. 2/6.

Speakers 3in. **12/6**; 5in. **13/6**; 6in. × 4in. **14/6**

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**

VALVES FULLY GUARANTEED INDIVIDUALLY PACKED

AC/HL 4/6, ACP4 6/-, AC6PEN 5/-, AL60 5/-, AR8 .. 5/-, ARP3 3/-, ARP12 2/6, ARP24 3/6, ARTP1 6/-, ATP4 2/3, ATP7 5/6, AU7 65/-, AZ31 9/-, BD78 40/-, B6H 14/-, BL63 10/-, BS4 8/-, BS5 20/-, BS84 47/6, BT19 25/-, BT35 25/-, BT45 150/-, BT83 35/-, CC3L 2/-, CL33 9/-, CV71 3/-, CV77 6/-, CV102 1/-, CV103 4/-, CV4004 7/-, CV4014 7/-, CV4015 5/-, CV4025 10/-, CV4049 6/-, CY31 .. 6/6, D1 .. 1/6, D41 .. 3/3, D61 .. 6/-, D77 .. 3/3, DA30 12/6, DAF96 6/-, DD41 4/-, DET5 8/-, DET20 2/-, DET25 15/-, DF73 5/-, DF91 3/-, DF92 .. 3/-, DF96 .. 6/-, DH63 5/-, DK92 8/-, DK96 6/6, DL92 4/-, DL93 4/-

DL94 5/9, DL96 7/-, DL810 8/-, DL819 15/-, DY86 7/6, E80F 23/-, E88CC 12/-, E90CC 10/-, E1148 2/6, E1266 50/-, E1415 30/-, E1624 12/6, E2154 16/-, EA50 1/-, EA73 7/-, EABC80 5/9, EAC91 3/6, EAF42 8/-, EB34 1/6, EB91 3/-, EBC33 6/-, EBC41 8/6, EBC81 6/-, EBF80 6/6, EBF83 7/6, EBF89 6/9, EC52 4/-, EC53 12/6, EC70 4/-, EC90 2/-, EC91 3/-, ECC81 4/-, ECC82 5/-, ECC83 6/-, ECC84 5/6, ECC85 6/6, ECC88 9/-, ECC91 4/-, ECF82 7/-, ECH42 9/6, ECH81 5/-, ECH83 7/6, ECL80 6/-, ECL82 7/6, ECL83 10/-, ECL86 10/-, EF36 .. 3/6, EF37A 7/-, EF40 .. 8/-, EF41 .. 6/-, EF50 .. 2/6, EF52 .. 6/-, EF53 .. 4/6, EF55 .. 8/-

EF71 .. 7/6, EF72 .. 5/-, EF73 .. 5/-, EF74 .. 4/-, EF80 .. 5/-, EF85 .. 4/6, EF86 .. 6/6, EF89 .. 5/-, EF91 .. 3/6, EF92 .. 2/-, EF95 .. 5/-, EF183 8/-, EF184 8/-, EH90 .. 7/6, EHT1 300/-, EL32 .. 3/9, EL34 10/-, EL35 .. 5/-, EL37 16/-, EL38 17/6, EL41 .. 8/-, EL42 .. 8/-, EL50 .. 8/-, EL81 .. 8/-, EL83 .. 6/3, EL84 .. 5/-, EL85 .. 8/-, EL91 .. 4/6, EL95 .. 6/-, EL360 20/-, EM80 6/-, EM81 7/6, EM84 6/3, EN31 10/-, ESU74 80/-, ESU208 6/-, EY51 5/6, EY86 6/6, EY91 3/-, EZ40 6/6, EZ41 6/6, EZ80 .. 5/6, EZ81 .. 3/6, F/6057 5/-, F/6061 5/-, F/6063 4/-, FW4/500 6/6, FW4/800 8/6, G1/236G 9/-, G1/370K 20/-, G50/2G 5/-, G180/2M 15/-

GM4 45/-, GZ32 10/-, GZ34 10/-, H63 .. 7/-, HK54 22/6, HL2K 2/6, HL23 6/-, HL23DD 5/-, HL41 4/-, HVR2 9/-, K3A 30/-, KT8C 22/-, KT32 8/-, KT33C 6/-, KT44 5/9, KT63 4/-, KT66 16/-, KT67 15/-, KT76 8/6, KT88 22/-, KTW61 4/6, KTW63 2/-, KTZ41 6/-, KTZ63 5/-, M8100 9/-, M8142 12/-, M8161 7/-, M8190 5/-, MH4 .. 5/-, MHLD6 10/-, ML6 .. 6/-, N78 .. 15/-, NE17 7/-, OA2 .. 6/-, OB2 .. 6/-, OB3 .. 7/-, OC3 .. 5/-, OD3 .. 5/-, OZ4A 5/-, PC86 .. 9/-, PC88 .. 9/-, PC900 12/-, PCC84 5/-, PCC89 10/-, PCF80 7/-, PCF82 6/6, PCF84 6/-, PCF86 9/-, PCF802 11/-, PCL81 9/-, PCL82 7/-, PCL83 8/6, PCL84 7/-

PCL85 8/6, PCL86 9/-, PEN25 4/6, PEN46 3/-, PEN220A 3/-, PFL200 17/6, PL36 .. 9/-, PL38 .. 16/-, PL81 .. 7/-, PL82 .. 5/-, PL83 .. 6/-, PL84 .. 6/6, PL500 15/-, PM24A 5/-, PT15 10/-, PT25H 7/6, PT25M 7/6, PX4 .. 14/-, PX25 .. 9/-, PY33 9/6, PY80 5/6, PY81 5/6, PY82 .. 6/-, PY83 6/-, PY800 8/-, PZ1-35 9/-, PZ1-75 12/-, QP21 .. 6/-, QP25 .. 5/-, QP230 6/-, QS150-15 10/-, QS95/10 5/6, QS1202 8/-, QV04/7 8/-, R3 .. 8/-, R10 .. 9/-, RG4/1250 60/-, RK72 6/-, S130 .. 12/6, SP2 .. 8/6, SP41 .. 1/6, SP61 .. 1/6, SP210 3/6, STV280/40 18/-, SU2150A 10/-, S11G12 10/-, T41 .. 16/-, TD04-20 70/-, TP22 .. 5/-, TP25 .. 15/-, TT11 .. 5/-, TT15 .. 35/-, TTR31 45/-, TZ0503 4/-, TZ20 .. 16/-, U81 .. 8/-

U12/14 8/-, U17 .. 5/-, U18 .. 6/-, U25 .. 11/-, U26 .. 11/-, U27 .. 8/-, U50 .. 4/6, U52 .. 4/6, U191 11/6, U801 18/-, UABC80 6/-, UBC41 8/-, UAF42 9/-, UBF80 5/6, UBF89 6/6, UBL21 11/-, UCC85 6/6, UCH42 8/-, UCH81 6/-, UCL82 8/-, UCL83 10/-, UF41 .. 7/-, UF89 .. 6/-, UL41 .. 7/6, UL84 .. 5/6, UU5 .. 7/-, UU9 .. 8/6, UY21 7/6, UY41 6/6, UY85 5/-, V1120 4/-, V1507 5/-, V1923 20/-, VMP4G 12/-, VP23 .. 8/-, VP133 9/-, VR99 8/-, VR105/30 5/-, VR150/30 5/-, VU33A 4/-, VU39 6/-, VX3256 4/-, VX8122 5/-, VX8124 5/-, W21 .. 5/-, W118 .. 8/-, W119 2/-, X66 .. 7/6, X118 .. 8/-, X145 .. 8/-, Y63 .. 5/-, Y65 .. 4/-, Y66 .. 8/-, Z800U 20/-, Z801U 10/-, 1A3 .. 3/-, 1A5GT 5/-, 1B23 30/-, 1C5GT 6/-, 1D8GT 6/-

1E7G 7/6, 1F2 .. 4/-, 1G6GT 6/-, 1L4 .. 2/6, 1LA6 .. 6/-, 1LC6 .. 7/-, 1LH4 .. 4/-, 1N21B 5/-, 1N43 .. 4/-, 1N70 .. 4/-, 1R4 .. 5/-, 1R5 .. 3/6, 1S4 .. 5/-, 1S5 .. 4/6, 1T4 .. 3/-, 2A3 .. 5/-, 2B26 .. 8/-, 2C26 .. 7/-, 2C26A 3/-, 2C34 .. 2/6, 2C45 .. 22/6, 2C46 .. 30/-, 2C51 .. 12/-, 2D21 .. 5/-, 2X2 .. 3/-, 3A4 .. 4/-, 3A/108A 20/-, 3A146J 35/-, 3A167/M 25/-, 3B7 .. 5/-, 3B24 .. 5/-, 3D6 .. 4/-, 3E29 .. 50/-, 3Q4 .. 6/-, 3Q5GT 7/6, 3S4 .. 5/-, 3V4 .. 5/9, 4C27 .. 35/-, 4D1 .. 4/-, 5A173G 5/-, 5A174G 5/-, 5B251M 25/-, 5B253M 15/-, 5B/254M 40/-, 5B/255M 35/-, 5R4GY 9/-, 5T4 .. 7/-, 5U4G 4/6, 5V4G 8/-, 5X4G 8/6, 5Y3G 4/6, 5Y4GT 5/-, 5Y3WGTB 9/-, 5Z4G .. 6/6, 5Z4GT 8/-

6AB7 4/-, 6AC7 2/-, 6AG5 2/6, 6AG7 6/-, 6AH6 10/-, 6AJ7 3/-, 6AK5 5/-, 6AK6 6/-, 6AK7 6/-, 6AL5 .. 3/-, 6AL5W 7/-, 6AM5 2/6, 6AM6 4/-, 6AQ5 7/-, 6AQ5W 9/-, 6AS6 4/-, 6AS6W 9/-, 6AS7G 20/-, 6AT6 .. 4/-, 6AU6 7/-, 6AX4 8/-, 6B7 .. 5/-, 6B8G .. 2/6, 6BA6 .. 5/-, 6BA7 .. 5/-, 6BE6 .. 4/3, 6BJ7 .. 7/-, 6BQ7A 8/-, 6BR7 9/-, 6BW6 9/-, 6C4 .. 2/-, 6C5G .. 2/6, 6C5GT 6/-, 6C6 .. 4/-, 6C6G .. 3/-, 6C8G .. 3/-, 6C21 80/-, 6CH6 .. 4/6, 6CL6 .. 9/-, 6D6 .. 3/-, 6E5 .. 6/-, 6F5G .. 5/3, 6F5GT 5/9, 6F6G .. 4/-, 6F7 .. 6/-, 6F8G .. 6/6, 6F12 .. 4/6, 6F13 .. 5/-, 6F17 .. 5/-, 6F32 .. 4/-, 6F33 .. 3/-, 6G6G .. 2/6, 6H6M 1/6, 6J4WA 10/-, 6J5 .. 6/-, 6J5G .. 2/-, 6J6 .. 3/6, 6J6W 6/-, 6J7G .. 5/-, 6J7M .. 8/-, 6K6GT 5/6, 6K7G 2/-

6K7GT 4/9, 6K8G 8/-, 6K8GT 8/3, 6K8M 8/6, 6L5G .. 6/-, 6L6GA 7/6, 6L6M 11/-, 6L7G .. 4/-, 6L34 .. 4/6, 6LD20 5/9, 6N7 .. 6/-, 6N7G 5/9, 6P25 .. 12/6, 6Q7G 5/-, 6R7 .. 5/6, 6SA7 .. 7/-, 6SA7GT 6/6, 6SC7 .. 7/-, 6SC7GT 6/-, 6SF7 .. 5/6, 6SH7 .. 3/-, 6SJ7 .. 5/-, 6SJ7GT 5/6, 6SJ7Y 6/6, 6SK7 .. 4/6, 6SL7GT 5/6, 6SN7 .. 3/6, 6SQ7GT 6/-, 6SS7 .. 2/-, 6U4GT 9/6, 6V6G .. 5/-, 6V6GT 7/6, 6V6M .. 8/-, 6X4 .. 3/6, 6X5G 5/-, 6XG5T 5/3, 6Y6G 6/-, 6-30L2 10/-, 6Z4 .. 5/-, 7B7 .. 7/6, 7C5 .. 10/-, 7C6 .. 7/-, 7C7 .. 6/-, 7H7 .. 7/3, 7Q7 .. 7/-, 7V7 .. 5/-, 7Z4 .. 4/6, 8D2 .. 2/6, 9D2 .. 3/-, 9D6 .. 3/6, 10F9 .. 9/-, 12A6 .. 2/6, 12AH7 5/-, 12AT7 4/-, 12AU7 5/-, 12AX7 6/-, 12AY7 10/-, 12BA6 5/6, 12BE6 7/-, 12BH7 7/-, 12C8 .. 3/-, 12H6 .. 2/-

12J5GT 2/6, 12J7GT 6/6, 12K7GT 2/-, 12K8M 10/-, 12Q7GT 3/3, 12SA7 7/-, 12SC7 4/-, 12SG7 3/-, 12SH7 3/-, 12SJ7 5/9, 12SK7 5/-, 12SN7GT 5/9, 12SR7 5/-, 12Y4 .. 2/-, 14L7 .. 7/-, 15D2 .. 6/-, 19R2 .. 15/-, 19G3 .. 20/-, 19G7 .. 5/-, 19H1 .. 6/-, 19M1 .. 5/-, 20P4 .. 13/-, 21B6 .. 9/-, 25L6GT 5/6, 25Y5 .. 6/-, 25Z4G 6/6, 25Z5 .. 7/6, 25Z6GT 8/6, 28D7T 6/-, 30 .... 5/-, 30C15 9/-, 30F5 .. 8/6, 30FL1 10/6, 30P12 10/-, 30P19 15/-, 30PL1 8/-, 35L6GT 7/-, 35T .. 17/6, 35W4 5/-, 35Z3 10/-, 35Z4GT 6/-, 35Z5GT 6/-, 37 .... 4/-, 38 .... 4/-, 50L6GT 8/-, 53A .. 7/6, 57 .... 6/-, 58 .... 6/-, 59 .... 6/-, 75 .... 5/6, 76 .... 5/-, 77 .... 6/6, 78 .... 5/-, 80 .... 5/6, 81 .... 9/-, 82 .... 8/-, 84 .... 8/-, 85A2 .. 8/-, 210VPT 7-pin 2/6, 215SG 6/-

220PA 7/-, 220TH 4/-, 225DU 9/-, 307A .. 5/6, 313C .. 25/-, 357A .. 70/-, 368A .. 5/-, 393A .. 15/-, 446A .. 8/-, 703A .. 30/-, 705A .. 10/-, 715B .. 50/-, 717A .. 3/-, 724A .. 15/-, 801 .. 6/-, 803 .. 22/6, 807 .. 8/-, 808 .. 8/-, 811 .. 22/6, 813 .. 65/-, 815 .. 35/-, 829B .. 50/-, 830B .. 4/-, 832A .. 45/-, 832 .. 15/-, 843 .. 6/-, 866A .. 14/-, 884 .. 10/-, 954 .. 4/6, 955 .. 2/6, 956 .. 2/-, 957 .. 5/-, 955A .. 4/-, 1612 .. 5/-, 1616 .. 3/-, 1619 .. 5/-, 1625 .. 6/-, 1626 .. 3/-, 1629 .. 4/6, 2051 .. 5/-, 4043C .. 13/6, 4063 .. 3/-, 4313C .. 30/-, 5704 .. 9/-, 5726 .. 6/-, 6060 .. 5-, 6064 .. 7/-, 6065 .. 6/-, 6080 .. 22/-, 7193 .. 1/9, 7475 .. 2/-, 8013A 25/-, 8020 .. 8/-, 9001 .. 3/-, 9002 .. 4/6, 9003 .. 6/-, 9004 .. 2/6, 9006 .. 2/6

C.R. Tubes
CV1596 (09J) 55/-

E4504/B/16 28/-, VCR97 28/-, VCR138 30/-, VCR138A 40/-, VCR517 35/-, VCR517B 40/-, VCR517C 40/-, 3EG1 40/-, 3FP7 45/-, 5CP1 30/-, 5FP7 12/6, 88D .. 40/-

Photo Tubes
G816 .. 12/6, 931A .. 55/-, 6097C 350/-

Special Valves
ACT6 .. £8, K301 .. £4, KRN2A £3/10/-, 1B24 .. 25/-, 2J22 £2/10/-, 2J54 £3, 417A .. 30/-, 3J/92/E £37/10/-, 714AY £4, 723A .. 30/-, 726A .. 19/-

Transistors
OC16 .. 20/-, OC22 .. 23/-, OC25 .. 12/-, OC44 .. 8/-, OC45 .. 6/-, OC71 .. 4/6, OC72 .. 6/-, OC73 .. 10/-, OC81M 7/-, OC82 10/-, OC122 16/-, OC200 10/6, XC141 10/-, XC142 15/-, XC155 20/-, XC156 22/6, 2N502 47/-, 2N247 9/6, 2N685 10/6, 2N1090 20/-, 2N1091 29/6

MANY OTHERS IN STOCK including Cathode Ray Tube and Special Valves

All U.K. orders £1 P. & P. 1/-: over £1 2/-: orders over £3 P. & P. free: C.O.D. 3/6 extra. Overseas Postage Extra at Cost.

H.R.O. SENIOR TABLE MODEL TYPE 5A. With "S" meter and crystal filter in excellent fully checked and tested condition together with set of 8 general coverage coils and mains P.S.U. £33. Carriage and packing 30/-.
DITTO but model "M" £28. Carriage and packing 30/-.

EVERSHED MEGGER CIRCUIT TESTER. 2 ranges. 0-1,000 ohms. 100-200,000 ohms with test leads, leather carrying case. Tested £4/19/6. P. & P. 3/6.

A.R.88D. RECEIVERS. Fully reconditioned. £55. Rebuilt model £85. Carriage paid U.K.

THERMAL PLUS MECHANICAL CIRCUIT BREAKER FOR A.C. & D.C. Current 1 amp. Protects against shorts (instantaneous cut out at approximately 8 amps.) and against overloads: 1.8 amp. 30 seconds; 2.1 amp. 15 seconds; 2.5 amp. 8 seconds. Delayed cut off may be adjusted to different currents and times. Separate pair of contacts to indicating device. Dimensions 3½ x 1⅜ x 7/16in. Price 12/6. P. & P. 2/6.

TELEPHONE HANDSET. Standard G.P.O. type, new 12/-. P. & P. 2/-.

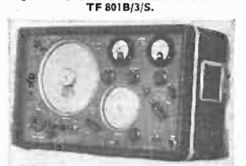
INSET MICROPHONE for telephone handset 2/6. P. & P. 2/-.

2 KW ULTRASONIC GENERATOR together with power supply unit for 200-250 v. A.C. Complete two chassis with interconnecting cables. Frequency 37 to 43 kc/s adjusted by fine control. Peak output 2 kw, average output 500 w. Completely new with valves and manual £65 carriage paid U.K. Large selection of mains and Heavy Duty L.F. TRANSFORMERS.

VARIOMETER for No. 19 sets, 17/6. P. & P. 3/-.

COMPLETE V.F.O. UNIT from TX53. Freq. range in 4 switched bands from 1.2-17.5 Mc/s. Two V.T. 501s as oscillator and buffer, 807 as driver, two S130s as voltage stabilizers. Output sufficient to drive two 813s in parallel. Slow motion drive directly calibrated in Mc/s. Provision for crystal control, metering of buffer and driver stage. Power requirements 400 v. and 6.3 v. D.C. Can also be used as low power transmitter. In excellent condition with valves and circuit diagram. £5/19/6. P. & P. 15/-.

MARCONI SIGNAL GENERATOR TYPE TF 801B/3/S.



Frequency range 12-485 Mc/s in five ranges. Directly calibrated frequency dial. Output waveform: C.W. sinewave A.M., pulse A.M. (from ext. source only). Internal modulation frequency 1,000 c/s. Output: a, normal—continuously variable directly calibrated from 0.1 μv.—0.5 v. b, high: up to 1 v. modulated or 2 v. unmodulated, output impedance 50 ohms. Fine frequency tuning control, carrier on/off switch, built-in crystal calibration for 2 Mc/s and 10 Mc/s. Stabilised voltage supply. In excellent "as new" condition. Fully checked and guaranteed. £115. Carr. 30/-.

"CONNECT AND FORGET, CANNOT OVERCHARGE" "ESSTRON" MARK I AUTOMATIC BATTERY CHARGER
Initial charging rate 6-7 amps. The charging rate automatically adjusts itself to the charge in the battery. Automatic current and voltage control. Patented application of magnetic amplification to battery charging. Indicator lights show battery fully charged, receiving charge incorrectly connected or faulty cells. Mains voltage 200/250 v. Built for 6 or 12 v. batteries. Measurements 7 x 5 x 5½in. Weight 8¼ lb. Price £7/19/6. P. & P. 3/6.

P. & C. RADIO LTD.
170, GOLDHAWK RD., W.12
SHEpherd's Bush 4946

WELL PROVEN RELIABLE COMMUNICATION RECEIVER P.C.R.3
(Made by Pye.) 3 bands, 1 medium wave, 2 120-43m, 3 43-13m. Overall sensitivity 1-2μV. S/noise ratio 10 dB at 6μV. Circuit incorporates an R.F. stage, two I.F. stages, tone control, A.V.C. antenna trimmer, 6V6 output. Set in as new condition together with headphones. Speaker plug. £9/12/6. With vibratory supply unit, 12 v. £10/15/-. With specially built in P.S.U. for 210-250 v. A.C., £11/17/6. Carriage either set 15/-.

C.R.100 RECEIVER. 60 kc/s.-420 kc/s, 500 kc/s-13 Mc/s. In 6 bands, 2 HF stages, 3 IF stages, AVC on both phone and C.W. Excellent condition, correctly tuned and guaranteed, £31. Carriage 30/-.

C.R.150/2. Frequency coverage 1.5-22 Mc/s in 4 bands. Price £31. Carriage 30/-.

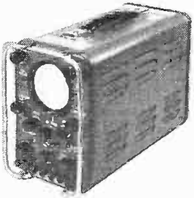
ULTRA MODERN POWER SUPPLY UNIT. Supply voltage A.C.: 105, 110, 115, 200, 205, 210, 220, 225, 230, 240, 245, 250 v. Available voltages D.C.:
(a) 1700-1900 v. Stabilised, adjustable approx. 1 mA.
(b) HT2 approx. 45 mA.
(c) 260-350 v. stabilised, adjustable, approx. 45 mA.
(d) 450 v. approx. 30 mA.
(e) 50 v. approx. 150 mA.
(f) 4.5 v. A.C., 4.5 amp. common earth.
(g) 6.3 v. A.C., 4.5 amp. common earth.
5 valves, 7 silicon rectifiers, 4 Solenium HV rectifiers. Brand new £9/10/-. Carriage 12/-.

PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy or ±1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition together with handbook and necessary connector. £45. Carriage 30/-.

32/44FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections, 14ft. (7 section) whip aerial with adaptor to fit the ⅞in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer etc. Absolutely brand new and complete, ready to erect, in canvas bag. £3/9/6. P. & P. 10/6.

20-480 FREQUENCY METRE TYPE TS 323/UR. High frequency version of BC 221. Accuracy better than 0.05%. Battery operated (6 v. and 130 v.). In as new condition with proper calibration charts. Laboratory tested and guaranteed. £60.

Open 9-5.30 p.m. except Thursday 9-1 p.m. PERSONAL CALLERS WELCOME



PORTABLE OSCILLOSCOPE CT.52
A compact general purpose instrument with many unusual features. Size 9in. high, 8in. wide, 16½in. deep. Time base 10 c/s. to 40 Kc/s. Y plate sensitivity 40V per cm. Tube 2¾in. Frequency compensated amplifier up to 38 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, metal transit case, instruction book and circuit diagram. BRAND NEW. Tested and guaranteed. £22/10/-. Carr. 10/-.

MICROAMMETERS
R.C.A. 0-500 microamps. 2¼in. circular flush panel mounting. Dials are engraved 0-15, 0-600 volts. As used in the American version of the No. 19 set. 15/-. P. & P. 1/6.

AR-88 SPARES

R.C.A. Headphones	12/6
Escutcheons (Windows)	8/6
Knobs. Medium size. Set of 8	10/-
Knobs. Large size	5/6
Block Condenser (3 × 4 mfd.)	12/6

AR-88D RECEIVERS
A good selection is available for callers at from £30. All are in good condition and are functioning perfectly. Realigned.

HEAVY DUTY TRANSFORMER
Input 220 volts to 250 volts at 50 cycles tapped every 5 volts. Secondary, 50 volts at 15 amps. Very conservatively rated. Size 7½×5½×7in. Wt. 28 lb. Brand new. £5/19/6. Carr. 7/6.

SILICON RECTIFIER. 800 P.I.V. The Modern Marvel. ⅜in.×⅜in. Can be used to replace T.V. rectifiers up to 500 mA. (40 Ω ballast resistor). 7/-.

TS-175 HETERODYNE FREQUENCY METER
A high frequency version of the well known BC-221. Accuracy 0·05%. Frequency range 80 to 1,000 Mc/s. As new condition with original calibration book. Tested and guaranteed. £75.

LABORATORY pH METER
Marconi type TF.1093/1. Range 0-14 pH direct reading. Full temperature compensation. Scale expansion providing discrimination of 0·01 pH. A.C. mains operation. Brand new complete with electrode stand and manual. Full details on request. £35.

CINTEL OSCILLOSCOPE
A 12in. demonstration oscilloscope with all controls at rear. **BRAND NEW £80.**

SANGAMO WESTON VOLTMETERS
S61. Dual range 0-5 and 0-100 v. D.C. FSD 1 mA. 3in. scale. Recent manufacture. Ideal for schools. Complete in super quality canvas carrying case, with test prods and leads. **BRAND NEW.** Boxed 32/6. Post 2/6.

SIGNAL GENERATOR CT-218 (FM/AM)
MARCONI TF 937. Covers 85 Kc/s to 30 Mc/s in 8 switched ranges. Effective length of film scale is 50ft. Output level variable in 1 dB steps from 1μV to 100 mV (75 Ω). Also 1V Outputs down to 0·1μV from an outlet at 7.5 Ω. Int. mod. at 400 c/s, 1 Kc/s, 1.6 Kc/s and 3 Kc/s. FM frequencies above 394 Kc/s. Variable mod. depth and deviation. Crystal calibrator 200 Kc/s and 2 Mc/s. Monitor speaker for beat detection. Fully metered, blower cooled, Panclimatic. A.C. mains 100 to 150 and 200 to 250 volts, 45 to 100 c/s. 17×20½×17½in. Weight 117 lbs. Fully tested and guaranteed. Under 10% of original price. £65. Carr. 50/-.

CINTEL EQUIPMENT
ELECTROLYTIC CAPACITANCE AND INCREMENTAL INDUCTANCE BRIDGE. No. 36601
A modern instrument, all solid state, which accurately measures the capacity of electrolytic condensers from 0·1μF to 1,000μF under operating conditions. Leakage current and polarizing voltage are separately metered. Inductances from 100 mH to 100 H can also be measured with currents up to 100 mA. A.C. mains operation. Unused with handbook. £100.
WIDE RANGE CAPACITANCE BRIDGE. No. 1864. A matching instrument to the above. All solid state. Mains operation. Measures from 0.002pF to 100μF. Unused with handbook. £100.

V.H.F. SIGNAL GENERATOR
MARCONI TF-801A. Covers 10 to 300 Mc/s (4 bands) DIRECTLY calibrated. Int. Mod. at 400, 1,000 and 5,000 c/s. Attenuated or force output. Guaranteed overhauled, accurate and in perfect working order. £32/10/-. Carr. £1.

HAMMARLUND SP-600-JX
20 valve dual conversion superhet receiver covering 540 kc/s to 54 Mc/s in 6 bands. This is a professional quality receiver of recent design with stability of 0.01% or better. Second channel rejection 74 dB down and spurious responses are at least 100 dB down. Bandwidth from 200 c/s to 13 kc/s. Crystal filter with crystal phasing control. Operates directly from A.C. mains 90-260 v. 50-60 c/s. Original cost £510. Supplied overhauled and in first class working order, £100. Fuller details on request.

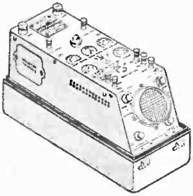
PCR-3 RECEIVERS
These receivers are in as new condition. They have 3 wavebands with a frequency coverage of 190-570 metres, 2.3-7.3 Mc/s, 7.0-23 Mc/s. R.F. stage, 6 valves. Output for 3 ohm speaker. Require external Power Supply or can be fitted with internal Mains Power Supply for £2 extra. Circuit supplied. Fully tested prior to despatch. £8/19/6. Carriage 10/6. Vibrator Supply Unit for operation from 12 v. car battery for caravans or boats, 15/6. Carriage 7/6.

DISTORTION FACTOR METER
MARCONI TF-142E. This instrument measures the percentage of total harmonic distortion in the fundamental frequency range 100 to 8,000 c/s. The lowest scale engraving is 0.05%. Will handle 2 watts (continuous) and will give satisfactory readings with only 1mW input. Mains operated. Output impedance 600 ohms. Very good condition. £30. Carr. £1.

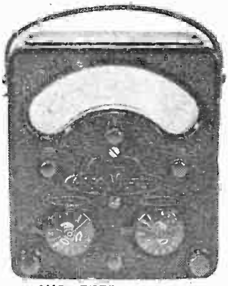
MINIATURE RELAYS. 240 v. A.C. coils. Contact assembly 2 "makes" and 1 C.O. 5 amps. Size 2×1½×1in. Unused and removed from brand new equipment. 8/6 post paid.

B. & R. RELAYS Type CO3. 230 volt A.C. coils. Very heavy duty contact assembly. 4 makes. Size 4in. × 3in. × 2½ in. weight 2 lb. BRAND NEW. 27/6. P. & P. 2/6.

HICKOCK OSCILLOSCOPE OS-8B/U
A high grade general purpose instrument made to exacting U.S.A. Navy specification. Detachable cover with carrying handle. Compact (13½ × 6 × 8¾in.), weight 17 lbs. Green trace 3 in. tube. Bandwidth "Y" amplifier D.C. to 2 Mc/s (D.C. coupled). Sensitivity 40 mV/cm. "X" amp. can be used separately. similar spec to "Y" amp. Leads are housed in case. For A.C. mains 105 to 125 v. 50 to 1,000 c/s. BRAND NEW, tested and guaranteed. £25. Carr. 10/-. *Auto transformer 15/6 extra.*



CHARLES BRITAIN (Radio) LTD.
11 UPPER SAINT MARTIN'S LANE
LONDON, W.C.2. *TEMple Bar 0545*
Near Leicester Sq. Station. (Opposite Thorn House)
Shop hours: 9-6 p.m. (9-1 Thursdays). Open all day Saturday.



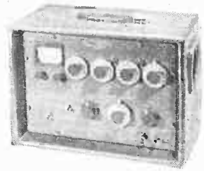
AVOMETER MODEL 7
Complete with leather carrying case, leads and batteries ready for use. Fully guaranteed. £13/13/-. Post 7/-.

PHASE MONITOR ME-63/U (AN-URM-67)
Designed to measure directly the phase angle between two applied audio frequency signals of from 20 to 20,000 c.p.s. ±1%. Direct indication on a panel meter. Input can be sinusoidal or non-sinusoidal from 2 to 30 volts peak. Of recent manufacture (1957) by Control Electronics Inc. and ex-U.S.A. Air Force. In first class condition with handbook. A complex instrument with 19 valves. £40. Carr. 30/-.

T.C.C. METALPACK CONDENSERS. 0.1 mfd. 500 v. D.C. wkg. at 70°C. Brand new, polythene wrapped., 7/6 doz., or £2 per 100. **T.C.C. METALMITE** 350v. D.C. wkg. 0.1 mfd. (CP37N); 0.05 mfd. (CP35N); 0.01 mfd. (CP.32N) all at 5/6 doz. or 32/6 per 100. **SPRAGUE METALCASED CONDENSERS** 0.01 mfd. 1,000 v. D.C. wkg., 5/6 doz., or 32/6 per 100.

T.C.C. VISCONAL CONDENSERS. 8 mfd. 800 v. D.C. wkg. at 71°C. CP 152 v. Size 3×1¾×5in. high. BRAND NEW (boxed), 8/6 each. **DUBILIER NITROGOL** 8 mfd. 350 v. D.C. wkg. at 71°C. Size 1¾×1¾×4¾in. high. With fixing clips. BRAND NEW (boxed) 5/-, each. **T.C.C. or DUBILIER.** 4 mfd. 600 v. wkg. CP 130T or similar. 1¾×1¾×4¾in. high. BRAND NEW (boxed), 4/6 each. All post paid.

STANDARD TRANSFORMERS
Vacuum impregnated, interleaved, E.S. screen, universal mounting. Size 4×3½×2½in. ALL BRAND NEW. 24/- each. Post 2/6.
Type 1. 250-0-250 v. 80 mA. 6.3 v. 3 a. tapped at 4 v. 4 a. 6.3 v. 1 a. tapped at 4 v. and 5 v. 2 a.
Type 2. as above but 350-0-350 v. 80 mA.
Type 3. 30 v. 2 a., tapped at 12, 15, 20 and 24 v. to give 3-4-5-6-8-9-10 v., etc.
Type 5. 0-6-9-15 v. 4 a. Ideal for chargers.



LOW CAPACITANCE BRIDGE
MARCONI TF 1342. Range 0·002 pF. to 1,111 pF. Accuracy 0·2%. Three terminal transformer ratio arm bridge allows "in situ" measurements. Internal oscillator frequency 1,000 c/s. 12×17×8½in. Weight 15¾ lbs. A.C. mains 200 to 250 and 100 to 150 v. 40-100 c/s. With leads and handbook. **ABSOLUTELY BRAND NEW. £45.**

20 Amp. L.T. SUPPLY UNIT

LATEST DESIGN HEAVY DUTY 12/24 VOLT D.C. Output: Adjustable up to 20 amps CONTINUOUS at 12/24 volts plus trickle. Input: 220/230/240 VAC 50 cycles. FULLY FUSED. Neon indicator, 0-20 amp. meter. Size: 16 × 12 × 20in. high, in heavy gauge steel cabinet. Grey Hammer finish. Weight: 50 lbs.

Plus 40/- Carr. & Pkg. G.B. (Inland) ONLY **£29 . 10 .**

CONSTANT VOLTAGE TRANSFORMER

AUTOMATIC MAINS STABILISER

Maintain "spot-on" test gear readings at all times.

★No Moving Parts
★No Maintenance
★No Attention.

Specification
Input: 240 v. A.C. ±20%—50 cycles.
Output: 240 v. A.C. Capacity: 250 watts.
Accuracy: ±1%. Size: 11×6½×6in. high.
Weight: 21 lbs. Fitted signal lamp and switch. **£11.10.0** Carr. & Pkg. 20/-.

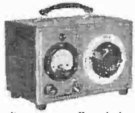
★ CORRECTED WAVE

Modern design in 2-tone grey hammer steel case with handle. Complete with lead and plug.

1,000 WATT MODEL

Input 240 v. A.C.±20%. Output accuracy ±1%. Fitted signal lamp and switch. Carr. and pkg. 25/-. **£29.10.0**

PORTABLE VARIABLE A.C. POWER SUPPLY UNIT



Designed for engineers whose requirements call for a visual indication of volts applied.
OUTPUT:
0-260 v. 1½ amps.
INPUT:
230 v. A.C. 50/60 c.p.s. Fitted with fuse, voltmeter, safety indicator, on-off switch and lead. Size: 8×5×5in. high.

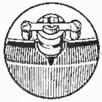
PRICE **£8.10.0** Carr. & Pkg. 10/-.

VARIABLE VOLTAGE TRANSFORMERS

WORLD FAMOUS "SLIDE-TRANS" AVAILABLE ONLY FROM I.M.O.

★ RATED CURRENT CONSISTENT AT ALL POINTS ALONG THE WINDING

Output: 0-260 V. Input: 230 V. A.C. 50/60 c.p.s. Shrouded fully variable transformers for bench or panel mounting.



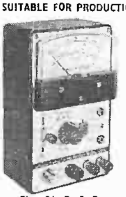
1 Amp.	£4 . 10 . 0
2.5 Amp.	£5 . 17 . 6
5 Amp.	£9 . 0 . 0
10 Amp.	£18 . 5 . 0
20 Amp.	£32 . 10 . 0

Carr. & Pkg. extra.

Inset shows latest type brush Gear providing 1 volt variation.

PORTABLE TRANSISTOR TESTER

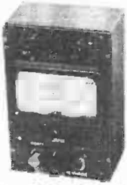
SUITABLE FOR PRODUCTION & LABORATORY USE



SPECIFICATION.
Alpha 0.7 to 0.997
Beta 5-300
ICO 0-50μA. 5mA
Capable of measuring GERMANIUM AND SILICON DIODES.
DESIGNED WITH RESISTANCE SCALE 200 ohms to 1 Megohm as an ADDED FEATURE. Housed in heavy duty plastic case, c/w internal battery.

Plus 5/- P. & P. Only **£7'7'-**

TRANSISTORISED MEGOHMMETER



★ PUSH BUTTON

USE 1966 EQUIPMENT

500 v. 1000 Megohms.
Superb portable instrument. Supplied c/w batteries, probes and carrying case.
ONLY **£23 . 10 . 0**
Carr. & Pkg. 7/6.

36ft. AERIAL MASTS

NEW LATEST PATTERN TUBULAR MAST

Check these vital points:
★Made from 6×1½in. dia. Sheradized steel sections, for durability and strength.
★Extra strong locating base.
★Top cap with fitted pulley and halyard.
★2 sets (8) Rotproof Guys.
★Rustproofed Steel Picketing Stakes.

ONLY **£13.10.0** ex works

Carr. 17/6. Returnable wooden case 20/-.

AC/DC VALVE VOLTMETER

Price ONLY **£35.0.0**

★11 megohms per volt.
★5 mV-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.

IMMEDIATE DESPATCH

FULL SPARES AND SERVICE AVAILABLE

DIELECTRIC BREAKDOWN TESTER

VARIABLE HIGH VOLTAGE UNIT

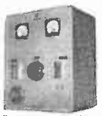
★ Range: Infinitely variable up to 3,000 volts. 0.1 amp.
★ Entirely suitable for continuous testing.
★ Automatic safety cut-out. Input: Mains voltage. Input and test leads with clips.

Model T30 **£32**

WALKIE TALKIE '88' SET

Made by E. K. Cole & Co. Weighs 5½ lb. (approx.) and measures 3½×5½×9½in. Crystal controlled. Dry battery—H.T./L.T. (i.e. Vidor L5537).
Supplied to Overseas Govts. ONLY **£10** EACH

5 AMP. A.C. & D.C. VARIABLE SUPPLY UNIT



Specification:
Output: 0-260 V.A.C.
0-240 V.D.C.
★Smooth stepless voltage variation from 0-Max.
★Current consistent throughout the controlled range.
★Ammeter and voltmeter fitted, and Neon indicator.
★Fully fused input and output.
Strong steel case with carrying handle and rubber feet. 11in.×7in.×14in. high. MADE IN ENGLAND

PRICE **£30.0.0** Carr. & pkgs. 40/-. (Gt. Britain inland)

30 Amp. L.T. SUPPLY UNIT

0 to 18 V D.C. WITH SMOOTH STEPLESS VARIATION.

Designed for CONTINUOUS use at max. loading.
★Fitted voltmeter and ammeter.
★Input and output fully protected.
Input: Mains A.C. robust construction. 2 tone grey hammer finish. Steel case.

£49 . 10 . 0 Carr. & Pkg. 40/- G.B. (Inland)

Entirely suitable for plating plants, laboratory supplies, etc.

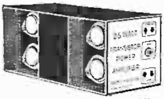
BUY DIRECT FROM MANUFACTURER

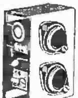
I · M · O (ELECTRONICS) LTD.

(Dept. WW4), 313 Edgware Road, London, W.2. PADington 2233/4


(1)

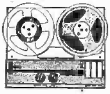

(2

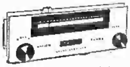

(4)

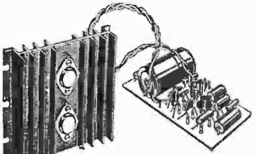

(3)


(5)


(6)

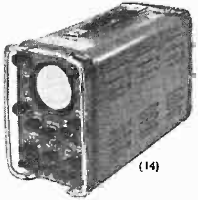

(8)

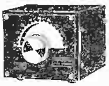

(7)

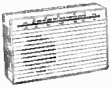

(9)

(10)


(12)


(14)


(13)


(16)


(15)

SPECIAL PARCEL PRICES FOR HIGH FIDELITY EQUIPMENT—LET US QUOTE—ALL MAKES

NEW 1966 CATALOGUE 150 PAGES

Fully detailed and illustrated components, equipment and Hi-Fi. All types and makes. 5000 Stock lines. 500 Transistors and Devices. 1000 Quartz Frequencies. 800 Valves and Tubes. The Finest and largest Range available. A mine of information and with FREE vouchers. Price 6/- post paid.

HENRY'S RADIO LTD.

303 EDGWARE ROAD LONDON W2

PADdington 1008/9
Open Mon. to Sat. 9-6. Thurs. 1 p.m.
Open all day Saturday

(1) ROADSTER MW/LW CAR RADIO

Supplied as Preassembled Panels. Permeability tuned superhet. Push-button wave-changer. Push-pull output. Fits any car. 7 × 4 × 2in. 12 volt (+) earth. Assembly **£8/19/6**, p.p. 3/6. Total cost. (Speaker/Baffle/Car Fixing Kit 20/-).

(13) VHF F.M. TUNER

Sensitive Superhet circuit. Covers 87-105 Mc/s. Geared tuning. 9-volt operated. Up to 1 volt output. For valve or transistor amplifiers. 4×3½×2¼in. Total cost £6/19/6, p.p. 2/6. to build. (Cabinet assembly, 20/- extra).

(6) GLOBEMASTER MW/LW/SW PORTABLE

Full tuning on 3 wavebands. Push - button wavechange. Superhet circuit. 1 Watt push-pull. Attractive cabinet with chrome fittings. 11 × 7½ × 3½in. (S.W. 17-50 mm) Total cost £8/19/6, p.p. 3/6. to build.

(12) MULTI-METERS

PT34 1kΩ/volt	£1	19	6
MI 2kΩ/volt	£2	9	6
TP10 2 kΩ/volt	£3	15	0
EP10K 10kΩ/volt..	£3	19	6
EP20K 20Ω/volt ..	£4	19	6
ITI-2 20kΩ/volt (illus)	£3	9	6
TP5S 20kΩ/volt ..	£5	19	6
EP30K 30kΩ/volt..	£6	10	0
500 50kΩ/volt....	£8	17	6
EP50K 50kΩ/volt..	£8	15	0
EP100K 100kΩ/volt	£10	10	0

(4) 25 WATT AMPLIFIER

8 transistor plus 2-rectifier design. Output for 7½ to 16 ohms speakers. 150mV input to 33K ohm ± 1 dB 30 c/s to 20 Kc/s. For use with valve or transistor preamplifiers for 25 watts rms output—50 watts peak (overall size 2⅞ × 2⅞ × 6½in.). Suitable for preamplifiers (10M) and (10) below **Price Built and Tested** £8/19/6, p.p. 3/-. Mains Unit 79/6, p.p. 2/6.

(14) MINIATURE OSCILLOSCOPE MODEL CT52

High sensitivity 'scope, fully portable with Mullard DG7/5 2¾in. tube. 10 c/s to 40 Kc/s. FREE running Time Base. Single Sweep. Pulse Monitoring 50 m/sec. to 0.1 u sec. Y Plate Sensitivity 40 v. per cm. 3 dB 25 c/s. to 2 Mc/s and up to 35 dB Gain on Amplifier. Full Input Facilities and Controls. 110 to 250 volt A.C. mains operated. Complete in portable case with leads. In new condition.

£22.10.0 Carr. & Pkg. 10/-.

FULL HANDBOOK AND CIRCUIT

SPECIAL OFFER

DEAC Rechargeable Batteries. (A) 3.6 volt 500 mA/H. 1½ × 1⅞in. dia. Price 12/6, p.p. 1/6. (B) 9.6 volt 225mA/H. 2⅞ × 1in. dia. Price 20/-. p.p. 1/6. BRAND NEW STOCKS

DEAC BATTERY CHARGER

Completely assembled in moulded case. 110-250 volt mains, fully transformer isolated, to charge 9.6 volt and 3.6 volt DEACS as above. Price 45/-, P. & P. 2/6.

MAINS ELIMINATOR

Transistorised and Zener Stabilised power supply. Output 9.6 volt 250 mA and 3.6 volt 300 mA. Fully isolated. 110-250 volts. A.C. operation. Assembled in moulded case. Price 67/6, p.p. 2/6.

