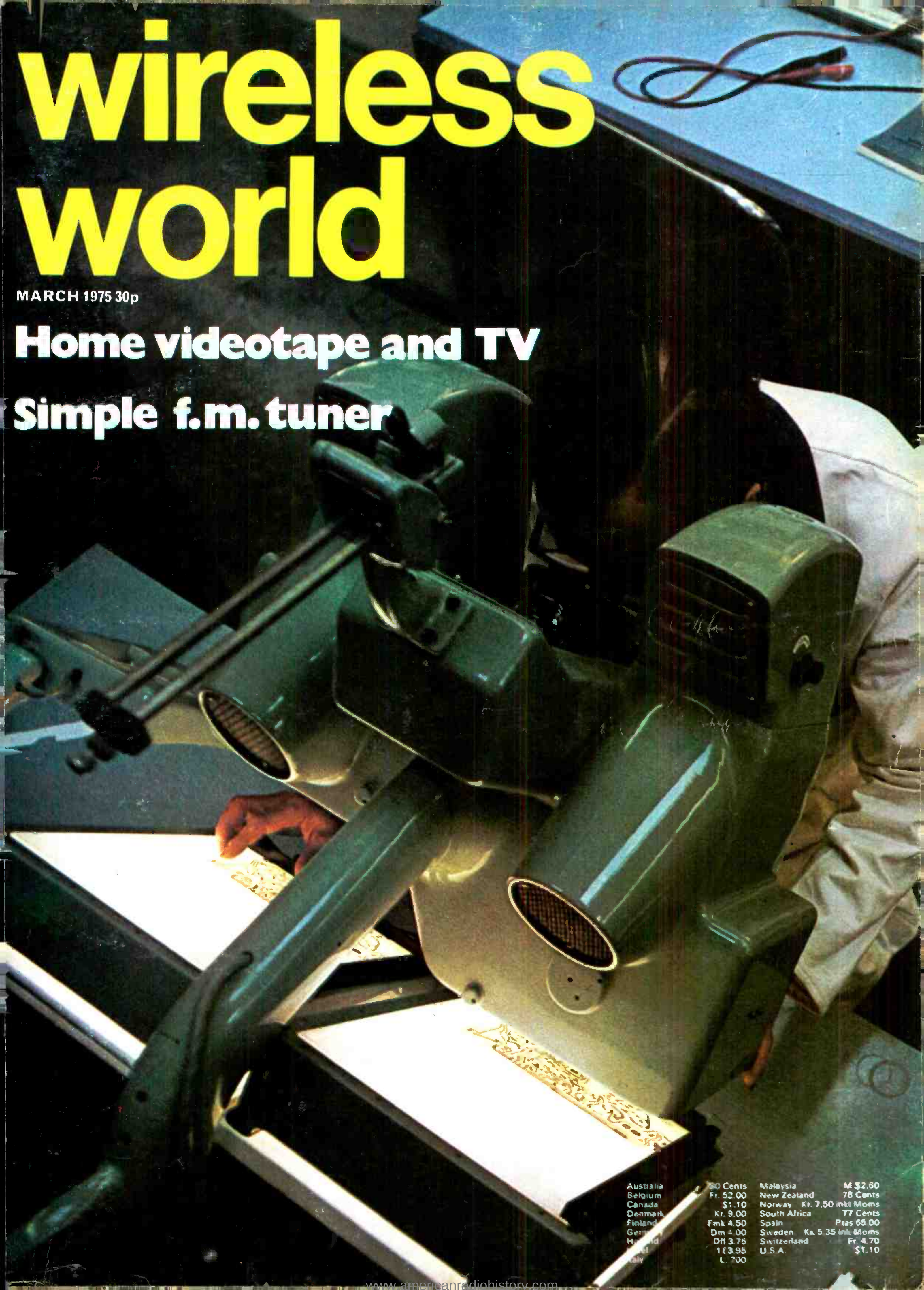


wireless world

MARCH 1975 30p

Home videotape and TV

Simple f.m. tuner

Australia	[illegible]0 Cents	Malaysia	M $2.60
Belgium	Fr. 52.00	New Zealand	78 Cents
Canada	$1.10	Norway	Kr. 7.50 inkl Moms
Denmark	Kr. 9.00	South Africa	77 Cents
Finland	Fmk 4.50	Spain	Ptas 65.00
Germ[illegible]	Dm 4.00	Sweden	Kr. 5.35 inkl Moms
H[illegible]nd	Dfl 3.75	Switzerland	Fr. 4.70
[illegible]el	I£3.95	U.S.A.	$1.10
[illegible]aly	L. 700		

Significant Form

The design engineers at **mi** all have to shape up to one essential fact: we consider good design to be all-important.

By good design we don't just mean an attractive outward form, however aesthetically pleasing it may be. We mean design that is right both outside *and* in. No cover-up jobs. No cosmetic operations. No makeshift solutions. Because whoever pointed out that beauty is more than skin deep knew what he was talking about.

The clean, compact, uncluttered lines of today's **mi** instruments signify more than good styling. They are the outcome of the most intensive application to the balance of form and function, of the eradication of any design that has failed to match our exacting standards.

In other words, they signify **mi**'s conviction that correct designing means correct functioning.

mi : THE STYLISTS

MARCONI INSTRUMENTS LIMITED

Longacres, St. Albans, Hertfordshire, England, AL4 0JN · Telephone: St. Albans 59292. Telex: 23350.

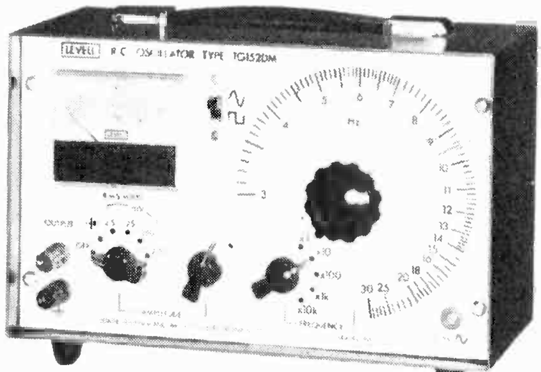
A GEC–Marconi Electronics company.

LOW COST RC OSCILLATORS

LEVELL

PORTABLE INSTRUMENTS

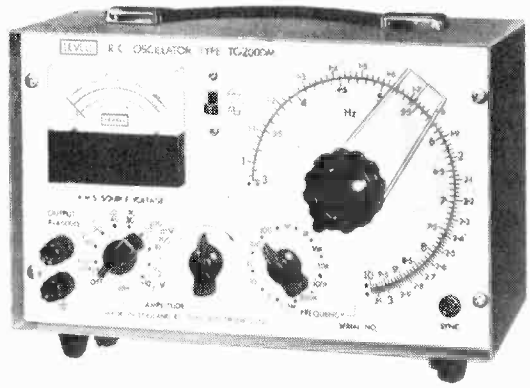
ANALOGUE



FREQUENCY	3Hz to 300kHz in 5 decade ranges
ACCURACY	±2% ±0.1 Hz up to 100kHz, increasing to ±3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to <200μV.
DISTORTION	<0.2% from 50Hz to 50kHz.
SQUARE OUTPUT	2.5V peak down to <200μV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
SIZE & WEIGHT	7″ high x 10¼″ wide x 5½″ deep. 8 lbs.

TG152D Without meter. **£48**

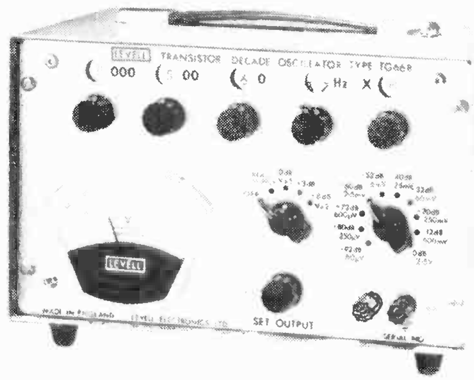
TG152DM With meter. **£58**



FREQUENCY	1Hz to 1MHz in 12 semi-decade ranges. 0 to 1% fine control included on TG200DMP
ACCURACY	±2% ± 0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200μV with Rs = 600Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	TG200D & DM only. 7V peak down to <200μV. Rise time <150nS.
SYNC. OUTPUT	>1V r.m.s. sine in phase with output.
SYNC. INPUT	±1% freq. lock range per volt r.m.s.
METER SCALES	TG200M, DM & DMP only. 0/2V, 0/7V & −14/+6dBm.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM	TG200DMP
£57	£60	£67	£70	£74

DIGITAL



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz ±0.3% from 6Hz to 100kHz ±1% from 100 kHz to 300 kHz ±3% above 300 kHz.
SINE OUTPUT	5V r.m.s. down to 30μV with Rs = 600Ω
DISTORTION	<0.15% from 15Hz to 15 kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage & −2/+4dBm.
SIZE & WEIGHT	7″ high x 10¼″ wide x 7″ deep. 12 lbs.

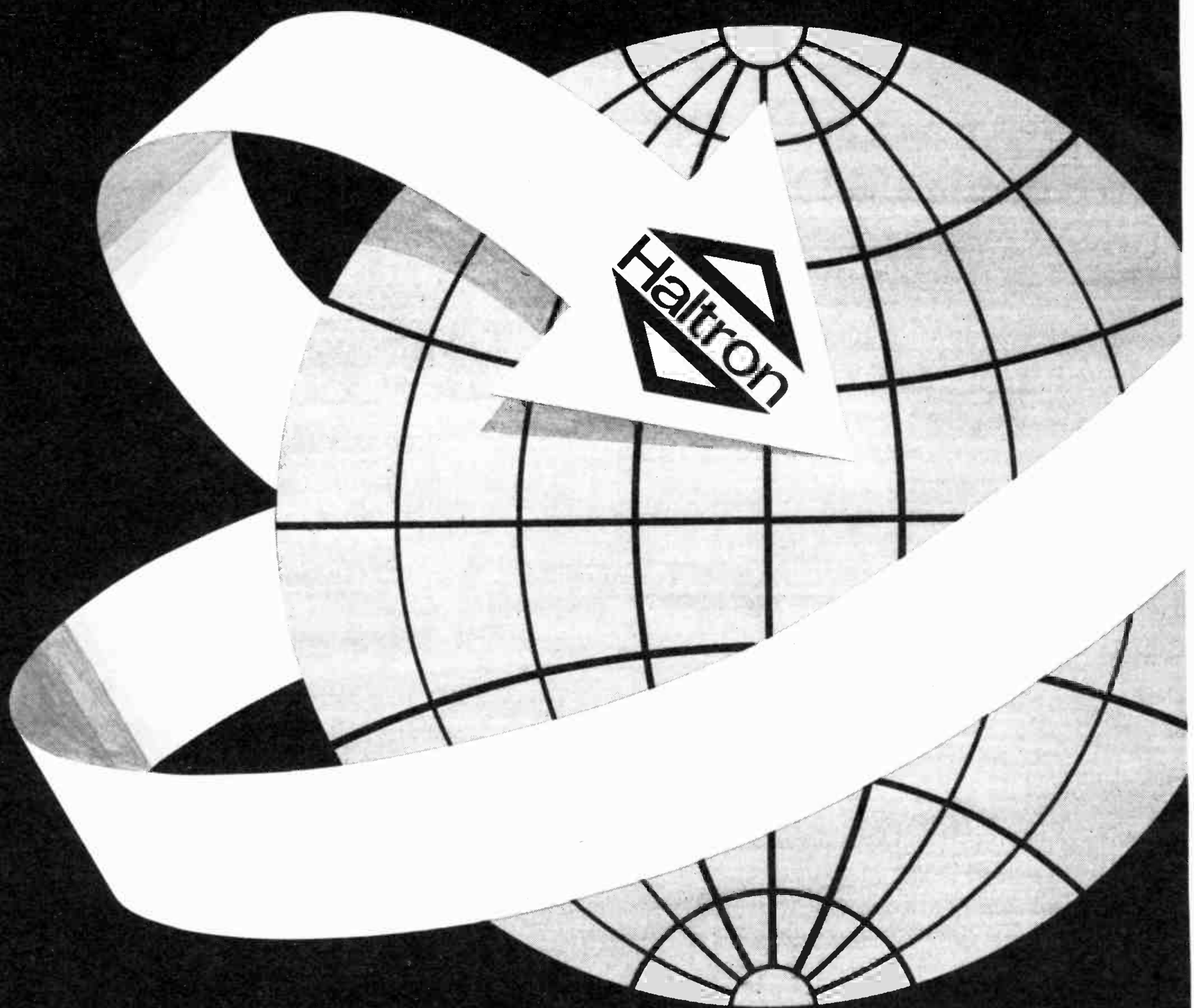
TG66B Battery model. **£156**

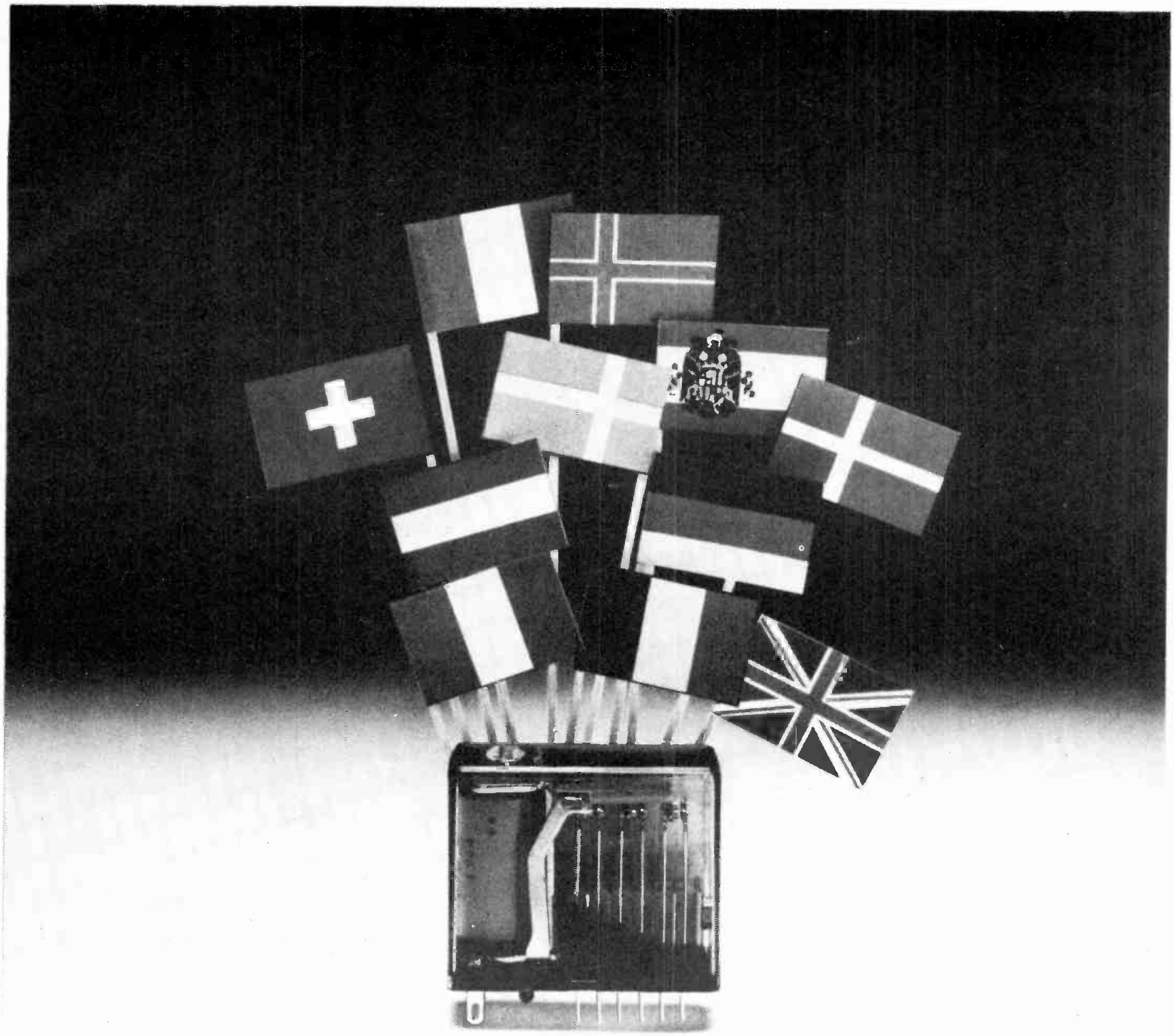
TG66A Mains & battery model. **£176**

LEVELL ELECTRONICS LTD.
Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

Prices include batteries and U.K. delivery. VAT extra.
Optional extras are leather cases and mains power units.
Send for data covering our range of portable instruments.

WW—008 FOR FURTHER DETAILS


Haltron



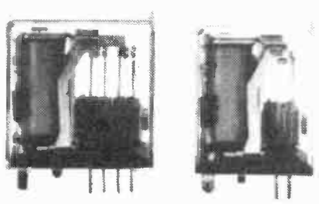
Euro relay

Varley is one of Europe's big names in miniature plug-in relays.

The Miniaturised Bi-stable polarised relay type VPR and the P.O. approved relay type 23 are but two from a range used and approved throughout the electronics world.

Each is built to uncompromising quality standards . . . with ultrasonic cleaning throughout coupled with exacting performance and timing checks.

Varley®



The same goes for our new AC range.

These miniature plug-in relays have the same physical dimensions as the DC range. Shown: 2 and 4-contact versions.
For all the help you need, contact Varley Technicians now – or send for the catalogue.

Oliver Pell Control Ltd.,
Cambridge Row, Burrage Rd., Woolwich London SE18.
Tel: 01-854 1422 Telex: 897071

Name____________________

Company____________________

Address____________________

WW3/75

Magnetic winner in the less-space race: the new Brimar M14-100.

Actual Size

The new Brimar **M14-100** is the smallest U.K. – made magnetic focus tube available with special phosphors. Although its maximum overall length is, in fact, only 184 mm., it has a minimum useful screen area of 110 mm. x 83 mm. Particularly suitable for data display and monitoring devices where a bright image with crisp display is required. (A typical linewidth is 0.23 mm. at a beam current of 30 µA.)

Advantages of this tube include low scanning power requirement, excellent focus performance and low wattage heater. Various phosphors are available, including W (TV White.) We can supply the deflection components too!

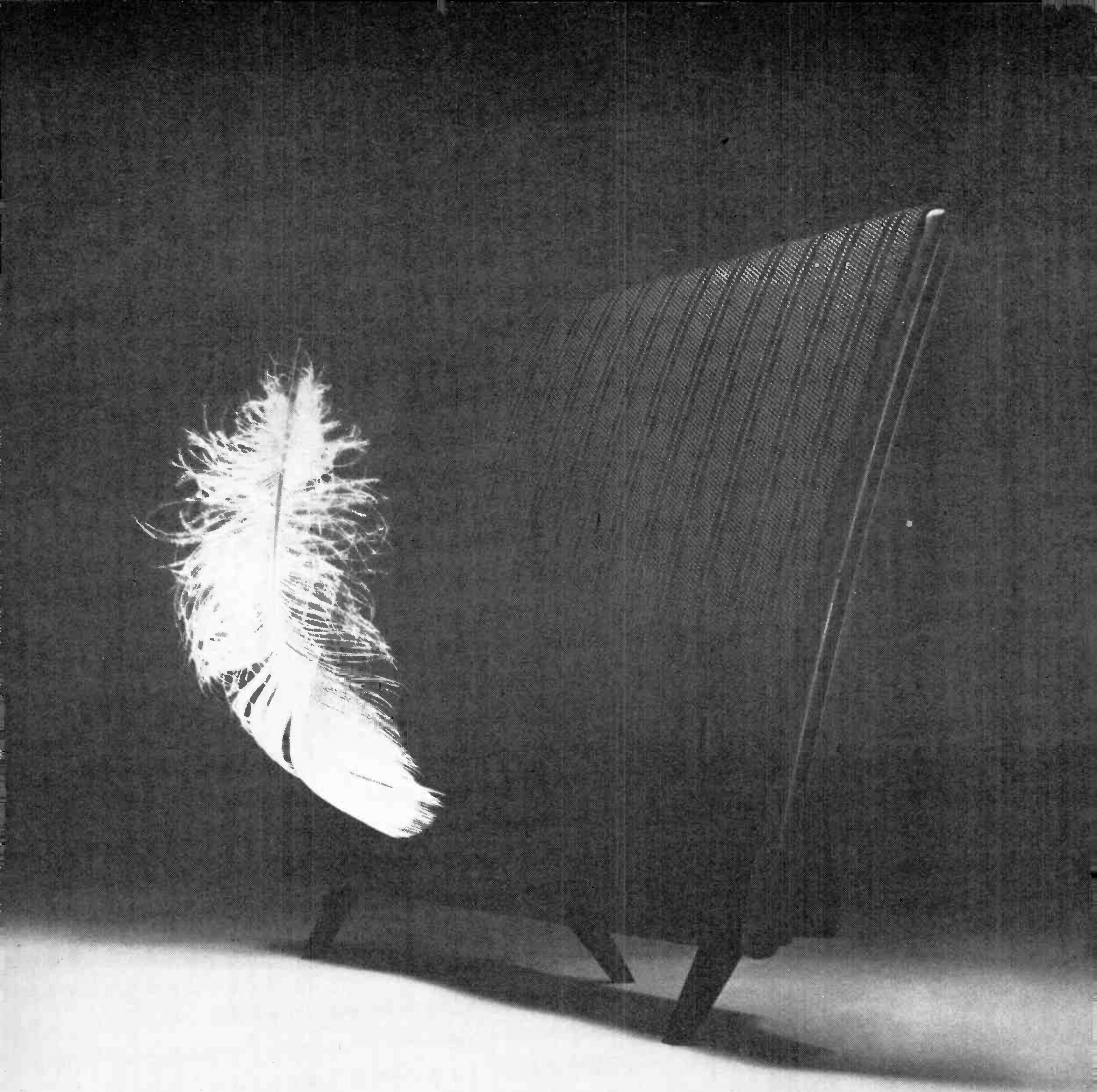
We'll gladly send you a descriptive leaflet on request.

BRIMAR

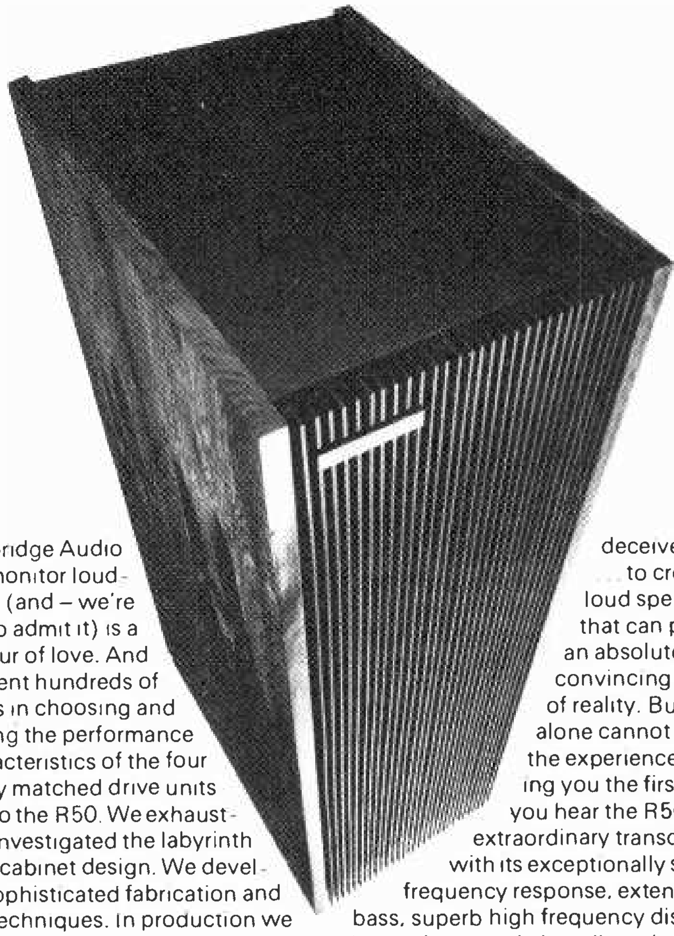
Thorn Radio Valves and Tubes Limited
Mollison Avenue, Brimsdown, Enfield, Middlesex, EN3 7NS.
Telephone: 01-804 1201.

THORN

WW—168 FOR FURTHER DETAILS



THE ILLUSION OF REALITY



Our Cambridge Audio R50 monitor loudspeaker (and – we're proud to admit it) is a true labour of love. And we've spent hundreds of hours in choosing and evaluating the performance characteristics of the four critically matched drive units that go into the R50. We exhaustively investigated the labyrinth paths of cabinet design. We developed sophisticated fabrication and testing techniques. In production we even go as far as to hand test and select each individual capacitor in the cross-over network. In short, nothing is spared in our single minded effort to deceive you . . . to create a loud speaker that can produce an absolutely convincing illusion of reality. But words alone cannot convey the experience awaiting you the first time you hear the R50. This extraordinary transducer with its exceptionally smooth frequency response, extended bass, superb high frequency dispersion and extremely low distortion has to be heard to be disbelieved. Only then will you begin to understand how close we have come to reality.

Cambridge Audio

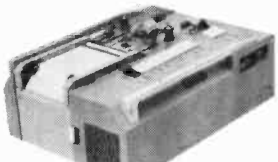
for people who listen to music
Cambridge Audio Limited
The River Mill
St. Ives
Huntingdon PE17 4EP
Telephone St. Ives 62901

WW—103 FOR FURTHER DETAILS

STRIP CHART RECORDERS

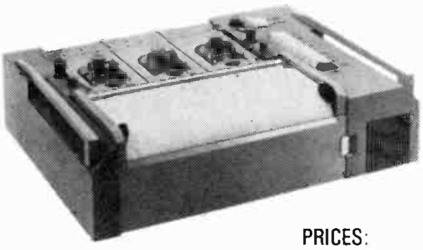
Made in USSR

Series H3020 Recorders



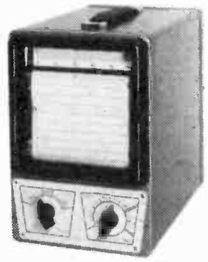
Sensitivity:	8mA F.S.D.
Speed of response:	5Hz
Chart width:	80mm per channel
Chart drive:	230–250V AC mains
Chart speeds:	0.1-0.2-0.5-1-2.5-12.5-25 mm/sec

Time and event marker pens fitted.



PRICES:
Single pen model H3020-1 **£80.00**
Three pen model H3020-3 **£130.00**

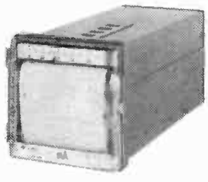
MULTI-RANGE UNIVERSAL PORTABLE AC/DC RECORDING VOLTAMMETER H390



Measurements ranges, AC/DC:	5-15-150-250-500mA, 1.5-5 Amps 5-15-150-250-500V
Accuracy:	1.5%DC, 2.5%AC
Chart width:	100mm
Chart drive:	220-250V AC mains
Chart speed:	20-60-180-600-1800-5400 mm/hour

PRICE: **£78.00**

SWITCHBOARD PATTERN MINIATURE RECORDING MILLIAMMETER H3100



Full scale deflection:	1mA DC
Accuracy:	2.5%
DC resistance of the coil:	18,100Ω
Chart width:	80mm
Chart drive:	220/250V AC mains
Chart speeds:	20-60-180-600-1800-5400 mm/hour

PRICE: **£44.00**

ALL THE ABOVE PRICES ARE EXCLUSIVE OF CARRIAGE AND VAT,
PLEASE WRITE FOR FULL DETAILS TO:

Z&I AERO SERVICES LTD,

44A WESTBOURNE GROVE, LONDON W2 5SF

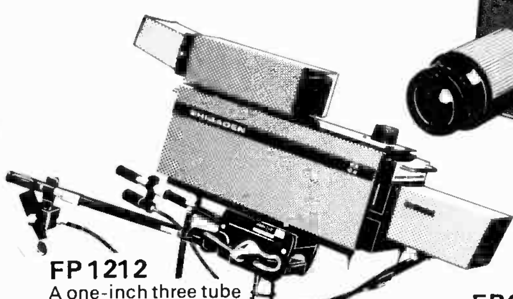
Tel: 01-727 5641 **Telex: 261306**

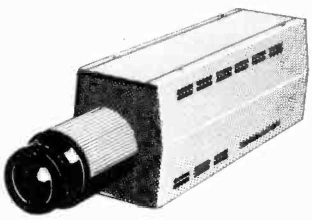
WW—155 FOR FURTHER DETAILS

5 good reasons why Shibaden colour cameras are the best!

FP 1500 As the HV 1500 but fitted with a 3" viewfinder for studio use.

HV 1100
An extremely compact, lightweight three tube colour TV camera ideal for surveillance and observation applications.





HV 1500
Compact, highly mobile unit, the only colour CCTV camera available with a single one-inch filter integrated colour vidicon tube.

FP 1212
A one-inch three tube Plumbicon® Camera with freely detachable electronic viewfinder. Ideal for outside broadcast work and studio.

FPC 1000
A vidicon/chalnicon camera designed to meet all NTSC and PAL requirements.

® Trade Mark N.V. Philips

The Shibaden range of colour cameras are compact, easy to operate and versatile in their application through educational, medical, business and broadcasting studios. Shibaden Colour Cameras are designed with the customer in mind both from an application and performance stand point. They are fully backed by Shibaden's in-depth opto-electronic technology, which has proved to be superior through many years of application in a vast range of broadcasting equipment.

When you buy Shibaden you buy the best.

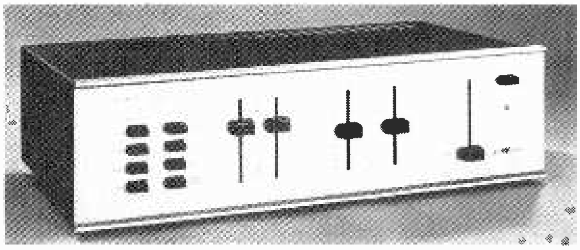
For further details on the Shibaden range of Colour Cameras, contact the Technical Service Department.

Hitachi Shibaden (UK) Limited
BROADCAST & CCTV EQUIPMENT MANUFACTURERS
Lodge House · Lodge Road · Hendon · London NW4 4DQ. Telephone: 01-203 4242/6

WW—122 FOR FURTHER DETAILS

A NEW STANDARD FOR SOUND REPRODUCTION

HD250 High Definition Stereo Control Amplifier



Designed for disc and tuner input and two tape machines, with complete recording and reproducing facilities.

The HD250 amplifier establishes a new standard in amplifiers for sound reproduction in the home. Improvements have been made in respect of performance, engineering design and quality of construction. We believe that no other amplifier in the world can match the overall specification of the HD250. Look at extracts from the specification below.

Power output.

Rated:	50 watts average continuous power per channel, into any impedance from 4 to 8 ohms, both channels driven.
Maximum:	90 watts average power per channel into 5 ohms load.

Distortion.

Pre-amplifier:	Virtually zero. (Cannot be identified or measured as it is below inherent circuit noise.)
Power amplifier. at rated output:	Less than 0.02% (typically 0.01% at 1kHz).
at 25w output:	Typically 0.006%.

Overload margin.

Disc input	40 dB min.

Hum and noise output.

Disc:	—83dBV Measured flat with noise band-width of 23kHz (ref. 5mV.)
	—88dBV Measured with 'A' weighted characteristic (ref. 5mV.)
Line:	—85dBV Measured flat (ref. 100mV.)
	—88dBV 'A' weighted (ref. 100mV.)
Size:	17 inches × $4\frac{3}{4}$ inches × 11 inches deep overall.
Weight:	21 lb.

Write or phone for leaflet which describes the design philosophy and conception of the HD250 together with a complete specification.

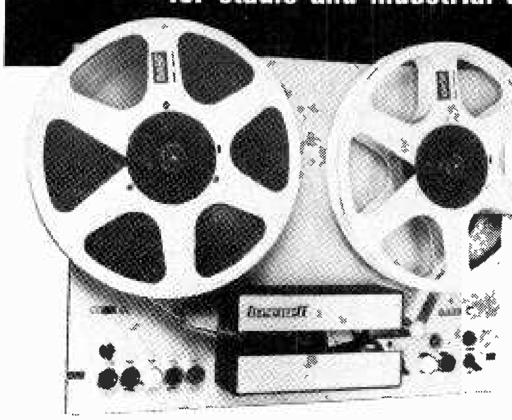
RADFORD AUDIO LIMITED, BRISTOL, BS3 2HZ Telephone: 0272 662301

WW—060 FOR FURTHER DETAILS

brenell

PROFESSIONAL TAPE TRANSPORTS

and multi-channel electronics for studio and industrial use



Type 19 25mm model

* Tapewidths up to 25mm
* Speeds: 3mm/s minimum up to 152cm/s max 2 and 4 speed models
* Reel Capacity up to 29cm
* Remote Control Facility
* Tape Tension Control
* Automatic Interlock against misuse
* Special models to customer requirements

Finance available

BRENELL ENGINEERING CO LTD

231-5 Liverpool Road, London N1 1LY. Tel: 01-607·8271

WW—077 FOR FURTHER DETAILS

Down to your last voltage stabiliser?

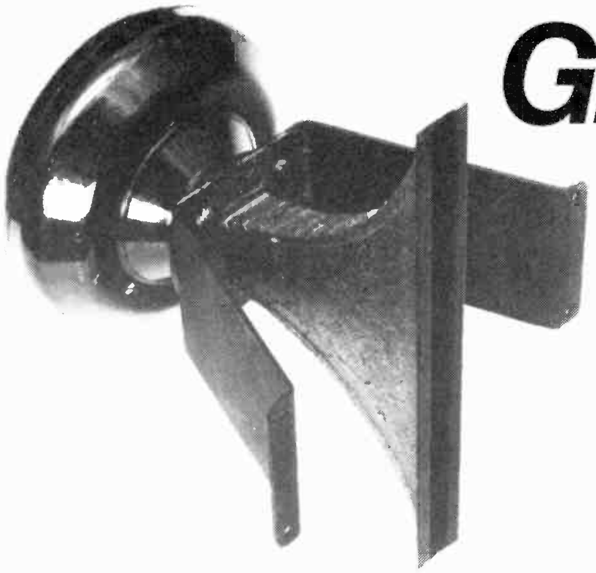
LAP94

Don't give up.
EEV are still making a wide range of rugged, reliable voltage stabilisers and reference tubes.
We are still meeting all requirements – including equivalents for types now discontinued by other makers.
Write or 'phone for voltage stabiliser data sheets and prices.

EEV and M-OV know how

ENGLISH ELECTRIC VALVE CO LTD. Chelmsford, Essex. England CM1 2QU
Tel 0245 61777 Telex 99103 Grams Enelectico Chelmsford

WW—154 FOR FURTHER DETAILS



Great Sound...

NOW THE

4KHZ HORN

GOES INTERCONTINENTAL . . .

Introduced to Europe at the
1975 Frankfurt International Trade Fair

Now going intercontinental after 12 tremendous months of UK success—the Vitavox 4KHZ Horn—shown to Europe for the first time at the 1975 Frankfurt International Trade Fair.

With the 4KHZ Horn, the Vitavox range is now 5 nucleus strong. The outcome of nine months' research, it is the latest concept in the continuing development of the range. Its arrival meant One Source—One Throat—for sound power only many horns together could give before.

The 4KHZ Horn is designed for use with the Vitavox S3 Pressure Unit for wide dispersion of the upper audio frequencies. When mounted in the vertical position it gives a wide sound distribution in the horizontal plane. Made from heavy gauge steel, treated with acoustic damping compound, finished in dramatic hammer black paint, and with a heavy duty mounting bracket to support the pressure unit weight, the 4KHZ Horn is geared throughout to meet the needs of BIG SOUND with THE GREAT SOUND OF VITAVOX.

Please send me further information on your product range
Name ______________
Company ______________
Address ______________
V-186 ______________

VITAVOX
Limited
Westmoreland Road
London NW9 9RJ
Telephone: 01-204 4234

ITA-TEAC

TEAC 4-CHANNEL INDUSTRIAL RECORDER

The complete mobile recording studio. Four totally independent channels. Sel sync on all channels. Mixing facilities. 63dB signal to noise ratio. Wide flat band-width.

ITA 10-4 MODULAR MIXER

Ten inputs. Four output groups. Four limiters. Base, mid, treble EQ. Balanced inputs. Modular construction. Headphone monitoring.

IMMEDIATE DELIVERY.
£590 + VAT

SOLE SUPPLIER: ***NOTE NEW ADDRESS~***

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Industrial Tape Applications
5 Pratt Street, London NW1 OAE. Tel: 01-485 6162 Telex: 21879

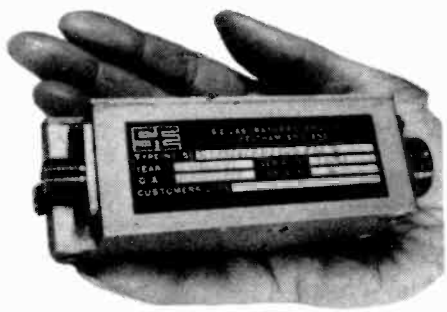
SE Labs range

Pressure

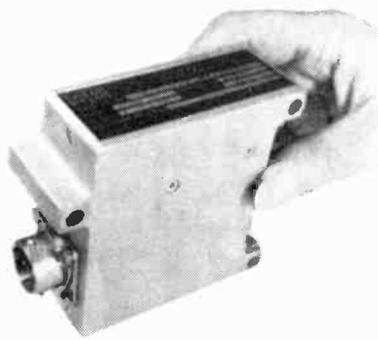
Variable reluctance wet/wet differential for use with most corrosive pressure media

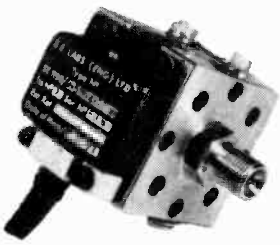
SE180
Established variable reluctance unit. Pressure range 5 - 5000 p.s.i. gauge, differential or absolute. A.C. excitation only. Total error band less than 1.5%. Temperature range -45°C to +150°C.

SE42
DC/DC variable reluctance unit. Pressures from 5 to 5000 p.s.i. gauge, absolute or differential. Temperatures from -45 to + 150°C. Total error band less than ± 1.5%.



SE40
DC/DC variable reluctance transducer. High level output ± 5V d.c. Pressure range 5 to 5000 p.s.i. gauge, differential or absolute. Temperature range -45 to + 150°C. Total error band less than 1.5%.



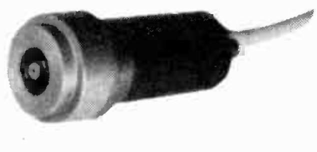


SE1150/W.G.
A.C. excitation variable reluctance transducer. 10 - 80 ins. water gauge. Ambient temperature. Total error band ± 1%.

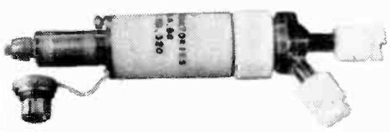
SE21
Industrial transducer 0-1volt four wire 4-20mA two wire ranges 5 to 500 PST gauge, differential or absolute compensated temperature range −10°C to +80°C. Total error band less than 0.25%.

SEMICONDUCTOR TYPES

SE792
Crystal diaphragm. Gauge only unit for general applications. Pressures from 5 to 1,000 p.s.i. Temperature range 0 - 125°C. Total error ± 1.5%.



SE794
Single crystal diaphragm miniature transducer for pressure scanning systems. Range 5 to 1000p.s.i. gauge. Total error band less than ± 0.5% over temperature range 10 - 60°C.



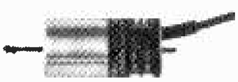
SE4-88
Physiological transducer range 0 to ± 300 mm Hg sensitivity 5mV/100 mm Hg excitation 5 volts, autoclavable

# of Transducers

Displacement

DC/DC TYPES

MINIATURE



SE350 – free unguided armature, ranges ± 1mm to ± 5mm. LVDT with integral oscillator/demodulator. Excitation 9 to 15 volts output > 1 volt at 12 volts excitation. Linearity 0.6% FSD

SE351
As SE350 but with guided armature

SE352
As SE350 but with captive spring return armature

SE355
Electronic gauging head ± 1mm to ± 5mm. Long stroke

LONG STROKE

SE353 – free guided armature ranges ± 12.5mm to ± 300mm excitation 9 to 15 volts. Output 1 volt at 12v excitation. Linearity 1.0% FSD

SE354
As SE353 but with captive spring return armature maximum range ± 125mm

AC TYPES
Available to special order

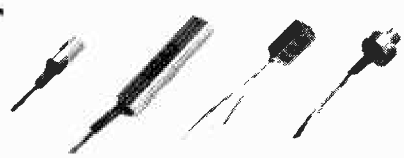
SE/Entran

Piezoresistive Accelerometers

SE/Entran Accelerometers
Miniature piezoresistive accelerometers up to 5000 'g' range, available in various mounting configurations. Up to 500 mV full scale. Bi-axial and tri-axial versions available.

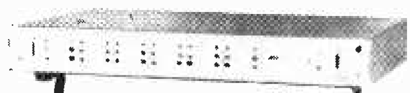
Pressure transducers

SE/Entran Pressure Transducers
Miniature piezoresistive pressure transducers with ranges 0 - 5 lb/in². Various configurations available, including hermetically sealed absolute versions. Up to 120 mV full scale.



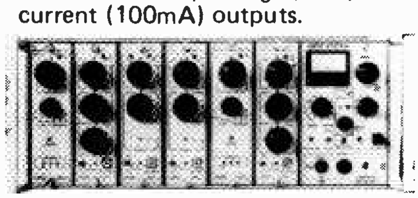
Signal Conditioning
SE has a wide range of signal conditioning equipment to energise and rationalise all the transducers shown.

SE994/993 'MINI' system
Simple 6 channel d.c. signal conditioning. Variable excitation and bridge completion. Rationalised 1 volt output for indicators or magnetic tape or via the SE993 into an SE recorder.



SE400/905 Carrier System
Basic 6 or 2 channel a.c. conditioning. 5V 3KHz. excitation. Simultaneous voltage and current outputs.

SE4000 Universal System
A sophisticated conditioning system of a.c. carriers, frequency/d.c. convertors, d.c. amplifiers. Completely interchangeable modules with a superb calibration system. 3 or 10 kHz. a.c. carrier, voltage (10V) and current (100mA) outputs.



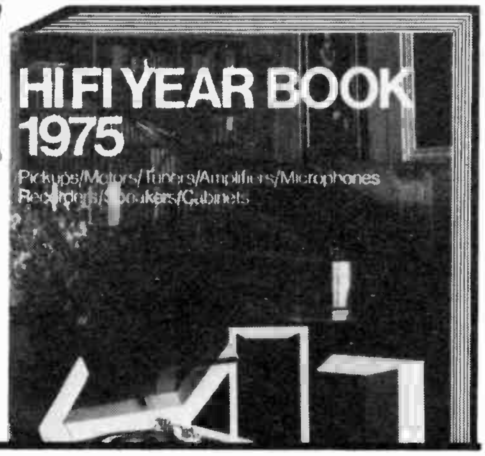
SE Systems
We have an experienced team to prepare data acquisition and recording systems to customers requirements.

SE Labs (EMI) Ltd North Feltham Trading Estate, Feltham, Middlesex. Telephone: 01-890-1166 Telex 23995
Northern Sales Office, Bessell Lane, Stapleford, Nottingham. Telephone: Sandiacre 7255
Scottish Office, 18, Sycamore Drive, Hamilton, Lanarkshire. Telephone: Hamilton 28674

EMI A member of the EMI Group of Companies
International leaders in Electronics, Records and Entertainment

WW—160 FOR FURTHER DETAILS

THE WHO, WHAT AND WHERE OF HI-FI



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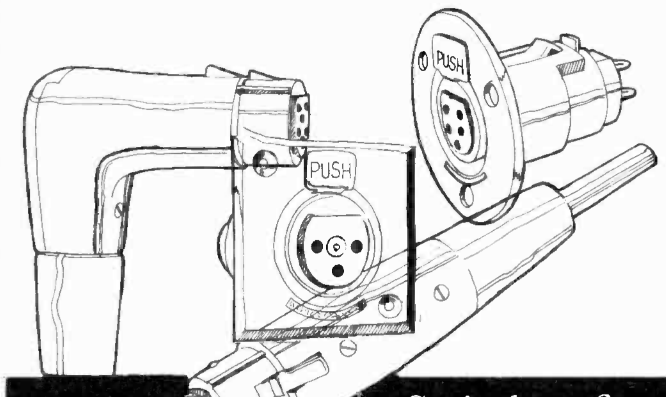

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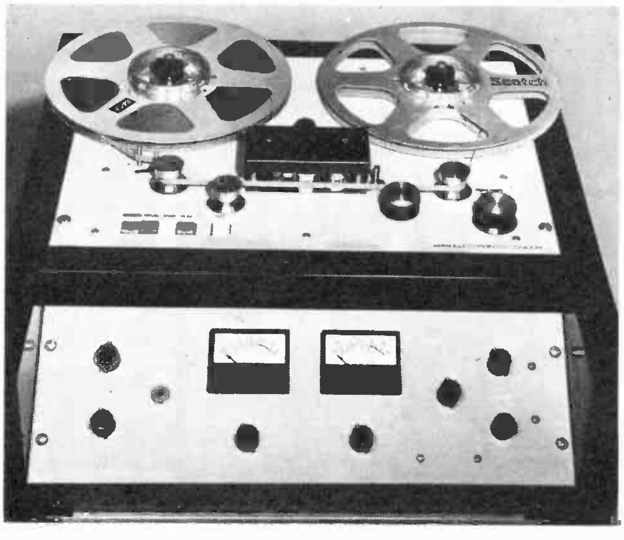

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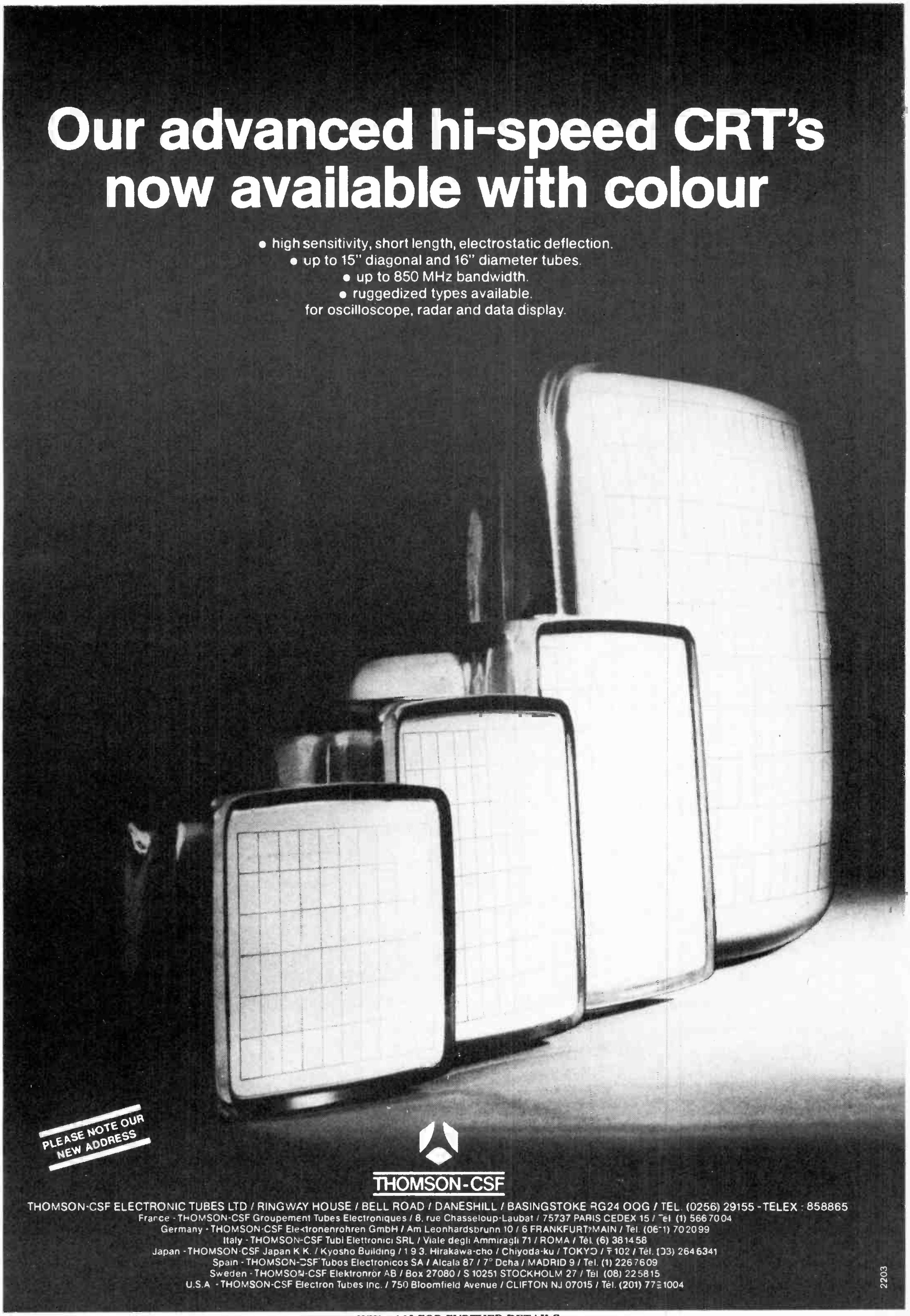

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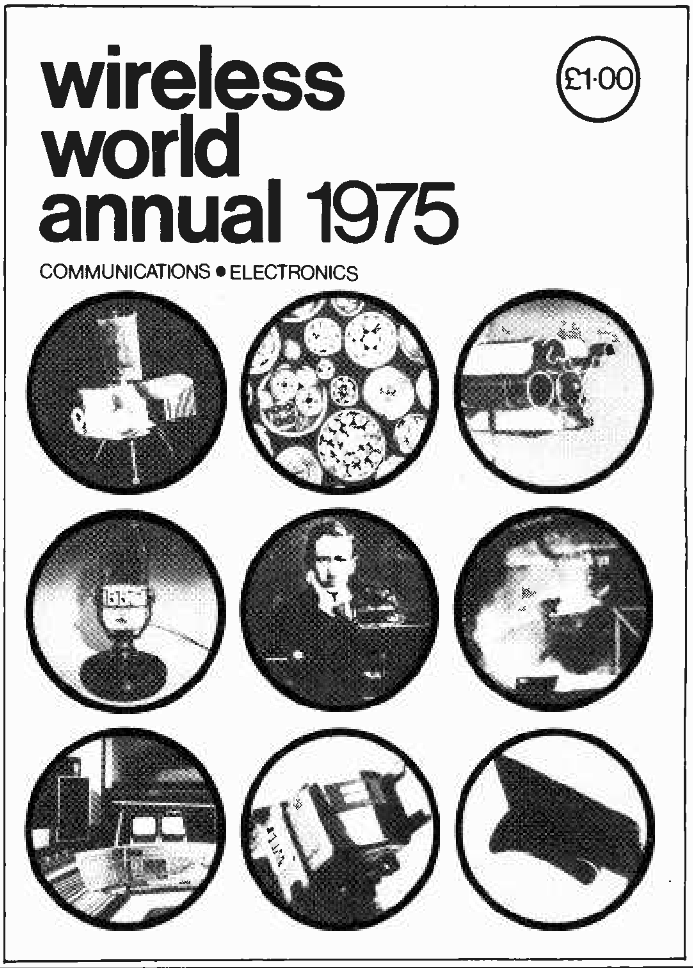

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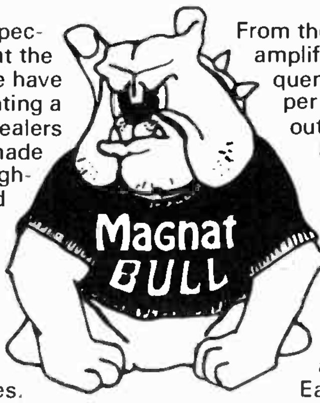

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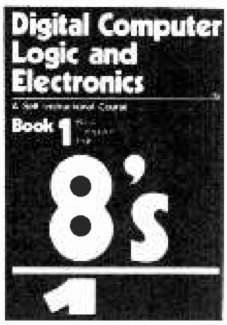

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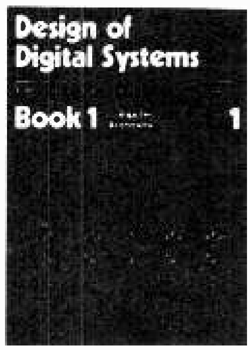

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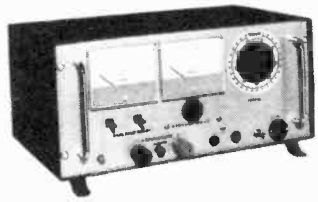

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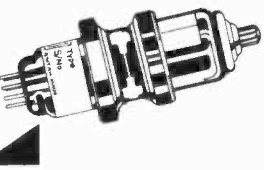

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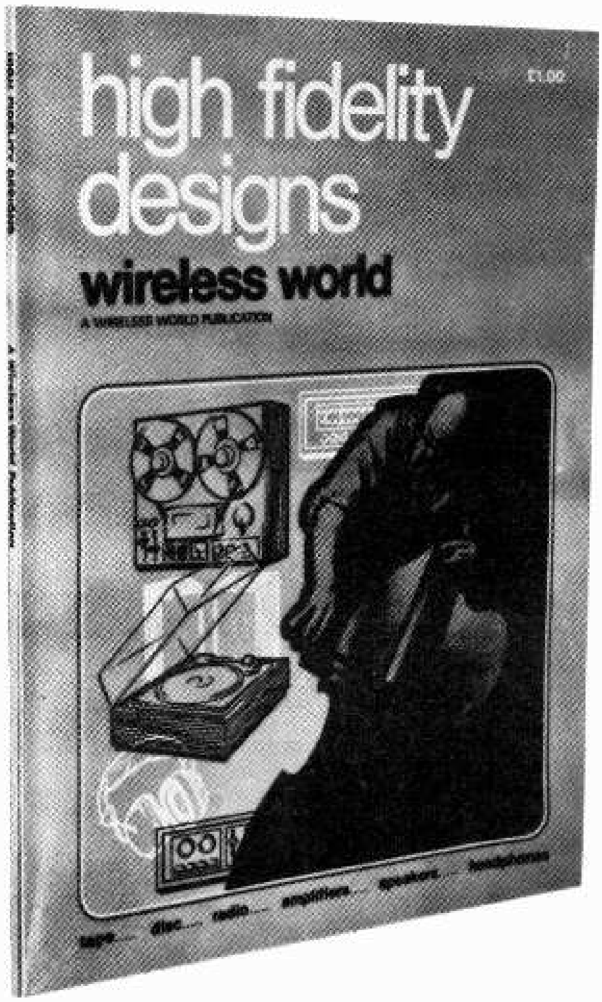

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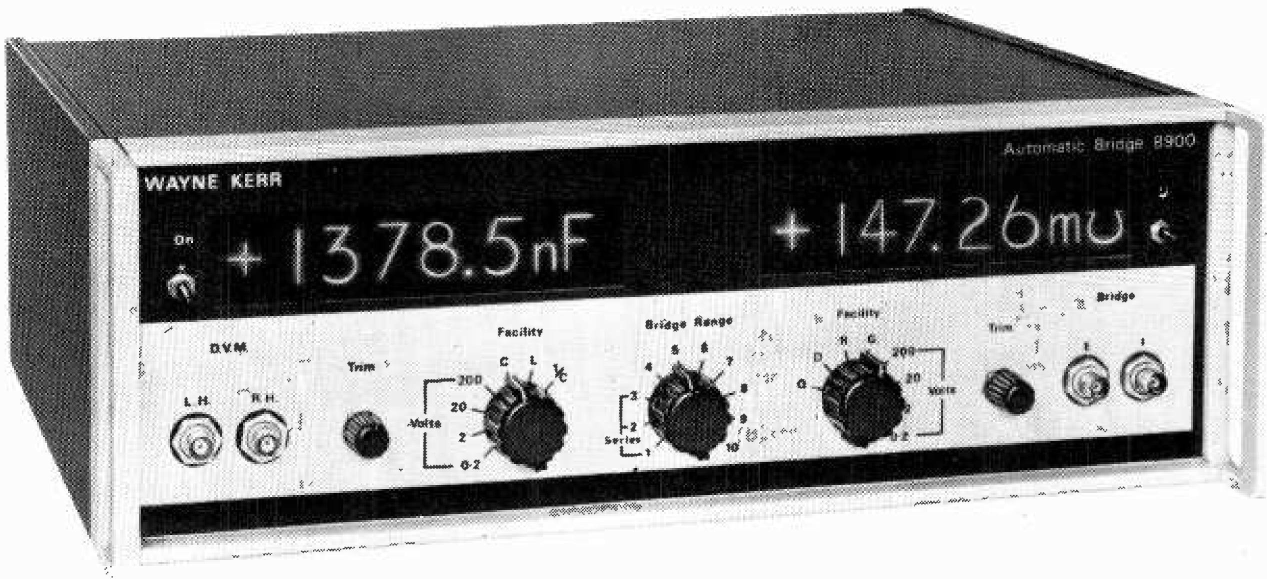

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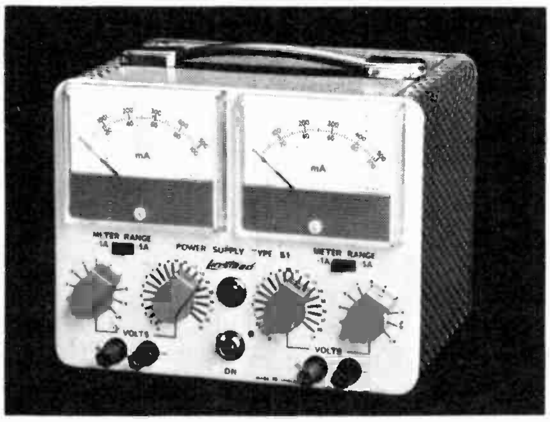

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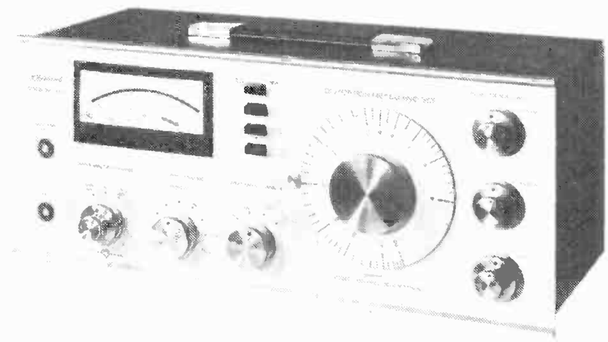

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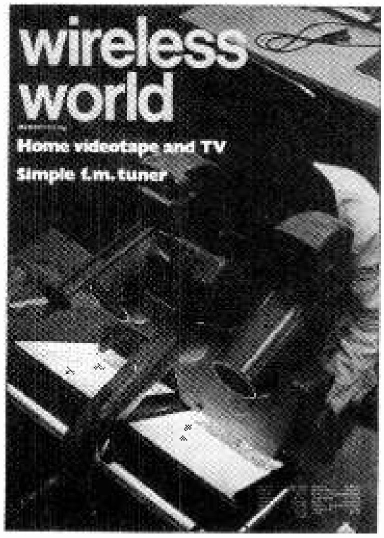

This month's cover picture shows the inspection of printed circuits on a Compariscope before assembly at Weir Electronics Ltd, Bognor Regis

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Video recorders survey
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Publisher: Gordon Henderson

The electronics engineer, along with other technologists, is used to the idea that he is changing society through his inventions—computers, colour television, satellites, automatic control systems and the like. In this respect he appears as a somewhat sinister figure in a white coat, a modern Frankenstein, a creative force without responsibility. But all this could be changed if Sir Frederick Catherwood's idea of a "professional forum" to help the country becomes a reality. This forum would be a group of people representing all the professions which would advise the government on long-term national problems after carrying out extensive study and research. By participation in such a group the technologist would be able to influence events in a much more controlled and responsible way—as a human being concerned with the welfare of his fellow men.

Sir Frederick, who is chairman of the British Institute of Management, says the professions have an important role to play in Britain because they embody the knowledge of a society which is based on knowledge: "We cannot base our society on capital—other countries now have more than we have. We cannot base it on labour—there are thousands of millions of low-paid workers in the world. This small island, importing half its food and almost all its raw material, can base its standard of living only on knowledge. We are a knowledge-based society and we must forever keep our knowledge a step ahead." The professional forum could be a unifying force in the country, counteracting the polarization of those two powerful organizations, the TUC and the CBI. And it would try to remove from government what Sir Frederick describes as the twin evils of "the art of the possible" and "the art of the next best thing" in decision-making on issues which are fundamentally non-party political.

Many people no doubt will view with misgiving the prospect of a council of professionals acquiring power in the country. It smacks of a technocracy, which could be as inhuman as the existing forces of capital and labour. George Bernard Shaw said that all professions are conspiracies against the laity (in *The Doctor's Dilemma*) and this is true to the extent that they are composed of people who band together for mutual support, sometimes for purposes which are against the interests of the rest of society. There is a feeling in the bones of the average Briton that governing the country is best entrusted to amateurs—hence our amateur Members of Parliament and our amateur Ministers of the Crown. But when our average Briton wants some particular service, e.g. brain surgery, he quickly changes his tune and demands the best professional that can be found.

Fortunately it is now being realized that you cannot run a highly complex industrial country without calling on the advice of those with specialized skills and knowledge. A scheme such as Catherwood's professional forum is an admirable way of harnessing these skills and knowledge to the needs of the country. And the electronics engineer, with his knowledge of modern means of information processing, communication and control, could well become an influential figure in the work of such an organization.

75 years of magnetic recording

by Basil Lane

Assistant Editor *Wireless World*

The magnetic tape recorder has now, through the medium of the Compact Cassette become an almost everyday household sight and yet this has only come about in the past ten to fifteen years. Compared to other components in the audio system, the modern tape machine has had a history that is full of intrigue, disaster, politics, espionage and even war-mongering. Aspects of the technology have been discovered and re-discovered and the whole tale is laced with fascinating human anecdotes behind which were some men of great inventive genius.

The story begins unexpectedly early and is noted in a unique article by Peter Ford[1] who, through careful research at the British Patent Office, discovered that the first projection of a magnetic recording (or rather playback) device was described by S. Tainter, Edison's assistant in a patent[2] dated August 29, 1885 and granted, May 4, 1886. Ford notes that Tainter, working on lines suggested by Edison and carried out at the Volta Laboratory, recorded in his notebook for March 20, 1881, "A fountain-pen is attached to a diaphragm so as to be vibrated in a plane parallel to the axis of a cylinder. The ink used in this pen to contain iron in a finely divided state, and the pen caused to trace a spiral line round the cylinder as it turned. The cylinder to be covered with a sheet of paper upon which the record is made. . . . This ink . . . can be rendered magnetic by means of a permanent magnet. The sounds were to be reproduced by simply substituting a magnet for the fountain-pen. . . ."

Obviously these ideas did not work too well, as the later patent application suggested a rather different recording and replay technique. Here, it was suggested that a standard hill-and-dale recording be made either on a cylinder or disc machine and from this master, a copper electrotype is produced, which in turn is used to provide a pattern for a mechanical engraver. This cuts an iron disc or cylinder, on which a prepared ridge has been cut. The graving tool thus removes varying amounts from the ridge, reproducing the original groove indentations in repoussé form.

Replaying this remarkable record was really quite simple and is illustrated in Fig. 1, adapted from the original patent drawings. A small needle of soft iron or steel is attached to one pole piece of a horseshoe magnet. The needle is also enclosed by a coil of wire wound on a bobbin. To replay the record, the tip of the needle was brought close to the surface of the rotating disc and maintained in its location just above the spiral ridge. Since the disc and its integral ridge represent an iron path for the flux between the pole pieces, the varying distances of closure produced by rotating the engraved ridge beneath the needle, would produce flux changes in the needle and coil. The generated electrical signal would then be reproduced by the telephone earpiece.

There is no evidence to hand to suggest that any of these machines were made, or even worked, but it showed that the inventors of those days certainly had very lively minds that ranged beyond the technology of the period.

Father of magnetic recording

Although Tainter's ideas were not completely oriented to both recording and replay by magnetic means, the next

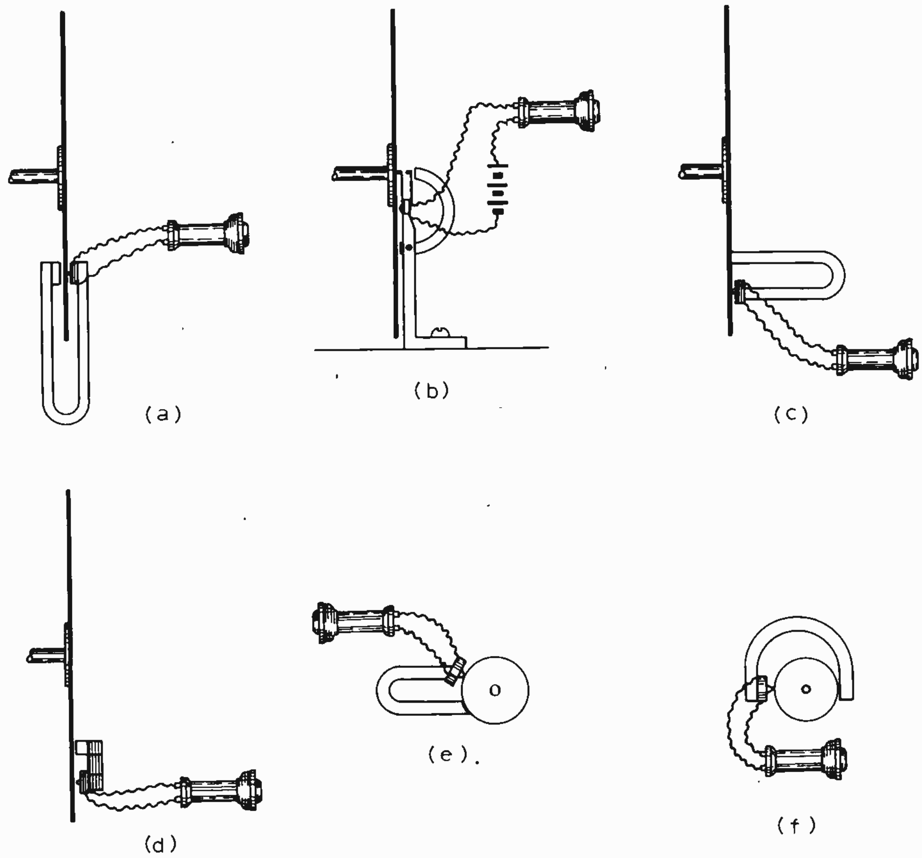

Fig. 1. The magnetic replay system patented by Edison's assistant, Sumner Tainter.

account of a man thinking about the subject is the well-known article by Oberlin Smith[3] published in 1888 and titled "Some possible forms of phonograph". Here Smith proposed the development of a machine to spin metallic dust into a cotton thread which could then be used as a carrier for magnetically recorded sound.

There then followed one of those odd quirks of technological development in general—a major step forward, but up what was eventually to prove a blind alley. One year after Smith wrote his article, the 24-year-old Dane, Valdemar Poulsen, became a student and a year later obtained his first university degree. Madsen, in a potted biography[4] of this engineering genius mentioned that Poulsen was to fail his entrance examination to the Polyteknisk Laerenstalt in Denmark—the Technical University—due to a weakness in mathematics.

In 1893 he joined the Copenhagen Telegraph Company as a mechanic and worked in the fault-finding workshop. He apparently discovered the magnetic recording principle in that same year, by the very simple experiment of moving an electromagnet along a wood chisel, so strictly speaking one could say that this is the 82nd year of magnetic recording. During the ensuing years Poulsen developed his ideas and finally on December 1, 1898, obtained a Danish patent[5] for the device that was to become so well known as the Telegraphone. The British patent[6] followed in March 1900 together with many others covering the same idea in most European countries, Russia and America. References to most of these early patents are given in the US Patent[7].

This early machine is shown in Fig. 3, adapted from the original patent drawing. It consisted of a vertical fixed cylinder (A) upon which a helix of steel wire has been wound.

Suspended from the outer frame is a stirrup (B) which can be rotated by a clockwork motor in the base, the speed of rotation being regulated by a simple brake just inside the top of the cylinder. Mounted on one side of the stirrup is the recording/replay head assembly, which is free to slide up and down the stirrup. When stationary, the head is out of contact with the wire and rests at the bottom of the stirrup.

To operate the machine, an electromagnetically operated brake (C) releases the clockwork drive which spins the stirrup round the cylinder via a gear drive just below the drum. The head is brought into contact with the wire by centrifugal force operating on a bob-weight mechanism (magnified view) attached to the head assembly. Since the head consists of a horseshoe electromagnet, or alternatively, two independent contiguous magnets the tips of which are shaped to fit over the wire, the whole head assembly is drawn up the stirrup by the guiding action of the wire helix on the drum.

When the head assembly reaches the top of the cylinder it breaks an electrical contact, releasing the electromagnetic brake which stops the clockwork motor. With the effect of the centrifugal force removed, the bob-weight on the head assembly drops, allowing the head to be withdrawn from the wire by a spring (D) and, in turn, permitting the head assembly to slide down the stirrup guide, under the force of gravity, to the rest position. The machine, it would seem, was regarded as being suitable for use as a telephone answering device and was connected to the normal telephone set.

Fig. 2. Valdemar Poulsen, the "father" of magnetic recording. He was also responsible for many other inventions including the Poulsen arc generator used for spark gap radio transmission. (Photo courtesy Philips Gloeilampenfabrik.)

Although the machine illustrated never appeared commercially, a horizontal version looking rather like a phonograph (Fig. 4) was produced in 1900 in commercial quantities, the first models having been displayed at the Paris Exhibition in 1900. Other important features certainly mentioned in the British patent are the possibility of using steel tape fed from a reel, a disc of magnetizable material, or a sheet or strip of paper or other insulating medium covered with a magnetizable metallic dust—shades of Oberlin Smith! Erasure was to be effected by using d.c. from a battery passed through the recording head while it travelled over the steel wire on a separate pass. A second steel tape machine using the same principles is illustrated in the patent and bears a remarkable resemblance to a machine attributed to Mix and Genest[4] and made in Berlin in 1900.

Either these patent applications produced a resulting development by others or, working on parallel lines, submitted patent applications coincidentally in the same year as Poulsen. But it is certainly a fact that the Mix and Genest machine was reported in 1900 and a George Kirkegaard filed a patent[8] application for a "telephonograph" using similar principles on November 18, 1899, followed by another application from P. O. Pederson[9] on June 21, 1901 and then from W. A. Rosenbaum[10] on June 22, 1901.

The Pederson patent is interesting for two reasons, first that it concerns new magnetic carriers consisting of iron, nickel or other magnetizable materials plated onto a wire, disc or drum. Secondly, it is interesting because Pederson took up a partnership with Poulsen at about this point, subsequent patents often bearing their joint names. The Rosenbaum patent was intended as a development of Poulsen's principles, as the latter patent is referred to. The idea

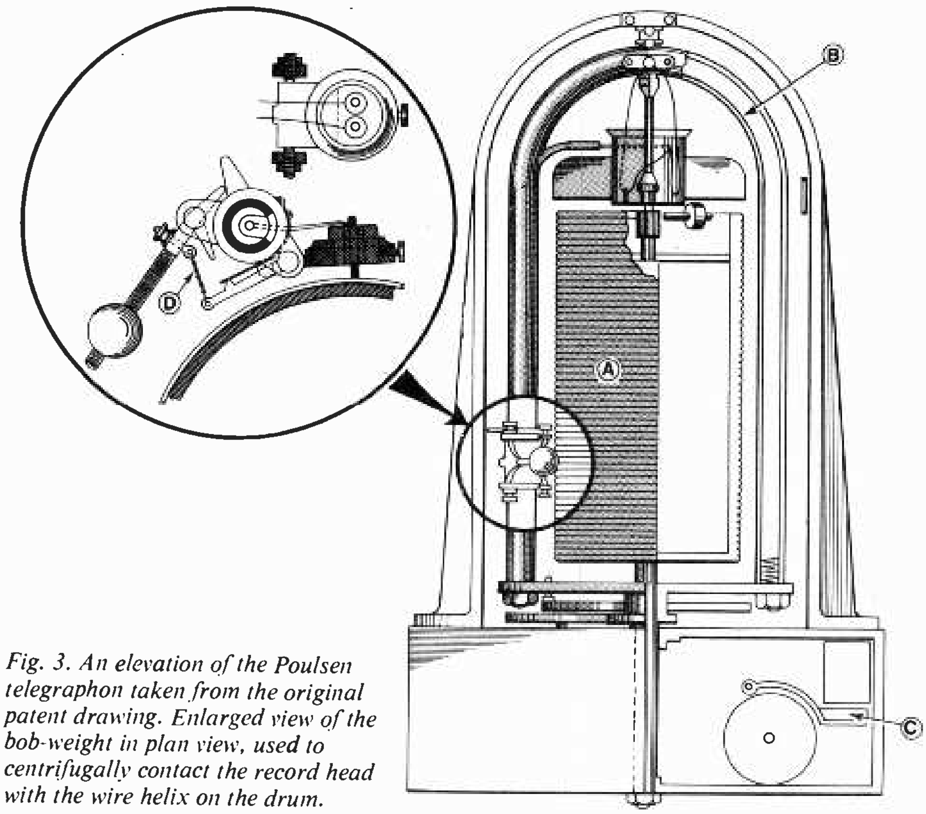

Fig. 3. An elevation of the Poulsen telegraphon taken from the original patent drawing. Enlarged view of the bob-weight in plan view, used to centrifugally contact the record head with the wire helix on the drum.

was not taken up commercially.

Recognition, development

From 1900 onwards there followed a period of intense activity with great efforts being made by Poulsen to gain recognition for his invention. A model was shown at the Paris Exhibition in 1900, this being reported in a number of journals in America and Europe[11, 12]. It was at this exhibition where the machine won the Grand Prix and gained the attention of Emperor Franz Joseph of Austria who made a recording at the exhibition, which survives to this very day. Companies to exploit the invention were later formed, appearing simultaneously in Denmark as the Dansk Telegrafonen Fabrik A/S and in the US as the American Telegraphon Company, in the year 1903. A British company was also formed which was to suffer a similar fate to all the Poulsen companies, final death through lack of commercial support, shortage of funds and failure to successfully appeal against a refusal to renew the expiring British patents. Both Ford[1] and Mooney[13] report a sorry tale of missed opportunities and even intrigue, mentioned in a little more detail in Begun's book[14]. However, although it was commercial factors that dictated the pattern of success, this short history is intended to document the technological developments and these did not stop.

The early telegraphone produced a transverse, "bipolar" recording, that is, the pole pieces of the record head were arranged to be diametrically opposite to each other, on each side of the wire or tape. The recording process would therefore produce areas of magnetization within the material that could be described as being transverse and having both a N and S pole across the thickness of the wire. However Poulsen and Pederson discovered[15] that this had disadvantages at high speeds and small wire diameters, when self-demagnetization caused a considerable reduction in sensitivity. By staggering the position of the two-pole pieces along the direction of travel an inclined field was recorded with a subsequent improvement in performance.

Up to mid-1902, the recording method had been somewhat crude and involved no amplifiers. For that matter the telegraphone was never teamed with an amplifier commercially, although it seems that Lee de Forest, the inventor of the Audion valve, did successfully experiment along these lines with a machine borrowed from the American company. One big improvement did appear in 1902, however, this being the principle of d.c. bias[16] to reduce distortion and improve sensitivity, the patent being finally granted in 1907.

Later in 1902 a more advanced telegraphone appeared[17], being essentially a long-playing machine with a form of footage counter and a more complex remote control facility. Again, this machine was intended for use as a telephone recorder but also as a dictation machine. An amusing point is that that machine could be made to stop at any predetermined point using the footage counter and adjustable indexes—an early version of the "memory counters" recently introduced on modern machines and claimed as a modern innovation! Recording time was said to be 30 minutes with a capability for larger wire spools to be fitted.

In 1903, Poulsen filed yet another patent application[18], this time relating to the use of iron drums, cones or discs as the "carrier" of the magnetic record. A disc machine was produced and has been illustrated[4] (Fig. 5) and there were later copies by other companies such as EMI. This idea was quite interesting for it introduced the idea of recorded "tracks" adjacent to one another on a continuous magnetizable surface. Of course, in this instance the adjacent tracks were simply parts of a continuous helical or spiral recording. Poulsen noted that reducing the size of the recording head pole tip made it possible to increase the recording

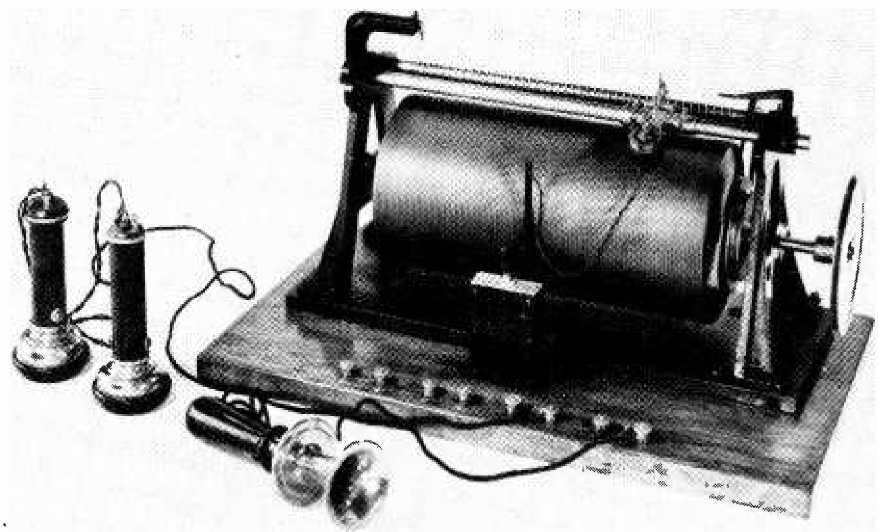

Fig. 4. A commercial version of the telegraphon, circa 1900. The electrical drive motor is not shown. (Photo courtesy Philips Gloeilampenfabrik.)

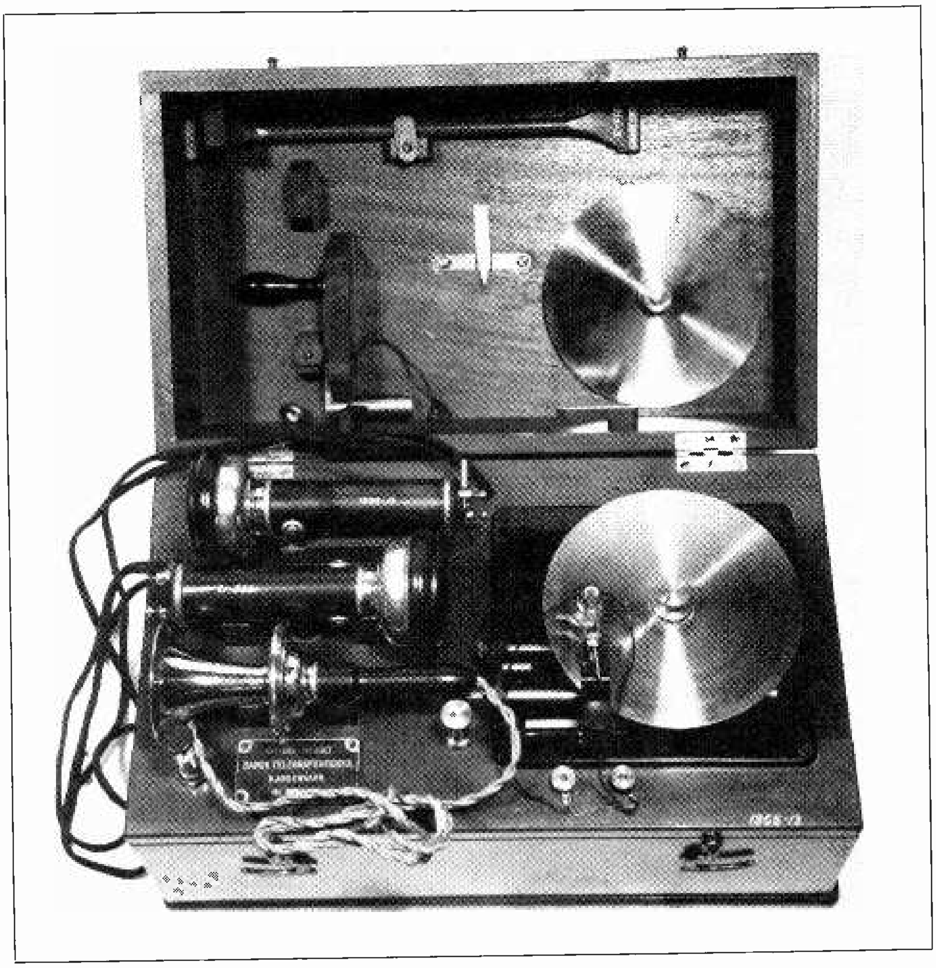

Fig. 5. The disc form of the telegraphon which appeared after 1903. (Photo courtesy the Science Museum.)

density by increasing the effective length of the recording time for a fixed speed.

Although Poulsen's companies were dogged with troubles, the telegraphone found service with the British Post Office, the War Office and the US Navy right through World War I, but by the end of the war the Poulsen telegraphone seems to have commercially died. Thus, a chapter in the story of magnetic recording closed leaving the "Danish Edison" with a firm claim to be the father of magnetic recording.

The press agent of magnetic recording

Magnetic recording entered into a period of stagnation after World War I and perhaps this is why two quite important patents taken out in 1918 and 1921 remained unnoticed and unsung for many years. The first of these was filed by Leonard F. Fuller[19] and suggested the use of a high frequency alternating current for erasure followed by a patent application in 1921 by Carlson and Carpenter[20] for the use of a.c. bias on a wire telegraphone. The same patent links the machine to the audio output of a wireless circuit which must represent the earliest example of off-air magnetic recording.

Not to be overlooked, was the fact that on the domestic front the disc and phonograph were advancing into the home entertainment field, making it much more certain that any rebirth of magnetic recording was to be at a professional level and was to require something of an entrepreneur.

A man who, in the 1920s and for some little while on, was to fulfil this role and even acquire the appellation "the press agent of magnetic recording" was Dr Kurt Stille[21]. He was a German subject who formed, in the early 1920s, the Telegraphic Patent Syndikat, whose object it was to obtain the rights of various magnetic recording patents—and also originate some of its own—and license these out for commercial exploitation. One of the earliest patents taken out by Stille[22] was applied for in April 1922 and described a telegraphone that used steel tubes as the carrier, in a similar fashion to the drum machines described by Poulsen in his 1903 patent. Mooney[13], in his chronological listing of events, suggests that Stille marketed a modified version of the Telegraphon in 1920 in Germany, and it may well have been this that gave him the ideas for his later patent. Also in 1920, he mentions that a subsidiary of the Stille organization called Ecophone Co marketed a wire recorder called the Dailygraph, intended primarily as a dictating machine.

A more important development was contained within a second early British patent secured by Stille[23] which described a method of producing sound, synchronized with a moving film. Up until then, the so-called "talkies" had been produced using synchronized disc recordings. The new technique involved the use of perforated steel tape driven by a sprocket which could easily be synchronized with the sprocket drive of the film projector. Also contained within the patent are suggestions for recording separate parallel tracks using separate or stacked record head cores, and even methods for remote control of the projector using recorded impulses on a pilot track. Although the idea of synchronized magnetic recorders for film sound was not new, an earlier patent having been secured by H. C. Bullis[24], Stille was the first man to indirectly demonstrate the idea successfully.

Pursuing the principle of licensing patents out for further development, Stille sold the rights of his machine to Louis Blattner who had formed the Blattner Colour and Sound Studios at Elstree near London. By 1929, Blattner had produced his first practical machine which was presented to the Press on October 18, 1929 and reported in *The Electrician*[25] as follows. "A system of making and reproducing sound records, which seems to be destined to supersede the old system employing discs or cylinders, was demonstrated last week to pressmen and others, by Mr Louis Blattner, at the Blattner Colour and Sound Studios, at Elstree. The nucleus of the new system, which is now ready for commercial exploitation, was discovered some 40 years ago; Dr Kurt Stille began to work upon it 25 years ago, and the Ludwig Blattner Picture Corporation of London and the Telegraphie Patent Syndikat of Berlin have recently conducted laboratory and studio work which has resulted in bringing the system to a stage which indicates that the invention will probably revolutionize present-day practice....

"The items in the demonstration referred to included a reproduction of a monologue recited by Mr Henry Ainley, whose enunciation was faithfully reproduced, and a 'talkie' picture of Miss Ivy St. Helier, who sang, to her own piano accompaniment, and concluded her perfomance with an amusing talk. This picture was very realistic, and the sound record was distinct and well synchronized.

"The most intriguing application of the invention demonstrated, however, was its use as a recorder of telephone conversations. A conversation through the Post Office exchange system was recorded, and afterwards heard, completely and clearly, through the hand-set attached to the instrument.

"Records can be repeated in this manner immediately after the short interval necessitated by the running back of the wire.

"Performances of instrumental music were also given in the studio, and the advantages afforded by the ability of the apparatus to give an accurate and immediate play-back were again realized.

"Many uses of the recording telephone will readily suggest themselves, such as its utility as a dictating machine, a recorder of messages in the subscriber's absence, a 'file' of conversation for use as evidence, and the teaching of languages and scientific and other lessons in schools.

"It is stated that research work in progress at the Stille Laboratories, Berlin, includes the electromagnetic fixing and reproducing of optical signs on steel tape as a substitute for television."

The machine, called the Blattnerphone, was bought by the BBC, though it is believed that the particular form used employed a sprocketless tape. Incidentally, the first public broadcast made using this machine seems to have been when Lord Reith opened the Empire Service of the BBC in 1932. It must have been quite horrifying to operate, since the steel tape passed through the machine at quite a high speed and a reel of tape was of considerable diameter. In the early machine, speed was manually controlled by observing a tachometer and breakages of the steel tape could cause considerable damage to anyone or anything nearby.

Steel tape machines were to become most important in broadcast organizations before World War II and shortly after Blattner's demonstration, the Marconi Company bought out the Blattnerphone and developed the Marconi-Stille steel tape machine.

However, it is around this time that we begin to move into a period of technology involving electronics—an aid which was never enjoyed by the telegraphone. And that, as they say, is another story—to appear in the second part of this article.

(To be continued)

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Research Notes

LDEs—not from alien space probes

A communications scientist, Mr Tony Lawton, has been taking a careful look at the theory that long-delayed echoes (LDEs) of radio transmissions come from an alien space probe in the orbit of the moon. LDEs were first reported in the 1920s during the trials of a short-wave transmitter which later became part of Radio Hilversum. Many other occurrences were noted, some by researchers at King's College, London, and some at what is now the Appleton Laboratory. They are believed still to occur but are now much more difficult to detect because of all the man-made noise on the short-wave bands.

In 1960 it was suggested that an alien probe was relaying the transmissions in a way designed to attract attention to itself. In 1973 Lunan claimed that a time-analysis of the delays could be interpreted as a star chart indicating the source of the probe.

Lawton's explanation is less romantic, but interesting. It rests on the assumption that the ionosphere occasionally extends a lot farther into space than is usually assumed, or at least that there are areas of ionization at about the moon's orbit. The records of LDEs are nearly all consistent with the presence of ionized matter at one special area, near the so-called "trailing Lagrange point" 60° behind the position of the moon. This is one of three points in space where the earth's gravitation and the moon's gravitation cancel one another. There is obviously such a point somewhere along a straight line between the earth and the moon, but this marks the top of a "gravitational hill". Matter placed there would be in unstable equilibrium and would run down to the earth or the moon. The other two zero-gravity points, the Lagrange points, one ahead of the moon and one behind it, are at the bottoms of gravitational valleys. Matter put there would tend to stay in place. (It would also tend to get ionized by radiation from the sun.)

Lawton thinks that matter occasionally gets swept into the trailing Lagrange area to form a sort of mini-ionosphere. Radio waves impinging on the area could then be subject to known ionospheric actions which could account for the LDE phenomenon. The actions are similar to those which give rise to "whistlers" (l.f. radio noises triggered by thunderstorms). The arriving radio wave creates a plasma shock wave. This travels slowly through the ionized region, getting amplified as it goes along. These effects could account for both the delay times and the strength of LDEs. The shock waves are reconverted to radio waves before returning to the earth. Delays of up to several days are theoretically possible.

Dielectric waveguide materials

The possibility of conducting microwaves through dielectric guides (on the lines of fibre-optic guides for light) has been known for many years. The problem has been to find dielectric materials with low enough losses to make the system practicable. It now looks as if the answer may lie in ordinary plastic materials such as polythene and polypropylene prepared in an unusual way. If these materials are fabricated as castings rather than the usual extrusions and mouldings they show much reduced absorption of millimetric and far-infra-red radiation.

Gravity waves: more problems for detection

When crystalline solids are subjected to stress, changes occur in their microstructure which give rise to acoustic vibrations. Quite small stresses can produce outputs, so that a large mass of metal, say, will produce outputs under the influence of the internal stresses caused by its own weight.

This is bad news for would-be detectors of gravity waves from space. Until now these experimenters have used anti-vibration mountings for the large lumps of aluminium which are the basis of their detection systems, and hoped that any audio frequency resonances detected in the masses were the result of incoming gravity waves. It now appears that the microstructure of worked aluminium is likely to promote audio outputs due to internal stress which are on just the frequencies used in some gravity-wave detectors. Future attempts may have to make use of carefully annealed metal masses with resonant frequencies selected to keep clear of likely microstructure resonances.

Nature, vol. 252, p. 639, 1974.

Optical fibre modulators?

Glass optical fibres with cores of the non-linear optical material meta-nitroaniline in single-crystal form have been made at the Post Office Research Department. These fibres act as efficient polarizers and it is hoped that further work will yield low-frequency fibre-optic modulators.

At last! The solid-state radio valve

When transistors were invented it occurred to various people that the way seemed open to the making of an exact solid equivalent of the triode thermionic valve. Such a device would use an emitting junction layer in place of the heated cathode; on top of this would be a "grid" layer to control electron flow; then an insulating layer to correspond to the grid-anode spacing of the vacuum triode; and finally a collecting contact corresponding to the anode.

Something rather like this has appeared from Westinghouse Research Laboratories, in the form of the "vertical m.o.s. transistor". Its performance figures are good: 1.2W output at 700MHz, with a prospect of 5W at 4GHz. And it's said to be relatively cheap to make.

Insect tracking by radar

Dr Glyn Schaeffer of Loughborough University, well known for his work on the tracking of birds by radar, has been turning his attention to insects. It has proved possible to track a single locust at two miles and determine its sex at one mile from the fact that the male's wings beat faster than the female's. Other agriculturally important insects which can be tracked are the cotton boll-worm moth and the spruce bud-worm moth. One surprising finding is that many insects migrate every night by flying down-wind for anything up to 200 miles.

Locusts, when they fly in swarms, concentrate in long lines which move through the air like an advancing army, on a front over 100 miles long but only one mile deep. This moving swirl of insects, or "line vortex", can be tracked at long range and might be attacked by laying, from aircraft, aerosols of insecticide in its path. Wind-tunnel tests show that when an insect flies through such an aerosol it picks up a lot more insecticide than it does when it is sitting on a crop plant which is sprayed. Thus the amount of insecticide needed for an airborne aerosol attack may be very small.

Tailpiece

The appearance of a handsomely coloured parrot on the cover of *Nature*, with the corresponding title page entry "Pupils of a talking parrot", sent readers hurrying to the article, where they found, not a report of parrots teaching humans, or even other parrots, but a lot of close-up pictures of the eye of the researchers' parrot Seraphita, each photo with an inset oscillogram taken at the same time. This data showed quite clearly that Seraphita's pupils contract when she speaks. The significance of this is as yet unknown, but the researchers hint at the possibility of "neural crosstalk".

Nature, vol. 252, p. 637, 1974.

Noise—confusion in more ways than one

1—Thermal noise and terminology

by K. L. Smith

University of Kent at Canterbury

Random fluctuations at the limit of sensitivity of radio receivers, amplifiers and other instruments that process tiny signals have become ever more significant in recent times. Because no single number exists for complete characterization of a system or device under all conditions, difficulties and confusion often arise when the quantities which have been suggested are misunderstood and used incorrectly. The ideas of the noise figure and noise temperature are discussed in this four-part article, with practical hints on how they can be measured with a good chance that the values obtained will bear some approximation to the truth. At first sight, the many special terms seem to have little in common: this first article looks at some of the basic ideas.

While sitting on the banks of our lake in the woods near the University Electronics Laboratory, the students' group discussion turned to noise. Not the airport or motorway sort—nothing could have been further from our thoughts, in the rather idyllic setting we are fortunate enough to have. Lest readers become incensed at this point with visions of lazy good-for-nothing students sitting about and are tempted to demand their taxes back from the Exchequer, I hasten to add that we were working—quite hard, trying to sort out a little order in that maze of a subject, electronic noise and its effect on the ultimate sensitivity of communications systems.

At one point in this discussion I asked, "What temperature would you observe using a microwave receiver whose horn aerial was pointing up at the clear sky, with the waveguide plumbing at around room temperature?" A quick reply was forthcoming, "Oh, about 300K". Such a high value for the received temperature of a system forming the subject of my question was incorrect and I said so. "What is it then?" was asked and I replied "Around 10K". "What, within a few degrees of absolute zero and the waveguide at 300K!" chorused back.

This serves to illustrate one of the first elementary fallacies found in the subject of noise in systems—that the temperatures everyone talks about must have something to do with physical temperatures. Following the line to show up this fallacy, I then pointed to another part of the sky and said, "Over there the same receiver could register an aerial temperature up to perhaps 10,000K". I was indicating in a direction towards the sun, of course.

The point is that the receiver measures the source effective temperature, not the actual physical temperature of the aerial components. To help drive the point home, the question was raised as to the temperature that would be seen if the horn "looked down" at a sheet of metal on the ground, which was therefore at the physical temperature of the earth (in other words, about 300K). The answer is the same as before, 10K.

The metal is so nearly a perfect reflector at centimetre wavelengths, that it is simply the sky that is seen. The sheet of metal hardly absorbs any r.f. signal power, therefore it hardly radiates any energy, even though it is at about 300K. The metal is anything but the "black body" of Max Planck, radiating at 300K. As it is such a poor absorber it is a very poor emitter indeed, its effective emission temperature probably being around a hundredth of a degree or less.

The noise figure muddle

The debate around the lake came to an end at this point, and with parting reminiscences of black bodies and Kirchoff's radiation laws reminding us that we had studied a little physics in the dim and distant past, thoughts turned to how much we owe to thermodynamics for the ideas which have enabled us to realize the ultimate limits of small-signal reception and to build low-noise equipment for handling the tiny signals near these limits, so often part of modern radar, satellite and radio-astronomical systems.

When looking at noise problems in communications one finds that misconceptions and confusion abound in the subject. Even the professionals cannot agree. William Mumford and Elmer Scheibe[1] noted that no less than nine definitions of "noise figure" exist in the literature, so pity the poor student or junior engineer! Then we have all that talk about "temperatures". It is worth noting the range of quantities and concepts that exist around the subject of electronic noise, so that as these articles proceed we stand a good chance of stripping some of the fuzziness away from these ideas and show how they relate and how some of them have arisen.

A cursory glance into the literature always turns up the well-known quantity F, the noise figure. Or is it noise factor? It was H. T. Friis[2] who defined and named F the noise figure. D. O. North defined what amounted to the same thing in a paper published at about the same time, only he called it noise factor. Therefore noise figure and noise factor have the same meaning. One meets F as a simple ratio or as $10\log_{10}F$ (i.e. noise figure in decibels).

The concept of excess noise figure is met. It turns out to be simply $F-1$. The spot noise figure is the figure defined at one frequency, whereas the average noise figure, sometimes written F, is that effective over the whole bandwidth under discussion. A concept which may come into more general use is the operating noise figure, F_{op} defined by Dr North as long ago as 1942[3].

Turning now to the idea of using absolute temperatures to discuss noise performance, one finds a bewildering array of signs and symbols, but paradoxically, working with temperatures is actually more straightforward than the confusing noise figure muddle. If the common use of noise temperatures had developed before noise figures as a concept, we may have been saved the duplication. Temperature is fundamental, being related to (thermal) energy and power. Noise temperatures are especially convenient when dealing with low-noise receivers and amplifiers, and the use of noise temperature is slowly taking over as a parameter in performance measurements.

Other than the concept of a general noise temperature (represented by T_N, T_i, etc.) one finds in particular the aerial temperature, T_a; the effective input noise temperature, T_e; a standard reference temperature, T_o (we shall see that everyone has agreed to 290K for T_o, after some persuasion by the American IEEE). There is the excess noise temperature, which turns out to be T_N-T_o, or the number of degrees in excess of 290K, the standard room temperature. From this, a quantity known as the excess noise ratio is obtained,

$(T_N - T_o)/T_o$, which is written $t-1$, so that t is the noise ratio, T_N/T_o. Finally, there is the concept of an operating noise temperature, T_{op}. Sometimes the system noise temperature, T_{sys}, is used instead of T_{op} in some articles.

The fact that there has been this proliferation of concepts and quantities, shows that either there are hidden subtleties in the subject, or that some of the definitions are unsatisfactory, or both. Even so, there are one or two other definitions that are vital to an understanding of noise problems, but they are much more general and useful in other contexts as well. These are the ideas of the available power from a source and the related available power gain of an amplifier stage. (Or loss, if the gain is less than one, as in an attenuator.) Noise and signal bandwidths (B_N and B_s) are also of importance.

Thermal agitation

Ever since the fall of the old caloric theory centuries ago and the subsequent rise of the mechanical theory of heat as the energy of the random jostling of the molecules in substance, it was suspected that the warmth of an object might set the limit to the accuracy of measurements on it. This was found to be so in examples like the Brownian motion and the jumping around of the light spot of very sensitive galvanometers.

Thermal noise in electronic devices has received a great deal of attention since the theoretical discussion of H. Nyquist[4] and the experimental work of J. B. Johnson[5] was published in 1928. You can follow this up a little in Cathode Ray's articles, "Heads, Tails and Noise"[6] and, "More about Noise"[7] of some time ago. It is worth quoting a few opening remarks from J. B. Johnson's paper: "... a phenomenon has been described which is the result of spontaneous motion of the electricity in a conducting body. The electric charges in a conductor are found to be in a state of thermal agitation, in thermodynamic equilibrium with the heat motion of the atoms of the conductor. The manifestation of the phenomenon is a fluctuation of potential difference between the terminals of the conductor which can be measured by suitable instruments. . . ." The value of the mean of the voltage squared is found to be

$$\overline{v^2} = 4kTR(f_2 - f_1)$$

and the power

$$w = \frac{\overline{v^2}}{R} = 4kT(f_2 - f_1).$$

For an amplifier operated at room temperature and covering the approximate voice frequency range of 5kHz, this power is 0.82×10^{-16} watt.

We have here the fundamental equation for the open-circuit noise e.m.f. derived experimentally by Johnson and theoretically by Nyquist

$$\overline{v^2} = 4kTRB \quad \ldots . 1$$

in which T is the absolute temperature of a resistor R, B is the noise bandwidth in Hz, and k is Boltzmann's constant (see Cathode Ray's discussion of "k" in *WW* November 1960[8]).

Dr Nyquist's derivation of equation 1 is now standard bookwork, see for instance, Robinson[9]. An interesting point is that equation 1 predicts a uniform output over the entire frequency spectrum. This gives rise to the expression white noise by analogy to white light (all frequencies present), Fig. 1. The presence of the thermal

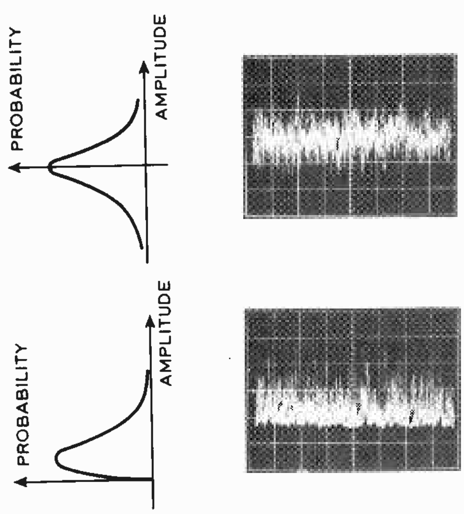


Fig. 1. White noise has a Gaussian distribution (upper oscillogram). After band limiting, white noise typically shows a Rayleigh distribution (lower oscillogram).

noise e.m.f. across a resistor means that power can be drawn by a load connected across it and the well-known equivalent circuit shown in Fig. 2 enables us to calculate the maximum, in this case thermal noise power, that can be drawn. From Fig. 2,

$$\overline{i^2} = \frac{\overline{v^2}}{(R+R_L)^2}$$

and the power dissipated in R_L is $\overline{i^2}R_L$. If we now make $R_L = R$, we have the matched condition and the maximum power is drawn.

$$N = \frac{\overline{v^2}}{4R} = \frac{4kTRB}{4R} = kTB \quad \ldots\ldots\ldots 2$$

In this equation N is the noise power under matched conditions. Of course, in thermal equilibrium, the two resistors feed this much power to each other so no net transfer of energy takes place. This balance is also

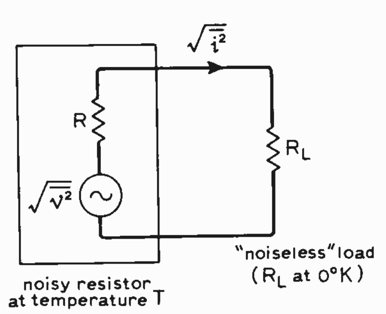


Fig. 2. R_L is absorbing power from R. Maximum power is absorbed when $R = R_L$, according to the well-known matching theorem.

true for every frequency band, as well as overall. Suppose for a moment that this was not so, and imagine a tuned circuit in parallel with the two resistors, which acts as a selective filter, then the resistor which had a higher output at one frequency band could continually supply power to the other even though the temperatures of the two are equal. Thermodynamics has something quite definite to say about the impossibility of doing that, so the balance is maintained across the whole spectrum. The kTB expression is called the available noise power. Equation 2 shows that the available noise power is directly proportional to the bandwidth B and absolute temperature T, but is independent of the value of R and of the frequency.

The above arguments about constancy with frequency begin to fail for frequencies around 1000GHz at room temperature. This frequency is much higher than the radio frequency spectrum in current use. The error is about 1%. But at low temperatures, say 1K, a 10% error already would exist at 10GHz. This is because the correct expression for thermal noise derived rigorously from thermodynamics is

$$\overline{v^2} = \frac{4RBhf}{\exp(hf/kT) - 1}$$

What all this means is that at very high frequencies and/or very low absolute temperatures we are running into quantum effects. If you glance into a mathematics textbook, $\exp x$ or e^x will usually be found expanded into a power series

$$= 1 + x + \frac{x^2}{2} + \frac{x^3}{2.3} + \ldots$$

If our x, which is hf/kT is small the quantity $\exp(hf/kT)$ can be taken for all intents and purposes equal to the first two terms, that is $1 + (hf/kT)$. Putting this into the equation, cancelling, etc., immediately gives Nyquist's simple form for $\overline{v^2}$.

Amplifiers and available gain

If amplifiers added no noise to signals they were processing, no problems would exist about gain and how much of it we could use. Also, it stands to reason that no amount of gain will put out a signal already buried in a large amount of noise. What is important is to amplify a weak signal already in noise so that it can resist further degradation by interference and while amplifying, to add the minimum amount of extra noise. Two requirements are needed for front-end amplifiers then: a high gain, and a low-noise performance. Even with the best amplifiers the output signal-to-noise ratio is worse than that at the input, because some noise will always be added by the circuit components.

There is some difficulty about what is meant by gain, which must be cleared up. Definitions of various gains abound in the electronics literature. There is the voltage gain, various power gains, current gain and so on. The usual requirement is to boost the power level of a weak signal so that it can operate fairly energetic transducers such as loudspeakers, pen recorders, etc.

Clearly, power gain is the idea we want. But, which power gain? If an amplifier has an extremely high input impedance, the input power is nearly zero. With a few watts output, a simple ratio of output power to input power is getting on for infinity! The best general definition to use is termed available power gain, G_A, and as can be seen from Fig. 3, is defined as $G_A =$

$$\frac{\text{available power from the output terminals}}{\text{available power from the input signal source}}$$

The point to remember now is that available power is the maximum that can be taken from a source or generator. In other words it is the matched power output into a load connected to a generator, as I mentioned earlier for noise power. It is at this stage that subtleties inviting confusion tend to crop up. The available power from the generator feeding some amplifier is, by definition, a fixed quantity depending only on the generator and its internal impedance.

It does not depend on the matching or otherwise at the input circuit. Similarly, the definition of output available power from an amplifier does not depend on the value of the load impedance. This is not to say that available power gain is independent of all matching conditions, because available output power is dependent on input matching. (In effect, available power from the source feeding the amplifier is a constant of the source, but actual power going into the input terminals does depend on matching.) Therefore, the definition of available power out includes the effects of any mismatching at the input, the conditions of which must be stated in the specifications of any particular case.

M. S. Gunston[10] wrote a critique on the use of available power gain and attempted to introduce a mismatch factor M, because of "errors" by using available gain ideas. I cannot agree and consider introducing more factors just adds complications. In the special case of complete input circuit matching, maximum available power gain is obtained. The idea of available power gain is versatile and useful. One or two cases are considered in the Appendix for readers who do not mind a few numbers. Whenever you see gain mentioned, I am talking of available power gain under the input conditions prevailing.

To be continued.

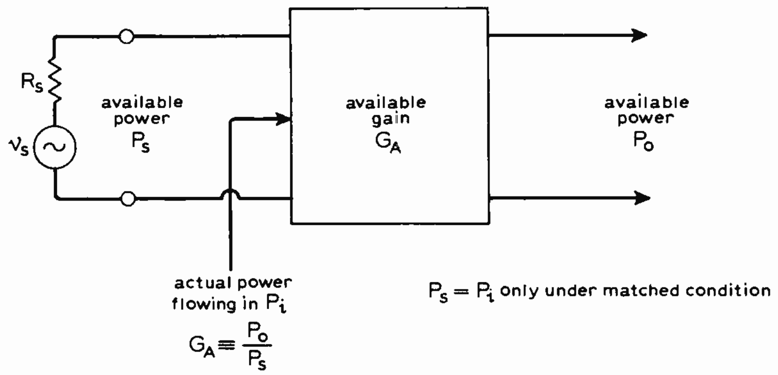


Fig. 3. Available power gain has no direct connection with matching, but maximum available power gain is only obtained when R_s matches the input resistance of the amplifier.

Appendix A

Available power

A very useful property resulting from the definition, is that available power from a source is unaltered if we put a network of reactances after it. On the other hand, a resistive network will change the available power, in practice always reducing it below the original value. You can see this by considering the examples shown in Fig. A1. The first shows a series reactance inserted after the generator. Available power from the generator on its own is $E_g^2/4R_g$. All we have to do is cope with $+jX$ and the available power is again drawn.

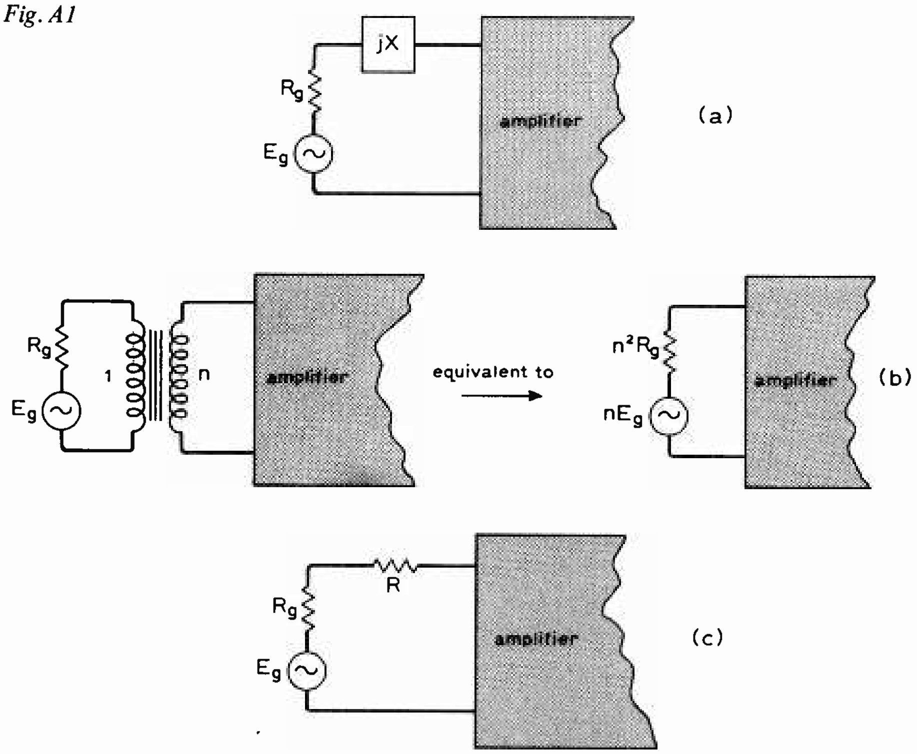
Fig. A1(b) shows the case of an ideal transformer with a step up ratio of 1:n The output voltage from the secondary will be nE_g, and the effective source impedance will be n^2R_g from transformer theory. Available power will be $(nE_g)^2/4n^2R_g$, which is as before. The last example shows that if a series resistance R is placed after the generator, as in Fig. A1(c), available power is $E_g^2/4(R_g+R)$ which is obviously less than $E_g^2/4R_g$.

Available power gain

Working from the definition for G_A above, we can write down the two available powers, take the ratio and thereby obtain G_A. As an example, Fig. A2(a) shows a voltage amplifier with input resistance R_{in} fed via a reactive network from a generator whose e.m.f. is E_g, with real internal impedance R_g. (Any imaginary part can be taken into the reactive network.) From network theory, any arrangement of reactances can be reduced to an equivalent transformer with a series resistance, for a shunt susceptance. Resulting from this you will see that the equivalent circuit shown in Fig. A2(b) can be drawn. Going one stage further in the simplification we arrive at Fig. A2(c), where the transformation of the generator voltage and internal resistance to nE_g and n^2R_g is shown. The magnitude of the voltage appearing across the terminals of the amplifier is

$$E_{in} = i_{in}R_{in} = \frac{nE_gR_{in}}{\sqrt{(n^2R_g + R_{in})^2 + X^2}}$$

Fig. A1



Available power output will be some constant of the amplifier, times E_{in}^2; or, what amounts to the same thing, it will be proportional to the square of the input terminal voltage.

$$\therefore P_{A(out)} = K \frac{E_g^2 R_{in}^2}{\left(nR_g + \frac{R_{in}}{n}\right)^2 + \frac{X^2}{n^2}}$$

Notice that I have deliberately rearranged n. As available input power is simply $E_g^2/4R_g$,

$$G_A = \frac{P_{A(out)}}{P_{A(in)}} = K' \frac{R_{in}^2 R_g}{\left(nR_g + \frac{R_{in}}{n}\right)^2 + \frac{X^2}{n^2}}$$

where K' is some constant.

Straightaway, you can see that for *maximum* available power gain, X should equal zero.

This means that any residual reactance should be tuned out at the front end. The term $[nR_g + (R_{in}/n)]^2$ is left in the denominator and for maximum available gain this should be minimized. If n, the transformer ratio, is very large the first term in the bracket dominates and G_A is small. If n is tiny, the second term becomes large and again G_A is small. Somewhere between these extremes an optimum value for n occurs to minimize the bracketed term, and this gives the largest G_A. By using calculus we can easily show there is a minimum when $n^2 = R_{in}/R_g$. This is the matching condition and gives the largest available power gain, as would be expected.

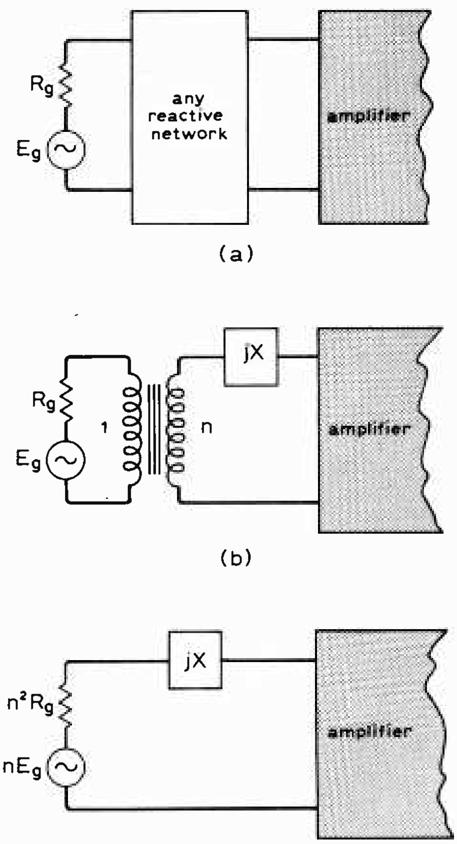
The whole idea of available gain is valid under any conditions, not just matching, as long as the conditions existing are given in any example. (In the example discussed here, these conditions would be the values of R_{in}, R_g, X and n.)

Suppose now we consider a chain of amplifier stages with available gains G_1, G_2, G_3, etc., each under the source conditions offered by the preceding amplifier. Then we can see that $G_1 = P_1/P_s$ where P_1 is the output available power of amplifier number one, and P_s is the available power from the generator. Similarly for G_2, G_3 etc. and so on. If we have N amplifiers, the last one will have a gain $G_N = P_o/P_{N-1}$.
Overall available gain is clearly $G_A = P_o/P_s$ and this is

$$G_A = G_1\, G_2\, G_3 \ldots .\, G_N = \frac{P_1}{P_s}, \frac{P_2}{P_1}, \frac{P_3}{P_2} \ldots . \frac{P_o}{P_{N-1}} = \frac{P_o}{P_s}$$

So the overall gain of a series of stages is the product of the available gains, under the conditions prevailing at each input.

Fig. A2



(a) (b) (c)

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Black holes: radiation transformers?

The concept of a black hole may seem so bizarre that to complicate matters by asking what might happen if the black hole were electrically charged might seem to be a case of scientific masochism. Nevertheless, the question has been asked, and answered, by Ulrich Gerlach of Ohio State University. The answer bears on the relationship between electromagnetism and gravitation. Gerlach calculates that if the charged black hole is immersed in an electromagnetic field then any electromagnetic radiation which comes near it will be transformed into gravitational radiation. The black hole acts as a catalyst which transforms one type of radiation into another.

The Psi particle

A new sub-atomic particle (or perhaps two similar ones) has been discovered independently at two US research laboratories (Brookhaven and Stanford). One team produced "Psi particles" by throwing protons at protons, the other by throwing electrons at protons. The Psi particle has a mass energy equivalent of 3GeV, which makes it about three times as heavy as a proton. Most particles of such a mass have very short lifetimes in isolation. The Psi article is a surprise in that it lives for about 10,000 times as long as would be expected before decaying into an electron and a positron. Physicists are trying hard to explain it. The one thing they seem sure of is that the Psi particle is *not* the elusive quark.

New thermal imaging tube

A thermal camera capable of taking "recognizable images of human faces or hands" has been developed at SERL, Baldock. The tube has a germanium window, a target of the pyroelectric material triglycine sulphate which reflects low-energy electrons to an extent dependent on the incident heat and a fluorescent screen to turn the electron beam, after acceleration, into a visible image. Temperature differences of 1°K are detectable.

Lasers detect paint-peeling masterpieces

If deterioration in oil paintings is detected early it is possible to take action to preserve the paintings. Laser holography has been shown to make early detection possible. The technique is the same as that used to measure minute changes in any object. A laser hologram is taken, the temperature of the painting is raised a little, and another hologram taken. Detached regions of paint, caused by its beginning to peel off the backing material, dissipate heat at a different rate from the rest and expand faster. Pronounced interference fringes appear when the holograms are superimposed, and where peeling has begun there are kinks in the fringes.

High-quality f.m. tuner

A simple design using the NE563 integrated circuit

by J. B. Dance, M.Sc.

University of Birmingham

This article shows how the amateur constructor can make a high-quality f.m. tuner with a minimum of effort. A commercially available front-end is employed with a new type of phase-locked loop demodulator circuit.

Although it is not very difficult to construct an f.m. front-end, the purchase of a complete front-end unit will save the constructor much work and should prevent the possibility of the performance being degraded by spurious oscillations. A varicap front-end was chosen for the circuit to be discussed, partly because this enables both switched and continuous tuning to be obtained without any of the problems associated with dials, gears or drive cords. In addition, the tuning controls can be some distance from the tuner unit itself.

Phase-locked loop demodulators are undoubtedly attractive because no inductors are required. However, the high frequency phase-locked loop integrated circuits which have been available in the past are rather more suitable for use in communications receivers than in high-fidelity equipment. The position has changed with the recent release of the Signetics NE563 device. This integrated circuit contains about 180 transistors and incorporates a high-gain amplifier/limiter in addition to circuitry for converting the i.f. signal to a lower frequency for the operation of the loop. The relatively large percentage frequency deviation at this lower frequency greatly influences the performance of the circuit.

Circuit

The circuit of the tuner (excluding the stereo decoder) is shown in Fig. 1 and the circuit for the tuning controls in Fig. 2.

A 0.01μF series capacitor is included in the internal EF-5603U output circuit. The output of this front-end unit can therefore be directly connected to the input of the NE563 amplifier/limiter; the latter provides a gain of up to 60dB with a bandwidth of about 22MHz. The signal then passes through the standard Vernitron FM-4 or Toko CFS ceramic filter marked F in Fig. 1. R_1 and R_2 are the filter matching resistors without which the desired band-pass characteristic[1] will be degraded. The limiter output impedance is about 270Ω and the mixer input impedance about 1.25kΩ, so the effective impedance on each side of the filter is about 330Ω.

The signal from the filter passes through C_5 into pin 2 of the NE563 and is mixed with a crystal-controlled 9.8MHz local oscillator signal. The 900kHz difference frequency is fed by an internal connexion to the phase-locked loop section of the NE563. The centre frequency of the loop is controlled by C_9. The loop filter connected to pins 13 and 14 controls the bandwidth and hence the noise level. The value of R_6 may be reduced if a smaller bandwidth is required for any reason. The output impedance of the loop filter is about 6.2kΩ.

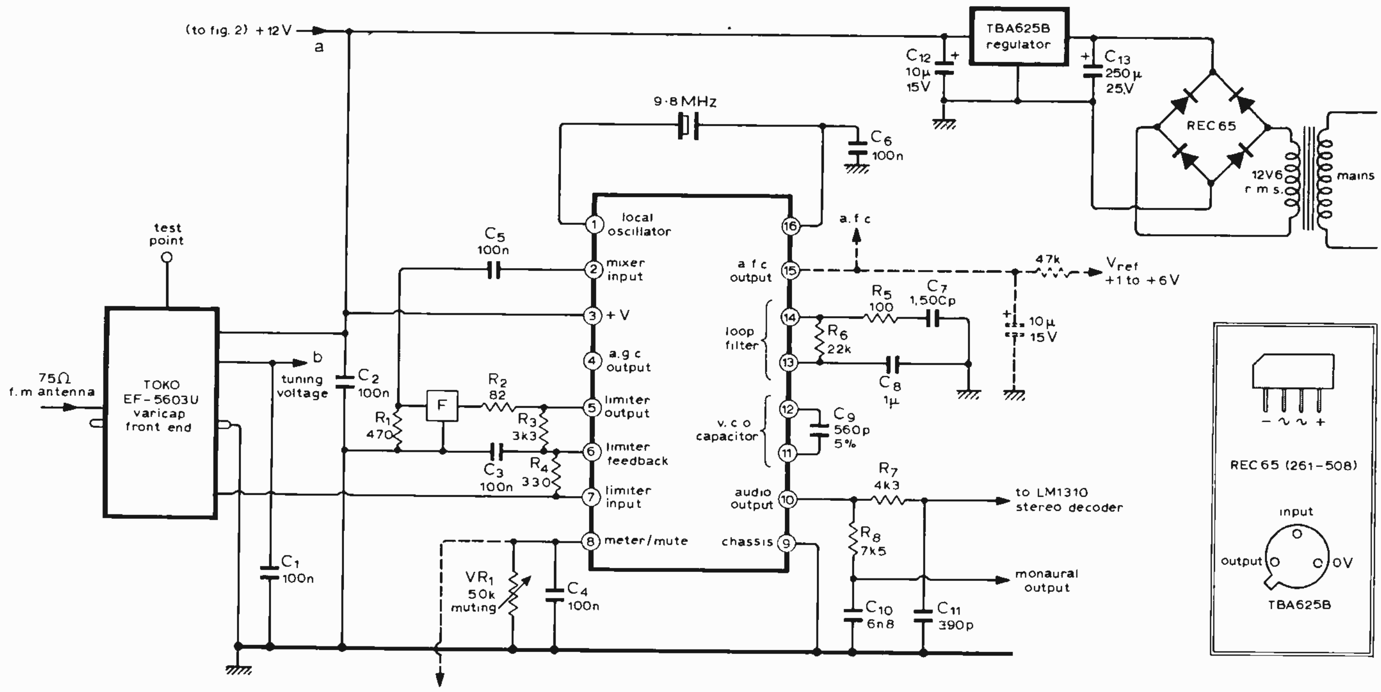

Fig. 1. The circuit of the tuner.

The output filter R_7—C_{11} attenuates radio frequencies, whilst R_8—C_{10} provides the normal 50μs de-emphasis for the monaural output. The effective resistance between pin 10 and ground should not be less than 2kΩ. A series capacitor (not shown in Fig. 1) will be required in each output circuit to prevent the steady component of the voltage at pin 10 from reaching the following audio amplifier or decoder.

The optional potentiometer VR_1 can be used to set the inter-station noise muting level. Muting will also be obtained if VR_1 is replaced by a fixed resistor of about 15kΩ, in which case a "mute defeat" switch should be included which can be used to connect pin 8 through a 100kΩ resistor to the positive line. If an indication of signal strength is required, a high-impedance voltmeter (f.s.d. about 5V) can be connected as shown by the dotted line joined to VR_1 in Fig. 1. The meter reading approximates to a logarithmic function of the input signal voltage and is affected somewhat by the setting of VR_1. The output impedance at pin 8 is about 20kΩ.

The writer has used a 9.8MHz Cathodeon crystal, type CX, manufactured to code AO4851 with the NE563 and has also used a crystal of the same frequency manufactured by Aero Electronics Ltd. Both types were designed for use with a parallel capacitance of 30pF and gave equally satisfactory results. The local oscillator input impedance is about 400Ω at 9.8MHz.

It is possible to make a more economical circuit by using a 9.8MHz ceramic resonator instead of the 9.8MHz crystal. The writer has tried the economical Taiyo type CR-9.8 resonators which were obtained from the USA; they are about 8.5mm square. One of these resonators was connected in parallel with a 2.2kΩ resistor between pins 1 and 16, C_6 being omitted. However, the performance was quite unsatisfactory. The trouble appeared to be due to spurious high frequencies being generated in the oscillator. It was found experimentally that a satisfactory performance could be obtained if a 5pF capacitor was connected in parallel with the CR-9.8 resonator and the resistor.

Power supply

An SGS-Ates TBA 625B voltage regulator in a TO-5 encapsulation was used in the prototype tuner to ensure a very low hum level in the varicap supply. The use of this device enables a much smaller value of smoothing capacitor to be used than would otherwise be required. The regulator incorporates "fold-back" short-circuit protection; that is, if the +12V line is shorted to ground, the current "folds back" to about 30mA. Thus the use of the TBA 625B should protect the NE563 from damage if accidental shorting occurs during the preliminary experimental work. A Jermyn type 2215 heat sink was fitted to the regulator, although this was not really essential. The capacitor C_{12} should be soldered close to the regulator to prevent possible instability, whilst C_2 should be soldered close to the EF-5603U and the NE563. In the prototype separate decoupling of the NE563 was found to be unnecessary; the internal circuit of the device provides 33dB of hum rejection at 100Hz.

The EF-5603U consumes not more than 17mA and the NE563 about 38mA (maximum 42mA). The regulator circuit can supply up to 130mA, so it can also be used to supply current to the LM1310 stereo decoder and to a light-emitting diode stereo indicator lamp.

Tuning

The writer feels that switched tuning is far more convenient than continuous tuning for normal domestic reception. On the other hand, so many local stations are now appearing that continuous tuning is also very desirable. The tuning unit shown in Fig. 2 has the advantage that both switched and continuous tuning are available.

When S_1 is in position 1, the Beckman 10 turn "Helipot" VR_2 is used to provide

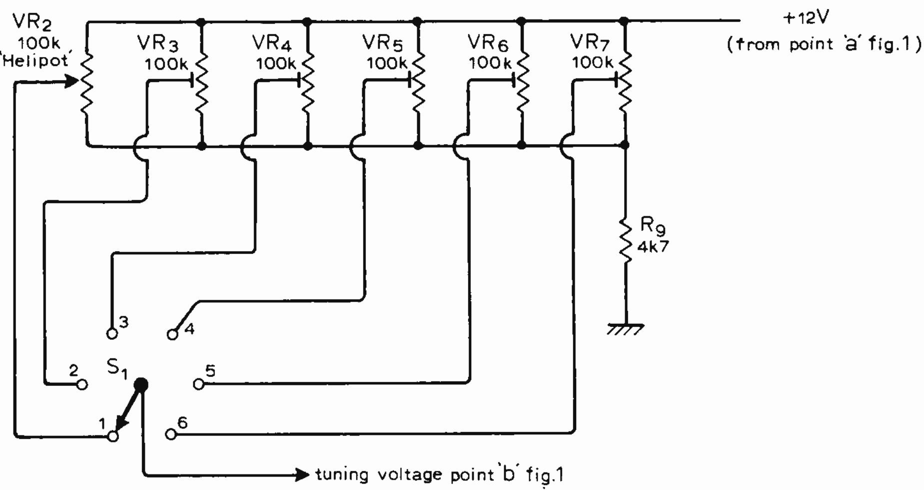

Fig. 2. The preset and continuous tuning unit.

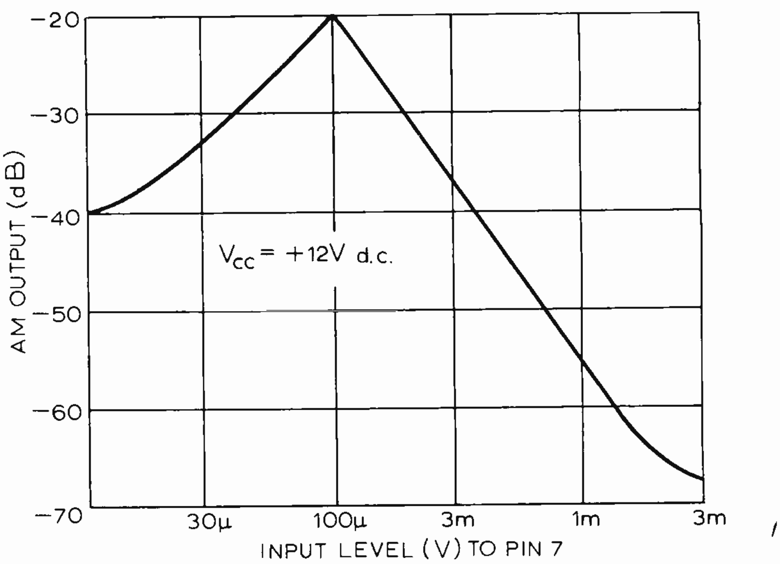

Fig. 3. A.m. rejection plotted against the signal input level to the NE563.

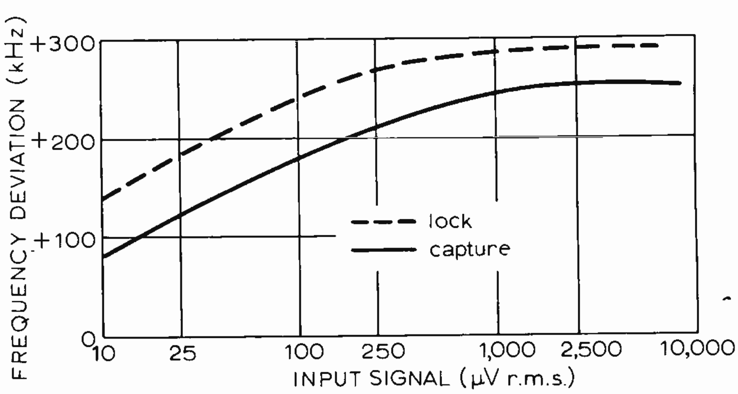

Fig. 4. Variation of the capture and lock ranges with the signal input level.

continuous coverage. The plastic type 7276 component used in the prototype is smaller and cheaper than the other types. A Beckman type RB dial was fitted to the Helipot. Although this is not calibrated in MHz, it does provide fine tuning facilities and can be accurately reset to any point without the constructor having to prepare a special scale.

The other five positions of S_1 enable five pre-selected frequencies to be received. Beckman 15-turn "Helitrims" type 89P were used for VR_3 to VR_7 inclusive, since they can be set much more accurately than a single turn trimmer.

The frequency range covered is approximately 87 to 102MHz for tuning voltages in the range 3 to 12V. It can be extended to 109MHz if a 25V supply is available for the varicaps, but R_9 would then have to be reduced.

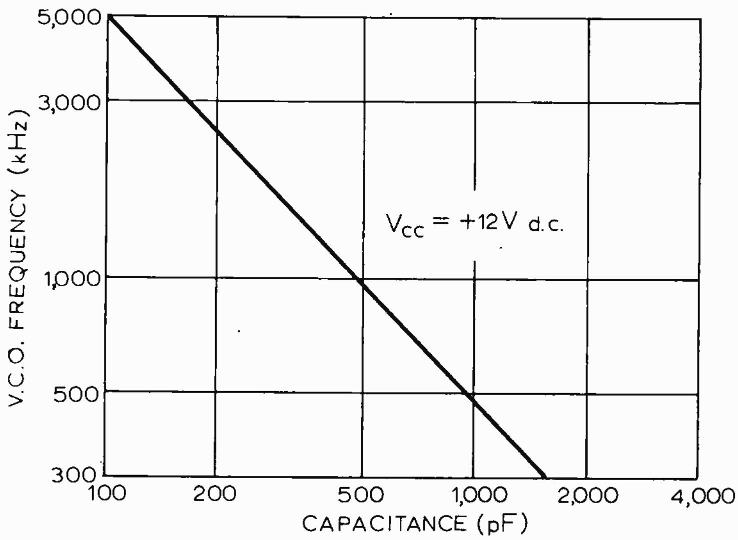

Fig. 5. Free running frequency of the v.c.o. plotted against the capacitance connected between pins 11 and 12.

Performance

The EF-5603U front-end incorporates a m.o.s.f.e.t. input stage and has three varicap tuned circuits between this stage and the mixer. This enables a minimum rejection of spurious frequencies of 90dB to be obtained. The noise figure is not more than 7dB. This unit has recently become available from a retail source (Ambit International, 37 High St., Brentwood, Essex, CM14 4RH).

A similar front-end, the EF-5600U, has provision for the application of a.f.c. and a.g.c. Pin 15 of the NE563 is not connected if the EF-5603U is used, but will provide a.f.c. to the EF-5600U if the components shown dotted in Fig. 1 are included. Similarly, if a 10kΩ resistor in parallel with a 0.1μF capacitor is connected from pin 4 to ground, an a.g.c. voltage may be obtained from this pin. At low signal input levels the potential at pin 4 is about +2.7V, but it starts to fall when the input to pin 7 approaches 1mV. At input levels above 20mV, the a.g.c. output is just over 0.6V.

The writer initially tried the NE563 with a more economical front-end (not a varicap one), but the results were quite unsatisfactory. The output of this front-end contained spurious oscillator voltage which appeared to develop beat frequencies in the NE563 mixer stage. Any such beat frequencies cause distortion or may even prevent the loop locking onto the desired signal.

The total harmonic content of the NE563 audio output is now quoted as typically 0.4% when the frequency deviation is 75kHz and the modulating frequency 1kHz. Under the same conditions the typical audio output level is 380mV r.m.s. The a.m. rejection is typically 65dB or more at signal levels exceeding 2mV at the limiter input; this is greater than that provided by other well-known demodulator circuits. However, this a.m. rejection figure falls at lower input levels as shown in Fig. 3.

The NE563 sensitivity is quoted as typically 9μV (allowing for a 6dB loss in the ceramic filter) for a 30dB signal-to-noise ratio at 10.7MHz, whilst the corresponding level at the mixer input (pin 2) is about 1mV. The front-end unit provides a minimum additional gain of 30dB. In practice, it has been found that the tuner is very sensitive, low power monaural local radio stations having been received at distances of up to 50 miles using a length of wire as an indoor aerial.

The NE563 becomes warm and some drift of the centre frequency occurs for up to about a minute after the power is first applied. However, this drift is of little consequence unless the signal strength is very low. A crystal or ceramic resonator is required to stabilize the local oscillator frequency, although the device will oscillate if one merely connects a capacitor between pins 1 and 16. A 22pF capacitor will produce a local oscillator frequency of about 9.8MHz.

The capture and lock ranges are about ±250kHz and ±290kHz respectively at an input level of 10mV when the loop filter shown in Fig. 1 is used. The variation of the capture and lock ranges with the input signal level is shown in Fig. 4; it can be seen that tuning becomes more critical at input levels under about 100μV.

The phase-locked loop section of the NE563 will operate from frequencies of less than 1kHz up to several MHz, but the free-running frequency must be kept reasonably close to the input frequency for capture and locking to occur. The value of the capacitor connected between pins 11 and 12 determines the free-running frequency of the loop, as shown in Fig. 5. The value of C_9 used in the prototype has been changed by up to about 20% and this merely resulted in the absence of locking with very weak signals. However, it is advisable to employ a component with a ±5% tolerance for C_9. The v.c.o. temperature coefficient is of the order of 500Hz/°C below 25°C and about half this figure at higher temperatures.

The stereo decoder circuit[2, 3] is quite conventional and will therefore not be repeated here.

The writer is indebted to Mr Russ Hansen of Signetics, California, for providing detailed information on the NE563.

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1. L. Nelson-Jones, "F.M. Stereo Tuner", *Wireless World*, **77**, 175 and 245 (April and May, 1971).
2. T. D. Isbell and D. S. Mishler, "LM1800 Phase-locked Loop FM Stereo Demodulator", National Semiconductor Application Report AN-81 (June 1973).
3. "Phase-Locked-Loop Stereo Decoder", *Wireless World*, **78**, 315 (July 1972).

Sources of supply

Toko EF-5603U, CFS filter. Ambit International, 37 High Street, Brentwood, Essex CM14 4RH.

Signetics NE563. Signetics Ltd, 63 Croydon Road, London SE20, or advertisers in *Wireless World*.

Cathodeon Crystals Ltd, Linton, Cambridge CB1 6JU.

Beckman pots. Beckman Instruments Ltd, Components International, Queen's Way, Glenrothes, Fife KY7 5PU.

FM-4 filter. Vernitron Ltd, Thornhill, Southampton SO9 5QF.

SGS-Ates TBA625B. ITT Electronic Services, Edinburgh Way, Harlow, Essex.

Doram REC 65 (order 261508). Doram Electronics Ltd, PO Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds LS12 2UF.

WIRELESS WORLD ANNUAL

We apologize to readers who may have been misled by advertisements for the 1975 Wireless World Annual stating that it would contain 140 pages. In fact 132 pages, including covers, were printed. This was not a deliberate attempt to deceive the reader but an error, which is very much regretted.

News of the Month

Celtic communications covered

Following the decision by the International Telecommunications Union to adopt "world-wide single-sideband telephony working", a comprehensive range of single-sideband communications is to be installed and tested at the Post Office station at Ilfracombe, providing ship-to-shore radiotelephone and teleprinter communication for offshore oil rigs throughout the British sector of the Celtic Sea. A total of four 1kW transmitters—one for telephony, one for telegraphy and two for standby—have been ordered for Ilfracombe. Operating on designated frequencies in the range of 1.6MHz to 3.8MHz, the installation will provide a reliable service to the oil rigs which will be shared by customers on a party-line basis.

Included in the equipment to be supplied are 15 Autospec II radiotelegraph error correcting terminals. This system uses a special error correction code, which has been developed to allow reliable radio communication to be achieved in all but the worst conditions of fading and interference. The equipment also provides a visual indication of error detection which allows the operator to make an assessment of the circuit efficiency at any time. Marconi Communication Systems is to provide the equipment for the Post Office.

A further Post Office project to ensure high-quality communications for gas and oil production platforms working in the North Sea has been recently announced. The new project will link the country's telephone and telex networks to radio stations which are to serve production platforms. The new microwave routes will also provide an improved telephone service for people living in North-East Scotland, the Orkneys and the Shetlands. When the new service opens in 1977 it will be possible for production staff on platforms up to 200 miles offshore to send telex messages almost anywhere in the world without calling in the operator and to make world-wide telephone calls through the British Post Office system.

Errors reduced on radio-teleprinters

Dramatic error-rate reduction on h.f. and troposcatter 100 w.p.m. teleprinter circuits has been demonstrated using a recently developed time-diversity system. Under a United States Air Force programme, mobile h.f. communications vans were equipped with time-diversity modems developed by Barry Research Corporation for the purpose of evaluating the new technique. Simultaneous time-diversity and frequency-diversity circuits were established over a 1,000 mile h.f. path, Oklahoma to Georgia, in July 1974, and the error performances compared. Results showed that character-error-rate (c.e.r.) reduction factors of up to 1,000 were frequently obtained using time diversity, with an overall c.e.r. in a six-day period of 0.014% observed on the t.d. circuit and 1.7% on the f.d. circuit. More recently, similar performance has been demonstrated using the t.d. system with an Air Force microwave troposcatter system.

The equipment has been designed to overcome the effects of signal fading and impulsive noise interference encountered on radio circuits used to transmit teleprinter information. The system accepts synchronous or non-synchronous data, clear or encrypted, at rates up to 75 bits per second. Further information can be obtained from Interface International, 29 Market Street, Crewkerne, Somerset TA18 7JU.

Visitors to Mars—it's only the tiny antenna that's going though, not the earthling who's peering at the communicator through its environmental dome. The S-bend antenna will make the 11-month, 460-million mile journey with the Viking spacecraft that is scheduled to land on Mars in 1976.