(7) VHF F.M. TUNER

Supplied as 2 Preassembled Panels, plus metal work Superhet design, 88-108 Mc/s, 9 volt operated. Total cost £12/17/6, p.p. 2/6.

(3) 5-WATT AMPLIFIER

6 Transistor push-pull to 3 ohms. 6 mV to 1 k. input, 12/18 volts operated. Size only 2⅜×2×1½in., 25 c/s to 16 kc/s. Ideal general purpose sensitive amplifier with 5 watts RMS output. **Built and Tested 79/6, p.p. 2/-** (Optional mains unit, 54/-)

(2) NEW MW/LW TUNER SUPERHET TO BUILD

MW/LW Superhet tuner. Output up to ½ volt peak. Full coverage with excellent sensitivity and selectivity. 9 volt operated. Complete with front panel, etc. Total cost to build **79/6**, p.p. 2/-.

(16) REGENT-6 MW/LW POCKET SET

6 Transistor Superhet, geared tuning. Push - pull output. Attractive cabinet 5×3×1½in. Total cost **69/6**, p.p. 2/-, to build.

SPECIAL PURCHASE LOWERS PRICE

(8) BUILD A QUALITY TAPE RECORDER

THREE-SPEED RECORDERS

Using **New '363' Decks**

★ **TWO-TRACK.** Deck **£10/10/-.** Amplifier **£11/11/-.** Cabinet and Speaker **£5/5/-.** Complete kits with FREE 7in. 1200ft. tape, spare spool and Acos 40 Mic., **£26**, p.p. 8/6.

★ **FOUR-TRACK.** Deck **£13/10/-.** Amplifier **£12/12/-.** Cabinet and speaker **£5/5/-.** Complete kits with FREE 7in. 1200ft. tape, spare spool and Acos 40 Mic., **£30**, p.p. 8/6.

FREE New 16-page valve transistor / rectifier and quartz crystal catalogue on request.

QUARTZ CRYSTALS

1 mc/s. HC6U (miniature)	20/-
100 Kc/s 3 pin........	15/-
100 Kc/s. Octal	25/-
500 Kc/s.	15/-
100 Kc/s. + 1 Mc/s.....	19/6
HC6U 6/12 volt 80°C. oven	22/6

(5) NOMBREX TEST EQUIPMENT

150 Kc/s.-350 Mc/s.

RF Generator..	£9	10	0
Resistance/Capacitance Bridge	£8	5	0
Transistorised Power Supply	£6	10	0
10 c/s-100 Kc/s Audio Generator	£16	15	0
Sensitive Inductance Bridge	£18	0	0

Complete Range of Test Equipment in Stock

10 AND 20 WATT MONO AND STEREO TRANSISTOR AMPLIFIERS AND PREAMPLIFIERS

(9) POWER AMPLIFIER

10 watts R.M.S. output. 10 mV. sensitivity, 30 c/s to 20 Kc/s. MPA10/3, 3 to 5 ohm Speaker. MPA10/15 12 to 16 ohm Speakers. Panel size 4×2½×1in. H/S size 4×4×1in. ***MPA10/3, £5/10/-**, p.p. 2/6. ***MPA10/15, £5/19/6**, p.p. 2/6. (Mains Unit, 59/6, p.p. 2/6. State type required).

(10M) MONO PREAMPLIFIER

For 10 watt or 25 watt amplifier Full range of controls. 8 inputs from 1½ mV. Sel./Treble/Bass/Filter/Vol. Controls For use with Valve or Transistor Amplifiers. 150 mV. RMS output. Size 9×2½×2in. ***MP2 £5/10/-**, p.p. 2/- (Front panel 8/6).

(10) STEREO PREAMPLIFIER

Two Channel Preamplifier for (2) 10 watt or 25 watt amplifiers 8 inputs per channel. Sel./Treble/Bass/Balance/Vol./etc. Controls. 1½ mV. input. For P.U.'s. Tuner. Tape, mic., etc. Size 9×3½×1⅝in. ***SP2 £10/19/6**, p.p. 3/6. (Front Panel 12/6).

ALL UNITS SUPPLIED BUILT AND TESTED WITH FULL DETAILS AND INSTRUCTIONS
FULLY ILLUSTRATED AND DETAILED LEAFLET ON REQUEST

GARRARD DECKS-BRAND NEW-FULLY GUARANTEED-WITH CARTRIDGE UNLESS STATED

1000 mono	£6	10	0	SP25 stereo	£10	19	6	AT6 mono	£8	19	6
1000 stereo	£6	6	0	SP25 Deram	£13	10	0	AT6 Stereo	£9	10	0
2000 mono	£6	6	0	AT60 less cart.	£11	10	0	AT6 Deram	£11	19	6
2000 stereo	£6	6	0	AT60 mono	£10	10	0	Deccadec Mk. II	£17	17	0
3000lm stereo	£8	19	6	AT60 stereo	£10	19	6	A70 less cart.	£10	19	0
SP25 less cart.	£9	19	6	AT60 Deram	£13	10	0	*(P. & P. 5/- any type)*			
SP25 mono	£10	10	0	LAB80 less cart.	£25	0	0				

ALL MAKES OF HIGH FIDELITY EQUIPMENT IN STOCK. VISIT OUR HI-FI ROOM.
LET US QUOTE FOR YOUR REQUIREMENTS FOR EQUIPMENT AND COMPONENTS.

STERN-CLYNE ELECTRONIC CENTRES

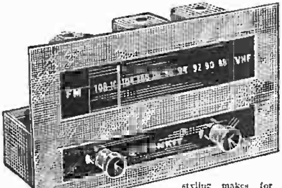
MAIL ORDER & ALL ENQUIRIES TO: DEPT. WW, 3-5 EDEN GROVE, HOLLOWAY, LONDON, N.7. Tel. NORth 8161/5

LONDON:
18 Tottenham Court Road, W.1. MUS 5929/0095
23 Tottenham Court Road, W.1. MUSeum 3451
309 Edgware Road, W.2. PADdington 6963
109 Fleet Street, E.C.4. FLEet Street 5812/3
162 Holloway Road, N.7. NORth 7941
9 Camberwell Church Street, S.E.5. RODney 2875
220 Edgware Road, W.2. PADdington 5607
CROYDON:
12 Suffolk House, George Street. MUNicipal 3250
BRISTOL:
26 Merchant Street, Bristol 1. Bristol 20261
LIVERPOOL: 52 Lord Street. Royal 7450
MANCHESTER:
20/22 Withy Grove, M/c 4. Blackfriars 5379/5246
SHEFFIELD: 125 The Moor. Sheffield 29993
NOTTINGHAM:
Eastown House, Lincoln Street. Nottingham 45889

Member of the Pantiya Group of Companies

★ **H.P. TERMS AVAILABLE FOR ALL GOODS OVER £13-10-0**

SUPERB NEW STERN-CLYNE F.M.I. VHF TUNER



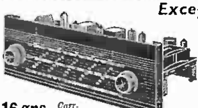
Features sparkling performance :— inherent stability.

Specially designed for the Amateur builder, a new, sensitive tuner unit that provides stable, interference-free reception of BBC FM transmissions. High quality output signal ensures optimum performance from any Hi-Fi audio system superb; styling makes for harmonious installation with existing equipment. Reliable, easily aligned circuit employs RF stage tuned-anodes tuned-grid freq. changer, 2 IFs. Noise Limiter & Ratio Detector. Valves are 4 × EF91 plus 2 diodes. Input sens. 100 mV. for 40 dB. Dist. less than 1% at full deviation. Power freq. 200 v. at 20 mA and 6.3 v. at 1.8 A. Panel black and silver-grey, size 8 × 5in. Chassis: cadmium plated, overall depth 4½in.

FM1 Kit of parts with Instruction Handbook. £7/9/6. *carriage 1/-.*
FM1 Assembled and tested. £10/9/6. *carriage 4/-.*
Optional Power Pack Type D Kit of Parts. £2/15/-. *carriage 3/6.*
Power Pack Type D, assembled and tested, £3/10/-. *carriage 3/6.*

Handbook only 3/- Post free
Descriptive leaflet on request.

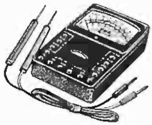
Exceptional offer of AM/FM Radiogram Chassis



16 gns. *Carr. 10/-.*

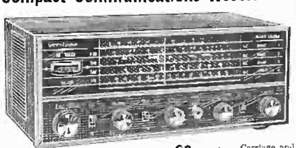
Superb new six valve unit covering long and medium wave on FM and all BBC VHF transmissions on FM. Highly sensitive AM circuit receives most stations through internal aerial, separate FM input employs famous Gorler tuning heart. Uncluttered facia covers whole frontal area and simplifies adaptation to existing cabinets or building into contemporary bookshelf units. Extra large illuminated dial and dual concentric controls for volume, tone selection and tuning simplify operation, enhance appearance. Powerful 4 W. output matches standard 3 ohms speaker. Inputs provide for external AM and FM aerials and gramophone pickup. For 200/250 v. A.C. operation. Size overall 15in. x 6¼in. x 7¾in. deep.

TEST 8 MULTIMETER 57/6 *Post and packing 2/6.*



Compact all purpose tester with 12 specially selected ranges for all home and motorcar wiring and servicing, amateur radio, T.V. fixing, electronic hobby work, etc. Extremely robust construction employs rugged large scale meter movement and plug-in range selection to obviate switch wear defects and ensure trouble-free life. In tough metal backed impact resisting case. Ranges: 0-10-250-500-1,000 v. A.C. and D.C. (sens. 100 ohms per volt) 0-10250 mA. D.C. current. 0-10000-100000 ohms resistance. Size only 4⅝ × 3½ × 1¼in. deep Complete with test leads and battery.

NEW ADVANCED DESIGN - Veritone Compact Communications Receiver



New, highly developed, extremely compact design. Veritone CR. 150 has portable radio proportions and a DX performance comparable with many highly expensive, professional receivers. Frequency coverage is continuous from 540 Kc/s to 30 Mc/s in 4 bands, plus band-spread on Ham frequencies of 3.5, 7, 14 and 28 Mc/s. Features include: extra large clearly marked dial "S" meter, variable pitch BFO, noise limiter, built-in loudspeaker and extending rod antenna to receive all but most distant stations.

20 gns. Carriage and Insurance 15/-

Extras include phone output jack, standby switch, etc. Size only: 13¼ × 5¼ × 8in. deep. Valves 12BE6, 12AV6, 12BA6 and 50C5 plus silicon rect. Invaluable for DXers, marine band listeners etc. Housed in handsomely finished metal case. For 220/250 volts A.C. or D.C. *Supplied with 128 page "Wireless World Guide to Broadcasting Stations."*

EXCLUSIVE OFFER OF TOP QUALITY RECORDING TAPE

New American branded tape by world renowned manufacturers and equal in quality to the best obtainable anywhere. Guaranteed splice free, red oxide, coated, with full frequency response and uniform output. Resistant to moisture, heat, cold and abrasion. Available in a wide range of Acetate and polyester qualities, each distinctively boxed and cellophane wrapped in colour coded cartons showing recording times at 7½, 3¾ and 1⅞ i.p.s. Compare the prices!

Ranges available:

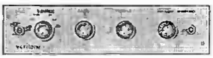
Both types post and packing 1/- per reel. Four or more reels post free.

Acetate		Polyester	
5in. 600ft. Standard	8/6	3¼in. 600ft. Double Play	11/6
5in. 900ft. Long Play	10/-	7in. 1,200ft. Standard	12/6
5¾in. 1,200ft. Long Play	12/6	5in. 1,200ft. Double Play	15/-
		7in. 1,800ft. Long Play	20/-
		5¾in. 1,800ft. Double Play	22/6
		7in. 2,400ft. Double Play	25/-

✱Designs by MULLARD- Interpreted by STERN

Justly famous—superb Hi-Fi designs from the Mullard Applications Research Laboratory, meticulously executed by Stern and Veritone. Buy them as hand-built and tested units, or in Stern-Clyne's famous Homebuild Kit form. Either way provides performance per £ unequalled anywhere. If you are working to a budget, kits offer a real saving plus real building satisfaction. Each is absolutely complete and backed by comprehensive, easy-to-follow building instructions.

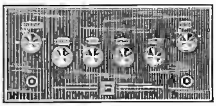
TWO VALVE PRE-AMPLIFIER



Assembled and tested **£9 - 10 - 0**
Add 6/- carriage. Kit **£6 - 6 - 0**

Specially designed for use with the Mullard series of 3, 10 and 20 watt amplifiers but entirely suitable for all Hi-Fi power units not requiring input of more than 250 mV for full output. Features include inputs for crystal and variable reluctance pick-ups with RIAA equalization, plus radio, sensitive microphone, and tape replay direct or from pre-amp. Controls include 6-position selector, volume, and wide range bass and treble boost. Valves 2 × EF86, size 9½ × 4½ × 2⅜in. high. Panel 10½ × 2⅝in. Requires 300 v. at 3 mA. and 6.3 v. at 0.6 amps.

THREE VALVE PRE-AMPLIFIER



Assembled and tested **£13 - 13 - 0**
Add 5/- carriage. Kit **£10 - 10 - 0**

Specially recommended for use with the 5-10 amplifier, but also suitable for use with all Mullard series mono amplifiers and any high quality unit requiring an input of up to 250 mV. for full output. Features include: wide range Bass and Treble controls, high and low pass filters, auxiliary input and record output sockets, switched inputs for crystal or magnetic pick-ups, radio, tape playback and auxiliary. Power required 250 v. at 6 mA. and 6.3 v. at 1 amp. Valves 2 × EF86 and ECC83. Size 11 × 4½ × 4in. high. Panel 12 × 4⅝in.

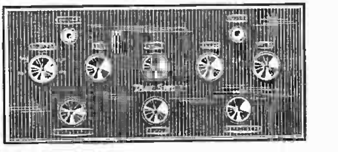
TEST 7 POCKET MULTIMETER

39/6

Carriage 2/-.

A really versatile instrument that makes a handy, pocket size tool. Measures AC or DC voltage in three ranges of 0-15-150-1,000 v. Resistance 0-100,000 ohms, and Current 0-150 mA. D.C. Size only: 3½ × 2¼ × 1¼in., with ingenious dial design providing a clear, easily read scale. Complete with battery and test leads.

DUAL CHANNEL PRE-AMPLIFIER



Actually twin Two-Valve Pre-amplifiers which together provide an extremely versatile and sensitive input arrangement for the Ten plus Ten amplifier in place of the Passive Control Unit. Features include dual inputs for mono and stereo Magnetic, Variable Reluctance, Crystal and Ceramic pick-ups, dual inputs for direct and pre-amplified tape playback and radio; separate, continuously variable Bass, Treble, and Volume and Balance controls. Switching permits Mono or Stereo operation. Equalization conforms to RIAA on disc replay. Power input 250/350 v. at 6 mA. and 6.3 v. at 1 amp. Size 11 × 5 × 4in. high. Panel 12 × 4⅝in.

Assembled and tested and supplied complete with Ten plus Ten Amplifier. **£34 - 0 - 0**
Kit Add 10/6 Carriage. **£27 - 0 - 0**
Dual channel pre-amplifier only—Assembled and tested. **£15 - 0 - 0**
Kit Add 5/- Carriage. **£12-10 - 0**

Head Office:

44a WESTBOURNE GROVE, LONDON, W.2.

Tel: **PARK 5641/2/3**
Cables: **ZAERO LONDON**
A.R.B. Approved for inspection and release of electronic valves, tubes, klystrons, etc.

Retail branch (personal callers only)
85 TOTTENHAM COURT RD., LONDON W.2. Tel: LANgham 8403

Zaerix BRAND

Please send all enquiries, correspondence and Mail orders to Head Office

TRANSISTORS

Type	Price
OC16	30/-
OC22	17/6
OC24	22/6
OC25	12/-
OC26	8/-
OC28	17/6
OC29	17/6
OC35	15/-
OC36	15/-
OC42	7/6
OC44	6/-
OC45	5/-
OC70	5/-
OC71	5/-
OC72	6/-
OC72D	6/-
OC73	11/-
OC75	6/-
OC76	6/-
OC77	8/-
OC78	6/-
OC78D	6/-
OC81M	7/-
OC81DM	7/-
OC83	6/-
OC139	12/-
OC140	18/-
OC141	25/-
OC170	7/-
OC171	8/-
OC200	9/6
OC201	20/-
OC202	15/-
OC204	17/6
OC205	20/-
OC206	22/6
2N410	3/6
2N412	3/6
2N697	13/-
2N1304	6/-
2S002	20/-
2S003	20/-
2S004	20/-
2S005	20/-
2S006	20/-
2S018	40/-
AC128	8/-
AF114	9/-
AF115	7/-
AF116	8/-
AF117	6/-
AF118	17/6
CXT1	3/-
GET114	5/6
GET115	8/6
GET116	12/-
GET880	10/-
MAT101	8/6
MAT121	8/6
T1166	6/-

Complementary pair 2N697(NPN) and 2N1132 (PNP) 50/-

ZENER DIODES

250mW 10%, BZY11 (60 v.), BZY13 (80 v.) all at 6/6.
280 mW 5%: 4.7 v. OAZ200 10/-; 5.1 v. OAZ201 9/6; 5.6 v. OAZ202 6/-; 6.2 v. OAZ203 7/-; 6.8 v. OAZ204 6/6; 7.5 v. OAZ205 6/-; 8.2 v. OAZ206 8/-; 9.1 v. OAZ207 9/6.
260mW 15%: 4.3 v. OAZ208 6/-; 4.7 v. OAZ209 6/-; 6.2 v. OAZ210 6/-; 7.5 v. OAZ211 5/6; 9.1 v. OAZ212 7/6; 12 v. OAZ 213 6/6.
1.5W 5%: ZNB10 10 v. 7/6; ZNB20 20 v. 9/6.
2.25W 10%: 4.25 VR425; 4.75 v. VR475; 5.75 v. VR575 all at 6/6.
5.25W 10%. 7.0 v. VR7A; 11 v. VR11A; 13 v. VR13A; 5.75 v. VR575V all at 8/-.
7.0W 5%, OAZ224 7.0 v. 10/-.

GERMANIUM POINT CONTACT DIODES

Type	Price
OA5	4/6
OA6	4/-
OA7	4/-
OA10	8/-
OA70	2/-
OA71	4/6
OA73	1/6
OA79	2/3
OA81	2/-
OA85	3/-
OA86	3/6
OA90	2/-
OA91	2/3
OA95	3/-
AAZ12	8/4
CG4E	2/-
CG10E	1/6
CG12E	2/-
GEX23	1/6
GEX44	1/6
GEX54	2/-

KLYSTRONS

Type	Price
2K28	180/-
2K41	400/-
6BL6	300/-
417A	40/-
707B	60/-
726A	80/-
5721	1000/-
5836	500/-
6116	600/-
6470	1500/-
CV129	80/-
CV228	200/-
CV237	80/-
SAL39	4000/-
VA220E	700/-

MAGNETRONS

Type	Price
2J42	300/-
4J50	700/-
4J53	250/-
5J26	500/-
CV160	160/-
CV370	250/-
CV1494 to CV1500	160/-
CV2281	300/-
CV5021	250/-
CV5117	200/-
JPT9-01	1200/-
M648	250/-
QK338	1200/-

COUNTER TUBES

GR10A—10-way register-indicator tube 45/-.
GC10/4B—bi-directional 10-way computing tube, double pulse, 50/-.
GC10B—scale-of-ten counter, 35/-.
GC10D—scale-of-ten counter for single pulse operation, 55/-.
GS10D—Bi-directional 10-way selector tube, 55/-.
GS10H—as GS10D but physically small, 40/-.

VALVES

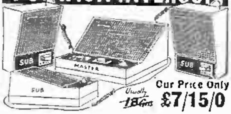
Type	Price
OA2	6/-
OA3	11/-
OA4G	20/-
OB2	6/-
OB3	6/-
OC2	14/-
OC3	6/-
OD3	5/-
OZ4A	5/-
1A3	3/-
1A5GT	5/-
1A7GT	8/-
1B3GT	7/-
1B24	40/-
1B35A	20/-
1B40	7/-
1B59	60/-
1B63A	70/-
1C5GT	8/-
1D5	7/6
1D6	8/-
1G4GT	8/-
1G6GT	7/-
1H5GT	7/-
1L4	2/6
1L6	17/6
1LA6	6/-
1LD5	4/6
1LN5	5/-
1N5GT	8/-
1R4	6/-
1R5	5/-
1S4	5/-
1S5	4/6
1T4	3/-
1T5GT	6/-
1U4	5/-
1U5	6/-
1V	5/-
1V2	10/-
1X2B	7/-
1Z2	35/-
2A3	5/-
2A4G	30/-
2A6	6/-
2A7	7/-
2AS15	80/-
2B22	12/-
2C26A	5/-
2C42	25/-
2C46	30/-
2C51	12/-
2C52	12/-
2C53	50/-
2CW4	12/-
2D21	6/-
2E26	30/-
2G21	12/-
2X2A	8/-
3A4	4/-
3A5	8/-
3A8GT	8/-
3B7	5/-
3B22	30/-
3B24	5/-
3B28	40/-
3C24	30/-
3CX100A5	100/-
3D6	4/-
3E29	60/-
3Q 195L	700/-
3Q4	6/6
3Q5GT	6/6
3S4	5/-
3V 53TE	900/-
3V4	6/-
4-1000A	700/-
4B32	80/-
4D1	4/-
4D32	120/-
4E27	60/-
4X250B	120/-
5R4GY	9/-
5T4	8/-
5U4G	5/-
5U4GB	6/6
5V4G	9/-
5X4G	8/-
5Y3GT	5/-
5Y4G	6/-
5Z3	7/6
5Z4G	8/-
6/30L2	11/-
6A7	10/-
6A8	8/-
6AB4	6/6
6AB7	4/-
6AC7	4/-
6AD4	18/-
6AD7G	10/-
6AF4	10/-
6AF6G	11/-
6AG5	2/6
6AG7	6/-
6AH6	10/-
6AJ5	9/-
6AK5	5/6
6AK6	7/-
6AL5	3/-
6AM5	2/6
6AM6	4/-
6AN4	15/-
6AN8	10/-
6AQ4	5/-
6AQ5	6/-
6AQ5A	7/6
6AQ6	8/-
6AR5	6/-
6AR6	6/-
6AR8	17/6
6AS5	5/-
6AS6	5/-
6AS7G	20/-
6AT6	4/6
6AU5GT	15/-
6AU6	6/-
6AV6	6/-
6AW8A	14/-
6AX4GT	8/-
6AX5GT	12/6
6B4G	16/-
6B7	5/-
6B8	7/-
6B8G	2/6
6BA6	5/-
6BA7	15/-
6BC4	17/6
6BE6	5/6
6BF6	6/-
6BG6G	15/-
6BH6	7/6
6BJ5	15/-
6BJ6	8/-
6BJ7	7/-
6BK4	25/-
6BL7GT	9/-
6BN6	7/6
6BQ5	11/-
6BQ7A	8/-
6BR7	12/-
6BR8	5/-
6BS7	17/-
6BW6	9/6
6BW7	10/-
6BZ6	6/-
6BZ7	11/-
6C4	2/6
6C5	8/-
6C5GT	6/-
6C6	4/-
6C8G	7/-
6C9	11/-
6C31	12/-
6CB6	5/-
6CD6GA	17/-
6CG7	10/-
6CH6	6/-
6CL6	9/-
6CW4	12/-
6CY5	10/-
6CY7	11/-
6D1	2/-
6D3	7/6
6D4	15/-
6D6	3/-
6DC6	12/6
6DK6	6/-
6DQ6	11/-
6EA8	11/-
6EY6	12/-
6F1	14/-
6F4	30/-
6F5	5/-
6F6	8/-
6F6G	5/-
6F8G	5/-
6F13	6/6
6F14	15/-
6F15	11/-
6F17	6/-
6F19	6/6
6F20	10/-
6F23	11/6
6F24	12/-
6F28	10/6
6F32	3/-
6G6G	2/6
6H6	2/-
6J4	9/-
6J5G	4/-
6J5GT	4/6
6J6	3/6
6J7	9/-
6J7G	5/-
6J8G	10/-
6K6GT	8/6
6K7G	2/-
6K7GT	5/-
6K8	8/-
6K8G	4/-
6K23	7/6
6K25	24/-
6L1	10/-
6L6G	6/-
6L6GC	8/-
6L7	5/-
6L18	8/-
6N7	8/-
6N7GT	7/-
6P1	11/-
6P25	12/6
6P28	12/6
6Q7G	6/-
6Q7GT	8/6
6R7	6/-
6S7	7/-
6SA7	8/-
6SC7	9/-
6SD7GT	5/-
6SF7	7/-
6SG7	6/-
6SJ7	8/-
6SK7	5/-
6SL7GT	5/-
6SN7GT	4/6
6SQ7	7/-
6SR7	8/-
6SS7	3/-
6SU7GT	10/-
6T8	7/-
6U4GT	10/6
6U8	7/6
6V6	9/-
6V6G	5/-
6V6GT	7/6
6WC5	7/-
6X4	4/-
6X4W	7/-
6X5	7/-
6X5G	4/6
6X5GT	6/-
6Y6G	10/-
6Z4	5/-
7A4	8/-
7A6	7/-
7A7	6/-
7A8	5/-
7AF7	13/-
7AG7	7/-
7B4	8/-
7B5	10/-
7B6	11/-
7B7	7/-
7C4	4/6
7C6	7/-
7C7	5/-
7D3	8/-
7D5	8/-
7D8	7/-
7E5	5/-
7E6	4/-
7E7	10/-
7H7	8/-
7J7	14/-
7K7	10/-
7Q7	9/-
7R7	12/-
7S7	18/-
7Y4	3/-
7Z4	6/-
9BW6	7/-
9D2	3/6
10C2	13/-
10D1	7/-
10F1	14/-
10F3	8/-
10F18	9/-
10L1	7/6
10P13	12/6
10P14	13/-
10Y	15/-
11D3	7/-
11D5	7/-
11E2	15/-
12A5	10/-
12A6	3/-
12A7	10/-
12A8GT	5/-
12AC6	8/-
12AD6	8/-
12AE6	7/6
12AL5	5/-
12AQ5	7/-
12AT6	5/-
12AT7	4/-
12AU6	6/-
12AU7	5/6
12AU7A	8/-
12AV6	6/-
12AV7	8/-
12AW6	20/-
12AX7	6/-
12AY7	10/-
12B4A	9/-
12BA6	6/-
12BE6	5/6
12BH7A	7/-
12BY7A	10/-
12C8	4/-
12E1	20/-
12F5GT	8/-
12H6	3/-
12J5GT	3/-
12J7GT	7/6
12K7GT	7/-
12K8	8/-
12Q7G	4/-
12SA7	7/-
12SC7	4/-
12SF5GT	9/-
12SG7	4/-
12SH7	4/-
12SJ7	4/-
12SK7	5/-
12SQ7	10/-
12SR7	5/-
12SY7	6/-
12Y4	2/6
12Z3	12/6
13D1	5/-
13D3	5/-
13E1	190/-
14H6	6/-
14S7	18/-
19AQ5	5/-
19G3	25/-
19H1	10/-
19H4	65/-
20A1	14/-
20P1	14/-
20P3	13/-
20P4	14/-
20P5	12/-
24B1	160/-
25A6G	5/-
25C5	10/-
25L6GT	8/-
25Y5	10/-
25Z4G	8/-
25Z5	10/-
25Z6GT	11/-
27M1	60/-
28D7	7/-
30	4/-
30A5	7/-
30C1	7/6
30C15	11/-
30C17	13/-
30C18	11/-
30F5	11/-
30FL1	12/-
30FL12	12/-
30FL14	12/-
30L1	6/6
30L15	12/6
30L17	14/-
30P12	10/-
30P16	7/6
30P18	7/-
30P19	14/-
30PL1	12/-
30PL13	12/-
30PL14	12/6
32	6/-
34	8/-
35A3	12/-
35A5	11/-
35B5	12/-
35C5	6/6
35D5	12/-
35L6GT	7/-
35W4	5/-
35Z3	10/-
35Z4G	4/-
35Z4GT	8/6
35Z5GT	6/-
37	6/-
38	5/-
41	5/-
42	5/-
43	7/6
45IU	7/-
47	10/-
50	18/-
50A5	12/-
50B5	7/-
50C5	6/6
50CD6G	30/-
50L6GT	6/6
50Y6GT	10/-
75	9/-
75B1	5/6
75C1	12/-
76	5/-
77	5/-
78	5/-
80	6/-
803	9/-
81	10/-
82	10/-
83A1	12/-
84	5/-
85A1	25/-
85A2	8/6
85A3	5/6
89	22/6
90C1	12/-
185BTA	15/-
211	30/-
220PA	7/-
300B	45/-
301A	15/-
368AS	30/-
401A	60/-
416B	200/-
715B	60/-
721A	10/-
803	30/-
807	9/-
811A	35/-
812A	55/-
814	20/-
815	40/-
828	80/-
829	30/-
832	20/-
836	25/-
866A	14/-
872A	35/-
884	15/-
889R	800/-
891R	1,200/-
931A	60/-
954	5/-
955	3/-
956	2/-
957	5/-
958	4/-
959	8/-
1267	20/-
1613	10/-
1614	20/-
1635	12/-
2050	12/6
4300A	45/-
4313C	30/-
5544	120/-
5557	80/-
5636	10/-
5642	13/-
5651	8/-
5654	8/-
5663	5/-
5670	10/-
5673	7/-
5678	8/-
5686	20/-
5691	25/-
5696	6/-
5726	7/-
5727	10/-
5750	12/-
5763	10/-
5814A	10/-
5840	10/-
5842	65/-
5847	60/-
5862	20/-
5879	12/-
5881	17/6
5949	400/-
5963	10/-
5965	5/-
6005	7/6
6021	12/-
6060	5/-
6072	15/-
6073	7/6
6080	25/-
6100	10/-
6101	7/-
6111	12/-
6135	10/-
6136	9/-
6140	30/-
6146	27/6
6147	17/-
6158	12/-
6159	32/-
6186	10/-
6197	20/-
6211	4/6
6336	80/-
6350	4/-
6463	7/-
6939	45/-
7199	15/-
7551	30/-
7586	22/6
7895	22/6
8005	65/-
8012	12/6
8013	25/-
8020	12/6
9001	4/-
9002	5/6
9003	9/-
9005	15/-
9006	2/6
A1820	20/-
A2087	17/6
A2134	8/-
A2293	16/-
A2426	45/-
AC/HL/DD	8/-
AC/HL/DDD	10/-
AC/P4	4/-
AC/TH1	10/-
AC/VP2	15/-
AC6/PEN	6/-
ACT6	170/-
ACT9	400/-
ACT22	240/-
ARP3	3/-
ARP12	3/6
AZ11	6/-
AZ12	9/-
AZ31	9/-
AZ41	7/-
B65	4/6
BT5	50/-
BT35	30/-
BT45	200/-
BT83	60/-
C1A	60/-
C3J	80/-
C6J	80/-
CBL31	17/-
CC3D	4/-
CL33	9/-
CX1120	160/-
CY31	7/-
D41	5/-
DA30	10/-
DA41	40/-
DAC32	7/-
DAF91	4/6
DAF92	6/-
DAF96	7/-
DC70	12/-
DET22	42/6
DET23	60/-
DET24	70/-
DET25	15/-
DF33	8/-
DF72	7/-
DF73	7/-
DF91	3/-
DF92	2/6
DF96	7/6
DH63	6/-
DH76	5/6
DK40	11/-
DK91	5/-
DK92	9/-
DK96	8/6
DL33	6/6
DL35	5/-
DL63	3/-
DL68	10/-
DL70	8/-
DL72	12/-
DL75	10/-
DLS10	12/6
DM70	5/6
DM160	10/-
DY80	7/-
DY86	8/-
DY87	9/-
E80CC	14/-
E90CC	12/-
E91H	8/-
E92CC	7/-
E180CC	8/-
E180F	20/-
E182CC	10/-
E186F	22/-
E810F	52/6
EA52	80/-
EABC80	7/-
EAC91	4/-
EAF82	9/6
EB41	5/-
EB91	3/-
EBC21	7/6
EBC33	7/-
EBC41	8/6
EBC81	6/6
EBC90	4/6
EBC91	6/-
EBF2	12/-
EBF80	7/6
EBF83	9/-
EBF89	7/-
EBL1	14/-
EBL21	11/-
EBL31	20/-
EC86	12/-
EC88	12/-
ECC32	4/-
ECC40	10/-
ECC81	4/-
ECC82	5/6
ECC83	6/-
ECC84	7/-
ECC85	6/6
ECC86	7/-
ECC88	10/-
ECC91	3/6
ECC189	12/-
ECC804	11/-
ECF80	8/-
ECF82	7/6
ECF86	11/-
ECF804	13/-
ECH21	10/-
ECH35	12/-
ECH42	9/6
ECH81	6/6
ECH83	7/6
ECH84	10/-
ECL80	7/6
ECL82	7/6
ECL83	9/6
ECL84	12/-
ECL86	9/6
EF14	6/-
EF36	5/-
EF37A	8/-
EF39	5/6
EF40	10/-
EF41	8/6
EF42	8/-
EF50	2/-
EF55	8/-
EF80	5/6
EF87	6/6
EF86	8/-
EF89	5/6
EF91	4/-
EF93	5/-
EF94	6/-
EF95	5/6
EF96	2/-
EF98	12/6
EF183	8/-
EF184	8/-
EF804	21/-
EFP60	10/-
EH90	7/6
EK2	10/-
EK32	6/-
EK90	5/-
EL2	8/-
EL5	10/-
EL11	10/-
EL31	12/-
EL32	3/-
EL34	11/-
EL35	5/-
EL36	9/-
EL37	17/6
EL38	17/6
EL41	9/6
EL42	9/-
EL50	6/-
EL81	9/6
EL82	8/-
EL83	8/-
EL84	5/-
EL85	8/-
EL86	8/-
EL90	6/-
EL91	2/6
EL95	6/-
EL360	22/-
EL821	6/-
EM4	10/-
EM31	5/-
EM34	12/-
EM35	8/-
EM71	12/6
EM80	7/-
EM81	7/6
EM84	8/-
EM87	7/-
EN30	35/-
EN31	10/-
EN91	6/-
EN92	6/-
ESU74	80/-
EY51	8/-
EY70	10/-
EY81	8/-
EY83	9/6
EY84	7/6
EY86	7/6
EY87	8/-
EY91	3/-
EZ35	5/6
EZ40	7/6
EZ41	8/-
EZ80	5/6
EZ81	5/6
EZ90	4/-
G24E	15/-
G55/1K	18/-
GD86W	10/-
GS10D	55/-
GS10H	40/-
GTE175M	12/-
GU20/21	75/-
GZ30	8/-
GZ32	10/-
GZ34	10/-
HABC80	8/-
HBC90	5/-
HBC91	6/-
HF93	6/-
HF94	6/-
HK90	5/-
HL2	3/-
HL2K	3/-
HL23	6/-
HL23DD	6/-
HL41	4/-
HL133DD	10/-
HR8	60/-
KT2	5/-
KT8	20/-
KT41	7/6
KT44	5/-
KT45	15/-
KT63	6/-
KT66	16/-
KT67	35/-
KT71	6/6
KT88	22/-
KTZ41	6/-
KTZ63	9/-
KY50	11/-
KY80	11/-
L63	6/-
LP2	7/-
MH4	5/-
MH41	9/-
ML6	6/-
MSPEN7	8/-
MSPENT	10/-
MT57	80/-
N78	15/-
NR88	10/-
NSP1	25/-
NSP2	22/-
OCP71	24/-
ORP12	12/-
ORP60	10/-
P2	10/-
P41	8/-
PABC80	7/6
PC86	12/-
PC87	12/-
PC97	9/6
PC900	12/-
PCC84	6/6
PCC85	8/-
PCC88	12/-
PCC89	12/6
PCC189	12/-
PCC805	12/6
PCC806	14/-
PCE800	12/-
PCF80	7/6
PCF82	8/-
PCF86	9/-
PCF87	13/-
PCF800	11/-
PCF801	11/-
PCF802	11/-
PCF805	11/-
PCF806	13/-
PCF808	12/-
PCL80	12/6
PCL81	9/-
PCL82	8/-
PCL83	8/6
PCL84	8/6
PCL85	9/6
PCL86	9/6
PCL88	12/6
PCL800	12/
PCL801	12/-
PENA4	7/6
PEN45	7/-
PEN45DD	12/-
PEN46	6/-
PEN220A	7/-
PEN 383	10/-
PEN384	7/-
PEN453/DD	10/6
PFL200	17/6
PL36	10/-
PL38	16/-
PL81	8/-
PL82	7/6
PL83	7/6
PL84	7/-
PL302	14/-
PL500	15/-
PL801	10/-
PP5/400	10/-
PX4	15/-
PX25	10/-
PY31	8/-
PY33	9/6
PY80	60/-
PY81	6/6
PY82	6/6
PY83	7/-
PY88	8/6
PY301	11/6
PY800	8/6
PY801	8/6
PZ30	10/-
QP25	5/-
QQV02-6	45/-
QQV03-10	35/-
QQZ04-15	60/-
QS105/45	15/-
QS1200	10/-
QV04-7	10/-
QY3-125	160/-
R1	8/-
R17	8/-
R18	7/6
SP41	5/-
SP42	8/-
ST61	4/-
TH233	6/-
TH2321	7/-
TP22	5/-
TP25	5/-
TP2620	7/6
TT12	60/-
TT15	35/-
TT21	35/-
TTR31	60/-
TZ40	40/-
U17	5/-
U18/20	7/-
U19	30/-
U21	7/-
U22	6/-
U25	11/-
U26	11/-
U76	4/-
U191	11/6
U201	6/6
U281	13/-
U282	14/-
U301	12/6
U403	7/-
U404	6/-
U801	18/-
UABC80	5/6
UAF42	9/-
UB41	11/-
UBC41	8/-
UBC81	8/-
UBF80	7/-
UBF84	7/6
UBF89	7/6
UBL21	11/-
UC92	6/-
UCC84	10/-
UCC85	7/-
UCF80	10/-
UCH21	9/6
UCH42	9/6
UCH81	7/-
UCL82	8/6
UCL83	10/-
UF41	9/-
UF42	9/-
UF43	8/-
UF80	8/-
UF85	8/-
UF86	11/-
UF89	7/6
UL11	9/-
UL41	9/-
UL84	6/6
UM4	10/-
UM80	7/-
UU5	8/-
UU7	8/-
UU9	7/-
UU10	8/-
UY1N	9/-
UY21	9/-
UY41	6/6
UY82	9/6
UY85	6/-
VGT21	15/-
VGT128	10/-
VP23	3/6
VP41	5/-
VP210	5/-
VR55	6/-
VR65	4/-
VR65A	5/-
VR136	6/-
VU39	8/-
VU71	7/-
VT72	25/-
VU111	7/6
VU120	10/-
VU120A	10/-
W21	5/-
W81M	6/-
W729	10/-
X63	6/-
X65	5/6
X66	8/-
X78	20/-
X81M	18/-
XB1	12/6
XC12	7/6
XC15	4/6
XH1-3200A	120/-
Y63	8/-
Z21	7/-
Z503M	45/-
Z700U	4/-
Z759	22/-
Z803U	15/-
CV74	80/-
CV85	60/-
CV121	10/-
CV128	45/-
CV239	30/-
CV242	15/-
CV2943	40/-
CV4001	5/-
CV4002	4/-
CV4003	10/-
CV4004	10/-
CV4006	18/-
CV4007	7/-
CV4011	10/-
CV4013	10/-
CV4014	8/-
CV4015	8/-
CV4016	10/-
CV4024	6/-
CV4025	7/-
CV4043	12/-
CV4044	7/6
CV4047	100/-
CV4055	12/-
CV4059	7/6
CV4062	17/6
CV4071	15/-
CV4104	15/-
CV4112	80/-

WHEN ORDERING BY POST PLEASE ADD 2/6 IN £ FOR HANDLING AND POSTAGE. MINIMUM CHARGE 1/6

PLEASE OFFER US YOUR SURPLUS STOCK OF VALVES, KLYSTRONS, MAGNETRONS, ETC. WE PAY £1.10.0 FOR 723A/B AND 2K25 KLYSTRONS, SUBJECT TO TEST.

WW—147 FOR FURTHER DETAILS.

4-STATION INTERCOM



Our Price Only ~~Usually 18 Gns.~~ £7/15/0

Solve your communication problems with this new **4-Station Transistor Intercom** system (**1 master** and **3 subs**), in de-luxe plastic cabinets for desk or wall mounting. Call/talk/listen from **Master to Subs** and **Subs to Master.** Operates on one 9 v. **battery.** On/off Switch. Volume control. Ideally suitable to modernise Office, Factory, Workshop, Warehouse, Hospital, Shop, etc., for instant inter-departmental contacts. Complete with 3 connecting wires, each 66ft. and other accessories. Nothing else to buy. P. & P. 4/6 in U.K.

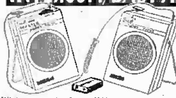
Transistor TELEPHONE AMPLIFIER

75/6

Why not increase efficiency of Office, Shop and Warehouse with this incredible De-luxe Portable Transistor **TELEPHONE AMPLIFIER** with Rotary Calendar and Pen-Holder which enables you to take down long telephone messages or converse without holding the handset. A status symbol? Yes, but very useful one. On/off switch. Volume Control. Operates on one 9 v. battery (supplied) which lasts for months. Ready to operate. P. & P. 3/6 in U.K.

WEST LONDON DIRECT SUPPLIES (W.W.), 6 Chignell Place, W. Ealing, London, W.13.

INTERCOM/BABY ALARM



Usually 6 Gns.

Our Price Only

59/6

This wonderful **TWO-WAY TRANSISTOR INTERCOM** consists of two units—Master and Sub—in Ivory plastic cabinets with chromium stands. Operates on one inexpensive battery. Call, talk or listen from Master to Sub and Sub to Master. On/off switch. Full Volume Control. **IDEAL AS A BABY ALARM.** Or communicate with your neighbour or listen for telephone bell in other room. Hundreds of other uses. Indispensable in Home, Shop, Nursery, Surgery and Office. A boon for spastics and disabled. Saves shouting and walking up and down the stairs. Complete with 60ft. connecting lead and a battery. Ready to operate. P. & P. 2/6 in U.K., 5/- abroad.

DO YOU STILL USE A HAMMER AND CHISEL TO CUT A SQUARE IN SHEET METAL?

Don't any more

We have a Hand-operated Tool now to cut any straight sided shape. Square R/Angles slots for Louvres. All you do is simply mark out your shape and follow the lines. You can also convert the Tool to a Punch-Louvre Forming and Riveting Tool.

NO DISTORTION OF METAL ON EITHER SIDE OF CUT

Also a number of Bench Type folding machines

EXPORT ORDERS DESPATCHED IMMEDIATELY

AVONLEA TOOLS, WOODEND MILL, MOSSLEY, LANCASHIRE.

MOSSLEY 2687

Introduction to Laplace Transforms

for radio and electronic engineers

W. D. Day, A.M.I.E.E., A.M.I.E.R.E.

Presents the theory of the Laplace transformation in easily understood language, dealing with electrical circuits from the very first paragraph to the stage when transforms are used to investigate transient conditions. The first part of the book is designed for home study while the second half is designed as an introduction to more advanced texts.

32s 6d net, by post 33s 6d

from leading booksellers

ILIFFE Books Ltd

DORSET HOUSE, STAMFORD STREET, LONDON, SE1

THE HIGH-FIDELITY MAIL ORDER SPECIALISTS

GOODS DESPATCHED BY RETURN

Carriage, Packing & Insurance (U.K.) FREE ! !

AMPLIFIERS · TUNERS · SPEAKERS
MOTORS · PICK-UPS · MICROPHONES
CABINETS · TAPE RECORDERS

A.D.C., ARMSTRONG, B. & O., BRENELL, CELESTION CHAPMAN, CONNOISSEUR, DECCA, DESIGN FURNITURE EDDYSTONE RADIO, F.I., FERROGRAPH, FI-CORD, G.K.D., GARRARD, GOLDRING, GOODMANS, GRAMPIAN, K.E.F., LEAK, LOWTHER, LENCO, LUSTRAPHONE, ORTOFON, PHILIPS, PYE, QUAD, RADFORD, RECORD HOUSING, REVOX, ROGERS, RONETTE, S.M.E., TANNOY, TANDBERG, THORENS, TRUVOX, VALRADIO VORTEXION, W.B., WEARITE, WHARFEDALE, ETC.