Computers respond to human voice

A series of general-purpose computer systems which are controlled solely by the human voice has recently been introduced for operation in a wide range of industrial, scientific and commercial situations, from machinery control to banking transactions. These revolutionary systems can recognize words irrespective of accent or dialect and also against substantial background noise levels.

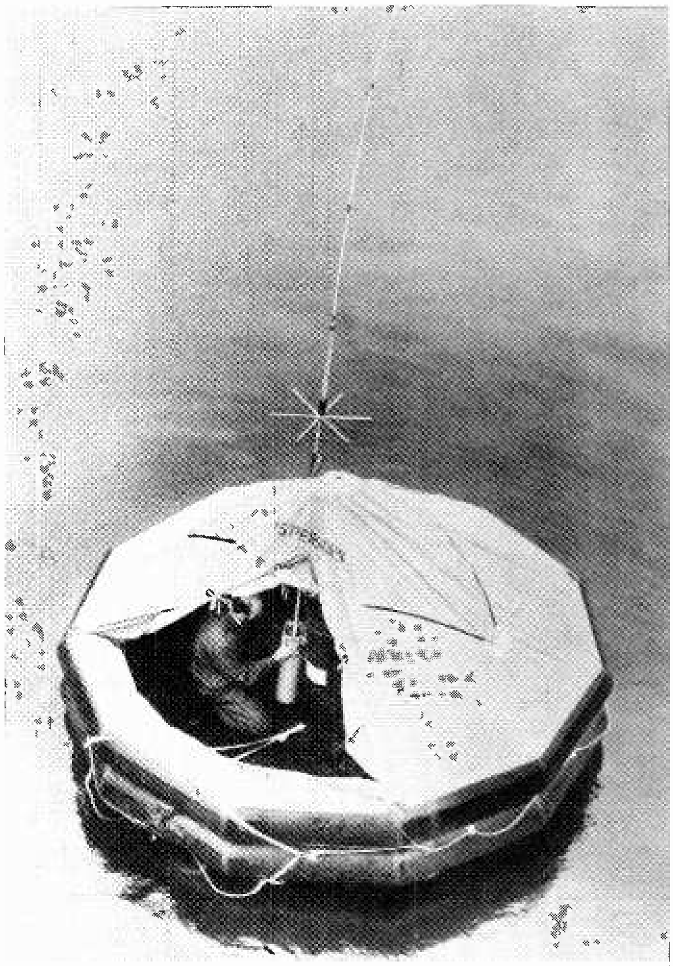
The first system unveiled in the series marketed by EMI Threshold is capable of accepting a vocabulary of up to 150 words or short phrases including digits. The equipment comprises a speech preprocessor unit measuring 18 × 20 × 26in, mini-computer, alpha-numeric display, microphone headset and standard teletypewriter. Communication with the equipment is not limited to one person. The system is quickly and easily programmed to accept instructions from up to 16 operators in sequence. The voice data of each person can be stored either in the system's memory, on orthodox punched paper tape or magnetic disc.

Initially the selected vocabulary is inserted by teletypewriter into the minicomputer, together with any programme of operations which the system will be carrying out later from spoken instructions. Users of the VIP 100 system then "train" the equipment to understand their individual pronunciation of the vocabulary by repeating each word either five or ten times into a noise cancelling microphone. The training time is less than 10s for each word. Repetition of each word enables the system to obtain an average voice pattern from the slight variations which occur each time the speaker pronounces the word. The speaker's pattern for each word is then stored in the memory against the relevant vocabulary data inserted by teletypewriter.

In use, each operator calls up his own voice pattern, identified by a reference number set on a control unit for speaker selection and word training. Each vocabulary word also has a reference number enabling the operator to call up any given word from the computer, at any time during use, for retraining should the operator's speech be affected by a cold or other causes since initially training the system. As each word is spoken, it appears on a visual display unit providing the user with instant verification that the computer has correctly "understood" the communication.

A control word such as "go" or "action" from the operator causes the system to despatch the inserted data either to whatever machine is linked to it such as a computer installation or machine tool or to the mini-computer's own memory. If when checking the data on the v.d.u., the operator discovers he has made an error, this can be deleted simply by using a second control word such as "erase" or "mistake".

A joint Anglo-American research programme into developing voice recognition techniques and applications still further is under way. At EMI's Central Research Laboratories the British research team's activities range from refining aspects of current voice recognition technology to long-term basic speech research associated with the voice control of future generations of machines. Future additions to the EMI Threshold range will include a system having specific relevance to the security field. It will have the facility to identify each voice by its individual and unique aural characteristics, offering potential applications including the control of access to restricted buildings.



Specialized aerial which radiates both 243MHz and 2.182MHz simultaneously is part of Ultra's new distress beacon which provides transmission on both the marine and aircraft distress frequencies.

Worldwide telephone link

A local telephone call to Loughborough now gives companies in Nottingham, Leicester, Derby and surrounding East Midland towns access via terminals to an extensive computer time-sharing service. The installation of a multiplexer in Loughborough by Honeywell opens up the Mark III service to the area at local call rates.

Based on a computer centre in Cleveland, Ohio, the Mark III service uses trans-Atlantic and trans-Pacific satellite and cable links to join North America, Japan, Australia and most of Western Europe. Terminals installed in users' own offices are connected to the Cleveland centre through the ordinary telephone system. The response at the terminal from the computer centre is a matter of seconds despite the distances involved and the technical complexity of the network. Honeywell estimates that it now offers local call access to Mark III to 85% of the potential commercial and industrial users in this country.

Test transmissions curtailed

In the light of its financial situation and the need to conserve fuel, the BBC has found it necessary to reconsider its trade test TV transmissions, which have been radiated throughout the day on BBC-2. The transmitters concerned use approximately 5,000kW of electrical power.

It has been decided to curtail these transmissions by about five and a half hours each weekday, while still maintaining some transmissions in the daytime for the benefit of dealers and installers. From Monday, January 20, the BBC-2 network has been on the air from 10.30 to 11.30 each morning, with a bulletin of service information at 10.30. Apart from any programme commitments, the network then closes until 16.00, when it reopens with the test card continuing until the start of evening programmes.

Safety for school TVs

The British Electrotechnical Approvals Board is inviting manufacturers and vendors to submit monochrome and colour TV receivers specially designed for use in schools for test and certification to the requirements of the British Safety Standard BS.415:1972, including amendments 1, 2 and 3. The tests will also take into account the safety requirements of clause 6 of BS.4958:1973 (specification for schools TV receivers and stands). Applicants should write to BEAB, Mark House, 153 London Road, Kingston-upon-Thames KT2 6NX, sending a list of models for which approval is required, together with descriptive literature. On receipt of this information BEAB will forward application forms and cost estimates for the necessary test work and certification fees.

Radio range increased twentyfold

The range of radio and television signals can be increased 20 times or even more by a new technique developed by a team of research scientists at Stanford Research Institute, California. The scientists have demonstrated that a temporary man-made bubble can be produced in the ionosphere which reflects radio signals back to earth. This makes possible an extension of their range to a point about 1,000 miles from the transmitter. Normally these signals would pass right through the ionosphere and are limited to a range of about 50 miles along a direct line from transmitter to receiver.

The bubble is produced by heating the ionosphere with a beam of shortwave radio signals from a ground-based "heating transmitter". The heating is based on principles similar to those on which microwave ovens are based. The bubble is typically about 100 miles in diameter. Invisible to the naked eye, the region can be photographed with an infra-red camera. When transmission is completed the reflecting irregularities disappear, leaving no pollution or ecological disruptions of any kind. The bubble would apparently be most useful for reflecting signals in the v.h.f. band. In essence, the heating transmitter required to produce the communications bubble is a 500kW short-wave radio transmitter connected to a special antenna.

New video system

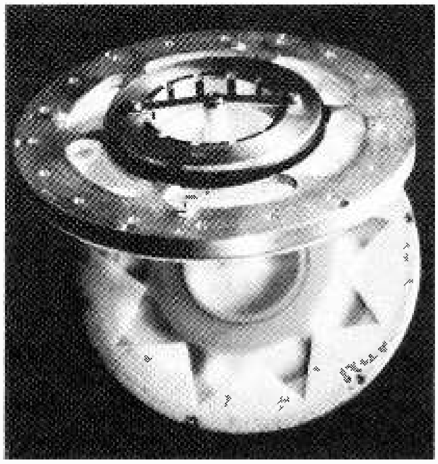
The Longitudinal Video Recorder (LVR) is a new video cassette system recently unveiled by BASF. Certain capabilities of the new system are claimed to extend beyond those of presently available video recorders. The new unit uses a small and compact cassette (118 × 110 × 16mm) loaded with 6.28mm wide chromium dioxide tape. Playing time is up to 120 minutes.

Recording and playback of video and sound signals are done with a fixed head. A system called "contact winding" allows the spool to move as the tape builds up on the spool with which the head is then able to maintain contact. Tape for an alternative 90 minutes playback time has a thickness of nine microns; the one for 120 minutes playback time is six microns. A single drive motor is used to provide a tape speed of 3m/s. Recording and playback of either colour or black and white is accomplished on a total of 28 tracks between which switching occurs in a period of 80ms. Compared with other video cassette systems, tape consumption is much lower and the cost for a playing time of one hour is expected to be around £10. Although a price for the LVR unit is not available yet, it should be approximately £500.

Laser pulses connect i.cs

Researchers have discovered a method of using laser pulses to form microscopic electrical connexions on fully-processed integrated circuit chips. The new technique provides a tool for repairing defective chips and for custom "wiring" of chips such as programmable logic arrays. Lasers have previously been used in electronic device fabrication for applications such as trimming resistors and cutting connexions. The key feature of the discovery, made by IBM scientists, is that laser pulses can also make new connexions through a layer of silicon dioxide, between an aluminium conductor on the surface of the chip and conducting channels in the silicon below. Connexions can be made without damaging adjacent fragile transistors or transistor-like structures.

The process involves a sequence of several short pulses (two to six nanoseconds) obtained from an organic dye laser. Longer pulses can cause extensive damage to surrounding regions. The sequence of pulses gives rise to three distinct processes. First, a small hole is produced by evaporation in the aluminium conductor. This is followed by explosive removal of the silicon dioxide between the aluminium and the underlying silicon at the connexion site. Finally the underlying silicon is melted and flows to the surface to form a connexion with the aluminium. The resulting connexion is less than five microns in diameter.



New flexible loudspeaker diaphragm material (see news item). Damping material is attached at the circumference and centre to prevent wave reflections within the material. Also attached to the diaphragm is the voice coil assembly. The chassis is shown at the top of the picture separately from the diaphragm.

Flexible speaker

Demonstrated at an IEE lecture during January was a new type of loudspeaker diaphragm which apparently defies the accepted necessity for a rigid cone structure. The diaphragm, which is flat, is made of a spongy flexible material, to which the voice coil is attached. The diaphragm is fixed at its circumference. The spongy diaphragm material provides a linear force against any pressure exerted against it. The aim is to eliminate inertial force and surround compliance properties associated with the conventional diaphragm, whose values are non-linear with respect to frequency. The new material provides resistive loading only and this should have a constant value throughout the frequency range so that applied force is always directly proportional to diaphragm velocity. In fact the response drops in a linear fashion above about 9kHz, but this can be compensated by electrical equalization. Bass resonance depends on signal amplitude and can vary in the region 20Hz to 40Hz.

The diaphragm is damped by foam material (see photograph) at the centre and around the circumference to prevent any wave reflection occurring within the diaphragm.

Audio/visual show for the Midlands

The first audio/visual show in the Midlands is to be held on April 11th, 12th and 13th, 1975. The first day will be for trade and press only. Site of the exhibition will be the conference and exhibition complex at the National Agricultural Centre, Kenilworth, Warwickshire. Exhibitors' products at the show will encompass video record and replay equipment, lighting effects, educational aids, sales training work and business aids. In addition there will be the widely based consumer items including cassette, radio, cartridge and record equipment.

High Fidelity 75 expands

As a result of the success of High Fidelity 74 in April last year, this year's exhibition is to be increased from five days to six, allowing three days for trade and press only. Extra exhibition space is to be provided at the Heathrow Hotel, Heathrow and part of the show moved into the nearby Skyline Hotel to cater for the expected increase in the number of visitors. The exhibition will run from April 8th to 13th inclusively and the first three days will be trade and press only. Opening times will be: trade days 9am to 7pm; public days 10am to 8pm and Sunday 11am to 6pm. A regular, free coach service will link the Hounslow West Underground station with the exhibition.

Briefly

More power from the BBC. Radio London's medium wave service on 206 metres (1457kHz) is now transmitted from a new high-power transmitter at Brookmans Park, near Potters Bar. Throughout the service area reception should be improved.

First retailer to head RTEEB. The Council of Management of the Radio, Television & Electronics Examination Board recently elected Mr Sydney Hetherington, Managing Director of Wright (Rental) Ltd of Coventry and Kenilworth, as its chairman.

Low-noise wideband amplifier

Design with paralleled transistors for use with low source resistances

by J. A. Grocock

The design of single transistor low noise pre-amplifiers is well known[1] and a noise figure close to unity is achievable for source resistances in the range 10kΩ to 100kΩ. In some applications, such as hot wire anemometry for measurement of gas temperature and gas flow, the source resistance is very low, lying within the range 4Ω to 100Ω. Typical signal voltages are 1–10μV peak over the frequency range 100Hz to 200kHz. Thus, a wideband low noise amplifier is required.

One method of solving this problem is to use a transformer to match the amplifier noise resistance to the source resistance; but when the bandwidth is as stated above the transformer design is difficult. A large primary inductance is necessary in order to obtain a suitable low frequency break point, but the requirements for the higher end of the frequency range are the opposite —minimum number of turns to reduce leakage inductance and winding capacitance. The use of transistors connected in parallel is a better solution and the principle will now be described.[2]

Transistors in parallel. Consider the two transistors connected as shown in Fig. 1 and the single transistor circuit shown in Fig. 2.

The collector signal current of each transistor in Fig. 1 flows through R_L and the signal gain is twice that of Fig. 2. (This assumes that Tr_1 and Tr_2 are identical and that $R_{IN}/2 \gg R_S$, where R_{IN} is the input resistance of Tr_1 and Tr_2.)

The collector noise currents of Tr_1 and Tr_2 in Fig. 1 are not correlated, (I_{CN} total$=\sqrt{I_{CN1}^2+I_{CN2}^2}$; I_{CN1} =collector noise current of Tr_1 and I_{CN2} =collector noise current of Tr_2) and the total noise current in R_L is $\sqrt{2}\,I_{CN1}$. The signal/noise ratio of Fig. 1 is $2I_{CS}/\sqrt{2I_{CN}}$ and in Fig. 2 is I_{CS}/I_{CN} where I_{CS} is the collector signal current of Tr_1 or Tr_2. Thus the signal/noise ratio for Fig. 1 is $\sqrt{2}$ times that for Fig. 2. If R_S is large then the above reasoning does not apply and the single transistor circuit has the best signal/noise ratio.

It can be shown (see Appendix) that the effect of connecting two identical transistors in parallel is to reduce the equivalent noise voltage resistance and equivalent noise current resistance by a factor of 2. This means that the optimum source resistance is also reduced by the same factor. Four transistors in parallel would produce an optimum source resistance one quarter of that for a single transistor.

Obviously there is a limit to the number of transistors that one can connect in this way. Increased collector capacitance reduces the bandwidth and the collector current cannot be reduced indefinitely.

Practical circuit. The amplifier shown in Fig. 3 is driven from a 75Ω source and has a bandwidth of 7Hz to 2.5MHz (−3dB). Two feedback paths are used, one to provide low d.c. gain and stabilize the bias voltages and the other to provide independent adjustment of a.c. gain. The circuit has a voltage gain of 70 and the output noise voltage was 67μV r.m.s. over the frequency range of 15Hz to 300kHz.

The noise figure can be calculated as follows:

$$\text{Total noise output power} = \frac{66.5^2 \times 10^{-12}}{R_L}$$

Noise volts V_N produced by R_S at room temperature$\approx \frac{1}{8}\sqrt{R(\mathrm{M}\Omega) \times B(\mathrm{Hz})}\,\mathrm{V}$.

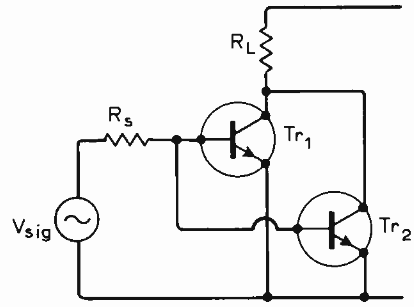


Fig. 1. Two transistors in parallel.

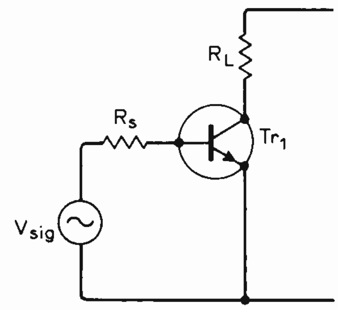
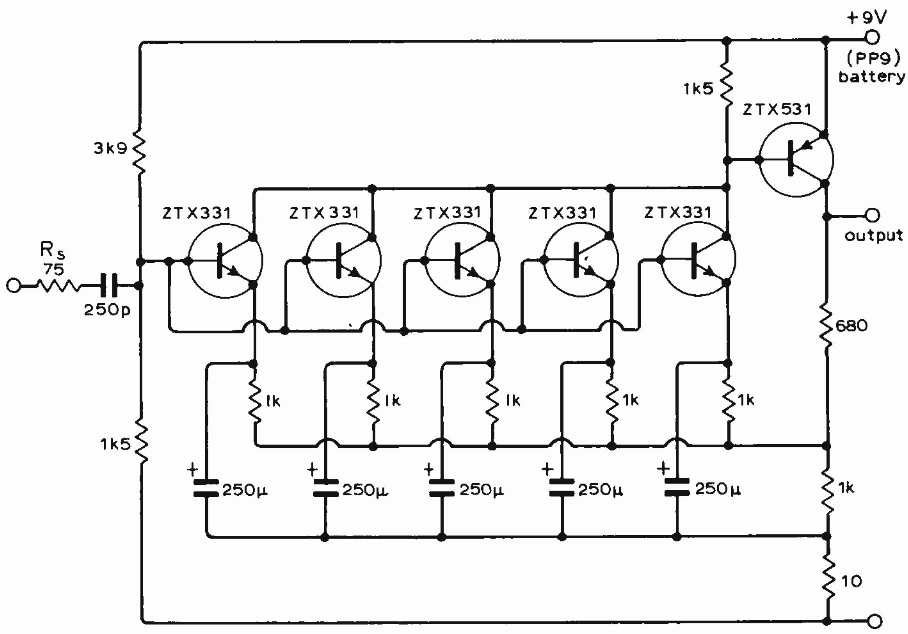


Fig. 2. Single transistor circuit.

Fig. 3. Amplifier design using transistors in parallel and having a bandwidth of 7Hz–2.5MHz. (Transistors are Ferranti types; resistors, carbon film; and capacitors, electrolytic.)



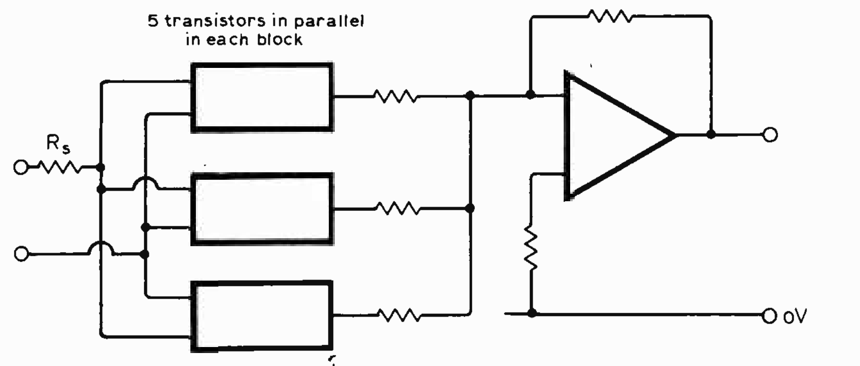


Fig. 4. Arrangement for using several of the Fig. 3 amplifiers and summing their outputs.

$\therefore V_N(75\Omega)=\frac{1}{8}\sqrt{75\times10^{-6}\times4.7\times10^{5}}$ μV r.m.s. (noise bandwidth$=\frac{\pi}{2}\times$3dB bandwidth)$\approx$0.75μV r.m.s.

Noise output power due to R_S above, is

$$\frac{(70\times0.75)^2\times10^{-12}}{R_L}$$

$$\therefore \text{NF}=10\log\frac{67^2}{52.5^2}\approx 2\text{dB}$$

Further improvements. A further reduction in noise figure can be obtained by using several of the amplifiers shown in Fig. 3 and summing their outputs as shown in Fig. 4. This technique would also be useful when the source resistance is lower than 75Ω.

Acknowledgements. My colleague Mr A. W. Doel has been of considerable help in the development of low noise amplifiers over the past year. Thanks are also due to Rolls-Royce (1971) Limited for permission to publish this article.

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"Probing transistor noise." Application Note 137, Hewlett Packard.

2. "Optimum design of low noise amplifiers" by E. A. Faulkner. *Electronics Letters*, Vol. 2, No. 11, pp. 426–427 (Nov. 1966).

Further reading

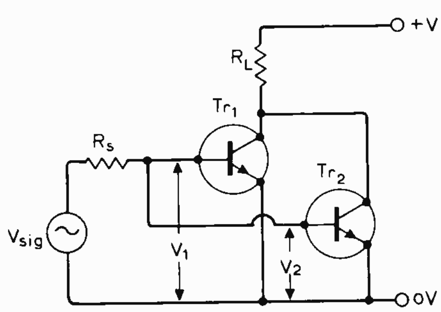
"Low noise audio amplifiers" by H. P. Walker, *Wireless World*, May 1972.

"Thermal noise in field effect transistors" by Van Der Ziel. *Proc. IRE*, August 1962.

"Analogue dialogue." Analogue Devices Ltd, March 1969.

Appendix

Consider the circuit shown below:



Tr_1 and Tr_2 are identical transistors with the same input resistance, current gain and noise generators.

Let:

R_I = input resistance of Tr_1 or Tr_2;

R_V = equivalent voltage noise resistance of Tr_1 or Tr_2;

R_I = equivalent current noise resistance of Tr_1 or Tr_2;

$V_1 = Tr_1$ input voltage;

$V_2 = Tr_2$ input voltage;

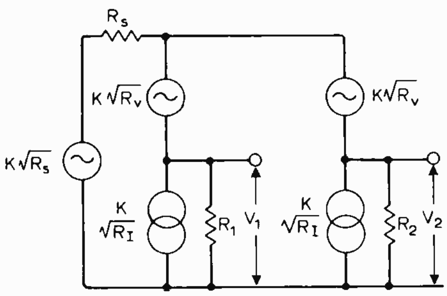
I_{C1} = collector current produced by Tr_1;

I_{C2} = collector current produced by Tr_2;

$\beta = Tr_1$ or Tr_2 current gain;

I_N = noise current in R_L.

The noise equivalent circuit is:



$$\text{NF}=\frac{\text{total noise output power}}{\text{noise output power produced by } R_S}$$

The total noise output power can be calculated by considering each generator in turn and replacing all other generators with a short circuit or open circuit.

Taking $K\sqrt{R_S}$ first,

$V_1 = K\sqrt{R_S} = V_2 (R_I \gg R_S)$

$\therefore I_{C1} = AK\sqrt{R_S} = I_{C2}$

where $A=\frac{\beta}{R_I}=\frac{\beta}{R_2}$

These two currents are correlated and the total noise current in R_L is:

$$I_N = 2AK\sqrt{R_S}.$$

Next, considering the two generators $K\sqrt{R_V}$ each generator will produce an input voltage across its associated transistor only, and the collector currents produced will be uncorrelated.

$V_1 = K\sqrt{R_V} = V_2$ (R_I and $R_2 \gg R_S$)

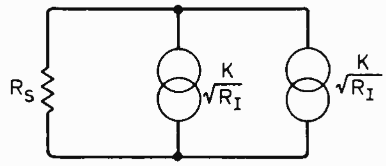
$$\therefore I_{C1}=\beta\frac{K\sqrt{R_V}}{R_I}=AK\sqrt{R_V} \text{ where } A=\frac{\beta}{R_I}$$

$$I_{C2}=AK\sqrt{R_V}$$

I_N total noise current in R_L is

$\sqrt{A^2K^2R_V+A^2K^2R_V} = AK\sqrt{2R_V}$

Finally, I_N produced by the current generators can be calculated with all voltage generators short circuit.



The noise voltage across R_S is the input voltage to both transistors.

$$V_1=V_2=R_S\sqrt{\frac{K^2}{R_I}+\frac{K^2}{R_I}} = KR_S\sqrt{\frac{2}{R_I}}$$

The two collector currents produced by this voltage are now correlated.

$$I_{C1}=I_{C2}=AKR_S\sqrt{\frac{2}{R_I}}$$

$$\therefore I_N = 2AKR_S\sqrt{\frac{2}{R_I}}$$

The total noise current in R_L can now be obtained:

$$I_N(\text{total})=\sqrt{4A^2K^2R_S+A^2K^22R_V+\frac{8A^2K^2R_S^2}{R_I}}$$

Total noise power=

$$A^2K^2R_L\left[4R_S+2R_V+\frac{8R_S^2}{R_I}\right]$$

Noise power produced by R_S alone=

$$4A^2K^2R_LR_S$$

$$\therefore \text{NF}=\frac{4R_S+2R_V+\frac{8R_S^2}{R_I}}{4R_S}$$

$$\text{NF}=1+\frac{R_V}{2R_S}+\frac{2R_S}{R_I}$$

$$=1+\frac{\frac{R_V}{2}}{R_S}+\frac{R_S}{\frac{R_I}{2}}$$

$$\frac{d(\text{NF})}{d(R_S)}=\frac{-R_V}{2R_S^2}+\frac{2}{R_I}$$

$$\therefore R_S \text{ optimum}=\sqrt{\frac{R_VR_I}{2}}$$

An i.c. telephone tone generator

A simple design suitable for use with elementary demonstration models of a telephone exchange

by R. Ball, B.Sc. (Eng)

Department of Electrical Engineering, Lanchester Polytechnic, Coventry

A tone generator was required for incorporating in a demonstration telephone exchange. The generator had to produce dialling tone, ringing tone, busy tone, and number unobtainable tone. The tones were required to be recognizable but did not have to conform rigidly to the normal specifications.

The tones that it was required to approximate were:
(a) Dialling tone—continuous 35–50Hz. (b) Ringing tone—400Hz modulated at 25Hz and interrupted as follows: ON—400ms; OFF—200ms; ON—400ms; OFF—2s. (c) Busy tone—400Hz interrupted as follows: ON—375ms; OFF—375ms. (d) Number unobtainable tone—400Hz continuous.

These had to be capable of driving up to four telephones at reasonable volume level.

It was decided that an electronic version would be suitable, and cheaper, than a version based on a motor, and a design was conceived using digital integrated circuits. It was also decided that the following tones would be recognizably close approximations to the standard tones, and would have advantages of economy in circuitry: (a) Dialling tone—continuous 30Hz. (b) Ringing tone—400Hz interrupted at 30Hz and also interrupted as follows: ON—375ms; OFF—375ms; ON—375ms; OFF—1.875s. (c) Busy tone—400Hz interrupted as follows: ON—375ms; OFF—375ms. (d) Number unobtainable tone—400Hz continuous.

Design details

The design involved the use of three astable oscillators built up from 74-series t.t.l. NAND gates. These were of conventional self-starting design (Fig. 1). The values of the capacitor C were as follows:

Oscillator 1, 400Hz; $C = 3.2\mu F$.
Oscillator 2, 30Hz; $C = 40\mu F$.
Oscillator 3, 1.33Hz; $C = 500\mu F$.

These use SN 7400N i.cs. The 1.33Hz signal was divided-by-two twice, using a D-type flip flop, SN 7474N, giving frequencies of 0.67Hz and 0.33Hz.

The 400Hz and the 30Hz signals were used directly for the number unobtainable and dialling tones respectively. The 400Hz signal was also fed into a NAND gate with

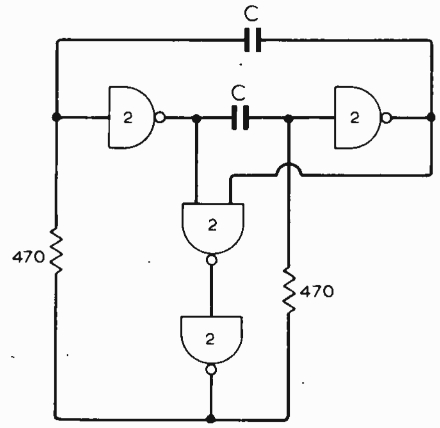


Fig. 1. Oscillator circuit assembled from t.t.l. NAND gates. For capacitor values for the three frequencies see text.

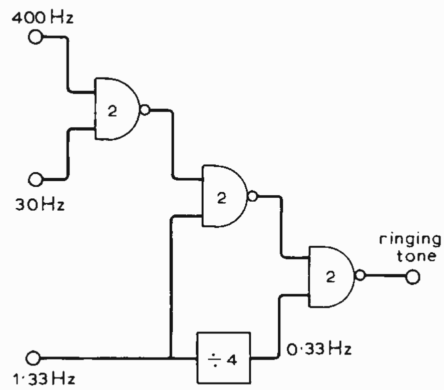


Fig. 2. System of gates used to obtain the ringing tone has inputs from all three oscillators, 400Hz, 30Hz and 1.33Hz.

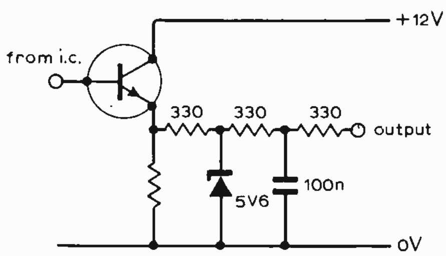


Fig. 3. Circuit used to protect output of tone generator from damage arising from uniselector voltages.

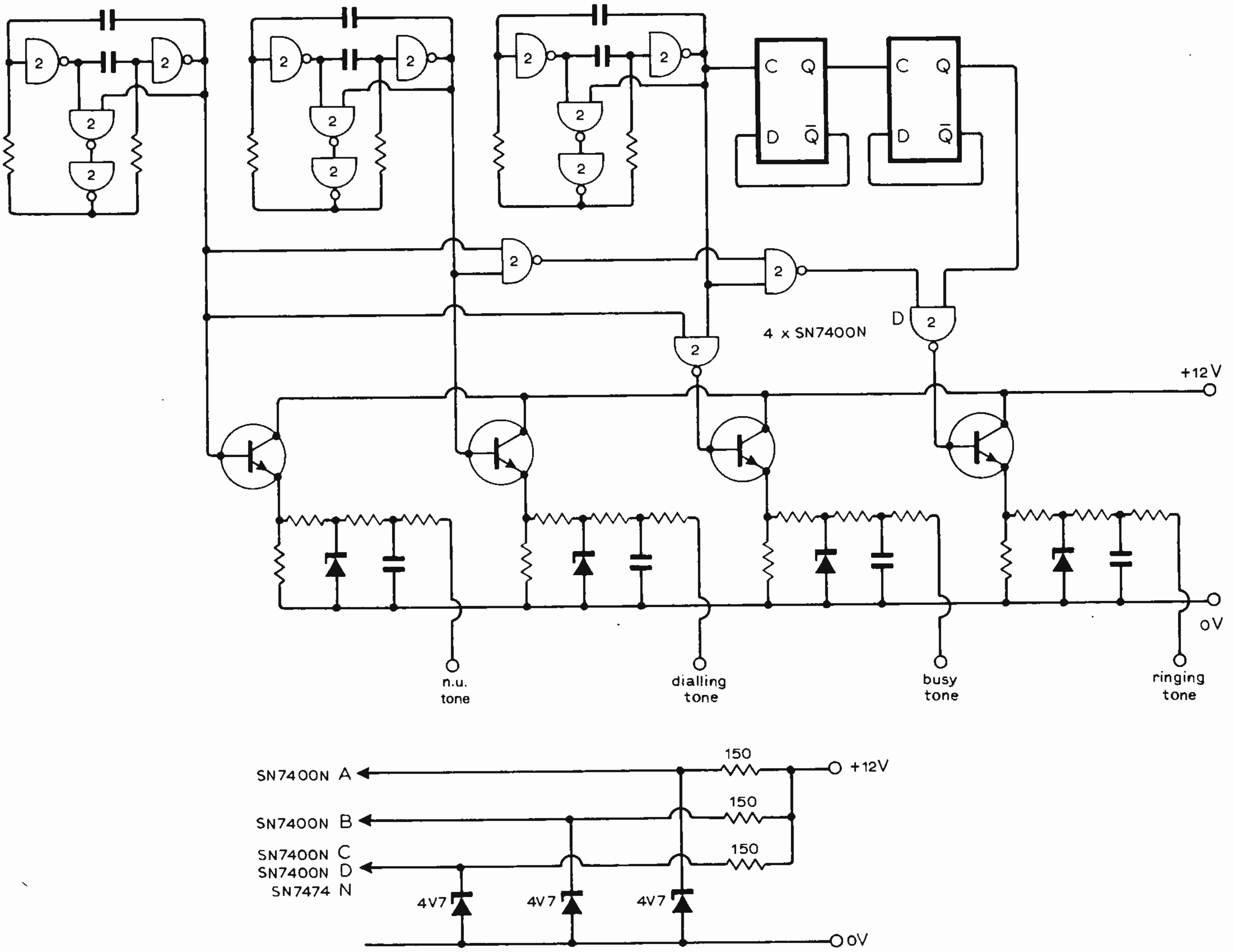


Fig. 4. Complete circuit diagram of the tone generator with voltage supply arrangements below.

the 1.33Hz signal and the output was used for the busy tone. To obtain the ringing tone, the 400Hz signal was first fed into a NAND gate with the 30Hz signal and this output was connected to a second NAND gate with the 1.33Hz signal. Finally this was then fed to a third NAND gate with the 0.33Hz signal to give the required output. This is shown diagrammatically in Fig. 2.

It was found necessary to select the capacitors used in the oscillators to obtain the most realistically sounding tones.

Output circuitry. Since the tone generator was to be used in conjunction with a normal uniselector relay-type demonstration exchange, its output had to be protected to avoid damage which might be caused by a short circuit; continuous 50V d.c. of either polarity; or fast high-level switching spikes; any of which might appear across the terminals.

This protection was achieved by using the circuit of Fig. 3. It was found that up to four telephone handsets could be connected to the output with an acceptable signal level in each.

Power supply. The tone generator was designed to run from a 12V d.c. supply. This voltage was used directly for the output transistors, and zener diodes were used to produce the supply voltage required by the integrated circuits.

The frequency of an astable multivibrator varies if the supply voltage is changed and it was found that if all the integrated circuits were run from the same zenered supply intermodulation occurred due to supply regulation. It was thus necessary to run the circuitry from three supplies each zenered independently.

A full circuit diagram of the generator is shown in Fig. 4.

Announcements

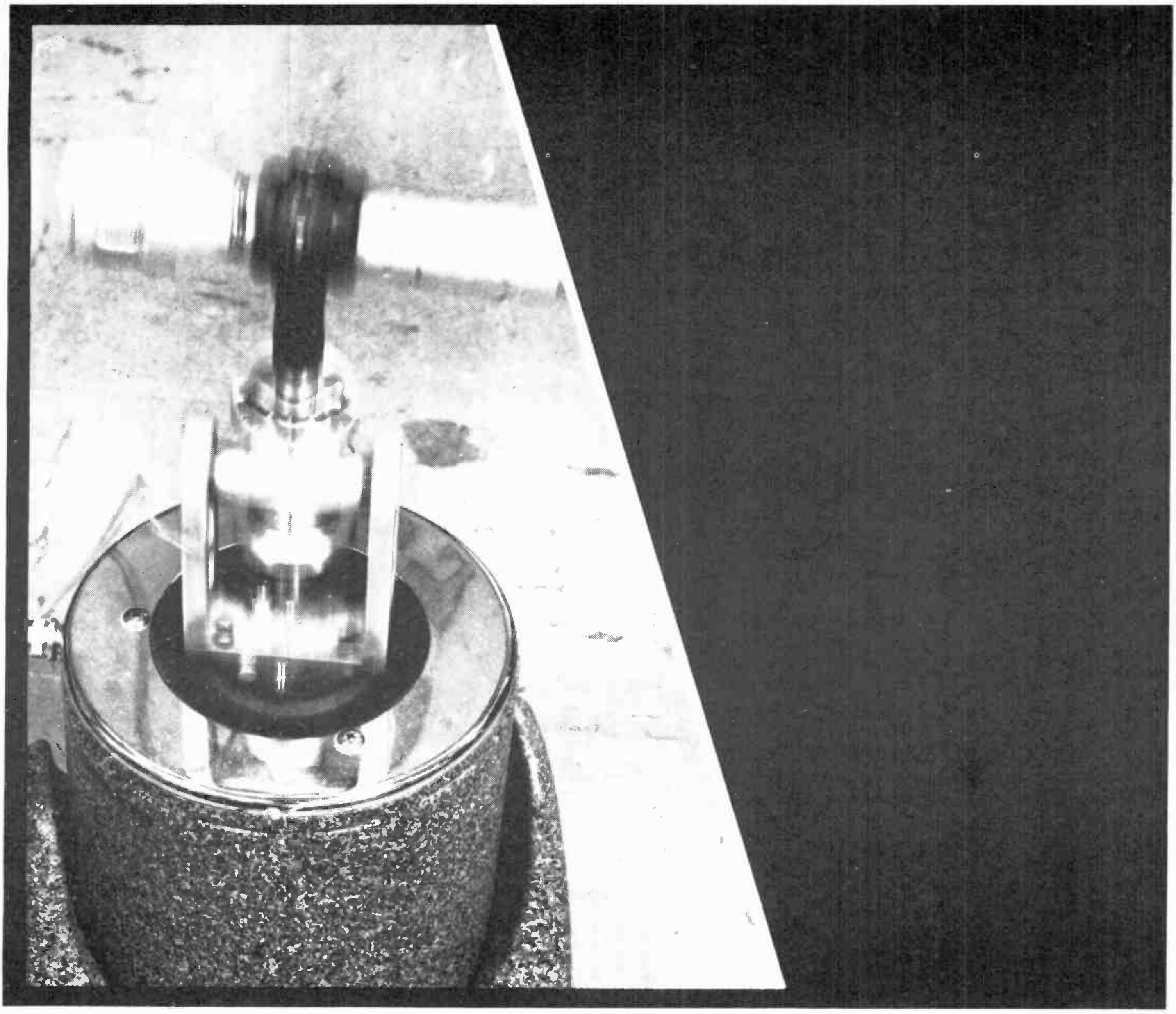
The Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester, Essex CO4 3SQ, will be holding its annual Electronics Summer School for the week of July 7–11. Two courses will be run simultaneously. The first course, ESS 8—**Linear Circuit Design**—is concerned with the use of transistors and operational amplifiers in linear applications such as amplifiers, filters and power supplies. The second course, ESS 9—**Digital Circuit Design**—concentrates on the use of the transistor as a switch and develops design, using integrated logic circuits; this leads on to combinational and sequential logic concepts. Both courses are aimed at the same introductory level and the Summer School is probably most suited to teachers running electronics clubs or taking "A" level science courses.

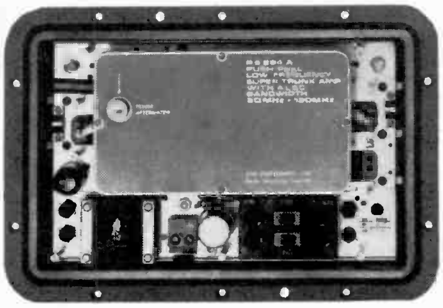
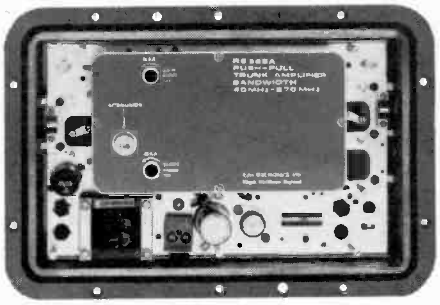
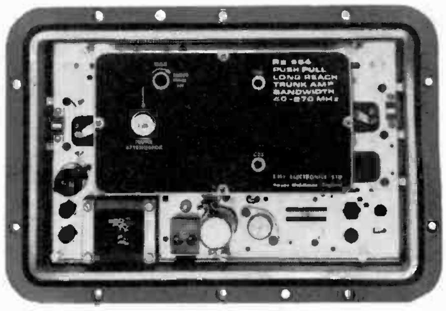
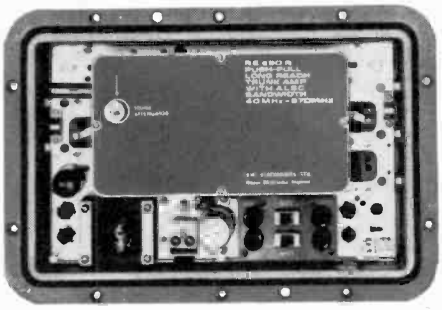
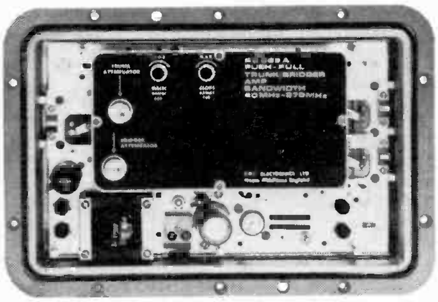
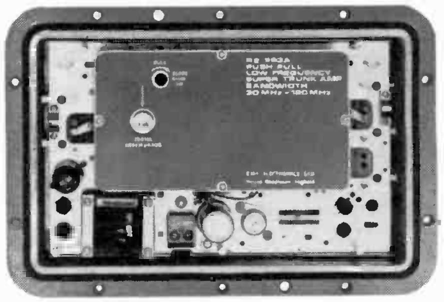
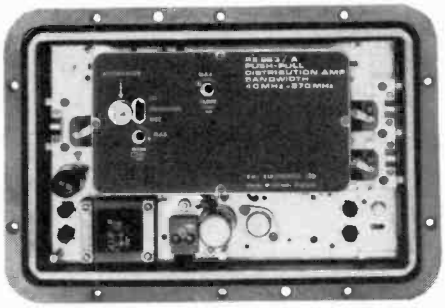
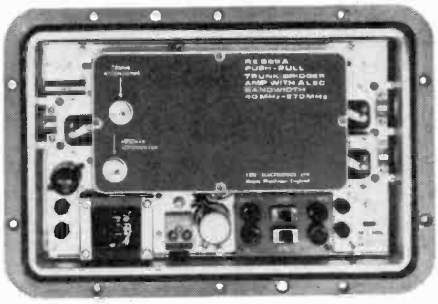
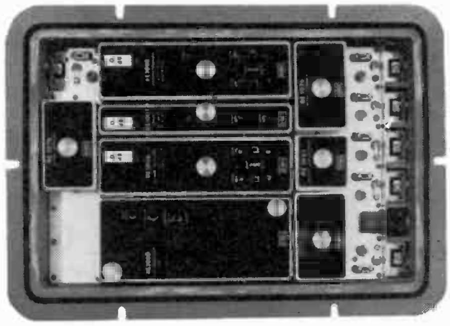
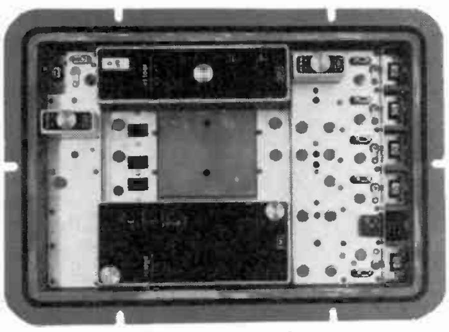
A new independent **microprocessor consultancy**, Pelco (Electronics) Ltd, 61 Lansdowne Place, Hove, Sussex BN3 1FL, has been formed to provide skilled advice as well as services not readily available from manufacturer or distributor, including hardware and software design programme testing and de-bugging. The consultancy is backed by Motorola in terms of technical resources.

Helios Electronics Ltd, manufacturer of professional multichannel **mixing desks**, has moved to Browells Lane, Feltham, Middlesex TW13 7ER.

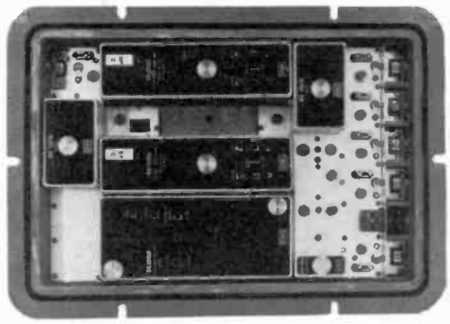
Lohuis Electro BV of Holland have appointed Leron Electronics Ltd, 78 Central Buildings, 24 Southwark Street, London SE1 1TU, as their sole distributors in the UK. In addition to a comprehensive range of standard filament and neon **instrument lamps**, Leron Electronics are also able to supply special lamps to meet most application requirements.

Advance Electronics has appointed Sensors & Systems Ltd as distributor for the Advance MT range of **magnetic transducers**. Sensors & Systems, of Melbourne, Derbyshire, will handle all small-quantity orders (for below 20 devices) at a price of £9 per device. In addition, Sensors & Systems will offer a service for the supply of complete systems incorporating transducers and other Advance control products.



EMI offers a wider choice of options in cable TV.



The quality of EMI Colorline cable television equipment is proved daily in systems bringing high quality television to hundreds of thousands of people—particularly in Europe.

Now EMI introduces a new range of modular VHF network amplifiers offering full two-way facilities.

The new range—the Colorline RE1000 series—has a basic forward bandwidth of 40-300 MHz with optional reverse band-widths of 5-30 MHz or 5-100 MHz. At the same time EMI also introduces a unique multi-channel VHF/UHF Distribution Converter. It enables up to seven channels to be converted from a VHF trunk network into the UHF bands for local distribution.

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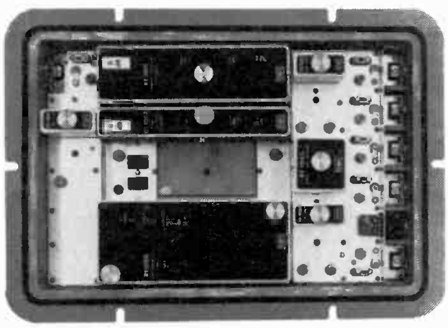

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The use of video tape recorders with domestic TV

by A. C. Smaal

Central Applications Laboratory N.V. Philips Gloeilampenfabrieken, Eindhoven

Domestic television receivers were not developed with any other requirement in mind but the reception of broadcast signals. The anticipated growth of video tape recorders for domestic use will pose problems in that mains-transformerless receivers will require isolation from v.t.rs, while the video signal must not suffer deterioration. Additionally, the reduction in quality of the recorded signal compared with a broadcast signal will mean design changes in receiver time-base circuitry. This article examines these problems, posing some possible solutions.

A basic video tape recorder (v.t.r.) requires a video frequency signal during recording and produces a video frequency output on playback. When a domestic TV receiver is employed either as a signal source or as a display monitor in conjunction with a v.t.r., the video information should ideally be exchanged at video frequencies. The fact that domestic TV receivers are usually not isolated from the mains supply is a serious obstacle to such a straightforward signal transfer; the TV receiver must be isolated or provided with some form of isolating adapter.

There are several methods of isolating the receiver. An isolating transformer can be inserted between the mains supply and the receiver; this is an effective but expensive solution. Alternatively, an isolating switch-mode power supply[1] could provide the answer, but at present this is not to be found in most receivers. It is also possible to employ a relay which automatically connects the receiver chassis to the mains neutral line, but this method requires that an earth connexion be available at the receiver, which is contrary to normal "entertainment" practice; furthermore, such an arrangement cannot be used with receivers containing a bridge rectifier power supply. Some form of chassis-isolated video-frequency adapter is thus needed to act as a safe output and/or input for the receiver, without introducing distortion.

Video-frequency adapters. Apart from providing electrical separation from the mains supply, the adapter should obviously transfer the wideband video signal. One method which is currently employed consists in modulating the video information on to a carrier and subsequently injecting it into the receiver. However, processing the video information in this way involves expensive and cumbersome circuitry if loss of video information is to be avoided.

A more attractive solution has been found in the design of a special wide-band video transformer, which fulfils the most important safety requirement. An adapter using such a transformer has recently been developed with satisfactory results. Other systems are still under investigation, for example a light-coupler (a light-emitting diode combined with a photo-detector in a common envelope), which provides the required isolation. This method is particularly promising because the performance of light-couplers is improving while at the same time their price is going down. Other isolating signal-transfer devices using Hall generators and piezo-electric materials are undergoing evaluation.

Adapter functions. So far only the transfer of video information has been considered, but in a practical system the adapter will have other functions to perform as well. It must transfer the audio signal, switching instructions and colour information, and, at the same time, it should not affect the proper operation of the receiver when the v.t.r. is connected.

There are no particular problems involved in the transfer of the audio signal. Isolating transformers with the necessary bandwidth are readily available.

The switching function is required to change the receiver from its normal state to one more suitable for monitoring. In particular the r.f., video and sound i.f. sections should be made inoperative to avoid interference by spurious signals while the receiver is acting as a monitor. Furthermore, v.t.rs may display considerable time-base errors so that the line flywheel constant in the receiver must be changed for optimum picture display.

Colour information may be transferred either in a composite signal, as in professional practice, or as decoded (chrominance separated from luminance) in the receiver; in the latter case the two components are applied separately to the recorder where they are combined in a form suitable for recording. However, from the proposal now circulating within the IEC and DIN[3], it appears likely that colour information transfer between receiver and recorder for domestic and educational purposes will be by means of a composite video signal.

If the receiver is to function correctly when used in conjunction with a v.t.r., the adapter must match the two equipments correctly and, moreover, ensure correct signal polarity, amplitude and level unless provision has been made in the receiver to do so.

The foregoing considerations are only general, and no attempt has been made to analyse the requirements of any particular adapter system. Because of the lack of standardization and the wide variety of both receivers and v.t.rs there would be little point in discussing a particular example. However, some degree of standardization has been achieved upon the introduction of the Philips video cassette recorder (VCR). The system used in this equipment has been accepted as a basis for standardization in Western Europe. (It is hoped that some standardization of the form and function of the connexion point provided for v.t.rs may also be achieved.) Wherever specific examples are required, the Philips VCR will therefore be cited.

Receiver design. The v.t.r. is the first equipment which is intended for connection to the domestic model TV receiver.[2] Hitherto, the TV receiver designer has had considerable design latitude, and this has, in turn, resulted in many different types of receiver chassis. However, as home video equipment sales increase, many customers will expect a receiver to be so designed that it can be adapted to recording and/or reproducing apparatus.

The extent to which domestic TV sets

will need modification depends on the characteristics of the recording/reproducing equipment with which they are to be used. This article will therefore discuss the peculiarities of v.t.rs as these affect the monitoring apparatus.

Video tape-recording

The present-day v.t.r. is a largely mechanical device, and, as is to be expected, any shortcomings of its mechanical properties may seriously affect signal processing. Electronics can be used to help to maintain the played-back signal to the original broadcast standards by means of servo systems, electronically variable delay lines, dropout eliminators or other devices. Unfortunately, economic or other considerations will often prevent the application of such correction methods.

Mechanical shortcomings are apt to assume greater importance when a tape recorded on one machine is to be replayed on another. As a general principle, it is desirable that an acceptable picture should still result if a recording is made on a v.t.r. whose tolerances are all at one limit, and played back via another v.t.r. whose tolerances are at the other limit.

The effects of electrical and mechanical spreads may not be the same for all recording systems. Before examining video recorder faults in detail, we shall discuss some variants of the v.t.r. with reference to the direction of the video tracks on the magnetic tape.

In *transverse recording*, shown in Fig. 1, the tape is held in contact with the curved surface of a spinning drum which contains the video heads. The tape is moved past the heads in a direction parallel with the axis of rotation of the spinning drum, and a succession of parallel tracks is recorded which run almost perpendicular to the length of the tape. The very high scanning speed of the heads provides sufficient bandwidth to allow frequency-modulated recording of the complete TV signal. Unfortunately, the mechanical and electronic complexity of this system makes it economically unattractive for domestic applications.

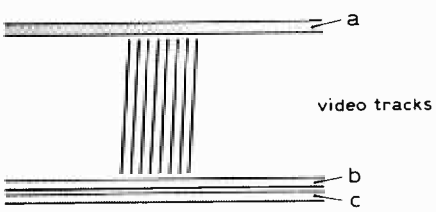


Fig. 1. Pattern of the tracks recorded onto a video tape produced by a "transverse" mode v.t.r. The edge tracks a, b and c are available for sound, synchronization pulses, and cue.

In the *longitudinal recording* method of Fig. 2, the tape is drawn past a stationary video head at the high speed necessary to allow a video signal to be recorded. The resulting high tape consumption and short playing time for any one tape track are distinct drawbacks of this system. Domestic recorders using the longitudinal system are still in the experimental stage.

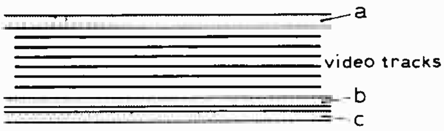


Fig. 2. Pattern of the tracks produced by a "longitudinal" mode v.t.r. Tracks a, b and c are also used for sound, synchronization pulses and cue.

In *helical recording* systems, of the Fig. 3 type, the tape is wrapped as a part turn of a helix around a revolving drum. The head rotates on the axis of the drum, and scans tracks at a small angle to the direction of motion of the tape. Recorders using the helical system are being used increasingly in applications wherever a picture quality less than broadcast standard is acceptable.

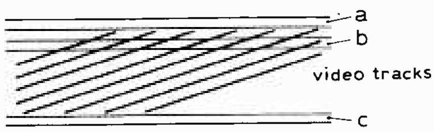


Fig. 3. Pattern of the track employed in helical recording. Again, a, b and c are sound, synchronization and cue tracks.

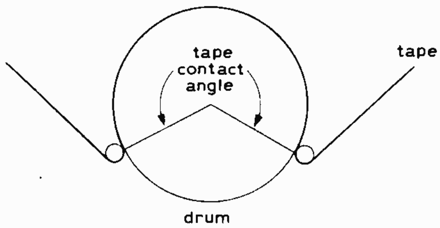


Fig. 4. Representation of the contact angle.

V.t.rs are available with practically every variation on the helical theme: the tape contact angle in Fig. 4 may range from 90° to 360°, one or several heads and one or several fields per video track may be used, and there are various tape transport speeds and tape widths in use. Most v.t.rs for the entertainment sector, including the Philips v.c.r., are of the helical type.

Shortcomings of helical-scan recorders

Line frequency deviation. The head-to-tape speed in a helical recorder has two components: the tape speed and the head speed. Provided the angle of the track with respect to the longitudinal direction of the tape is small, the effective head-to-tape speed is nearly equal to the algebraic sum of the two components.

If a tape receives a video recording at a given scanning speed and is played back at a different scanning speed, the line frequency observed at playback will be shifted in the ratio of the two scanning speeds. Head-to-tape speed in helical recorders is therefore controlled by means of synchronization pulses recorded on to the tape together with the programme material; one of the tracks *a*, *b*, or *c* of Figs. 1, 2 and 3 may be used for this purpose.

At playback these pulses can be applied to servomechanisms to control either the rotational speed of the head or both the head and tape speed. If only the head speed is controlled, the tape speed being determined by a mains-driven synchronous motor, then any deviations in tape speed (whether caused by mains frequency or other variations) will directly affect the frequency of the synchronization pulses obtained from the tape and, hence, the head speed. In recorders using servo control of both head and tape speed the variation of the line frequency observed will be essentially determined by the stability of the reference oscillator from which the synchronization pulses are derived, and with which they are compared.

If the various factors which determine line frequency deviations fluctuate in time, the reproduced line frequency will be subject to continuous modulation. The magnitude of this frequency "wobbling" depends on the tolerances imposed on the head and tape speeds of the apparatus used.

Phase jump. When, during both recording and playback, the tape speed, head disc angular velocity, and tape contact angle are all kept constant, the scanning speed will vary if the drum diameter is subject to changes (due to temperature fluctuations). Since the rotational speed remains constant, a varying scanning speed will result in a line frequency deviation. If this occurs and the field frequency remains correct, the number of lines per field will change, and this will result in a jump in the position of the sync pulse and in the picture content as the heads change over from one track to another.

If the tape is distorted, whether as a result of humidity, tension, or changes in temperature, the track length will also be changed, and this will have the same effect as a varying drum diameter.

Gap. Another fault, which can be associated with the effect of mechanical spread, is the loss of lines in a raster, causing a gap. This may occur when the position of the video head orbit with respect to the tape is incorrect. Such changes are normally due to guiding errors.

Fig. 5 illustrates the effect of such a tape guiding error during recording. When the distance between the tape guide and the chassis during recording is h, then a track *P-Q* is scanned (Fig. 5a). If, on playback this distance is h' (Fig. 5b), the scanned track will be *P′-Q′*. Consequently, information recorded on *Q-Q′* is lost, and no signal is found on section *P-P′*. As a result, a gap appears in the video signal. Since guiding errors do not influence the lengths *P-Q* and *P′-Q′*, these errors will not affect the reproduced line frequency.

A similar effect is observed when the angles between the tape transport direction and the orbit of the video heads are not identical during recording and playback.

Lastly, a reduction in the angle of contact between the tape and the video head drum will lead to loss of video information since the recorded track will not be scanned at either end during playback.

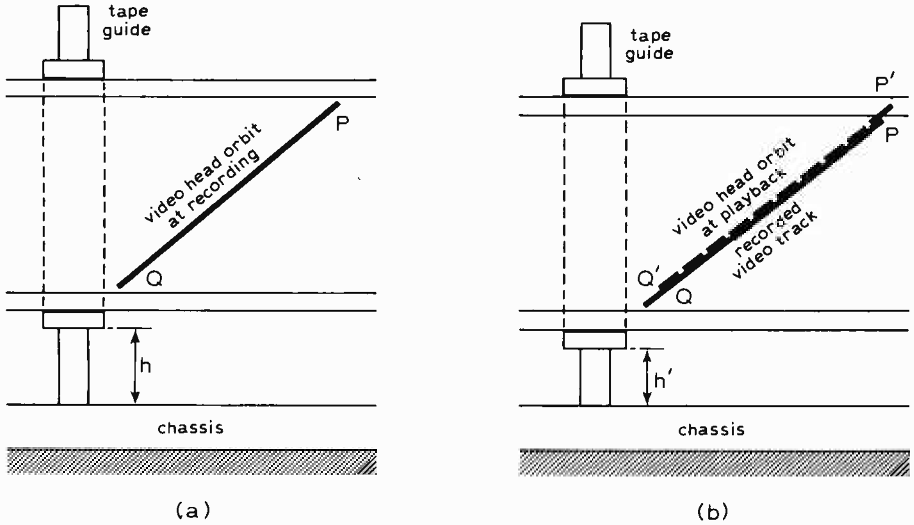


Fig. 5. Effects of tape guiding errors.

The designer of a v.t.r. can arbitrarily choose the location of any gap which may occur during the field scan. If a phase jump is to occur it will take place immediately after the gap. It is logical that most of the picture disturbance resulting from a phase jump should be concealed by the frame blanking interval. This can be done by locating the gap either immediately before or after the vertical sync pulse.

Head position error. If two circumferentially mounted heads are not placed exactly opposite each other on the scanning disc, the intervals between their coming into contact with the tape will differ. Since the heads might both be either in or out of contact with the tape simultaneously, either two signals will be present together or there will be a momentary lack of video signal. In addition, the line scanned at the moment of head changeover will be alternately too long or too short.

Burst phase fault with slowed-down or "frozen" picture display. Unlike the other recording systems mentioned earlier, helical recording allows slow-motion or still picture display by simply slowing down or stopping the tape. As the tape speed is altered, the length of the track scanned by the video heads will become different from the track recorded. However, the servo system will keep the field time during which the track is scanned identical to that during which it was recorded, thus changing the number of lines in each field. If the tape moves against the direction of the heads, then the number of lines in a stationary picture field will be decreased, whereas the number will be increased if the tape moves with the heads.

If, in a "frozen" colour field, the number of lines is odd, the phase of the alternating burst (PAL) will be incorrect at each repetition at the beginning of each field, making it necessary for the receiver to re-identify every time. (This re-identification must occur sufficiently fast to obtain a correct colour picture.) For an even number of lines in the field, the burst phase will always be correct and repeated re-identification by the receiver will not be necessary.

Practical considerations. The errors so far described may occur independently of each other, and will thus seldom be present simultaneously. In fact they may compensate each other to some extent. For example, a variation of the drum temperature will affect the track length, but if this is accompanied by the same temperature variation of the tape, this tends to compensate for it.

Nevertheless, the errors described above may be so serious that they impair the operation of current model TV receivers. To minimize these errors, the key components should be manufactured to extremely close tolerances. Taking the scanning assembly of the Philips VCR as a case in point, the tolerance allowed on the drum diameter of 105mm is only 22μm, and that on the angular separation of 180° of the video heads is within 5μm of the mounting diameter, at the circumference of the disc. Further mechanical precision is hardly practicable in mass production, and the remaining errors may be corrected far more cheaply by adaptation of the TV receiver than by closer tolerance manufacture methods.

In order that the adaptation problems encountered by the receiver designer may be fully appreciated, some examples will be given of the size of the errors likely to be encountered. Pending international agreement on consumer v.t.r. standards, the errors quoted will be based either on those of the Philips VCR model N1500, or upon proposals, for the VCR system standard or for the interconnection between v.t.rs and TV receivers, made to the IEC and DIN.

First, five errors are dealt with which are essentially due to mechanical tolerances of the equipment. Subsequently three errors are considered which depend mainly on the electrical circuits employed.

Tolerances of the VCR video signal

Mean line frequency deviations. In the IEC draft recommendation for 50Hz 625-line PAL or SECAM VCR standards for other than professional-type equipment, tape speed and tolerances are as given in the Table. In equipment provided with only a head-disc servo system, the recorded line frequency may deviate by ±2%. This implies that under worst-case conditions the variation between recorded and reproduced line frequencies may be ±4%.

In equipment provided with both head and tape speed servos, the mean line frequency deviation is restricted to 1% under worse-case conditions. This figure is mainly governed by the reference source (usually the mains electricity supply) which is used during playback.

Line frequency wobble. In addition to the mean value of the line frequency being subject to deviations, the line frequency may be modulated so that it wobbles. Because it is seldom practicable to determine the spectral components of this modulation theoretically, the permissible percentage of wobble is presented in the form of a graph, Fig. 6. The curve gives the limit of the permissible "wobble figure" W as a function of the modulation frequency; W is defined as the ratio of f_{Ln}, the nominal line frequency, to Δf_L, the total frequency swing about f_{Ln}.

Fig. 6 applies essentially to the presence of only one modulation frequency. It is difficult to predict the subjective effect on the picture when the line frequency is modulated by several wobble frequencies

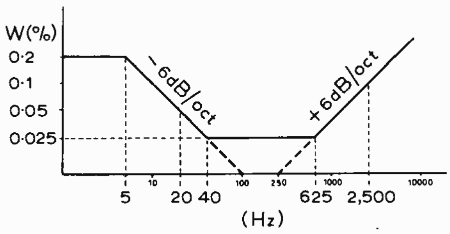


Fig. 6. Limits imposed on the frequency components of line frequency "wobbling" in the Philips model VCR N1500. The wobble figure W is defined by $W = \Delta f_L / f_{Ln}$ where f_{Ln} is the nominal line frequency and Δf_L is the total frequency swing about f_{Ln}.

simultaneously, since their amplitude and phase vary during playback. Experience has shown that the picture will be acceptable when the wobbling is within the limit shown in Fig. 6, provided that the line sync circuit of the monitoring receiver has been suitably modified for use with a v.t.r.

Gap width. The gap width does not exceed five lines.

Phase jump. The theoretical worst-case values of the phase jump are +20μs and −20μs, but in practice it is sufficient to allow for a phase jump of ±15μs.

Head position error. The maximum phase jumps occasioned by head location tolerances are ±0.6μs, so that for the played back signal allowance should be made for a phase jump of ±1.2μs due to head position errors.

Gap. The gap and the video signal deterioration discussed below, which are to be attributed mainly to the electrical circuits,

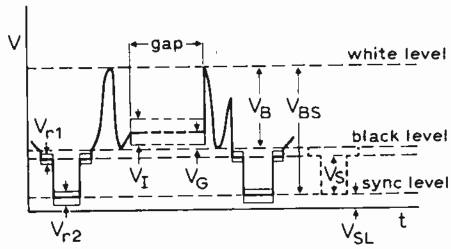


Fig. 7. Signal parameters used for defining errors of the video signal.

will be discussed with reference to Fig. 7, which defines the various signal parameters.

The centre of the gap is located eight lines before the vertical sync pulse with a maximum spread of +7 and −5 lines. The signal level of the gap, V_G, and the interference level, V_I, do not exceed $0.3V_B$ and $0.6V_S$ respectively.

Video signal deterioration. Assuming the luminance and chrominance signals to be available separately, the peak-to-peak value of the signal V_{BS} (including the sync pulse) produced across a 75Ω load, is 1.0V, ±3dB, V_{SL} not exceeding 1.5V. The ratio of the sync pulse to the signal amplitude, V_S/V_{BS}, during playback may differ up to 10% from this ratio during recording. The remainders of the carrier on the sync pulse, V_{r1} and V_{r2}, do not exceed $0.2V_S$ and $0.3V_S$ respectively.

Chrominance deterioration. Again assuming the luminance and chrominance signals to be available separately, the peak-to-peak value of the colour burst amplitude of the VCR is 80mV ±3dD. (In the composite video signal proposed it will be 300mV, +0, −6dB.)

The time difference between luminance and chrominance at playback is equal to that on recording. Subcarrier frequency fluctuations are kept within ±150Hz by a special frequency mixing system.

When a picture is "frozen" by stopping the tape transport mechanism, the number of lines is increased from 312.5 to 318 per field, which, from the considerations discussed previously, does not make it necessary for the receiver to re-identify for each field.

Special requirements imposed on the TV receiver

Because of the shortcomings which are associated with low-cost video recorders for the entertainment market, the video signal which the domestic v.t.r. delivers differs markedly from broadcast standards. Until the advent of the home v.t.r., a domestic TV receiver was only required to cope with standard signals, and considerable circuit refinement has been introduced which is intended to optimize sync performance on weak, but standard, signals.

Until an inexpensive v.t.r. equipment appears which delivers a high-standard video signal, optimal results from the combination of v.t.r. and TV receiver can be achieved only if receiver manufacturers introduce certain design modifications. The following sections indicate some of the more important arguments on which these modifications should be based.

Synchronization. The quality of the picture on the screen of a TV receiver is largely dependent on the stability of the line timebase. Most modern receivers employ flywheel sync circuits, the time constants of which are a compromise between the large value required to reduce the influence of unwanted signals (noise, interference etc.), and the short value required to obtain a large catching range.

It is an inherent property of the flywheel circuit that the line oscillator will correct itself only slowly after any phase jump such as may be present in the v.t.r. signal. This effect is illustrated by the photographs of Figs. 8 and 9, which show a normal test pattern displayed by a receiver with a "standard" timebase, and the same test pattern, but with a +16μs phase jump, displayed on the same receiver.

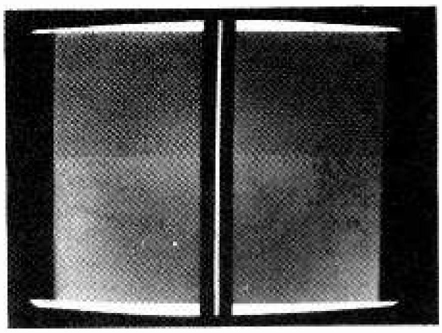


Fig. 8. Test pattern displayed on the screen of a normal TV receiver; no specific abnormalities in the video signal, the receiver has a slow flywheel circuit.

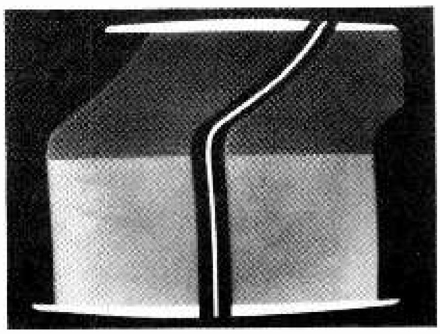


Fig. 9. Test pattern of Fig. 8 applied to the same receiver. In this case the video signal is affected by a +16μs phase jump.

Evidently, when a domestic TV receiver is to be used with a v.t.r., optimum performance will not be obtained unless a new balance is struck between the conflicting requirements for the flywheel constant. If the phase jump disturbance, even when it is concealed in the vertical blanking pulse, is not to persist into the visible picture, then the flywheel circuit should meet the following characteristics:

—The maximum of the overshoot should be reached, at the latest, 20 lines after the phase jump.

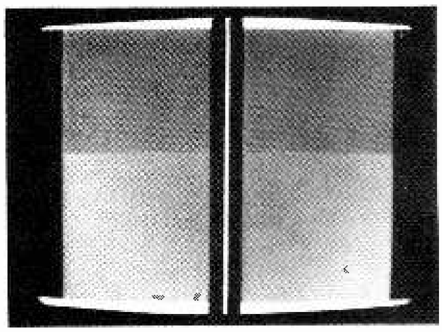


Fig. 10. Same signal as in Fig. 9, but applied to a receiver with a faster flywheel circuit.