CASH OR TERMS— CALL, WRITE OR PHONE

WORLD WIDE EXPORTERS

★ OVERSEAS ORDERS SENT FREE OF PURCHASE TAX AND SHIPPED PROMPTLY AT MINIMUM COST ★

Fully illustrated catalogue 4s. 6d. U.K. (Export 7s. 0d. or $1.00). Refundable against first purchase value £7. 0s. 0d. or $20.00.

C. C. GOODWIN (SALES) LTD.

(Dept. W74) 7 THE BROADWAY, WOOD GREEN, LONDON, N.22.

Telephone: BOWes Park 0077/8

1 minute from Wood Green Underground
Open 9-6 Monday to Saturday (Thursday 9-1 p.m.)

BRAND NEW POLYESTER P.V.C. & MYLAR RECORDING TAPES

also

Pre-Recorded Language Courses

Both manufactured by world reputable German and British firms. They are boxed and have fitted leaders, these tapes are not to be confused with sub-standard, off-cuts, or imported inferior tapes. This is a genuine truly genuine less than half-price offer.

S.P.	3in.	150ft.	2/–
	5in.	600ft.	6/–
	5¾in.	900ft.	7/–
	7in.	1,200ft.	9/–
L.P.	3in.	220ft.	2/6
	5in.	900ft.	8/–
	5¾in.	1,200ft.	10/6
	7in.	1,800ft.	13/–
D.P.	3in.	400ft.	4/6
	5in.	1,200ft.	12/6
	5¾in.	1,800ft.	16/–
	7in.	2,400ft.	21/–

Postage and Packing on all goods 1/- per tape, 3 or more post free

Special limited offer.

Why not learn a foreign language the easy way from one of our brand new pre-recorded language courses in GERMAN—FRENCH—SPANISH and ITALIAN?

Each tape consists of 26 step-by-step lessons recorded at 3¾ i.p.s., supplied complete with handbook.

Price only 20/6 each. Normal retail price is 59/6 per course.

Fully guaranteed, you will be delighted with the results

STARMAN TAPES

26 LINKSCROFT AVENUE, ASHFORD, MIDDX.

ASH 53020

Communications Equipment

H.F. TRANSMITTER/RECEIVER. RE series 10 Watts RF.
Overall weight 12½lbs.

Current drain on full transmit power—4 Amps/12V.

Transmit—3 switch selected crystal channels.
Receive—Continuous tuning or preset channels.

3 models available—RE.15 for 1.6-3.5 mc/s.
RE.26 for 2.5-5.5 mc/s.
RE.41 for 4.0-9.3 mc/s.

Suitable for service in extreme climatic conditions—as used in antarctic expeditions.

TRANSISTORISED P.S.U. Suitable for direct replacement of Rotary Transformer PSU in W/S 62.

FIELD TELEPHONES FT.1A. Rugged lightweight for point-to-point use or with any type of manual switchboard system without necessity for separate switching. Performance to highest standard.

FIELD TELEPHONES FT.2A. Steel cased, extensively sealed and protected against extreme weather conditions.

CARRIER TELEPHONY SYSTEMS. 1+1 and 1+4—all spares.

FREQUENCY FILTERS. Audio and Carrier frequencies.

LINE TRANSFORMERS, COILS REPEATING, INDUCTION RETARDATION — PROTECTIVE DEVICES AND ACCESSORIES for SWITCHBOARDS, OVERHEAD AND UNDERGROUND LINES, etc.

R. GILFILLAN & CO. LTD.,

93 Dominion Road, Worthing, Sussex.

Tel.: 8719. Cables: "GIL".

CLASSIFIED ADVERTISEMENTS

DISPLAYED: £5 5s per single col. inch.
LINE advertisements (run-on): 6/- per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to MAY 5 for the JUNE issue, subject to space being available.

SITUATIONS VACANT

CIVILIAN Instructors Grade III Telecommunications:—
5 POSTS for men fully experienced in the maintenance of radio and/or terminal channelling equipment (including ancillary equipment such as DC telegraph machines and telephone exchanges) to teach Royal Signals technicians and trainees. Possession of appropriate O.N.C., C. & G. certificates or equivalent qualifications desirable. Selection by written examination and interview.
STARTING salary £894 (at age 21)—£1,243 (at age 30 or over) rising to £1,366.
PROSPECTS of pensionable appointment and promotion.
OPPORTUNITIES exist for further technical study and Day Release will be granted where possible.
ACCOMMODATION may be provided for single and for unaccompanied married men on a temporary basis.
WRITE for application form to CEPO, Peronne Lines, Catterick Camp, Yorkshire.
CLOSING date 13th May, 1966. [1481

ENGINEER Technicians. Diplomatic Wireless Service.
THE Diplomatic Wireless Service have vacancies for about 20 posts in (a) Grade II, (b) Grade III.
THIS Department operates a world-wide network of radio communication stations which is in the process of being modernised and expanded and the most up-to-date techniques in radio teleprinter systems are being employed. The duties of engineers in this field involve installation, modification, maintenance and operation of radio transmitters and receivers of the most modern types, remotely tuned aerial systems, teleprinter and voice frequency telegraph equipment. In addition several high powered broadcasting stations relaying programmes in both the H.F. and M.F. bands. The transmitters involved include some of the highest powers yet produced for this purpose. The duties in this field include the installation, modifications, maintenance and operation of these very high power transmitters, the most modern receiving equipment, tape recorders, diesel generating plant, etc. The Department's policy is to encourage versatility and to carry out as much installation and modification work as possible with its own staff. The initial appointments will be either to Crowborough, Sussex, or Hanslope, Bucks. Liability for service overseas.
QUALIFICATIONS: O.N.C. in Electrical or Mechanical Engineering or a City and Guilds Telecommunications. Electrical, or Mechanical Engineering Technicians Certificate (Nos. 49, 57 or 293). Equivalent qualifications may be accepted. Higher qualifications will be an advantage.
SALARY (national interim): (a) £1,129-£1,288; (b) £796 (at age 21), £1,009 (at 28 or over)-£1,129. Promotion prospects. Non-contributory pension.
WRITE (preferably by postcard) to Civil Service Commission, Savile Row, London, W.1, for application forms quoting S/6111/65. Closing date extended to 20th May, 1966. Candidates who have already applied need not do so again. [1486

AN OVERSEAS CAREER with International Aeradio Limited.
TO meet the requirements of constant growth and expansion we invite applications from technicians and engineers for an overseas career in North, West and East Africa, the Mediterranean area and the Arabian Gulf. If you have recently completed service in a trade such as Ground Wireless Fitter in the R.A.F., Radio Electrical Artificer in the Royal Navy or R.E.M.E., Army, or have other experience in the maintenance of H.F. and V.H.F. communications, R.T.T. and navigational aids, we should be interested to hear from you. Successful candidates would normally spend six weeks at our Radio Engineering School, Southall, Middlesex, before proceeding overseas, but in some cases staff with suitable qualifications and experience may be offered immediate posting. Overseas staff receive a tax-free salary with married and child allowances if appropriate and accommodation, bachelor or married, is provided free; other benefits include generous U.K. leave and membership of an excellent pension and life assurance scheme.
WRITTEN applications, please, to Personnel Manager, International Aeradio Limited, Aeradio House, Hayes Rd., Southall, Middlesex. [156

FOR SALES AND WANTED ADVERTISEMENT FORM TURN TO PAGE No. 141

WHY STICK IN A RUT?

WHEN YOU CAN

PROGRESS... with

TRANSIPACK®

A GO-AHEAD, LIVELY COMPANY

TESTERS · DEVELOPMENT ENGINEERS
LAYOUT DESIGNERS · PROJECT PLANNERS

POWER ELECTRONICS

FOR BROMLEY OR HASTINGS

for informal chat—phone or write

INDUSTRIAL INSTRUMENTS LIMITED

Stanley Road
Bromley Kent
Ravensbourne 9212
Telegrams
Transipack Bromley

SEEKING ALTERNATIVE EMPLOYMENT?

Our dynamic organisation is geared to obtain for you the best job available in the area you require. If you are seeking employment in S.E. England and have at least two years' experience in British industry, contact Electronics Appointments Ltd., who are the foremost source of employment in Great Britain. Write or phone for details of our free and confidential service.

Electronics Appointments Ltd.,
Norman House, 105-109 Strand,
W.C.2. TEMple Bar 5557-8.

MARINE SERVICE TECHNICIANS TO WORK IN CANADA

Immediate openings are available with the Canadian Marconi Company in Quebec, Ontario and the Maritime Provinces.

Starting salaries will be in the order of $450.00 monthly depending on the qualifications of the individual candidate.

Applicants must be experienced with marine radio and radar equipment. 2nd PMG or amateur certificate as well as some sea-going experience could be useful.

Those applying must be capable of working independently with a minimum of supervision. Candidates familiar with the following types of equipment will be given first consideration: Radar: H/F, W/T and R/T; VHF, FM and R/T; M.F.D.F. and Echo Sounders.

Please write with full details, quoting reference WW2990.B to:

Technical Staff Officer, English Electric House, Strand, London, W.C.2.

CMC CANADIAN MARCONI

MONTREAL

QUEBEC

VACANCIES FOR PRODUCTION INSPECTORS AND TECHNICAL AUTHORS MINISTRY OF DEFENCE (NAVY DEPARTMENT)

Production Inspectors and Assistant Production Inspectors are required in the Navy Department for a wide range of duties concerned with production, inspection and testing of equipment in the fields of Radio Communication, Sonar, Radar, Missile and Weapon Control, and Computers. The work includes Test and Inspection in factories, Testing and Tuning of Weapon Systems in Ships, Calibration, Qualification Approval, preparation of Production Specifications, technical liaison with Contractors and Research and Development Teams. There are also vacancies in the field of Codification and for Technical Authors to prepare Technical Handbooks used in maintenance of Weapon and Ship Propulsion equipment in the Fleet.

LOCATION

Portsmouth, Bath, Copenacre, Portland, Slough and main manufacturing and shipbuilding centres. At Portland mainly concerned with production of Underwater Weapons and Sonar, at Portsmouth with Radar and Communication equipment. Portsmouth is also the normal base for mobile teams responsible for setting to work, tuning and testing of Weapon Systems in Ships, but posts arise in other main shipbuilding areas. Posts at Bath are concerned with production of Surface and Underwater Weapons, at Slough with Navigational systems, and at Copenacre with Test, Inspection, Calibration and Codification.

Technical Author posts at Bath, Portsmouth, Portland and Slough.

QUALIFICATIONS

Full apprenticeship: practical experience in the above field(s): possession of an ONC (or equivalent) in Electronic or Electrical Engineering. Possession of Higher Technical qualifications an advantage.

SALARY SCALES

National rates are:—

Production Inspectors (Technical Class Grade II) / Technical Authors (Technical Class Grade II)	**£1,129** per annum by four annual increments to **£1,288** per annum.
Assistant Production Inspectors (Technical Class Grade III)	**£796** per annum age 21 rising to **£1,009** per annum at age 28, thence **£1,038** per annum to **£1,129** per annum by four annual increments.

(Above rates under review. Posts in London area attract an allowance)

Prospects of pensionable employment and promotion to higher grade posts.

APPLICATIONS

Write to Superintendent of Production Pool (Naval), Ministry of Defence (Navy) Offices, Empire Hotel, Bath, Somerset for Application Form.

1460

PYE CAMBRIDGE WORKS, Ltd., Haig Rd., Cambridge.
- SINGLE sideband equipment
- VHF radiotelephone equipment.
- HI-FI reproduction equipment.

WE require trained personnel for production testing and fault finding of modern equipment.
WE have limited vacancies for more senior and experienced men with drive, who can lead small teams engaged on this work.
WE have also limited vacancies for persons of less experience who can be trained for such work.
APPLY to: The Personnel Manager. [131

SENIOR Electronics Engineers.—Vacancies exist for senior engineers, H.N.C. or B.Sc. or equivalent. Candidates must be first-class technicians with some practical experience and must be capable of administration and co-ordination of complete projects. Considerable periods will be spent abroad and only single men will be considered.—Box W.W. 1462, Wireless World.

GRAMPIAN REPRODUCERS, Ltd., Hanworth Trading Estate, Feltham, Middlesex, require a senior engineer for development of audio frequency transistorised equipment in public address applications. [1405

COLOUR television engineer, well versed latest techniques, required by new development company; apply in confidence, giving age, details of experience. —Box W.W. 54, c/o Wireless World.

A FULL-TIME technical experienced Salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager Henry's Radio, Ltd., 303, Edgware Rd., London, W.2. [149

SALES engineers with good knowledge of Hi-Fi equipment and the electronic industry are offered responsible and remunerative position in various parts of the United Kingdom. Applicants are invited to write giving full details of past work to: Britimpex, Ltd., 16-22, Great Russell St., London, W.C.1. [1464

ELECTRONIC Service Engineers required to service and install Airborne Navigational Equipment at London Airport, Home Counties and Overseas.—Apply The Decca Navigator Co., Ltd., Spur Road, Feltham, Middlesex. Tel. Feltham 4098. [1478

AIRCRAFT Radio Radar Engineers and Mechanics with specific workshop experience in one of the following: X Band Radar, VHF, HF, ILS/VOR, or ADF; 40-hour week, 3 weeks' holiday, pension scheme: apply —Managing Director, Air Transport (Charter) (C.I.), Ltd., Willow Rd., Colnbrook, Slough, Bucks. [1446

OPPORTUNITY for man to join electronics team engaged on wide variety of applications to scientific research. Applicants should be about H.N.C. standard and have experience in design or development of electronic equipment as well as servicing experience. Salary up to £1,250. Generous leave.—Application forms from Establishment Officer, University College London, Gower St., W.C.1, quoting Chem/6. [1483

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.1. Telephone HOLborn 7033

BOROUGH POLYTECHNIC

Borough Road · London · S.E.1

Applications are invited for the following posts in the Department of Electrical and Electronic Engineering:

Chief Technician (Electronic)
Chief Technician (Departmental Workshop—Instrument-type)
Senior Technician (Electrical Machines)
Technician (Electrical Machines)
Technician (Electronics)

A broad experience in Electrical/Mechanical workshop practice is more important than academic qualification, although this is desirable for the senior posts.
Experience in industry, or in the Services, in one of the above fields would be most appropriate.

Salary, according to age, experience and qualifications:

Chief Technician: £1,120-£1,290 per annum
Senior Technician: £875-£1,135 per annum
Technician: £650-£930 per annum

Apply in writing, stating the post for which application is made, giving the names of two referees, to the Secretary.

The Civil Service

Professional and Technical Appointments

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.

SALARY (Inner London): £877—£1,806. Salary under review. Promotion prospects.

AGE: At least 21 and normally under 35 on 31.12.66. Some extensions for service in H.M. Forces or Overseas Civil Service. (Reference: S/322).

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.

SALARY (Inner London): £1,143 (at 25)—£1,718. Salary under review. Promotion prospects.

AGE: Normally at least 25 and under 35 on 31.12.66. Some extensions for service in H.M. Forces or Overseas Civil Service. (Reference: S/85).

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/68).

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.

English Electric Leo Marconi

Computer servicing

English Electric Leo Marconi is Britain's foremost computer company. Ever increasing sales mean that we need more engineers to maintain computers on our customers' premises.

Experience in the development, testing or servicing of transistorised electronic equipment and the ability to understand the logic of advanced computers are the qualifications we are looking for.

Training, salaries and fringe benefits are all that you would expect from a leader in the computer field and prospects are limited only by ability.

Jobs exist in most parts of the country, but the greatest number of vacancies is in the London Area, the Midlands and South West Lancashire.

To obtain more information write to:—
The Personnel Officer,
Dept. WW.M.16,
English Electric-Leo-Marconi Computers Ltd.,
24, Minerva Road,
London, N.W.10.

AN 'ENGLISH ELECTRIC' COMPANY

STAVELEY-SMITH CONTROLS LIMITED

TECHNICAL ASSISTANTS

Vacancies exist for technical assistants to Project Engineers to cover day-to-day handling of a wide range of radio, electronic and electrical control gear. Applicants must have had a good and wide experience in handling and organizing installations, testing and servicing in the field, control of reports, spares 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 seagoing 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 **Shepley Industrial Trading Estate, Audenshaw, Manchester.**

HOVERCRAFT electronics are different. Join a company who service these and be in the forefront of a new venture. Good pay and a generous bonus scheme. Apply in complete confidence to Smye-Rumsby Engineering Co., Ltd., 2, Queen St., Dover, Kent. [1467

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: O.N.C. or experience as first-class skilled radio mechanic.—Box W.W. 1461, Wireless World.

RADIO and radar technicians required for the operation, maintenance and development of airborne and ground equipments at a flying unit in North West Wales: basic 5-day week with overtime: single hostel accommodation.—Apply Short Brothers and Harland, Ltd., R.A.E., Llanbedr, Merioneth. [1440

TELECOMMUNICATIONS TECHNICIANS required by the Government of Zambia, General Post Office, on contract for one tour of 36 months in the first instance. Commencing salary according to experience in scales (including Overseas Addition) indicated below. A supplement of not less than £200 a year is also payable. Gratuity 25% of total salary drawn. Liberal leave on full salary or terminal payments in lieu. Free passages. Quarters at low rental. Children's education allowances.

Candidates for appointment as Equipment Technicians (salary scale rising to £1,855 a year) should possess Inter. C. and G. Cert. and must have had at least 10 years training and experience in one or more of the following branches of telecomms. engineering: (i) Carrier: (ii) H.F. and V.H.F. Radio: (iii) Auto Exchanges: (iv) Telegraphic Machines. Overseas experience: "B" year C. & G. Certs. and a knowledge of external telephone distribution systems and subscribers installations would be advantageous. Age limits 26-45. Ref: M2T/62916/WF.)

Candidates for appointment as Line Technicians (salary scale rising to £1,580 a year) should possess at least two appropriate C. & G. Certs. and must have had at least 10 years' training and experience in one or more of the folowing branches of telecomms. engineering (i) underground and overhead cable distribution; (ii) overhead line systems: (iii) subscribers installations. Overseas experience. Inter. C. & G. Cert. and familiarity with other aspects of telecomms. engineering would be advantageous. Age limits 26-45. (Ref. M2T 62959 WF.)

Apply to Crown Agents, M. Dept., 4, Millbank, London, S.E.1, for application form and further particulars, stating name, age, brief details of qualifications and experience, and quoting the relevant reference. [1471

PYE VHF TEST 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.**

TEST Engineers required for testing, calibration and fault finding on a variety of valve and transistorised laboratory instruments. H.N.C. or equivalent desirable but engineers with several years experience in similar fields will be considered. Apply: Miss Bond, Electronic Instruments Ltd., Richmond, Surrey. [1463

WEST London Aero Club invite "A" and "B" licensed engineers with capital and/or necessary equipment to commence Radio Workshop. Alternative propositions may be considered. Write full details to—White Waltham Airfield, near Maidenhead, Berks. [158

RADIO engineers.—Junior electronics engineers required by internationally known organisation; candidates must be single, medically fit and prepared to spend periods of up to two years abroad; qualifications: O.N.C. or experience as first-class skilled radio mechanic. Box 1475, c/o Wireless World.

PRINTED circuit technicians. Devon. Westward Circuits Limited have vacancies for an experienced Shop Foreman and for Printed Circuit Technicians; good pay and prospects offered to suitable applicants who should write or telephone.—Westward Circuits, Limited, Ottery St. Mary, Devon. Tel. 494. [1477

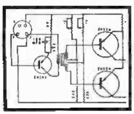
THE UNIVERSITY OF LIVERPOOL. A special technician is required to be responsible for the day-to-day organisation of the electron microscope unit (the instrument is an A.E.I. EM6-B) which is shared by the Departments of Zoology and Botany. The minimum qualification is an H.N.C. or equivalent. Salary according to qualifications and experience up to a maximum of £1,400. Applicaton forms may be obtained from the Registrar, The University, Liverpool, 3. Please quote Ref. 491/WW. [1473

Radiomobile

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. Sharkey,
RADIOMOBILE LIMITED,
Goodwood Works, North Circular Road, N.W.2
Telephone GLAdstone 0171 Ext. 129

A SUBSIDIARY OF SMITHS INDUSTRIES LIMITED

TELECOMMUNICATIONS ENGINEER

Required by the GOVERNMENT OF UGANDA for service in Ministry of Internal Affairs (Police) on contract for one tour of 21-27 months in the first instance. Salary (including overseas addition) according to age and experience in scale £1,188–£2,202 a year. Gratuity 25% of total emoluments. Educational allowances. Outfit allowance £30. Liberal leave on full salary. Accommodation provided at reasonable rental, or hotel allowance in lieu.

Candidates, between 30 and 45 years of age, must possess a City and Guilds Final Certificate course 49 or equivalent qualification with at least 6 years' practical experience including installation and maintenance of fixed and mobile V.H.F. equipment (A.M. and F.M.); H.F. medium and low power S.S.B. and D.S.B. transmitters and receivers; Radio teleprinter equipment; Small diesel and petrol electric generating plants. Duties will also involve the supervision and instruction of local maintenance staff under training.

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 M2T/62331/WF.

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

C L & Co

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 formal 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 ond 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 entry to the Company's Superannuation Scheme, etc.
Applications in writing, enclosing full personal details to:-

RACAL
THE RACAL GROUP

Personnel Manager
Racal Electronics Ltd.
Western Road, Bracknell, Berkshire

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 communications 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/WF.

RADIO TECHNICIANS

A number of suitably qualified candidates will be required for training, leading to permanent and pensionable employment, normally at Cheltenham but with opportunities for service abroad or appointment to other UK establishments including London.

Applicants must be 19 or over and be familiar with the use of Test Gear and have had Radio/Electronic Workshop experience. They must offer at least "O" level GCE passes in English language, Mathematics and/or Physics or hold the City and Guilds Telecommunications Technician Intermediate Certificate or equivalent technical qualifications.

Pay according to age, e.g. at 19 **£747**, at 25 **£962** (highest pay on entry) rising by four annual increments to **£1,104**.

Prospects of promotion to grades in salary range **£1,032-£1,691**.

Annual leave allowance of 3 weeks 3 days, rising to 4 weeks 2 days.

Normal Civil Service sick leave regulations apply.

Apply:
Recruitment Officer (RT/3),
Government Communications Headquarters,
Oakley, Priors Road, Cheltenham, Glos.