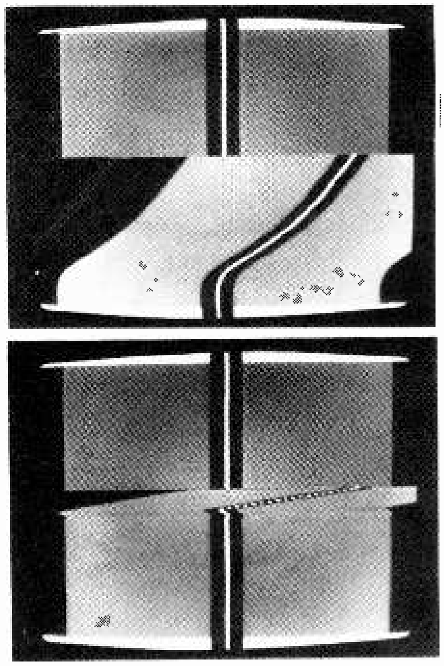


Fig. 11. To emphasize the effect of the speed of the flywheel circuit, the phase jump is made to appear in the centre. In (a) the receiver has the usual slow flywheel circuit, whereas in (b) the flywheel circuit of the same receiver has been speeded up.

—This maximum should not reach 5% of the phase jump.

—Following the maximum, the overshoot should decay linearly to zero.

Provided that these requirements are met, the distortion of the vertical lines will be scarcely perceptible. Comparison between slow and fast flywheel circuits is provided by Figs. 10 and 11, which show the effect of phase jumps with and without timebase modifications.

In arriving at the foregoing conclusions it has been assumed that the horizontal sync circuit control loop is continuously updated. This may not always be the case. If a coincidence detector is used in the sync pulse path, for example if updating information is supplied to the control loop only during flyback, or if phase comparison is carried out by means of short pulses instead of by means of the sync pulse and a sawtooth voltage, then the flow of control information can be interrupted by a large phase jump. The line timebase will then fail to be corrected immediately after the phase jump, and distortion of the type shown in Fig. 11 will persist for a longer period of time. Such an effect may be observed, for instance, with the "Gassman" circuits. To avoid this type of difficulty, the line oscillator sync circuit should continue to function through phase jumps of $\pm 15\mu s$.

A circuit in which all these requirements are met will generally have a larger noise bandwidth. Since this will increase the likelihood of interference to the picture during reproduction, the noise bandwidth increase should be minimized.

Since the parameters which determine the performance of the line sync circuit cannot be optimized for good response both during normal reception and v.t.r. monitoring, the flywheel constants should be altered during v.t.r. playback. The requirement for such a change is independent of the way in which the receiver is linked to the v.t.r. (r.f., i.f. or v.f.).

Picture distortion, image raggedness for example, may also result from line frequency fluctuations (wobbling). However, if the timebase characteristics have been modified to accommodate a 15μs phase jump, this type of picture distortion will also be reduced to an acceptable level, at least theoretically.

When the video signal is transferred to the receiver by r.f. or i.f. signals the absence of line sync pulses must not influence the a.g.c. voltage applied to the r.f. or i.f. sections of the receiver. If the a.g.c. system were to respond to the loss of lines during a gap, the sync separator might detect part of the video signal.

Chrominance section. Line frequency deviations and phase jumps affect the time relationship between the sync pulse and the line flyback pulse. In colour receivers, where the burst key pulse is derived from the horizontal flyback, this effect may cause the burst detector to be fed with either the wrong information or none at all. The time constant of the colour killer circuit should therefore be such that reaction to misleading information of this sort is avoided. In addition, the time constants of the circuit must be such that the gain is kept substantially constant during this period.

The duration and extent of this unwanted situation depend on the behaviour of the line flywheel circuit during playback. Since the phase jump will be less than one line period, no lines are skipped, so the PAL alternating burst will have the correct phase at the start of each new frame and repeated identification by the receiver will not be necessary.

Subcarrier oscillator. The lock-in range of the reference oscillator must be large enough to ensure synchronization at the extremes of the deviations of the frequency of the reproduced subcarrier.

References

1. Wolf, G. 1973. Mains isolating switch-mode power supply, E.A.B. 32 (1): 28–43.
2. "Magnetic-tape cassette video recorders". *Wireless World*, Dec. 1972, p.580.
3. International Electrotechnical Commission and Deutsche Industrie Normen.

Meetings

March meetings
LONDON

4th. IEE—"Stored programme control" by Dr K. Warren at 18.00 at Thames Polytechnic, Beresford St., SE18.

5th. IERE—Colloquium on "Exploiting the PROM" at 14.00 at 9 Bedford Sq., WC1.

5th. AES—"A. D. Blumlein: inventor extraordinary" by F. P. Thomson, E. L. C. White and P. B. Vanderlyn at 19.00 at the Wellcome Lecture Hall, The Royal Society, 6 Carlton House Terrace, SW1.

5th. BKSTS—"Gevachrome II—a new colour reversal system for production and news" by R. Huybrechts and R. Verbrugghe at 19.30 at Thames Television Theatre, 308–316 Euston Road, NW1.

6th. IERE/IEE/IEETE/SERT—Colloquium on "Modular courses" at 10.00 at 9 Bedford Sq., WC1.

6th. IEE—"The scanning electron microscope and other electron probe instruments" 66th Kelvin Lecture by Prof. Sir Charles Oatley at 17.30 at Savoy Pl., WC2.

6th. RTS—"How scientific programmes are put together" by P. D. J. Daly at 19.00 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

10th. IEE—"Microwave heating" by Dr R. B. Smith at 17.30 at Savoy Pl., WC2.

11th. IEE—Discussion on "On-line computing in a control systems teaching laboratory" at 17.30 at Savoy Pl., WC2.

12th. RI of Naval Architects—"The changing situation in long-haul navigation" by A. White at 17.00 at 10 Upper Belgrave St., SW1.

12th. IEE/IES—"The impact of electronics on lighting" by A. Isaacs at 17.30 at Savoy Pl., WC2.

12th. IERE—"Acoustical holography" by J. W. R. Griffiths at 18.00 at 9 Bedford Sq., WC1.

17th. IEETE—Panel on "Europe today" at 17.45 at the IEE Lecture Theatre, Savoy Pl., WC2.

18th. IEE—Discussion on "Have batteries a future in aircraft?" at 17.30 at Savoy Pl., WC2.

19th. IERE—Colloquium on "Wedding calculators to instruments" at 10.00 at 9 Bedford Sq., WC1.

19th. IEE—Discussion on "Further degrees—should they be industry or college based?" at 14.00 at Savoy Pl., WC2.

19th. BKSTS—"A review of electronic grading methods" by L. B. Happé at 19.30 at Thames Television Theatre, 308–316 Euston Road, NW1.

24th IEE—"Data transmission aspects of the British Railways T.O.P.S. project" by W. K. H. Dyer at 17.30 at Savoy Pl., WC2.

25th. IEE/IERE—Colloquium on "Solid state serial stores" at 14.30 at Savoy Pl., WC2.

25th. IEE—"Automated animation and the computer" by Dr A. Jebb at 17.30 at Savoy Pl., WC2.

26th. IEE—"Landing guidance systems for the future—who rules the microwaves?" by C. P. Sandbank at Savoy Pl., WC2.

26th. BKSTS—"BKSTS test films" by Ray Knight at 19.30 at Thames Television Theatre, 308–316 Euston Road, NW1.

CHATHAM

6th. IERE—"Flight recording in civil aviation" by P. Waller at 19.00 at the Lecture Theatre, 18 Medway and Maidstone College of Technology, Maidstone Rd.

CHELMSFORD

26th. IEE—"Sonar and underwater communications" by D. J. Creasey at 18.30 at the King Edward VI Grammar School, Broomfield Rd.

DORKING

19th. IEE—"X-ray astronomy" by Prof. R. L. S. Boyd at 19.30 at Mullard Space Science Laboratory, Holmbury St. Mary.

EDINBURGH

11th. IEE—Faraday lecture—"The social computer" by Desmond H. Pitcher at 14.00 and 19.00 at the Usher Hall.

EXETER

6th. IEETE—"The Sony colour cartridge video cassette" by D. Hyde at 19.30 at Imperial Hotel, St. David's Hill.

LEEDS

20th. IEETE—"Electrical and electronic engineering in hospitals" by K. H. Dale and B. Collins at 19.00 at Kitson College, Cookridge St.

LIVERPOOL

24th. IEE—Faraday lecture—"The social computer" by Desmond H. Pitcher at 14.30 and 18.45 at the Philharmonic Hall.

LOUGHBOROUGH

4th. IEETE—"Digital techniques in telecommunications" by D. Crampsey and D. G. Bennett at 19.00 at King's Head Hotel, High St.

MAIDSTONE

3rd. IEE—"Electricity in medicine" by Dr. L. H. Green at 19.00 at the Royal Star Hotel.

MANCHESTER

6th. IEETE—"Planned maintenance" at 19.30 at UMIST, Reynold Building, Sackville St.

17th. IEE—Faraday lecture—"The social computer" by Desmond H. Pitcher at 19.30 at the Free Trade Hall.

18th. IEE—Faraday lecture—"The social computer" by Desmond H. Pitcher at 14.30 and 18.30 at the Free Trade Hall.

NEWCASTLE

4th. IEE—Faraday lecture—"The social computer" by Desmond H. Pitcher at 14.15 and 19.15 at the City Hall.

READING

6th. IERE—"Liquid crystals and device applications" by I. A. Shanks at 19.30 at the J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

Sixty Years Ago

March 1915, and Britain was well in the thick of World War I, with wireless playing quite a remarkable part considering its rather primitive nature. This short item from the *Wireless World* for that month describes an incident in which wireless was instrumental in aiding the destruction of the German warship Emden.

"The December 21 issue of *The Katipo*, the official organ of the New Zealand P. and T. Officers' Association, came recently to hand, and contains much interesting matter. In the account of the Emden capture, which figures in this number, we read: 'Now that the details are dribbling through, our service can throw its chest out in very aggressive style.' The narrative goes on to describe the good work done by Sapper W. C. Falconer, of the Eltham Staff, who was the first to pick up the messages from Cocos Island on November 9. It would appear that the Emden tried to block the message by continuous interruption, but by altering the tune of his receiver the operator continued to read the Cocos Island message, and duly reported it to the Naval Transport Officer. The result we all know, the Sydney went in hot pursuit of the Emden and destroyed her. This stirring story our contemporary ends with the words, 'All honour to Sapper Falconer for a fine piece of work for the Empire.'"

Letters to the Editor

HORN LOUDSPEAKER OUTPUT

I would like to draw attention to a common fallacy concerning horn loudspeaker operation, which is propagated in the March, 1974, article by Mr Dinsdale. Mr Dinsdale mentions ". . . the uneven bass response illustrated in Fig. 4", the diagram showing graphs of throat impedance component values plotted against frequency. Throat resistance is shown in solid lines, and the implication seems to be that the sound output is directly related to this value.

Inasmuch as Fig. 4 carries the connotation "(after Olson)", I will cite the appropriate areas of *Acoustical Engineering* in dispute of the implications drawn from the figure.

Firstly, sound output is a function of *motional* impedance for a given current flow (pp. 212–214). *Mechanical* impedance (here, horn throat value) is *inversely* related to motional impedance:

$$Z_{EM} = \frac{(Bl)^2}{z_M} \times 10^{-9}$$

(equation 7.1, page 213)

Z_{EM} is motional impedance; z_M is mechanical impedance.

Obviously it is not proper to associate frequency response directly with throat impedance, even neglecting reactive effects, since a rise in throat impedance will produce a *drop* in motional impedance and may tend to reduce the output.

Secondly, the magnitude of the effect of throat impedance variations on sound output cannot be simply stated, and in general will be less than the magnitude of the impedance variation (a very fortunate circumstance for the designer). For brevity I exclude the mathematical development and offer some short passages from the text:

". . . a relatively smooth output response frequency characteristic can be obtained from a horn having a mechanical impedance characteristic varying over wide limits."—page 220

". . . the throat acoustical resistance may vary over wide limits without introducing large variations in power output."—page 220

There is in this same section an example shown in which

"Although the variation in acoustical resistance is 6 to 1, the variation (in) power output is only 2dB."

(This example includes a generator resistance, which will be close to zero in many amplifiers, but the effect is not dependent on its presence.)

In the 'thirties, the telephone company here produced a classic horn design. (I refer to the reference system done by Dr E. C. Wente, now deceased, of Bell Labs, who held patents for the invention of the multicellular horn, as originated for this system, in addition to those for the driving units and bass horn of the system. Possibly the condenser microphone would be the best known of his innumerable inventions—he in fact wrote to me that the speaker system was considered an easy design to do, trivial. This system was capable of outputs which exceed that of an entire symphony orchestra, with accuracy sufficient for facsimile reproduction in live vs. wired music demonstrations.) As the system was investigated, it was found necessary to position the high-frequency unit back from the folded bass section so as to preserve approximately equal (within about two feet) path lengths for the high and low notes. I believe that this piece of history is of value in considering the positioning of low- and high-frequency units of particular designs. (Cf. J. K. Hilliard, "Notes on How Phase and Delay Distortions Affect the Quality of Speech, Music and Sound Effects," *IEEE Trans. Audio*, vol. AU-12, pp. 23–25, Mar.–Apr., 1964.) It may be that the suggestions in the June issue for horn designs (the "no-compromise horn" and the "mini-horn") should be considered with these data in hand. I see that the final article in Mr Dinsdale's series, like the rest, contained no data on the parameters which affect efficiency.

Let me close on a humorous note: I see in the "References" listing of "Private communication", which seems a continuation of an unfortunate trend in horn literature, along with Klipsch's references to "Private correspondence", "Private communication", and Olson's gem, "Unpublished Report" of someone or other. If this keeps up we are going to have a terrible communication problem!

David R. Schaller,
Milwaukee,
Wisconsin, USA.

Mr Dinsdale replies:

I expressed the hope in the concluding paragraph of my final article on horn loudspeaker design (June 1974 issue) that engineers far more expert than myself in this subject might be persuaded to recount their own experiences, and I am delighted that Mr Schaller has responded.

His comments regarding the effects of variations in throat impedance on sound output are most valuable, and will be reassuring to all who are designing and building horns with restricted mouth dimensions.

I was also interested in Mr Schaller's warning that the high frequency unit in a multi-horn system should be positioned back from the bass unit so as to preserve equal path lengths. I must confess that I have not so far experienced any audible distress from this cause in my own domestic listening, and I feel that it might be impossible to separate the two units as advocated in a relatively small horn system for domestic use.

I am not aware of any quantitative data being available regarding which parameters affect the efficiency of a horn loudspeaker, and I would be grateful if Mr Schaller or any other reader could enlighten me on this subject. I would of course respect the confidences expressed in any private correspondence which resulted from this request, and so I regret that it would inevitably be referred to once again as a "Private Communication".

BROADCASTING DUPLICATION

In your leader in the January issue you discuss frequency planning in a manner which is generally reasonable and impartial. However, I must take exception to the prejudice you display in applying the phrase "wasteful duplication" to m.f./l.f. and v.h.f. radio services.

These services are not duplicated either in terms of coverage or of ease of use in a particular environment and often have totally different programme content. They are, in fact, complementary services each catering for the needs of particular sections of the total radio audience. The v.h.f. service is understandably the darling of most of your readers but it is nevertheless useless for car radios, saddles the housewife who carries her "transistor" around the house with a flapping telescopic aerial and drives the old folk scatty trying to meet its fiddling tuning requirements. For these and other good reasons, and despite attempts to dissuade them by propaganda and deliberate distortion of the programme material, the majority of ordinary radio listeners have preferred to use the m.f./l.f. services throughout the 18-year period that v.h.f. has been available. Why should they not continue to exercise their preference?

Later in the same issue in "News of the month", you exhibit a further touch of prejudice by inserting the word "allegedly" into the reason given by the International Radio Consultative Committee when rejecting the use of high degrees of signal compression on m.f./l.f. broadcast services. It is only necessary for you to switch on your radio to verify that the BBC's obsession with this technique results in their putting out some of the poorest quality m.f./l.f. transmissions in Europe. The IRCC recommendations embody the considered opinions of the cream of Europe's broadcasting engineers and, in a situation where we seem to be bedevilled by theoreticians who probably never actually listen to the radio but who itch to apply their ideas to perfectly satisfactory services, the recommendations represent a triumph for commonsense. I

only hope that the BBC will take heed of them and consign its compressors and bandwidth limiters to Lisle Street.
C. Higham,
Olney,
Bucks.

TWIN VOLTAGE-STABILIZED POWER SUPPLY

I feel your readers may be interested in the following suggested modifications to the "Twin voltage-stabilized power supply" by J. L. Linsley Hood in the January 1975 issue. My first suggestion concerns the use of the supply as a permanent "split-rail" supply (I too dabble with amplifiers!) where the positive and negative outputs are required to be of the same magnitude, i.e., to track each other. Referring to Fig. 5 of the article, potentiometer R_{1a} may be replaced by a 33kΩ fixed resistor, and the 33kΩ resistor which is shown connected to +12V reference voltage disconnected therefrom and taken to the positive output terminal instead. The negative output will now track the positive output voltage, which is set up on R_1 as before.

There are several advantages to be gained by making this modification:
(1) The output voltage meter may be permanently connected to one rail, thereby saving a switch (and precious time!).
(2) R_1 may be a multi-turn potentiometer, instead of half a ganged potentiometer, which allows finer control over the output voltage.
(3) The accuracy of output tracking is no longer dependent on poorly matched "stereo" potentiometers—indeed, well-matched linear ganged potentiometers are rare items—but on the accuracy of the divider components which may be 1% if required.

Finally, a sombre note. I would point out that if Tr_1 (or for that matter Tr_{1a}) is of rather low gain then its base driver transistor can dissipate well over 5 watts under adverse loads. Failure of this transistor usually produces excessive base drive, and over full output voltage appears on the terminals with disastrous results! Of course, the obvious course of action is to provide base driver transistors of adequate ratings fitted with suitable heatsinks. Some degree of protection can, however, be afforded by the inclusion of resistors in the collectors of Tr_2 and Tr_{2a}. This has two functions: (a) transistor dissipation is reduced; (b) in the now unlikely event of failure of these driver transistors—or for that matter failure in the remaining circuitry—the base drive to Tr_1 (or Tr_{1a}) is limited to a safe value. 470Ω 5-watt resistors are suitable.
L. Cook,
Prescot,
Merseyside.

It is with trepidation that I, as a technician, voice doubts about a Linsley Hood design! But surely the twin voltage-stabilized power supply of Fig. 5, page 44, January issue, cannot live up to its claim to supply safely 0–35V at 2A maximum.

Suppose one uses it to give 5V, 2A. If V_{RES} (reservoir) is, say, 40, we then have Tr_{1a} dissipating 2 × 35=70W. But with a mica, even on a large 1.1°C/W heatsink, this transistor, type 2N3055, will stand only 55W (30°C summer ambience). Short-circuited by students or by a faulty audio amplifier, it wouldn't stand a chance. To live up to the claimed performance, Tr_1 and Tr_{1a} would need to be shunt pairs (with 5Ω or 10Ω resistors in bases, to equalize power sharing).

A 2500μF reservoir capacitor will blow up at 2A d.c. unless of high-ripple type. If of lower than marked value, peak ripple will exceed 3V at 2A. Thus with low mains voltage, negative ripple peaks may bring V_{RES} below viable value, creating negative output-voltage notches. Using, say, two shunt 5000μF/50V capacitors would be safer, if bulkier.

Surely the designation 33V, 2A on the transformers will lead the unwary to order transformers of 2A a.c. rating, whereas 3A a.c. rating will barely suffice with good ventilation for a 2A d.c. output.

The divisor-chain values (100kΩ pot. and 33kΩ resistors) seem very high, both from the electrostatic field pick-up viewpoint (from the transformer) and from the 741 drift viewpoint. The drift would not be taken up round the feedback loop.

The use of the pass transistors Tr_1 and Tr_{1a} in the reverse mode from usual (page 43, third column) may be noted long before 1971. See General Electric's "Transistor Manual", 1964, p. 228.
Douglas Boxall,
Chelsea College,
University of London.

Mr Linsley Hood replies:
I would like to thank Mr Cook for his letter and his comments on my design. The use of one rail as a "reference" for the other is certainly an interesting possibility, especially if some decoupling is introduced in the "reference" feed to prevent one half from trying to reproduce any ripple on the other. I am also grateful for his suggestion for a resistor between Tr_2 collector and Tr_1 base. This was an oversight on my part, and is desirable. Also, I would like to add, with my apologies, that a 2-amp, 50-volt silicon diode should be connected (in their non-conducting mode) across each output to the 0-volt line, to avoid the possibility of trouble if one "live" line is shorted to the other.

I would also like to thank Mr Boxall for drawing my attention to the earlier use of pass transistors in the reversed mode. It seems a useful method of operation which is very rarely employed. His comments on the need for components always to be used within their ratings are salutary and stand frequent repetition. However, in this particular instance I fear that he has overstated his case. The 2N3055 series of transistors have a permitted maximum dissipation of 80 watts at a case temperature of 75°C. Obviously one should provide adequate heatsinks for the use envisaged, but this is not impossible. Similarly, reservoir capacitors of normal type *will* survive use at a 2-amp d.c. output without exploding. Finally, if one wishes to parallel the pass transistors in order to extend the output current range, 0.25-ohm 2-watt emitter circuit resistors will be found to be adequate, but a device having somewhat larger dissipation limits than the Motorola MPSU series would be advised for Tr_2 and Tr_{2a}.

REDUCING AMPLIFIER DISTORTION

Techniques similar to Mr Sandman's (October 1974 issue, page 367) were described by J. C. H. Davis in 1958 (*Electronic and Radio Engineer,* vol. 35, no. 1, p. 40). Davis's circuits were based on valves, and contain transformers, but the underlying principle, which Davis called "total differential feedback", is essentially the same. He points out that the technique enables the amount of negative feedback to be "squared" (e.g., increased from 20dB to 40dB) without sacrifice of stability margin. The possibility of adding a third, fourth, etc., feedback path as suggested by Sandman is also referred to, with a note on the problems which then arise.

I have lost my reference, but I remember seeing the principle applied to repeater amplifiers for submarine telephone systems using valves. The advantage (which can be seen by referring to Sandman's Fig. 2) is that if one amplifier goes out of action because of failing emission in a valve the second carries on, giving much the same gain and output as before but with some increase in distortion.
G. W. Short,
South Croydon.

SETTLING TIME IN AUDIO AMPLIFIERS

Referring to Mr Linsley Hood's letter on audio amplifier settling times (January 1975 issue). I would like to point out that for many years I have been measuring and displaying this parameter in various reviews (in terms of step response function under conditions of both resistive and reactive loadings). I thoroughly agree with Mr Linsley Hood that the parameter would be better expressed actually in terms of settling time referred to a given error band, but to make the test universally meaningful a number of conditions would have to be properly understood and stipulated.
I would suggest:
(1) that the error band be ±5%;
(2) that the peak voltage across the test load correspond to that required for −3dB of the amplifier's power *capacity* (some amplifiers would violently reject

to a greater peak voltage under stepped signal drive);
(3) that the load be of an impedive nature, preferably to correspond to the analogue of notoriously difficult loudspeaker loading (see later);
(4) that the settling time be defined as the time elapsed from the application of an ideal step function (in reality of rise time not greater than 100ns) to the time that the amplifier enters and remains within the stipulated error band (*not* to the time required by the amplifier to settle within the linear small-signal region, which is sometimes the implied expression with operational amplifiers). The error band is thus $E_o \pm \Delta E$, where E_o is the final settling voltage, and the settling time, as just defined, can then be referred to $\Delta E/E_o \times 100$.

Because an amplifier with a high slewing rate may often exhibit a relatively long settling time, it cannot be concluded unconditionally that an amplifier with a small settling time will have all the characteristics required for the least transient intermodulation distortion (t.i.d.), but because a small settling time requires the amplifier to have a closed-loop response that is very slightly less than critically damped (i.e. open-loop response dominated by a single-pole roll-off filter) taking effect before slewing rate limiting, at least one of the requirements for minimal t.i.d. is achieved.

The overall picture is more clearly presented by also including the measured slewing rate, and this I have been doing in recent reviews and test reports.

I concur with Mr Linsley Hood regarding the tonal impairment that can arise with steep-slope low-pass filters but, provided this can be switched out, this is better than a -20dB/decade artifice which does little more than the treble control at full cut. A recent investigation of a long-settling amplifier exposed the use of a two-pole filter for pre-amplifier roll-off. In fact, this turned out to be the 12dB/octave low-pass filter whose fascia switch merely shifted the turnover higher up the spectrum in the off position! Clearly, in the interest of the least t.i.d. (depending on the h.f. power response, amount of feedback, etc.) preamplifier treble response limiting is necessary, but this should be -6dB/octave (-20dB/decade) and exponential for the least tonal distortion.

Some designers appear to be obsessed with obtaining the fastest small-signal rise time possible. This, in general, is incompatible with the least t.i.d.; in any case, it is totally unnecessary since the effective transient speed of even high-quality programme signal is barely any smaller than 15μs. In view of this, measurements of t.i.d. with step functions as fast as 100ns would appear to have no practical merit.

We hear about different "sounding" amplifiers even when the amplifiers have very comparable prime parameters. Much of this difference in my judgment results from the nature of the load the loudspeaker presents to the amplifier. Unfortunately, very few loudspeaker manufacturers publish load analogues; and, conversely, very few amplifier manufacturers take full account of the varying and various nature of the load presented by the loudspeaker. It seems almost impossible for amplifier and loudspeaker designers to join in close technical liaison. Thus we are presented with the crazy situation where a highly engineered amplifier, and one which measures prime parameters faultlessly, gives a poorer sound from a similarly engineered loudspeaker of probably complex load impedance than from a less advanced model of relatively simple frequency-divider configuration.

The blame for this cannot be placed at the door of the amplifier designer. The loudspeaker designer should let him know exactly what kind of load to design for. Measurement of the settling time may help to pin-point those amplifiers which are particularly load sensitive—but the load for the test still has to be determined by the test engineer! The electrical analogues of some of the more difficult loudspeakers are being derived so as to make the test more meaningful.

Gordon J. King,
Brixham,
Devon.

Mr Linsley Hood replies:
I am most grateful to Gordon King for his interesting reply to my letter. It is indeed true, as he says, that the more thorough reviews of audio amplifier performance over the past few years have shown the square-wave response of the system under resistive and reactive load conditions, but the most commonly adopted reactive load analogue (8 ohms in parallel with 2μF) is not necessarily either the closest equivalence to an actual loudspeaker or the load circumstance which will produce the most unsatisfactory response from the amplifier within the range of those which are feasible. (For example, 8 ohms in parallel with 0.1 μF may sometimes be worse.)

Moreover, there has been a tendency for resistive load rise time to be optimized in the design stage, at the expense of the "settling time" under more realistic load circumstances. If Mr King can devise more appropriate analogues for "difficult" l.s. loads, this would be a valuable contribution to design optimization; to which I would like to add my hope that the measured "settling time" might be added to the existing photographic illustrations of square-wave performance.

DISTORTION TRANSMUTED?

Audio engineers have for some time been aware that amplifiers in general have serious shortcomings. Transient intermodulation distortion has been mooted as an explanation but is not generally accepted as the best answer.

It was my friend John Keble of the IERE who introduced me to "head-in-speaker" testing. This reveals all sorts of strange sounds from a class B solid state amplifier that are absent from a class A non-feedback design.

It is with some diffidence that I advance yet another explanation of this phenomenon. It is generally understood that a physical quantity cannot be destroyed but can only be altered into something else, e.g. matter into energy in the Bomb. Now distortion is a physical quantity produced by modification of the signal and so cannot be destroyed, only changed into something else.

It can be argued that the ultimate fate of distortion in an amplifier with a feedback loop (which must have a delay before it operates) is to reappear as noise. An intermediate stage to this conversion is a sharpening up of wavefronts with a noticeable harshness in the reproduction.

All these effects are readily detectable by the "head-in-speaker" test, particularly when one conducts an A-B test with a low distortion non-feedback amplifier.

I personally feel that the feedback loop amplifier has had its day and we have got to go back to something like the *WW* Quality Amplifier and start again.

T. Marshall,
Goldring Ltd,
London, E11.

AMERICAN INSULARITY

We were amused to note that in a recent copy of *Electronics* (November 28, 1974, page 140) under "New Products", was described an ordinary hand-cranked Megger.

How have Americans checked insulation all these years? We know their electrical standards are low, but this is ridiculous!

J. G. C. Fox,
Royal Postgraduate Medical School,
University of London,
London, W12.

"MORE THINGS IN HEAVEN AND EARTH . . ."

Further to "Vector's" article in the November issue, which certainly gave food for thought, could I put forward a rather plebeian explanation for the high incidence of gamma radiation in the vicinity of the mill cottage?

It was stated that a stream ran under the floor of the building, and presumably was dammed for the purpose of operating the mill wheel, so would it not be reasonable to suggest that radioactive particles contained in heavy particles of stone washed down from granite particles over the centuries had collected in this position, so causing a concentration at that position? I would respectfully suggest that the psychic matter was purely coincidental.

C. G. Warren,
Banstead,
Surrey.

Solid state digital clock

2—Construction and setting up

by David D. Clegg

The power supply circuits are designed to power both the logic and the display when the external supply is present, and to power only the logic, from the standby supply, when the external supply is absent. Furthermore, this changeover between the two supplies must be accomplished without a break, which would cause a loss of accuracy, or worse still, reset the time or alarm registers.

The circuit shown in Fig. 7 achieves this; when the external supply is present current from the display flows through D_{30}, while that from the logic flows through D_{31}. The external supply is greater than the standby supply (12 volts compared with 9 volts) and D_{32} is, therefore, reverse biased. If the standby supply is a re-chargeable battery, then it is charged by current flowing through D_{33} and R_{51}. (If a dry cell is used as the standby supply, D_{33} and R_{51} are omitted from the p.c. board.) Failure of the external supply causes the display to be extinguished, D_{31} is reverse biased and the voltage at the anode of D_{32} falls from about 11.3 volts to about 8 volts, D_{32} becomes forward biased and the standby supply thus powers the logic. The display can be powered for short periods of time by pressing the "display" button, K_{12}. This shorts $V_{display}$ to V_{dd}; the standby supply then supplies both the logic and the display.

With R_{51} of the value shown (100 Ω) the cell charging current was between 12 and 15mA; this resistor should be chosen to suit the cells used by individual constructors. Using the specified cells the clock will run for at least 48 hours, provided the display is not energised too often. If these cells are considered too large (NCB-55 has a capacity of 550mAH) then the smaller NCB-20 (200mAH) or the NCB-9 (90mAH) might be considered; they are also much cheaper than the NCB-55.

Assembly

Before describing the assembly of the clock, it is worth mentioning that the p.m.o.s.-l.s.i. clock chip and the c.m.o.s. i.cs can all be damaged by quite small static charges generated if carelessly handled: these i.cs will be supplied in conductive black plastic foam—resist the temptation to remove them from this until you are ready to install them in the board! The author did not use integrated circuit sockets on the prototype, but if preferred these can be used. Whether sockets are used, or not, the integrated circuits *must* be mounted on the board last.

The keys should be mounted on the board first; the two plastic locating pegs on the keys are not symmetrically displaced about the line joining the terminal pins, they can, therefore, be mounted in only one way. When all the keys are mounted, and before soldering them in, check that the manufacturer's name and the type code (AKS) embossed on the top of the key all face the same way. It is possible to disassemble the keys, but a word of warning here; if they are re-assembled incorrectly, there may be interaction between adjacent keys on the board.

After mounting the keys, the remainder of the small components can be soldered on the board, taking care to check that the diodes are the correct way round. The marking on the 1N914 diodes is not at all clear sometimes, so if there is any doubt, check the polarity with a multimeter; remembering that on the majority of meters, the red terminal is negative with respect to the black terminal, on the ohms ranges.

The author found that it did not make any difference which way the resistors were wired in: it does make the board look neater, however, if the tolerance bands on the groups of resistors are all at the same end. The reed relay, crystal and the adjustable components can next be mounted on the board.

The crystal must be wired to the board directly, as there is not enough room for a socket. Solder about 1in of tinned copper wire (22 s.w.g.) to the ends of the pins on the crystal taking care not to overheat it. Under no circumstances should any attempt be made to bend the pins on the crystal. This should support the crystal securely enough for most uses to which the clock might be put; if a more secure fixing is required, drill two small holes at each side, cover the underside of the crystal with a thin layer of silicone rubber and tie the crystal down with a short piece of thread.

The next components to be wired to the board are the i.c. sockets, or the i.cs themselves if sockets are not used. In addition to the possibility of damaging the i.cs by overheating them when soldering them in (in common with all other semiconductors) there is the possibility of destroying them due to static charges—on the soldering iron, for example. The following precautions *must* be taken whether sockets are used, or not.

The work surface must be conductive and earthed; a plain metal tray or a sheet of aluminium "kitchen" foil earthed. All the i.cs in the plastic foam, the partly

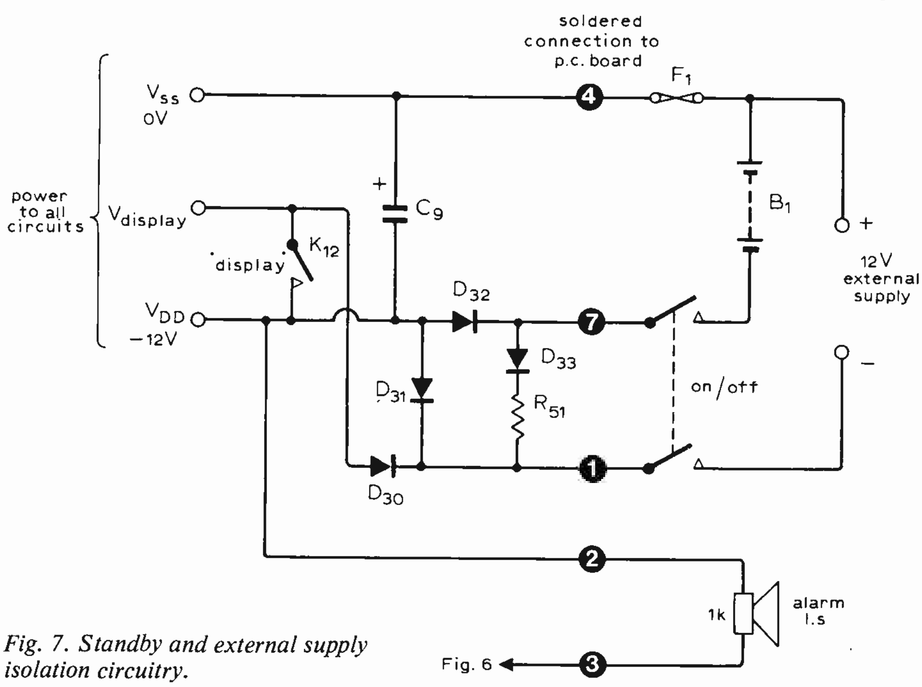


Fig. 7. Standby and external supply isolation circuitry.

assembled p.c. board, the tools and the solder must rest on this surface during assembly. If the i.cs are to be soldered in, a small soldering iron with an *earthed* bit must be used. Under no circumstances should an iron with an isolated bit be used. It is also important that the constructor should be earthed, a condition which is best achieved by resting the hands on the work surface.

These precautions appear daunting, but if they are followed the chances of accidentally destroying an i.c. are very slight.

Testing and setting up

After assembly is complete, and before applying power to the board, check that all components are in their correct locations, and that polarised components (diodes, transistors, and integrated circuits) are in the right way round.

Set the variable resistors R_{31} and R_{32} to their mid positions, connect a milliammeter in series with the supply fuse and then switch on. The current should not be more than 140mA and the display will show 88.88.88; the alarm may also sound. Pressing the "set time" button will clear the display to 00.00.00; if this button is now released, the seconds will start to increment. Check that the "update" buttons are functioning correctly by setting the clock to the right time; set the clock one minute fast, hold the "set time" button and release it as indicated by a suitable reference clock (for example the Speaking Clock).

Now push the "set display alarm" button, and the display should read 00.00.00. By holding this button down and simultaneously pressing the required "update" button, the alarm time is set. Releasing the "set display alarm" button should return the display to clock time which is not affected by looking at the alarm time. Check that the alarm and relay work correctly by setting the alarm time a few minutes ahead of the clock time.

During the above testing it might have become obvious that the accuracy of the clock is very poor indeed; the following setting up procedure will correct this.

The display multiplex frequency can be adjusted by setting the alarm so that it sounds, and adjusting R_{31} until the alarm tone is about 700Hz; the display multiplex frequency will then be about 100kHz. This frequency is not at all critical, and this method of setting it by ear is perfectly adequate. If desired, it can be adjusted with the aid of a frequency counter.

Such an instrument is essential to adjust the crystal oscillator frequency and should have a high input impedance—at least 10MΩ—and low input capacitance. The counter should be connected to pin 2 of IC_1 (see Fig. 2); using a plastic trimming tool, adjust C_5 until the frequency is 204.800kHz. If the variable capacitor cannot adjust the frequency to this value, C_4 may require adjustment; increasing C_4 lowers the frequency and vice-versa.

Now observe the seconds count on the display, and adjust R_{32} slightly clockwise until the intervals between successive seconds are obviously less than a true second; i.e. the clock is running fast. The "Standby 50Hz" control (R_{32}) should now be adjusted anticlockwise; the clock will slow down and at some point there will be no further change. This is the point at which the crystal oscillator "takes over" from the standby oscillator.

If a frequency counter is not available, the clock can be set up quite accurately by trial and error with reference to some standard time source, for example, the Speaking Clock. The time can be set correctly and then checked every 10 hours, adjustments being made as required. Using this technique, the author found that the clock could be adjusted to the required accuracy within a week.

In view of the fact that the overall dimensions of the clock are quite small, it was decided not to have an integral mains power supply as this would have occupied at least the same volume as the clock itself, if not more, and would have seriously limited its usefulness. Although the clock was designed for use with two

Fig. 9 (opposite). Printed-board pattern. Component side is shown at (a), reverse side at (b).

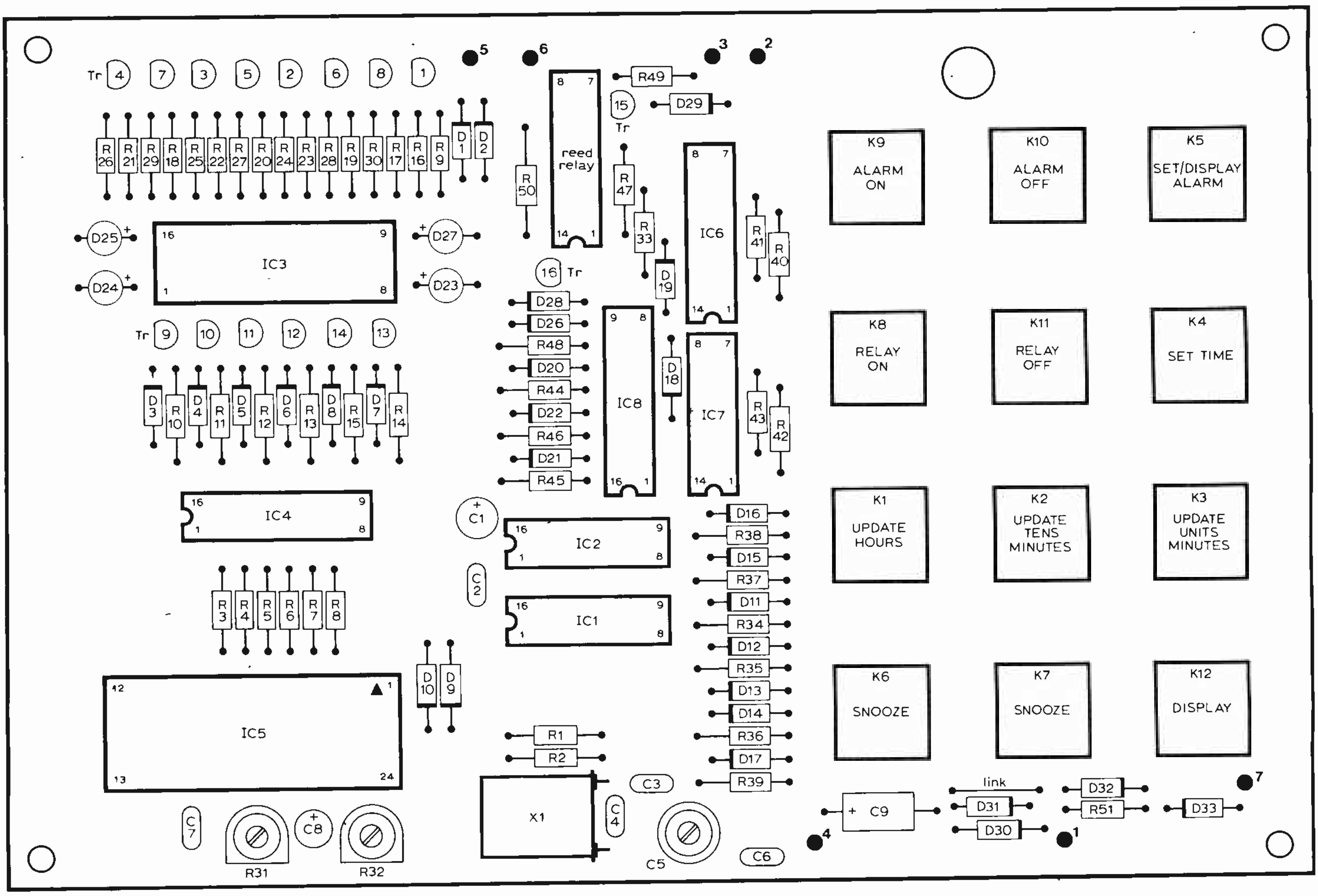
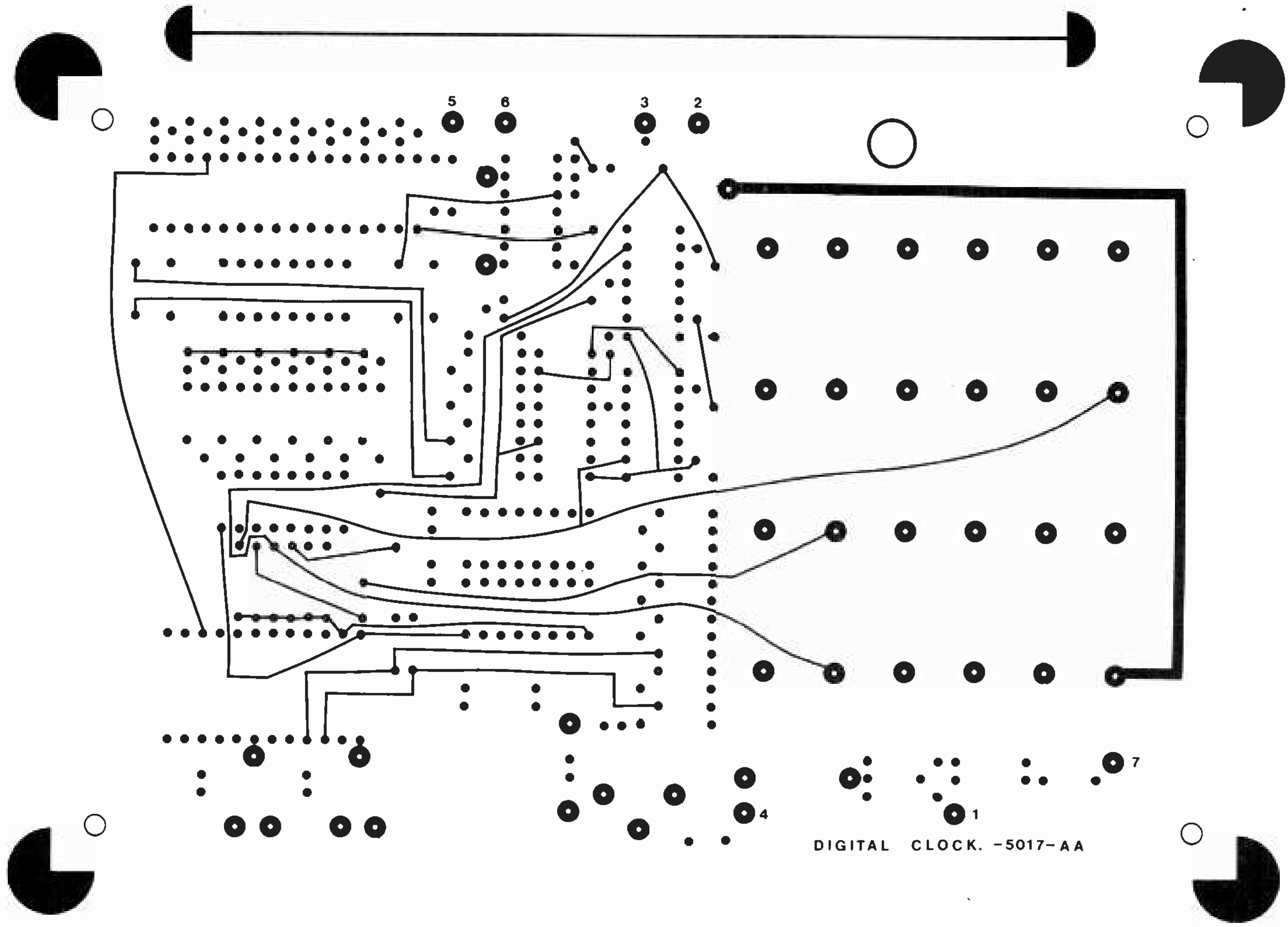
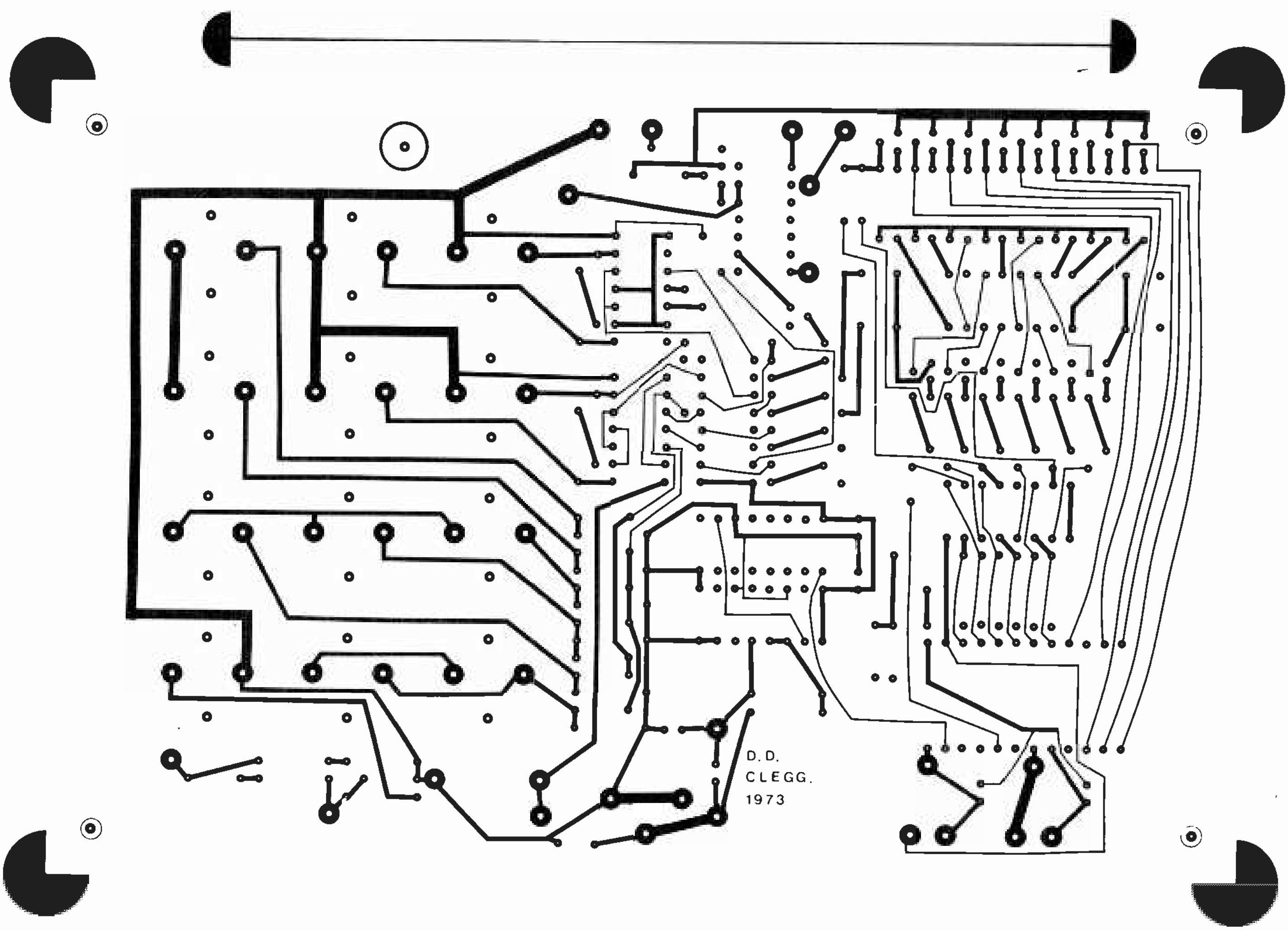


Fig. 8. Layout of components on printed-circuit board. Numbered circles are connecting pins on Figs. 6 and 7.


5
6
3
2
7
4
1
DIGITAL CLOCK. -5017-AA


D.D.
CLEGG.
1973

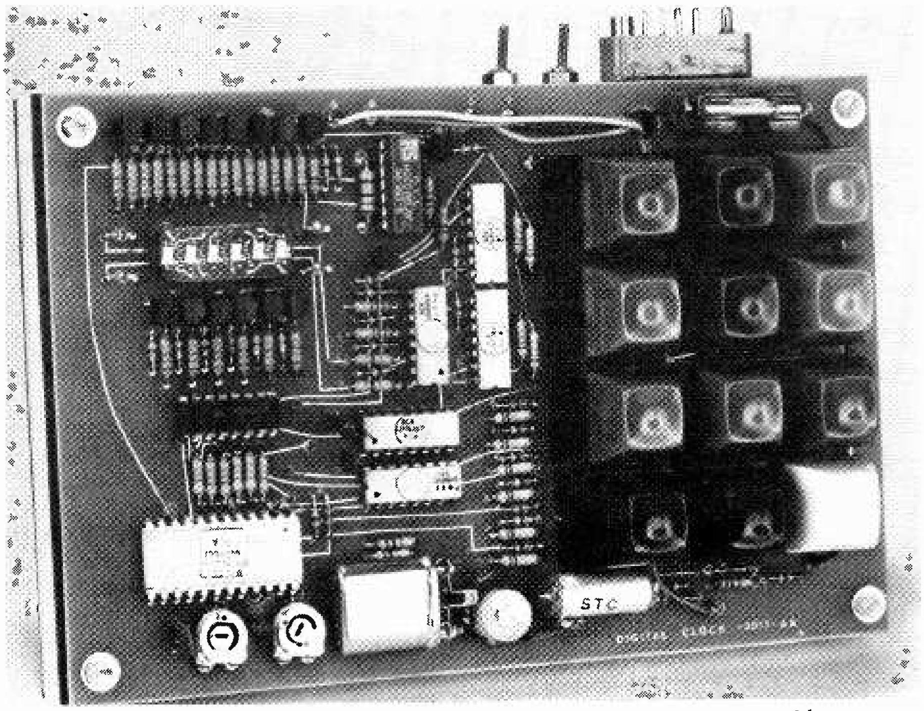


Fig. 10. The complete unit, assembled in a "tray" with the alarm speaker and batteries underneath the board.

supplies, a main one and a standby one, a number of different supply arrangements are possible. If, for example, it is thought that it is wasteful of power to display the time continuously, and a single reliable power source is available, then this may be connected between p.c. board connexions 4 (positive) and 7 (negative). A toggle switch can then be fitted to short circuit connexions 7 and 1 together when the display is required; the "display" button remaining operative for a "quick look".

The above is given only to illustrate that the power supply need not be exactly as shown in Fig. 7. There are, however, two "don'ts"; under no circumstances must power be applied to the display without the logic being powered, and do not exceed 12 volts.

Controls

Alarm on. This key enables the alarm so that at the set time the alarm sounds and the relay contact closes.

Alarm off. This key cancels the alarm if it is sounding (the relay contacts, however, remain closed) or prevents the alarm from sounding at the set time, if it is not. (The relay contact will not operate.)

Relay on. This key causes closure of the relay contact. It obviates the need to reset the alarm to operate the apparatus connected to the relay.

Relay off. This key opens the relay contact if it is closed.

Snooze. When the alarm sounds, this key will silence it for seven minutes, after which it will again sound. This can be repeated for up to an hour after the set alarm time. (There are, in fact, two "snooze" keys side by side. It was intended that they should be fitted with a double width button top; a suitable one is not, however, available.)

Display. The display consumes over 90% of the power required by the clock. When the external supply fails, the standby supply does not, therefore, power the display. This button allows it to do so when it is pressed.

Set/display alarm. This key causes the display to indicate the contents of the alarm register and in conjunction with the three "update" keys allows the alarm time to be set.

Set time. This key inhibits the counters in the clock, thereby freezing the time, and resets the seconds to "00". It is used to synchronise the clock to an external time source, e.g. GTS.

Update hours. Pressing this key causes the hours to increment at the rate of about 2 hours per second. It may be operated with the "set time" key pressed or not, as required. It is therefore possible to update the hours without losing timekeeping accuracy. (This is useful when changing from G.M.T. to B.S.T. etc.)

Update tens minutes. Pressing this key causes the tens of minutes to increment as for the hours key.

Update units minutes. Pressing this key causes the units of minutes to increment as above.

Suppliers

RCA Celdis Ltd, 37–39 Loverock Road, Reading, RG3 1ED.
SASCO Ltd, P.O. Box 2000, Crawley, Sussex RH10 2RU.
REL Equipment & Components Ltd, Croft House, Bancroft, Hitchin, Herts.
Semicomps Northern Ltd, 44 The Square, Kelso, Roxburghshire.
Monsanto Semicomps Ltd, 5 Northfield Industrial Estate, Beresford Avenue, Wembley, HA0 1SD.
Semiconductor Specialists (U.K.) Ltd, Premier House, Fairfield Road, Yiewsley, West Drayton, Middx.
Texas Blue Line Services, Edinburgh Way, Harlow, Essex.
Quartz Crystal Co., Wellington Crescent, New Malden, Surrey.
Alma Components Ltd, Diss, Norfolk.
MOSTEK SDS Components Ltd, Gunstore Road, Hilsea Industrial Estate, Portsmouth, PO3 5JW.
Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts.
A. M. Lock & Co. Ltd., Neville Street, Middleton Road, Oldham, Lancs.
Trampus Electronics, 58–60 Grove Road, Windsor, Berks.
Doram Electronics Ltd., P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds LS12 2UF.

Component list

Resistors (*R*)

1	10M	
2	10k	
3–8	47k	
9, 33	100k	
10–15	2.7k	
16, 24–30	680	
17–23	68k	0.25W, 5% (Doram Type CF 0.25W)
34–39	150k	
40–43	56k	
44, 48	1.5k	
45, 46	47	
47	1k	
49, 51	100	
50	68, 0.5W	(Doram Type 0.5W)
30, 31	100k	open cermet preset (Doram)

Capacitors (*C*)

1 10μ 16V tantalum bead
2 10n 30V ceramic
3 22p 68V ceramic
4 see text. Author's unit needed 19.7p (15 + 4.7).
5 6-25p ceramic trimmer
6 100p 68V ceramic
7 68p 68V ceramic
8 100n 35V tantalum bead
9 100μ 15V solid tantalum

Diodes (*D*)

1–22, 26, 28, 29	1N914
23–25, 27	MV50 (Monsanto)

Transistors (*Tr*)

1–8	BC182A
9–14	2N3704
15	BC213LA
16	BC182A

Integrated circuits (*IC*)

1, 8	CD4009AE	(RCA)
2	CD4040AE	(RCA)
3	TIL360	(Texas)
4	CD4010AE	(RCA)
5	MK-5017-AA	(MOSTEK)
6, 7	CD4011AE	(RCA)
8	CD4009AE	(RCA)

Miscellaneous

Reed relay	d.i.l. type (Doram)
X_1	Crystal, F_r 204.800kHz, for 50p loading (Quartz Crystal Co.)
Cells	7 NCB-55 button cells (Ever Ready)
Alarm	1kΩ telephone earpiece
K_1–K_{12}	AKS reed keys with button tops (Alma)

Sinclair Project 80

For elegant, versatile, stereo hi-fi systems designed and built by you!

Until recently, if you wanted a first-class hi-fi system you had two ways to get it.

You could buy the individual electronic components and build a system from scratch. If you were an electronics genius – fine.

Or you had to buy ready-made units. Expensive – and dull. About the only creative pleasure you'd get would be matching your amp and your speakers, or making your speaker enclosures.

So what's new?

A comprehensive hi-fi system, combining the enjoyment and satisfaction of build-it-yourself (without too much struggle) . . . a real value-for-money feeling . . . and results of the highest quality.

It's the new Sinclair Project 80.

How does Sinclair Project 80 work?

Project 80 is a comprehensive set of hi-fi modules, or sub-assemblies. Amps . . . pre-amps . . . FM tuners . . . stereo decoders . . . control units . . . everything you need to assemble hi-fi units. They're all designed to look alike and they're all completely compatible with each other. Simply decide on the specifications of the unit you want to build . . . buy the necessary modules . . . connect them . . . and house them.

No need to buy everything at once for your eventual set-up. All the modules are designed so that you can add to them as your system grows – whether or not it's based on Project 80.

This applies to refinements, like filters . . . to up-grading, adding a second set of amps, say, for greater output . . . or to real innovation, like quad. (Add a Project 80 quad decoder, a power supply, a pair of amps, and a pair of speakers – and your stereo's gone quad.)

Is it difficult to build?

Not at all. The modules are complete in themselves. All you do is connect them to your turntable . . . your speakers . . . or to each other. It's absorbing, but if you can solder wires to a 5-pin DIN plug, you can build a complete system with Project 80.

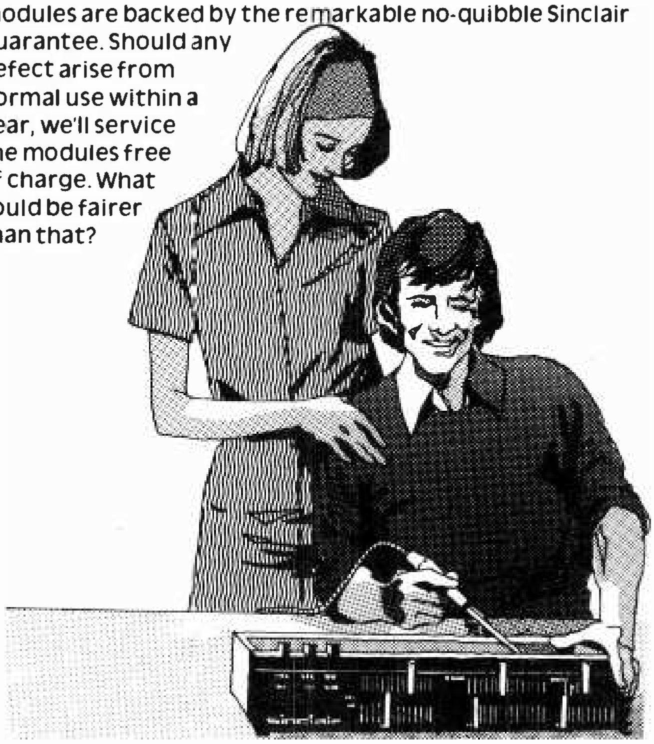
And if you're not so hot with a soldering iron? Use Project 805. Project 805 uses Project 80 modules, but provides special clip-on tagged wire connections – absolutely *no* soldering required.

And, of course, both Project 80 and Project 805 come complete with instructions for easy, step-by-step assembly. But if you do run into problems, just call our Consumer Advisory Service who are always happy to help.

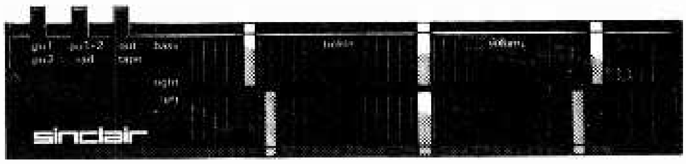
OK. Where do I go from here?

Over the page! There you'll see for yourself the exacting specifications to which Sinclair Project 80 modules are made, and you'll see some suggested systems.

As you skim the suggestions, remember all Project 80 modules are backed by the remarkable no-quibble Sinclair guarantee. Should any defect arise from normal use within a year, we'll service the modules free of charge. What could be fairer than that?



Choose the Project 80 modules that are right for you.

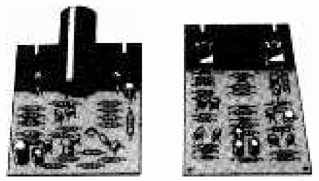


Project 80 pre-amp/control unit

The control centre of Project 80. With its distinctive white-on-matt-black styling and plastic control sliders, it's a pleasure to look at, as well as to use.

Specification
(9½ in x 2 in x ¾ in.) Separate slider controls on each channel for treble, bass and volume. **Inputs:** *PU* magnetic – 3 mV (RIAA corrected), ceramic – 350 mV; *Radio* 100 mV; *Tape* 30 mV. **S/N ratio:** 60 dB. **Frequency range:** 20 Hz to 15 kHz ± 1 dB. **Outputs:** 100 mV and tape plus AB monitoring. **Press buttons** for PU, radio and tape. **Operating voltage:** 20 V – 35 V.

Price: £13.95 + VAT



Project 80 power amplifiers

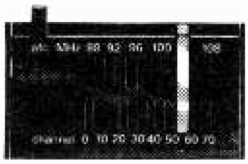
Two different amplifiers, designed to be used separately or combined, with Project 80 modules or as add-ons to existing equipment. Protected against short circuits and damage from mis-use.

Z40 Specification
(2¼ in x 3 in x ¾ in.) 8 transistors. **Input sensitivity:** 100 mV. **Output:** 12 W RMS continuous into 8 Ω (35 V). **Frequency response:** 30 Hz – 100 kHz ± 3 dB. **S/N ratio:** 64 dB. **Distortion:** 0.1% at 10 W into 8 Ω at 1 kHz. **Voltage requirements:** 12 V – 35 V. **Load imp:** 4 Ω – 15 Ω; safe on open circuit. Protected against short circuit.

Price: £5.95 + VAT

Z60 Specification
(2¼ in x 3⅘ in x ¾ in.) 12 transistors. **Input sensitivity:** 100 mV – 250 mV. **Output:** 25 W RMS continuous into 8 Ω (50 V). **Frequency response:** 10 Hz to more than 200 kHz ± 3 dB. **S/N ratio:** better than 70 dB. **Distortion:** 0.02% at 10 W into 8 Ω at 1 kHz. **Voltage requirements:** 12 V – 50 V. **Load imp:** 4 Ω min; max safe on open circuit. Protected against short circuit.

Price: £7.45 + VAT



Project 80 FM tuner

Excellent reception from a tuner only 3½ in long x ¾ in deep! Styled to match Project 80 control unit.

Specification
(3½ in x 2 in x ¾ in.) Tunes 87.5 MHz to 108 MHz. **Detector:** IC balanced coincidence (IC equivalent to 26 transistors). **Distortion:** 0.3% at 1 kHz for 30% modulation. **Sensitivity:** 5 μV for 30 dB signal to noise. **Output:** 100 mV for 30% modulation. **Aerial imp:** 75 Ω or 240-300 Ω. **Features:** dual Varicap tuning, 4-pole ceramic filter, switchable AFC. **Operating voltage:** 23 V – 30 V.

Price: £13.95 + VAT

Power supply units

Range of power supply units to match desired specification of final system.

PZ5 Specification
Unstabilised. 30 V output. Including mains transformer.

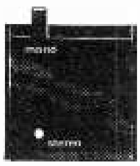
Price: £5.95 + VAT

PZ6 Specification
Stabilised. 35 V output. Including mains transformer.

Price: £8.95 + VAT

PZ8 Specification
Stabilised. Output adjustable from 20 V to 60 V approx. Re-entrant current limiting makes damage from overload or even shorting virtually impossible. Without mains transformer.

Price: £8.45 + VAT

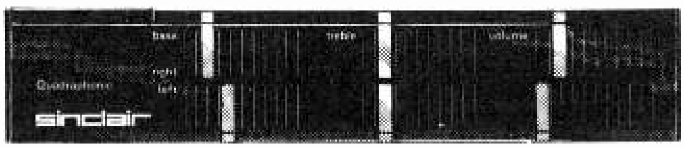


Project 80 stereo decoder

Designed for use with Project 80 FM tuner. Sold separately to keep down the price of a mono FM system, but also to make the stereo decoder available for use with existing mono FM tuners.

Specification
(1¾ in x 2 in x ¾ in.) 1 IC equivalent to 19 transistors. LED stereo indicator glows red.

Price: £8.95 + VAT

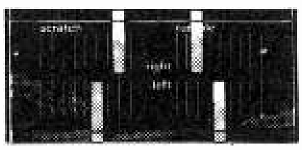


Project 80 SQ quadraphonic decoder

Combines with and exactly matches Project 80 control unit for true quadraphonics. This unit is based on the CBS SQ system and is a complete quadraphonic decoder, rear channel pre-amp and control unit.

Specification
(9½ in x 2 in x ¾ in.) Connects with tape socket on Project 80 control unit or similar facility on any stereo amplifier. Separate slider controls on each channel for treble, bass and volume. **Frequency response:** 15 Hz to 25 kHz ± 3 dB. **Distortion:** 0.1%. **S/N ratio:** 58 dB. **Rated output:** 100 mV. **Phase shift network:** 90 ± 10 100 Hz to 10 kHz. **Operating voltage:** 22 V – 35 V.

Price: £18.95 + VAT



Project 80 active filter unit

Eliminates scratch and rumble (high and low-frequency noise).

Specification
(4¼ in x 2 in x ¾ in.) **Voltage gain:** –0.2 dB. **Frequency response:** filter at zero: 36 Hz – 22 kHz; HF (scratch) out: variable 22 kHz to 5.5 kHz, 12 dB/octave slope; LF (rumble) out: –28 dB at 28 Hz, 9 dB/octave slope.

Price: £7.45 + VAT

WW—165 FOR FURTHER DETAILS

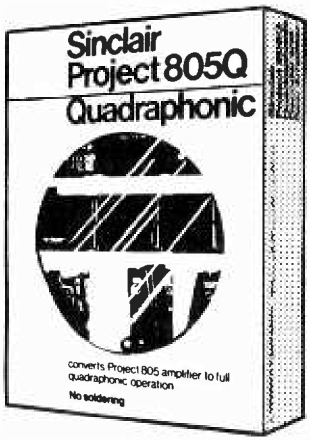
Some system suggestions from Sinclair

Project 805 amplifier kit

Contains following Project 80 units:

Project 80 control unit
2 x Z40 power amplifier modules
1 x PZ5 power supply unit
Masterlink unit
On/off switch
plus pre-cut wiring loom with clip-on tagged wire connections, nuts and bolts, instruction manual.

Price: £39.95 + VAT



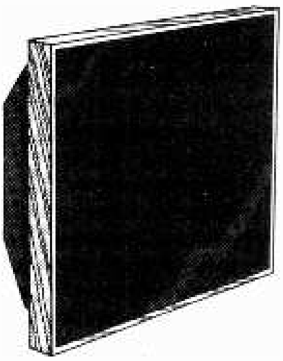
Project 805Q quadraphonic add-on kit

Converts your existing stereo hi-fi system to quad using solderless connections.

Contains following Project 80 units:

Project 80 SQ quad decoder/rear channel pre-amp and control unit
2 x Z40 power amps
PZ5 power supply unit
Masterlink unit
On/off switch
plus pre-cut wiring loom with clip-on tagged wire connections, nuts and bolts, instruction manual.

Price: £44.95 + VAT



Sinclair Q16 speaker

Original and uniquely designed speaker of outstanding quality.

Specification
(9⅜ in square x 4¾ in deep.) Pedestal base. All-over black front. Teak surround. Balanced sealed sound chamber. Special driver assembly. **Frequency response:** 60 Hz to 16 kHz. **Power handling:** up to 14 W RMS. **Impedance:** 8 Ω.

Price: £8.95 + VAT

1. Quadraphonic system: 25 W per channel RMS
Pre-amp/control unit + quadraphonic decoder + 4 x Z60 amps + 2 x PZ8 mains power supplies + (2 x mains transformers) + (4 x equivalent speakers) + (turntable). Total Project 80 cost: £79.60 + VAT.

2. Stereo amplifier: 12 W per channel RMS
Pre-amp/control unit + 2 x Z40 amps + PZ6 power supply + 2 x Q16 speakers. Total Project 80 cost: £52.70 + VAT.

3. Stereo tuner/amplifier: 12 W per channel RMS
Pre-amp/control unit + FM tuner + stereo decoder + 2 x Z40 amps + PZ6 power supply + 2 x Q16 speakers. Total Project 80 cost: £75.60 + VAT.

Other applications

4. PA system
(Mic) + pre-amp/control unit + Z40 amp + PZ6 power supply + 2 x Q16 speakers. Total Project 80 cost: £46.75 + VAT.

5. Convert existing mono record-player to stereo
Pre-amp/control unit + Z40 amp + Q16 speaker. Total Project 80 cost: £28.25 + VAT.

What more can we tell you?

The basic facts are covered on these two pages: And you'll find Project 80 at stores like Laskys and Henry's.

But before you look, why not get really detailed information? Clip the FREEPOST coupon for the fully-illustrated Project 80 folder – today!

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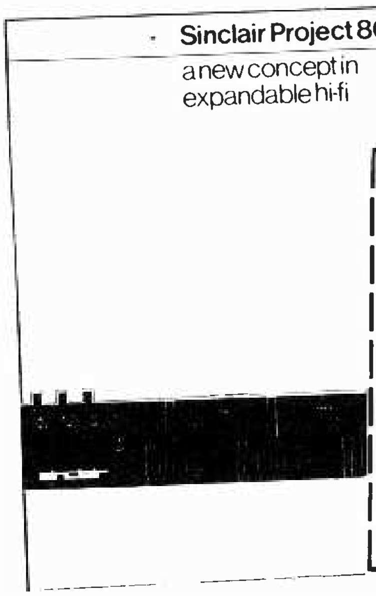

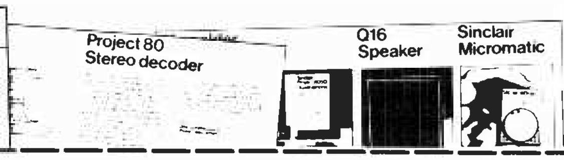

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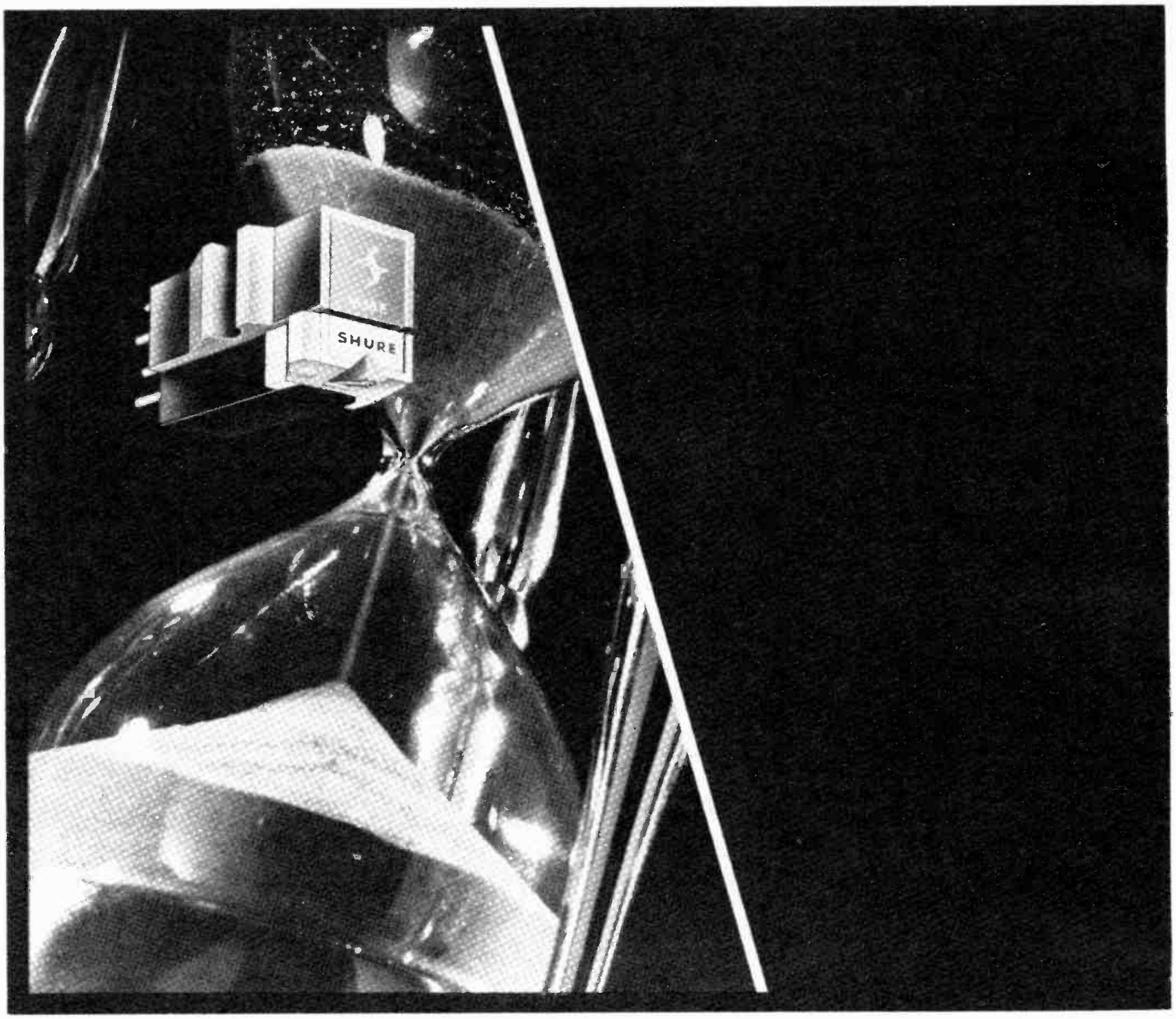
Please print FREEPOST – no stamp needed WW/3/75


SHURE

Charge-coupled devices

4—Imaging applications

by Ted Williams

Royal Radar Establishment, now with ICI Ltd, Runcorn

The c.c.d. is a very flexible type of integrated circuit. Not only can it handle both digital and analogue electrical signals but it can also have charge injected into it optically. This final part of this series shows how this ability to accept optical injection of charge has produced some exciting applications. Whether these applications are turned into a commercial success will depend on many factors—scientific, economic and political.

Some of the technical problems associated with c.c.d. imagers are discussed later, but first consider what happens when a light spot falls on a c.c.d. line imager. A line imager is almost identical to a c.c.d. serial shift register, such as the two-bit c.c.d. shown in Fig. 2 of part 1 of this series[1]. The only difference is that the input or source diode is omitted because the electrical injection of charge is no longer needed.

Charge is generated by the light spot producing electron-hole pairs at and just below the silicon surface of the silicon dioxide interface. This charge is only generated by light which has a greater energy (or shorter wavelength) than the semiconductor energy band gap. In the case of silicon the band gap is in the infrared so visible light will effectively generate charge.

To collect this charge one of the clock pulses must be biased with a similar direct voltage to that used for signal processing applications (say -20 to -30 volts for p-channel or $+10$ volts for n-channel devices). This bias is applied for an integration time of the order of a few milliseconds. During this time the charge collects at the interface under the biased electrodes in a surface channel device. The amount of charge collected under each electrode is proportional to the light intensity in the gaps closest to the electrodes if the electrodes are of aluminium and not transparent to light. Hence an analogue charge "picture" of the light spot is built up in the imager. This picture is then read out in the normal signal processing manner by sequentially turning on the clock phase voltages. This sequence of integration and read out is then continuously repeated and the output fed via a suitable amplifier to a display monitor. The read-out time must be much faster (say 50μs) than the integration time if smear is to be prevented.

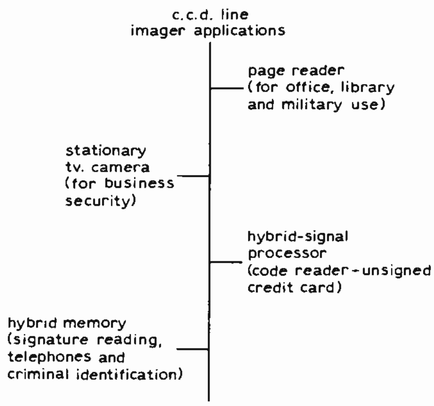


Fig. 1. Possible applications for a c.c.d. line imager.

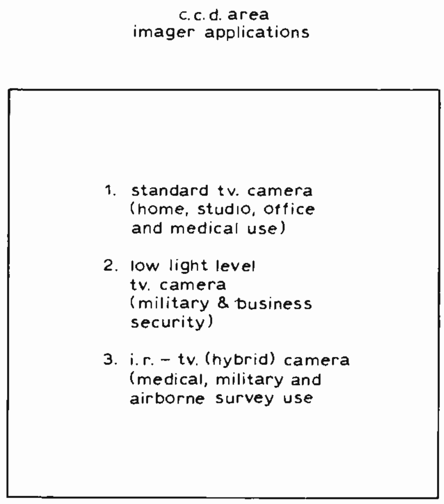


Fig. 2. Three applications for c.c.d. area imagers.

To view a two-dimensional picture the image must be scanned continuously over the line imager to generate the full picture line by line. This can be done either by placing the picture on a rotating drum or by moving the imaging lens to produce a scan.

Charge loss occurs during the collection and transfer of charge by recombination at the interface states at the silicon-silicon dioxide interface and at trapping sites in the bulk of the silicon. These last-mentioned trapping sites could be impurities of crystal defects. Loss also occurs during integration if the device is saturated by the light. Hence light levels falling on the device need to be tailored to the device operating conditions and vice versa.

Finally, charge loss through residual charge loss is very important during the read-out time. This process was described in detail in part 3 of this series[2]. Residual charge loss can be minimized by choosing the right fabrication technique for the particular imaging application that is under consideration. Before we discuss this choice some of the possible applications for c.c.d. line and area imagers are discussed, together with the operation and design of an area imager.

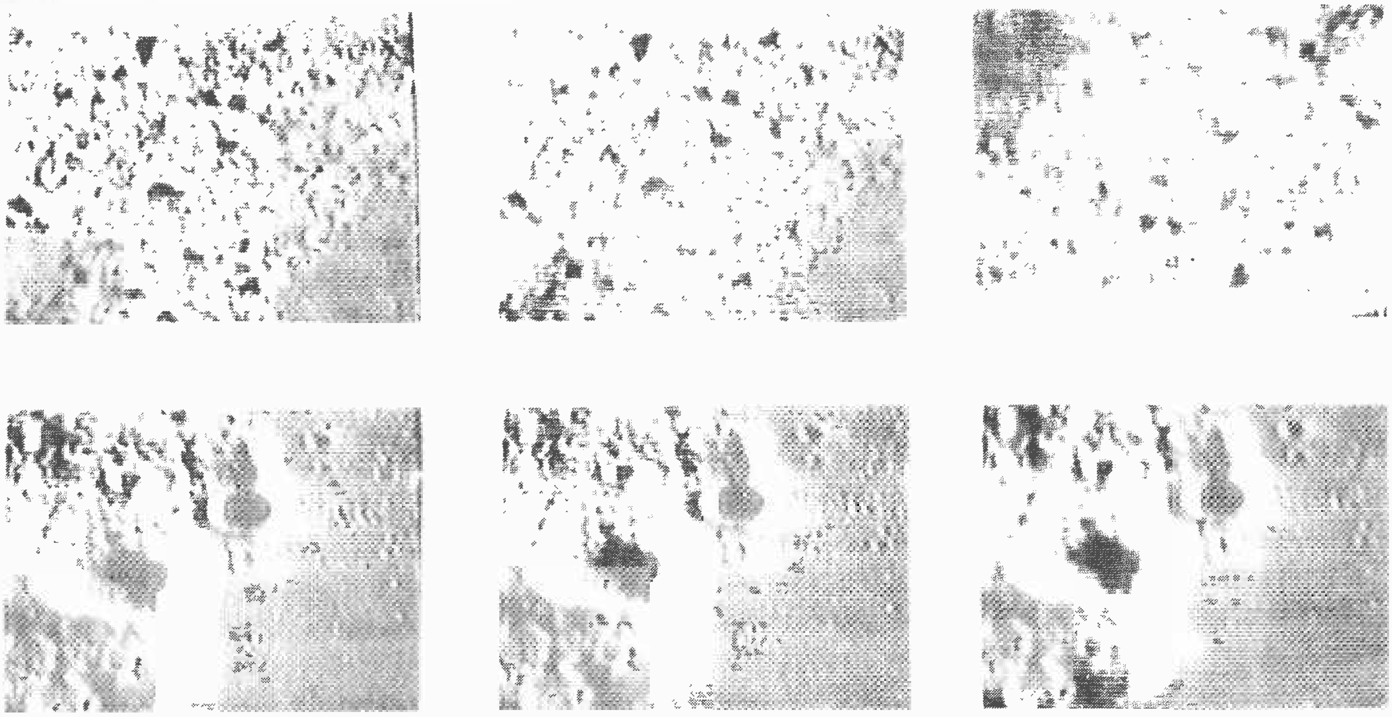
Possible applications of line imagers

In the first figure some of the possible applications of line or serial imagers are shown. The page reader and the business security television camera are both applications for stationary cameras. The word stationary hints at the basic disadvantage of a line imager. Only one line of information can be read out at a time so the scene has to be mechanically scanned over the imager. However, they are much simpler to design and operate than the area imager because they have only one line of transfer electrodes and only one clock. This basic simplicity means that initially it is likely that they will be used in any fixed application where the camera system can be set up and left unattended. It is also possible that line imagers will be tried out on a first trial basis in hybrid systems in combination with signal processors and memories (see later).

Applications for area imagers

There is little doubt that as scientists and engineers working on c.c.d. imagers gain experience the line imager will take a back seat and the area imager will be increasingly adopted. This is because the area imager is portable and hence more versatile because the whole of the viewed scene can be imaged on to it while the camera is moving or stationary.

Since this change in emphasis from line to area imagers is already happening, and because the line imager can be operated in the same way as the serial signal-processing c.c.d., the rest of this



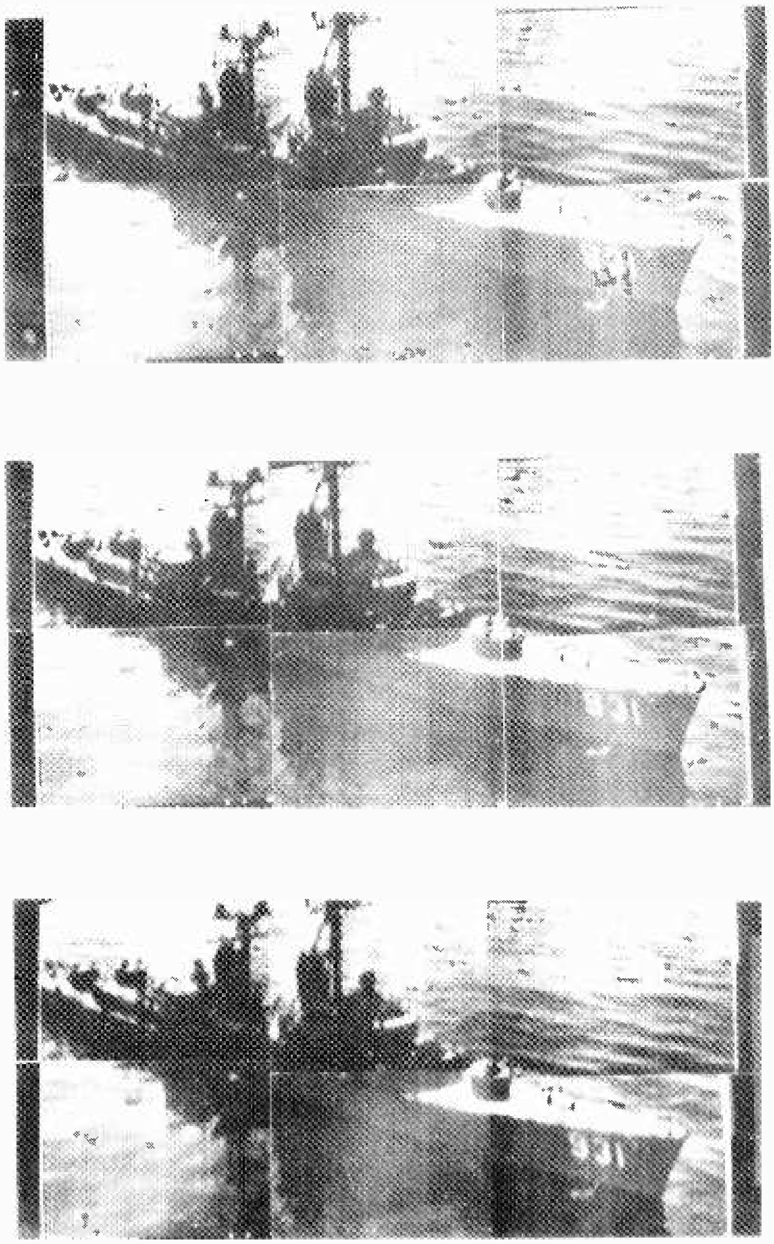


Fig. 3. Lunar landscape photographs reproduced by a c.c.d. camera (ref. 3) taken under three focus conditions.

Fig. 4. Composite of six c.c.d. camera pictures of a ship (ref. 3) taken under three focus conditions.

article concentrates on the area imager. Nevertheless, much of what is said applies equally to line imagers.

The c.c.d. area imager could be used in all of the applications shown in Fig. 1, but in addition it is being used in research laboratories for the three areas shown in Fig. 2. Black and white and colour* television cameras have already been made with c.c.d. area imagers and these can either be hand held or mounted in a fixed position.

Examples of photographs taken with c.c.d. cameras are shown in Figs 3 to 6. In Figs 3 and 4 the 100 × 100-bit Fairchild buried-channel imager was used[3]. In Fig. 3 the resolution for small moon craters is remarkable and in Fig. 4 a composite picture has been made of a ship by combining six c.c.d.-camera photographs. The battery-operated portable camera made by Bell Labs and the 256 × 220-element surface-channel c.c.d. chip that was used in it is shown in Fig. 5[4]. A photograph of a picture taken with the camera is shown in Fig. 6[4]. Absence of defects in the picture shows how much c.c.d. imager technology has advanced recently and makes the goal of full television resolution on a single silicon chip so much nearer.

Provided the c.c.d. camera can be made cheaply enough the market for office use could be enormous. In the medical field a c.c.d. colour camera would

*For a description of the colour c.c.d. camera see H. A. Watson, *Bell Laboratories Record*, October 1973, p. 266.

be extremely useful as several specialists could be shown the patients' symptoms on large monitor screens in the comfort of their own homes. For library references a microfilm could be shown on a monitor in the library and the information transmitted with a c.c.d. camera to an office monitor which had a copier coupled to it so that any page of an article that was of interest could be duplicated.

For home use the c.c.d. camera is obviously an attractive possibility for home movies and a picturephone[5]. There are three snags, however. First, for home movies the present video tape recording systems are extremely expensive and this market still awaits the invention of a cheaper system. Second, for picturephone, as a recent trial system has shown in America, it appears that most people do not want to see their mother-in-law over the phone. Third, there are transmission problems because the bandwidth required is wider than that currently used with telephone transmission.

Low-light-level television cameras are an area where the c.c.d. shows a great deal of promise. High sensitivity or low noise is required and the buried channel structure, discussed in part 2, is particularly useful in this respect. Some degree of cooling is still required with the present devices to get the noise level down to the low level required for some military uses.

The hybrid infrared television camera will be discussed in detail later. It will be particularly useful for military applications. As for the low-light-level camera, however, considerable sensitivity will be required if small temperature differences between targets and the background are to be detected. This high sensitivity will also be required for medical use, for example, for the detection of small tumours from hot spots on body temperature pictures, and also for satellite geological survey temperature pictures.

A replacement for video camera tubes?

The potential advantages of the c.c.d. camera in comparison with the currently used video camera tubes are listed below:

c.c.d. cameras	video camera tube
Small size	Large
Low power consumption	High power consumption
Self scanning	Electron-beam scanned
More rugged—all solid state	Glass tube
No warm up time	Warm up
No colour fringing	Colour fringing
No image lag	Image lag

Difficulties do exist with the c.c.d. camera, but before discussing the problems the area imager and its operation are examined in more detail.

How an area imager works

Fig. 7 shows a schematic diagram of a type of c.c.d. area imager that was originally designed for the standard aluminium-gate surface-channel described in part 1 of this series[6]. This imager is known as the frame transfer type. The upper part

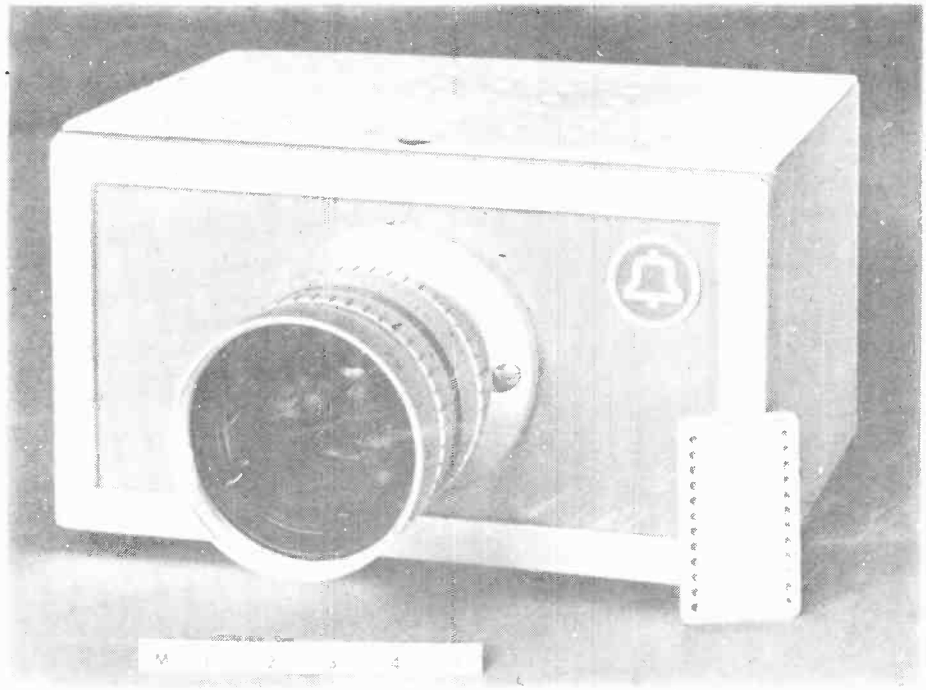
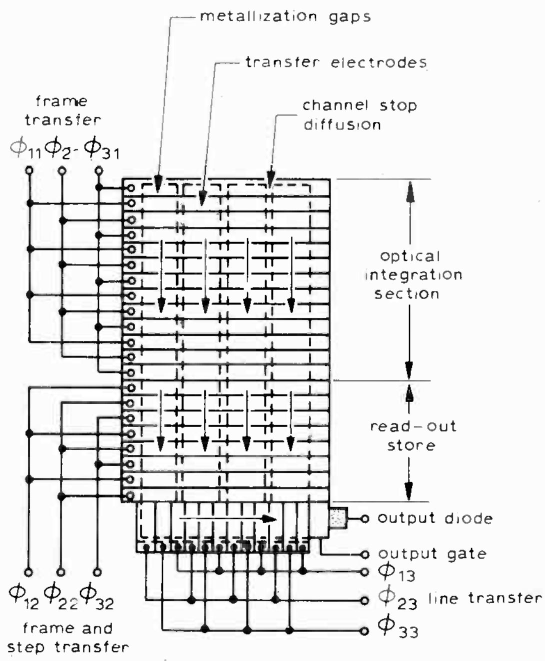


Fig. 5. Battery-operated television camera and the 256 × 220 element c.c.d. area image sensor that was used in it (ref. 4).

Fig. 6. Photograph of a picture reproduced with the camera shown in Fig. 5 (ref. 4).

Fig. 7. Schematic diagram of a frame transfer charge-coupled image area sensing array (ref. 6).



of the array is called the optical integration section; the area of the device upon which the image of the scene falls.

During the integration period a quantity of charge which is proportional to the light intensity is generated in each storage element or bit. As with the signal processing devices one bit represents the minimum area resolution cell or picture element. Movement of charge from one cell of the device to another in the horizontal direction is prevented by the column channel-stop diffusion.

After the integration time the whole frame of charge is transferred or clocked into the read-out store. If resolution is not to be lost this store must be the same area as the optical integration section.

After this the whole frame is moved line-by-line out of the store into the output line or serial register. Finally, the charge is transferred out of this register to the output gate by pulsing the output gate. As all the charges are detected by only one small output diode the output capacitance is minimized and a good signal-to-noise ratio may be obtained.

The first video amplifiers were separate from the c.c.d. chip but more recently low-noise amplifiers have been integrated on chip and connected directly to the output diode.

Design choice for area imagers

Fig. 8 shows that there are two other types of design besides the frame transfer ones that have been used in c.c.d. area imagers[7]. The first of these is the interline transfer technique, where the storage columns are situated in between the imaging columns. This means that the charge from one resolution cell can be transferred into the neighbouring store with little loss of charge so that a higher signal-to-noise ratio results. In addition, on a multilevel gate structure the store and the image columns can overlap.

Interlacing increases the packing density of the resolution cell and improves the overall resolution. The disadvantage is that it is more difficult to make and can result in lower yields than those achievable for devices made with the frame transfer design.

The final design shown in Fig. 8 is the line transfer one. In this device one line at a time is read out by switching the transfer pulses on to each line in turn with a scan generator[6].

Design choice

It has already been shown in part 2 of this series that the number of c.c.d. design techniques to choose from is large[8]. At the moment it seems that almost every company that makes c.c.d. imagers has its own pet technology. Fairchild makes buried-channel imagers with conventional m.o.s. polysilicon gates. Bell Telephone prefer surface channel with overlapping polysilicon-gate electrodes of their own unusual design. Texas Instruments have used their anodized aluminium technique to make thinned backside-illuminated imagers[9]. RCA have used overlapping polysilicon-gate technology and the conventional aluminium-gate structure. GEC in England have made both buried-channel and surface-channel devices. Plessey have also made buried-channel devices.

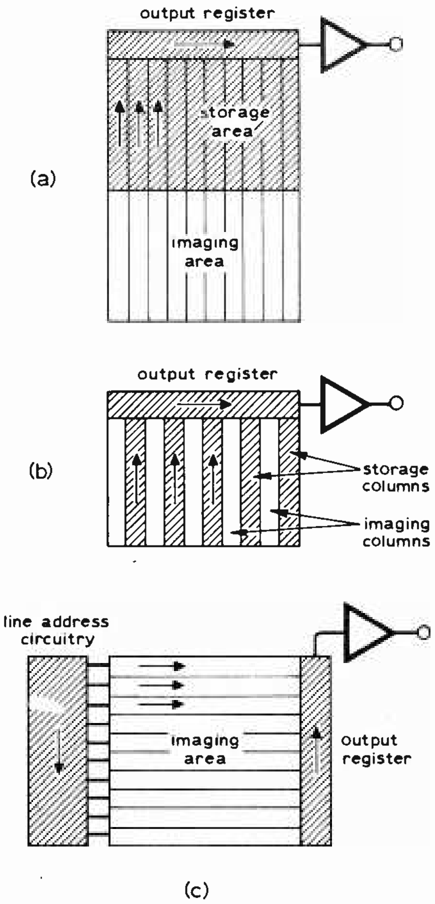


Fig. 8. Design choices—(a) frame transfer, (b) interline transfer, (c) line transfer (ref. 7).

Of all these structures there are two in particular that have achieved low transfer efficiencies in the region of 10^{-5}. These are the Bell Telephone polysilicon-gate structure[4] and the Fairchild buried-channel device[10]. Which of these two technologies is the best is open to argument. However, it appears to be generally agreed that for low-light-level applications the higher sensitivity of the buried-channel structure is ideal.

It is also agreed that the conventional aluminium-gate surface-channel technique is not very suitable for large area imagers. Even for 100 × 100 imagers the small gap of 2μm between transfer electrodes is extremely difficult to reproduce over the area of the devices and shorts between the electrodes are also quite a problem. In addition the electrodes are exposed and can easily be damaged if they are not sealed in with a deposited insulating, oxide overcoat.

One problem that is common to all techniques is the preparation of high purity and pinhole-free oxides. Production of high purity oxides was discussed previously[8]. Preparation of pinhole-free oxides over a large area requires considerable skill in silicon processing. The photolithography masks must also be made as defect-free as possible. Another technique for improving oxides is to grow two oxides one on top of the other using the mask in two different positions when the photoresist is exposed to define the oxide areas[11]. This ensures that any defects or holes in the oxide which are produced by spots or holes in the chrome or emulsion masks will be covered.

The three largest area imagers that have been operated are compared in Table 1[7]. Fig. 6 shows a picture taken with one of them, the 256 × 220 element one[4].

Back face imagers

All that has been said so far has been concerned with front surface imagers in which the scene is incident upon the front (gate) surface of the c.c.d. imager. These imagers suffer from optical reflection and absorption losses:

—Optical absorption in the blue region of the visible spectrum by the semi-transparent polysilicon electrodes. This absorption varies depending on the angle of incidence of the light.

—The silicon dioxide insulator and the deposited protective layer are the wrong thickness to give an anti-reflection coating.

—Reflection from the metallic electrodes when aluminium-gate technology is used.

These disadvantages can be eliminated by thinning the silicon substrate to about 20μ and imaging on to the back face. To lower the surface recombination velocity and hence improve the quantum efficiency, the back face of the n-channel device is given a shallow p^+ diffusion (p^+ means a high doping level of about 10^{19} boron atoms per ml). On top of this p^+ diffusion an anti-reflection coating is applied.

With these two modifications the back face imager generally has a higher resolution (modulation transfer function), improved grey scale and better spectral response at shorter wavelengths than the front surface imager.

TABLE 1 Large area c.c.d. imagers*

Number of non-overlapping image sensor elements		Chip size				
Horiz	Vert	H (mm)	V (mm)	Design type	Technique	Ref.
190	244	6.3	6.1	Interline transfer	Buried channel polysilicon gate	7
220	128	8.6	12.4	Frame transfer	Surface channel polysilicon gate	4
320	256	12.7	19.0	Frame transfer	Surface channel aluminium gate	12

*Adapted from Table 2 of reference 7

The disadvantages are, firstly, thinning the silicon uniformly and reproducibility is a problem. Thickness must not vary across the imager because different thicknesses can have different wavelength responsivities. And secondly, the extra diffusion step further complicates the technology.

Noise sources

In common with both front and backface imagers are the noise generating sources. Here is a list of some of them.

—Shot noise in the optical signal (photon noise).

—Shot noise in the dark current background level.

—Spikes in the dark current across the array. (Causes white spots on the monitor picture.)

—Transfer noise produced by poor transfer efficiency and local variations in transfer efficiency—dominated by interface—state noise. (Produces smearing on the picture.)

—Noise due to the "fat zero" used for surface channel devices.

—Noise due to the output amplifier.

—Clock noise.

Of these noise sources there is only one, the photon noise, that cannot be reduced in some way. Dark current background level can be reduced by cooling. Spikes in dark current can be reduced by improvements in processing. The exact origin or origins of the spikes are not understood but it is known that they can be caused by impurities or defects in the silicon and at the silicon-silicon dioxide interface producing recombination-generation centres. For the transfer noise, as has already been mentioned, improvements in fabrication have reduced this to a tolerable level. By going to buried channel techniques this noise source and "fat zero" noise are substantially reduced. Noise due to the amplifier has been considerably reduced by using on-chip amplifiers like the floating-gate amplifier[7]. Finally, clock noise is reduced by bringing all the output signals through a single output diode.

Blooming

In addition to noise, blooming can be quite a problem for many c.c.d. camera applications. Blooming is the spreading of charge outside a resolution cell when it is intensely illuminated by reflection from objects like glass lenses and windows. There are two types of blooming: bulk blooming and channel blooming.

Bulk blooming is produced by carrier diffusion in the undepleted substrate and results in distorted, large area, bright spots on the monitor. In area imagers it is reduced by the introduction of vertical or column overflow drains between each horizontal resolution cell in the imaging section in the same position as the channel-stop diffusion. The overflow drain diffusion or implant is a reverse-biased diode which collects or sinks excess charge carriers diffusing through the substrate or at the interface with the oxide from any resolution cell to another.

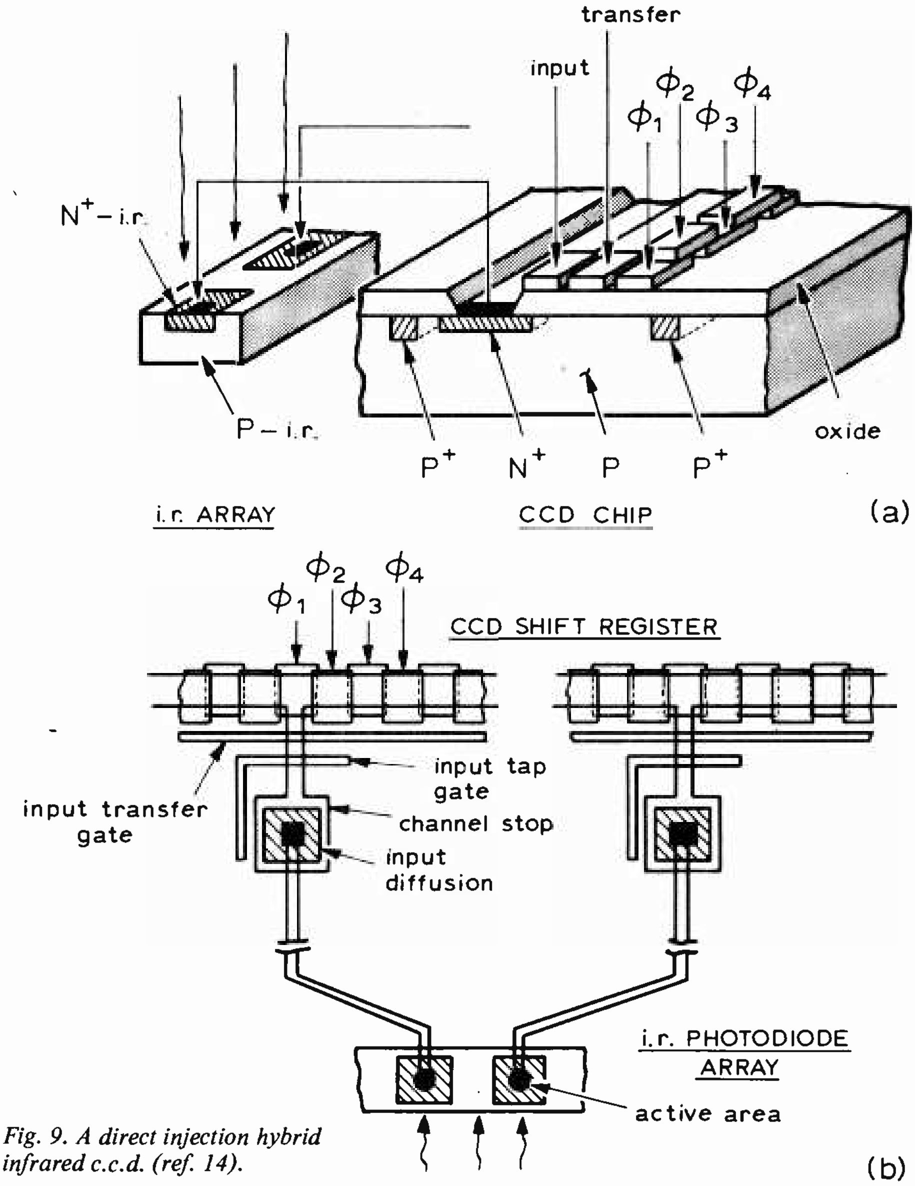


Fig. 9. A direct injection hybrid infrared c.c.d. (ref. 14).

Channel blooming is produced by excess light-generated carriers overflowing along the transfer channels in the imaging section of the device. One method that can be used to minimize this type of blooming is to reduce the voltage on the electrodes which are not being used during the light integration period so that the silicon surface under them is near accumulation[13].

Hybrid imagers

The versatility of the c.c.d. for use in signal processing, imaging and memory applications makes it an attractive proposition for hybrid systems where two or more different types of operation are performed either on chip or on adjacently mounted devices. The system which has been looked at in most detail is the infrared imager—signal processor hybrid. A review of some of the different types of infrared hybrid imager has been given by Steckl et al.[14] Fig. 9 shows a diagram of one of the imagers that he described.

This type is known as the direct injection hybrid c.c.d. because the photogenerated charge carriers are directly introduced into the c.c.d. shift register The figure shows in part (a) the coupling concept for a single line array of n-p infrared detecting diodes. The diodes are connected in parallel to a silicon coupling diode which is diffused into the same chip as the n channel c.c.d. The input gate of the c.c.d. is used to reverse-bias the infrared diode and the silicon coupling diode and the transfer gate is used to introduce the photogenerated carriers into the c.c.d. In this way the low noise properties of the c.c.d. can be fully used in processing the optically generated carriers. Direct injection devices using eight input taps into a 100 bit p-channel c.c.d. with an InSb diode array have been fabricated and operation at 80°K has been achieved. By adding or integrating detector signals in the c.c.d. the signal-to-noise ratio for an infrared detector array can be considerably improved because the noise from each detector is random and is therefore summed non-coherently. Fig. 9(b) shows the array layout.

Two other types of hybrid imager are indicated in Fig. 1. These use the visible imager—signal processor and the visible imager—memory systems. The first of these will undoubtedly be used where improvements in picture quality are necessary and integration will be performed by directly coupling the c.c.d. imager into a c.c.d. signal processor. The second system is less likely to be developed as extensively because of the limitation of the c.c.d. memory operation to one second of storage times and the consequent requirement of refreshing the memory. However with the development of integrated c.c.d.—m.n.o.s. memory systems with their long-term memories this position could change.

The combination of c.c.d. imaging, signal processing and memory on a single silicon chip is likely to be realized in the next year or two provided that interest in the c.c.d. continues at its present rate.

Final comments

In this series we have tried to show the remarkable progress of the c.c.d. in the four short years since it was invented. This has been achieved by the development of promising new techniques and the construction of c.c.d. signal processing, imaging and memory prototype systems.

The factors of small size and the ability to handle analogue, digital and optical signals have also made numerous new applications possible for the c.c.d.

Imaging. The large area imager has been developed to the point at which full television area resolution on a single silicon chip should be achieved in 1975. There is little doubt that 1,000 × 1,000 bit chips will also be produced in competition with the silicon diode array vidicons.

Whether these c.c.d. area imagers will find their way into the home movie camera market depends on two things. First, whether the promising high yields obtained with the recently developed technologies, like the buried channel and the surface channel—polysilicon overlapping gate, can be maintained when the devices go into production. And second, the invention of a cheap video tape recording system. The future for military and commercial infrared hybrid imagers also looks promising. The development of a buried-channel c.c.d. based on different semiconductors like gallium arsenide and indium antimonide in which both the infrared imaging and the signal processing could be done by the same chip also seems a possibility.

Signal processing. The future looks very bright for signal processing c.c.ds. The advantage of analogue signal processing, the recent achievement of linearity of response and the new non-destructive tapping techniques that have been invented have made the c.c.d. very attractive for radar systems applications such as moving-target indication, frequency and matched filters. The lower power consumption and small size have also encouraged their early application in signal processing applications for frequencies up to 10MHz. Applications for frequencies above this have been opened up by the development of a new family of devices called the peristaltic c.c.ds which, like the buried-channel devices, uses transport of charge in the bulk silicon. In these devices operation at frequencies of 135MHz have readily been achieved with transfer inefficiencies as small as 5×10^{-5} (reference 15).

Memory. Little has been said about memory devices partly because some of what has been said about area imagers in this final article can also be applied to area memory arrays, and partly because commercial success in this area is not as certain as in the other application areas.

Adoption of c.c.d. serial memories will depend on the acceptability of this mode of organization rather than the m.o.s. random access type. It remains to be seen whether the c.c.d. memory will be developed on a long-term basis or if it will just be used on a short-term basis—say for the next five years—until the bubble memories are developed. Much will depend on the opinions of systems designers in the computer field to use new machine architecture, i.e. serial rather than read/write memories.

Acknowledgements. The author is grateful to John Mavor and Don MacLennan for their many helpful comments and to Chris Wareing for her rapid execution of the typing. Opinions expressed in these c.c.d. articles are those of the authors alone.

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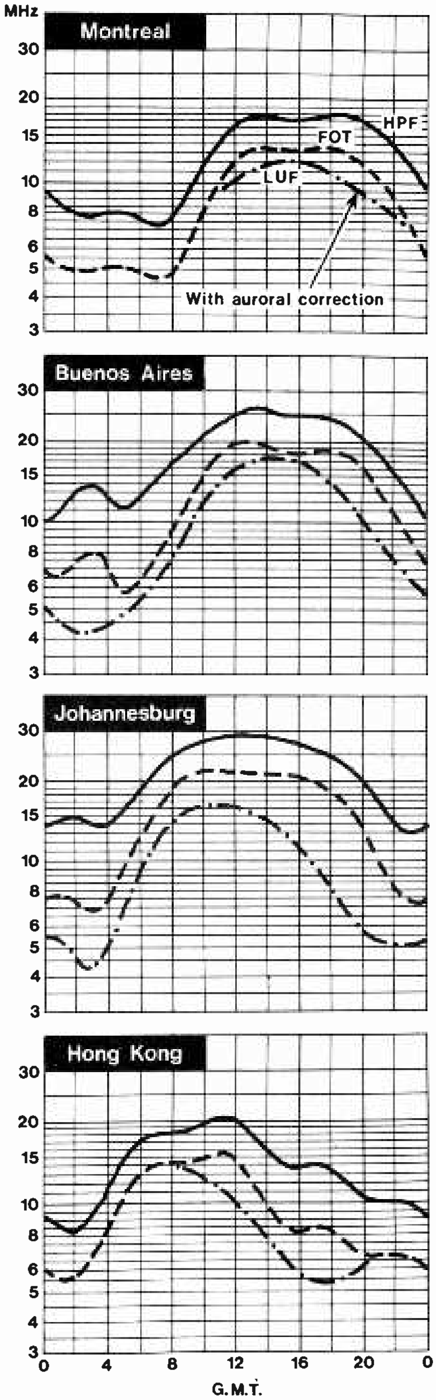
HF predictions

Summary of past conditions

	Solar Index		Disturbed days	
	1972	1974	1972	1974
Jan	58	7	10	6
Feb	78	12	4	10
Mar	100	27	8	21
Apr	90	19	4	20
May	90	23	4	22
Jun	82	21	2	16
Jul	94	29	2	18
Aug	96	20	10	21
Sep	83	25	7	22
Oct	80	26	11	25
Nov	56	22	5	17
Dec	49	16	6	19



Power supply delayed switching

Simple circuits for control of damaging current and voltage transients

by P. J. Briody

It is generally accepted that the switching of power supplies causes damaging transients in electronic loads. Some people go as far as to say that it is the greatest single cause of circuit failure and deterioration. Whether this extreme view is correct or not, theoretical and practical considerations tend to suggest that some more gentle methods of applying power would increase equipment life and reliability. One has only to hear the alarming loudspeaker switching thumps produced by some domestic audio amplifiers to be completely convinced that a remedy is necessary. Hence the purpose of this article is to examine the problem and describe some practical solutions with audio equipment mostly in mind.

Before finding a cure it is necessary to decide what transient would be acceptable to any amplifier. It should be safe to assume that a transient which has the dimensions of a normal amplifier signal would be harmless. Furthermore, if the ear is not to be offended, the highest frequency component of the switching waveform should be below the lower 3dB point of the response curve. If both current and line voltage are gradually applied over a period of a few seconds then the goal will be achieved. All that remains is to find a method of doing this.

Controlled application of power

Most regulated power pack circuits are easy to modify to produce gradual application of line voltage. A simple *RC* network at the regulator reference point will suffice. If, however, the supply is not regulated then a circuit such as that shown in Fig. 1 will be necessary. Operation of switch *S* will cause the output voltage to rise and decay according to the time constants CR_1 and $CR_1\ R_2/(R_1+R_2)$. In a practical circuit Tr_1 would be a Darlington combination of two or more transistors.

Unfortunately it is found that with many modern transistor power amplifiers, controlled line voltage application merely postpones the switching transient. There are two reasons for this—firstly most transistor amplifiers "switch on" sharply at fixed voltages—secondly the low output impedances of most power supplies allow large current spikes to be fed to the load even if the voltage is closely controlled.

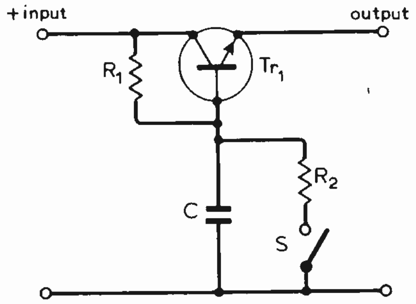


Fig. 1. Basic voltage control circuit.

These drawbacks force us to consider the merits of controlled current application instead of, or in addition to, voltage control.

Current control

An amplifier will usually switch on sharply at a fixed voltage to full quiescent current. If, however, the supply current is very gradually increased from zero, this transient may be eliminated altogether. Unfortunately some amplifiers have a negative resistance characteristic at the switch-on point and the sharp drop in voltage may be just as much of a problem as the current spike. Increasing the current run-up time will usually cure this secondary problem. It is thought, therefore, that current control alone will in most cases be a complete remedy.

Current switching control can be achieved using the basic (and practical) circuit of Fig. 2. Operation of the switch will allow C_1 to charge up with the time constant $C_1R_1R_2/(R_1+R_2)$. Opening the switch will allow C_1 to discharge through R_2. The voltage and hence the current through the silicon power diode D_1 is controlled by the voltage on C_1. Thus run-up and run-down of the supply current is achieved. It should be noted that R_3 is necessary to ensure that C does not limit supply current once the run-up time is complete. Also a power diode was chosen rather than a resistor to allow a wide span of control without too much of a supply voltage penalty. This circuit can be very effective indeed and most amplifiers produce no audible switching thump at all when fed by it. The steady-state drop across AB is only 2V at 2A.

The tightness of current control by the circuit of Fig. 2 is naturally degraded by additional loads (i.e. several amplifiers in parallel). This can be overcome by using two such circuits in tandem as shown in Fig. 3. The original circuit forms the emitter load of Tr_4 and much greater sensitivity is achieved.

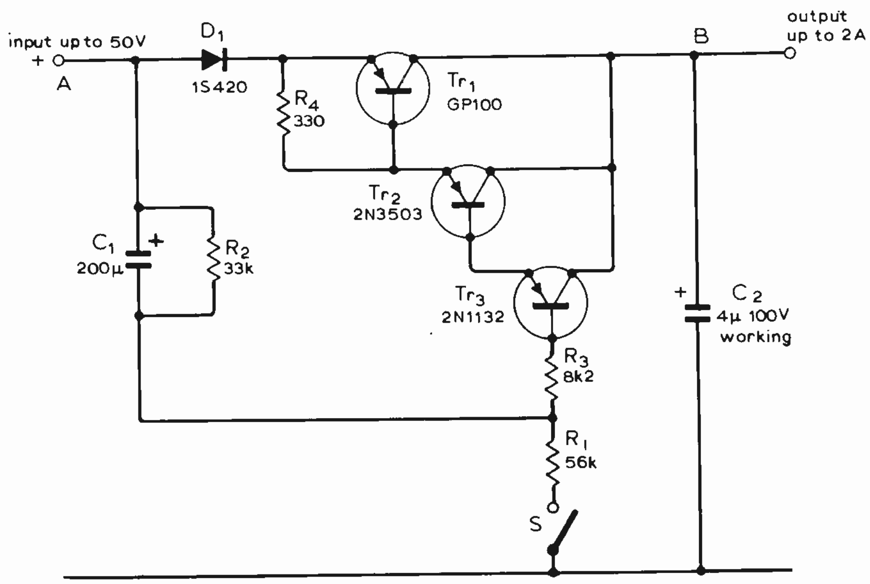


Fig. 2. Current control alone will be adequate in most cases.

The circuits of Figs 2 and 3 are best used with unregulated supplies. If, however, the supply is regulated, the addition of current control is much simplified. Fig. 4 shows theoretically how this may be done for a supply fed from only one transformer secondary. Diode D_5 ensures reasonable d.c. conditions in the differential amplifier prior to the run-up phase. The zener voltage should be less than the sum of all the series base-emitter voltages in the stabilizer so that the output voltage will be reduced to negligible proportions when Tr_1 is fully conducting. The run-up phase is initiated by opening the switch S and C_1 charges up with time constant $C_1R_2R_3/(R_2+R_3)$. Diode D_4 has a zener voltage only about 1V greater than D_5 to keep the aiming voltage of C_1 to a minimum. This will allow a low voltage, large value, electrolytic capacitor to be used for C_1. Once again a power diode is chosen as the current sensor. The forward voltage drop should be less than the excess (1V) voltage on D_4, if current limiting is not to occur during normal use of the supply. Opening of the switch S allows the supply current to decay with approximately the same time constant as the run-up. This can be arranged to "beat" the natural discharge of the smoothing capacitors. Conversely, the charge-up of the smoothing circuit will be much faster than the current run-up. This means that S may be simply a third pole on the power pack on/off switch rather than a relay.

A practical circuit based on Fig. 4 is shown in Fig. 5. This is the author's own 2A, 40V power pack regulator. The run-up and run-down times are a few seconds

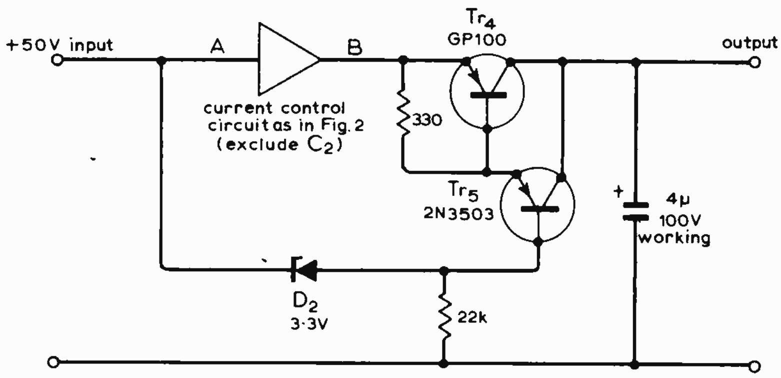


Fig. 3. Practical tandem current control circuit for several parallel loads.

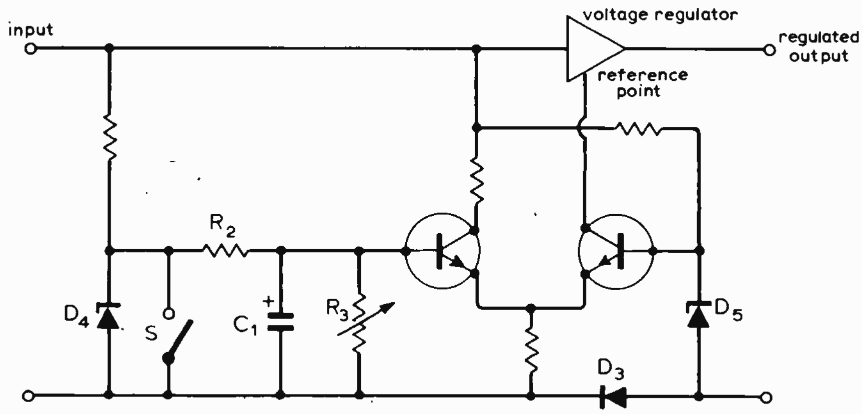


Fig. 4. Theoretical current control of regulated supply.

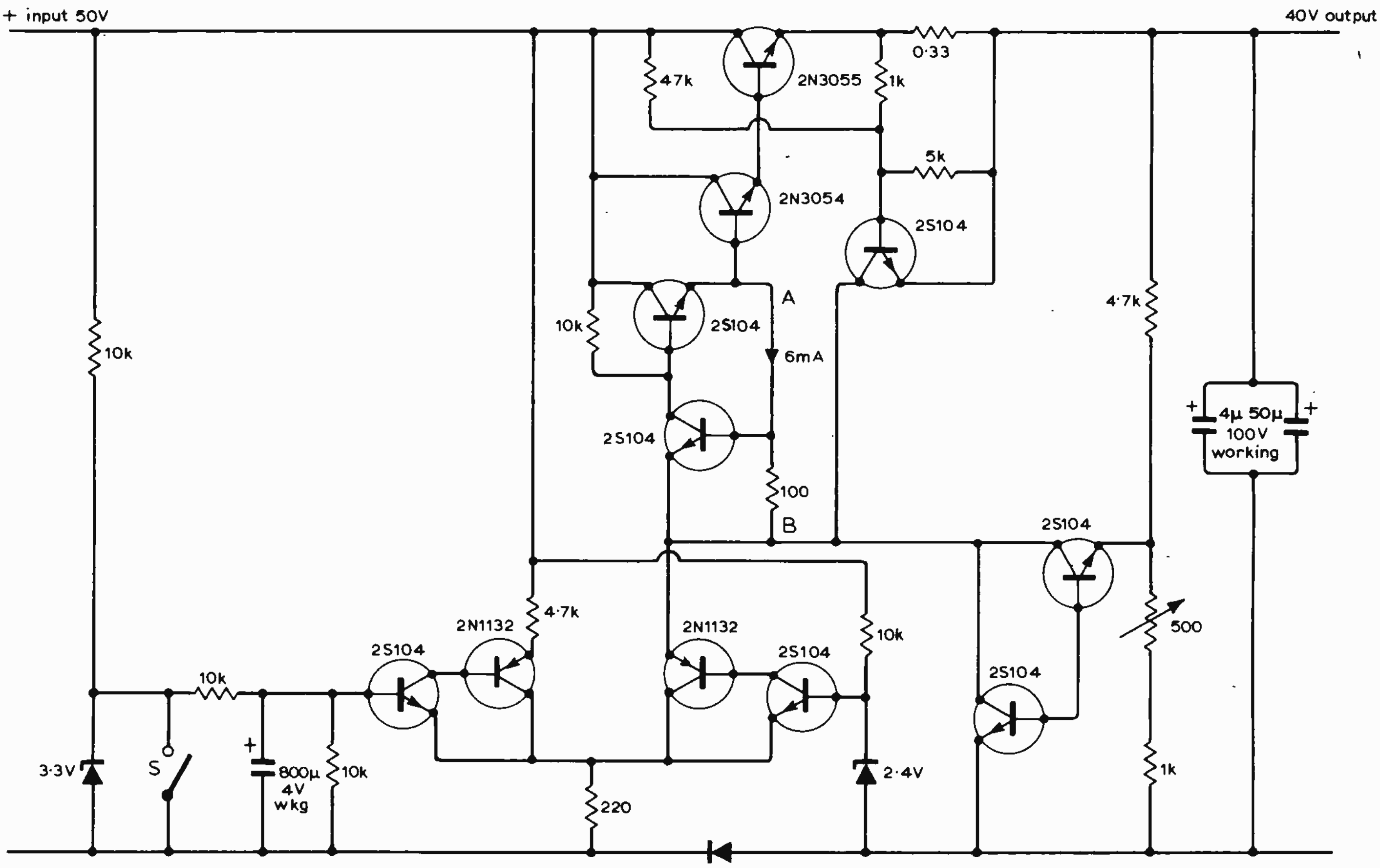


Fig. 5. Complete regulated power pack with current switching control.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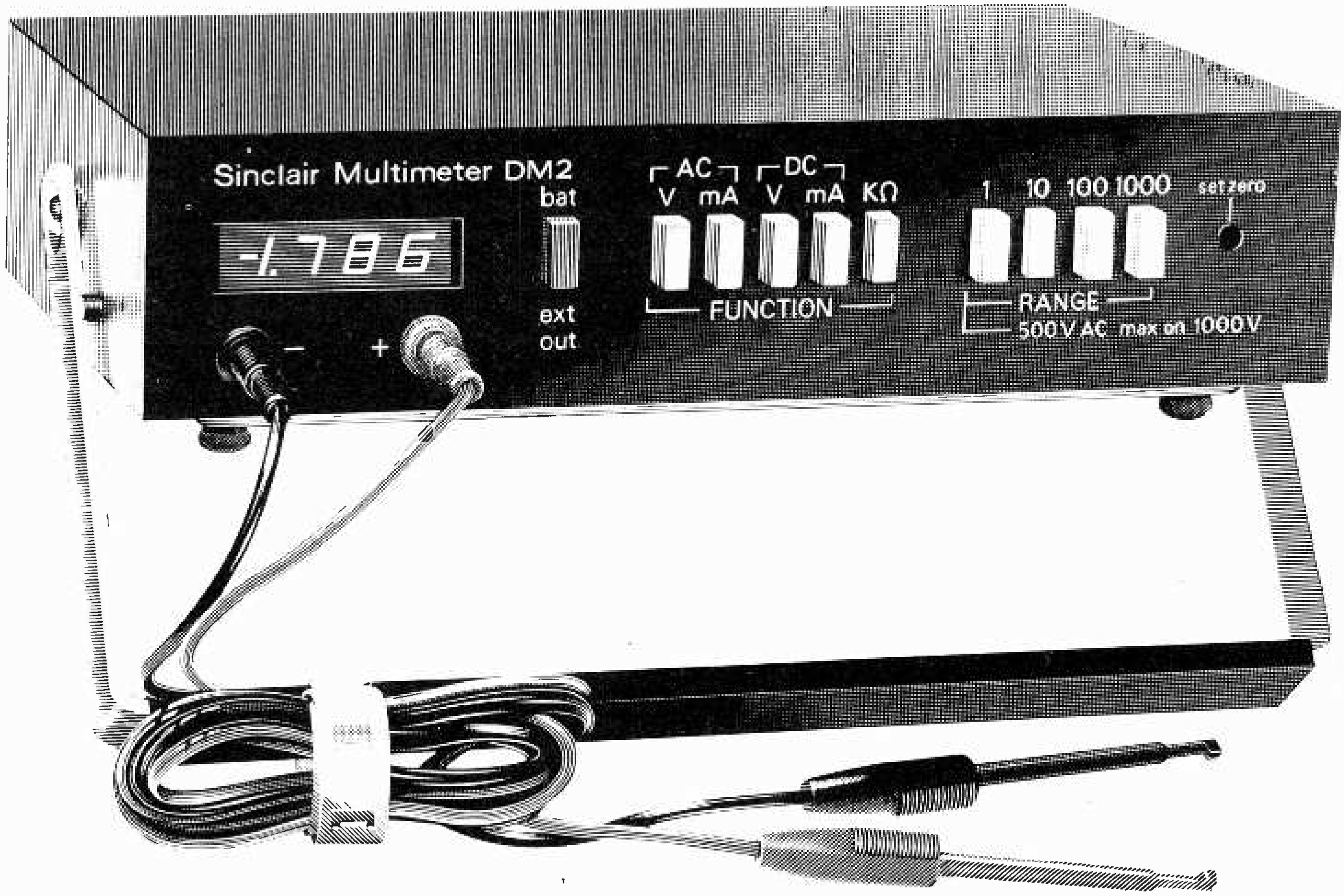

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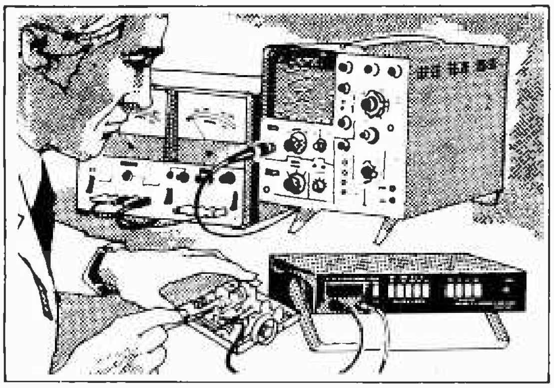

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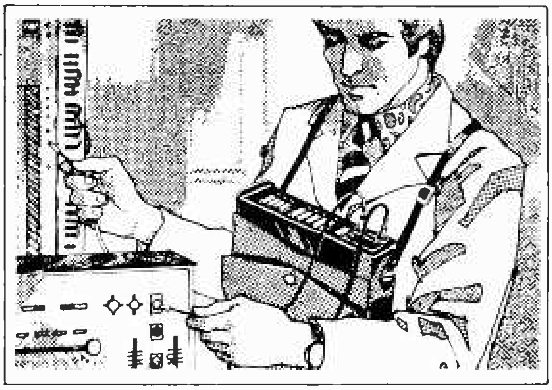

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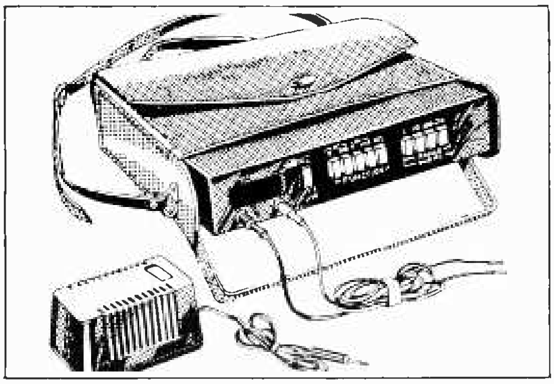

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1000 V	0·5% ± 1 ,,	10 MΩ	1 V

Maximum overload – 350 V on 1 V range
1000 V on all other ranges.

AC Volts

Range	Accuracy	Input Impedance	Frequency Range
1 V	1·0% ± 2 Digits	10 MΩ/40 pF	20 Hz–3 KHz
10 V	1·0% ± 2 ,,	10 MΩ/40 pF	20 Hz–3 KHz
100 V	2·0% ± 2 ,,	10 MΩ/40 pF	20 Hz–3 KHz
1000 V	2·0% ± 2 ,,	10 MΩ/40 pF	20 Hz–1 KHz

Maximum overload – 300 V on 1 V range
500 V on all other ranges.

DC Current

Range	Accuracy	Input Impedance	Resolution
100 μA	2·0% ± 1 Digit	10 KΩ	100 nA
1 mA	0·8% ± 1 ,,	1 KΩ	1 μA
10 mA	0·8% ± 1 ,,	100 Ω	10 μA
100 mA	0·8% ± 1 ,,	10 Ω	100 μA
1000 mA	2·0% ± 1 ,,	1 Ω	1 mA

Maximum overload – 1A (fused).

AC Current

Range	Accuracy	Frequency Range
1 mA	1·5% ± 2 Digits	20 Hz–1 KHz
10 mA	1·5% ± 2 ,,	20 Hz–1 KHz
100 mA	1·5% ± 2 ,,	20 Hz–1 KHz
1000 mA	2·0% ± 2 ,,	20 Hz–1 KHz

Maximum overload – 1A (fused).

Resistance

Range	Accuracy	Measuring Current
1 KΩ	1·0% ± 1 Digit	1 mA
10 KΩ	1·0% ± 1 ,,	100 μA
100 KΩ	1·0% ± 1 ,,	10 μA
1000 KΩ	1·0% ± 1 ,,	1 μA
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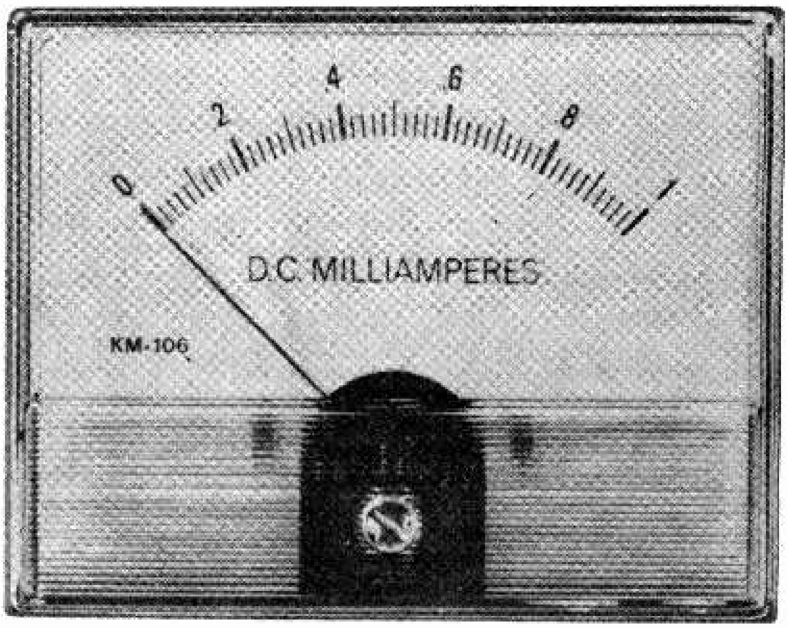

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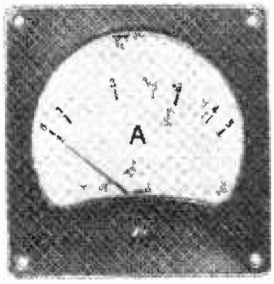

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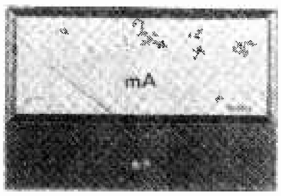

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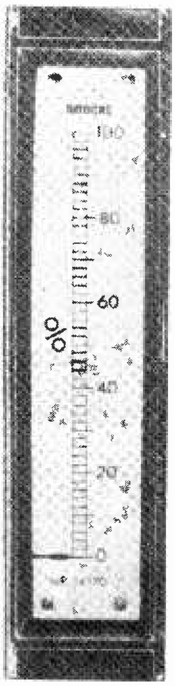

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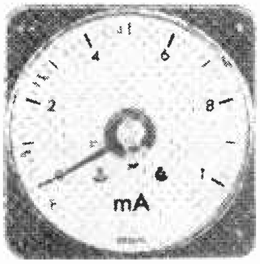
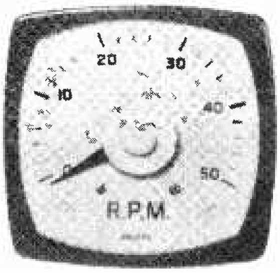


Oxford Long Scale 240°. 2 models, 5·5", 8" scales. DC moving coil and AC moving coil rectified.



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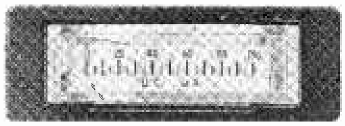

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depending on the amplifier quiescent current. It is worth mentioning a couple of points on the regulator itself. Firstly the short-circuit protection circuit is the very elegant one by Dr A. R. Bailey*. Secondly, the constant current excitation is unusual in that it is collector-fed, thus losing the advantage of hum reduction offered by the emitter-fed version. It was arranged this way so that excitation current is drawn from the low impedance point A, allowing very low regulator output impedance but at the same time producing high control gain at point B. A power supply using this design is very cheap to build and gives outstanding regulation stability (less than 0.05% for $\pm$ 10% input variation). The output impedance for d.c. up to 1A is less than 0.01Ω (not during run-up or run-down).

Conclusions

Having rejected voltage control at an early stage as a general solution to switching transients, three very basic current control circuits have been described in this article. Of these the last (Fig. 5) offers possibilities for further development. An interesting first step in this direction would be to replace the differential amplifier with a high gain i.c. version. With skill and care it should be possible to control current transients of magnitude less than 0.01% of the floating value during run-up. This would provide transient protection for pre-amplifier stages as well. For those wishing to simply eliminate large transients, any of the circuits of Figs 2, 3 or 5 will suffice.

Reference

*Bailey, A. R., "Output Transistor Protection in A.F. Amplifiers," *Wireless World*, June 1968, p154.

Centenary of the crystal rectifier

In November 1874 Ferdinand Braun, a grammar school teacher in Leipzig, published an article on *Current flow through metallic sulphides*. Braun, who later became full professor of experimental physics at Strasbourg University, drew the attention of his fellow scientists to a phenomenon he had discovered while investigating the conductivity of sulphide crystals: the intensity of the current flowing through the crystal depends on the direction of the current. Braun was not able to explain this departure from Ohm's Law, but he assumed that the rectifying effect was either caused by a gas layer between crystal and wire or was due to the crystal structure itself.

A similar effect was discovered in 1876 by Werner von Siemens while examining the light sensitivity of selenium. He also spoke of the rectifying effect as a "peculiar and contradictory phenomenon" and suspected that the cause lay in an electrolytically influenced boundary layer.

Twenty-five years passed before Braun used the crystal rectifier to prove the existence of electromagnetic waves and thus found a replacement for the "coherers". With the development of wireless telegraphy the crystal detector became more and more important. About 50 years ago the first wireless listeners sat with headphones on in front of the "detector", and fiddled around with the wire contact in an attempt to improve reception by applying it to just the right point on the crystal. The point contact rectifiers were followed by surface contact crystal rectifiers in the 1920s. The latter, which found a wide field of application in a.c. techniques, replaced the less stable electrolytic rectifiers. The first member of the series of "dry rectifiers" was the copper-oxide rectifier in 1926, followed by the selenium rectifier in 1930.

Depletion layer theory

The principle underlying all crystal rectifiers was a metal semiconductor contact —or so everybody thought at that time— and efforts were made to find a physical explanation of the rectifying phenomenon. The most significant contribution came from Walter Schottky, who published his depletion layer theory in 1939: as a result of the differing work functions of electrons in a metal and a semiconductor, electrons can travel from the semiconductor to the metal (with suitably selected materials). A carrier-depleted space charge region, which acts as a barrier layer, is created. Depending on the polarity of the applied voltage, this depletion zone either disappears (conduction) or expands (blocking).

Around 1930 the point contact detector had to make way for the electron tube. About ten years later the point contact diode was once again in favour, because the delay effects inherent in thermionic diodes rule out their employment at very high frequencies, as is customary in radar engineering. The place of natural sulphur crystals was taken by pure germanium and silicon crystals with a certain degree of doping. The Ge and Si point contact diodes were developed around 1940 and basically identical diodes are still in use today. Siemens was producing Ge rectifier elements in Berlin by the end of 1942.