AIRCRAFT Radio Engineers and Mechanics with specific workshop experience in one of the following: VHF, HF, or ADF. 40-hour week, 3 weeks' holiday. Pension Scheme.—Apply Managing Director, Air Transport (Charters) (C.I.), Ltd., Willow Road, Colnbrook, Slough, Bucks. [1485

INTERNATIONAL ALLOYS LIMITED, Aylesbury, require Electronics Technician for maintenance and fault finding on direct reading spectrographic equipment; experience on this type of equipment desirable but not essential; experience on high voltage equipment advantageous; salary based on qualifications and experience; hours of work 37 per week; additional hours paid at overtime rates; the Company operates pensions and life insurance schemes, three weeks' holiday per year after first year; canteen facilities available.—Apply to Personnel Manager. [1480

INSTITUTE OF CANCER RESEARCH: ROYAL CANCER HOSPITAL ELECTRONICS TECHNICIAN required in the Chester Beatty Institute, Fulham Rd., S.W.3, to take charge of the servicing of equipment (e.g. spectrophotometric and other instruments) and the construction and development of prototype apparatus. Appointment will be in the Senior Technician's Grade, M.R.C. scale, £965-£1,265 with London Allowance, depending on age, qualifications and experience. Apply with names of two referees to the Secretary, 34, Sumner Place, S.W.7, quoting ref. 301/B/242. [1474

HYDROLOGICAL research unit; electronic engineer: an electronic engineer is required by the hydrological Research Unit, Natural Environment Research Council, Howbery Park, Wallingford, Berkshire, to assist in the development of electronic and electromechanical instruments for hydrological measurements; the post is at assistant experimental officer grade and applicants should have an H.N.C. in electrical engineering and some years experience in electronic development work; examples of salary: £744 at 21, £970 at 25; a day release scheme operates for further studies.—Apply to the above address, telephone number Wallingford 2381. [1459

BOOKS, INSTRUCTIONS, ETC.

CIRCUITS for audio and tape recording, 7/6, now available at all good bookshops or 8/6 post free from Haymarket Press, Ltd., 9, Harrow Rd., London, W.2. [1465

MANUALS, circuits of all British ex-W.D. 1939-45 wireless equipment and instruments from original R.E.M.E. instructions: s.a.e. for list, over 70 types—W. H. Bailey, 167a, Moffat Rd., Thornton Heath, Surrey. [143

BOOKS WANTED

MANUALS or instruction books, data, etc., on American or British Army, Navy or Air Force radio or electrical equipment.—H. Harris, 93, Wardour St., London, W.1. [1416

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 electronics, Radar, Radio and T.V., or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to:

Service Manager,
SUMLOCK COMPTOMETER LTD.,
102/108 Clerkenwell Road,
London, E.C.1.

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 RAF 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

Applicants 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 £1,009. These rates are under review.

Prospects for Pension

Established appointment (for pension and gratuity) can be obtained by passing Civil Service Commission Open Competitions 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,
Chessington,
Surrey.

PYE TELECOMMUNICATIONS

We have vacancies for Fault Finders, Testers, and Inspectors to work on interesting and advanced equipment including H.F. SINGLE SIDEBAND, V.H.F. RADIO TELEPHONES, U.H.F. MINIATURE EQUIPMENT.

Transistor experience is desirable but not essential. Vacancies exist at all levels and training will be given where necessary.

Apply: **Personnel Manager,**
CAMBRIDGE WORKS LTD.,
Haig Road,
Cambridge.

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, £820 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 the troposphere.
Study of the upper atmosphere and ionosphere with apparatus in rockets and satellites.
The use of an 80ft. radio telescope in the study of radio waves and their travel through the ionosphere and troposphere. The engineering development of specialised electronic and other 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.
Opportunities for overseas service.

Qualifications required:—
S.O./S.S.O. 1st or 2nd Class Honours Degree (or equivalent) in appropriate subject plus (for S.S.O.) at least three years post-graduate experience.
A.E.O./E.O. Suitable Degree, Dip. Tech., H.N.C. (or equivalent), or if under age 22, two G.C.E. 'A' levels in scientific subjects.

Salaries:—
S.O./S.S.O. Between £926 and £2,155.
A.E.O./E.O. Between £568 and £1,734.

Send for details to
The Secretary, S.R.C. Radio and Space Research Station, Ditton Park, Slough, Bucks.

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.

THE RANK ORGANISATION

projects engineer

Due to the expansion of the Communication Division of Rank Relay Services a vacancy has arisen for a Projects Engineer with detailed knowledge of closed circuit television and audio techniques.

He will be required to produce work costings, prepare tenders and liaise with customers. In addition there will be work of a more practical nature in the way of surveying, commissioning and supervising installations.

The post is based at Whyteleafe, near Purley, Surrey, but considerable travelling throughout the United Kingdom will be necessary. It is desirable that applicants have some formal qualifications such as H.N.C. or City and Guilds Telecommunications although men with good practical experience should certainly apply. An attractive starting salary will be offered along with Company Car and comprehensive fringe benefits.

Please write showing how you meet the above requirements to:—

HOME & LEISURE SERVICE DIVISION

The Personnel Officer, Central Personnel Department, The Rank Organisation Limited, 439/445 Godstone Road, WHYTELEAFE, Surrey.

Vacancies in Cambridge

Considerable expansion of our Radio Communications Division is planned and immediate vacancies exist for the following technical staff—

(1) Senior Development Engineer for S.S.B. Radio Equipment. Experience with solid state circuitry essential.

(2) Engineer familiar with micro-miniaturisation techniques.

(3) Three Assistant Circuit Development Engineers with experience of H.F. S.S.B. equipment.

(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.

ARTICLES FOR SALE

GOOD secondhand Ferrographs often available.—Reg. 2745 (Lon.). [110

2 Phillips pro. 20 tape machines. 2 track stereo: £650 each new, mint condition; offers.—Box 1469, Wireless World.

PUBLIC Address Amplifiers, mains operated. 25w output, £15; 40w £25, 70w £35, 120w £50; external re entrant loudspeaker, £6 10 each.—Harringay Supplies, Ltd., 435, Green Lanes, London, N.4. Mou. 5241. [1482

DISC cutter with power amplifier, equalizer amplifier, hot stylus unit, pick-up and pre-amplifier, spare head, several blanks, etc., as new; £150 o.n.o. Further details Malconi Disc Recordings, 592, Hessle Rd., Hull. [1470

AMPEX series 600 professional recording tape, type 641, 1,800ft Mylar on 7in spool, complete with leader, brand new in makers boxes; usual price £3, limited quantity available at 67/- for two spools, p. & p. 2/- (or 37/- singly, p. & p. 1/6).—E. C. Kingsley & Co., 93, Tottenham Court Rd., London, W.1. Euston 6500. [1472

FOR sale.—1961 Decca River Radar equipment, Type 215, comprising aerial, gearbox, transceiver, display unit, motor alternator, voltage controller, hood, visor, magnifier unit, pivot mast and scanner. Squares, Type 215N, cover for radar mast winch. Full particulars and address for viewing on application to County Supplies Officer, County Supplies Department, Sandling Road, Maidstone, Kent, to whom offers must be returned on or before 2nd May, 1966. [1479

ELECTRONIC Voltmeter and Ohmmeter (Electronic Designs Inc.); Cossor F.M. Receiver Alignment Generator Model 1324 Serial 4380; Advance Signal Generator Type 62 Serial 421; Avo Test Bridge, 50 c/s 240V; Marconi Crystal Calibrator, pair S.G. Brown Super-K Headphones Stereophonic; Parmeko Gain Leakage Meter; peak level reflectograph; quantity air dielectric trimmers, resistors, capacitors, semi-conductors; Property of deceased electronics engineer. Reasonable offer accepted.—Apply J. W. Barber, Stanhope Arms, Brasted, Westerham. Tel. XMB-592. [1476

HIGH quality professional recording and reproducing equipment comprising Quad 22 stereo pre-amplifier with two Quad main amplifiers, Quad FM radio unit, Vortexion four-way mixer, Shure pickup and Garrard transcription turntable. Ampex four-track 1200 series tape recorder. Equipment housed in small sapele cabinet 3ft×3ft×18in approx. Price 250 guineas o.n.o. Two Lockwood large monitor enclosures complete with 15in Tannoy dual-concentric speakers. Price 125 guineas o.n.o.—Tel. Weston 3153 or write R. Frov, 30, Monckton Court, Melbury Rd., London, W.14. [1487

SYSTEMS TEST ENGINEERS

PYE TELECOMMUNICATIONS 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:

The Personnel Officer, The Decca Navigator Company Limited, 88 Bushey Road, Raynes Park, London, S.W.20. *Telephone: WIMbledon* 8011.

ECC **ELECTRIC CONSTRUCTION**

ELECTRONICS ENGINEERS

for work on Thyristor applications. Some experience with transistor circuits desirable.

MINIMUM QUALIFICATIONS H.N.C.

Pensions and Life Assurance and Sick Pay Schemes in operation.
Modern Restaurant and Recreational Facilities available.

Apply

Personnel Manager,
Electric Construction (W'ton) Limited,
Bushbury Engineering Works,
WOLVERHAMPTON.

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, ENTerprise 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.

BOROUGH POLYTECHNIC
Borough Road, London, S.E.1.

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. Salary Scale: Head of Department (Grade V) £2,900—£3,140, plus "London Allowance" of £70 per annum.

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.
28th March, 1966.

ARTICLES WANTED

WANTED. TV cameras, any type.—Weston, 11, Fearnville Ave., Leeds 8. Tel. 656378. [55

GARRARD magazine type tape decks, please send details to Smye-Rumsby Engineering Co., Ltd., 2, Queen St., Dover, Kent. [1468

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [140

TAPE RECORDING ETC.

SAVE on cost of hi-fi. See Audio Supply notice (advert. No. 111). [109

TAPE to disc transfer using latest feedback disc cutters; EP's from 21/-; s.a.e. leaflet.—Deroy, 52, Hest Bank Lane, Lancaster. [44

YOU ought to send for a copy of "Psychology and Whisper Teaching" to 3, York House, Huddersfield—5/9 post free. [133

A UNIQUE Tape Buy! Top brand, 7in. 2,400ft. 25/-; 5¾in. 1,200ft. 15/-, p. & p. 2/-, 2 at 2/9, 3-6 at 3/6; bargains in all sizes; s.a.e. for list.— E. C. Kingsley Co., Ltd., 93, Tottenham Court Rd., London, W.1. Euston 6500. [113

TAPE/DISC TAPE transfer editing; duplicating: if quality and durability matter (especially with LPs from your precious tapes), consult Britain's oldest transfer service.—Fund raising records published for schools, musical societies (tax free).—Sound News Productions, 10, Clifford St., London, W.1. Reg. 2745. [108

VALVES

VALVE cartons by return at keen prices: send 1/- for all samples and list.—J. & A. Boxmakers, 75a, Godwin St., Bradford, 1. [116

VALVES WANTED

WE buy valves for cash, large or small quantities, old types or the latest; send details, quotations by return.—Waltons Wireless Stores, 15, Church St., Wolverhampton. [134

TELEVISION SERVICE ENGINEERS

Here is a splendid opportunity for you to widen your sphere of knowledge and join an expanding Company manufacturing Television Test Equipment.

The positions available carry staff status and offer generous salaries with good prospects of advancement.

If you would like to know more about us, why not come along for an informal chat?

Apply: **Mr. D. G. Greatrex,**
Gresham Lion Electronics Limited,
Twickenham Road,
HANWORTH, Middlesex.
TWIckenham Green 5511.

NEW GRAM AND SOUND EQUIPMENT

GLASGOW.—Recorders bought, sold, exchanged; cameras, etc., exchanged for recorders or vice-versa.—Victor Morris, 343, Argyle St., Glasgow, C.2. [120

SERVICES OFFERED

LEAVE it to us.

FOR all electronic wiring, large or small, metal fabrication, engraving, etc., competitive prices and excellent delivery.
APPLY: Contracts Manager, Shirehall Electronics, Ltd., Station Yard, Borough Green, Sevenoaks, Kent. Tel. Borough Green 2612. [152

JOIN Audio Supply Association, 7/6 p.a. (65-page photographically illustrated, non-advertising) hi-fi catalogues, 4/6; your best guide for safe buying.—10, Clifford St., London, W.1. [111

ELECTRONICON, Ltd.—From drawing board to production with minimum delay; let us be your research development, design and prototype department. Pilot production runs a speciality.—176, Lythalls Lane, Coventry. Tel. Nuneaton 2353 or Coventry 86544. [157

EXCHANGES

WE purchase for spot cash, modern used hi-fi equipment, quality tape recorders, communication RXs, stereo gear, etc., etc.: call, write or telephone, best prices given.—Miller's Radio, 38a, Newport Court, few yards from Leicester Square Underground station, Ger. 4638. Est. 20 years. Buyer can collect within 100 miles radius. [137

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 smear.

Size A

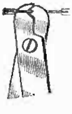
4/6 (subject)

Bib THE PROFESSIONAL TAPE SPLICER

All metal—beautifully plated—compact in size. Easily and permanently attached to a tape recorder. Clamps hold the magnetic or leader tapes in the precision cut channel—no damage to the edges. Right angle and oblique cutting slots.

Complete with Razor Cutter 18/6 (subject)

Bib WIRE STRIPPER AND CUTTER



This efficient tool strips insulation, cuts wires cleanly and splits plastic twin flex. It is adjustable to most wire thicknesses.

4/- (Subject)

If you have any difficulty in obtaining these items they will be sent post free. (U.K. only)

MULTICORE SOLDERS LTD.
HEMEL HEMPSTEAD, HERTS.
TEL: HEMEL HEMPSTEAD 3636

M16

WW—157 FOR FURTHER DETAILS.

Audix

SOUND SYSTEMS
AUDIO EQUIPMENT MANUFACTURES
STANSTED, ESSEX.
Phone: STANSTED 3132

WW—158 FOR FURTHER DETAILS.

SERVICE & REPAIRS

B.B.C.2, TV, RADIO, TAPE REC., SPARES.

BB.C.2/625. Complete conversion kits, or tuners and IF panels separately: send for free lists. Special offer, manufacturer's complete UHF conversion kit, tuner, transistorised sound and vision IF panel, controls, fittings, etc., only £8 10, post 3 6. TV Signal Booster Units, Labgear B1 3. or UHF 75 -, masthead 105 -. Perdio UHF 70/-, post free. L.O.P.T.s. Philips, Stella 1768, 1617, etc., 98 6. Ekco-Ferranti U25 types 42/6, Ekco-Ferranti U26 and Perspex types 74 6. Ferguson 306, 308, 42/6, 406, etc., 75 6. Sobell, TS17, 48/6, 173, etc., 72 6. Pye V4 to V700, etc., 64/6 post 3/6: also Alba, Cossor, Decca, G.E.C., K.B., Invicta, Pam, Philco, McMichael, R.G.D., Dynatron, Emerson, Regentone, Ultra, H.M.V., Marconi, etc.; Scan coils, frame O/P, Frame osc., Line osc., mains sound O P transformers width lin coils mains droppers dual controls, etc.; Tuner Units, Fireball, incremental, turrets, channel coils; CRTS Mullard, Mazda, 14in, 17in, 85/-, 21in 120/-, 110° types 30 - extra, carriage 10/-. Tape Recorders, belts, heads, motors, etc., salvaged components—large selection clean, serviceable turrets, transformers, etc.; enquiries invited, C.O.D. 2/6. MANOR Supplies, 64, Golders Manor Drive, London, N.W.11. Callers, 589b, High Rd. (near Granville Rd.), N. Finchley, N.12. Hil. 9118 (day), Spe. 4032 (evg.); open all week incl. Sat. [101

SPEEDY and expert tape recorder and hi-fi repairs by England's leading hi-fi specialists.—Telesonic, Ltd., 92, Tottenham Ct. Rd., London, W.1. Mus. 8177. [126

AGENCIES

MANUFACTURER'S agents, already calling on radio and electrical retailers in London, Birmingham and Manchester, are required by high quality recording tape producers. Reply in first instance with full details of area visited at present and other products handled, to Box WW 1484, Wireless World.

LONDON CENTRAL RADIO STORES

10-WAY PRESS-BUTTON INTER-COM TELEPHONES in Bakelite case with junction box. Thoroughly overhauled. Guaranteed. **£6 10 -** per Unit. Complete Installation **£60.** Wiring Diagram for 10 and 20 ways on application.

ELECTRICITY SLOT METERS (1/- in slot) for A.C. mains. Fixed tariff to your requirements. Suitable for hotels, etc. 200/250 v. 10 A. **84/-**; 15 A **94/-**; 20 A **104/-**; other amperages available. Reconditioned as new. 2 years' guarantee.

SUPERIOR TYPE DESK PHONES. Black Bakelite cases. Complete with Hand Set. Dial 0-9 and internal bell. **£2 17 6.**

GARRARD RC75A. A.C. mains. 3-speed autochanger, complete with stylus. Approx. size 13in. × 11in. Height approx. 6in. **45/-.** P. & P. 10/-.

EX EQUIPMENT COLLARO. 3-speed autochangers complete with arm and p.u. Hi-Fidelity Model BC54 also Model RC531. A.C. mains. Approx. size 13in. × 11½in. Height 7in. **£3.** P. & P. 10/-.

QUARTERLY ELECTRIC SLOT METERS. Reconditioned as new. 200/250 v. 10 A. **42/6**; 15 A. **52/6**; 20 A. **57/6.** Other amperages available. 2 years' guarantee.

TWIN GONG TELEPHONE, extension bells. 21/-.

TELEPHONE TYPE HAND GENERATORS. 50 v. bell ringing **9/6.**

20-WAY PRESS-BUTTON INTER-COM TELEPHONES in Bakelite case with junction box. Thoroughly overhauled. Guaranteed. **£7 15 -** per Unit. Complete Installation **£135.**

BRASS JACK STRIPS. 10 Jack Sockets in each strip. Size approx. 11 × 2½in. **12/6.** Also 20 Jack Sockets in each strip. Size approx. 11 × 3½in. **19/6.**

P.M. MOVING COIL SPEAKERS. 5in. **9/6.** 8in. 3 ohm **10/6.** Elliptical 7 × 4in. 3 ohm. **10/6.**

MOVING COIL HEADPHONES chamois leather earpieces **25/-.**

8-BANK UNISELECTOR SWITCHES. 25 contacts, alternate wiping **£2/15/-.** 8 bank half wipe **£2/15/-.** 6 bank half wipe, 25 contacts **47/6.**

DESK PHONES. Black bakelite cases complete with hand set and internal bell **47/6.**

HIGH-SPEED ELECTRO-MAGNETIC COUNTERS. Ex-Govt. 0-999, 25/50 v. D.C. Size 1 × 1 × 4in. Single coil, 23,000Ω. Single coil 300Ω **10/6.**

WIRELESS SET No. 38 A.F.V. Freq. range 7.3 to 9.0 Mc/s. Working range ½ to 2 miles. Size 10½in. × 4in. × 6¼in. Weight 6½lb includes power supply 8lb.—and spare valves and vibrator, also tank aerial with base. **£6** per pair or **£3** single. Callers only

All prices include carriage in United Kingdom except where otherwise stated.

23 LISLE ST. (GER. 2969) LONDON, W.C.2

Closed Thursday 1 p.m. Open all day Saturday

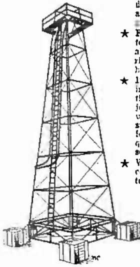
EXCLUSIVE OFFER

PERMANENT OR TRANSPORTABLE STEEL 60-FOOT AERIAL TOWERS

As supplied to British and other Governments

* **Unique design.**
* **Scientific Construction.**

having the following remarkable features.



★ Entirely self supporting requiring no guys, stays, foundations, pickets or spikes, or any attachment to the ground.

★ Fitted with step ladder to the top and balcony with railings all round. (You can walk right round the top with both hands free.)

★ 12 feet square at base tapering to 6 feet square at top, they are quite safe when subject to gale force winds and will accept 60 square feet superficial area on top at force of 60 m.p.h. They require ground area of 20 feet square.

★ Will support up to 2 tons of equipment on top, the whole tower can be completely lowered to the ground by 2 men in 20 minutes and raised in the same time.

★ Can be completely erected and dismantled by 3 men.

★ Breaks down for transport by 2 ton lorry into parts easily handled by 2 men; there are no small loose parts, no nuts or bolts to get lost or damaged; all screws and adjustments are fully protected from rust and so designed to be free from damage when transported or left loose on the ground.

★ Foolproof—the Tower cannot be erected if not assembled correctly. No skilled labour is required and no special tools are necessary.

★ Can be raised and lowered, erected and dismantled and removed as many times as desired.

★ Everything necessary for the complete tower to be put into use and raised and lowered is provided; full drawings and instructions.

These fine Towers were made in England by B.I.C.C. and cost the Government £2,200 each. They are BRAND NEW and in maker's original packing. You can see one erected at our premises.

Cost £2,200
Price Brand New
£345

40-page list of over 1,000 different items in stock available—keep one by you.

★ SP-600 Hammarlund Receivers	£145	0
★ E.M.I. BTR/2A Recorders	£350	0
★ Marconi S.S.B. Receivers HR-22 2/32 m/cs.	£140	0
★ 9 foot BC-610 Whip Aerials	£1	15
★ R C.A. 420 Mc/s. Yagi 5 el. Beams	£2	10
★ Model 15 Teletype Page Printers	£29	10
★ Model 14 Teletype Tape Readers	£25	0
★ Model 14 Teletype Reperforators	£25	0
★ R.C.A. 25 watt Projector Loudspeakers, range 1 mile	£14	10
★ Metro-Vickers Vacuum Pumps 230 v. A.C.	£22	10
★ Precision Mains Filter Units		10
★ E.M.I. Recording Bridges	£12	10
★ Avo Geiger Counters	£7	10
★ Philco W.S. No. 43 Transmitters 350W.	£75	0
★ Metro-Vickers HS.500 Waveform Monitors	£135	0
★ E.M.I. 3794 Waveform Monitors on trolleys	£45	0
★ Motorola 6 v. Mobile Transmitters 30/40 M/cs	£12	10
★ Pen-type Personal Dosemeters		15
★ E.M.I.-BTR-1B Tape Recorders	£250	0
★ Western Electric Relay Test Sets I-181	£9	10
★ Monitor Type 56 and Power Units	£7	10
★ Marconi TF 1053 Noise Meters	£45	0
★ AN/UPM-17 Spectrum Analysers 10/16000 M/cs	P.U.R.	
★ AN/URM-33, 34, 35 Signal Generators 1000/8000 M/cs	P.U.R.	
★ AN/PDR-27 Radiac Sets	£17	10
★ SG1A ARN and MD-83A ARN V.O.R. Test Sets	P.U.R.	