Brattain and Bardeen discovered the transistor effect in 1948. Two point contacts, attached to a Ge crystal for the examination of surface properties, led to the crystal amplifier. Shockley put forward the theory of the p-n junction in 1949, which became the principle underlying the p-n diode and the transistor. The rectifier mechanism of the metal-semiconductor contact could now be contrasted with that of the p-n junction. It was even discovered that selenium rectifiers and germanium point contact diodes formed by a current pulse have p-n junctions.

High voltage and current

The silicon p-n rectifier lent itself ideally to high voltage and current applications. Difficulties however arose in manufacturing pure-state silicon single crystals. In Germany E. Spenke and his team working in Pretzfeld near Erlangen succeeded in developing rectifiers made from pure-state silicon with—initially—an active area of a few mm². Nowadays, there are silicon rectifiers with crystal areas of up to 12cm², which can be used at voltages up to 6kV and currents of over 1000A. By inserting a weakly conducting zone between the p and n regions, the structure was expanded to obtain p-i-n and p-s-n rectifiers.

Transistor technology advanced in 25 years from the point contact transistor via the alloy transistor to mesa and planar transistors (1960). Silicon planar technology can, however, be used for metal-semiconductor contacts as well as for p-n junctions. The Schottky diode (since about 1963) combines the high frequency advantages of the Si point contact diode with the advantages of the mechanical and electrical stability of the planar semiconductor elements.

The most significant difference between the two types of rectifiers, p-n diodes and Schottky diodes, lies in their dynamic behaviour. In the case of p-n diodes, charge carriers diffuse via the p-n junction when a current flows and increases the number of minority carriers in the neutral region. On switching over to the reverse direction, these charge carriers have to be swept away before the barrier layer effect can appear. Switchover is associated with an inertia effect. In the metal-semiconductor contact only majority carriers are involved; there is practically no storage effect. For this reason, metal-semiconductor diodes can also be used for microwave applications (varactors, mixers, avalanche diodes, etc). The Schottky contact has also found application as a clamping diode in bipolar integrated circuits, and in field effect transistors.

World of Amateur Radio

Milliwatts and coherent c.w

For many years, the patient art of achieving practical 1.8MHz and h.f. communication using very low power has attracted the interest of numbers of radio amateurs. Most use input powers of the order of 1–5 watts, but some think more in terms of milliwatts. For example, a few years back Bert Hammett, G3VWK, carried out some interesting experiments using an "active aerial" consisting of a conventional 1.8MHz aerial with a 20-milliwatt integrated-circuit transmitter and battery suspended from the T-insulator and with the only lead from the aerial being the microphone lead. Using double-sideband suppressed-carrier techniques he achieved phone contacts exceeding 100 miles. Or again, in 1954 J. M. Osborne, G3HMO, made several 1.8MHz contacts over distances up to 15 miles using as power supply 2mA at 4 volts from a solar battery. In 1961 the New Zealand station, ZL1AAX, made a number of 3.5MHz contacts of up to 160 miles or so using a single tunnel diode as a transmitter powered from a 1.5-volt battery. And in the professional communications field, an RCA investigation over a decade ago showed that with a high-stability transmitter and receiver, so that receiver "noise bandwidths" of only a few hertz could be used, it was possible with a signalling rate of just three bits per minute to transmit messages at milliwatt levels reliably on h.f. over distances up to 2,000 miles. Transmitter stability was achieved by using body temperature to provide a "crystal oven". This work was aimed at such applications as allowing a crashed pilot to report his position. It is very largely a question of having good enough stability to allow the receiver bandwidth to be reduced to a very small figure and then avoiding using a frequency already occupied by a high-power station.

For some years, *The Milliwatt*, published at the University of South Dakota, has been encouraging this type of operation and is devoted exclusively to "under 5-watt amateur radio". P. J. Shephard of Maidstone, Kent, has drawn my attention to some proposals in the journal by Raymond Petit, W7GHM, who has been using a novel type of "coherent c.w." technique which he claims can result in typically a 20dB signal-to-noise-ratio improvement at moderate signalling rates. This requires stability of the order of 2–3Hz and with an electronic keyer using an accurately controlled master clock. In practice all stations would transmit on 3550kHz and have a high-stability 4MHz oscillator which would provide outputs on 4MHz (for receiver conversion to 450kHz), 400kHz (for second conversion to 50kHz) and also 200kHz, 4kHz and 10kHz for operation of a special "coherent receiving filter" and the clock of the electronic keyer. The system, in effect, depends on the receiving filter knowing in advance that if a dit or dah is to begin or end, it will do so at a precisely known time, allowing integration of the signal over a period of time.

World Radio Club

The BBC's World Service weekly programme "World Radio Club" has recently enrolled its 20,000th member—representing an increase of 4,000 during 1974. In a change of programme times it now goes out on Wednesdays at 1330 (times in GMT) and 2315, Fridays at 2030 and Sundays at 0815. This means that the transmissions on medium-wave (1088kHz) which are most reliably received in the UK from Crowborough is now at 2315 on Wednesdays instead of Fridays. The programme continues to be produced by Reg Kennedy, with Peter Barsby as presenter and Henry Hatch, G2CBB, as regular contributor.

Norman Fitch, G3FPK, has been appointed Vice President International of the Amateur Radio News Service—an independent American-based group who are anxious to help amateur radio clubs in the production of better club newsletters and in improving public relations (details from G3FPK, 40 Eskdale Gardens, Purley, Surrey).

IARU celebrates 50 years

When representatives from the 40 or so member societies of the Region 1 Division of the International Amateur Radio Union meet in Warsaw on April 14, it will be 50 years to the day since IARU was founded in Paris. This followed an earlier meeting in March, 1924, at which a provisional committee for an "International Union of Wireless Amateurs" had been set up at the prompting of Hiram Maxim, W1AW, then president of ARRL and General Ferrie, the noted French pioneer of radio, Gerald Marcuse, G2NM, and others.

In the 1925 meetings at the French Academy of Science there were over 250 delegates including 22 from Britain. Apart from discussing the setting up of the IARU the delegates surveyed arrangements for international tests, allocations of definite wavebands for international working, adoption of an auxiliary language (Esperanto was chosen), "intermediate letters" (the early form of international prefix). Headquarters facilities were to be provided by ARRL and there would be individual members with subscriptions of $1.

But the Union soon ran into teething troubles and many of the original high aims had to be put to one side. The idea of individual membership was abandoned and a new Constitution in 1928 made the IARU an international federation of the independent national societies. But despite its low-key profile it continued to do useful work to further amateur radio and protect frequencies. Then in 1950 a big step forward was taken with the setting up in Europe of the first of the Regional bureaux to take active steps to watch over and safeguard the amateur frequency allocations and to co-ordinate activities.

Now, in 1975, the Union is already actively preparing for the ITU World Administrative Radio Conference to be held in 1979 and the Warsaw meetings this April will concentrate on a plan for possible expansion of h.f. allocations which seems feasible in view of the transfer to communications satellites of many professional long-distance communications circuits. A few weeks earlier, from March 4 to 10, an IARU Region 3 Conference is being held in Hong Kong.

Italian FAX

Prof. Franco Franci, I4LCF, is anxious to encourage more use of facsimile transmission by amateurs. There is now a regular FAX net around Bologna on 144MHz but he would like to arrange FAX schedules with amateurs in other countries, including the UK. He is normally active on 14.225MHz about 1100 GMT on Sunday mornings. I have seen several examples of his FAX pictures using 120rpm and 60rpm machines and they seem of high standard. Unfortunately it still appears to be difficult (if not impossible) for British amateurs to obtain permission to transmit FAX on h.f. although slow-scan TV permits are, of course, issued.

In brief

The annual BERU contest is being held on March 8–9 and March also sees the second leg of the 41st ARRL DX Contests (March 1–2 'phone, March 15–16 c.w.). . . . Canada is proposing to lift a number of restrictions on its 27MHz General (Citizens Band) radio service, including allowing hobby and skip communications. . . . "Even though sunspots in general are at a low ebb don't ignore ten metres"—*QST*. . . . The Midland Amateur Radio Society is holding the North Midlands Mobile Rally on Sunday, April 20, at Drayton Manor Park, Tamworth. . . . The Morse proficiency transmissions by G3BZU of the Royal Navy Amateur Radio Society on the first Tuesday of each month (3520kHz) now includes a section at 15wpm in addition to 20, 25, 30, 35 and 40wpm. . . . The Vintage Wireless Museum of the Wireless Preservation Society has moved from Lincolnshire to the Isle of Wight (Mr Douglas Byrne, G3KPO, Alverstone Manor Hotel, Shanklin; (Tel Shanklin 2586).

PAT HAWKER, G3VA

Kirchhoff's voltage law

More about e.m.f. and p.d.

by M. G. Scroggie

"What is e.m.f.?" (in the August 1974 issue) stirred up quite a bit of controversy. I could hardly have asked for better evidence to support my case that people who are concerned with the practical applications of electricity (including of course electronics) tend to rely for their basic principles on hazy memories of old unhappy far-off things and lessons long ago. Most of the time one can get away with this. An accurate and comprehensive understanding of the laws of thermodynamics is not absolutely essential in order to utilize them for travelling from A to B by driving a motor car. But it is useful if one wants to design a better engine for the car. Or even for controlling its temperature to achieve the utmost fuel economy.

At the end of the aforementioned article I warned readers not to suppose that acceptance of the ideas about e.m.f. that I had put forward in some detail, or of any alternative treatments they could find elsewhere, would necessarily make the distinction between e.m.f. and p.d. quite clear, leaving no room for doubt or disagreement. If in spite of this warning there are any who do feel competent to sort out e.m.fs and p.ds in any situation, I invite them now to stay with us for a few minutes.

To make the discussion relate to something not too airy-fairy, let us consider Kirchhoff's voltage law. This is second only to Ohm's law in the ABC of circuits. Looking up a rather elderly book, I find it stated thus:

> "In any closed circuit, the algebraic sum of the products of the current and resistance of each part of the circuit, is equal to the electromotive force in the circuit".

Applied to the simple circuit in Fig. 1, this would mean that

$$IR_1+IR_2=E$$

where I is the current throughout the circuit and E the e.m.f. of the battery. (If the resistance of the battery was not negligible, and was denoted by R_b, one would have to add IR_b to the left-hand side.) IR_1 and IR_2 are, of course, the potential differences (p.ds) across R_1 and R_2 respectively. Often they are denoted by V_1, V_2, etc.

I don't know what German word was translated above as "circuit", but I'm quite

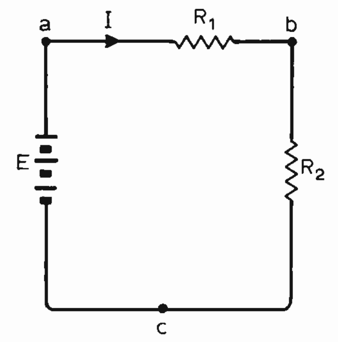


Fig. 1 Simple d.c. circuit for illustrating Kirchhoff's voltage law.

sure that Kirchhoff didn't mean what is understood nowadays by this word when we refer to the circuit of, say, a stereo amplifier. A better word would be "mesh". However complicated the circuit it consists of meshes, or closed paths. In Fig. 1 there could be circuit connections to other meshes at a, b and c. So it would be quite possible for the current in R_1 not only to be different in value from that in R_2, but not even flowing in the same direction. Hence Kirchhoff's insistence on *algebraic* sum. We must take account of plus and minus. And that means we must have some reliable system for distinguishing between these throughout the mesh. It is no good following the example of many (including authors of textbooks on electrical engineering still being published) who, for some reason that has never been explained to me, identify V_1 etc. on a diagram by double-headed arrows, thereby obliterating the somewhat important distinction between positive and negative. (If you are a student and your teacher does this, do me a favour and ask why, and then tell me the answer.) Reliable systems for this purpose are the main subject of the book "Phasor Diagrams" mentioned in my previous article.

I have little doubt that if we had been able to suggest to Kirchhoff a slight elaboration of his law to cover circuits with more than one e.m.f., by amending the latter part of the wording to "is equal to the algebraic sum of the electromotive forces in the mesh" he would readily have replied "Ja wohl!".

So, in applying Kirchhoff's voltage law to a mesh, especially one with a lot of e.m.fs and p.ds in it, forming part of a complicated circuit, one has to draw up a sort of balance sheet of voltages; Vs on one side and Es on the other. As in every acceptable balance sheet, the sum on each side must be the same. And just as one cannot hope to draw up a reliable balance sheet without being able to tell the difference between an asset and a liability, so in applying Kirchhoff's law we have to be able to tell which voltages are Es (e.m.fs) and which are Vs (p.ds).

In ordinary d.c. circuits (which presumably, in 1847, were the only sort Kirchhoff knew about) there is no problem. But what about a.c.?

We have become so accustomed to the concept of impedance that we may forget what a clever labour-saving idea it is. Without it, we would have to solve differential equations, usually of the second order, whenever we had to calculate even simple a.c. circuits. With it, we can bring them within the familiar d.c. circuit laws, such as Ohm's law and Kirchhoff's laws, by simply substituting the word "impedance" for "resistance". Of course we don't get this enormous advantage absolutely for free. Firstly, it is restricted to the sinusoidal waveform. But that covers, more or less, most practical cases. The other thing is that although the forms of the d.c. laws and equations are preserved, the use of them is rather more complicated because we have to take account of phase. There are various ways of doing this, such as drawing phasor diagrams, in which phase relationships are represented by angles; or the j method, in which separate account is kept of the resistance and reactance parts of impedance. I'm going to take all this as read, and concentrate on the application to a.c. circuits of Kirchhoff's voltage law.

Apart from the above-mentioned complication that arises when resistance is generalized into impedance, this might seem to be quite straightforward. But perusal of many textbooks on electrical engineering and circuit theory convinced me that it was not. That is, when Kirchhoff's voltage law is used in its original form—the one I quoted, in which all the voltages in the circuit have to be sorted out into Vs and Es. Instead of

$$IR_1 + IR_2 = E$$

or

$$V_1 + V_2 = E$$

as in Fig. 1, we would have, for example,

$$IZ_1 + IZ_2 = E$$

In Fig. 2, $Z_1 = R$ and $Z_2 = j\omega L$, so we get

$$IR + j\omega LI = E$$

No room for argument, surely?

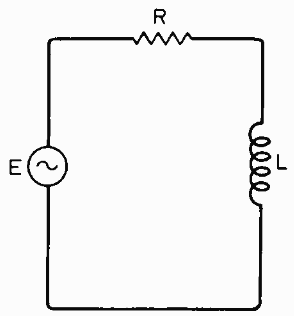


Fig. 2 Simple circuit for illustrating Kirchhoff's voltage law as extended to a.c.

Yet at this point the textbooks immediately fall into disarray. Before they get to the stage of ωL (or X_L) they will have had to explain that the voltage across L ($=IX_L$) is "the e.m.f. of self-induction". There is also IX_C, which is treated exactly the same except for its opposite sign. But the books have nothing to say about a capacitive counterpart to the inductive e.m.f. Most of them maintain a discreet reserve on the subject, but one gets the impression that officially no e.m.f. is involved, in spite of the fact that it is easier to drive a current through a resistor with a charged capacitor than with a magnetized inductor!

Some of the books stick strictly to the impedance concept and the form of Kirchhoff's law. X_L and X_C are impedances, so they too should be multiplied by I and then classed as Vs. The poor student, having learnt all about the e.m.f. of self-induction in one chapter may well be perplexed when in a later one he is told that this e.m.f. is not to be put on the e.m.f. side of the equation but on the other side! This seems to be outdoing Humpty Dumpty who made words mean just what he chose, by making them mean opposite things in different parts of the book. However, the analogy between reactance and resistance (though they are really quite different things) does make the circuit sums much easier, so the student may be prepared to accept this voltage *volte face*. But while it may be all right with a simple inductor, even when it is the primary winding of an unloaded transformer, what does he do if someone connects a generator to its secondary winding? Besides the "impedance p.d." across the "primary" there is now a voltage coming through from the "secondary", and surely this is an e.m.f.?

So some books put the voltage on the V side when it arises from an inductor and on the E side when it is a transformer. Another lot class IX_L as an e.m.f. (more specifically, a "back e.m.f."). Others put "forward e.m.fs" on one side of the equation and "back e.m.fs" (even IR has been known to be so classified!) on the other. Again, they divide on the IX_C issue.

So there does seem to be a need to look a little more closely at this "e.m.f. or p.d.?" question. If then we decide to put e.m.fs on the p.d. side of the Kirchhoff equation we shall at least be doing it with our eyes open.

The Bellman, preparing his crew for hunting the Snark, was able to tell them "the five unmistakable marks by which you may know, wherever you go, the warranted genuine Snarks". I'm afraid I won't be able to do as well as this for e.m.fs. One might begin with the revised British Standard* definition of e.m.f., which says it is "the p.d. in a static-electrification field or in an induced electric field". According to this, then, not being a p.d. fails to qualify as an "unmistakable mark". But is the BS right about this? Reluctant though I am to question what the committee of wise men arrived at after due deliberation, I would respectfully draw their attention to Fig. 3 showing a cross-section of a core through which a magnetic flux is increasing at a constant rate, surrounded by a ring of uniform resistive wire. No p.d. can be found between any two points on this wire, yet there is undeniably an e.m.f. along it. So the BS definition immediately falls down.

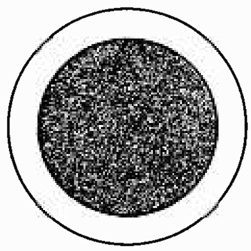


Fig. 3 In this arrangement there is an e.m.f. but no p.d. So how can it be right to define e.m.f. in terms of p.d.?

Reading it once again, one might suppose that a "static-electrification field" was one due to opposite electric charges, say on the plates of a capacitor. But the definition says it is "an electric field brought on in a substance, or at the junction of two dissimilar substances, by one of various phenomena such as contact, thermal, photo or mechanical effects, or by a chemical reaction". This obviously refers, among other things, to batteries, thermocouples, photodiodes and rapidly removed nylon vests. But it does not seem to include capacitors, charged perhaps by a battery, which are covered by another definition, of "electric field". This definition does *not* include induced electric fields, nor, presumably, "static-electrification" fields, so it ought really to have been distinguished as, say, "charge field".

So, trying to make sense of a rather confusing set of definitions, I gather that electric fields can be sorted into three classes, according to cause: electromagnetic induction; electric charges separated by any of the agencies mentioned in the definition of static-electrification field; and electric charges separated electrically. Fields are reckoned in volts per metre. The volts in all three classes are volts of p.d., but in the first two only they are also volts of e.m.f.

P.d. between two points is defined as numerically equal to the work of removing a unit negative charge from one point to the other. Unit charge being (in SI) one coulomb, or the charge which needs 1 gigavolt ($=10^9$ volts) to transfer from plate to plate of a 1nF capacitor, I suspect that it might well affect the p.d. one was attempting to measure; but let that pass. There can be no doubt that if a p.d. exists between two points it tends to make a positive electric charge move from the more positive point to the other. Just as the gravitational difference of potential between the table and the floor can make a weight drop from one to the other. But to replace the weight, or put it there in the beginning, someone has to pick it up and do work on it, transferring energy from himself to it. And an e.m.f. is needed to transfer electric charges against a p.d.

Where disagreements begin again is over where the electrical energy provided by an e.m.f. can come from. Fig. 4(a) shows what looks like a circuit, in which a current I is being made to flow through R against an undoubted p.d., by the charged capacitor C. Fig. 4(b) looks remarkably like (a), and its actual behaviour is essentially the same. Both capacitor and cell can keep the current flowing as long as their store of energy lasts. The probability that the cell has more energy than the capacitor makes no difference to the principle. But in (a) the electrical energy being dissipated in R comes from electrical energy in C. And I believe most—but perhaps not all—would agree that one of the unmistakable marks of an e.m.f. is that the energy coming into the circuit must be from a non-electrical source. So (a) doesn't qualify, but (b) does because the driving energy is of a chemical nature.

Fig. 4(c) is a bit more tricky, as readers of "What is e.m.f.?" may recall. This circuit was the one then under discussion. L (but nothing else) is supposed to be in a steadily varying magnetic field, which causes in it what would, I'm sure, be generally agreed to be a steady e.m.f., also capable of driving a current through R. (I do realize that if you managed to read "Electricity *and* Magnetism?" in the September and October issues you would

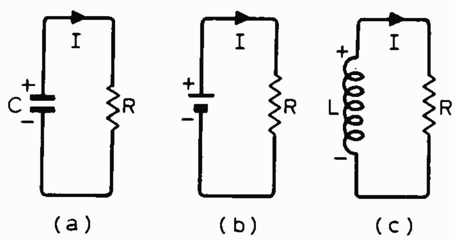


Fig. 4 These three circuits look similar and are all doing the same thing, but do they all include e.m.fs? Are they all circuits?

*BS 4727:Part 1:Group 01:1971.

be ready to point out that magnetism is only electricity in another manifestation, so if (a) doesn't qualify neither should (c). But please don't be awkward!)

Passing hastily on, we note that whereas in (b) and (c) the charges of which the current is composed can go right round the circuit (given time) in (a) they can go only from one capacitor plate, through R, to the other. So, strictly, (a) is not a circuit at all. And whereas in (a) some energy from outside is needed to carry a positive test charge from negative to positive plate of the capacitor *by either route* (via R or direct) in (b) and (c) it can pass freely from negative to positive, through the source of e.m.f. which exactly neutralizes the charge field from positive to negative. Not even any of the people who wrote in to disapprove of some feature or other of "What is e.m.f.?" questioned that in Fig. 4(c) there was an e.m.f., associated with L. (Yes; I do remember that we are supposed to be talking about Kirchhoff's law as applied to *a.c.* Although I haven't come across an a.c. battery, there is no difficulty in converting Fig. 4(c) to a.c. simply by putting L in a sinusoidally varying magnetic field, conveniently by making it the secondary winding of a transformer.)

All these things being so, there seems to be no doubt that in (b) and (c) there are e.m.fs and in (a) there is none, and that (b) and (c) are circuits but (a) is not. This corresponds to the three classes of electric field defined in BS 4727.

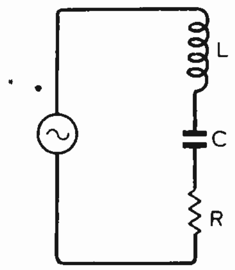


Fig. 5 Is this truly a circuit?

One result of the above conclusions is that we must stop calling Fig. 5 a circuit. It is just the same in principle as Fig. 4(a); merely a capacitor, with a rather elaborate system, including two sources of e.m.f., for periodically charging and discharging it. Your study of a.c. theory, which has taught you to treat L and C as opposite varieties of the same thing, has proved to be false. Their beautiful symmetry, seen to perfection in a tuned circuit, are opposed in L by the e.m.f. of self-induction and in C by something different. And Kirchhoff's law gets into a right old mess.

Appalled by the implications of what seem to be those inevitable conclusions, many teachers reinstate X_L and X_C as positive and negative kinds of the same thing. Fig. 5 is admitted as a circuit by using the idea of displacement current between the plates of C. (The same concept helps mightily with electromagnetic waves.) Admitting C (with reservations) as a source of e.m.f. ends the difficulty with Kirchhoff's law, because every voltage is then either an e.m.f. or an IR drop. Or does it? The fact remains that there is no consistent and generally agreed principle for deciding on how to classify voltages in a.c. circuits into Es and Vs.

Not only so, but the task of separating Es from Vs is complicated by the fact that some circuit elements can behave sometimes as sources of energy and sometimes as receivers. This happens twice every cycle, of course, with L and C; but I mean longer-term behaviour. There was the transformer with a generator in the secondary circuit. And there are synchronous a.c. motors. With such circuits one would be kept busy transferring voltage entries from one side of the ledger to the other. The very object of the exercise of drawing phasor diagrams or making circuit calculations may be to find out which elements are generators and which are loads, so an equation that relies on sorting these out before one can begin is no help at all.

Going back to Kirchhoff we recall that his first or current law says that "the algebraic sum of the currents that meet at any point is zero". Since his time the principle of duality has been established, in which the "dual" of current is voltage, and the dual of a node (i.e., a place where currents meet) is a mesh. So the dual of the current law is a voltage law with no distinction between Es and Vs, so none of the arguments and problems we have been discussing. And the law in this form is quite general, ready-made for a.c. I'm quite sure that if the ghost of Kirchhoff were to be approached along these lines, his "Ja wohl!" to this second amendment to his second law could be confidently expected.

Many present-day teachers and textbook writers, with or without Kirchhoff's consent, do indeed state his second law as "The algebraic sum of the voltages around any mesh is zero". Briefly, in symbols, $\Sigma V \equiv 0$. The advantages are so numerous and manifest that one might expect that by now this form would be universal. But no; there are books that continue to follow the original version with all its disadvantages and limitations, thereby condemning their readers to the wholly unnecessary confusion and difficulties we have been reviewing. One wonders why.

The only trace of a justification put forward seems to be that "it is important to know which voltages are e.m.fs and which are not". But this is not something that need be known in advance; it is something that emerges when the circuit is examined and its phasor diagram drawn. Those voltage components that are in phase with the current are e.m.fs and those that are in antiphase are resistances or the equivalent. In a.c. circuits there are other phase relationships than these, so one resolves each voltage into two components: (1) directly for or against, 0° or 180°, and (2) quadrature, 90° or 270°. The (2) lot are associated with no average loss or gain of energy in the circuit, because the borrowings by pure L and C are fully repaid every half-cycle. No question need arise as to whether the e.m.f. of self-induction in L should be classed in Kirchhoff's law as a negative e.m.f., a positive back e.m.f., a potential drop, or whatever. It is just a voltage, "at right angles to" the current. Whether it is 90° or 270° depends on how current and voltage are identified. The most reliable identification for voltages is by naming the two points in the circuit between which it exists; e.g., V_{ab} in Fig. 1. There is no need even to bother the printer or typist with subscripts; ab is enough. If there are, for example, four nodes in a mesh, then the Kirchhoff voltage law equation can be written down at once without even seeing the diagram, $ab+bc+cd+da \equiv 0$, and it must always be true of any four-node mesh. The dual of a node is a mesh, so the most reliable way of identifying currents is in terms of the two labelled meshes between which it flows. But that is another story, told in "Phasor Diagrams".

Corrections

In **"Silent switch for stereo pair comparisons"** by K. Moulana, published in the January 1975 issue, the following corrections should be made.

1. In Fig. 2, the gate terminal of the f.e.t. should be pointing towards the source terminal, i.e., the one which is connected to the positive end of C_6.
2. In Fig. 3, the top plate of C_{13} should be marked positive.
3. On page 34 the second sentence following "Line-up procedure" should read: "Adjust R_{52} so that the ammeter reads 12mA."
4. On page 35 the first sentence of the first paragraph should read: "The switching speed of the unit was measured in terms of a parameter called the 'Fade-Time' which is defined as the time taken for the output level of the switch to change by 60dB."

In the final part of the article *"Weather Satellites Ground Station"* by G. R. Kennedy (January pp. 21–26), C_{100} should be 6.8μ and R_{105} is 390Ω. Under the heading Display system operation, the two unlabelled switches are S_5 and S_6 respectively. If difficulty is experienced obtaining the transistor 2N726 or 2N706, types BC157 and 2N316 (or BF248) can be used respectively as alternatives. In the appendix, R_{53} should be R_{57} and C_{67} should be C_{68}.

OBITUARY NOTICE

John Sargrove

The death is reported of John A. Sargrove, Ch.Eng, M.I.E.E., M.I.Prod.E., M.I.E.R.E., M.I.Mech.E., well known as the designer of ECME, a fully automatic circuit-making equipment. He was with the Tungsram Valve Company for many years, until forming his own company. He received the Clerk Maxwell award of the IEE in 1947.

New Products

Graphic equalizer

A recent addition to the Klark-Teknik range of equalizers is the 27s comprising 27 overlapping l.c.r. filters arranged for boosting or cutting each audio band by up to 12dB. The slider controls give a calibrated graphical display of the frequency response of the unit. Specifications for the unit include: a noise level of better than −89dBm and a t.h.d. of less than 0.01%. Klark-Teknik Ltd, Summerfield, Kidderminster, DY11 7RE.
WW317 for further details

Double gun c.r.t.

A high-sensitivity double-gun instrument c.r.t. now in production at the M-O Valve Co features two identical electron guns with independent horizontal and vertical deflection systems, enabling the user to display two different sweep speeds simultaneously. The tube, type E14-110GM, has a 14cm diagonal rectangular faceplate, mesh post-deflection acceleration, aluminium-backed screen and compensated deflection blanking system. The display area for each beam is 4×10cm and the overlap is 2cm. The final anode voltage is 8kV and the maximum deflection factors are D_y:5V/cm and D_x:12V/cm. M-O Valve Co Ltd, Brook Green Works, Hammersmith, London W6 7PE.
WW309 for further details

F.m. alignment generator

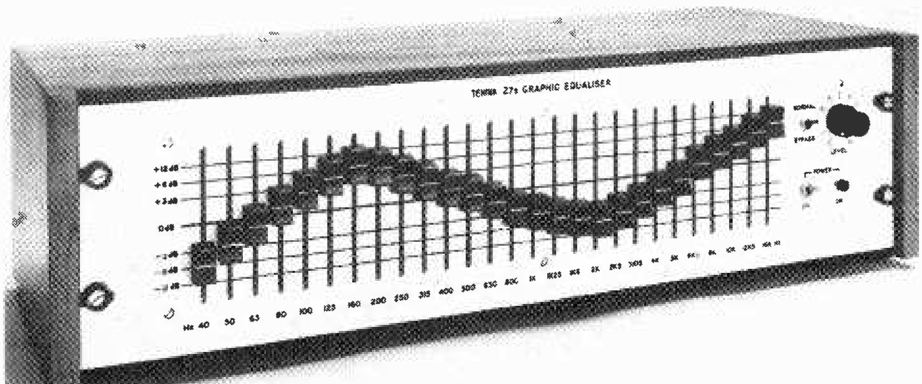
The Sound Technology 1000A alignment generator has been designed to permit fast and accurate adjustment of mono/stereo f.m. systems. A dual-sweep facility enables distortion and tuning characteristics of a receiver to be displayed on an oscilloscope by connecting the r.f. output of the 1000A to the aerial terminals of the receiver and feeding the audio output from the receiver to the 1000A's built-in filter. Other features of the instrument are an r.f.-level piston attenuator calibrated from 0.5 to 30,000μV which permits a comparison of receiver alignment against r.f. level, a total harmonic distortion for the r.f. output of less than 0.1%, and a stereo modulator, using crystal-controlled digital circuits, which provides a claimed separation of better than 50dB at 1kHz. C. E. Hammond & Co Ltd, Lamb House, Church Street, Chiswick, London W4 2PB.
WW303 for further details

Trimmer potentiometers

A new series of $\frac{3}{4}$in multi-turn wirewound trimmer potentiometers, model 47, is available in four basic versions in a resistance range from 10Ω to 20kΩ. Features of the device include a multi-finger contact and a "T" slider block design which is claimed to be unique. The four versions available are standard, clear housing, 0.2in pin configuration and a panel mounting version. Specifications for the potentiometer include: resistance tolerance ±10%, power rating 1W at 40°C derated linearly to zero watts at 125°C, rotational life 200 cycles minimum with a maximum change of ±2% in total resistance. Spectrol Reliance Ltd, Drakes Way, Swindon, Wiltshire.
WW300 for further details

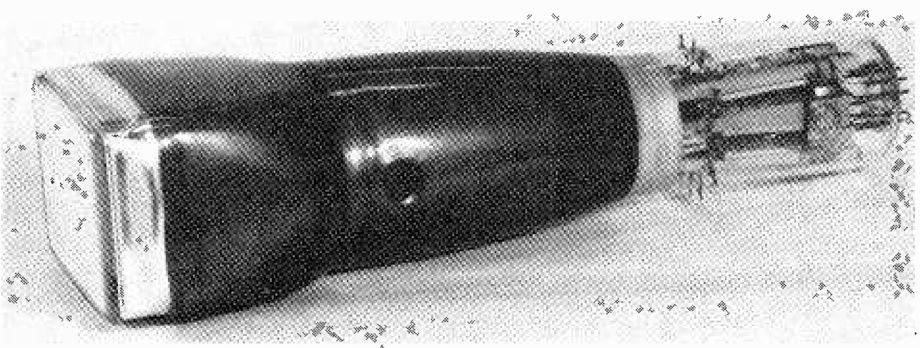
Multimeter

Electronic Brokers Ltd are now marketing the ICE Supertest 680R multimeter. This versatile instrument has a sensitivity of 20kΩ/V with an accuracy to within 1% d.c. and 2% a.c. of indicated reading. The tester has 11 alternating voltage ranges from 2 to 2500V, 13 direct voltage ranges from 100mV to 2000V, 11 direct current ranges from 50μA to 10A, ten alternating current ranges from 250μA to 5A, five ohms ranges from X1 to X10,000 plus a low-ohms scale, a detector reactance range from 0 to 10MΩ, two frequency ranges from 0 to 5kHz, nine voltage output ranges from 10 to 2000V, ten decibel ranges from −24 to +70dB, and six capacity ranges from 0 to 20,000μF.

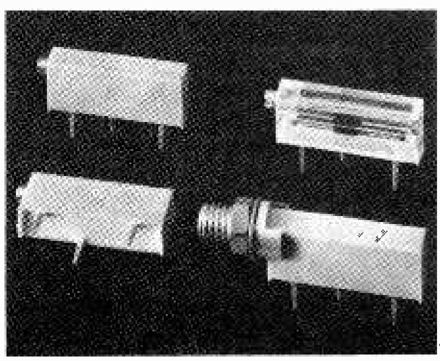


WW317

WW303



WW309



WW300

The multimeter costs £18.50 complete with case and probes from Electronic Brokers Ltd, 49/53 Pancras Road, London NW1.
WW315 for further details

Function generator

The latest function generator from Interstate Electronics, the model F77, offers a total frequency range from 0.0002Hz to 20MHz with an output adjustable by a five-step, 60dB attenuator up to a maximum of 15V into 50Ω. Sweeps may be logarithmic or linear in continuous, triggered or sweep and hold modes, with sweep times variable from 10μs to 1000s. The start-stop phase of sine and triangle waveforms in the trigger and gate modes may be adjusted between +90° and −90° and a variable symmetry control permits 5% to 95% time symmetry adjustment of waveforms to 1MHz, and fixes the duty cycle. Rise and fall times of output pulses are 15ns and pulse width are adjustable from 30ns to 10ms. Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1.
WW311 for further details

Portable r.f.i. meter

The Singer model NM-65T radio-frequency interference meter can be powered from a rechargeable battery, which provides up to ten hours operation, or from a 240V a.c. supply. The instrument measures field intensity, in the 1 to 10GHz range, by means of the direct peak and slideback peak methods. An i.f. and four simultaneous video outputs are provided by the NM-65T, as well as impulse bandwidths of 0.1, 0.5 and 5MHz.

Specifications for the instrument are: an average c.w. sensitivity at the 100kHz bandwidth of 0.7μV rising to 4.9μV at the 5MHz bandwidth. Accuracy is within 2% of the indicated value. R.E.L. Equipment & Components Ltd, Croft House, Bancroft, Hitchin, Herts SG5 1BU.
WW307 for further details

Proximity switch

A barrel-mounted all-metal-sensing proximity switch, model 8-220, will detect ferrous metal targets at a distance of 0.10in and non-ferrous targets at 0.05in with a repeatability of ±10%. The differential travel is from 0.001 to 0.010in with a response time of 3ms giving a switching rate of 20k cycles per minute. The device operates from a 20–30V d.c. supply in a temperature range from −65°F to +180°F and is available in a precision version. Elliott Relays, 70 Dudden Hill Lane, London NW10 1DJ.
WW301 for further details

Mains filter

Suppression Devices Ltd have incorporated a mains-transient filter inside an IEC line connector which complies with all current specifications applicable to detachable power lines. The filter is designed to suppress incoming mains transients and other electrical disturbances in the supply system which could affect electronic equipment.

The device will operate from lines of 115/250V, 50 to 400Hz and is available in current ranges of 0.5, 1, 2.5 and 5A. Suppression Devices (Burnley) Ltd, Woodfield Works, Trafalgar Street, Burnley, Lancs.
WW313 for further details

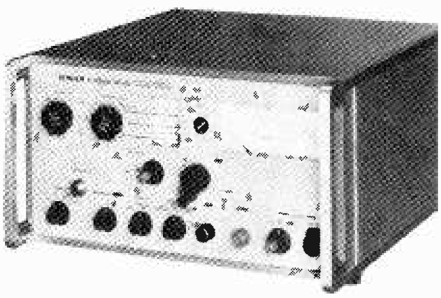
Spectrum analyzer

The Nelson Ross model 236 spectrum analyzer provides amplitude versus frequency displays from 100Hz to 25MHz. Specifications for the instrument include a 0 to 25MHz preset scan, adjustable 0 to 10MHz scan widths at any centre frequency. Resolution bandwidths: 100Hz to 20kHz automatic and selectable, a sensitivity of 1.25μV, and 60dB logarithmic, linear and square law scales.

The instrument is also provided with crystal controlled marker combs at 100kHz and 1MHz intervals, which enable accurate frequency calibration. The display has a calibrated graticule and adjustable scale illumination. Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QP.
WW304 for further details

Amateur radio

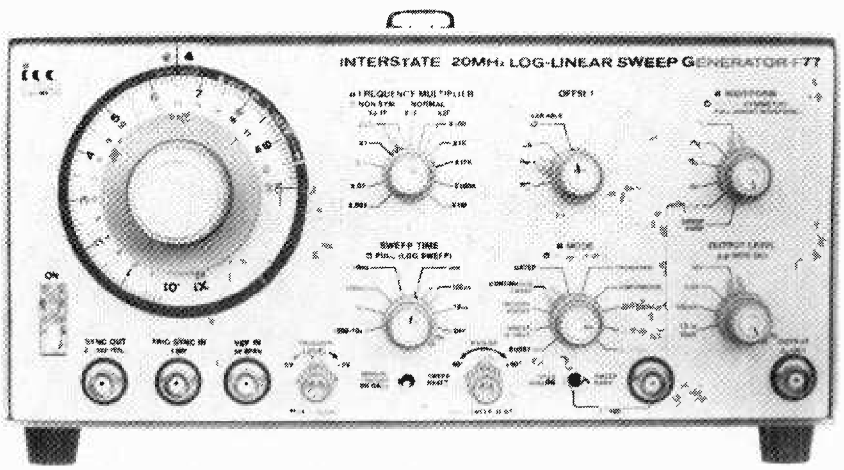
A new range of kits for the amateur has been introduced by Heathkit. The range includes a s.s.b. transceiver capable of delivering 100W, a station console which incorporates a 24-hour digital clock, ten-



WW307

WW301

WW313



WW311

WW304

minute timer, r.f. wattmeter, s.w.r. bridge and a phone patch. Other items in the range are a station monitor which will monitor s.s.b., c.w. and a.m. signals up to 1kW from 80 to 86 metres, a linear amplifier delivering up to 1200W p.e.p. s.s.b., and an a.c. power supply which provides the 13.8V d.c. required by the transceiver. Heathkit (Gloucester) Ltd, Gloucester GL2 6EE.
WW312 for further details

Semiconductor test set

The Berkeley Instruments model 70 is a semiconductor test set which provides the capability of sophisticated systems by the addition of plug-in units to perform test procedures. The basic main frame contains power supplies and a metering system for setting bias conditions. The plug-in modules together with component adapters can be selected for the required tests. Test modules which are available include the measurement of beta under pulsed condition, hybrid parameters, saturation, low leakage and voltages, pulsed breakdown and d.c. parameters. Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1.
WW305 for further details

Standard-frequency receiver

The type 103 receiver provides a frequency standard by phase locking a 10MHz crystal oscillator to the Droitwich transmission. This provides a short term stability of 1 part in 10^8, in the temperature range 0 to 40°C, with outputs of 1 and 10MHz at 3V square wave. An automatic lock facility eliminates the need for manual controls. The instrument uses a ferrite rod aerial, and measures $8\frac{3}{4}\times7\times3\frac{5}{8}$in. R.C.S., National Works, Bath Road, Hounslow, Middx TW4 7EE.
WW306 for further details

Noise generators

Lyons Instruments are now offering a range of solid-state noise generators manufactured by Elgenco Inc. The instruments have Gaussian amplitude probability distribution covering user-specified bands. Series 624A generators are available with lower frequency limits of 10, 20, 50 or 200Hz and upper limits of 20, 50, 100, 200 or 500kHz with a spectral flatness specification between the selected upper and lower limits of ±0.5, ±1, 2 or 3dB.

The output is 3V r.m.s. maximum with a five-position attenuator and variable amplitude vernier. The dynamic range is 3.5:1 peak to r.m.s. at full output. The instruments, which measure $5\frac{1}{4}\times8\frac{5}{8}\times11$in, are priced from £227 plus v.a.t. Lyons Instruments Ltd, Hoddesdon, Herts.
WW302 for further details

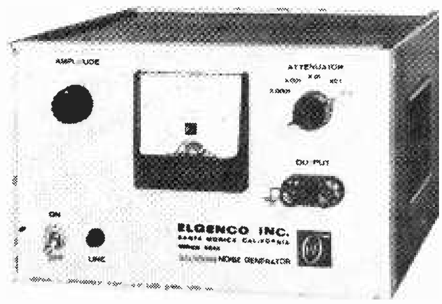
Spray-proof relays

The new flat-form relays type AZ1530 and AZ1531 from Zettler are intended for p.c.b. use where flux and solvents may penetrate the contacts or cause damage to the coils. The base plates and caps of these relays are ultrasonically welded together to form an air-tight encapsulation. The relays are available with coil voltages from 6 to 60V and switching capacities of 100 or 200VA. Zettler UK Division, Equitable House, Lyon Road, Harrow, Middx HA1 2DU.
WW308 for further details

Cartridge preamplifier

A "no-compromise" audio preamplifier, the JC-1, designed to operate in series between a turntable and the standard phono inputs of a preamplifier is available from Mark Levinson. Specifications for the unit include equivalent input noise -147dBV,

WW306



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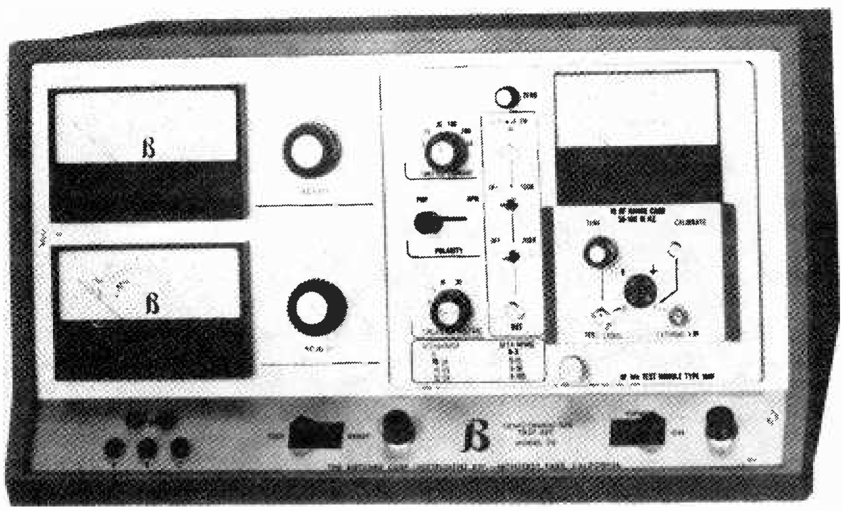
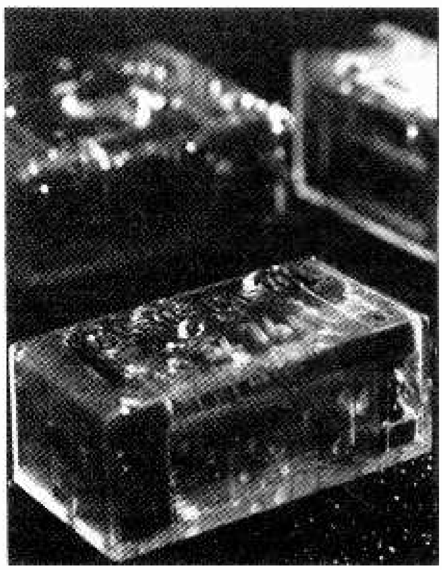


WW305



WW308

Bench operation...

The new 7050's look different because they are different. They're the products the benchman has always wanted but never had available *at a price he was prepared to pay*.

Now five 9's instruments are no longer a luxury. The LSI technology built into our high volume DMM's is available in the new 7050's – and they have a large, bright display that has to be seen to be believed, instant autorange, full multimeter d.c., a.c., ohms and current, and fully automatic operation. For the bench man who needs everything there are also instruments in the range with BCD options. Write for full details, or mail the magazine's reader reply card.

	71
Scale length	
DC Volts Autoranging	
AC Volts Autorangin	
Res	

Bench operation...

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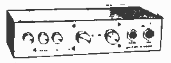
	7140/7144	7050/7054
Scale length	9999 + 10%	99999 + 10%
DC Volts Autoranging	100mV–1000V (resolution 10µV)	1V–1000V (resolution 10µV)
AC Volts Autoranging	100mV–700V (resolution 10µV)	1V–700V (resolution 10µV)
Resistance Autoranging	1k Ω–10M Ω (resolution 100m Ω)	1k Ω–10M Ω (resolution 100m Ω)
Current DC Autoranging	10µA–1mA (resolution 1nA)	100µA–1mA (resolution 1nA)

VHF 105

This unit will give instant reception of the ground-to-air, air-to-ground waveband. Simply place beside any AM or FM Radio, covering 535–1605 kHz, 88–108 MHz – no conversion or connection required. This converter is self powered by one 9-volt (PP3 Type) battery and comes complete with a full set of instructions and battery.

OUR PRICE £3.50 P&P 50p

SPECIAL OFFER! CONVERT YOUR STEREO SYSTEM TO 4D SOUND



This clever unit enables you to add 4D sound to your existing system. Complete with simple connection details. Use this converter (together with 2 extra speakers) to achieve the fantastic 4D quadrophonic sound! The effect of being immersed within the music becomes a thrilling new experience (2 year guarantee).

OUR PRICE £3.95 P&P 50p

WALKIE TALKIES

SKYFON NV7
Super low cost transmitter/receivers. 100MW with call buzzer and on/off volume control. 7 transistors. Telescopic rod antenna.

OUR PRICE £31.50 per PAIR P&P 50p

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WE ARE APPOINTED STOCKISTS AT Oxford Street, [42 & 257 Tottenham Court Road. 34 Lisle Street, 152, Fleet Street, 311 Edgware Road, CROYDON BIRMINGHAM KINGSTON LEICESTER NORTHAMPTON SOUTHEND TUNBRIDGE WELLS WOLVERHAMPTON branches, or by Mail Order.

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.
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AF20 Mono amplifier	£5 61
AF25 Mixer	£3.29
AF30 Mono pre-amplifier	£3 20
AF35 Emitter amplifier	£2 42
AF80 0.5W mic. amplifier	£4 86
AF305 Intercom	£7 67
AF310/2 Mono Amplifier	£7 55
M160 Multi-vibrator	£2 18
M1302 Transistor tester	£8 33
M191 VU Meter	£5 37
M192 Stereo balance meter	£5.93
LF380 Quadraphonic device	£ 8 42
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AT30 Photo cell switch unit	£6 68
AT50 400W triac light dimmer/speed control	£5 18
AT56 2,200W triac light dimmer/speed control	£6 75
AT60 1 channel light control	£10 82
AT65 3 channel light control	£16 52
GU330 Tremolo unit	£8 10
HF61 Diode detector	£3 87
HF65 FM transmitter	£3 21
HF75 FM receiver	£3 66
HF310 FM tuner	£16 32
HF325 Deluxe FM tuner	£26 33
HF330 Decoder (HF310/325)	£10 55
GP310 Stereo pre-amplifier for use with 2 x AF310	£22 98
GP312 Circuit board	£10.02
GP304 Circuit board	£5 33
HF380 lw/vhf aerial amplifier	£6 02
HF395 broadband aerial amp.	£2 10
NT10 Stabilised power supply 100mA, 9V	£6 27
NT300 Stabilised p. supply	£13 16
NT310 Power Supply 240 V AC or 2 x 18 V D.C. at 2 amps	£5.64
NT305 Voltage converter	£5 64
NT315 Power supply 240V AC to 4,5/15V DC, 500mA	£12 06

Amateur Electronics by Josty-Kit, the professional book for the amateur – covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 listed below.

OUR PRICE £3.30 (No VAT) P&P 25p plus VAT.

AE1 100mW output stage	£1.55
AE2 Pre-amplifier	£1.32
AE3 Diode receiver	£2.05
AE4 Flasher	£1.26
AE5 Astable multi-vibrator	£1.14
AE6 Monostable multi-vibrator	£1.11
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AE10 CCIR filter	£1.05

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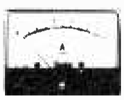
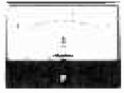
*Items with asterisk are Moving Iron type, all others are Moving Coil

CLEAR PLASTIC MODEL SD640
Size: 85 x 64mm



50uA	£3 90	10V DC	£3 75
100uA	£3 85	20V DC	£3 75
200uA	£3 80	50V DC	£3 75
500uA	£3 75	300V DC	£3 75
50-0-50uA	£3 85	15V AC	£3 85
100-0-100uA	£3 80	300V AC	£3 85
1mA	£3 75	VU Meter	£4 00
5mA	£3 75		
10mA	£3 75		
50mA	£3 75		
100mA	£3 75		
500mA	£3 75		
1A DC	£3 75		
5A DC	£3 75		
10A DC	£3 75		
5V DC	£3 75		

CLEAR PLASTIC MODEL SW100
Size: 100 x 80mm



50uA	£4 70	150V AC	£4 55
100uA	£4.60	300V AC	£4 55
500uA	£4 40	VU Meter	£5 00
50-0-50uA	£4 60		
100-0-100uA	£4 55		
1mA	£4 40		
1A DC	£4 40		
5A DC	£4 40		
20V DC	£4 40		
50V DC	£4 40		
300V DC	£4 40		

EDGWISE MODEL PE70
Size: 90 x 34mm

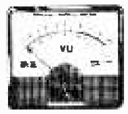
50uA	£4 25
100uA	£4 20
200uA	£4 15
500uA	£4 00
50-0-50uA	£4 20
100-0-100uA	£4 15
1mA	£3 95
300V AC	£4 05
VU Meter	£4 40

MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals

A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.

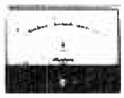
50uA	£8 70	20V DC	£7 80
100uA	£8 10	50V DC	£7 80
50-0-50uA	£8 10	300V DC	£7 80
1mA	£7 80	500mA/5A DC	£8 80
1-0-1mA	£7 80	5V/50V DC	£8 80
1A DC	£7 80	5V/15V DC	£8 80
5A DC	£7 80	1/5A DC	£8 80
5V DC	£7 80		
10V DC	£7 80		
15V DC	£7 80		

CLEAR PLASTIC MODEL MR 85P
Size: 120 x 110mm



50uA	£5 80	300V DC	£5 40
100uA	£5 55	15V AC	£5 45
200uA	£5 50	300V AC	£5 45
500uA	£5 40	S Meter 1mA	£5 35
50-0-50uA	£5 55	VU Meter	£5 70
100-0-100uA	£5 50	1A AC	* £5 35 *
500-0-500uA	£5 35	5A AC	* £5 35 *
1mA	£5 35	10A AC	* £5 35 *
1-0-1mA	£5 35	20A AC	* £5 35 *
5mA	£5 35	30A AC	* £5 35 *
10mA	£5 35		
50mA	£5 35		
100mA	£5 35		
500mA	£5 35		
1A DC	£5 36		
5A DC	£5 36		
15A DC	£5 36		
30A DC	£5 55		
10V DC	£5 36		
20V DC	£5.35		
50V DC	£5 36		
150V DC	£5 36		

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm



50uA	£4 40	10V DC	£4 20
100uA	£4 35	20V DC	£4.20
200uA	£4 30	50V DC	£4 20
500uA	£4 25	300V DC	£4.20
50-0-50uA	£4 35	15V AC	£4 30
100-0-100uA	£4 30	300V AC	£4 30
1mA	£4 20	VU Meter	£4 60
5mA	£4.20		
10mA	£4 20		
50mA	£4 20		
100mA	£4 20		
500mA	£4 20		
1A DC	£4 20		
5A DC	£4 20		
10A DC	£4 20		
5V DC	£4 20		

CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm

50uA	£3 30	300V AC	£3 15
100uA	£3.25	S Meter 1mA	£3 05
200uA	£3 20	VU Meter	£3 50
500uA	£3 10	1A AC	* £3 05 *
50-0-50uA	£3 25	5A AC	* £3 05 *
100-0-100uA	£3 20	10A AC	* £3 05 *
500-0-500uA	£3 05	20A AC	* £3 05 *
1mA	£3 05	30A AC	* £3 05 *
5mA	£3 05		
10mA	£3.05		
50mA	£3 05		
100mA	£3 05		
500mA	£3 05		
1A DC	£3 05		
5A DC	£3 05		
10V DC	£3 05		
20V DC	£3 05		
50V DC	£3 05		
300V DC	£3 05		
15V AC	£3 15		

CLEAR PLASTIC MODEL MR 38P
Size: 42 x 42mm

50uA	£3.20	20V DC	£2 85
100uA	£3 15	50V DC	£2 86
200uA	£3 10	100V DC	£2 85
500uA	£2 90	150V DC	£2 90
50-0-50uA	£3 15	300V DC	£2 90
100-0-100uA	£3 10	500V DC	£2 96
500-0-500uA	£2 85	750V DC	£2 95
1mA	£2 85	15V AC	£2 95
1-0-1mA	£2 85	50V AC	£2 95
2mA	£2 85	150V AC	£2 95
5mA	£2 85	300V AC	£2 95
10mA	£2 85	500V AC	£3 10
20mA	£2 85	S Meter 1mA	£2 85
50mA	£2 85	VU Meter	£3 30
100mA	£2 85		
150mA	£2 85		
200mA	£2 85		
300mA	£2 85		
500mA	£2 85		
750mA	£2 85		
1A DC	£2 85		
2A DC	£2 85		
5A DC	£2 85		
10A DC	£2 85		
3V DC	£2 85		
10V DC	£2 85		
15V DC	£2.85		

CLEAR PLASTIC MODEL SD460
Size: 59 x 46mm

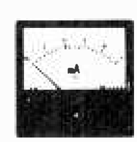
50uA	£3 60	10V DC	£3 40
100uA	£3 55	20V DC	£3 40
200uA	£3 50	50V DC	£3 40
500uA	£3 45	300V DC	£3.40
50-0-50uA	£3 55	15V AC	£3 55
100-0-100uA	£3 50	300V AC	£3 56
1mA	£3 40	VU Meter	£3 76
5mA	£3 40		
10mA	£3 40		
50mA	£3.40		
100mA	£3 40		
500mA	£3 40		
1A DC	£3 40		
5A DC	£3 40		
10A DC	£3 40		
5V DC	£3 40		

POSTAGE & PACKING 15p

CLEAR PLASTIC MODEL MR 65P
Size: 86 x 78mm

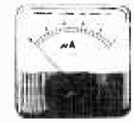
50uA	£4 06	300V DC	£1 80
100uA	£3 95	15V AC	£3.90
200uA	£3 90	50V AC	£3.90
500uA	£3 85	150V AC	£3.90
50-0-50uA	£3.95	300V AC	£3 90
100-0-100uA	£3 90	500V AC	£4 00
500-0-500uA	£3 80	S Meter 1mA	£3 90
1mA	£3 80	VU Meter	£4.20
1-0-1mA	£3.80	1A AC	* £3 80 *
5mA	£3.80	5A AC	* £3.80 *
10mA	£3.80	10A AC	* £3.80 *
50mA	£3 80	20A AC	* £3 80 *
100mA	£3 80	30A AC	* £3.80 *
500mA	£3 80	50mA AC	* £3.80 *
1A DC	£3.80	100mA AC	* £3 80 *
5A DC	£3 80	200mA AC	* £3 80 *
10A DC	£3 80	500mA AC	* £3.80 *
15A DC	£3 80		
20A DC	£3 90		
30A DC	£3 95		
50A DC	£4 15		
5V DC	£3.80		
10V DC	£3 80		
15V DC	£3.80		
20V DC	£3 80		
50V DC	£3 80		
150V DC	£3 80		

BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm



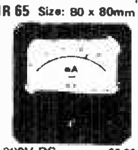
50uA	£4 60
100uA	£4 55
500uA	£4 30
50-0-50uA	£4 55
100-0-100uA	£4 60
1mA	£4 30
1A DC	£4 30
5A DC	£4 30
20V DC	£4 30
50V DC	£4 30
300V DC	£4 30
300V AC	£4 40
VU Meter	£4 80

CLEAR PLASTIC MODEL MR 52P
Size: 60 x 60mm



50uA	£3 80	S Meter 1mA	£3 40
100uA	£3 60	VU Meter	£3.90
500uA	£3 45	1A AC	* £3 40 *
50-0-50uA	£3 60	5A AC	* £3 40 *
100-0-100uA	£3 45	10A AC	* £3 40 *
1mA	£3 40	20A AC	* £3 40 *
5mA	£3 40	30A AC	* £3 40 *
10mA	£3 40		
50mA	£3 40		
100mA	£3 40		
500mA	£3 40		
1A DC	£3 40		
5A DC	£3 40		
10V DC	£3 40		
20V DC	£3 40		
50V DC	£3.40		
300V DC	£3 40		
15V AC	£3 50		
300V AC	£3 50		

BAKELITE MODEL MR 65 Size: 80 x 80mm



25uA	£5.40	300V DC	£3.90
50uA	£4 10	30V AC	* £3.70 *
100uA	£4 05	50V AC	* £3.70 *
500uA	£3 75	150V AC	* £3 70 *
50-0-50uA	£4 05	300V AC	* £3.70 *
100-0-100uA	£4 00	500V AC	* £3.70 *
500-0-500uA	£3 70	VU Meter	£4 20
1mA	£3 70	1A AC	* £3.70 *
1-0-1mA	£3.70	5A AC	* £3.70 *
5mA	£3 70	10A AC	* £3.70 *
10mA	£3 70	20A AC	* £3.70 *
50mA	£3 70	30A AC	* £3.70 *
100mA	£3 70	50A AC	* £3.70
500mA	£3 70	500mA AC	* £3 70
1A DC	£3.70	50mV DC	£3.86
2A DC	£3 70	100mV DC	£3.86
5A DC	£3.70		
10A DC	£3 70		
15A DC	£3.70		
30A DC	£3 70		
50A DC	£3.90		
5V DC	£3 70		
10V DC	£3 70		
15V DC	£3 70		
20V DC	£3 70		
50V DC	£3.70		
150V DC	£3 70		

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All silicon, transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery.
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OUTPUT: 50mV per channel.

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8A	£30.35	£1.00
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20A	£85.00	£1.50
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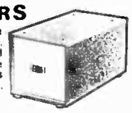
TRANSFORMERS

CASED TRANSFORMERS



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SAFETY ISOLATING

Prim. 120/240V. Sec. 120/240V. Centre Tap with screen

VA (WATTS)	REF. No.	PRICE Cased £	PRICE Plugs 2 Pin + 1 Earth £	PRICE Open £	Post £
60	149	7·35	0·80	4·00	0·38
100	150	8·22	0·80	4·60	0·52
200	151	10·20	0·80	7·40	0·52
250	152	11·68	0·80	8·88	0.65
350	153	14·10	0·80	10·80	0·80
500	154	15·68	0·80	12·38	1·00
750	155	24·63	1·00	18·72	1·20
1000	156	32·19	1·00	26·50	1·20
1500	157	38·18	1·00	30·34	O.A.
2000	158	45·20	2·40	34·68	O.A.
3000	159	66·50	2·40	53·35	O.A.

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS Sec. 1	VOLTS Sec. 2	MILLIAMPS Sec. 1	MILLIAMPS Sec. 2	TYPE No.	PRICE £	Post £
3-0-3	—	200	—	238	1·23	0·10
0-6	0-6	500	500	234	1·30	0·10
0-6	0-6	1000	1000	212	1·95	0·22
9-0-9	—	100	—	13	1·23	0·10
0-9	0-9	330	330	235	1·43	0·10
0-8-9	0-8-9	500	500	207	1·75	0·22
0-8-9	0-8-9	1000	1000	208	2·30	0·30
15-0-15	—	40	—	240	1·23	0·10
0-15	0-15	200	200	236	1·30	0·10
20-0-20	—	30	—	241	1·23	0·10
0-20	0-20	150	150	237	1·30	0·10
0-15-20	0-15-20	500	500	205	2·47	0·38
0-20	0-20	300	300	214	1·72	0·22
0-20	—	3500	No Screen	1116	3·00	0·40
20-12-0-12-20	—	700 (D.C.)	—	221	2·31	0·30
0-15-20	0-15-20	1000	1000	206	3·22	0·38
0-15-27	0-15-27	500	500	203	2·73	0·38
0-15-27	0-15-27	1000	1000	204	3·52	0·38

12 and 24 VOLTS PRIMARY 200-240 Volts.

AMPS 12V	AMPS 24V	TYPE No.	PRICE £	Post £
0·3	0·15	242	1·34	0·22
0·5	0·25	111	1·38	0·22
1	0·5	213	1·58	0·22
2	1	71	2·09	0·22
4	2	18	2·58	0·38
6	3	70	3·80	0·42
8	4	108	4·20	0·52
10	5	72	4·80	0·52
12	6	116	5·01	0·52
16	8	17	6·22	0·52
20	10	115	9·47	0·69
30	15	187	11·95	0·97
40	20	232	13·26	1·00
60	30	226	15·30	1·10

30 VOLTS

PRIMARY 200/240V.
SECONDARY 12, 15, 20, 24, 30V.

AMPS	Ref. No.	Price £	Post £
0.5	112	1·72	0·22
1	79	2·21	0·38
2	3	3·26	0·38
3	20	4·10	0·42
4	21	4·68	0·52
5	51	5·80	0·52
6	117	6·50	0·52
8	88	8·50	0·67
10	89	8·47	0·67

50 VOLTS

PRIMARY 200/240V.
SECONDARY 19, 25, 33, 40, 50V.

AMPS	Ref.	Price	Post
0·5	102	2·33	0·30
1	103	3·00	0·38
2	104	4·57	0·42
3	105	5·20	0·52
4	106	6·89	0·52
6	107	11·17	0·67
8	118	14·19	0·97
10	119	15·47	0·97

60 VOLTS

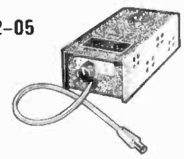
PRIMARY 200/240V.
SECONDARY 24, 30, 48, 60V.

AMPS	Ref.	Price	Post
0·5	124	2·08	0·38
1	126	2·96	0·38
2	127	4·63	0·42
3	125	6·84	0·52
4	123	7·94	0·67
5	40	8·86	0·67
6	120	10·15	0·82
8	121	13·58	1·00
10	122	18·15	1·00
12	189	16·00	1·10

BRIDGE RECTIFIERS

	Price
ONE AMP	
50 P.I.V.	0·25
100 P.I.V.	0·25
200 P.I.V.	0·28
600 P.I.V.	0·30
FOUR AMP	
100 P.I.V.	0·55
200 P.I.V.	0·59
400 P.I.V.	0·65
600 P.I.V.	0·75
TWO AMP	
50 P.I.V.	0·35
100 P.I.V.	0·40
200 P.I.V.	0·45
400 P.I.V.	0·50
SIX AMP	
50 P.I.V.	0·65
100 P.I.V.	0·70
200 P.I.V.	0·08
400 P.I.V.	0·90

POWER UNIT TYPE CC12–05



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AUTO TRANSFORMERS

VA (Watts)	Ref No.	PRICE Cased £	PRICE Plugs 2 & 3 pin £	PRICE Open £	Post £
Tapped at 115, 220, 240 Volts					
20	113	3·00	0·15	1·55	0·30
Tapped at 115, 200, 220, 240 Volts					
150	4	5·80	0·15	3·98	0·39
200	65	6·40	0·15	4·50	0·40
300	66	7·27	0·15	5·28	0·52
500	67	9·99	0·15	8·29	0·67
750	83	12·56	0·75	9·76	0·82
1000	84	15·70	0·75	12·40	0·82
1500	93	19·88	0·75	16·58	1·50
2000	95	30·10	1·44	22·05	1·50
3000	73	43·58	1·90	32·00	1·90

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0–100 micro A.	580	0–100 micro A	730
0–500 micro A.	170	0–500 micro A	200
0–1 mA	170	0–1 mA	200
0–5 mA	170	0–5 mA	200
0–10 mA	6	0–10 mA	6
0–50 mA	0·5	0–50 mA	0·5
0–100 mA	0·5	0–100 mA	0·5
0–500 mA	0·5	0–500 mA	0·5
0–1 AMP	0·5	0–1 AMP	0·5
0–2 AMP	0·5	0–2 AMP	0·5
0–25 Volt	15K	0–25 Volt	15K
0–50 Volt	50K	0–50 Volt	50K
0–300 Volt	300K	0–300 Volt	300K
"g" Meter	170	"g" Meter	200
VU Meter	5250	VU Meter	5250

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U4313—high sensitivity high accuracy AC/DC multimeter. 39 ranges covering AC/DC volts up to 600V and AC/DC amps up to 1.5A. Mirror scale. Accuracy 1.5%AC, 2.5%DC.

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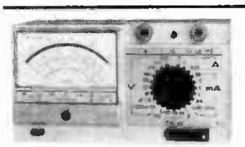
U4315—high sensitivity medium accuracy AC/DC multimeter. 43 ranges covering AC/DC volts up to 1000V and AC/DC current up to 2.5A. Accuracy 2.5%DC, 4%AC. **Price £10.00**

Note: The above instruments, although extremely resistant to overload, do not incorporate any protection.