Carriage extra at cost on all above.

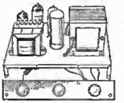
We have a large quantity of "bits and pieces" we cannot list—please send us your requirements—we can probably help — all enquiries answered.

P. HARRIS

ORGANFORD — DORSET

WESTBOURNE 65051

WW—159 FOR FURTHER DETAILS.

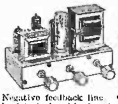


HSL "FOUR" AMPLIFIER KIT

3-VALVE, 4 WATT USING ECC83, EL84, EZ80 VALVES, for A.C. mains 200/240 v.

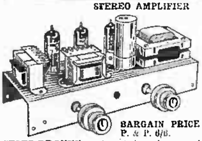
Special features include: ★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate bass treble and volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensures high output at excellent quality with very low distortion factor. ★ Suitable for use with guitar, microphone or record player. ★ Provision for remote mounting of controls or direct on chassis. ★ All this builds on to a chassis size only 7½in. wide × 4in. deep. Overall height 4½in. ★ All components and valves are brand new. ★ Very clear and concise instructions enable even the inexperienced amateur to construct with 100% success. ★ Supplied complete with valves, output transformer (3 ohms only), screened lead, wire, nuts, bolts, solder etc. (No extras to buy). **PRICE 79/6.** P. & P. 6/-. Comprehensive circuit diagram, practical layout and parts list 2/6 (free with kit). *This kit although similar in appearance to HA34 employs entirely different and advanced circuitry.*

3-VALVE AUDIO AMPLIFIER MODEL HA34



Designed for Hi-Fi reproduction of records. A.C. mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker separate bass, treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves etc., wired and tested for only **£4/5/-**. P. & P. 6/-.

STEREO AMPLIFIER



Incorporating 2 ECL82s and 1 EZ80; heavy duty, double wound mains transformer. Output 4 watts per channel. Full tone and volume controls. Absolutely complete.

BARGAIN PRICE ONLY £4/19/6. P. & P. 6/6.

SUPER DE LUXE version of above incorporating ECL86 valves, separate bass and treble controls and full negative feedback. **8 Gns.** P. & P. 6/6.

QUALITY RECORD PLAYER AMPLIFIER

A top-quality record player amplifier. This amplifier (which was used in a 29 gn. record player) employs heavy duty double wound mains transformer, ECC83, EL84, EZ80 valves. Separate bass, treble and volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 2¾in. d. × 5½in. h. Ready built and tested. **PRICE 69/6.** P. & P. 4/9. ALSO AVAILABLE mounted on board with output transformer and 6in. speaker ready to fit into cabinet below. **PRICE 89/6.** P. & P. 5/9.

QUALITY PORTABLE R/P CABINET

Uncut motor board. Will take above amplifier and B.S.R. or GARRARD Autochanger or Single Record Player Unit. Size 18 × 14 × 8½in. **PRICE £3/9/6.** Carr. 7/6.

4-SPEED PLAYER UNIT BARGAINS

All brand new in maker's original packing.

SINGLE PLAYERS. Carr. 5/6 on each.

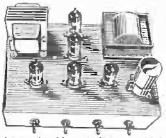
B.S.R. TU/12	£3	9	6
B.S.R. GU7 with unit mounted pick-up arm	£4	18	8
Garrard SP25 de luxe	£12	10	6
E.M.I. with unit mounted pick-up arm	£4	9	6
AUTO. CHANGERS. Carr. 6/6 on each.			
Latest B.S.R. UA25 Super slim	£6	2	6
GARRARD AT6	£9	10	0
GARRARD Auto-Slim, 4 pole motor, plug-in head	£5	10	0

All the above units are complete with t/o mono head with sapphire styli or can be supplied with stereo head at **12/6** extra.

BRAND NEW CARTRIDGE BARGAIN!

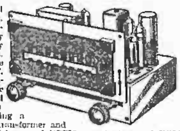
ACOS GP67-1. Mono. List price **21/-.** Our Price **13/6.** P. & P. 1/-.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good life and cut. Valve line-up: 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 1/6. (Free with parts.) All parts sold separately. **ONLY £7/9/6.** P. & P. 8/6. Also available ready built and tested complete with standard input sockets, **£9/5/-.** P. & P. 8/6.

HARVERSON'S F.M. TUNER MK. I

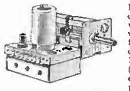


● F.M. tuning head by famous maker. ● Guaranteed non-drift. ● Permeability tuning. ● Frequency coverage 88-100 Mc/s. ● Balanced diode output. ● Two I.F. stages and discriminator. ● Attractive maroon and gold diode (7 × 3in. glass) ● Self-powered, using a good quality mains transformer and valve rectifier. ● Valves used ECC85, two EF80s, and EZ80 (rectifier). ● Fully drilled chassis. ● Size of completed tuner 8 × 6 × 5½in. ● All parts sold separately. Set of parts if purchased at one time **£5/19/6**, plus, 8/6 P.P. and ins. Circuit diagram and instructions 1/6 post free. **Mark II Version** as above but complete with magic eye, front panel and brackets, **£6/12/6.** P. & P. 8/6. **Mark III Version** as Mark I but with output stage (ECL82) and tone control. **£7/7/-.** P. & P. 8/6.

SPECIAL PURCHASE! TURRET TUNERS by famous maker. Brand new and unused. Complete with PCC84 and PCF80 valves, 34-38 Mc/s. I.F. Biscuits for Channels 1 to 5 and 8 and 9. Circuit diagram supplied. **ONLY 25/-** each. P. & P. 3/9.

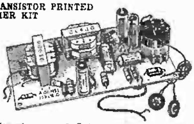
GÖRLER F.M. TUNER HEAD. 88-100 Mc/s., 10.7 Mc/s. I.F. **15/-.** P. & P. 2/- (ECC85 valve 8/6 extra).

ANOTHER HARVERSON SCOOP! FM/AM TUNER HEAD



Beautifully designed and precision engineered by Dormer and Wadsworth Ltd. Supplied ready fitted with twin .0005 tuning condenser for AM connection. FM section covers 86—102 Mc/s. I.F. output 10.7 Mc/s. Complete with ECC85 (6L12) valve and full circuit diagram of tuner head. All prealigned F.M. and perfect. Another special bulk purchase enables us to offer these at **27/6** each. P. & P. 3/-. Order quickly! Limited number also available with precision geared 3:1 reduction drive, **30/-.** P. & P. 3/-.

HIGH GAIN 4-TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT
Type TA1



● Peak output in excess of 1½ watts. ● All standard British components. ● Built on printed circuit panel, size 6 × 3in. ● Generous size driver and output transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET 114 or 81 Mullard OC81D and matched pair of OC81 o/p). ● 9 volt operation. ● Everything supplied, wire, battery clips, solder, etc. ● Comprehensive easy to follow instructions and circuit diagram 1/6 (Free with Kit). All parts sold separately. **SPECIAL PRICE 45/-.** P. & P. 3/-. Also ready built and tested **52/6.** P. & P. 3/-. A pair of TA1s are ideal for stereo.

B.S.R. MONARDECK (Single speed) 3¾in. per sec., simple control uses 5¾in. spools. **£6/15/-,** plus 7/6 carr. and ins. Tapes extra.

LATEST COLLARO MAGNAVOX 363 TAPE DECK DE LUXE. Three speeds. 2 track, takes up to 7in. spools. **10 gns.** Plus 7/6 carr. and ins. (Tapes extra).

QUALITY PORTABLE TAPE RECORDER CASE. Brand new. Beautifully made. Few only at **49/6.** P. & P. 5/-.

MAINS TRANSFORMER. For transistor power supplies. Tapped pri. 200-250 v. Sec. **40-0-40 at 1 amp.** (with electrostatic screen) and 6.3 v. at ·5 amp. for dial lamps, etc. Drop through mounting. Stack size 1¾ × 3¼ × 3½in., **27/6.** P. & P. 4/6.

SMOOTHING CONDENSER suitable for above 4000. mfd. 40 v., size 1¾in. dia. × 3½in. high. **3/6** each. P. & P. 1/6 and 2800 mfd. 25 v., 1¾in. dia. × 3in. high, 3/-. P. & P. 1/-. **7-10 watt OUTPUT TRANSFORMERS** to match pair of ECL86s in push-pull to 3 ohm output. **ONLY 11/-.** P. & P. 2/6.

7-10 watt ULTRA LINEAR OUTPUT TRANSFORMERS to match pair of ECL82s in push-pull to 3 ohm output. **ONLY 15/-.** P. & P. 2/6.

MATCHED PAIR of 2½ WATT TRANSISTOR DRIVER AND OUTPUT TRANSFORMERS. Stack size 1¼ × 1¼ × ⅞in. Output trans. tapped for **3 ohm** and 15 ohm output. **10/-** pair, plus 2/- P. & P. Worth double.

TRANSISTOR DRIVER and O/P TRANSFORMERS. (Tapped 3 ohm and 15 ohm output). Plus 4 suitable Transistors giving approx. 1 watt output. **25/-.** P. & P. 2/6.

BRAND NEW 3 OHM LOUDSPEAKERS

5in. **12/6**; 6½in. **15/-**; 8in. **21/-**; 10in. **25/-**; 12in. **27/6**; (12in. 15 ohms **30/-**); 10 × 6in. **26/-**; E.M.I. 13½ × 8in. with high flux ceramic magnet, **42/-** (15 ohm **45/-**). (P. & P. 5in. 2/-; 6½ and 8in. 2/6; and 10 and 12in. 3/6 per speaker).

BRAND NEW 12in. 15 watt H/D SPEAKERS

3 or 15 ohm. Current production by well known British maker. Offered below list price at **89/6.** P. & P. 5/- (25 w. guitar model **£5/5/-**). (35 watt guitar model **£8/8/-**).

SPEAKER & CABINET FABRICS. Approx. 54in. wide. Usually 35/- yard. Our price **13/6** per yd. length. S.A.E. for samples.

NEON A.C. MAINS INDICATOR

For panel mounting, cut out size 1⅛ × ⅝ × ⅞in. deep, inc. terminal. White case with lens giving brighter light. For mains 200/250 v. **2/6** each. P.P. 6d. 6 or more post free.

HARVERSON SURPLUS CO. LTD.
170 HIGH ST., MERTON, S.W.19. CHErrywood 3985
Open all day Saturday *Early closing Wed., 1 p.m.*

A few minutes from South Wimbledon Tube Station. (Please write clearly.)

Overseas P. & P. charged extra. S.A.E. with all enquiries.

TRANSISTORS FOR TECHNICAL COLLEGES

This book will be of particular value to students of electronic engineering in all types of Technical Colleges. With its practical approach it will also serve as an elementary design text for the many industrial engineers.

By L. Barnes, M.Sc. Tech. A.M.I.E.E.

25/-. Postage 1/-.

MOTOROLA SEMICONDUCTOR DATA MANUAL. 30/-. Postage 3/-.

THE RADIO AMATEUR'S HANDBOOK by A.R.R.L. 1966. 40/-. Postage 2/6.

MODERN ELECTRONIC COMPONENTS by G. W. A. Dummer. 63/-. Postage 1/6.

BASIC INDUSTRIAL ELECTRICITY. 2 parts. 18/-. ea. Common Core Book 1/6.

ELECTRONICS POCKET BOOK by J. P. Hawke and J. A. Reddihough. 21/-. Postage 1/-.

NETWORK ANALYSIS FOR TELECOMMUNICATIONS & ELECTRONICS by R. A. Lampitt. 63/-. Postage 1/6.

COMPLETE CATALOGUE 1/-.

THE MODERN BOOK CO.

BRITAIN'S LARGEST STOCKIST
of British and American Technical Books

19-21 PRAED STREET
LONDON, W.2

Phone: PADdington 4185
open 6 days 9-6 p.m.

TEST EQUIPMENT — SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [141

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

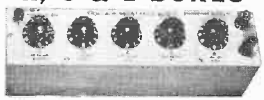
HRO Rx's, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [142

MISCELLANEOUS

METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar. PHILPOTT'S METAL WORKS, Ltd., Chapman St., Loughborough. [151

URGENTLY wanted, manuals or instruction books, data, etc., on American or British Army, Navy or Air Force radio or electrical equipment.—H. Harris, 93, Wardour St., London, W.1. [1416

R, C & L BOXES



CAPACITY 15pf to 111µF
RESISTANCE 0.1Ω to 100KΩ
INDUCTANCE 1mH to 10H
VOLTAGE DIVIDERS and
WHEATSTONE BRIDGES

LIONMOUNT & CO. LTD.
BELLEVUE ROAD, NEW SOUTHGATE, LONDON, N.11, ENGLAND.
Tel: Enterprise 7047.

WW—160 FOR FURTHER DETAILS.

PERSONAL

HOUSE names in gold leaf on wood, 4in×16in, post free 57/6 from Wood Lodge Studio, Hilltown, N.I. [155

CAPACITY AVAILABLE

COIL winding and electronic assembly capacity available.—Sweetnam & Bradley, Ltd., Bremilham Works, Bristol Rd., Malmesbury, Wilts. 'Phone 2334. [1415

RECTIFIERS. Selenium and Silicon units supplied for all applications, keen prices, good deliveries. J. R. SERVICES & DEVELOPMENTS, 231, Rivermill, Harlow, Essex. Tel. Harlow 1706. [112

AIRTRONICS, Ltd., for coil winding, assembly and wiring of electronic equipment, transistorised sub-unit, sheet metal work.—3a, Walerand Rd., London, S.E.13. Tel. Lee Green 1706. [107

TRANSFORMERS: Winding and design of transformers, chokes and inductors: signal and instrument types. "C" core and laminated patterns up to 2 KVA, power transformers 250 VA to 20 KVA: your enquiries invited; our representatives will be pleased to call upon you to discuss your application.—Avimash Electronic, Ltd., Manor Works, Old Town, Clapham, London, S.W.4. Tel.: Mac. 4226/7/8. [1413

RESERVE capacity available mechanical, electro-mechanical assembly, electronic assembly and wiring. Lead time six weeks. Top quality assurance and supporting technical service Based North Wales. Box 1466, Wireless World.

ASSEMBLY and wiring facilities available for the production of all types of electronic equipment, prototypes and production runs from your designs.—Woodstock Agencies, Ltd., Broadway Court Offices, Brighton Rd., Lancing, Sussex. Tel. Lancing 2844. [1433

TECHNICAL TRAINING

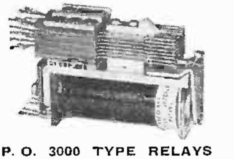
CITY & Guilds (electrical, etc.), on "Satisfaction or Refund of Fee" terms. Thousands of passes. For details of modern courses in all branches of electrical engineering, electronics, radio, T.V., automation, etc., send for 156-page handbook—FREE.—B.I.E.T. (Dept. 152K), 29, Wrights Lane, London, W.8. [146

P.M.G. Certificates, City & Guilds Examinations, I.E.R.E., also many non-examination courses in radio, TV and electronics: study at home with world famous I.C.S.—Write for free prospectus, stating subject, to International Correspondence Schools (Dept. 443), Intertext House, Parkgate Rd., London, S.W.11. [153

ROTARY TRANSFORMERS. Input 12 v. D.C. Output 275 v. 110 mA. Brand New. **27/6.** Carr. 4/-.
500 MICRO AMP. METERS. Panel mounting miniature type. 1¾in. dial. Brand New. **12/6.**
VARIABLE TWIN GANG. Solid dielectric 190-210 pF. Min. type 1×1×¾in. **4/6.**
11FT. WHIP AERIALS. 6 sections, copperized steel and painted. Dia. ⅜in.-¼in. Complete with moulded base 2¼×3½in. **9/6** each. Post 1/6.
TELESCOPIC AERIAL MASTS. Tubular Steel copperized spray finish. Ring cam locking on each section provides for full or any height required. Suitable all fixings and base locations. 34ft. (6 sections), closed 6ft. 6in. Wgt. 20 lbs. Base dia. 1¾in. **75/-.** Carr. 5/-. 20ft. (4 sections), **55/-.**
SIGNAL GENERATOR. Type 106. Coverage 5.5 Megs. to 55 Megs. Max. Sig. O/put 10 M/volts. Brand New. Manufactured Salford Insts. **£5.** Carr. 10/-.
3 KVA. AUTO TRANSFORMERS. 110/250 v. Mounted in steel case with external hand voltage regulator. 7 Taps. Brand New. **£12.** Carr. 10/-.
HEADPHONES. Balanced armature, DLR5. Brand New. **9/6** pr. Moving coil type, with ear muffs for noise excluding, **12/6** pr. Same fitted with moving coil mike, **17/6** pr. Carbon hand mike, **7/6** each.
TANNOY LOUDHAILERS. Ideal for all outdoor uses, enclosed in waterproof wooden case, complete with steel baffle designed to produce directional reproduction at 5 watts, 7.5Ω. **27/6** each. Carr. 2/6.
R.220 Mk.III. RECEIVERS—Superhet complete with 3in. ohm, built-in speaker 230-250 v. A.C. Mains power pack. Easily converted to amateur bands. Chassis only. Complete with valves. Less Xtal. **£3/15/0** carr. 5/-
SMALL GEARED MOTORS. Working voltage 6-12. v. D.C. Overall size 4×2×2in. **15/-** ea. Carr. 1/6. Miniature blower motor 6-12 v. D.C. **12/6** each. Carr. 1/6.
TRANSMITTER. BC 625, part of T/R SCR.522. Chassis only. Complete with valves, *except* 832's, and Relay. Range 100-156 Mc/s. **21/-** ea. Carr. U.K. 4/-.
LINEAR ACTUATOR. 24 or 12 v. D.C. Will operate 100 lb. load in either direction. 3in. travel through motor operated gearbox. **£4/10/0** each. Carr. 3/6.
38 SETS A.F.V.-6-9 Mc/s. New condition. Complete with valves. Untested. **21/-** ea. Carr. 3/-. **37/6** pr. Carr. 5/-.
SIEMENS MINIATURE RELAYS. Size 1½×1×¾in. Res. of coils 700 or 250 ohms. 2 pole 2 way contacts, contact rating up to 2 amps. **6/-** ea. P.P. 1/-.
SIEMENS HIGH SPEED RELAYS. H96B type 50+50 ohms., **10/6** ea.; Type H96D 500+500 ohms., **10/6** ea.; Type H96E 1,700+1,700 ohms, **14/6** each.
CARPENTERS TYPE RELAY. 5HM52 Operating coil triple coil, 1.2 ohms, 100 turns, 150 ohms, 3,000 turns, and 250 ohms, 3,000 turns, **15/-** ea. **G.E.C. Sealed** type **670** ohms, 2 M, 2 b, **7/6** each.
POST OFFICE TYPE RELAYS. 3,000 sers. 2 c/o: 2 m.; slugged coil 140 ohms.; 2 c/o.; 2 m. coil 1,000 ohms.; 2 c/o. slugged coil 500 ohms. All at **6/-** each.
D.P.CO. AERIAL CHANGE-OVER RELAY. 12 v. D.C. coil, heavy silver contacts. American Surplus. **12/6** each. Carr. 1/-.
MORSE KEYS complete with leads, terminals and cover, **6/6** each.
PRESSURE GAUGE. 2in. round brass case. 0-160 lbs. **9/6** each.
MINIATURE PLUGS AND SOCKETS. 8 way. Jones, **3/6** pair.
VIBRATORS. 6 v. 4 pin, 12 v. 4 pin; 12 v. 7 pin. Syn. All **6/-** each.
BLOCK CONDENSERS. Paper. 1.7+1.7 Mfd. 3 KV. **8/6** ea. 2 Mfd. 250 v. **4/6** ea.; 8 Mfd. 600 v. **6/-** ea.; 10 Mfd. 350 v. **7/6** ea.
ELECTRIC PUMPS. 24 v. D.C. Overall size 7×2½×2½in. 7 G.P.H. Brand New. **37/6** ea. Carr. 2/-.
NEW COMPONENTS. Min. con. 1.64 Mfd. 15 v. **1/8** ea.; 100 Mfd. 6 v., 12 v., 25 v. at **2/-**; 250 Mfd. 12 v. **2/-**; 250 Mfd. 25 v. **2/3**; 500 Mfd. 15 v. **2/3**; 1,000 Mfd. 15v. **2/6**; 2,000 Mfd. 25 v. **5/6**; 8 mfd. 450 v. **2/3**; 8+8 450 v. **3/6**; 16 Mfd. 400 v. **3/6**; 16+8, 450 v. **4/-**; 16+16 Mfd. 450 v. **4/6**; 16+32 Mfd. 350 v. **5/6**; 32 Mfd. 450 v. **4/6**; 32+32 Mfd. 500 v. **6/9**; 32+32+32, **5/-**; 100+200+200 Mfd. **9/9**; 25 at 25 v. 100 at 25 v.; 100 at 50 v., a.. at **2/-**. Stand Jack **3/-**. Screened **3/9**. Sockets **2/-** or **3/3**. 3.5 mm. plugs and sockets, **2/6**. V/C. 5k., 10k., 25k., 50k., 100k., 250k., 500k., 1 Meg., 2 Meg. All at **3/-**. With d/sw. **5/-**. 500 ohms W/W. pre-set, **2/6**. All values ½ watt res. 4d. each. Enquiries invited. No lists.
HYDRAULIC RAMS. Miniature. 200 P.S.I. WT. ½lb. ¾in. travel 3in. screwed extension. Gimbal fitting one end. 9in. long, cylinder 2¼×3½in. Brand new, **30/-** ea. incl. carr.

S.A.E. all enquiries.

B. S. Radio and Electrical Stores
108 CHESTER ST., BIRKENHEAD, CHESHIRE



P. O. 3000 TYPE RELAYS
AT A PRICE YOU CAN AFFORD
Reconditioned as new. Built up to customers' requirements. Return of post delivery. Let us quote you.
CATALOGUE 2/6 POST FREE.