U4317—high sensitivity high accuracy AC/DC multimeter. 42 ranges covering AC/DC volts up to 1000V and AC/DC current up to 5 amps. Mirror scale. Accuracy 1.5%DC, 2.5%DC. Meter incorporates transistorized cut-out protective relay. **Price £17.00**

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OC23	0.60	ASZ16	0.80
OC24	0.60	ASZ17	0.80
OC25	0.50	ASZ18	0.80
OC26	0.40	BD115	0.80
OC28	0.70	BD116	0.65
OC29	0.60	BD121	0.65
OC35	0.50	BD123	0.80
OC36	0.65	BD124	0.60
AD149	0.45	BD131	0.40
AD161	0.38	BD132	0.50
AD162	0.38	BD133	0.55
ADZ11	1.25	BD135	0.30
ADZ12	1.25	BD136	0.32

AC CLAMP VOLT-AMMETER

TYPE U91
Made in USSR

Measurement ranges:
10-25-100-250-500A 300-600V
Accuracy: 4%

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„	1N4003	200 p.i.v.	£1.35
„	1N4004	400 p.i.v.	£1.45
„	1N4005	600 p.i.v.	£1.55
„	1N4006	800 p.i.v.	£1.85
„	1N4007	1000 p.i.v.	£2.10

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AMPLIFIER KITS OF *Distinction*

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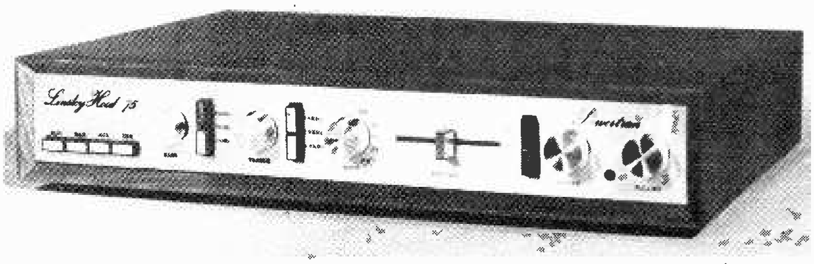
In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972–February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Hi-Fi News Linsley-Hood 75 W Amplifier Mk III Version (modifications as per Hi-Fi News April 1974)



Full circuit description in handbook (pack 15—price 30p)

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1	Fibreglass printed-circuit board for power amp.	£0.85
2	Set of resistors, capacitors, pre-sets for power amp.	£1.70
3	Set of semiconductors for power amp. (now using BDY56, BD529, BD530)	£6.50
4	Pair of 2 drilled, finned heat sinks	£0.80
5	Fibreglass printed-circuit board for pre-amp.	£1.30
6	Set of low noise resistors, capacitors, pre-sets for pre-amp.	£2.70
7	Set of low noise, high gain semiconductors for pre-amp.	£2.40
8	Set of potentiometers (including mains switch)	£2.05
9	Set of 4 push-button switches, rotary mode switch	£3.70
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V, 25-0-25 V.	£9.15
11	Fibreglass printed-circuit board for power supply	£0.65
12	Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting cable, control knobs	£4.25
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16	Teak cabinet	£7.35
	2 each of packs 1–7 inclusive are required for complete stereo system	
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(*or at current rate if changed)

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POWERTRAN

SEE FOLLOWING PAGE

TRANSISTORS

Type	Price (£)	Type	Price (£)	Type	Price (£)	Type	Price (£)	Type	Price (£)	Type	Price (£)	Type	Price (£)
				BD115	0·65	BF273	0·16	BUY79	2·85	ZXT313	0·12	2N3794	0·20
				BD123	0·98	BF336	0·35	C106F	0·43	ZTX500	0·17	2N3819	0·35
AC107	0·35	BC119	0·29	BD124	0·80	BF337	0·35	C111E	0·56	ZTX502	0·17	2N3820	0·49
AC117	0·24	BC125	0·22	BD130Y	1·42	BF458	0·60	CRS1/40	0·45	ZTX504	0·42	2N3823	1·45
AC126	0·25	BC125B	0·25	BD131	0·45	BF459	0·63	CRS3/40	0·55	ZTX602	0·24	2N3866	1·70
AC127	0·25	BC126	0·20	BD132	0·50	BF596	0·70	D40N1	0·45	2N525	0·86	2N3877	0·25
AC128	0·25	BC132	0·15	BD135	0·19	BF597	0·15	E1222	0·55	2N696	0·23	2N3904	0·16
AC141	0·26	BC134	0·20	BD136	0·46	BFR41	0·30	E5024	0·20	2N697	0·15	2N3905	0·18
AC141K	0·27	BC135	0·19	BD137	0·48	BFR61	0·30	ME6001	0·16	2N706	0·12	2N3906	0·15
AC142K	0·19	BC136	0·20	BD138	0·50	BFT43	0·55	ME6002	0·17	2N706A	0·15	2N4032	0·31
AC151	0·24	BC137	0·20	BD139	0·55	BFW10	0·55	ME8001	0·18	2N708	0·35	2N4036	0·52
AC152	0·25	BC138	0·20	BD140	0·62	BFW11	0·55	MJE340	0·68	2N744	0·30	2N4046	0·35
AC153K	0·28	BC142	0·30	BD144	2·19	BFW16A	1·70	MJE341	0·72	2N914	0·19	2N4058	0·17
AC154	0·20	BC143	0·35	BD145	0·75	BFW30	1·38	MJE370	0·65	2N916	0·20	2N4123	0·13
AC176	0·25	BC147B	0·13	BD163	0·67	BFW59	0·19	MJE520	0·85	2N918	0·42	2N4124	0·15
AC187	0·25	BC148	0·12	BD183	0·56	BFW60	0·20	MJE521	0·95	2N930	0·35	2N4126	0·20
AC187K	0·25	BC149	0·14	BD234	0·75	BFW90	0·28	MJE2955	1·20	2N1304	0·21	2N4236	1·90
AC188	0·25	BC152	0·25	BD519	0·76	BFX16	2·25	MJE3055	0·74	2N1305	0·21	2N4248	0·12
AC188K	0·26	BC153	0·20	BD520	0·76	BFX29	0·30	MM721	0·70	2N1306	0·31	2N4284	0·19
AC193K	0·30	BC154	0·20	BDX18	1·45	BFX30	0·35	MPF102	0·40	2N1307	0·22	2N4286	0·19
AC194K	0·32	BC157	0·15	BDX32	2·55	BFX84	0·25	MPSA05	0·47	2N1308	0 26	2N4288	0·13
ACY28	0·25	BC158	0·13	BDY16A	0·38	BFX85	0·26	MPSA55	0·50	2N1309	0·36	2N4289	0·20
ACY39	0·68	BC159	0·15	BDY18	1·78	BFX86	0·26	MPS6566	0·21	2N1613	0·34	2N4290	0·14
AD140	0·50	BC161	0·48	BDY20	0·99	BFX87	0·28	MPSU05	0·66	2N1711	0·45	2N4291	0·18
AD142	0·52	BC167B	0·15	BF115	0·20	BFX88	0·24	MPSU06	0·76	2N1890	0·45	2N4292	0·20
AD143	0·51	BC168B	0·13	BF117	0·45	BFY18	0·53	MPSU55	1 26	2N1893	0·48	2N4871	0·24
AD149	0·50	BC169C	0·13	BF120	0·55	BFY40	0·40	MPSU56	1·26	2N2102	0·31	2N4902	1·30
AD161	0·48	BC170	0·15	BF121	0·25	BFY41	0·43	OC26	0·38	2N2217	0·36	2N5042	1·05
AD162	0·48	BC171	0·15	BF123	0·28	BFY50	0·25	OC28	0·65	2N2218	0·60	2N5060	0·32
AF114	0·25	BC172	0·14	BF125	0·25	BFY51	0·23	OC35	0·50	2N2219	0·50	2N5061	0·35
AF115	0·25	BC173	0·20	BF127	0·30	BFY52	0·23	OC36	0·55	2N2221A	0·41	2N5064	0·45
AF116	0·25	BC176	0·22	BF158	0·25	BFY57	0·32	OC42	0·55	2N2222A	0·50	2N5087	0·32
AF117	0·20	BC177	0·20	BF159	0·27	BFY64	0·42	OC44	0·15	2N2369A	0·42	2N5294	0·35
AF118	0·50	BC178	0·22	BF160	0·22	BFY72	0·31	OC45	0·15	2N2401	0·60	2N5296	0·37
AF121	0·32	BC178B	0·22	BF161	0·45	BFY90	0·70	OC70	0·15	2N2484	0·41	2N5298	0·38
AF124	0·25	BC179	0·20	BF162	0·45	BLY15A	0·79	OC71	0·15	2N2570	0·18	2N5322	0·85
AF125	0·20	BC179B	0·21	BF163	0·45	BPX25	1·90	OC72	0·15	2N2646	0·53	2N5449	1·90
AF126	0·20	BC182L	0·11	BF167	0·25	BPX29	1·70	OC73	0·51	2N2712	0·12	2N5457	0·30
AF127	0·20	BC183	0·11	BF173	0·25	BPX52	1·90	OC75	0·25	2N2904	0·22	2N5458	0·35
AF139	0·35	BC183K	0·12	BF177	0·30	BRC4443	0·68	OC81	0·53	2N2904A	0·26	2N5494	1·85
AF147	0·35	BC183L	0·11	BF178	0·33	BRY39	0·47	OC81D	0·57	2N2905	0·72	2N5496	2·05
AF149	0·45	BC184L	0·13	BF179	0·33	BR101	0·47	OC139	0·76	2N2905A	0·73	2N6027	0·65
AF178	0·55	BC186	0·25	BF180	0·35	BSW64	0·38	OC140	0·80	2N2926G	0·13	2N6178	0·71
AF179	0·60	BC187	0·27	BF181	0·33	BSX19	0·13	OC170	0·25	2N2926Y	0·12	2N6180	0·78
AF180	0·55	BC208	0·12	BF182	0·44	BSX20	0·19	OC171	0·30	2N29260	0·12	2SC643A	1·36
AF181	0·50	BC212L	0·12	BF183	0·44	BSX76	0·15	OCP71	0·43	2N3019	0·75	2SC1172Y	2·80
AF186	0·40	BC213L	0·12	BF184	0·26	BSX82	0·52	ON188	2·19	2N3053	0·21	3N140	1·21
AF239	0·40	BC214L	0·15	BF185	0·26	BSY19	0·52	ON236A	0·65	2N3054	0·55	40250	0·60
AF279	0·84	BC238	0·10	BF194	0·15	BSY41	0·22	ORP12	0·55	2N3055	0·60	40327	0·67
AL100	1·10	BC261A	0·28	BF195	0·15	BSY54	0·50	R2008B	2·05	2N3133	0·54	40361	0·48
AL102	1·10	BC262A	0·18	BF196	0·15	BSY56	0·80	R2010B	2·10	2N3134	0·60	40362	0·50
AL103	1·10	BC263B	0·25	BF197	0·17	BSY65	0·15	TAG3/400	1·54	2N3232	1·32	40429	0·80
AL113	0·95	BC267	0·16	BF198	0·20	BSY78	0·40	TIC44	0·24	2N3235	1·10	40439	2·67
AU103	2·10	BC268C	0·14	BF199	0·25	BSY91	0·28	TIC46	0·44	2N3254	0·28	AC128/	
AU110	1·90	BC294	0·37	BF200	0·35	BT101/300	1 05	TIC47	0·58	2N3323	0·48	AC176	0·52
AU113	2·40	BC300	0·60	BF218	0·35	BT101/500	1·15	TIC29A	0·49	2N3391A	0·23	AC141K/	
BC107	0·12	BC301	0·35	BF222	1·08	BT102/300	1·02	TIP30A	0·58	2N3702	0·13	AC142K	0·56
BC107A	0·13	BC303	0·60	BF224J	0·15	BT102/500	1·12	TIP31A	0·65	2N3703	0·15	AC187/	
BC107B	0·14	BC307B	0·12	BF240	0·20	BT106	1·24	TIP32A	0·67	2N3704	0·15	AC188	0·60
BC108	0·12	BC308A	0·10	BF241	0·22	BU105/02	1·95	TIP33A	0·99	2N3705	0·11		
BC108B	0·13	BC309	0·15	BF244	0·18	BU108	3·25	TIP34A	1·73	2N3706	0·10	AC187K/	
BC108C	0·14	BC323	0·68	BF254	0·45	BU126	2·99	TIP41A	0·80	2N3707	0·13	AC188K	0·61
BC109	0·13	BC377	0·22	BF255	0·45	BU204	1·98	TIP42A	0·91	2N3715	2 30	AC193K/	
BC109C	0·14	BC441	1·10	BF256	0·45	BU205	1·98	TIS43	0·30	2N3724	0·72	AC194K	0·71
BC113	0·13	BC461	1·58	BF257	0·49	BU207	3·00	TIS73	1·36	2N3739	1·18	AD161/	
BC114	0·20	BCY33	0·36	BF258	0·66	BU208	3·15	ZTX109	0·12	2N3771	1·70	AD162	0·95
BC115	0·20	BCY42	0·16	BF259	0·93	BU209	2·55	ZTX300	0·16	2N3772	1·90		
BC116	0·20	BCY71	0·22	BF262	0·70	BUY77	2·50	ZTX304	0·22	2N3773	2·90	BC142/	
BC117	0·20	BCY88	2·42	BF263	0·70	BUY78	2·55	ZTX310	0·10	2N3790	4·15	BC143	0·70

DIODES

Type	Price (£)
AA113	0·15
AA119	0·09
AA129	0·20
AA143	0·10
AAZ13	0·30
BA100	0·50
BA102	0·25
BA110U	0·30
BA115	0·12
BA141	0·17
BA145	0·17
BA148	0·17
BA154	0·13
BA155	0·16
BA156	0·15
BA147	0·25
BAX13	0·06
BAX16	0·07
BB104	0·52
BB105B	0·52
BB105G	0·45
BR100	0·50
BY100	0·15
BY103	0·22
BY126	0·16
BY127	0·17
BY133	0·23
BY140	1·40
BY164	0·55
BY176	1·76
BY179	0·70
BY206	0·31
BYX10	0·15
OA47	0·07
OA81	0·12
OA90	0·08
OA91	0·07
OA95	0·07
OA200	0·10
OA202	0·10
OA210	0·29
IN914	0·07
IN916	0110
IN4001	0·05
IN4002	0·06
IN4003	0·07
IN4004	0·08
IN4005	0·09
IN4006	0·11
IN4007	0·14
IN4148	0·05
IN4448	0·10
IN5400	0·15
IN5401	0·17
IN5402	0·20
IN5403	0·22
IN5404	0·25
IN5404	0·27
IN5406	0·30
IN5407	0·34

ZENERS

400m W 3-33V	0·12
1W 3·3-100V	0·18

THYRISTORS, TRIACS AND TRIACS WITH TRIGGER

IF VRM:	50V	100V	200V	400V	600V
3A	—/—/—	—/28/30	—/34/36	—/50/52	—/66/70
4A	26/—/—	30/—/—	38/—/—	60/—/—	75/—/—
6A	29/—/—	33/44/46	42/56/58	68/80/84	80/100/105
8A	32/—/—	38/50/52	47/64/61	75/92/97	90/114/120
10A	36/—/—	42/60/63	51/74/78	84/104/109	100/128/13
16A	—/—/—	—/82/90	—/88/95	—/132/140	—/175/185

Notes: All prices are in pence per unit. First price in each group is thyristor, second is triac, third is triac with trigger. Encapsulation depends on current rating and device type. Connection data supplied with each device. Quantity enquiries welcomed.

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Type	Price (£)	Type	Price (£)
CA3045	1·40	TAA630Q	4·18
CA3046	0·70	TAA630S	4·18
CA3065	1·90	TAA700	4·18
MC1307P	1·90	TAA840	2·02
MC1310P	2·94	TAA861A	0·49
MC1327PQ	1·01	TAD100	2·66
MC1330P	0·76	TBA120S	0·99
MC1351P	0·75	TBA240A	2·97
MC1352P	0·72	TBA480Q	1·90
MC1358PQ	1·85	TBA500	1·99
MC1496L	0·87	TBA500Q	2·00
MC3051P	0·58	TBA510	1·99
MFC4000B	0·43	TBA520Q	3·34
MFC4060A	0·70	TBA530	2·71
MFC6040	0·91	TBA530Q	2·71
PA263	1·90	TBA540	3·21
SL414A	1·91	TBA540Q	3·21
SL901B	3·84	TBA550Q	4·10
SL917B	5·12	TBA560C	2·71
SN76003N	2·92	TBA560CQ	4·10
SN76013N	1·95	TBA570	1·17
SN76013ND	1·72	TBA641	0·76
SN76023ND	1·72	TBA673	2·28
SN76023N	1·95	TBA700	2·59
SN76033N	2·92	TBA720Q	2·45
SN76530P	1 05	TBA750Q	2·33
SN76533N	1·20	TBA800	1·75
TAA300	1·76	TBA810AS	1·75
TAA320	0·94	TBA920Q	4·23
TAA350A	2·02	TBA990	4 10
TAA435	0·85	TBA990Q	4·10
TAA450	2·70	TCA270Q	4·18
TAA550	0·55	ZN414	1·20
TAA570	2·02	u6A995159	2·52

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IN4004	3.8	3.3
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Component packs for a choice of three outstanding amplifiers are stocked together with packs for a regulated power supply suitable for use with a pair of any of them. Also stocked are packs for a very well-established pre-amplifier—the Bailey-Burrows design which features six inputs, a scratch and rumble filter and wide range tone controls which may be either rotary or slider operating.

30W BAILEY	
Pk. 1 F/Glass PCB	£0.80
Pk. 2 Resistors, capacitors, pots	£1.75
Pk. 3 Semiconductor set	£4.70
30W BLOMLEY	
Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.15
Pk. 3 Semiconductor set	£5.60
20W LINSLEY-HOOD	
Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.40
Pk. 3 Semiconductor set	£3.35
60V REGULATED POWER SUPPLY	
Pk. 1 F/Glass PCB	£0.75
Pk. 2 Resistors, capacitors, pots	£1.40
Pk. 3 Semiconductor set	£3.10
BAILEY-BURROWS PRE-AMP	
Pk. 1 F/Glass PCB	£2.05
Pk. 2 Resistors, capacitors, pre-sets, transistors	£4.95
Pk. 3R Rotary potentiometer set	£1.60
Pk. 35 Slider potentiometer set (with knobs)	£2.70

STUART TAPE RECORDER

A set of three printed-circuit boards has been prepared for the stereo integrated circuit version of this high-performance Wireless World published design.

TRRP Pk. 1	Reply amplifier F/Glass PCB	£0.90
TRRC Pk. 1	Record amp./meter drive cct., F/Glass PCB	£1.40
TROS Pk. 1	Bias/erase/stabilizer cct. F/Glass PCB	£1.00

For details of component packs for this design please write for free list.

TOROIDAL T20 + 20

Developed from the famous Practical Wireless Texan

20 WATTS/CHANNEL

Designed by Texas engineers and published in a series of articles in **Practical Wireless**. The TEXAN was a remarkable breakthrough in delivering true Hi-Fi performance at exceptionally low cost. Now further developed to include a true Toroidal transformer, this slimline integrated circuit design, based upon a single F/Glass PCB, features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and headphones socket.

FREE TEAK CASE and HANDBOOK with full kits

KIT PRICE only **£28.25**

post free (U.K.)

Pack		Price
1	Set of all low noise resistors	£0.80
2	Set of all small capacitors	£1.50
3	Set of 4 power supply capacitors	£1.40
4	Set of miscellaneous parts including DIN sockets, fuses, fuse holders, control knobs, etc.	£1.90
5	Set of slide and push-button switches	£0.90
6	Set of potentiometers and selector switch	£1.45
7	Set of all semiconductors	£8.25
8	Special Toroidal Transformer	£4.95
9	Fibreglass PC Panel	£2.50
10	Complete chassis work, hardware and brackets	£4.20
11	Preformed cable/leads	£0.40
12	Handbook	£0.25
13	Teak Cabinet	£2.75

ACTIVE FILTER CROSSOVER

An essential and critical component in a high-quality speaker system is the crossover unit conventionally comprising of a series of passive networks which unfortunately, though introducing reactive impedances between the amplifier and the speakers, result in the loss of the advantage of high amplifier damping factor and renders the speakers prone to overshoots and resonances. An elegant solution to this problem, described by D. C. Read in **Wireless World**, involves the use of a series of active filters splitting the output of the pre-amplifier into three channels, of closely defined bandwidth, each of which is fed to the appropriate speaker by its own power amplifier. A design for a suitable 20-watt amplifier, based on a proven Texas circuit, was also described by Mr Read. The printed-circuit board for this has been designed such that three amplifiers may be stacked and mounted together on a common heat sink to achieve a conveniently compact module.

ACTIVE FILTER

Pack		
1	Fibreglass PCB (accommodates all filters for one channel)	£1.05
2	Set of pre-sets, solid tantalum capacitors, 2% metal oxide resistors, 2% polystyrene capacitors	£4.20
3	Set of semiconductors	£2.65

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READ/TEXAS 20w amp.

Pack		
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3	Sets of semiconductors	£2.40
	6 off each pack required for stereo system	
4	Special heat sink assembly for set of 3 amplifiers	£0.85
5	Set of 3 O/P coupling capacitors	£1.00

2 off packs 4, 5 required for stereo system

POWER SUPPLY

FOR 20W/CHANNEL STEREO SYSTEM

Pack		
1	Fibreglass PCB	£0.50
2	Set of rectifiers, zener diode, capacitors, fuses, fuse holders	£2.60
3	Toroidal transformer	£4.95

ENQUIRIES WELCOME
For quality sets of speakers

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2N699	£0.25	2N4302	£0.60	BC182L	£0.10	MJ481	£1.20	TIP29C	£0.71
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ADZ12	BCY31	CRS3/30	OC26	OC170	2N1304	2N4785
AF114	BCY33	CRS3/40	OC28	OC172	2N1305	2N5295
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AF117						3N159
AF118						2S303
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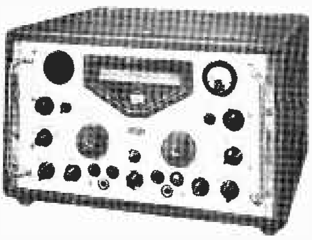

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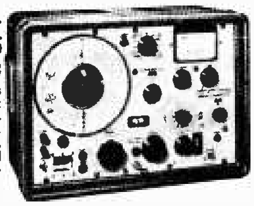

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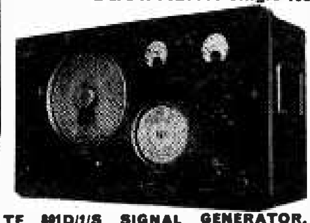

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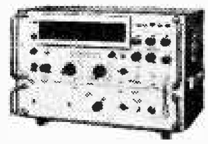

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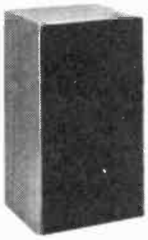


These superb simulated teak-finished speaker kits have been specially designed by RT-VC for the cost-conscious hi-fi enthusiast who wants top quality speakers but doesn't want to spend the earth. Built to EMI's exacting specification, these new RT-VC speaker kits (350 type kit) incorporate 13"×8" woofer, 3¼" tweeter and matching cross-over. Easily put together with just a few basic tools.

Specification (each speaker):
Impedance 8 ohms. Power handling 15 watts r.m.s. (30 watts peak).
Response 20–20,000Hz. Size 20"×11"×9½" approx.
Comparable built units (EMI LE3) sold elsewhere for over £45 pair.

ONLY £18.95 Pair complete +£4 p & p

SYSTEM 1: £51.00

40-watt Amplifier. Viscount III—R102 now 20 watts per channel.
System 1 includes:
VISCOUNT III Amplifier—volume, bass, treble and balance controls, plus switches for mono/stereo on/off function and bass and treble filters. Plus headphone socket.
Specification:
20 watts per channel into 8 ohms. Total distortion @ 10W @ 1kHz 0.1% P.U.1 (for ceramic cartridges), 150mV into 3 Meg. P.U.2 (for magnetic cartridges) 4mV @ 1kHz into 47K equalised within—1dB R.I.A.A. Radio 150mV into 220K (sensitivities given at full power). Tape out facilities: headphone socket, power out 250mW per channel. Tone controls and filter characteristics. Bass +12dB to −12dB @ 60Hz. Bass filter: 6dB per octave cut. Treble control: treble +12dB to −12dB @ 15kHz. Treble filter: 12dB per octave. Signal to noise ratio: (all controls at max) −58dB. Crosstalk better than 35dB on all inputs. Overload characteristics better than 26dB on all inputs. Size approx. 13¾"×9"×3¾".
GARRARD SP 25 Mk III Deck with magnetic cartridge, de luxe plinth and hinged cover.
TWO DUO TYPE II MATCHED SPEAKERS—enclosure size approx. 17½"×10¾"×6" in simulated teak. Drive unit 13" ×8" with parasitic tweeter. 10 watts handling.
Complete System £51·00

SYSTEM 2: £69.00

Viscount III Amplifier (as system 1). Garrard SP 25 Mk III Deck (as system 1). Two Duo Type III Matched Speakers—enclosure approx. 27" × 13" × 11½". Finished in teak simulate. Drive units 13" × 8" bass driver, and two 3" (approx) tweeters. 20 watts R.M.S. 8 ohms frequency range—20Hz to 18,000Hz. **Complete System £69·00**

Scotland p & p surcharge System 1 £1·75. System 2 £3·50

PRICES: SYSTEM 1.

Viscount III R102 amplifier	£24·20+£1	p & p
2 Duo Type II Speakers	£14·00+£2·20	p & p
Garrard SP 25 with Mag. Cartridge de luxe plinth and hinged cover	£21·00+£1·75	p & p
TOTAL:	£59·20	
Available complete for only:	£51·00+£3·50	p & p

PRICES: SYSTEM 2.

Viscount III R102 Amplifier	£24·20+£1	p & p
2 Duo Type III Speakers	£39·00+£4·00	p & p
Garrard SP 25 with Mag. Cartridge de luxe plinth and hinged cover	£21·00+£1·75	p & p
TOTAL:	£84·20	
Available complete for only:	£69·00+£4·00	p & p

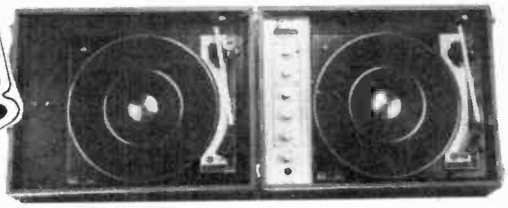
DISCO AMPLIFIER *

Reliant Mk IV Mono Amplifier, ideal for the small disco or house parties. Outputs 20 watts R.M.S. into 8 ohms (suitable for 15 ohms). Inputs ★ 4 electrically mixed inputs. ★ 3 individual mixing controls. ★ Separate bass and treble controls common to all 4 inputs. ★ Mixer employing F.E.T. (Field Effect Transistors.) ★ Solid State circuitry. ★ Attractive styling.

INPUT SENSITIVITIES—Input 1—Crystal mic. guitar or moving coil mic. 2 and 10 mV (selector switch for desired sensitivity).
Inputs 2, 3, 4. Medium output equipment—ceramic cartridge, tuner tape recorder, organs, etc, all 250mV sensitivity. AC Mains 240V operation. Size approx. 12½"× 6"×3½".

£15.00 +60p p & p

PORTABLE DISCO CONSOLE *



INCORPORATES: Pre-amp with full mixing facilities including switched input for mic. with volume control, switched input for auxiliary with volume control, bass and treble controls, volume control and blend control for turntables.
TWO B.S.R. single-play professional series decks, fitted with crystal cartridges.
The turntables are designed and precision engineered. They combine clean modern styling with superb reproduction. Their many special features include square section aluminium tonearms (high precision low mass design fully counter-balanced, with calibrated stylus pressure control for perfect tracking), and conveniently grouped easy to read linear controls. The turntables have viscous cueing devices which allow the tonearms to be placed or lifted at any point on the record. The two lightweight cartridge shells have slide-in-holders to facilitate easy inspection of needles and cartridges.

Yours for only £45.00 +£3·50 p & p

TECHNICAL SPECIFICATION:

PRE-AMP—Output—200mV
Auxiliary inputs—200mV and 750mV into 1 meg. Mic. input 6mV into 100K. 240 volt operation.

TURNTABLES CAPACITY—7", 10", or 12" records.

RUMBLE, WOW and FLUTTER
Rumble better than −35dB. Wow better than 0.2%. Flutter better than 0.06% (Gaumont kalee meter).

FINISH—Satin black meinplate with black turntable matt inlaid with brushed aluminium trim. Tonearm end controls in black and brushed eluminium.

CONSOLE SIZE
Unit closed—17¾"×13¾"×8¾" (approx.)
Unit open—35½"×13¾"×4⅜" (approx.)
This disco console is ideally matched for the Reliant IV and Disco 50 or any other quality amplifier.

The unit is finished in black PVC with contrasting simulated teak edging, diamond spun control knobs with matching control panel.

PUSH BUTTON RADIO KIT *

THE TOURIST II

NOW BUILD YOUR OWN PUSH-BUTTON CAR RADIO

Easy to assemble construction kit comprising fully completed and tested printed circuit board on which no soldering is required. All connections are simple push fit type making for easy assembly. Fine tuning push-button mechanism is fully built and tested to mate with printed circuit board.

Technical specification: (1) OUTPUT 4 watts R.M.S. output. For 12 volt operation, negative or positive earth. (2) INTEGRATED CIRCUIT output stage, pre-built three-stage IF Module. CONTROLS VOLUME, MANUAL tuning and five push-buttons for station selection, illuminated tuning scale covering full, medium and long wave bands.
Chassis size 7" wide, 2" high and 4¾" deep approx. **£7·70** + 55p p & p.
SPEAKER including baffle and fixing strip **£1·65** + 23p p & p.
CAR AERIAL RECOMMENDED—fully retractable **£1·37** + 20p p & p.

£7.70

NO SOLDERING REQUIRED!

The Tourist I Kit for the experienced constructor. If you can solder on a printed circuit board you can build this model. Same technical specification as Tourist II.

PRICE £6·60 + 55p P & p.

Mail orders to Acton. Terms C.W.O. All enquiries stamped addressed envelope. Goods not despatched outside U.K. Leaflets available for all items listed thus ★. Send stamped addressed envelope. All items subject to availability. Prices correct at 1st February, 1975 and subject to change without notice. All prices include V.A.T. at 8% rate.

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CURRENT RANGE OF NEW L.T. TRANSFORMERS FULLY SHROUDED TERMINAL BLOCK CONNECTIONS ALL PRIMARIES 220/240v

Type	Sec. Taps	Amps	Price	Postage
1A	25-33-40-50v	15	£14·00	75p
1B	25-33-40-50v	10	£12·00	75p
1C	25-33-40-50v	6	£8·50	60p
1D	25-33-40-50v	3	£7·50	60p
2A	4-16-24-32v	12	£10·00	75p
2B	4-16-24-32v	8	£8·00	60p
2C	4-16-24-32v	4	£4·95	45p
2D	4-16-24-32v	2	£3·50	40p
3A	24-30-36v	10	£9·00	60p
3B	24-30-36v	5	£7·50	50p
3C	24-30-36v	2	£3·50	40p
4A	12-20-24v	20	£12·00	75p
4B	12-20-24v	10	£7·50	60p
4C	12-20-24v	5	£4·95	40p
5A	3-12-18v	20	£10·00	60p
5B	3-12-18v	10	£6·95	60p
5C	3-12-18v	5	£4·50	40p
6A	48-56-60v	2	£4·50	40p
6B	48-56-60v	1	£3·50	40p
7A	6-12v	20	£7·90	60p
7B	6-12v	10	£4·50	40p
7C	6-12v	5	£3·50	40p
8A	17-32v	8	£8·00	60p
9A	12-24v	1	£2·50	30p
10A	9-15v	2	£2·50	30p
11A	8-0-8v	2	£2·50	30p

PLEASE ADD 8% V.A.T.

HEAVY DUTY UNSHROUDED TYPES 9 INCH FLYING LEADS ALL PRIMARIES 240v.

Type No.	Sec. Volt Tap.	Amps.	Price	Carr.
1	24-30-36	20	£14·95	£1·00
2	12-20-24	30	£14·95	£1·00
3	3-12-18	30	£14·95	£1·00
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TRANSFORMERS FOR LINSLEY HOOD AMPLIFIERS

Fully shrouded, terminal block connections. Pri. 220-240v. Screen tap. Sec. 30-25-0-25-30v., 2 amps. **£4·75,** carr. 40p. Heavy duty type 36-25-0-25-36v. 5 amps. **£9·75,** carr. 50p.

STEP DOWN 240/110v AUTO TRANSFORMERS

3000 watts. Built into steel case with two American 2 pin grounded socket outlets. Carry handle. 6 ft. mains lead. **£29·50,** carr. £2. Without case and fittings **£22·00,** carr. £1·50.
Other Types Available. 80-1500 watts, fully shrouded, with American socket outlet and 6 ft. mains lead. Let us know your requirements. Lists available.

PARMEKO POTTED L.T. TRANSFORMERS

Pri. 115-230v SCR. Sec. tapped 40-45-50v 5 amps. **£8·50,** carr. 75p.
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All types conservatively rated. Brand new. Fraction of maker's price.

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10 M/H 25 amps., **£8·75,** carr. £1.00.

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No. 7 Pri. 220-240v Sec. 630-0-630v 105 M/A. 5v 4A 5v 2A **£4·50,** P.P. 75p.
No. 8 Pri. 220-240v Sec. 140v 195 M/A 6·3v CT 1·25A. 50v potted type 1A **£3·50,** P.P. 50p.
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Suitable for scope replacements. Pri. 240v., Sec. 2300v 10 M/A. 300-0-300v 50 M/A, 6·3v 4A. 6·3v 1·5A. Table top connections. Size 5×3¼×3¼ ins. **£3·75.** P.P. 45p.

GARDNERS C CORE HT TRANSFORMERS

Pri. 110-220-230v. Sec. 250-0-250v. 60 M/A 2·8-0-2·2·8v 28 amps. 24v 3 amps. 6·3v 3 amps. 5v 2 amps. **£4·75,** P.P. 65p.

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GARDNER 'C' core types. 10H 250 M/A **£2·00,** post. 40p. 20H 180 M/A **£2·00,** post. 40p. 12H 100 M/A **85p,** post. 25p. 50H 25 M/A **85p,** post. 25p. **PARMEKO** Potted types, 10H 180 M/A **£2·00,** post. 40p. 5·2H 350 M/A **£2·50,** post. 50p. 10H 300 M/A **£2·50,** post 50p. 5H 100 M/A **75p,** post. 25p. 15H 75 M/A **75p,** post 25p. 50H 25 M/A **75p,** 25p.

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Input 240v + 20% — 10% output 240v + or — 0·5% 30 watts enclosed in metal case, 5¼×4×4 ins **£2·00,** P.P. 50p.

OIL-FILLED BLOCK CAPACITORS

MFD	DCV WKG	PRICE
8	2500	£3·00
8	800	75p
8	600	60p
8	350	40p
6	750	60p
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4	2000	£1·00
4	1000	60p
4	600	40p
4	350	30p
1	600	20p
1	200	10p

P.P. Add 5p each 1-4 MFD.
10p each 6-8 MFD.
25p each 8 MFD 2500v.
Plessey 2+2+2 MFD 1500v. WKG 70°C. **75p,** P.P. 10p.
TCC block electrolytic capacitors 1000 MFD 100v DC WKG **50p,** P.P. 15p.

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AC 240v 25% duty. Approx 2 ins. ½ in. pull. Size 2×1½ × 1ins. Res. 350Ω **75p** P.P. 10p.

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0·80v **DC.** 3 in. square, 2½ in. panel hole **£1·25,** P.P. 25p.
0-100 M/A **DC.** 3½ in. round. 2½ in. panel hole. **£1·50,** P.P. 25p.
0-500 UA DC. 2½ in. square. 2 in. panel hole. **£1·75,** P.P. 25p.

DIAMOND H Double pole toggle switches type 7T2 250v 20 amps, centre single hole fixing **60p.** P.P. 10p.

SEMICONDUCTORS

TRANSISTORS & DIODES

AD142	**0.46**	BD140	**0.45**	2N1305	**0.18**
AD143	**0.40**	BFY50	**0.20**	2N1306	**0.22**
AD149	**0.48**	BFY51	**0.18**	2N1307	**0.22**
AL102	**0.65**	BFY52	**0.19**	2N1308	**0.23**
AL103	**0.65**	BSX19	**0.14**	2N1309	**0.23**
BA102	**0.15**	BSX20	**0.15**	2N2102	**0.32**
BC107	**0.14**	BSX60	**0.60**	2N2904	**0.17**
BC108	**0.13**	CRS3/05	**0.31**	2N2905	**0.18**
BC109	**0.14**	CRS3/10	**0.38**	2N2905A	**0.20**
BC168B	**0.10**	CRS3/20	**0.42**	2N2926G	**0.10**
BC261A	**0.10**	CRS3/40	**0.65**	2N2926O	**0.10**
BC267A	**0.12**	OA5	**0.60**	2N2926Y	**0.10**
BCY32	**1.07**	OA9	**0.20**	2N2926R	**0.10**
BCY39	**1.25**	OA10	**0.37**	2N3053	**0.15**
BCY70	**0.13**	OC44	**0.08**	2N3054	**0.38**
BCY71	**0.18**	OC45	**0.08**	2N3055	**0.42**
BCY72	**0.12**	OC70	**0.08**	2N3415	**0.12**
BDY60	**0.61**	OC71	**0.08**	2N3442	**0.80**
BDY61	**0.53**	OC75	**0.08**	2N3714	**1.16**
BDY62	**0.45**	OC139	**0.45**	2N3715	**1.21**
BDY90	**2.28**	OC140	**0.65**	2N3716	**1.28**
BDY91	**2.16**	OC205	**1.25**	2N3771	**1.25**
BDY92	**1.75**	OC206	**1.25**	2N3773	**2.18**
BD131	**0.32**	OC207	**1.40**	2N3904	**0.12**
BD132	**0.44**	TIC47	**0.35**	2N3906	**0.12**
BD135	**0.32**	2N697	**0.11**	2N4036	**0.38**
BD136	**0.34**	2N930	**0.14**	2N4123	**0.12**
BD137	**0.36**	2N1302	**0.15**	2N4124	**0.12**
BD138	**0.38**	2N1303	**0.15**	2N5064	**0.25**
BD139	**0.41**	2N1304	**0.18**		

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DL707 7 seg led **0.90**
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TAA435 **0.55**
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TBA641 **0.88**
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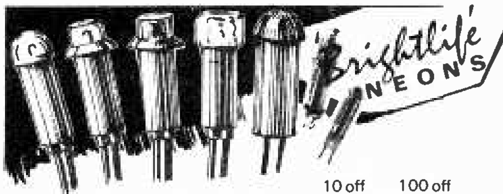
WW—108 FOR FURTHER DETAILS

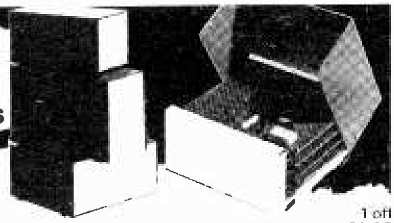


Brightlife neons (illustrated are PC/A or C, PC/F, PC/E, PC/G or I, PP/A or B, Q and S) are brighter and give an average of 25,000 hrs. life. The 0.5" dia. are red or white, the 0.375" are red, amber or white: these have three cap shapes and all may be supplied for 115, 240V or the PP neons in 110, 240, and 440V with 6" or 30" leads.

dia.	leads	volts	10 off	100 off incl. P. & P.
3/8" PC/A to I	6"	110 or 160–260	**17½p**	**16½p**
3/8" PC/A to I	30"	110 or 160–260	**19½p**	**18½p**
½" PP/A	6"	110 or 160–260	**17½p**	**16½p**
½" PP/A	30"	110 or 160–260	**19½p**	**18½p**
Q type	none	110 or 160–260	**29p**	**27p**
S type	none	—	**23p**	**21p**

Add 8% VAT. Min. quantity each type 10 off. Prices correct January 1975.

CONTIL samos miniature cases

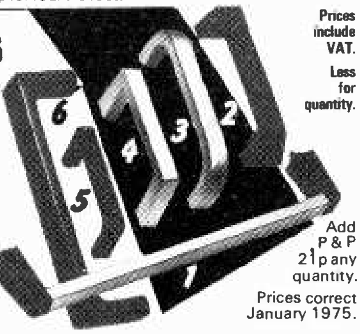


in easy-to-work blue and white PVC/steel. Assemble in the lower half; complete before springing cover into place—four Pozidrives, two to hinge it, two to fasten it. Carries four P.C. boards horizontally, or two vertically: four required for each case (for one vertical board, two each case) Prices correct January 1975.

		1 off
S1	100 × 50 × 50mm	**£1.05**
S2	100 × 100 × 50mm	**£1.19**
S3	100 × 150 × 50mm	**£1.35**
S4	125 × 50 × 75mm	**£1.51**
S5	125 × 100 × 75mm	**£1.71**
S6	125 × 150 × 75mm	**£2.03**
S7	125 × 200 × 75mm	**£2.25**

much less for quantity. Prices include P. & P., 8% VAT. four feet and four plated screws. Special feet to carry Printed Circuit Boards sold separately. Price, incl. 8% VAT, 25p for four PC feet.

CONTIL handles

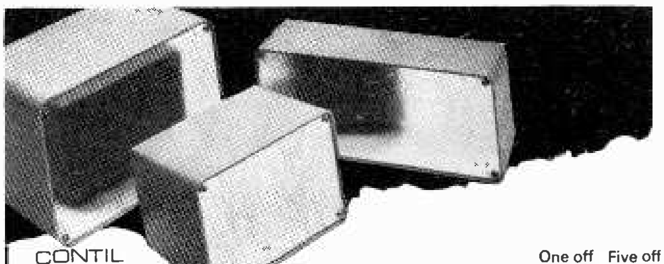


Prices include VAT. Less for quantity.

(1) No. 265.55. Anodised aluminium centre bar. Black plastic brackets with moulded-in core. 75mm @ **£1.16.** Five more sizes up to 254mm.
(2) No. 281. 1 Nylon 112mm. Load 50Kg @ **50p.**
(3) No. 277. Ali. ground polished anodised 88mm. @ **£1.08.** 120mm @ **£1.22.**
(4) No. 268. Satin ali. 57.5mm **£1.08;** 102mm. @ **£1.16;** 146.5mm @ **£1.38.** (5/6) No. 250 Black nylon very comfortable 75mm @ **33p.** 110mm. @ **47p.** 155mm. @ **54p.**

Add P & P 21p any quantity.

Prices correct January 1975.



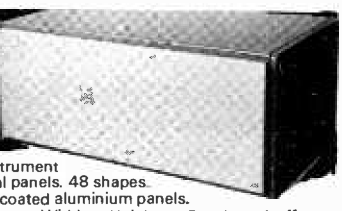
CONTIL ELF cases

		One off	Five off
Elf	6" × 4" × 4"	**£1.97**	**£1.79**
Long Elf	9" × 4" × 3"	**£2.13**	**£2.08**
Giant Elf	8" × 5½" × 5"	**£3.44**	**£3.32**

Tough little cases in glass-fibre polyester add very little to the cost of the job. Grey, with protected aluminium front panel (16 s.w.g.), and chassis and feet.

Also available less panels.
No handles obtainable.
Prices correct January 1975.
Less for quantities.
Prices include feet, P & P and 8% VAT.

CONTIL MOD·2



The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes. Low cost. Blue PVC/steel with grey PVC-coated aluminium panels.

	Width	Height	Depth	1 off		Width	Height	Depth	1 off
A	4.5"	3"	6.5"	**£4.74**	M	4.5"	3"	13"	**£5.78**
B	4.5"	7"	6.5"	**£5.78**	N	4.5"	7"	13"	**£7.08**
C	4.5"	10"	6.5"	**£6.40**	O	4.5"	10"	13"	**£8.98**
D	9"	3"	6.5"	**£6.40**	P	9"	3"	13"	**£7.08**
E	9"	7"	6.5"	**£7.08**	Q	9"	7"	13"	**£8.98**
F	9"	10"	6.5"	**£8.16**	R	9"	10"	13"	**£10.49**
G	13"	3"	6.5"	**£7.08**	S	13"	3"	13"	**£8.98**
H	13"	7	6.5"	**£8.16**	T	13"	7"	13"	**£10.94**
I	13"	10"	6.5"	**£8.98**	U	13"	10"	13"	**£13.25**
J	18"	3"	6.5"	**£8.16**	V	18"	3"	13"	**£10.95**
K	18"	7"	6.5"	**£10.49**	W	18"	7"	13"	**£13.25**
L	18"	10"	6.5"	**£13.25**	X	18"	10"	13"	**£15.83**

Woodgrain: D @ **£6.49.** E & G @ **£7.47.** H @ **£8.21**

Prices include screws, rubber feet, one or two chassis according to size. P. & P., and 8% VAT.

Prices correct Jan 1975.

WEST HYDE WH

Increases in postal charges, due in March, not included.

WEST HYDE DEVELOPMENTS Ltd, Ryefield Cres., Northwood Hills, Northwood, Middx HA6 1NN
Tel: Northwood 24941/26732 *WRITE OR 'PHONE FOR NEW FREE CATALOGUE* **Telex: 923231**

WW—034 FOR FURTHER DETAILS

TRANSISTORS AND DIODES

Type	Pc	VCBO	FT MHz	
BSY29 (SNPN)	300mw	15	20	**17p**
BD107 (SNPN)	11·5w	64	100	**65p**
2N711B/2G106 (SPNP)	150mw	18	120/150 Tot. Sw. Time 275 nS	**45p**
2N985 (GPNP)	300mw	15	Tot. Sw. Time 115 nS	**£1·00**
2N1304 (GPNP)	150mw	30	6	**17p**
2N1309 (GPNP)	150mw	30	15	**32p**
2N1046 (GPNP)	50w	100	20	**£2·60**
2N1146A (GPNP)	90w	70	15	**50p**
2N1557 (G)	106w	40	0·35	**55p**
2N2080 (G)	170w	70	0·2	**£1·20**
2N2082 (G)	170w	40	0·2	**£1·20**
2N2405 (SNPN)	1w	120	120	**57p**
2N3054 (SNPN)	29w	90	1·2	**45p**
2N3055 (SNPN)	115w	100		**47p**
2N3375 (SNPN)	11·6w	65	500	**£3·60**
2N4427 (SNPN)	3·5w	40	700	**55p**
2N5322 (SNPN)	10w	65	325	**55p**

ASZ16/OC26 **25p** OC35 **45p.** OC42 **45p.** OC71 **12p.** CV7006/OC72 **20p.** OC75 **25p.** OC83 **28p.** GET110/NKT303 **25p.** OC702 **10p.** OA10 **25p.** RAS508AF **25p.** RAS310AF **25p.** STC Wire End 400PIV1A 4 for **50p.** IN3193 **13p.** IN3194 **14p.** IN3255 **20p.**

RECTIFIER STACKS

GEX541B1P2 ..... **£6·88**
GEX541D2P1 ..... **£3·50**
GEX541NB1P1F ... **£6·00**
GEX541HP3F ..... **£6·00**
SX751N1B1P1F ... **£6·00**

INTEGRATED CIRCUITS

MC353G Half Adder **£2·20**
MC356G 3 Inp OR/NOR GATE ..... **£1·60**
MC358AG AC coupled JK Flipflop ..... **£5·50**
MC365G Line Driver **£5·50**
CA3020 Wideband Pow. Amp. ..... **£1·00**
CA3021 Low power video ..... **£1·30**
CA3028A RF 1F Amp. ..... **£1·00**
CA3038A Operational Amp. ..... **£2·30**
CA3055 Pos. Volt. Regulator ..... **£1·35**
CA3085 Pos. Volt. Regulator **90p**
CD4035AE 4-stage Serial Register ..... **£2·00**
CD4017AE Decade Counter Divider ..... **£4·00**
CD4047AD Monostable Astable Multivibrator **£4·00**

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GE2N1774 200v. 5a. **£1·20**
CR1-021C 20v. 1a. .. **25p**
CR10-101B 100v. 10a. .... **£1·00**
CR10-021 10a. .... **£1·00**
CR10-40B 10a. .... **£1·00**
CR10-051 10a. .... **£1·00**
CR10-017 10a. .... **£1·00**
BTX 92 1200R 16a 1200v. .... **£2·85**

RCA PHOTOMULTIPLIER C31005B **£37·50**

BRIDGE RECTIFIERS 1B40K05 50v 4a **£1·00**

SWITCHES

Edwards High Vacuum "Speedivac" model VSK1B range 25·760 torr contact ratings 250v. 5a. volume 4·2 cu. cm. max. working pressure 15lb/sq. in. gauge net weight 17 ozs. .... **£6·50**
Belling Delay hand reset L415 .... **£1·25**
Stackpole min. rocker 125v. 10a. 250v. 5a **25p**
Tippalite Rocker 12v. **65p**

CIRCUIT BREAKERS 250V AC each £1·35

AMP	TRIP	TYPE
2·0	D	Westingh. 550
4·0	—	Securex 5000
7·0	Inst.	Westingh. 550
7·0	4	Heinemann (60c.) AM12
8·0	Inst.	Westingh. 550
8·0	—	Securex 5000
9·0	Inst.	Westingh. 550
10·0	—	Securex 5000
20·0	—	ETA Magnetic

DIGITAL COUNTERS

Veeder Root Mech. Reset 4 dig. **55p**

STABILIZED POWER SUPPLIES

Gresham Lion GX60/10a—60v. 10 amp. set to 30v .... **£65·00** incl. carriage
Lambda CC28v—Inp 205–265v. output 28v dc ±5% 3·4 amp **£38·50** incl. p. & p.
Power Elect. Inp 240v outputs 20v 6·5a 10v 3·4 amp + 10v 300ma .... **£38·50** inc. carr.

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Varley Min. 700 Ω 12v. **50p**
Siemens Min. 12/15v. **50p**
Magnetic Dev. Type 596E .... **£2·00**

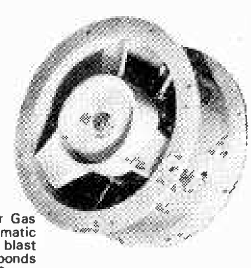
CONNECTORS

McMurdo Red Range. Plug RP24 ...... **56p**
McMurdo Red Range. SKT RS32 ...... **90p**
Eng. Elect. Edge. 36 way 0·2 inch . pair **£1·00**
Sylvania Edge. 48 way 0·125 inch .. pair **40p**
Amphenol MS3106B-36-10 .... **£4·50**
Continental microminiature 2B 1080IN26 **£1·30**

CAPACITORS

Daly Electrolytic 9000μF 25v **60p** p/p 15p: 500μF 50v **35p** p/p 10p: TCC 16μF + 16μF + 8μF 450v **75p** p/p 15p: CCL 50μF + 50μF 275v **45p** p/p 10p: CCL Suppressor Unit Type SU103/1 comprising capacitor Diode and Resistor **45p** p/p 10p: Dubilier Metalised Paper type 426 100μF 15v **60p** p/p 25p: RIC 1·8¼F 440v a.c. **40p** p/p 10p.

FANS, CENTRIFUGAL BLOWERS & MOTOR



Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425cfm free air weight 9½lbs. inc. p.p **£23·00.**

Woods Aerofoil short casing type S. Ref HS895/4/66 Cap. 2·5μF. Non-reverse 220/240v 1ph 50c 0·19a 2700rpm. 6" cast alum. impeller 4 blades width casing 2⅝" total 5¼" weight 5¼lbs incl p.p. **£13·00.** Aerofoil Code 7.5 280K 200/250v. 1·0a 1ph 50c 2700rpm 550cfm free air. 7½" impeller 14 blades incl p.p. **£14·50.**

Service Electric Hi-Velocity Fans, suitable for Gas combustion Systems. Steam exhausting. Pneumatic conveying. Cooling Electronic equipment. Air blast for Oil burners. **Secomak** Model 365 (corresponds to 575) Airblast Fan. 440v 3ph 50c 0·75hp 2850rpm. continuous 160cfm 12 in w.g. nett weight 44lb. price incl. carr. **£45·00. Secomak** model 350 250v 1ph 50c 0·166hp. 2800rpm continuous 50cfm 2 in. w.g. net weight 34lbs. price incl. carr. **£30·00.**

Air Controls type VBL4 200/250v 1ph 50c 110cfm free air weight 7½lbs price incl. p.p. **£15·50.**

Type VBL5 200/250v 1ph 50c 172cfm free air. Weight 10¼lbs. price incl. p.p. **£19·50.**

William Allday Alcosa rotary vane oil free Single Stage Vacuum Pump Model HSPOB 8 HG. Rpm 1420. E.E. 3 phase induction motor 1/3hp cont 220/250v. 380/440v. Class E ins. incl. carr. **£28·00.**

Alcosa blower FAD 3·8cfm at 5psi. Rpm 1420. Motor EE 3ph 50c ¼hp 1400rpm. incl. carr. **£28·00.**

Gast MFG. Vacuum pump 0522-P702-R26X. Motor 110/120v a.c. 1ph 60c 1725rpm. Class E. 10cuft to 10in Mercury in 2 mins maintains vacuum. 635mm Mercury. Or as compressor 10psi int. or 15psi cont. incl. carr. **£28·00.**

3 phase 2HP motor 60/50c.. 1800/1500 RPM. 208/220/440v .... **£23·50** incl. Carriage
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Where p.p. not advised add 10p per £ handling and post (in UK). Cash with order. Personal callers welcome. Open Mon.-Wed. 9.30-5.00 Fri.-Sat. 9.30-5.00. Free Car Park adj. **PRICES SHOWN ARE EXCLUSIVE OF V.A.T.**

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Type	£	Type	£	Type	£	Type	£
AZ31	0.60	ECH35	1.50	EZ80	0.30	PEN45DD	0.75
AZ41	0.70	ECH42	0.85	EZ81	0.31	PFL200	0.70
CBL31	1.40	ECH81	0.35	EZ90	0.45	PL36	0.63
CL33	1.50	ECH83	0.50	GY501	0.90	PL38	1.25
CY31	0.60	ECH84	0.50	GZ30	0.65	PL81	0.55
DAF91	0.40	ECL80	0.60	GZ32	0.65	PL82	0.50
DAF96	0.60	ECL82	0.42	GZ34	0.75	PL83	0.50
DCC90	1.35	ECL86	0.55	H63	0.90	PL84	0.50
DF91	0.40	ECLL800	3.50	HL41DD	0.70	PL500	0.85
DF96	0.60	EF37A	1.20	HN309	1.50	PL504	0.85
DK91	0.50	EF39	1.25	KT61	2.50	PL508	0.90
DK92	1.00	EF41	0.75	KT66	2.95	PL509	1.55
DK96	0.75	EF52	1.25	KT81 (7C5)	1.30	PL801	1.00
DL92	0.50	EF80	0.35	KT88	3.25	PL802	1.00
DL94	0.48	EF85	0.45	KTW61	1.50	PY32	0.63
DL96	0.55	EF86	0.50	KTW62	1.50	PY33	0.63
DM70	0.70	EF89	0.35	N78	3.50	PY81/800	0.50
DY86/7	0.45	EF91	0.40	OA2	0.45	PY82	0.45
DY802	0.47	EF92	0.50	OB2	0.45	PY83	0.50
EABC80	0.38	EF98	0.80	OZ4	0.55	PY500	1.10
EAF42	0.70	EF183	0.40	PC86	0.65	PY801	0.55
EAF801	0.50	EF184	0.40	PC88	0.65	SP41	3.00
EBC33	1.00	EH90	0.60	PC900	0.55	SP61	0.75
EBC41	0.75	EL33	2.50	PCC84	0.45	T41	1.00
EBC81	0.40	EL34	0.70	PCC89	0.55	U25	1.00
EBF80	0.40	EL37	2.50	PCC189	0.65	U26	0.85
EBF83	0.40	EL41	0.90	PCF80	0.40	U191	0.75
EBF89	0.32	EL42	1.65	PCF86	0.65	U404	0.75
EBL31	2.00	EL84	0.35	PCF801	0.60	U801	1.18
ECC40	1.00	EL91	1.00	PCF802	0.55	UABC80	0.40
ECC81	0.45	EL95	0.60	PCF805	0.90	UAF42	0.75
ECC82	0.38	EL360	1.60	PCF806	0.80	UBC41	0.60
ECC83	0.38	ELL80	2.00	PCF808	0.90	UBF80	0.50
ECC85	0.45	EM80	0.55	PCL82	0.45	UBF89	0.50
ECC88	0.50	EM81	0.60	PCL83	0.70	UCC85	0.50
ECF80	0.45	EM84	0.60	PCL84	0.50	UCH42	0.80
ECF82	0.45	EY51	0.45	PCL85	0.60	UCH81	0.50
		EY86	0.45	PCL86	0.50	UCL82	0.40
		EZ40	0.60	PD500	1.50		
		EZ41	0.75				

Type	£	Type	£	Type	£
UCL83	0.70	6CD6G	1.25	30C15	1.00
UF41	0.75	6CH6	1.50	30C17	1.00
UF89	0.50	6E5	1.00	30C18	0.90
UL41	0.85	6F23	0.90	30F5	1.00
UL84	0.50	6J5G	0.20	30FL1	1.00
UY41	0.55	6J5GT	0.55	30FL14	0.90
UY85	0.45	6J7GT	0.45	30L15	0.95
VP4B	1.25	6K6GT	0.80	30L17	0.95
VR75/30	0.55	6K7GT	0.35	30P12	1.00
VR105/30	0.40	6K8GT	0.50	30P19	0.95
VR150/30	0.45	6P25	2.50	30PL1	0.95
Y63	1.50	6Q7GT	0.43	30PL13	1.10
1R5	0.50	6SG7M	0.50	30PL14	1.10
1S5	0.40	6SJ7GT	0.30	35L6GT	0.80
1T4	0.40	6SL7GT	0.55	35W4	0.60
3S4	0.50	6SN7GT	0.55	35Z3	0.80
3V4	0.85	6U4GT	0.75	35Z4GT	0.70
5R4GY	1.00	6U5G	1.50	50C5	0.70
5U4G	0.55	6V6GT	0.60	50CD6G	1.20
5V4G	0.60	6X4	0.45	80	0.75
5Y3GT	0.65	6X5GT	0.65	807	1.00
5Z4G	0.65	7B6	0.80	6080	2.50
6/30L2	0.90	7B7	0.80	6146	2.50
6AL5	0.30	7C5	1.30	TUBES	
6AQ5	0.50	7C6	1.00	2AP1	4.00
6AS7	1.00	7H7	0.80	3BP1	4.50
6AT6	0.60	7S7	2.25	3DP1A	4.00
6AU6	0.40	7Y4	0.80	3EG1	8.00
6AV6	0.50	12AC6	0.80	3FP7	2.00
6BA6	0.38	12AD6	0.80	3GP1	5.00
6BE6	0.45	12AE6	0.75	5BP1	5.00
6BH6	0.75	12AT6	0.45	5CP1	5.00
6BJ6	0.75	12AT7	0.45	5FP7	6.00
6BQ7A	0.55	12AU6	0.50	88D	15.00
6BR7	1.20	12AU7	0.38	CV429	27.50
6BW6	1.00	12AX7	0.38	DG7-5	8.00
6BW7	1.00	12BA6	0.50	VCR138	10.00
6C4	0.40	12BE6	0.60	VCR139A	8.00
		12BH7	0.60		

TRANSISTORS & ICs

Type	£	Type	£	Type	£
AA119	0.7	BF179	0.33	OC44	0.20
AAZ13	0.12	BF180	0.36	OC45	0.20
AAZ15	0.10	BF181	0.35	OC71	0.18
AC107	0.51	BF194	0.10	OC72	0.28
AC126	0.25	BF195	0.13	OC76	0.30
AC127	0.25	BF197	0.16	OC77	0.54
AC128	0.20	BF200	0.32	OC81	0.29
AC176	0.25	BFS61	0.25	OC81D	0.28
AC187	0.21	BFS98	0.25	OC81Z	0.45
AC188	0.20	BFX29	0.28	OC83	0.27
ACY21	0.22	BFX88	0.24	OC140	1.00
ACY39	0.78	BFY50	0.21	OC170	0.30
AD140	0.50	BFY51	0.20	OC171	0.30
AD149	0.50	BFY52	0.20	OC200	0.55
AD161	0.44	BFW10	0.61	OC201	0.80
AD162	0.44	BY100	0.27	OC202	0.90
AF115	0.25	BY126	0.14	OC203	0.55
AF116	0.25	BY127	0.12	OCP71	1.20
AF117	0.24	BZX61 series	0.20	ORP12	0.60
AF186	0.48	BZY88 series	0.10	ORP60	0.55
AF239	0.44	CRS1-05	0.30	T1005	0.20
ASY27	0.33	CRS1-40	0.45	TIC44	0.29
ASY28	0.25	CRS3-05	0.40	TIC226D	1.50
BA102	0.25	CRS3-40	0.75	TIL209	0.20
BA115	0.10	MJE340	0.47	ZTX107	0.12
BC107	0.14	MJE370	0.68	ZTX108	0.8
BC108	0.13	MJE520	0.63	ZTX300	0.13
BC109	0.14	MJE2955	1.27	ZTX301	0.14
BC113	0.15	MJE3055	0.77	ZTX302	0.18
BC117	0.21	MPF102	0.40	ZTX304	0.24
BC143	0.30	MPF103	0.36	ZTX500	0.15
BC147	0.10	MPF104	0.35	ZTX501	0.15
BC148	0.8	MPF105	0.36	ZTX503	0.16
BC169C	0.15	NKT404	0.66	ZTX531	0.25
BC182	0.12	OA5	0.72	ZTX550	0.18
BC182L	0.12	OA10	0.40	IN914	0.06
BC184L	0.13	OA79	0.10	IN4001	0.06
BCY32	0.85	OA81	0.18	IN4002	0.7
BCY33	0.38	OA91	0.7	IN4003	0.8
BCY34	0.45	OA200	0.08	IN4004	0.8
BCY70	0.18	OA202	0.06	IN4005	0.10
BCY71	0.22	OC16	1.00	IN4006	0.12
BCY72	0.15	OC20	2.00	IN4007	0.12
BCZ11	0.65	OC23	1.25	IN4009	0.08
BD121	1.00	OC25	0.40	IN4148	0.06
BD124	0.65	OC28	0.66	IS921	0.07
BD131	0.42	OC35	0.55	IS2033	0.20
BD132	0.50	OC36	0.65	IS2051A	0.20
BF115	0.20	OC42	0.40	IS2100A	0.20
BF167	0.25			IS3010	0.25
BF173	0.28			2N696	0.15

Type	£	Type	£	Type	£
2N697	0.15	3N141	0.81	SN7476	0.45
2N706	0.12	40360	0.40	SN7480	0.80
2N706A	0.12	40361	0.45	SN7482	0.87
2N1131	0.25	40362	0.40	SN7483	1.20
2N1132	0.24	40430	0.85	SN7484	1.00
2N1302	0.18	SN7400	0.16	SN7486	0.47
2N1303	0.18	SN7401	0.16	SN7490	0.55
2N1304	0.28	SN7402	0.16	SN7491AN	1.10
2N1305	0.22	SN7403	0.16	SN7492	0.70
2N1306	0.28	SN7404	0.26	SN7493	0.70
2N1307	0.28	SN7405	0.28	SN7494	0.80
2N1308	0.28	SN7406	0.40	SN7495	0.80
2N1309	0.30	SN7407	0.40	SN7496	1.00
2N1613	0.21	SN7408	0.28	SN7497	3.87
2N1614	0.45	SN7409	0.28	SN74100	1.89
2N2147	0.75	SN7410	0.16	SN74107	0.51
2N2160	0.75	SN7411	0.25	SN74110	0.58
2N2369A	0.18	SN7412	0.30	SN74111	0.86
2N2646	0.50	SN7413	0.50	SN74118	1.00
2N2904	0.20	SN7416	0.36	SN74119	1.68
2N2904A	0.25	SN7417	0.36	SN74121	0.57
2N2905	0.32	SN7420	0.16	SN74122	0.70
2N2905A	0.25	SN7422	0.25	SN74123	1.00
2N2906	0.20	SN7423	0.37	SN74141	0.90
2N2926	0.12	SN7425	0.37	SN74145	1.26
2N3053	0.18	SN7427	0.37	SN74150	1.75
2N3055	0.45	SN7428	0.45	SN74151	1.00
2N3525	0.91	SN7430	0.16	SN74154	2.00
2N3614	0.65	SN7432	0.37	SN74155	1.15
2N3615	0.65	SN7433	0.37	SN74156	1.15
2N3702	0.11	SN7437	0.37	SN74157	0.95
2N3703	0.12	SN7438	0.37	SN74170	2.52
2N3704	0.14	SN7440	0.20	SN74174	1.57
2N3705	0.15	SN7441AN	0.92	SN74175	1.10
2N3706	0.11	SN7442	0.79	SN74176	1.26
2N3707	0.13	SN7450	0.16	SN74190	2.00
2N3708	0.07	SN7451	0.16	SN74191	2.00
2N3709	0.10	SN7453	0.16	SN74192	2.00
2N3710	0.11	SN7454	0.16	SN74193	2.00
2N3711	0.11	SN7460	0.16	SN74194	1.30
2N3819	0.38	SN7470	0.36	SN74195	1.10
2N3820	0.50	SN7472	0.38	SN74196	1.20
2N3823	0.50	SN7473	0.41	SN74197	1.20
2N3903	0.15	SN7474	0.42	SN74198	2.77
2N3904	0.20	SN7457	0.59	SN74199	2.52
2N3905	0.25	3M125	£2.00		
2N3906	0.25	1S131	0.13		
2N4058	0.15				
2N4059	0.10				
2N4060	0.13				
2N4061	0.13				
2N4062	0.14				
2N4289	0.30				

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5B/255M, 5B/256M, 5B/257M, 5C22, 5D21, 5R4GY, 5U4GB, 5Z3, 5Z4G, 6AF4A, 6AK5, 6AM5, 6AM6, 6AN5, 6AN8, 6AR5, 6AS6, 6AU4GTA, 6AU5GT, 6AU6, 6AV5GTA, 6AW8A, 6AX5GT, 6B4G, 6BA8A, 6BK4, 6BK7A, 6BL7GTA, 6BN6, 6BR7, 6BS7, 6BX7GT, 6BZ6, 6CB6, 6CH6, 6CL6, 6CW4, 6DK6, 6DQ6B, 6EA8, 6F33, 6H6(metal), 6K7GT, 6U8A, 6V6GT, 11E3, 11E13, 12AY7, 12B4A, 12BY7A, 12E1, 12E14, 13E1, 28D7, 29C1, 53KU, 75B1, 75C1, 83A1, 85A1, 85A2, 90AG, 90AV, 90C1, 90CG, 90CV, 95A1, 100TH, 150B2, 150B3, 150C1, 150C2, 150C3, 150C4, 250TH, 328, 329

705A, 715A, 715B, 723A/B, 725A, 801, 803, 805, 807, 808, 811, 811A, 812A, 813, 815, 828, 829B, 830B, 860, 866, 866A, 866E, 872A, 881R, 891R, 954, 955, 956, 957, 1625, 2050, 2050W, 2051, 4003A, 4212E or H, 4242A, 4313C, 4328A, 4687, 5544, 5545, 5642, 5644, 5651, 5670, 5672, 5676, 5687, 5696, 5702, 5718, 5719, 5725/6AS6W, 5726/6AL5W, 5727/2D21W, 5749, 5750, 5751, 5802, 5814, 5823, 5840, 5963, 5965, 6005/6AQ5W, 6021, 6057, 6058, 6059

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CV131, CV132, CV133, CV135, CV136, CV137, CV138, CV140, CV144, CV160, CV173, CV187, CV188, CV190, CV220, CV261, CV273, CV284, CV286, CV287, CV315, CV329, CV337, CV342, CV345, CV354, CV359, CV360, CV371, CV372, CV378, CV391, CV395, CV397, CV428, CV434, CV447, CV449, CV466, CV469, CV488, CV491, CV492, CV493, CV717, CV808, CV1072, CV1076, CV1092, CV1219, CV1343, CV1475, CV1476, CV1477, CV1478, CV1794, CV1480, CV1481, CV1482, CV1787, CV1832, CV1833, CV1835, CV1994, CV2000, CV2131, CV2154, CV2155, CV2160, CV2179, CV2235, CV2237, CV2238, CV2253, CV2289, CV2520, CV2522, CV2721, CV2901, CV3523, CV3929

CV3986, CV3988, CV3991, CV3998, CV4001, CV4002, CV4003, CV4004, CV4005, CV4006, CV4007, CV4008, CV4009, CV4010, CV4011, CV4012, CV4013, CV4014, CV4015, CV4016, CV4017, CV4018, CV4019, CV4020, CV4022, CV4023, CV4024, CV4025, CV4028, CV4033, CV4035, CV4038, CV4039, CV4040, CV4056, CV4059, CV4060, CV4062, CV4063, CV4064, CV4079, CV4501, CV4502, CV4503, CV4504, CV4507, CV4508, CV5060, CV6004, CV6008, CV6045, DA30, DA41, DA42, DA100, DET22, E55L, E80CC, E80FC, E80F, E80L, E80T, E81CC, E81L, E82CC, E83CC, E83F, E88CC, E90CC, E90L, E91H, E92CC, E180CC, EA50, EA52, EA76, ECC35, ECF804, EF50

EF54, EF55, EF804, EFP60, EL91, EN30, EN31, EN32, EN91, ESU74, ESU76, ESU77, F6057, F6060, F6061, F6063, FX219, FX225, FX227, G1/371K, G120/1B, G150/2B, G180/2M, G240/2D, G400/1K, GN4, GT1C, GTR120W, GTR150MS, GU18, GU20/21, GU50, GXU1, KT66, KT67, KT88, M8079, M8080, M8081, M8082, M8083, M8091, M8096, M8097, M8098, M8100, M8136, M8137, M8140, M8141, M8142, M8144, M8149, M8157, M8161, M8162, M8163, M8167, M8179, M8190, M8196, M8204, M8212, M8214, M8223, M8224, M8225, M8232, M8237, M8245, ME1400, ME1401, OA2, OA3, OA4G, OB2, OB3

OD3, OG3, OZ4, OZ4A, PT15, QA2400, QA2403, QA2404, QA2406, QA2407, QB3/300, QB3-5-750, QB4-1100, QF41, QF45, QQV02-6, QQV03-10, QQV03-20, QQV03-20A, QQV04-15, QQV06-40, QQV06-40A, QS70/20, QS75/20, QS75/40, QS75/60, QS83/3, QS92/10, QS95/10, QS105/45, QS150/40, QS150/45, QS150/80, QS1200, QS1202, QS1203, QS1205, QU37, QV03-12, QV04-7, QV05-25, QV06-20, QY3-125A, QY4-250A, QY4-400A, R10, R17, R18, S11E12, S130, S130P, STV280/40, STV280/80, SU41, SU42, TD03-10, TT15, TT21, TTR31MR, TZ40, U17, U19, U27, VLS631, Z300T, Z759, Z803U

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EX-MINISTRY CT436 Double Beam Oscilloscope DC-6 megs. Max Sensitivity 10mv/cm. Small compact. Size 10 × 10 × 16 in. Suitable for Colour TV servicing. Price **£85** each including copy of manual.

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TB-100 nanosecs per cm. to 5 secs. per cm. in 24 calibrated ranges. 20 nanosecs per cm. with times 5 expansion. 5" flat-faced tube. Trace locator. 0–2 microsec. signal delay. Built-in calibrator. 1KHz square wave. 200 micro volts to 100 volts in 18 calibrated ranges. Complete with manual. **£95** each.

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Miniature Transformer. Standard 240V input. 3V 1 amp output. Brand New. **65p** ea. P. & P. 15p. Discount for quantity.

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As above but can have extended cover range down to 20KHz by addition of external capacitors. Order LX63E. Price **£11.50** P. & P. 35p.
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20HZ to 200KHZ SINE AND SQUARE WAVE GENERATOR

In four ranges. Wien bridge oscillator thermistor stabilised. Separate independent sine and square wave amplitude controls. 3V max sine, 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£8·85** each. P. & P. 25p. Sine Wave only **£6·85** each. P. & P. 25p.

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5 MHZ to 150 MHZ (Useful harmonics up to 1·5 GHZ) up to 15 MHZ sweep width. Only 3 controls, preset RF level, sweep width and frequency. Ideal for 10·7 or TV IF alignment, filters, receivers. Can be used with any general purpose scope. Full instructions supplied. Connect 6·3V AC and use within minutes of receiving. All this for only **£6·75**. P. & P. 25p. (Not cased, not calibrated.)

TRANSISTOR INVERTORS

TYPE A	TYPE B	TYPE C	TYPE D
Input: 12V DC	Input: 12V DC	Input: 12V to 24V DC	Input: 12V to 24V DC
Output: 1.3kV AC 1.5MA	Output: 1.3kV DC 1.5MA	Output: 1.5kV to 4kV AC 0.5MA	Output: 14kV DC 100 micro amps at 24V. Progressively reducing for lower input voltages
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MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH. 2 HZ to 8 MHZ. Hook up a 9 volt battery and connect to your scope and have two traces for ONLY **£6·25**. P. & P. 25p. **STILL AVAILABLE** our 20 MHZ version at **£9·75**. P. & P. 25p.

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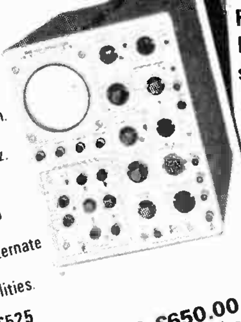
ELECTRONIC

TEKTRONIX 585A OSCILLOSCOPE



80MHz Dual Beam, dual timebase-calibrated sweep delay. TB-A 50nS/cm to 2S/cm TB-B 2μS/cm to 1S/cm. Trigger to beyond 150MHz. 100mV/cm sensitivity (10mV/cm 75 MHz B/W). Chopped, alternate and single sweep facilities.

PRICE £525 (limited stock).

Tektronix 453A £650.00

Tektronix 661 Sampling scope. 5T3 timing unit and 451 or 452 Sampling Unit PRICE P.O.A.

SOLARTRON CD 1014 2·3

Dual beam 5MHz 100mV/cm sensitivity, more sensitive on Y2. Timebase 1μS/cm to 1S/cm. LIMITED STOCK

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CT436 OSCILLOSCOPES PRICE **£79.50**

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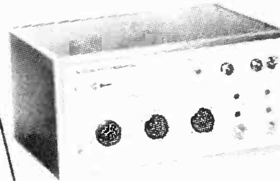
ADVANCE SQUARE WAVE GENERATOR SG21

Frequency Range 9Kc/s to 100Mc/s, Rise time less than 1nS Ex-Demonstration. New condition in manufacturer's original carton.



9Kc/s to 100Mc/s continuously variable.
Accuracy ±4%, ±1% F.S.
MAIN OUTPUT 20mV–1V into 50 ohm external termination continuously variable.
Accuracy ±5%.
Maximum output on open circuit 2V.
RISE TIME less than 1nS up to 500mV.
TRIGGER OUTPUT
0.2, 0.4, 1.0, 2.0V into 50 ohm external termination maximum output on open circuit 4V.
Rise time nominally 1.5nS.
Fall time nominally 3.5nS.
Size: 11inW, 5½inH, 9inD.
Wt. 7.1 lb.
LAST LISTED PRICE £95

OUR PRICE £35 P/P £1.50
Also available SG21A 100Kc/s–30Mc/s.

MODULAR PULSE GENERATOR PG52

P1 Clock Gen, P2 Width or Delay, PL, P2, P3 Outputs, P5 Variable Slope. Complete Modular Construction. Clock 0.1Hz to 30MHz in switched decade steps. Delay 25nS to 1S in switched decade steps. Output-up to 20V in 500 Ohms. Variable slope-rise and fall rates 1nS/V to 100mS/V independently adjustable over 10:1 range. Double pulse output. Short circuit protection. **PRICE £275**

ADVANCE PG 56 DOUBLE PULSE GENERATOR

Independently variable 2Hz–3MHz pulse width. Delay 70nS–0.2 secs in 19 steps, rise time better than 10nS. External trigger and internal rate generator.

PRICE £120

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Output in form of modulated signal at VHF and UHF at level suitable for aerial sockets of receiver. Two ranges. Band III on fundamental (MOD). Band IV & V On Harmonics (–MOD). Modulation 405 Lines or 625 Lines.
Ex-Demonstration, Brand New

SPECIAL OFFER THIS MONTH ONLY £29.50

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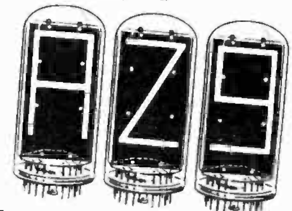

From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including
★ 170V–21mA ★ All DC operation
★ Uniform, continuous line characters of equal height
★ Memory with simple solid state drive circuits
★ Readability in high ambient light ... 200 footlamberts brightness ★ Long life with no loss of brightness
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Price only **99p** each plus 16p
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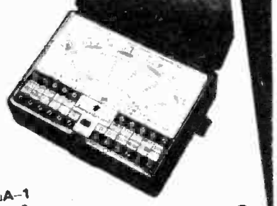
JUST ARRIVED!! NUMERIC INDICATOR TUBES
ultra-long life, high quality, 0–9 and 2 independent decimal points. Supply voltage 200V D.C. Current 14mA. Pulse duration 100μs. Characture height 0.51, overall size 1.4. Brand new, guaranteed. Surplus to manufacturers requirements. Type B5853st. Price 1–25 **£1.00** 25+ **90p**. 100+ **80p**. 1000+ price on application.

THE REVOLUTIONARY SUPERTESTER 680R



FOUR INTERNATIONAL PATENTS – SENSITIVITY 20,000 Ohms per Volt 10 FIELDS OF MEASUREMENT AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.

OUTSTANDING FEATURES:
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£18.50 with shockproof case

THESE ACCESSORIES CAN BE USED IN CONJUNCTION WITH THE SUPERTESTER 680R and MICROTESTER 80

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Producing 1KHz and 500 KHz signals for circuit testing. £5.95

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For measuring magnetic field strengths £11.95

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For transistors and diodes £11.95

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Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. £24.00

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For measuring a.c. currents from 250mA to 500 amps. £11.95

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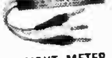

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Covering the range −50 to +200°C £11.95

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FANTASTIC NEW MICROTEST 80

MEASURES ONLY 90×70×18 mm
AMAZING VALUE
at **£11.95**

8 fields of measurement and 40 ranges

● 20,000 ohm per volt sensitivity ● 1000 times overload (on the ohmetric ranges only) ● Scale width and small case dimensions ● Printed circuit board is removable without soldering ● Fully screened against external magnetic fields ● Full ranges of accessories ● Accuracy and stability of indicated reading <2% in A.C.-D.C.> ● Simplicity and ease of use and readibility **Volts D.C. 6 ranges:** 100mV–2V.–10V.–50V.–200V.–1000V. (20kΩ/V). **Volts A.C. 5 ranges:** 1.5V.–10V.–50V.–250V.–1000V. (4kΩ/V). **Amp. D.C. 6 ranges:** 50μA–500μA–5mA–50mA–500mA–5A. **Amp. A.C. 5 ranges:** 250μA–2.5mA–250mA–2.5A. **Ohms 4 ranges:** LowΩ–Ω×1–Ω×10–Ω×100 (da 1/10 di Ω fino a 5 Mega Ω). **V Output 5 ranges:** 1.5V.–10V.–50V.–250V.–1000V. **Decibels 5 ranges:** +6dB, +22dB, +36dB, +50dB, +62dB. **Capacity 4 ranges:** 25μF–250μF–2500μF–25,000μF.

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VZM1 Measuring set for measuring phase and amplitude modulation distortion for Colour T.V. Sub carrier (PAL Systems)
£495.00

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£295.00

VZM83 Generator and Receiver used to measure transmission distortion on FM radio link systems. Superimposed signal 52/304/556kHz.
£275.00

PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi-pole multi-throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 2 planes. 24 × 50 **£29.** 20 × 11 **£15.**
Pins now available at 15p each.

Stop Press

AMPEX SP-300 FM/DIRECT RECORDER/REPRODUCER 4 Channels. Speed 1⅞, 3¾, 7½ 15 ips. Flutter 0.15% at 151 ips. Frequency Response: Instrumentation 50Hz to 40Hz at 15 ips. Audio 50Hz to 18Khz at 15 ips. **£1950**

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An unusual offer of a system up to 15 Mc/s for the measurement of level attenuation on telephone carrier equipment and wide band radio relay systems.

SIEMENS sweep frequency system consisting of: 3W518 Level Oscillator 10 Kc/s–17 Mc/s; 3D335 Level Selective Meter 10 Kc/s–17 Mc/s; 3W933 Sweep Attachment; 3D346 Large Screen Level Tracing Receiver. Offered as a complete system as a 32M701.
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Price Per Pair **£950.00**

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Made to meet the most stringent Government Service Standards

DC–40MHz DUAL TRACE

Solartron C.T.484 oscilloscope. 3% accuracy. Dual Trace Displays.

DUAL TRACE Y AMPLIFIER. Bandwidth: D.C.–24 Mc/s. Rise Time: 14 nanosecs. Sensitivity: 50 mV/cm. Input Impedance: 1 M.ohm 26pF. Measuring Accuracy: ±5% direct. ±3% with calibrator.
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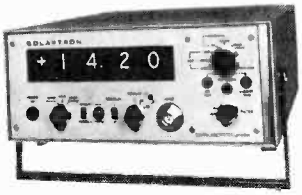
X AMPLIFIER. Bandwidth: D.C.–150 Kc/s. Input Sensitivity: 200 mV/cm and 1 V/cm. Input Impedance: 1 M.ohm 40 pF.
INTERNAL CALIBRATOR. Accuracy: ±3%.
WIDE BAND Y AMPLIFIER PLUG ALSO AVAILABLE: Bandwidth: D.C.–40 Mc/s. Rise Time: 8 nanosecs. Sensitivity: 50 mV/cm. Input Impedance: 1M.ohm 22pF Measuring Accuracy: ±5% direct. ±3% with calibrator.
P.O.A.

£149.50

INCREDIBLE DIGITAL VOLTMETERS



Digital Voltmeters Type LM1420 **£195**
Type 1420.2 **£235**
Type 1420.2BC (Remote Ranging) **£325**
Type 1420.2BM (DC + Wide Band Mean AC Sensing DVM) **£395**
Wide Range of spares for Solartron Data Loggers Compact 1 and Series 2.
Roband DM2004 **£75**
Dynamco 2001 mk2 **£175**

FABULOUS RANGE OF SIGNAL GENERATORS

H.P. VHF Signal Gen. 608B 10MHz to 400MHz **£175**
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H.P. UHF Signal Gen. 612A 450MHz to 1250MHz **£495**
H.P. UHF Signal Gen. 614A 800MHz to 2100MHz **£225**
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TF867 **£139**
801B.3 **£195**
TF810D **£275**
General Radio UHF Unit Oscillator + PSU 250MHz to 960MHz p.o.a.
Marconi PHM/AM Signal Generator TF2003 400KHz to 12.5MHz p.o.a.

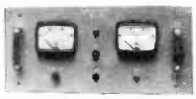
NEW TOUCHLESS RETRO-REFLECTIVE TACHOMETER

FEATURES
- Reads RPM from as far as 24" away!
- Four ranges: 0–1,000, 3,000, 10,000, 30,000 RPM*
- Instant field calibration
- Reads low or high speed on any type of machinery
- Battery powered—built-in voltage checker

- "Touchless" (no torque loss) measurements
- Direct reading, mirror type scale
- Hand portable (only 32 oz.) (0.9 Kg)
- Accuracy: 1½% if full scale
- Aluminium case—baked enamel finish
- Reads on marked shafts as small as 1/16 dia.
- Marking tape provided
- Complete solid-state circuitry
- Push-button reading
- Hidden probe cable, extends to 24" (60cm)

ONLY £89.50

6V 25A Power Supplies



10% VARIABLE VOLTAGE HIGH CURRENT HIGH STABILITY HIGH RELIABILITY

These power supplies were designed for continuous operation in computer equipment. Manufactured to highest engineering standard for long-term reliability and stability. Independent voltage and current meters. C Core Transformer.
Manufacturer's price probably in excess of £200. **£25**

MULTI OUTPUT POWER SUPPLIES

Ex-Computer offered at mere fraction of original manufacturer's cost.

APT 13334 Mk III
Input 200/240V. +10V –5Amp. –10V –2Amp. +24V –2Amp. +20V –5Amp. –20V –2Amp. PRICE **£19.50**

Advances DC197
6V 7.5Amp. 6V 11Amp. 28V 9Amp. PRICE **£35**

BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK Model 88

This recorder indicates the magnitude of applied currents of voltages by a continuous distortion free line on pressure sensitive paper. Moving coil movement scale calibrated 1 milliamp D.C. internal resistance 100 ohms. Chart Drive motor 240V 50Hz.
Chart speeds 90" per hour **£39**
1" per hour **£45** or 6" or 12".

SINGLE PEN RECORDER by Record Electrical

3" chart sensitivity 1 milliamp chart speed 1 and 6" per hr. Size 8" × 11" × 6". Offered complete with pen assembly. Listed at over £120—this month's special price due to bulk purchase.

1mA version £50
500μA version £60

AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification
Measurement ranges:—Current 10–25–100–250–500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283×94×36mm. Weight 1.5 lbs.

£12.50

Potentiometers

TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
50		Beckman	AR/S	£2.25
100	0.5	Beckman	A.S.	£2·00
200	0.5	Beckman	A.	£2·00
500	0.1	Beckman	S.	£2·50
500	1·0	Relcon	HEL107-10	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07–10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·1	Beckman X	A.	£3·50
15K		Colvern	CLR2402	£3·00
25K	0·5	Helipot	SAJ337	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K	0·5	Beckman	A.	£3·00
100K	0·1	Beckman	A.	£3·50
100K		Colvern	2501	£2·25

THREE TURN 780° ROTATION

100/100	Beckman	Type C	£3·00

FIFTEEN TURN 5400° ROTATION

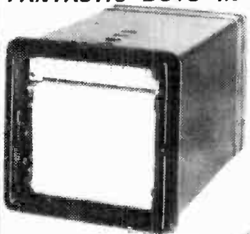
25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

NEW "Strobette" STROBOSCOPE–TACHOMETER

Combined Stroboscope-Tachometer. 200 to 6000 flashes per minute.
200 to 6000 r.p.m. Accuracy 3% or better. Beam angle 80°.
Flash Duration: 10 to 25 microseconds. Light colour Xenon white 500°.
Compact lightweight (27 oz.) easy to use one/off and on switch.

ONLY £49.50

FANTASTIC BUYS IN PEN RECORDERS

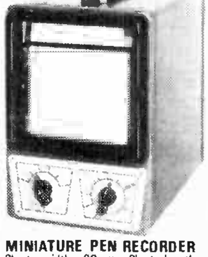


HIGH SPEED PEN RECORDER
Chart length 175 ft. Footage indicator. Width of recording channel 80mm Chart speeds (selected by push buttons) 1.2-6-12-30-60-120-300-600-3000mm per minute. Full deflection current 8mA. Internal Impedance 210 ohms. External Impedance 800 ohms. Dimensions 320×340×175mm. Weight 35 lbs. Price complete with accessories.

10 CHANNEL EVENT RECORDER
Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160 × 160 × 255mm. Weight 9 lbs. Price complete with accessories

£52.00

Single Channel £180
Three Channel £310



MINIATURE PEN RECORDER
Chart width 80mm Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120×120×285-mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories **£39.00**

PORTABLE AC/DC RECORDING VOLTAMMETER
Fitted with separate zero-marking pen. Accuracy 1.5% DC. 2.5% AC. Measure ments ranges—AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Price complete with accessories

£78.00

Carriage and packing charge extra on all items unless otherwise stated.

Please note: all instruments offered are second-hand and tested and guaranteed 12 months unless otherwise stated.

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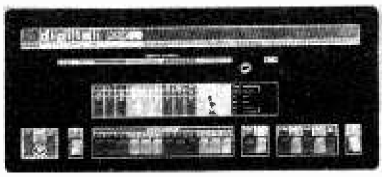
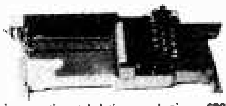


Little-used PDP8E 12K system including: High Speed Paper Tape Reader. High Speed Paper Tape Punch. Memory Drum. ASR33 Teletype.
Just arrived—PDP8L 4K processor with 8K extender box.

A phone call could save you a bomb! Ring now for price. Other models becoming available all the time—let us know your requirements.

Peripherals



ECONOMY RANGE OF 80 COLUMN HAND PUNCHES
£69.50 Plus Carr. & VAT
Also available: De luxe model incorporating tabulating mechanism—£89.50 + carriage & VAT; Electric Hand Verifier—£96.00 + carriage & VAT. All machines supplied with numeric keytops and dust cover and covered by our 12 month guarantee. Optional extras: Alphanumeric Keytops, Chiptray and Wreck Knife.
Ideal for stock control, sales analysis, back-up in existing computer installations, OP training centres, schools, etc.

Add 8% VAT to all prices shown
Carriage extra—details on request

PAPER TAPE PUNCHES & READERS

DEC High-Speed Paper Tape Reader/Punch for PDP8I. Hardly used Our special price **£1,500**.

DAT DYNAMICS 1114 Rack-Mounted 110 cps Punch, as new. Mounted in sound-reducing rack cabinet and complete with control and interface electronics and power supply unit with short circuit and overload protection. Asynchronous operation up to 110 cps. Our special price **£550**.

FACIT 4060 150 cps Rack-Mounted 150 cps Punch. Heavy duty punch suitable for all types of tape inc. Mylar. UNUSED SURPLUS—**A BARGAIN AT £595**.

TELETYPE BRPE 110 cps Synchronous Punch 5/7/8 channel. Self-contained mains-operated unit consisting of punch unit, base, motor and tape supply spool. Price **£145.00**. Sound-reducing cabinet available at **£15.00**.

INVAC P135 solenoid-actuated punch. 35 cps. 5/6/7/8 channel. Compact unit $7\frac{1}{2}'' \times 6\frac{1}{4}'' \times 5''$. Power Requirements: Tape transport solenoids 26V DC 2A. Punch solenoids 26V 4.5A. Punch return solenoids 26V 2A. Minimum pulse width 16 millisec. Price **£69.50**.

FACIT 4001 High Speed Reader. rack-mounted version. 5/6/7/7 channel dielectric reader for speeds up to 500 cps (or 1000 cps using separate spooler). One BRAND NEW unit available in original manufacturer's packing—**OUR BARGAIN PRICE £895.00**. One little-used second-hand unit also available at **£650.00**.

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FERRANTI TR5 photoelectric transistorised reader. 300 cps. 5/6/7/8 channel tape. Mains-operated. Price **£90.00**.

INVAC Photoelectric Reader. Motorless. solenoid-operated solid state unit to read any 5/6/7/8 hole tape at speeds up to 20 cps. Compact unit $6\frac{3}{4}'' \times 4'' \times 6''$. Power Requirements: Solenoids −26VDC 2A. Amplifier −12VDC 500mA. Price **£55.00**.

FERRANTI TR2 Photoelectric Reader. Mains operated up to 200 cps. 5/7 channel tape. Price **£35.00**.

CORE STORES

MULLARD 1K 18 bit Core Stores. 4 matrix planes 64×32. Price **£15.00**.

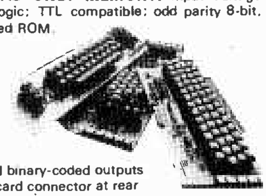
Keyboards

ELECTRO-MECHANICAL NUMERIC AND ALPHANUMERIC KEYBOARDS originally designed for 80 column card punch and verifier machines. Numeric with 12 character keys and 8 instruction keys. Alphanumeric with 47 character keys and 8 instruction keys.
Price: Numeric **£4.50**. Alphanumeric **£15**.

PAPER TAPE PUNCH/VERIFIER KEYBOARDS. Full alphanumeric keyboard with 65 keys + 4 shift keys in 4-bank layout. ISO coded. Operating speed up to 25 ch./sec. Mounted in attractive case with control panel. Price **£25**.
Reed-Switch 4-bank Alphanumeric keyboard, mounted on PC board and housed in metal case. 43 character keys + 2 shift keys and 16 instructional keys. Ideal for data displays. computer programming, etc. Price **£30**.

PHOTO-ELECTRIC ENCODED KEYBOARDS. No metallic switches or contacts. Generates any eight bit code to specification. Photoelectric keyboard combines Photoelectric encoders and power assisted solenoid actuators. 45 key alphanumeric keyboard + space bar + key interlock. Output—Photocells 500K to 2 Meg. for Logic 1. 800 Ohm–2 KOhm for Logic 2. −12V DC–OVDC Logic 1. Voltage requirements −26V DC mA. −12V 60 mA. + 6V 5mA. Price **£45**.

JUST ARRIVED—FABULOUS BRAND NEW KEYBOARDS WITH READ ONLY MEMORY. Input Voltage −12V DC; positive logic; TTL compatible; odd parity 8-bit. two-key rollover; strobed ROM 4-bank alphanumeric keyboard with 77 key positions + space bar. Ideal for communications equipment. Complete with associated integrated circuitry. Power supply connections and binary-coded outputs are made to a printed card connector at rear of keyboard. OUR INCREDIBLE PRICE **£49.50**.



COMPUTER SALES & SERVICES (EQUIPMENT) LIMITED
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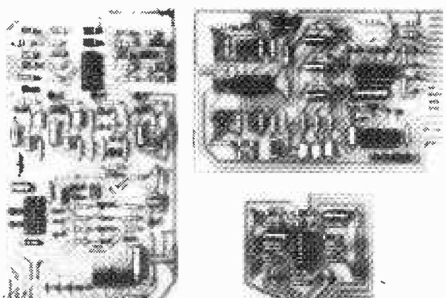

SQ QUADRAPHONIC DECODERS

SQ the leading quadraphonic system, designed by CBS engineers, offers not only 4 channel ambiophony from the fast expanding range of SQ encoded discs but also immensely increased depth and fullness of sound from standard stereo recordings too.
Feed 2 channels (200–1000mV as obtainable from most pre-amplifiers) into your choice of any of our 3 decoders and take 4 channels out with no overall signal level reduction. On the logic enhanced decoders Volume, Front-Back, LF–RF, LB–RB and Dimension controls can all be implemented by simple single gang potentiometers—no need for exotic 4-gang units!
These state-of-the-art circuits, used under licence from CBS, are offered in kit form comprising first grade components only—fibre glass circuit boards of professional quality designed for edge connector insertion, all resistors 2% metal oxide, all polystyrene and polycarbonate capacitors 5% or better and in decoder L2 ultra low noise (MPS A18–0.5dB typ.) transistors used in each amplifying stage.
M1 Basic matrix decoder with fixed '10–40' blend. 10 Resistors, 14 Capacitors, 1 Integrated Circuit. Printed Circuit Board. **£6·54**.
L1 Full logic controlled decoder with 'wave matching' and 'front-back logic' for enhanced channel separation using three specially designed Integrated Circuits. 24 Resistors 42 Capacitors, 3 Integrated Circuits. Printed Circuit Board. **£19·80**.
L2 More advanced full logic decoder with 'variable blend', extended frequency response, increased front-back separation. 43 Resistors, 44 Capacitors, 3 Integrated Circuits, 9 Transistors, 6 Diodes. Printed Circuit Board. **£28·20**.
All kits include IC sockets and construction notes. Prices include CBS licence fee.
Please write for further details in FREE LIST.
United Kingdom: Post Free Please add 8% VAT. Overseas: No VAT. Please add (per kit) £1·50 p & p AIR MAIL or 80p p & p SURFACE MAIL.

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ANDOVER, HANTS SP10 3EQ

WW—079 FOR FURTHER DETAILS

HART ELECTRONICS

Audio Kit Specialists since 1961

BAILEY/BURROWS/QUILTER PRE AMP This is the tone control section of the best pre-amp kit currently available. Consider the advantages:—*First quality fibreglass printed circuits with roller tinned finish and all component locations printed on reverse. *Low noise carbon film and metal film resistors throughout. *Finest quality low-noise ganged controls with matched tracks and shafts cut to length. *Well engineered layout for total stability. *Special decoupling and earthing arrangements to eliminate hum loops. *Controls, switches and input sockets mount directly on the boards to TOTALLY ELIMINATE wiring to these components. (We know of one pre-amp kit which claims its controls mount directly on the board—and so they do, by their shaft bushes! You still have to wire them up!!)
*We incorporate the Quilter modification which is most important as it reduces distortion and increases the bass and treble control range.
As can be seen from the photograph the tone control unit is very slim (only $1\frac{1}{2}''$ from front to back) and may therefore be used in many other applications than our Bailey metalwork which it is designed to fit.

METALWORK AND WOODEN CASES These have been under review for some time: please send for latest information.

F.M. TUNER This latest addition to our range is designed to offer the best possible performance allied to the ease of operation given by push button varicap tuning. We have taken great care to look after the constructors' point of view and there are no coils to wind, no RF circuits to wire and no alignment is required, in fact the whole unit can be easily completed and working in an evening as there are only 3 transistors, one IC and two ready built and aligned modules comprising the active components. We have abandoned the concept of having a tuner as large as the amplifier and this new unit has a frontal size of only $1\frac{1}{2}$ in. $\times$ 4 in. It can be mounted on the side of our Bailey amplifier metalwork thus turning it into a tuner/amplifier whilst only increasing its width by $1\frac{1}{2}$ in.
Cost of tuner chassis (no case) is **£22** for mono, **£25.45** for stereo. Metal case **£3.55**. An extended wooden case to fit tuner and amplifier will be offered shortly.

STUART TAPE CIRCUITS Our printed circuits and components offer the easy way to convert any suitable quality deck into a very high quality Stereo Tape unit. Input and output levels suit Bailey pre amp. Total cost varies but around **£35** is all you need. We can offer tape heads as well if you want new ones.
All above kits have fibreglass PCB's. Prices exclude VAT but P&P is included.

FURTHER INFORMATION ON ALL KITS FREE if you send us a 9 in. × 4 in. S.A.E.
REPRINTS Post free, no VAT.
Bailey 30W 18p.
STUART TAPE RECORDER All 3 articles under one cover **30p**.
BAILEY/BURROWS/QUILTER Preamp circuits, layouts and assembly notes **15p**.
All prices exclude VAT.

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Personal callers are always welcome, but please note we are closed all day Saturday

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RECTIFIERS

V	1A		3A		6A		12A	
50	IN4001	6½p	IN5400	15½p			BYX61 - 50	£3.21
100	IN4002	7½p	IN5401	16½p			BYX61 -100	£3.48
200	IN4003	9p	IN5402	17½p	BYZ13	58p	BYX61 -200	£3.76
400	IN4004	9p	IN5404	22p	BYZ12	66p	BYX61 -400	£4.29
600	IN4005	11p	IN5406	26p	BYZ11	73p	BYX62 -600	£4.29
800	IN4006	13½p	IN5407	28p	BYZ10	85p		
1000	IN4007	16½p	IN5408	31p				

BRIDGES

V	1A	2A	6A
50	20p	35p	75p
100	20p	40p	78p
200	22p	45p	90p
400	25p	50p	£1.05
600	25p		£1.20
1000	38p		

TRIACS

	4A	
25v	2N6068	45p
50v	2N6069	52p
100v	2N6070	58p
200v	2N6071	63p
400v	2N6073	68p
600v	2N6075	£1.49

SOLDERING

Desolder Braid
Reel 64p

Multicore
18 swg size 5 32p
22 swg size 15 36½p
carton size 1 50p
" " 12£1.57

Adcola Invader
L706 19 watt ⅛" bit £2.88
L646 20 watt 3/16" bit £3.13

DIN CONNECTORS

Pins	Plugs	Sockets	Line Couplers
2	9p	7p	11p
3	10p	7p	11p
4	11p	7p	11p
5 (180)	11p	8p	11p
5 (240)	11p	8p	11p
6	11p	9p	11p
7	13p	9p	11p

4mm.

Available in seven colours
Terminals 15p
Plugs 13p

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TO 3 10p
TO 66 10p

TV2 (TO66) 15p
TV3 (TO 3) 16p
TV4 (TO 126) 14p
TV5 (TO 220) 14p

5F (TO 5)
18F (TO18) 7½p

173 for SL414 SL415 18½p

AY-1-4 35p

10D N 400-4

U1(TBA800) 16p
U1(TBA810S) 16p
U2(TBA810AS) 16p
U2(TCA940) 16p
U3(TDA2020) 35p

47½p

CO~AXIAL

Plug - Screened 11p
- Plastic 9p

Sockets
Chassis 10½p
Surface 11p

Coupler 25p

PHONO

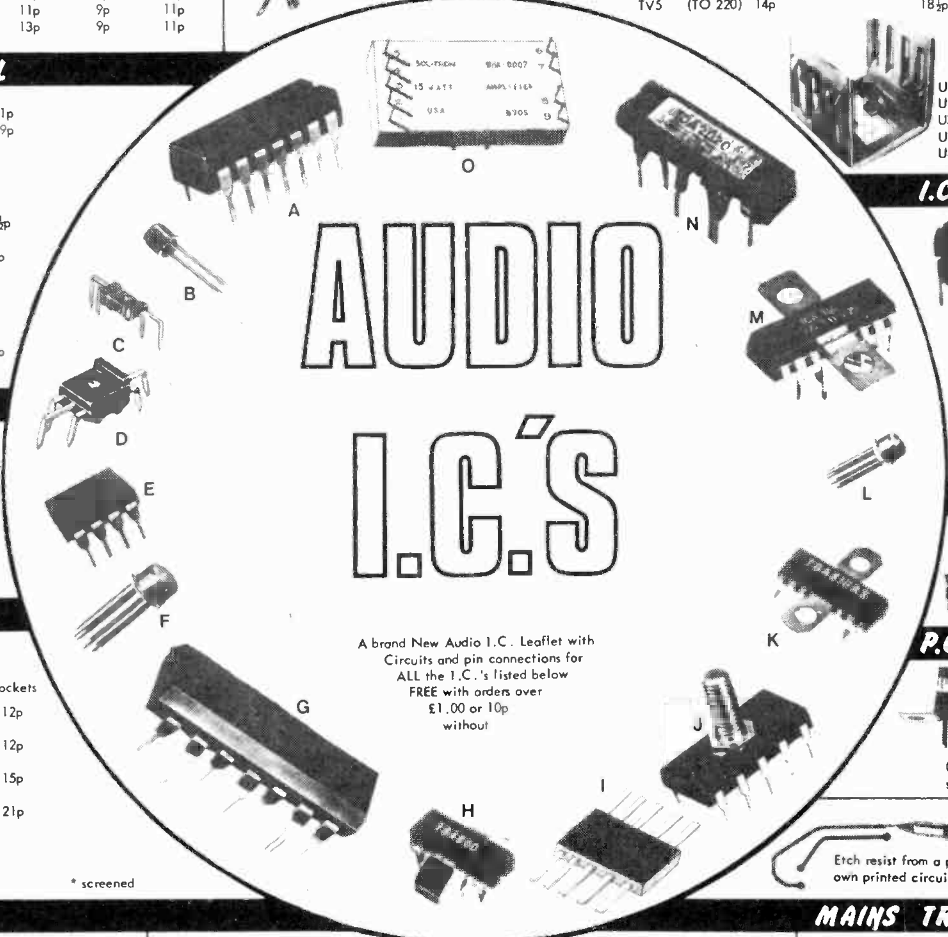
Sockets
1 way 5p
2 way 7p
3 way 7p
4 way 8p

Plugs:
Plastic Moulded 7½p
Chrome Screened 12½p
Coupler screened 15p

JACK

	Plugs	Sockets
2.5mm *	20p	12p
3.5mm *	20p	12p
standard *	25p	15p
stereo *	27p	21p
side entry standard	48p	

* screened



A brand New Audio I.C. Leaflet with Circuits and pin connections for ALL the I.C.'s listed below FREE with orders over £1.00 or 10p without

I.C. SOCKETS

TO5 Style
8 pin 31p
10 " 35p

Dual-in Line	
8 pin	13p
14 pin	15p
16 pin	15p
24 pin	26p
28 pin	30p
36 pin	37p
40 pin	44p

I.C. PIN SOCKETS

I.C. pins in strips of 100.
Just snip off what you need.
65p per strip

P.C. CONNECTORS

0-1" pin centres 24 way + key supplied with ends 64p

Etch resist from a pen. Draw your own printed circuit, then etch it. 86p

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High Quality 250v 1A
S.P.S.T 25p
D.P.D.T. 45p

Rotary 2A Mains Switches 35p

Rendar Subminiature Toggle
S.P.D.T. 48p

Bulgin push-to-make 25p

Slide D.P.D.T. 12p

Erg Dil Switches
1 pole 8 way 99p
2 pole 4 way 85p
4 pole 2 way £1.24

Lorlin Water Switches 27p
1 pole 12 way; 4 pole 2 way
3 pole 4 way; 4 pole 3 way

POWER OUTPUT WATTS	Supply Volts	Load Ohms	Style	Power I.C. Amplifiers	Price
0.25	9	16	C	MFC4000B	78p
0.5	9	8	E	MC1306P	68p
1	9	8	F	TAA300	£1.76
2	12	8	G	TBA820	74p
2	18	8	A	LM380	£1.08
2½ + 2½	18	8	A	LM377	£2.91
3	18	8	J	SL414	£1.72
5	24	16	J	SL415	£2.24
5	24	8	H	TBA800	96p
7	16	4	H	TBA810S	£1.07
7	16	4	K	TBA810AS	£1.07
10	20	4	M	TCA940	£1.94
15	30	3	O	BHA0002	£2.60
35 driver	25	8	F	NE540L	£1.08
20	±15	4	N	TDA2020	TBA

Pre-Amplifiers	Supply Volts	Style		Price
Dual Low Noise	+24	A	LM381	£2.16
Dual Low Noise	±14	A	LM382	£2.19
Dual Pre-Amp	±13	A	MC1303L	£1.59
Dual Low Noise	±12	A	MC1339P	£1.31
Dual Low Noise	±15	A	TBA231	88p
General				
D.C. Controlled attenuator			MFC6040	83p
3 stage G.P. amp.		B	TAA263	80p
Tape Pre-Amp		F	TAA310	£1.34
Bi-Fet		B	TAA320	97p
Hear/Aid Amp 1.3v		I	TAA370	£5.05
PPL stereo decoder(i)		A	MC1310	£2.14
4 channel SQ " (ii)		A	MC1312	£2.42
4 " pre-amp (ii)		16	MC1314	£4.05
CBS SQ Logic (ii)		16	MC1315	£5.37

(i) & (ii) Separate leaflets available free only with purchases over £1

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secondaries

6-0-6v, 100mA 97p ; 20-0-20v 1A £4.55
9-0-9v, 100mA 97p ; 24-0-24v ½A £2.48
12-0-12v, 100mA 97p ; 28-0-28 1A £6.18
18-0-18v, 200mA plus 0-24v 40mA 97p

	1A	2A	4A
0-9-17v	£1.95	£2.27	£2.64
0-12-15-20-24-30v	£2.48	£4.15	-
0-24-30-40-48-60v	£5.18	£7.02	-
	½A	1A	2A
0-19-25-33-40-50	£2.70	£3.40	£4.53

RENDAR INSTA~POWER

safe; inexpensive; quick, A.C. mains connector. A 13 amp plug top containing snap connectors £1.75

VAT INCLUSIVE PRICES AT 8%

OVERSEAS CUSTOMERS DEDUCT 2/27
VAT INVOICES ON REQUEST
P&P On U K Orders 15p Overseas Orders at Cost

WW—153 FOR FURTHER DETAILS

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT: £6.08 per single col. centimetre (min. 3cm).
LINE advertisements (run on): 86p per line (approx. 7 words), minimum three lines.
BOX NUMBERS: 35p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU).
PHONE: Allan Petters on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Advertisements accepted up to 12 noon Monday, March 3rd for the April issue subject to space being available.

Radio Operators. How to see more of your wife without losing sight of the sea.

Join the Post Office Maritime Service. We have openings for Radio Operators at several of our coastal stations.

The work is just as interesting, just as rewarding as aboard ship, but you get home to see your wife and family more often. You need a United Kingdom General or First Class Certificate in Radiocommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay for a man of 25 or over is £2,270, plus cost of living allowance with further annual increases after that. Though we're happy to take people from 19 up.

In addition to your basic salary, you'll get an average allowance of £450 a year for shift duties and there are opportunities for overtime.

Other benefits include a good pension scheme, sick pay and prospects of promotion to Senior Management.

For more information, write to: ETE Maritime Radio Services Division (L532), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AS.

Post Office Telecommunications

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Test Gear Engineers

Consumer Electronics

ITT, one of Europe's leaders in the field of consumer electronics, has achieved an enviable reputation for the high quality of its range of audio products and monochrome and colour TV.

At Hastings we can offer excellent scope to Test Gear Engineers within the Industrial Engineering Department.

Assistant Chief Engineer

To deputise for the Chief Engineer – Test Gear and co-ordinate the Test Gear Department in respect of appraisal of test gear requirements for new R & D designs; design, development and manufacture of all test gear and its installation in the factory and at sub-contractors. In addition, he will be responsible for budgeting and project appropriation and all maintenance activities on test gear installations.

This position calls for an HNC and at least five years' experience in the organisation and design of complex test equipment in the consumer electronics industry.

Senior Test Gear Engineer

Reporting to the Chief Engineer –Test Gear, he will be responsible for supervising a team of test gear engineers engaged in installation and both routine preventative and emergency breakdown maintenance of all test equipment at Hastings and satellite locations.

Essential requirements are HNC coupled with several years' experience at senior level maintaining electronic equipment, covering audio to UHF frequencies and pulse techniques.

Attractive salaries will be offered together with a wide range of benefits including pension/sickness schemes and assistance with relocation expenses, where appropriate, to this particularly pleasant area. The Company is situated close to the sea with some of the most attractive countryside in the South East on the doorstep.

Write with details of your qualifications and experience to David Harris, Personnel Officer, ITT Consumer Products (UK) Limited, Theaklen Drive, Hastings, Sussex.

The heart of Hastings **ITT**

4456

HER MAJESTY'S GOVERNMENT COMMUNICATIONS CENTRE

HANSLOPE PARK MILTON KEYNES MK19 7BH

has vacancies in the following fields of R & D work:

(a) HF Communications
(b) VHF/UHF Communications
(c) Communication Field Trials
(d) Acoustics
(e) Optics including Infra-Red
(f) Microwave
(g) General Circuit Design—Analogue, Digital
(h) Statistics/Operational Analysis/Systems Analysis

Most posts will be at Hanslope Park but some will be in London.

Candidates for post (h) should be experienced scientists/engineers who have specialised later in one of the required fields. An ability to deal with non-technical people is essential.

Appointments will be made within the grades of Higher Scientific Officer except for (e), (f) and (h) where appointments may also be made within the Senior Scientific Officer grade. In addition to the salary scales quoted, all posts attract the Threshold Agreement Payment (£229 p.a.) and a non-contributory pension.

HIGHER SCIENTIFIC OFFICER

Applicants should be under 30 years of age but this requirement may be waived if special qualification or experience can be offered. They should have one of the following qualifications:

(a) A degree in a scientific or engineering subject
(b) Degree-standard membership of a Professional Institution
(c) A Higher National Certificate or Higher National Diploma in a scientific or engineering subject
(d) A qualification equivalent to (c) above

In addition the following relevant experience is required:

(a) Applicants with 1st or 2nd class honours degrees—at least 2 years post-graduate experience.
(b) Applicants with other qualifications—at least 5 years post qualification experience.

Salary Scale: £2,461—£3,371 with entry point dependent upon experience beyond the minimum required.

SENIOR SCIENTIFIC OFFICER

Applicants should be at least 25 and under 32 years of age, although the upper age limit may be waived if experience of special value can be offered.

Applicants should have obtained a 1st or 2nd class honours degree and have had a minimum of four years appropriate post-graduate experience.

Salary Scale: £3,157—£4,441. Entry will normally be at the minimum of the scale but applicants with experience of special value may be entered above the minimum.

Applications, stating the field of work and grade required, should be made to

Administration Officer
HM Government Communications Centre
Hanslope Park
Hanslope
MILTON KEYNES MK19 7BH

[4478

TEST TECHNICIANS

Kelvin Hughes the Marine Division of Smiths Industries require Test Technicians who are capable of fault finding on sophisticated marine radar and echo sounding equipment.

The work is challenging with complex electronic circuitry necessitating a high degree of diagnostic ability. Experience or radar and/or echo sounding equipment is desirable although specific training in the equipment will be given.

A salary commensurate with experience and previous ability will be paid together with conditions of employment which would be expected of a large Company.

The factory is situated in a pleasant residential area within a few minutes walk of Hainault Central Line Station. Applications should be made either in writing or by telephone to Mr. R. J. Stewart, Personnel Officer, Kelvin Hughes, New North Road, Hainault, Ilford, Essex. Telephone 01-500 1020.

KELVIN HUGHES
A DIVISION OF SMITHS INDUSTRIES LIMITED

[4480

prowest

SENIOR DEVELOPMENT ENGINEER

Prowest Electronics Ltd, a leading Company in the field of Television, has a vacancy for an engineer with experience in the design of Television Receivers or Picture Monitors.

The successful candidate will be responsible for the design and development of the latest range of professional Monitors, both Monochrome and Colour.

This post could be of particular interest to an engineer who has already had experience in TV receiver design and now wishes to progress to a less "fettered" environment.

A minimum salary of £3,500 p.a. is envisaged, and an applicant of outstanding ability can expect appreciably in excess of this. The Company offers an excellent pension scheme and four weeks leave will be given.

Please write or telephone in the first instance to Mr A. Pratt, Chief Development Engineer.

Prowest Electronics Ltd.,
Alma Road, Windsor, Berkshire SL4 3JA.
Tel: Windsor 53111

4464

ELECTRONICS ENGINEERS
(Test/Test Equipment)

We seek to recruit Electronics Engineers (Test/Test Equipment) who have attained a technical education not less than HNC (Electronics), and who have acquired industrial experience in the design, operation and maintenance of test equipment used in a high-volume production unit. Applicants must be "self-starters" in every respect, knowledgeable, and able to motivate others in similar work.
Salary would be not less than £2,600 per annum but might be substantially more for entirely suitable applicants.

SENIOR QUALITY ENGINEER

Applicants must already possess the experiences of maintaining high quality standards on a production line capable of producing a very high volume of printed circuit board assemblies.
He must be completely conversant with the techniques applied to PCB production such as flow soldering and connected quality requirements. He must be able to initiate and operate quality control procedures required for "feedback" to production management.
Practical experience of the above work will outweigh technical/academic excellence, as we seek to employ an experienced, successful practitioner of quality engineering who is accustomed to handling high-volume PCB production quality requirements.
The salary range is naturally geared to the applicant's age and experience, but will be not less than £2,700 per annum to the right person.
The above posts are senior appointments carrying monthly salaried staff status and benefits. Relocation expenses, where applicable, will be admissible. Holidays are three weeks per annum plus statutory holidays. Our factories are located in Perth, Central Scotland, centre of great scenic and leisure-time amenities, and in a marvellous working environment.
Please write in the first instance giving your age, experience, present salary, marital status, etc., to:

J. Bandeen,
G. R. INTERNATIONAL ELECTRONICS LTD,
Almondbank, Perthshire, Scotland, PH1 3NQ.

4443

AS A RESULT OF OUR PROGRAMME OF CONTINUED EXPANSION VACANCIES EXIST FOR THE FOLLOWING STAFF.

CCTV ENGINEER

Fully conversant with modern video recording systems. Circa £3,000.

INSTALLATION ENGINEERS

Experienced in installation of security systems and first line servicing. Company van supplied. Circa £2,500.

SALES ENGINEER

Of proven ability. Full sales back up given. Company car provided. Circa £3,000.

MANAGER

For thriving video and audio-visual hire department. Interesting and varied work. Salary around £2,500.

All positions are permanent and pensionable. Good working conditions in friendly atmosphere.

Applications in own hand writing, giving details of past three years employment to:

M Biddle
Dixons Technical Limited
3 Soho Square,
London, W1

4468

SENIOR LOUDSPEAKER DESIGN ENGINEER

Minimum of 5 years' design experience in audio engineering required. Professional background must include primary design responsibility for loudspeakers, acoustic enclosures, loudspeaker systems and related audio products for industrial and hi-fidelity markets.

TANNOY ®

Apply in writing, giving fullest details to
Personnel Manager
Tannoy Products Limited
Norwood Road, London SE27 9AB

4469

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG, SOUTH AFRICA

Bernard Price Institute for Geophysical Research

Applications are invited for the following vacancies:

ELECTRONICS TECHNICIAN—MARINE RESEARCH

Involves construction, maintenance and repair of marine geophysical equipment. Two to three months of 1975 will be spent on scientific cruises in the Indian Ocean. During early 1976, there will be a two month cruise to Antarctica.

ELECTRONICS ENGINEER or TECHNICIAN

Research project on mechanisms of rock deformation and tremors, requires experienced worker in electronics design and construction. Will work on electronics gear for (I) seismic recording and playback decks (II) ultra-sensitive tiltmeters (III) linear strain gauge arrays. Experienced man can soon assume responsibility for important part of project.

Starting salary for all posts will be determined according to qualifications and experience within the range R4,020—R7,380 (£1 = R1.62 approximately).

Intending applicants should obtain the information sheet relating to these posts from the Registrar, University of the Witwatersrand, Jan Smuts Ave., Johannesburg, South Africa to whom applications should be sent not later than 5th March, 1975. UK applicants may obtain the information sheet from the London Representative, University of the Witwatersrand, 278 High Holborn, London WC1 to whom a copy of the application should be sent. [4467

ST. HELIER HOSPITAL
Carshalton, Surrey

MEDICAL PHYSICS TECHNICIAN GRADE II

required for District Medical Physics Department. Salary scale from £2,601 to £3,390 p.a. plus £312 London Weighting Allowance. Further details can be obtained from Chief Technical Officer—01-644 4343. [4463

THE OPEN UNIVERSITY AUDIO-VISUAL DEPARTMENT

MAINTENANCE TECHNICIAN

A vacancy exists in the Audio-Visual Department of the Operations Area for a Maintenance Technician.

The suitable applicant should have served a recognised apprenticeship followed by 6 years experience in the repair and maintenance of audio-visual equipment, including at least 2 years with CCTV and VCR equipment.

Qualifications—ONC or City and Guilds Final Electronics.

Salary on Technicians Grade 4 scale: £2,247—£2,628 per annum.

Application forms and further particulars are available from the Personnel Manager (MT2), The Open University, P.O. Box 75, Walton Hall, Milton Keynes, MK7 6AA. Closing date: Monday, 3rd March, 1975. [4465

Electronics Test Engineers: career openings that affect all sorts of people...

. . . you most of all, naturally. Mainly because, by joining the world's largest exporter of radio-telephone equipment you will inevitably open up for yourself career advantages that very few companies can provide. Pye Telecom is growing at an ever-increasing rate – and the potential for its products has as yet been only fractionally utilised.

But the work you do will also be vital to an incredible number of others. Very frequently, life itself depends on the efficiency of the UHF and VHF equipment you'll be working on. Police, firemen and ambulance staff are a small sample of the extensive range of users. Which explains the exacting specifications of the test procedures in operation – and why previous fault-finding and testing experience is an essential requirement. If it relates to communications equipment, so much the better, but this is not absolutely essential. More important is practical proficiency, which may well have been gained in the armed forces.

Find out more right now by phoning or writing to Mrs Audrey Darkin at:

Pye Telecommunications Ltd
Cambridge Works, Elizabeth Way,
Cambridge CB4 1DW. Tel: Cambridge 58985

A member of the Pye of Cambridge Group 4446

Young Electronics Engineers
A mobile future in broadcasting?

We require Engineers qualified, or about to qualify, to H.N.C. or equivalent level and possibly with a few years' experience, who will learn to operate and maintain the advanced electronic equipment at our Transmitting Stations throughout the country bringing Independent Television and Radio into millions of homes.

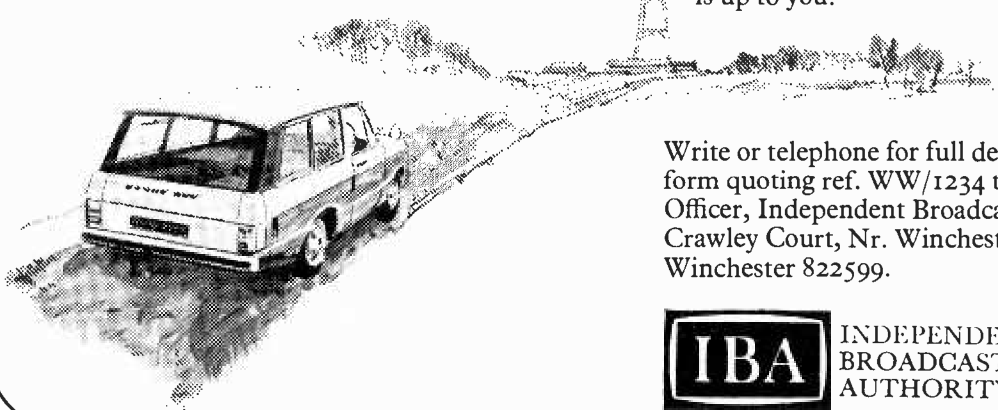
Our Engineers may be called upon to rectify a fault anywhere, anytime and in all weathers. It's a job that requires flexibility about when and where you work; you'll need a driving licence and you must be prepared to undertake a demanding training course.

Paid While You Train

IBA's special eighteen month training course, which combines theoretical study with practical 'on station training' will give you a comprehensive knowledge of operations and maintenance techniques, plus an additional recognised qualification, and you will be paid a training salary of not less than £1841, more for those with experience.

The Future

On completion of your training, you will be in the field, full-time on a salary range of £2861-£4167. Further promotion to Team Leader and beyond is up to you.



Write or telephone for full details and an application form quoting ref. WW/1234 to: The Personnel Officer, Independent Broadcasting Authority, Crawley Court, Nr. Winchester, Hants. Tel: Winchester 822599.

IBA INDEPENDENT BROADCASTING AUTHORITY

4477

Technician Engineers

Marconi Elliott Avionics are recruiting electronics engineers and technicians who have a sound grounding in modern electronics theory with at least 2 years' practical experience in testing or servicing electronic equipment.
These vacancies occur at two separate sites, and offer a secure future with bright prospects to competent technicians. Attractive salaries will be offered, together with generous relocation expenses where necessary.

STANMORE (Middlesex)

To service and overhaul up to date airborne electronic units from airline communication, navigation and radar systems.

BASILDON (Essex)

To carry out full range of final test on airborne communication/navigation equipment or on C.C.T.V systems. Also needed are test equipment engineers capable of the design and manufacture and commissioning of modern specialised test equipment.

Applications (stating location preferred) should be addressed, in the first instance, to:– **Mr. R. A. Bezant, Senior Personnel Officer, Marconi Elliott Avionic Systems Limited, Christopher Martin Road, Basildon, Essex.**

MARCONI ELLIOTT AVIONICS
A GEC-Marconi Electronics Company

4455

UNIVERSITY OF SURREY

Department of Linguistic and Regional Studies

TECHNICIANS

GRADE 3
£2,013 to £2,343

Two full time vacancies are available in this rapidly expanding Department. One candidate should have experience of servicing and maintaining tape recording, T.V. equipment and associated audio visual apparatus. Experience with TTL circuits would be an advantage. One candidate with experience in one or other of the following: Language Laboratories, Closed Circuit T.V., Cine Projectors.

Application forms may be obtained from the Staff Officer, University of Surrey, Guildford, Surrey, GU2 5XH, or tel: Guildford 71281, Ext. 452.

[4452

AVIONICS IN EDINBURGH
ELECTRONIC ENGINEERS

FERRANTI in Edinburgh are involved in many important defence contracts including the Multi Role Combat Aircraft.

We need Engineers of experience and technical capability to join expert teams on a variety of interesting projects with high technological content. We are looking for

TEST SPECIFICATION WRITERS
TEST ENGINEERS
TRIALS ENGINEERS
TECHNICAL AUTHORS
SERVICE ENGINEERS

and would be particularly interested to hear from candidates with qualifications and experience in any of the following areas: **DIGITAL AND ANALOGUE TECHNIQUES, MICROWAVE ENGINEERING, LASERS AND OPTICS, ELECTRONIC DISPLAYS, AUTOMATIC TEST TECHNIQUES, AIRBORNE RADAR, INERTIAL NAVIGATIONAL SYSTEMS.**

Priority will be given to incoming staff for Scottish Special Housing. The Company operates a contributory pension and life assurance scheme, and will assist with relocation expenses where necessary. Salary up to £3,000.

Apply in writing with details of qualifications and experience to the:

Staff Appointments Officer
Ferranti Limited
Ferry Road
Edinburgh EH5 2XS
Tel: 031-332 2411

FERRANTI

4451

Hertfordshire County Council
LETCHWORTH COLLEGE OF TECHNOLOGY

RESEARCH ASSISTANT

post available for Graduate Engineer/Physicist.

Higher Degree research work on new methods of helping deaf children to acquire speech skills; in collaboration with the Department of Phonetics and Linguistics, University College, London.

Salary: £1,544 x £55 (2) to £1,654.

Please write to The Principal, College of Technology, Broadway, Letchworth SG6 3PB.

[4457

University of Bradford
TECHNICIAN (Grade 6)

required in Educational Technology. We have an interesting vacancy in our well-equipped Television Studio for a Technician to be concerned with all aspects of the operation and maintenance of equipment in use in the Television Studio Complex. He will be expected to work with the minimum of supervision and to deputise for the Head of the Television Studio in his absence. Candidates should be mature electronics engineers, preferably with experience in television. HNC or equivalent qualifications essential. Salary ranging from £2,844-£3,450 per annum depending upon experience and qualifications.

Application forms and further details (please quote ref ET/T6/1/WW) from the Personnel Office, University of Bradford, Bradford, West Yorkshire BD7 1DP.

[4459

1970 BNEC Export award for smaller firms 1970 MEMBER KEF

KEF ELECTRONICS LIMITED
have a vacancy for a

SERVICE MANAGER

The Service Manager controls and organises a small team of people responsible for servicing and repairing products supplied by the Company and maintaining and servicing equipment in use in the Company.

We are seeking a mature person with a proven success in the Audio/Electronics field, possessing a good personality and interested in maintaining our Company's image of quality, reliability and customer service.

If you are interested in this position and feel that you have the necessary qualifications, please contact the undersigned. We will send you the appropriate application form.

C. J. Goodman—Production Director
Kef Electronics Limited, Tovil, Maidstone, Kent.
Tel. No. Maidstone (0622) 57258

4490

SCOTTISH HOME AND HEALTH DEPARTMENT

WIRELESS TECHNICIAN

Applications are invited from men, aged 17 or over, for two posts of Wireless Technician in the Scottish Home and Health Department. The posts are located in the Montrose area.

QUALIFICATIONS

Sound theoretical and practical knowledge of Wireless Engineering, including HF, VHF and UHF and Communications equipment generally. Possession of an HN or C & G certificate an advantage but provision may be made for those who wish to continue their studies for one of these qualifications. The work involves installation and maintenance of equipment located a considerable distance from headquarters. Candidates must be able to drive private and commercial vehicles and have a clean driving licence.

SALARY

£1,530 (age 17) to £2,210 (age 25 or over): scale maximum £2,575.

These are unestablished appointments with prospects of establishment after one year's continuous satisfactory service.

Application forms and further information may be obtained by writing to the Scottish Office Personnel Division, Room 220, 22/25 Queen Street, Edinburgh EH12 1LY quoting reference PM(PTS)2/2/75. Closing date for receipt of completed application forms is 19 March 1975.

[4458

RADIO TECHNICIANS

The Home Office has vacancies at Baldock, Hertfordshire for Radio Technicians to carry out installation, maintenance, modification and construction of complex specialised radio communications equipment and systems.

Pay:

is £1695 at 19 rising to £2575 plus a cost of living supplement which is at present £19.14 a month.

A Secure Future

with a good pension scheme, prospects of promotion and generous leave allowance. Five day week of 42 hours.

Qualifications:

City & Guilds, Intermediate Telecommunications Certificate or equivalent together with 1 year's practical workshop experience.

Interested?

Then write or telephone for an application form to Miss C. Philips, Home Office Whittington House, 19-30 Alfred Place, LONDON WC1E 7EJ. Telephone 01-637 2355 Ext. 87.

Home Office

4466

Opportunities in the

ELECTRONICS FIELD

Men with analogue or digital qualifications/ experience seeking higher paid posts in: TEST – SERVICE – DESIGN – SALES. Phone Mike Gernat. Ref. WW.

NEWMAN APPOINTMENTS
360 Oxford St. W1
01-629 7306

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UNIVERSITY OF DUNDEE
DEPARTMENT OF PSYCHOLOGY

Applications are invited from candidates with a degree or equivalent qualification in an appropriate subject (such as Electronics) for the post of

TECHNICAL OFFICER

in the above Department.

The position offers the possibility of working in a research-oriented environment and calls for the exercise of considerable personal initiative. The Technical Officer will be responsible for the administration of the Departmental workshops and will work in collaboration with members of staff on the design and maintenance of electronic equipment. The Department possesses two laboratory computers and some experience of interface design and construction would be an advantage.

The Salary scale is £2,118-£2,931 plus threshold agreement supplements and the post is superannuable under the University's own superannuation scheme. A grant will be made towards removal expenses to Dundee.

Applications, quoting Ref. EST/108/75WW, and including the names of two referees, should be sent to The Secretary, The University, Dundee, DD1 4HN, as soon as possible. [4460

CHELSEA COLLEGE
University of London

ELECTRONICS TECHNICIANS

GRADE 3

required for the development, construction and servicing of electronic research equipment. One post is for work in the development of automated teaching equipment for which a knowledge of optics, photography and cinematography is desirable. The second post is for work in an electronics workshop for prototype and servicing work mainly for research in Electronics and Physics. For both posts an interest in and knowledge of electronics is essential. Day release facilities may be available for further study. Salary scale: £2,423 to £2,753 per annum including London Allowance.

Application forms and further details from the:

Departmental Superintendent,
3.E1, Departments of Electronics and Physics,
Pulton Place, London, SW6 5PR

[4488

DUNDEE COLLEGE OF EDUCATION

Applications are invited for the post of

TECHNICIAN

in the Television Service

The duties of the post cover all aspects of the operation, maintenance and development of an extensive and well equipped television facility.

Applicants should hold a Higher National Certificate (Electrical), although a City and Guilds Final Certificate in Telecommunications would be considered in lieu. They should be able to show evidence of ability in electronics and will preferably have experience of television techniques including video recording.

The salary scale attached to the post, based on NJC Technical Division, Grades C/D, will lie within the range £2,244 to £2,982, and the commencing salary will depend on age, present salary and experience. In addition, Threshold Agreements will be paid.

Forms of application, together with statement of duties and conditions of service, may be obtained from **the Principal, Dundee College of Education, Park Place, Dundee, DD1 4HP,** and should be returned to him not later than February 28, 1975.

[4449

RADIO OFFICERS

Do you have PMG I, PMG II, MPT 2 years operating experience?

Possession of one of these qualifies you for consideration for a Radio Officer post with composite signals organisation.

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £3,096 pa; commencing salary according to age—25 years and over £2,276 pa. During training salary also by age, 25 years and over £1,724 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer,
Government Communications Headquarters,
Room A/1105, Priors Road, Oakley,
Cheltenham, Glos GL52 5AJ
Telephone Cheltenham 21491 Ext 2270

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Radio Technicians

A secure future with Overseas Division of one of the world's largest airlines is within easy reach if you are interested in either aircraft or ground radio and have at least 5 years' experience.

The vacancies are at Heathrow Airport —London.

Starting pay is £49.66 per 40 hour week and there are chances of rapid promotion to £56.04 per week.

Additional benefits include a contributory pension scheme, a first-class sports and social club and opportunities for concessional holiday air travel world wide.

Please write, quoting reference 430/WW/BW, to:

Manager Selection Services, British Airways Overseas Division, PO Box 10, Heathrow Airport—London, Heathrow TW6 2JA

4021

British airways

T.V. Engineers for New Zealand

Are you dissatisfied with your present position, feeling like a change of scene? Do something about it now! Be our guest—come down under and join the Tisco Team, N.Z.'s largest service organisation.
We are in service only and our engineers are all important people, every one of our 30 managers is an ex engineer.
We are now selecting staff to sponsor under the Immigration Scheme to arrive in N.Z. mid 1975.

If you,

- Have 5 years experience, preferably some in colour.
- Single or married with 3 children or less.

write now enclosing a photograph and details of past experience to:-
The Technical Staff Supervisor, Tisco Ltd, Private Bag, Royal Oak, AUCKLAND, NEW ZEALAND.

[4070

mi MARCONI INSTRUMENTS Ltd.
AT ST. ALBANS AND LUTON
ELECTRONIC TECHNICIANS

We are a company that manufactures precision electronic measuring instruments and have a range of technical career vacancies within our Production and Engineering departments at St. Albans and Service Division at Luton.
To fill these posts we are looking for people with a good electronic background, but not necessarily qualified.
Attractive salaries are offered for the right candidates along with the normal benefits of staff employment.

For further information and or application forms contact John Prodger, mi Ltd., Longacres, St. Albans, Herts. Tel:59292.

A G.E.C. Marconi Electronics Company.

4356

Grampian

Audio Systems Testers

Grampian, leaders in the field of industrial sound systems, manufacture a wide range of electronic and electro-acoustic equipment. Part of the Telephone Rentals groups, Grampian supply this equipment both for direct sale and also for long-term rental contract, where high reliability is a prime requisite. In order to maintain this reliability, whilst expanding production, there are vacancies for Systems and Final Testers. These positions offer excellent job security, competitive salaries, and pension and life assurance schemes. Applicants should have a sound, practical knowledge of electronics, and preferably previous test experience, particularly of audio equipment. Relevant formal qualifications would be an advantage.

Telephone Mr. Turner on 01-894 9141. Or write for application form to:
Grampian Reproducers Ltd.,
The Hanworth Trading Estate, Feltham, Middlesex TW13 6EJ

4486

Electronic/ Communications Engineer

Rank Xerox is a name linked with the future. Currently we're engaged in the development of new and existing machines and communications equipment, including our telecopier. There is currently in hand an extensive programme of work on products which are destined to be among the most significant ever produced by the Company.

We have a requirement for an engineer to participate in the design of a new business system. They will work within a small team on the design and development of circuitry, which could involve very high frequencies.

Applicants should be qualified to honours degree level with two years experience in the electronics industry, preferably in the telecommunications field. Experience in the design and development of solid state circuitry at very high frequencies and digital circuitry would be an advantage.

The Company offers above average salaries and fringe benefits including generous assistance with relocation expenses where appropriate.

Please write or telephone to **Alan Preston, Rank Xerox Limited, P.O. Box 17, Bessemer Road, Welwyn Garden City, Herts. Tel. Welwyn Garden 28177.**

RANK XEROX
ENGINEERING GROUP

COURSES

M.SC. COURSE IN ELECTRICAL ENGINEERING

with specialisation in any one of the following:

Communication Systems

Electronic Instrumentation

Control Engineering and Digital Electronic Systems

Design of Pulse and Digital Circuits and Systems

The Course, which commences in October 1975, may be taken on a Full Time, Part Time, Sandwich or Block Release basis, and is open to applicants who will have graduated in Science or Engineering, or who will hold equivalent qualifications, by that date. The Science Research Council has accepted the Course as suitable for the tenure of its Advanced Course Studentships.

A Diploma Course, in some of the above topics or in Power Systems, is also open to applicants with the above, or slightly lower qualifications.

Research in Electrical Engineering

Applications are also invited from similarly qualified persons who wish to pursue a course of research leading to the Degree of M.Phil. or Ph.D. in any of the above topics.

Application forms and further particulars from the Head of the Department of Electrical Engineering (Ref. M.Sc. 5), The University of Aston in Birmingham, Birmingham B4 7PB.

THE UNIVERSITY OF ASTON IN BIRMINGHAM

4444

ARTICLES WANTED

Are you obtaining the full benefit from the disposal of your electronic and computer scrap ?

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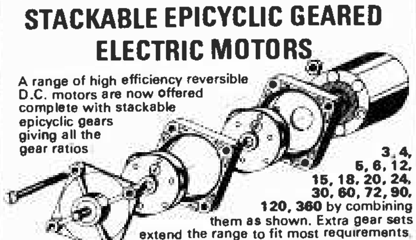

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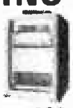

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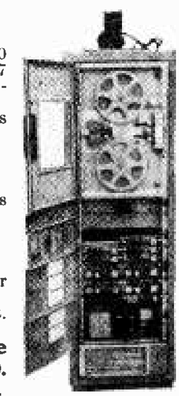

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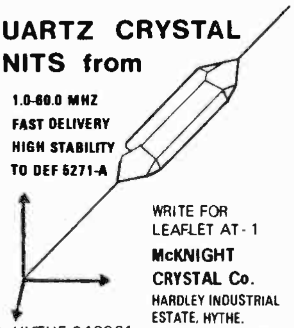

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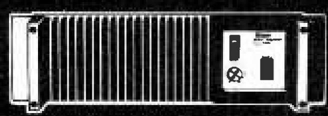

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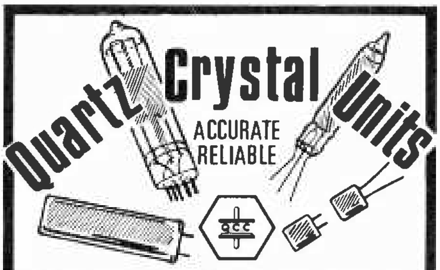

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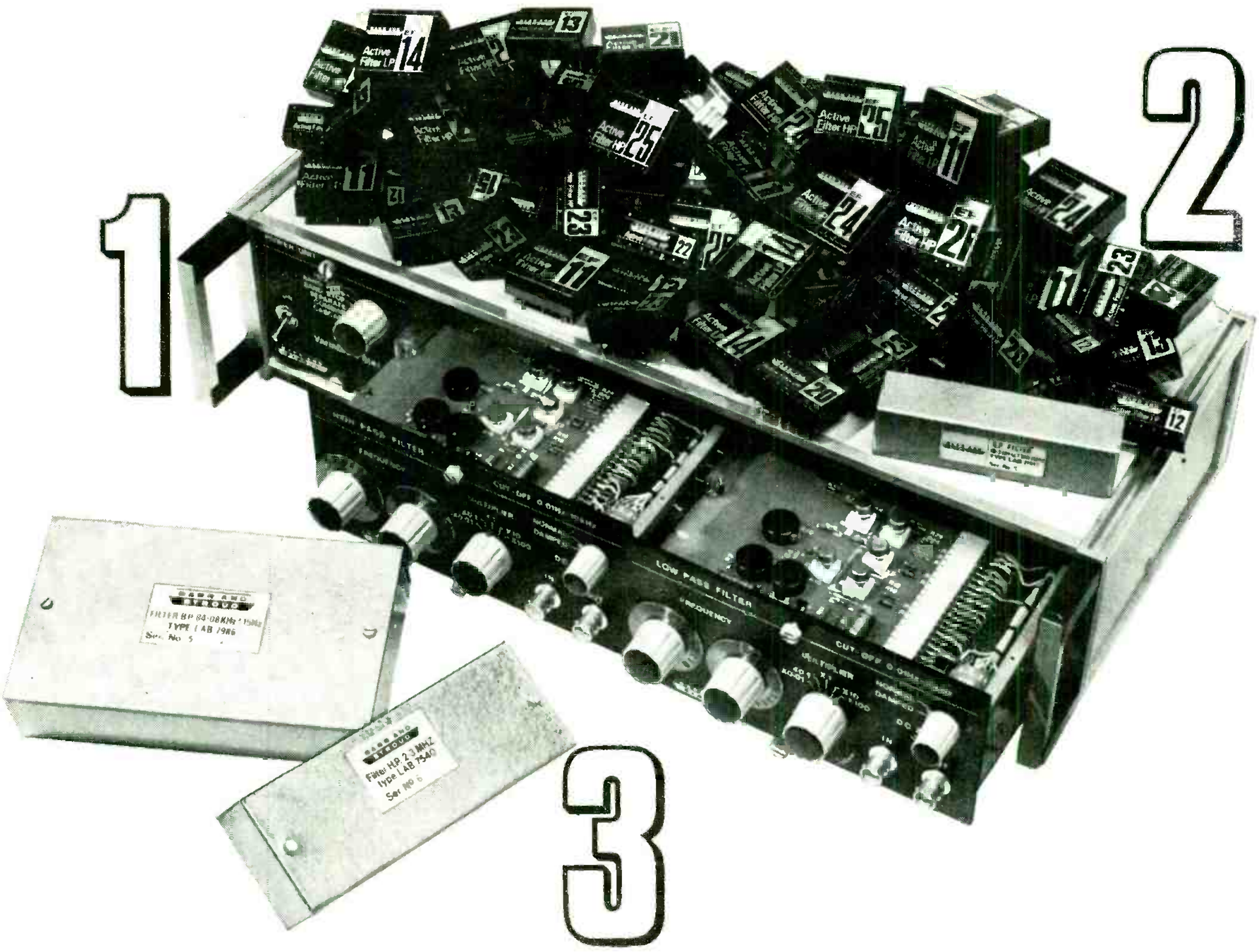

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These are compact, solid state, encapsulated units providing basic filter functions to be customer set for cut-off frequency and characteristic. The present range contains Low Pass and High Pass types with cut-off frequency coverage from 1.0Hz to 30kHz in overlapping ranges, with attenuation rates up to 24dB/octave/module. Universal modules specifically for Band Pass and Band Stop operation are part of the range.

3. Custom Build Service

If our standard filter range does not meet your specification we welcome the opportunity to study your requirement. Broadly our capability stretches from d.c. to 25MHz with experience in passive and active designs. We can work to normal commercial standards or strict defence requirements and construction can be as dictated by the environmental conditions of your application.

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WW—002 FOR FURTHER DETAILS