RADIO CONTROL
Phone BRIGHTON 65806
ARTHUR SALLIS RADIO CONTROL LTD
93 NORTH ROAD BRIGHTON SUSSEX
EX GOVT. ELECTRICAL SURPLUS

TUITION

RADIO officers see the world. Sea-going and shore appointments. Trainee vacancies during 1966. Grants available. Day and boarding students. Stamp for prospectus.—Wireless College, Colwyn Bay. [128

I.E.R.E., City & Guilds and R.T.E.B. exams., specialised I.C.S. home-study course will ensure success.—For details of wide range of exam. and diploma courses in radio, TV and electronics, also new practical courses with kits, write to I.C.S. (Dept. 522), Parkgate Rd., London, S.W.11. [106

A.M.I.Mech.E., A.M.I.E.R.E., City & Guilds, G.C.E., etc. Become a technician or technologist for high pay and security. Thousands of passes. For details of exams. and courses in all branches of engineering, building, electronics, etc., write for 156-page handbook.—FREE.—B.I.E.T. (Dept. 151K), 29, Wrights Lane, London, W.8. [147

TV and radio—A.M.I.E.R.E. City & Guilds, R.T.E.B. Cert., etc., on "Satisfaction or Refund of Fee" terms. Thousands of passes. For details of exams. and home training courses (including practical apparatus) in all branches of radio, T.V. and electronics; write for 156-page handbook—FREE.—B.I.E.T. (Dept. 150K), 29, Wrights Lane, London, W.8. [148

OSMABET LTD

A NEW RANGE OF RADIOGRAM CHASSIS

The latest "Continental" AM/FM Stereophonic Radiogram Chassis. Piano Key Operation, 4 Wavebands, S.M.L. plus VHF/FM, provision for tape record and playback, together with many other outstanding features. A superb chassis. Model PBS7.
Our price 24 Gns. + 15/- p.p.

The latest "Continental" AM Stereophonic Radiogram chassis. 3 wavebands S.M.L. Piano Key Operation, Internal Ferrite Rod Aerial, etc., etc. A chassis of outstanding performance, Model PBS6.
Our price 15½ Gns. + 15/- p.p.

The latest "Continental" HI-FI AM chassis. 3 wavebands S.M.L. Piano Key Operation. Internal Ferrite Rod Aerial, etc., etc. Better than the best in its class. Model PBAM5.
Our price 13 Gns. + 15/- p.p.

We offer a full range of chassis in addition to the above, full details in our catalogue, 6d. stamp please. We supply direct to user, and give the finest value for money.

(S.A.E. all enquiries) Mail Order Only
46, Kenilworth Road, Edgware, Middx.
Tel.: STOnegrove 9314

NEW FROM PITMAN

Transistor Electronic Organs for the Amateur

Alan Douglas / S. Astley

This is the fourth book by Alan Douglas, who is probably the leading writer on this type of equipment. It presents not only a detailed design for a full scale organ, but a complete explanation of everything to do with transistorized organs. Written in simple style especially for the home constructor, and profusely illustrated with clear diagrams. 18s. net.

The Silicon Gate-Controlled Switch

Edited by G. H. Pridham

Aimed at H.N.C. and higher level electronics students, this short monograph was originally presented as a symposium by experts from four major electronic companies at Enfield College of Technology The device is a transistor-type mechanism, recently developed, which has found wide applications in computer and other electronic circuitry.
12s. 6d. net.

Connectors, Relays and Switches

G. W. A. Dummer / N. E. Hyde

This is the sixth volume in the series Radio and Electronic Components, and is the first book in the world that covers the subject of electronic connections. This subject is now of extreme importance, because of the improvement in reliability of both conventional components and integrated circuits: requiring similar improvements in connection methods. 50s. net.

The Radio and Electronic Components series is designed to meet the needs of the rapidly expanding electronics industry for information about specific components. The first books of their kind in this field, they fill a wide gap in present technical literature. Titles in the series are:

Vol. 1 *Fixed Resistors* 28s. net.
Vol. 2 *Variable Resistors and Potentiometers* 45s. net.
Vol. 3 *Fixed Capacitors* 45s. net.
Vol. 4 *Variable Capacitors and Trimmers* 32s. 6d. net.
Vol. 5 *Wires and R.F. Cables* 47s. 6d. net.
Vol. 6 *Connectors, Relays and Switches* 50s. net.

PITMAN · PARKER ST. · LONDON W.C.2

WW—169 FOR FURTHER DETAILS.

RESISTANCE WIRES

EUREKA - CONSTANTAN
Most Gauges Available

NICKEL-CHROME MANGANIN
NICKEL-SILVER

COPPER WIRE

ENAMELLED, TINNED, LITZ,
COTTON AND SILK COVERED
SMALL ORDERS PROMPTLY DESPATCHED
B.A. SCREWS, NUTS, WASHERS
soldering tags, eyelets and rivets
EBONITE and BAKELITE PANELS.
TUFNOL ROD, PAXOLIN TYPE COIL FORMERS AND TUBES. ALL DIAMETERS
SEND STAMP FOR LIST. TRADE SUPPLIED

POST RADIO SUPPLIES
33 Bourne Gardens, London, E.4
Phone: Clissold 4688

WW—170 FOR FURTHER DETAILS.

BOOKS

"BASIC Mathematics for Radio and Electronics." By F. M. Colebrook, B.Sc., D.I.C.A.C.G.I. Revised and enlarged by J. M. Head, M.A. (Cantab.), presents in readable form a complete course in basic mathematics from engineering students of all kinds and leads on to the more advanced branches of mathematics of increased importance to radio engineers. In this edition the chapter covering the application of mathematics to radio has been revised and enlarged, while new subjects covered include Stability, Linear Differential Equations, Elementary Statistics, Short-Cuts to Numerical Calculations and an Introduction to Matrices. Will be invaluable to those without previous knowledge of the subject. 17/6 net from all booksellers. By post 18/6 from Iliffe Books, Ltd., Dorset House, Stamford St., London, S.E.1.

"WIRELESS Servicing Manual." W. T. Cocking, M.I.E.E. This is the tenth edition of a book which since 1936 has been known to radio servicemen everywhere as a reliable, thorough and comprehensive guide to solving most of the problems that arise in the repair, maintenance and adjustment of the modern radio receiver. In the present edition a major addition is a chapter devoted to transistors and transistor sets. The author of "Wireless Servicing Manual" is well known to a wide circle of readers as former editor of "Electronic Technology" and now of "Industrial Electronics." His crisp lucid style makes this handbook of utmost value to the service man and amateur alike. 25/- net, 26/- by post from Iliffe Books Ltd., Dorset House, Stamford St., London, S.E.1.

ELECTRONIC SERVICE

WE DESIGN, DEVELOP AND PRODUCE TO YOUR PRECISE REQUIREMENTS:

TRANSISTORISED AMPLIFIERS
INSTRUMENTS
TELEMETRY AND CALLING SYSTEMS
RADIO DIRECTION FINDERS
TAPE REPLAY PROGRAMMERS
VHF REMOTE CONTROL RADIO RECEIVERS AND TRANSMITTERS

RCS ELECTRONICS
NATIONAL WORKS, BATH ROAD, HOUNSLOW, MIDDX. HUD. 0933

WW—171 FOR FURTHER DETAILS.

SURPLUS HANDBOOKS

19 Set Circuit and Notes	3/6.	P.P.	6d.
1155 Instruction Handbook	4/6.	P.P.	6d.
H.R.O. Instruction Handbook	3/6.	P.P.	6d.
46 Set Walkie-Talkie Circuit and Notes	3/6.	P.P.	6d.
88 Set Walkie-Talkie Instruction Handbook	4/6.	P.P.	6d.
38 Set Instruction Handbook	3/6.	P.P.	6d.
Frequency Meter BC221 Instruction Handbook	3/6.	P.P.	6d.
Wavemeter Class D Instruction Handbook	3/6.	P.P.	6d.
18 Set Circuit Details and Notes	3/6.	P.P.	6d.
R1116/A Circuit Diagram and Details	1/9.	P.P.	6d.
R1224/A Circuit Diagram and Details	1/6.	P.P.	6d.
R1355 Circuit Diagram and Details	1/6.	P.P.	6d.
RF Units 24, 25, 26, Circ. Diagrams and Details	1/6.	P.P.	6d.
Amplifier A1134 Circuit Diagram and Details	1/9.	P.P.	6d.
Resistor Colour Code Indicators.	1/6.	P.P.	6d.
R.107 Instruction Handbook	5/-.	P.P.	6d.
A.R.88D Instruction Handbook	15/-.	P.P.	1/6d.
C.R.100/B28 Receiver Handbook	8/6.	P.P.	9d.
T1154 Circ. Diagram and Details (all models)	2/-	P.P.	6d.

MAIL ORDER ONLY TO INSTRUCTIONAL HANDBOOK SUPPLIES (DEPT. W.W.), TALBOT HOUSE, 28 TALBOT GARDENS, ROUNDHAY, LEEDS, 8

WW—172 FOR FURTHER DETAILS.

DAMAGED METER?

Have it repaired by Glaser

Reduce overheads by having your damaged Electrical Measuring Instruments repaired by L. Glaser & Co. Ltd.

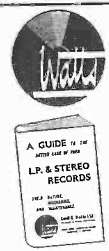
INSTRUMENT REPAIRS

We specialise in the repair of all types and makes of Voltmeters, Ammeters, Microammeters, Multirange Test Meters, Electrical Thermometers, Recording Instruments, etc.

As contractors to various Government Departments, we are the leading Electrical Instrument Repairers in the Industry. For prompt estimate and speedy delivery send defective instruments by registered post, or write to Dept. W.W.:—

L. GLASER & CO. LTD.
1-3 Berry Street, London, E.C.1
Tel.: Clerkenwell 5481-2

WW—173 FOR FURTHER DETAILS.



THE ONLY COMPREHENSIVE RANGE OF RECORD MAINTENANCE EQUIPMENT IN THE WORLD!

Send stamps value 9d. for 16 page booklet and supplementary data sheets Nos. 1 and 4 giving the fullest and latest information.

CECIL E. WATTS LIMITED
Darby House
Sunbury-on-Thames, Middx.

WW—174 FOR FURTHER DETAILS.

COMPONENTS POSTAL SERVICE

★ **SWITCH KIT.** Includes quality 2 and 8 button push-button Switches, Rotary Switch and Control Knobs 13/6

★ **SLIDER SWITCHES.** Professional grade D.P.D.T. Special silver contacts, voc. 2 off 5/9

★ **RESISTORS**—5% Hi-Stab Carbon Film 75Ω to 1MΩ (½ watt): 10 off, one standard value 4/-

★ **CAPACITORS**—Polyester Foil: 160 VDC/100 VAC.
33 pF to .1μF: 5 off, one standard value .. 3/6
.15μF to .47μF: 5 off, one standard value .. 5/-

★ **ASSORTED RESISTORS**—Hi-Stab. 300 off (5% or better) 10/-
(P. & P. 1/6 per order, C.W.O.)

ELMBRIDGE INSTRUMENTS LTD.
26 Ganghill, Guildford, Surrey.

WW—175 FOR FURTHER DETAILS.

A.B.C'S of SILICON CONTROLLED RECTIFIERS

by Lytel, 16/-. P. & P. 1/-.

Radio Amateurs Handbook 1966 ed., by A.R.R.L., 40/-. P. & P. 3/-.

Sound Mixers, building and using, by Steele, 30/-. P. & P. 1/3.

How to build Proximity Detectors and Metal Locators by Shields, 20/-. P. & P. 1/-.

Know your Signal Generators, by Middleton. 20/-. P. & P. 1/-.

Transistor Pocket Book, by Hibberd, 25/-. P. & P. 1/3.

Transistor Specifications and Substitution Handbook, by Techpress, 15/-. P. & P. 1/-.

Electronic Guitar Amplifier Handbook, by Darr, 24/-. P. & P. 1/-.

Know your Test Meters (VOM-VTVM) by Risse, 21/-. P. & P. 1/-.

Where possible 24-hour service guaranteed.

UNIVERSAL BOOK CO.
12 LITTLE NEWPORT ST., LONDON, W.C.2
(Leicester Square Tube Station)

TO ALL

Manufacturers, Wholesalers, Importers, etc. of the Radio and Electronic Industries
We are spot cash purchasers for all types of redundant and surplus stocks.

Phone or write Hillside 2713
Stonegrove 7624

Broadfields Disposals Ltd.,
8, Broadfields Avenue,
Edgware, Middx
or
Mayco Products Ltd.,
21 Lodge Lane,
N. Finchley, N.12

WW—176 FOR FURTHER DETAILS.

ELECTRIC TIME SWITCHES

MADE BY SIEMENS. 200/250 A.C. with 10 amp. Contacts. Once ON once OFF every 24 hours at any manually pre-set times. Used but perfect and fully guaranteed. Wiring instructions supplied. With metal case—no lid—7/6 extra **39/6** P.P. 3/-

HORSTMANN ELECTRIC TIME SWITCHES. 200/250 v. 10 amp. Contacts. Twice ON twice OFF every 24 hours at any manually pre-set times. Used but perfect. Complete with mounting base. Metal case for above 10/- extra. **49/6** P.P. 3/6.

VENNER 40-DAY CLOCKWORK TIMESWITCH. in metal case. 0.1 amp. rating. Switches on every half hour for adjustable periods from three to thirty seconds. Size 7¾in. × 6in. × 4½in. **45/-** P.P. 4/6.

ELECTRIC CHECK METERS

200/250 v. A.C. 25 amps.

For checking electricity consumption. Reconditioned and perfect, fully guaranteed. **29/6**

SANGAMO WESTON 40 amp. model **35/-**
P.P. on each item 3/9.

Ex Admiralty Sound Powered Hand Sets—no batteries required 35/- per pair. P.P. 3/6.

All meters guaranteed two years.

State voltage—QUANTITY DISCOUNTS
Slot Meters available—send for Price List.
Box 365, Kingswood Supplies (W.W.3.)
4, Sale Place, London, W.2. *PAD. 8189*

WW—177 FOR FURTHER DETAILS.

BROADWAY ELECTRONICS

92 Mitcham Road, Tooting Broadway, S.W.17
BALham 3984
(four minutes from Tooting Broadway Underground Station)

GARRARD 4 SPEED DECKS WITH CARTRIDGE
Autochangers: AT60 £10/10/-; 3,000 £8/8/-; 2,000 £7/7/-; 1,000 £6/6/-; Autoslim £5/5/-; De Luxe Autoslim with plug in head, £5/15/-, p. and p. 6/-.
Single players: SP25 £10/10/-; SRP12 £5; Garrard Plinth W.B.1 £3/12/6. p. and p. 4/6 for plinth.
CARTRIDGES: Ronette Stereo 25/-; Acos GP67 15/-; G.C.2 Garrard 15/-; AT6 Shells 5/-, p. and p. 6d. HGP83/2 Stereo 20/-.
SPEAKER ENCLOSURES: "TONY" Corner Cabinet 20 x 10 x 7in. takes 10 x 6 speaker covered in grey Rexine and Vynair 45/-, P. & P. 5/-.
"BLAKE" 12in. heavy duty cabinet size 24½in. x 18in. x 9in. The baffle is ¾in. thick. Covered Rexine and Vynair £5. P. & P. 10/-.
"BLAKE DE LUXE" veneered with woodgrain Formica and standing on smart 6in. legs £6/5/-. P. & P. 10/-.
"HAYDON" 16½ x 15 x 7½in. Fabric covered suitable for 12in. speaker 45/-. P. & P. 7/6.
Crystal Mike 200C replaces BM3 30/-. P. & P. 2/-. Stand for same 9/6. P. & P. 1/9.
Guitar Pick-up with Screened Lead 12/6. P. & P. 6d.
Neon Panel Light Arcolectric 240 v. A.C. 2/6. P. & P. 6d.
BARGAINS IN TRANSISTORS
AC127, AF114, 115, 116, 117, 118, 119, OC169, 170, 171, 172, 5/6 ea. OC72, 75, 82, 3/6. OC71, 81M 3/-.a. RF Packs 1 OC44, 2 OC45 8/6, AF Packs 1 OC81D, 2 OC81 6/-. AF Pack a GET 118, 2 GET119 5/6. OC26, 28, 29 7/6. ORP12 Light Cell 7/6. Diodes OA81 2/3. OA91 1/9. P. & P. on all these 6d.
EARPIECES with cord and 3.5 mm. plug. 8 ohm magnetic 3/-; 250 ohm 4/-; 170 ohm magnetic with clip 6/6; Crystal 4/-. P. & P. 6d.
SPEAKERS: ELAC Heavy Duty Ceramic Magnet 11,000 lines. 10in. round. 10 x 6in. 15 or 3 ohm 42/6. P. & P 3/6. 8in. round 15 or 3 ohm 38/6. P. & P. 3/6. E.M.I. 13½ x 8in. 15 or 3 ohm 42/6. P. & P. 3/6.
Stockists for Eagle Products, Goodmans, W.B., Wharfedale, Bakers, Tripletone, Linear, all makes of Amplifiers and speakers supplied. Let us quote for your requirements. S.A.E. please. **NO C.O.D.**

TELECOM MK. II
Pocket size V.H.F. 118-136 Mc/s AIRCRAFT BAND TRANSISTOR RECEIVER

complete with telescopic aerial, loudspeaker and battery.

£26.0.0

carr. paid in U.K.

BRITEC LIMITED
17, Charing Cross Road,
London, WC2 WHItehall 3070

WW—178 FOR FURTHER DETAILS.

"RADIO Designer's Handbook." Editor, F. Langford-Smith, B.Sc., B.E., Senior Member I.R.E. (U.S.A.), A.M.I.E. (Aust.), a comprehensive reference book, the work of 10 authors and 23 collaborating engineers, containing a vast amount of data in a readily accessible form: the book is intended especially for those interested in the design and application of radio receivers or audio amplifiers. Television, radio transmission and industrial electronics have been excluded in order to limit the work to a reasonable size. 65/- net from all booksellers. By post 67/9 from Iliffe Books Ltd., Dorset House, Stamford St., London, S.E.1.

AMERICAN

TEST & COMMUNICATIONS EQUIPMENT

AN/ARC-3	V.H.F. Transceivers.
AN/ARC-33	U.H.F. Transceivers as detailed in Sept. Advt. Price £85.
AN/TRC-24	U.H.F. Radio Terminal or Relay equipments 100/400 Mc/s.
AN/VRC-19	& -19X Mobile F.M. Transceivers. Freq. 152/174 Mc/s P.O. 25W. Supply/V 24 and 12 respectively. Price £10 and £12.
AN/URC-4 &	AN/URC-11 V.H.F./U.H.F. "S.O.S." band "Handy-Talkies."
AN/ARN-6 &	AN/ARN-44 Compass Receivers
AN/ARN-14	Power supplies DY-66DY-66.
AN/FPN-13	X band Radar Beacons.
BC-610/E	H.F. Transmitters, 2/18 Mc/s.
BC-1332	Transmitters (P.O. AN/MRN-3 I.L.S.).
CU-168/FRR	2/32 Mc/s Antenna Couplers.
AN/PSM-6	Multimeters 1k-20k opv.
AN/USM-24C	Measuring Oscilloscopes.
LA-239	"Lavoie" Oscilloscopes.
TS-27/TSM	Precision R-C Bridges.
TS-297/U	General purpose Multimeters.
TS-382D/U	AF/RF Signal Generators, 20 cps/200 kc/s.
TS-505B/U	V/voltmeters dc/500 Mc/s.
TS-147A/UP	Radar Test Sets.
TS-917A/CG	(Stelma TDA-2) Telegraph Distortion Analysers.
ME-22/PCM	Decibel Meters-45/+25 DBM.

★ GENERAL CATALOGUE AN/101 1/- ★
s.a.e. for current additions to above.

SUTTON ELECTRONICS
Salthouse, Nr. Holt, Norfolk. Cley 289.

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- Rate: 6/- PER LINE. Average seven words per line.
- Name and address to be included in charge if used in advertisement.
- Box No. Allow two words plus 1/-.
- Charges etc., payable to "Wireless World" and crossed "& Co."
- Press Day 9th June for July 1966 issue.

NAME..

ADDRESS ....

....

			REMITTANCE VALUE..............................ENCLOSED		

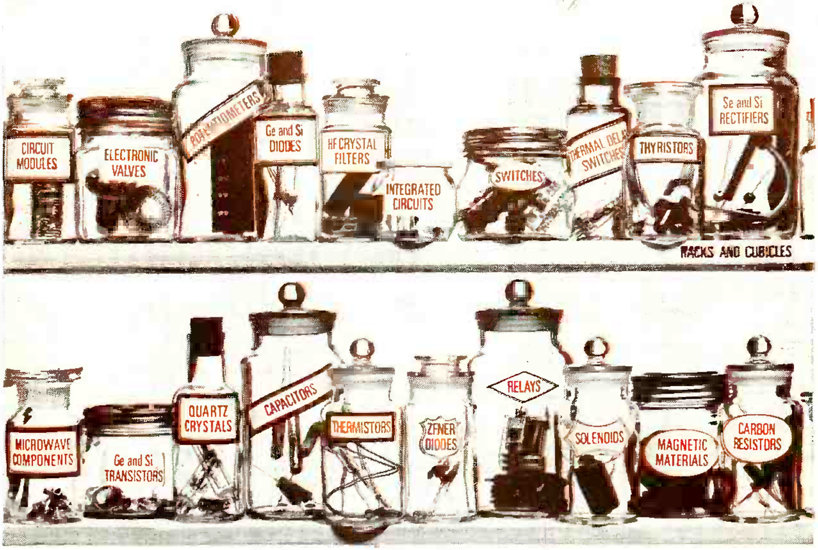
Please write in block letters with ball pen or pencil.

NUMBER OF INSERTIONS....................

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 123 to 134

Printed in Great Britain for the Publishers, ILIFFE ELECTRICAL PUBLICATIONS LTD., Dorset House, Stamford St., London, S.E.1, by CORNWALL PRESS , Paris Garden, London S.E.1. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch, Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm Dawson Subscription Service, Ltd.; Gordon & Gotch, Ltd. SOUTH AFRICA: Central News Agency, Ltd.; William Dawson & Sons (S.A.), Ltd. UNITED STATES: Eastern News Co. 306 West 11th Street New York 14.



Only one-fifth of the story!

Yes, STC Components Group is able to supply you with about five times the number of different types of components shown—*off the shelf*. And the range of components is being extended all the time. If your requirements are urgent, STC Electronics Services Division offers *same day despatch*.

Each STC Division maintains an Applications Department with Engineers ready to help you choose the most suitable and most economic components and circuits for your equipments or systems.

Wherever your location on the map, STC Components Group, made up of nine successful Divisions and a single mobilized field force, can put the finest components service right on your doorstep. The Group is represented in practically every country through ITT (International Telephone and Telegraph Corporation).

To obtain your copy of the STC 'Designers Digest' write, phone or telex STC Components Group, Footscray, Sidcup, Kent. Telephone: FOOtscray 3333. Telex: 21836.

high-grade components by **STC** COMPONENTS GROUP

65/2M